FINAL REMEDIAL INVESTIGATION REPORT QUENDALL TERMINALS SITE, RENTON, WASHINGTON

Volume I:
Executive Summary and Sections 1 through 9

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On behalf of
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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

ES.1 Introduction

A Remedial Investigation (RI) and Feasibility Study (FS) for the Quendall Terminals Site ("the Site", also referred to as "the Quendall Site") are being conducted by the Quendall Terminals owners (Altino Properties, Inc., and J.H. Baxter & Company; the Respondents) under the direction of the United States Environmental Protection Agency (EPA). The Quendall Site is a former creosote manufacturing facility that was added to the National Priorities List in 2006. The resulting Quendall Administrative Settlement Agreement and Order on Consent, as amended (referred to as "the AOC") was approved pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, under which the work is being conducted.

This RI Report contains background information and describes the RI field investigation conducted in 2009 at the Quendall Site consistent with the EPA-approved Data Collection Work Plan (Anchor QEA and Aspect 2009a).[1] The findings presented in this RI Report are based on historical and RI investigations of hazardous substances in the upland soil, off-shore sediment (including sediment porewater), surface water, and groundwater at the Quendall Site, and were used to develop a conceptual site model (CSM) for the Site. The CSM describes the relationship between Site historical operations and contaminant sources, the nature and extent of dense non-aqueous phase liquid (DNAPL) and the nature and extent of DNAPL contamination in Site media, contaminant fate and transport processes, and chemicals of concern (COCs) that have the potential to pose unacceptable risks to human health and the environment.

The sections that follow briefly describe the major topics addressed in each main section of the RI, focusing on those aspects that will affect future cleanup activities at the Site:

- Section ES.2 – Site History and Environmental Data
- Section ES.3 – Environmental Setting
- Section ES.4 – Nature and Extent of DNAPL

[1] Preliminary fieldwork for the 2009 RI field investigation was performed in 2008.

- Section ES.5 – Nature and Extent of Contamination in Site Media
- Section ES.6 – Contaminant Fate and Transport
- Section ES.7 – Baseline Risk Assessment
- Section ES.8 – Conclusions and Recommendations

Section ES.9 lists the references cited in this Executive Summary. Figures and tables are provided following Section ES.9.

ES.2 Site History and Environmental Data

The Quendall Site (Figure ES-1) is located on Lake Washington in the northernmost limits of the City of Renton, within a former industrial area that now includes residential and commercial uses. The physical address is 4503 Lake Washington Boulevard North. In addition to the portion of the Site owned by Quendall Terminals (referred to as the Quendall property), the Site also includes the Burlington Northern Railroad right-of-way to the east (referred to as the Railroad property) and state-owned aquatic lands to the west.

The upland portion of the Site encompasses approximately 22 acres, is relatively flat, and occupies the middle portion of a roughly 70-acre alluvial plain that has been modified over the last 90 years by filling and grading. Shortly after the lowering of Lake Washington in 1916 to construct the Lake Washington Ship Canal, the Site, including newly exposed portions of the former May Creek delta, was developed into a creosote manufacturing facility. May Creek originally ran through the Site to Lake Washington until it was diverted to the south of the property prior to 1936. Creosote was manufactured on the Site until 1969. From 1969 to approximately 1983, some of the aboveground storage tanks at the Site were used intermittently for storage of crude oil, waste oil, and diesel fuel. From 1975 to 2009, the Site was used primarily for log sorting and storage. The Site is currently vacant and fenced.

The Quendall Site borders approximately 1,500 feet of Lake Washington shoreline. Access to the Site is from Lake Washington Boulevard North, located along the eastern boundary of the property. Shoreline properties immediately adjacent to the Site include Conner Homes to the south (the former Barbee Mill site) and Football Northwest to the north (a former J.H.

Baxter & Company property). Interstate 405 (I-405) is located approximately 500 feet to the east.

Portions of the aquatic lands adjacent to the facility are either owned privately or by the State of Washington.[2] The area of the lake adjacent to the property is also considered prime habitat for the rearing of juvenile salmonid stocks, including Chinook salmon, which are listed as threatened under the Endangered Species Act (ESA). The Site is located within the Usual and Accustomed (U&A) fishing grounds used by the Muckleshoot, Suquamish, and Tulalip Tribes. Recreational fishing (catch and release) also occurs offshore from the property.
Previous Site activities, including the operation of log sorting yards, have resulted in the accumulation of wood chips and bark materials in the central and eastern portions of the property. The exposed Site soil is relatively fine-grained, which slows infiltration during rainy periods thus causing ponding in many areas.

The following sections briefly discuss the historical releases of contaminants at the Quendall Site and a summary of the CSM for the Site.

Historical Releases of Contaminants

Creosote manufacturing was conducted at the Site from 1916 through 1969. Coal and oil-gas tar residues (collectively referred to as coal tar) were distilled into several fractions that were shipped off-Site for a variety of uses. The light distillate fraction was typically used as feedstock in chemical manufacturing. The middle distillate fraction, creosote, was used in the wood preserving industry. The bottom fraction, pitch, was used for applications such as roofing tar. During this period, releases of coal tar and distillate products to the soil occurred at various locations in the uplands and in the offshore where product transport, production, storage, and/or disposal were performed. These releases have resulted in the presence of DNAPL in the subsurface uplands and in offshore sediment.

[2] Aquatic lands adjacent to the facility managed by the Washington State Department of Natural Resources were historically leased for log rafting and vessel storage, but those leases were terminated in the 1990s.

Figure ES-2 shows the locations of historical Site features and sources of DNAPL contamination. Historical releases of DNAPL in the form of coal tar and distillate products occurred in five general Site areas, as follows:

- **Former May Creek Channel Area** – The former May Creek Channel south of the manufacturing plant and nearby storage tanks received wastes from historical operations. Wastes from nearby tanks were reportedly placed in the eastern portion of the former channel, and the western portion of the channel received creosote wastes discharged from a former plant sewer outfall.
- **Still House Area** – Around the former Still House, coal tar was distilled and creosote and light distillates were transferred to surrounding tanks via piping. A pipeline was present between the tanks west of the Still House and the property to the north of the Site (formerly occupied by J.H. Baxter & Company, which operated a wood-treatment plant from 1955 until 1982). This pipeline was used to transport creosote used in the wood-treatment process. Reported releases included product spills directly onto the soil floor of the Still House.
- **Railroad Loading Area –** The Tank Car Loading Area at the railroad tracks east of the Still House was located on a trestle built over May Creek and was the location of reported spills. A platform for loading solid materials (e.g., tar, pitch) was also located farther north on the tracks.
- **Quendall Pond/North Sump Area –** The north and south sumps received liquid wastes from the manufacturing process involving creosote and tars. Tank bottoms from nearby storage tanks were also reportedly placed west of the north sump, where Quendall Pond is now located. The south sump was reportedly filled in before 1950. Shortly after the plant was shut down, approximately 50 truckloads of material were excavated from the larger north sump and disposed of at the Coal Creek Landfill.
- **T-Dock Area –** Offshore, along the former T-Dock, coal tar feedstock was offloaded and transferred to Site upland areas through a pipeline located on the deck of the dock. A large spill (reportedly 30,000 to 40,000 gallons of coal tar feedstock) occurred sometime between 1930 and 1940 at the western end of the T-Dock during barge offloading. Contamination in surface sediment along the former main stem of the T-Dock indicates that there may have been spills from leaks in the piping.

Some solid wastes produced in the manufacturing process were also disposed of at the Site. Heavy tar produced by the distillation process was cooled and solidified in pitch bays north of the Still House. Waste pitch, also called Saturday Coke, was chiseled out and reportedly placed near the Site shoreline. Solid tar products have also been observed in shallow soil around the northern railroad loading area, where solid products were loaded onto railcars.

After the creosote plant was closed in 1969, all structures except for six aboveground storage tanks (ASTs) and the office were demolished. Petroleum was stored at the Quendall Site using the remaining tanks for approximately 13 years, from 1969 to 1982. Reported spills during this period may also have impacted Site media, and while there were reported spills of petroleum product around the ASTs, investigations have not indicated the presence of free-phase light non-aqueous phase liquid (LNAPL) at the Site.

In 1972, Quendall Pond (Figure ES-1) was initially created to capture product originating at the north sump and inhibiting its migration to Lake Washington. In spite of this, contamination has migrated from Quendall Pond into the nearby groundwater, lake surface water, and nearshore sediment.

Environmental Data

The RI Report relies on environmental data from both historical and recent (2009 RI) field investigations. A quality assurance (QA) screening was conducted for historical environmental datasets and appropriate data quality designations (QA2, QA1, or QA0) were assigned to each dataset, as follows:

- QA2 quality data are usable for all RI/FS purposes, including assessing boundaries of contamination at the Site and performing risk assessment exposure calculations.
- QA1 quality data are usable for evaluating the nature and extent of contamination, and can be used with QA2 quality data to assist in assessing boundaries of contamination. QA1 quality data are not as desirable as QA2 data for performing risk assessment exposure calculations, but may be used in cases where QA2 quality data are not available.
- QA0 quality data have too much uncertainty associated with them because of age, analytical method, or lack of complete laboratory documentation, and are not

considered usable for assessing boundaries of contamination or performing risk assessment exposure calculations. These data may be used in conjunction with higher-quality data and/or other lines of evidence to assist in identifying contaminants of interest (COIs), refining assessments of the nature and extent of contamination, and qualitatively evaluating historical trends in contaminant occurrences.

All environmental data generated during the recent 2009 RI field investigation were designated as category QA2 (i.e., the highest quality). These and other historical QA2 quality data were used as the primary line of evidence for delineating the approximate spatial boundaries of Site contamination and for conducting a baseline risk assessment. However, QA1 historical data were considered to support both contamination boundary delineation and the baseline risk assessment in specific circumstances.

During the work planning process, preliminary remediation goals (PRGs) were identified based on federal and state applicable or relevant and appropriate requirements (ARARs) and risk-based criteria. COIs were identified as those chemical constituents exceeding PRGs and associated with products or materials that have been historically used or manufactured at the Quendall Site or similar sites. Because a relatively large number of hazardous substances have been detected at the Site at concentrations above the most stringent PRGs, a subset of the Site COIs, referred to as "indicator chemicals", were used to more efficiently characterize the nature and extent of contamination and the related fate and transport characteristics of those chemicals. Two general categories of Site indicator chemicals were identified: 1) chemicals associated with coal tar products, and 2) chemicals associated with sources other than coal tar products (i.e., from other potential sources). The indicator chemicals in each category are as follows:

- Coal tar products: benzene and polynuclear aromatic hydrocarbons (PAHs) (acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene).

- Other potential sources: arsenic, chromium (III),[3] copper, total polychlorinated biphenyls (PCBs), phenol, 4-methylphenol, pentachlorophenol (PCP), and total organic carbon (TOC).

Benzene and PAHs are associated with the DNAPL present at the Site as the result of the production of coal tar and creosote. Various risk-based metrics of PAH toxicity (carcinogenic PAHs [cPAHs], high-molecular-weight PAHs (HPAHs), low-molecular-weight PAHs [LPAHs], and PAH equilibrium partitioning sediment benchmark quotients [ESBQs] are used for the assessments in the RI Report. Arsenic is of interest because of its historical use at the former Barbee Mill site (now the Conner Homes Property, to the south of the Quendall Site), and PCP because of its potential association with the wood-treating activities at the former J.H. Baxter & Company Property (now Football Northwest, to the north of the Site). The other metals and PCBs are of interest because of the historical storage of waste oil at the Quendall Site. Phenol, 4-methylphenol, and TOC are included because they can be used to characterize the potential adverse effects of wood debris in the shallow sediment offshore from the Site. A list of all COIs and indicator chemicals is provided in Table ES-1.

The remainder of this Executive Summary describes the environmental setting at the Site, where indicator chemicals occur, in what form, and their current and possible future impacts to Site media and potential receptors. Conclusions drawn from the RI and recommendations for further action at the Quendall Site are presented in Section ES.8.

ES.3 Environmental Setting

The Quendall Site is located in the southeastern part of the Puget Sound Lowland. The geologic units beneath the Site consist of highly heterogeneous alluvial and lacustrine silts, sands, and peat underlain by a coarser sand-gravel alluvium. The groundwater flow system is characterized primarily by recharge in the upland areas east of the Site and the May Creek drainage south/southeast of the Site, with flow towards the west and discharge to Lake Washington. Site groundwater likely originates from precipitation on and east of the Site

[3] Soil conditions at the Site are characterized by high organic carbon content, supporting a reducing environment and neutral pH. Because the oxidizing environment required to maintain chromium (VI) is not present at the Site, chromium (VI) was not retained as a COI.

and recharge from alluvial deposits in the May Creek drainage immediately south of the Site. The local geology and hydrology are significant factors affecting the migration patterns of contaminants throughout the Quendall Site.

Site Geology

The shallow geologic units that affect the distribution of contaminants and are of importance to the future cleanup of the Quendall Site include the following:

- An upper Fill Unit ranging from 1 to more than 10 feet thick that occurs across the entire Site. The unit is heterogeneous but permeable, and consists of a mix of silt, sand, and gravel as well as wood debris, glass, brick, and pitch-like material.
- The Shallow Alluvium that occurs beneath the Fill Unit, ranging to depths between 30 and 50 feet below ground surface (bgs), and consists of interbedded and discontinuous layers of generally low-permeability, heterogeneous layers of sand, silt, and peat that dip to the west, consistent with their deltaic depositional origin. The sand layers provide preferential pathways for groundwater flow.
- The Deeper Alluvium that occurs beneath the Shallow Alluvium, and consists of more permeable, homogeneous sand and gravelly sand, with occasional lower-permeability interbedded silt to silty sand layers. This unit extends to depths of between 90 and 140 feet bgs.

The presence of heterogeneous, interbedded, and discontinuous layers of lower-permeability materials complicates the fate and transport of both DNAPL and resulting dissolved-phase contaminants in groundwater. Evidence from field observations suggests that interbedded, low-permeability layers in the Shallow Alluvium create stratigraphic “traps” that can stop, slow, or alter migration of DNAPL.

Site Groundwater Hydrology

The shallow hydrologic units that affect the distribution of contamination and are of importance to the future cleanup of the Quendall Site include the following:

- The Shallow Aquifer that occurs in the Fill Unit and in the Shallow Alluvium to depths of approximately 30 to 50 feet bgs, with the water table typically encountered

at depths of 6 to 8 feet.

- The Deep Aquifer that occurs in the Deeper Alluvium (beneath the Shallow Alluvium) to a depth of approximately 140 feet bgs.

Site groundwater generally flows horizontally across the Site in an east to west direction, ultimately discharging to Lake Washington. Vertical hydraulic interaction between the Shallow and Deep Aquifers is limited by the horizontal stratification of the Shallow Alluvium. However, vertical groundwater movement varies depending on where the groundwater flowpaths originate. Shallow groundwater in the eastern portion of the Site near the Railroad Property typically flows downward through the Shallow Aquifer and reaches the upper portion of the Deep Aquifer. Within the central areas of the Site, groundwater flow is primarily horizontal and vertical exchange between the two aquifers is limited. Near the shoreline of Lake Washington, groundwater in the Deep Aquifer has an upward flow component, traveling through the Shallow Aquifer before discharging to surface water. Groundwater flow through the Shallow and Deep Aquifers has been defined by modeled groundwater flowpaths as illustrated in Figure ES-3.

While the discontinuous geological layers of silt, sandy silt, and peat provide varying degrees of hydraulic separation between the Shallow and Deep Aquifers, geological studies have not found a well-defined aquitard between the two aquifers. The presence of bedrock and fine-grained deposits limits the lateral extent of local aquifers encountered beneath the Site, isolating them from regional aquifers located to the south in the Cedar River valley.

Bathymetry and Sediment Characteristics

The lake bottom offshore from the Site is relatively flat, with water depths up to 31 feet at the westernmost extent of the Quendall property boundary (the inner harbor line). The bottom substrate is typically a fine silt/mud, although several areas consist of sandier material, including the Quendall Site sand spit and sediment near the outer harbor line south of the former T-Dock.

Natural Resources

The Site includes upland, riparian, wetland, and nearshore habitats. Upland vegetation consists primarily of early successional species and invasive species including large stands of Himalayan blackberry and Scot's broom. Because of the most recent log handling and storage uses in the uplands, there are large deposits of wood debris covering access roads and storage areas. Riparian vegetation is generally present across the Site shoreline, with the exception of the southern log handling area. Aquatic vegetation consists mostly of dense beds of Eurasian milfoil. Fish that may use the Site include Chinook salmon, steelhead, and bull trout, all of which are listed as threatened species under the ESA. Juveniles of all three species may use the nearshore for rearing; however, steelhead are more likely to remain in their natal streams until they migrate directly to Puget Sound.

Groundwater beneath the Site and Lake Washington are considered potable water supplies; however, neither is currently used as a source of drinking water. The valued habitats, ESA-listed species, and potable water supply designation are significant considerations for future cleanup activities.

ES.4 Nature and Extent of DNAPL

The distribution and varied characteristics of DNAPL at the Quendall Site have a significant effect on the nature and extent of contamination present in Site groundwater, soil, and sediment (described in Section ES.5). DNAPL at the Site was characterized based on the following descriptions:

- No visible evidence – No visible evidence of oil on sample.
- Sheen – Light to heavy and colorful film on sample (or as a result of a sheen test).
- Staining – Visible brown or black staining on sample. Can be visible as mottling or in bands. Typically associated with fine-grained materials.
- Oil-coated – Visible brown or black oil coating on sample grains. Typically associated with coarse-grained materials.
- Oil-wetted – Visible brown or black oil wetting the sample grains. Oil appears as a liquid and is not held by the sample grains.

Soil and sediment that appeared oil-coated or oil-wetted were identified as containing DNAPL. Figure ES-4 shows a generalized CSM of the presence of DNAPL at the Site and how it affects other media. DNAPL that was spilled or disposed of on surface soil and sediment at the Quendall Site continues to serve as an ongoing source of contaminants to Site soil, groundwater, surface water, and sediment (and sediment porewater). The natural environment at the Quendall Site has significantly affected the current DNAPL architecture and the extent of DNAPL-related contamination. As indicated on the figure, DNAPL in the uplands at the Quendall Site is generally found in shallow stringers located in permeable soil, rather than in one or more continuous "pools". Of 57 borings where DNAPL was encountered, 44 had only one layer of DNAPL.

Figure ES-5 shows the extent of DNAPL observed both in the uplands and in sediment. The left panel shows the cumulative DNAPL thickness, and the right panel shows the maximum depths where DNAPL has been encountered.[4] DNAPL has been observed in the following five general Site areas, which are correlated to historical releases of creosote and coal tar products, geography, and particular facility operations:

- **The Former May Creek Channel Area**, which includes an area west of a former sewer outfall where wastes from the Still House were reportedly discharged, and an area south of former ASTs (Tanks 1 through 5) where tank bottoms were reportedly placed.
- **The Still House Area** where coal tar was refined into creosote.
- **The Railroad Loading Area** where creosote was loaded onto railcars, coal tar was offloaded from railcars, and spills reportedly occurred.
- **The Quendall Pond/North Sump Area** where coal tar and creosote manufacturing wastes, such contaminated condenser effluent, were reportedly discharged.
- **The T-Dock Area** where coal tar was offloaded from freighters, and spills reportedly occurred.

[4] The nature and extent of DNAPL, or the potential for DNAPL presence, have been defined using field screening (observations from soil and sediment borings), measurement of DNAPL accumulation in wells, and soil and groundwater concentrations as indicators of the potential presence of DNAPL.

Table ES-2 presents the approximate acreage of soil and/or sediment containing DNAPL, the average cumulative thickness of layers of DNAPL, the maximum depth of DNAPL encountered during drilling, and the volume of impacted media (cubic yards) and DNAPL (gallons) for each of the five general areas of the Site where DNAPL has been found. It is estimated that approximately 445,000 gallons of DNAPL are present in the subsurface at the site, impacting a total of 9.7 acres of the Site.

The majority of DNAPL in the uplands is found within the top 20 feet of the Shallow Aquifer. The deepest that DNAPL is found in the uplands is in the Railroad Loading Area at 30 feet and in the Former May Creek Channel Area at 34 feet. Upland DNAPL is found only within the Shallow Aquifer with an exception of a thin layer of DNAPL within the top layer of the Deeper Aquifer in the Former May Creek Channel Area. The highest cumulative thicknesses of DNAPL are found within the Former May Creek Channel Area (8.8 feet) and the Railroad Loading Area (11 feet). The Quendall Pond/North Sump Area contains the most DNAPL in terms of volume and affected acreage.

Offshore occurrences of DNAPL are sporadic. The maximum depth of DNAPL observed in the T-Dock Area is 3.8 feet, although most of the DNAPL along the T-Dock occurs very near the surface, indicating that the DNAPL occurrences in sediment in this area are associated with leaks and spills from historical operations. DNAPL has also migrated from the uplands to nearshore sediment and has been found as deep as 16 feet immediately west of Quendall Pond.

ES.5 Nature and Extent of Contamination in Site Media

The highest levels of contamination in Site environmental media are associated with occurrences of creosote and coal tar DNAPL. As noted above, DNAPL serves as an ongoing source of contaminants to Site soil, groundwater, and offshore sediment (including sediment porewater, and ultimately surface water). Because the nature and extent of Site groundwater contamination help inform the contaminant distribution in other Site media, the groundwater contamination at the Site is discussed first, followed by soil and sediment. The section closes with a discussion of solid tar products found in the Fill Unit at the Site.

Nature and Extent of Groundwater Contamination

Coal-tar-product indicator chemicals (i.e., benzene and other PAHs) and arsenic are present in groundwater where DNAPL is present. Groundwater contamination at the Site has resulted from historical releases of aqueous wastes and from contaminant leaching/ dissolution from DNAPL and DNAPL-impacted soil present either above or below the water table. Site groundwater in the uplands is encountered at relatively shallow depths (typically 6 to 8 feet bgs). The approximate extents of groundwater contamination for benzene, naphthalene, cPAHs, and arsenic (based on comparison to PRG screening levels) are shown on Figure ES-6. The left panel shows Shallow Aquifer contamination; the right panel shows Deep Aquifer contamination.

The highest contaminant concentrations in groundwater have been detected in the Shallow Aquifer, and at the top of the Deep Aquifer, in and downgradient from DNAPL areas. Concentrations decrease with depth, and the vertical extent of benzene and naphthalene contamination in the deep groundwater interval is estimated to be less than 110 feet bgs near the shoreline. In contrast, cPAHs were not detected above PRG screening levels in the deep groundwater interval during the 2009 RI sampling events, which is not unexpected given that cPAHs are relatively insoluble and therefore less mobile in groundwater than the other indicator chemicals.

Arsenic concentrations exceeded both the PRG screening level (based on the maximum contaminant level [MCL]) of 10 micrograms per liter [μg/L]) and the state-wide background level of 5 μg/L at most locations. Concentrations of arsenic in soil are considered to be consistent with background levels; therefore, elevated groundwater concentrations may result from the greater mobility of naturally occurring arsenic under reducing conditions, which occur in areas of peat, DNAPL, and dissolved-phase hydrocarbon contamination. The vertical extent of arsenic concentrations exceeding the PRG screening level is less than 85 feet.

Based on the available RI field investigation data, metals (with the exception of arsenic), PCP, and PCBs have not been detected in groundwater or have not been detected at concentrations above PRG screening levels.

Nature and Extent of Soil Contamination

Site soil has been contaminated by historically-placed fill materials, historical DNAPL and/or aqueous waste releases, and as the result of DNAPL and contaminated groundwater migration. Potentially contaminated materials historically used as Site fill include heavy tar distillates such as pitch and Saturday Coke that are solid or semi-solid, and foundry slag. Because solid and semi-solid tar products are not mobile, their distribution is limited to the Site locations where they were placed. The vertical extent of Site solid and semi-solid tar products is limited to the shallow Fill Unit, which extends to 10 feet bgs. Solid and semi-solid tar products are typically only present above the water table, but may occur within areas that are seasonally saturated; however, because of their low leachability, these products are not significant contributors to groundwater contamination.

Benzene, naphthalene, and cPAHs have been detected in soil at high concentrations in the former May Creek Channel, near the Still House, near Quendall Pond, and in the Railroad Loading Area, and are strongly correlated with DNAPL or solid tar products. In areas of solid tar products, benzene concentrations are typically low or not detectable and cPAH concentrations are typically greater than naphthalene concentrations. Outside these areas, the extent of elevated benzene and/or naphthalene concentrations in soil corresponds to areas of groundwater contamination.

Benzene and naphthalene concentrations in surface soil (less than 5 feet bgs) are either low or not detectable, and are likely related to fill placement in 1983 after the creosote plant was shut down; however, concentrations of cPAHs significantly exceed the PRG screening levels in surface soil. In subsurface soil (5 feet bgs and deeper), the highest benzene, naphthalene, and cPAH concentrations are consistent with the presence of DNAPL or solid tar products, both vertically and laterally. The vertical extents of benzene and naphthalene in subsurface soil can also generally be delineated by their respective vertical extents in groundwater.

In contrast to coal-tar-product indicator chemicals, indicator chemicals related to metals, PCP, and PCBs have generally not been detected at the Quendall Site or, in the case of naturally occurring substances such as metals, have been detected at concentrations below PRG screening levels or close to natural background concentrations.

Nature and Extent of Sediment Contamination

Surface and subsurface sediment contaminant sources at the Site include historical spills and leaks from ships, barges, and overwater conveyances, and ongoing contaminated groundwater inputs from upland sources. Two sediment areas impacted by hazardous substance releases are shown on Figure ES-7:

- **Nearshore Groundwater Discharge Area:** Located adjacent to Quendall Pond, this area currently receives contaminated groundwater loading from upland sources; this area was also the location of historical spills and leaks that discharged directly to surface water.
- **T-Dock Spill Area:** This area in the vicinity of the former T-Dock received historical releases of coal tar and fuel oil products directly to surface water and sediment from leaks and spills.

The primary indicator chemicals for sediments in these areas are PAHs, specifically naphthalene, cPAHs, and PAH ESBQs. The same indicator chemicals found in Site sediment were also found in sediment porewater. These indicator chemicals are also associated with coal tar product leaks and spills along the T-Dock, and transport of soluble DNAPL constituents in groundwater to the Nearshore Groundwater Discharge Area. Samples from both areas exceeded the PRG screening levels for naphthalene, cPAHs, and PAH ESBQs; however, benzene was not detected above the PRG screening level. Naphthalene concentrations in sediment porewater were highest directly offshore from Quendall Pond in the Nearshore Groundwater Discharge Area, which is consistent with the surface bulk sediment results as well as with naphthalene concentrations in shallow groundwater. cPAHs and PAH ESBQs in surface sediment were highest in the vicinity of the former T-Dock cross span. Bioassay data were collected to corroborate chemical data in surface sediment related to coal tar and fuel oil products. These results were evaluated as part of the baseline ecological risk assessment (summarized in Section ES.7).

ES.6 Contaminant Fate and Transport

Contaminants present in environmental media at the Quendall Site can migrate from one location to another via bulk flow (advection) or chemical gradient (diffusion) processes. Contaminants can also be transferred among air, water, and soil media via various partitioning mechanisms (e.g., volatilization, dissolution, and sorption) during migration, thereby modifying the rate of movement through the subsurface. In addition, contaminant concentrations can be reduced or attenuated by various combinations of chemical processes (e.g., diffusion and abiotic transformation), biological processes (e.g., biodegradation), or physical processes (e.g., dispersion and dilution), as well as by the partitioning mechanisms listed above. These contaminant transport, partitioning, and attenuation processes affect how the nature and extent of contamination may change over time, and provide a basis for assessing the potential effectiveness of technologies and remedial alternatives in the FS. Figure ES-8 shows a generalized CSM illustrating contaminant fate and transport processes operating at the Site.

DNAPL Movement and Dissolution

As noted above, DNAPL is present in an estimated 9.7 acres of the Site. Most DNAPL is located below the water table and in constant contact with groundwater, and leaching of contaminants from the DNAPL occurs at a fairly steady rate.

DNAPL moves through the subsurface soil from its original source areas based on its Site-specific mobility. Mobility characteristics vary based on variations in local geology, soil architecture, and product characteristics. The Shallow Alluvium at the Site dips towards Lake Washington and consists of numerous permeable, discrete, thin sand or silty sand layers separated by low-permeability silt or peat. Because the density and viscosity of DNAPL are greater than those of water, DNAPL will migrate vertically until it becomes trapped by low-permeability materials. At that point, DNAPL will tend to: 1) accumulate on top of the lower-permeability layers and 2) migrate laterally through seams of higher permeability until becoming trapped by other intersecting lower-permeability layers. As DNAPL migrates through soil, it leaves behind a residual coating of product on the soil grains (referred to as "residual DNAPL" or "oil-coated" soil), diminishing the available volume of mobile DNAPL. DNAPL mobility in sediment is affected by the same parameters as mobility in soil.

However, additional parameters affect the mobility of DNAPL released to surface water (e.g., Lake Washington). In these cases, DNAPL mobility as a result of spilled or leaked material is a function of the location and volume of the spill event, the nature of the material, and physical conditions including weather and currents.

Contaminant Transfer from DNAPL to Other Site Media

In evaluating the fate and transport of DNAPL, three pathways are of particular importance when evaluating potential contaminant exposures under current and future conditions:

- The DNAPL/soil/groundwater to air pathway
- The DNAPL/soil to groundwater to sediment/porewater pathway
- The groundwater to lake pathway

For the DNAPL to air and DNAPL to porewater pathways, computer model simulations that incorporated the transport, partitioning, and attenuation/transformation mechanisms described above were used to evaluate contaminant migration.

DNAPL/Soil/Groundwater to Air Pathway

For the DNAPL/soil/groundwater to air pathway (also called the vapor intrusion pathway), contaminants present in the subsurface are transported via soil gas into the aboveground air. Contaminants present in DNAPL and soil in the unsaturated zone, and in groundwater at the top of the water table, volatilize into soil gas according to the partitioning relationships described above. Contaminant migration in soil vapor may be retarded by sorption onto soil, and contaminants may be removed by biodegradation. Indoor air modeling conducted in support of the Draft Task 3 Report (Anchor and Aspect 2007) indicated that exceedances of air PRGs for benzene and naphthalene are possible in future structures under baseline (unremediated) conditions. This finding was corroborated by the baseline human health risk assessment.

Based on the widespread occurrence of volatile contaminants in shallow Site soil and groundwater, and the results of a screening-level evaluation performed by EPA, it is anticipated that the design of future Site structures will need to include an evaluation of

vapor intrusion and will likely require that some form of vapor intrusion mitigation, either passive or active, is incorporated into the design.

DNAPL/Soil to Groundwater to Sediment/Porewater Pathway

For this pathway, contaminants present in Site DNAPL or soil dissolve into groundwater and are transported in groundwater toward Lake Washington, where they are either discharged to the lake (discussed below) or, prior to discharge, are transformed or sorbed onto sediment.

At the Quendall Site, multiple DNAPL sources impact the Shallow Alluvium and Shallow Aquifer, such that dissolved contaminants are present at shallow depths in most of the Site. Dissolved contaminants enter the Deep Aquifer through the Shallow Aquifer in response to downward vertical gradients and dispersion (especially in the eastern portion of the Site). Once contaminants enter the Deep Aquifer they continue to migrate to depth in the Deep Aquifer through the dispersion process, as documented by Site monitoring data and computer modeling results.

To the west, upward groundwater gradients in the Nearshore Groundwater Discharge Area result in significant contaminant concentrations in surface and subsurface bulk sediment and in sediment porewater in that area. Contaminant transport modeling that was used to approximate the mixing and attenuation processes showed that undifferentiated abiotic and biodegradation may be important processes affecting the concentrations of the mobile indicator chemicals such as benzene and naphthalene, particularly in the Nearshore Groundwater Discharge Area. However, these degradation processes are not expected to have any appreciable effect on the concentrations of less mobile indicator chemicals such as cPAHs and arsenic.

Groundwater to Lake Pathway

Contaminant fate and transport mechanisms that affect the groundwater to lake pathway are more numerous and variable, and thus are more complex than the mechanisms that affect the previous pathways. Detailed sampling and analysis of groundwater and sediment porewater concentration gradients were performed for the upper 4 feet of sediment in the Nearshore Groundwater Discharge Area of the Site. In addition to porewater analysis for

benzene and naphthalene, the sediment porewater samples were also analyzed for several relatively non-reactive "tracer" cations (sodium, potassium, calcium, and magnesium) to help differentiate between chemical/biological concentration attenuation processes that affect Site COIs and simple dilution with surface water. The results of the evaluation of these data showed significant attenuation (more than two to three orders of magnitude) of benzene and naphthalene as compared to the tracer cations, indicating the existence of biodegradation and/or chemical attenuation processes in the transition zone between groundwater and Lake Washington.

It is important to note that conclusions regarding degradation at the Site are applicable to existing conditions and processes. To the extent that future fate and transport characteristics of the Site are altered from existing conditions (e.g., following the implementation of remedial actions), these may lead to changes in fate and transport mechanisms and/or rates. Evaluation of future attenuation characteristics is included in the detailed evaluation of alternatives in the FS.

ES.7 Baseline Risk Assessment

Baseline human health and ecological risk assessments were conducted in accordance with EPA guidance using data of sufficient quality that have been collected from the Site.

The baseline human health risk assessment evaluated the following exposure scenarios:

- **Future Residential Exposure Scenario.** The residential scenario was based on potential redevelopment of the Site for residential purposes and future Site use by adults and children. The potential routes of exposure to contaminants in soil (to a depth of 15 feet bgs) and groundwater include incidental ingestion, dermal contact, and inhalation of fugitive dusts and vapors. Inhalation of vapors migrating from groundwater into future residential buildings is also possible.
- **Future Occupational Worker Exposure Scenario.** Adult workers could potentially be exposed to chemicals in soil (from 0 to 15 feet bgs) by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors. Vapor intrusion into future non-residential buildings and exposure to groundwater by occupational

workers are also possible; however, these pathways are addressed under the more health-conservative residential exposure scenario.

- **Future Construction/Excavation Worker Exposure Scenario.** Adult construction/ excavation workers could potentially be exposed to chemicals in soil (from 0 to 15 feet bgs) by incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors generated during excavation activities. Potential routes of exposure to shallow groundwater for the construction/ excavation worker include dermal contact and inhalation of ambient vapors generated during excavation activities.
- **Current and Future Recreational Beach User Exposure Scenario.** The recreational beach user scenario addresses individuals engaged in recreation at the shoreline, gaining access either from Site uplands or via boat. Potential routes of exposure to nearshore surface sediment (0 to 4 inches bgs) and surface water include incidental ingestion and dermal contact.
- **Current and Future Recreational Fishing Exposure Scenario.** The recreational fishing exposure scenario addresses adult recreational anglers gaining Site access by boat or land and harvesting fish or shellfish for personal consumption using hook and line, traps, digging, or other methods. Potential exposure routes include ingestion of contaminants that bioaccumulate in fish/shellfish tissue, and incidental ingestion of and dermal contact with sediment during angling activities.
- **Current and Future Subsistence Fishing Exposure Scenario.** Lake Washington is a U&A fishing ground for the Muckleshoot, Suquamish, and Tulalip Tribes. Potential exposure routes under this scenario include ingestion of contaminants that bioaccumulate in fish/shellfish tissue, and incidental ingestion of and dermal contact with sediment during angling activities.

Figure ES-9 shows a generalized CSM illustrating exposure pathways relevant to human receptors at the Site.

EPA default exposure assumptions were used to evaluate these scenarios, including the subsistence fishing scenario. As discussed in the Human Health and Ecological Risk Assessment (HERA) Work Plan (Anchor QEA and Aspect 2009b), if no risk is indicated from subsistence fishing using this default ingestion rate, regional Tribal consumption rates (which

may be greater than the default subsistence rates) may need to be evaluated to see that Tribal and subsistence anglers are adequately protected.

The baseline human health risk assessment evaluated potential noncancer and cancer effects. For noncancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular chemical with the highest level of exposure that is considered protective. The ratio is termed the hazard quotient (HQ). When the HQ for a chemical exceeds 1, there is a concern that noncancer health effects are possible. To assess the potential for noncancer effects posed by exposure to multiple chemicals, a hazard index (HI) approach is used in accordance with EPA guidance (1989).

The potential for cancer effects is evaluated by estimating excess lifetime cancer risk (ELCR). This risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer (i.e., if no exposure to Site chemicals occurs).[5] In interpreting estimates of excess lifetime cancer risks, EPA under the Superfund program generally considers action to be warranted when the multi-chemical aggregate cancer risk for all exposure routes within a specific exposure scenario exceeds 1×10^{-4}. Action generally is not required for risks between 1×10^{-6} and 1×10^{-4}; however, this is judged on a case-by-case basis.

The results of the baseline HHRA are summarized in Table ES-3. As indicated in the table, the results of the human health risk characterization indicate that non-cancer HIs exceed 1 for all but the recreational beach user and recreational fishing scenarios. HIs exceeding 1 range from 3 (subsistence fish ingestion) to 7,995 (groundwater exposure for the future resident). ELCR estimates exceed 1×10^{-4} for all six scenarios using Site data, ranging from 2×10^{-4} (recreational fish ingestion) to greater than 8×10^{-1} (groundwater exposure for the future resident). The residential indoor air pathway is also of concern. The ELCR estimate for this pathway is 2×10^{-2}, with the primary risk contributors being benzene, naphthalene, and ethylbenzene.

[5] For example, an ELCR of 2×10^{-6} means that for every 1 million people exposed to a carcinogen throughout their lifetimes, the average incidence of cancer may increase by two cases of cancer.

For the beach user and fishing scenarios, risk estimates were also developed using sediment samples from background locations in order to understand the contribution of background concentrations to Site risks and provide information that may be used for risk management decisions. When using the background sediment dataset, HIs are less than 1 for all three scenarios, and ELCR estimates for recreational and subsistence fish ingestion exceed 1×10^{-6} but are less than 1×10^{-4}.

Ecological receptors potentially include the animals and plants that use terrestrial and/or aquatic habitats within the Site. These ecological receptors can generally be segregated into plants, invertebrates, reptiles and amphibians, fish and shellfish, and mammals and birds. Representative species from groups including plants, invertebrates, fish, shellfish, birds, and mammals were selected as receptors of concern and further evaluated in a baseline ecological risk assessment to assess if and to what degree they may be at risk from contaminated media at the Site.

Ecological HQs were estimated using multiple lines of evidence; these included comparison of bulk soil (for soil invertebrates and terrestrial plants) and surface water/porewater concentrations (for fish and aquatic plants) to screening levels, and a multi-media exposure model approach that compared estimated total dietary intakes (TDIs) with literature toxicity reference values (TRVs) for both terrestrial and aquatic-dependent wildlife. Benthic invertebrate risk was assessed directly through sediment bioassays and by using the ESBQ approach for PAHs (EPA 2003).

The results of the ecological risk assessment indicate that risks for both terrestrial and aquatic-dependent wildlife receptors exceed an HQ of 1. The primary risk drivers are PAHs in soil, sediment, and sediment porewater. Site sediment that poses a PAH-related risk to benthic macroinvertebrates has been delineated in the Nearshore Groundwater Discharge Area (adjacent to Quendall Pond) and the T-Dock Spill Area. Benthic toxicity measured in sediment bioassays correlates closely with porewater PAH concentrations and is corroborated by PAH ESBQs that exceed 1.

If a cumulative ELCR of 1 x 10^{-4} was exceeded for a given medium, the individual constituents that pose an ELCR of 1 x 10^{-6} were identified as COCs for human health. Constituents that exceeded an HQ of 1 for either human or ecological receptors were also identified as COCs. Table ES-4 provides a list of the COCs by medium. The primary COCs that pose risks to human health throughout the Site are cPAHs, naphthalene, benzene, and arsenic. The primary COCs that pose risks to ecological receptors throughout the Site are PAHs, represented as both individual chemicals and as totals (LPAHs, HPAHs, total PAHs, and PAH ESBQs).

ES.8 Conclusions and Recommendations

A total of 445,000 gallons of creosote and coal tar DNAPL is estimated to be present in the subsurface at the Quendall Site, covering approximately 9.7 acres of the Site (including offshore portions of the Site beneath Lake Washington), and typically observed in the upper 20 feet bgs. Coal tar and creosote product indicator chemicals (i.e., benzene, naphthalene, and cPAHs) and arsenic are present above PRGs in groundwater where DNAPL is present, with impacted groundwater generally extending downgradient (both horizontally and vertically) from DNAPL-impacted areas. The migration of contaminated groundwater from DNAPL source areas represents a secondary source of contamination to soil and sediment; therefore, the horizontal and vertical extent of contamination in groundwater is a good indicator of the extent of impacts to these other media. The results of the baseline human health and ecological risk assessment indicate that risks posed to humans and ecological receptors based on exposure to contaminated Site media exceed EPA's acceptable levels. The primary contributors to unacceptable risk are PAHs, naphthalene, benzene, and arsenic.

Based on these findings, it is recommended that:

- Identification and evaluation of remedial alternatives that address DNAPL and other affected Site media with contaminants exceeding PRGs should be pursued in the FS.
- Groundwater flow and fate/transport modeling tools should continue to be updated as new groundwater monitoring data become available; the models should be enhanced in anticipation of their value in assessing candidate remedial alternatives developed during the FS.

- Groundwater monitoring should continue to support ongoing analysis of groundwater quality trends and the horizontal and vertical migration of DNAPL over time.
- Until the selected remedy is fully functional, public access to the Site should be restricted by use of upland fencing, and signs prohibiting access to lake sediments and collection of shellfish for human consumption.

ES.9 References

Anchor and Aspect, 2007. Draft Task 3 – Preliminary Conceptual Site Model, Remedial Action Objectives, Remediation Goals, and Data Gaps, Remedial Investigation/Feasibility Study, Quendall Terminals Site (Draft Task 3 Report). Report prepared for U.S. Environmental Protection Agency, Region 10, on behalf of Altino Properties, Inc., and J.H. Baxter & Company by Anchor Environmental, LLC, Seattle, WA and Aspect Consulting, LLC, Seattle, WA. November 2007.

Anchor QEA and Aspect, 2009a. Final Data Collection Work Plan, Remedial Investigation/Feasibility Study, Quendall Terminals Site, Renton, Washington. Prepared for U.S. Environmental Protection Agency, Region 10, on behalf of Altino Properties, Inc., and J.H. Baxter & Company by Anchor QEA, LLC and Aspect Consulting, LLC. June 2009.

Anchor QEA and Aspect, 2009b. Final Work Plan, Human Health and Ecological Risk Assessment, Quendall Terminals Site, Renton, Washington (HERA Work Plan). Prepared for U.S. Environmental Protection Agency, Region 10, on behalf of Altino Properties, Inc., and J. H. Baxter & Co. by Anchor QEA, LLC, and Aspect Consulting, LLC. November 2009.

EPA (U.S. Environmental Protection Agency), 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002. December.

EPA (U.S. Environmental Protection Agency), 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: P AH Mixtures. EPA/600/R-02/013. November 2003.

Legend

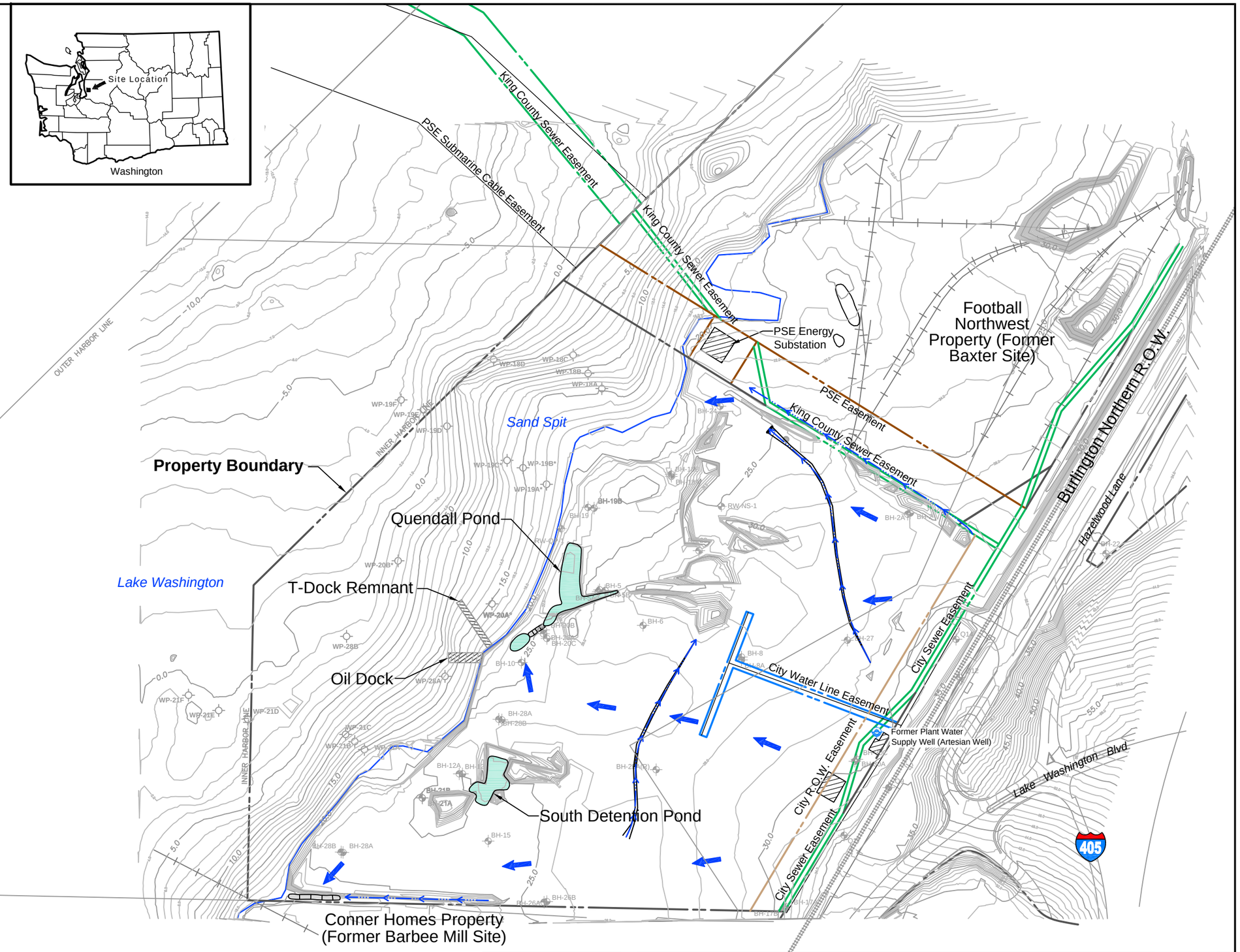
- Current Shoreline
- Existing Monitoring Wells
- Former Plant Water Supply Well (Artesian Well)
- Existing Wellpoints
- Existing Structures
- Puget Sound Energy (PSE) Easement Boundary
- City Right-of-Way (R.O.W.) Easement
- Sewer Easement Boundary
- Water Line Easement Boundary

Surface Water Features and Stormwater Control Structures

- Detention pond
- Stormwater drainage ditch with silt fence and/or rock check dams (approximate location)
- Overland drainage flow direction
- Ditch flow direction
- Shallow interceptor swale

Notes:

1) Wellpoints with *'s, WP-19 A/B/C and WP-20 A/B, were confirmed to still exist in September 2002. WP-21C could not be located at that time. Attempts to locate remaining wellpoints have not been made since Retec last sampled them in 2001.
2) "City" refers to City of Renton in easement labels.
3) The southern boundary of the PSE Easement is the northern boundary of the Quendall Site.



N

0 200 400
Feet

Aspect CONSULTING

Quendall Terminals Site Locations and Current Features

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/TDC	
DRAWN BY: PMB	FIGURE NO. ES-1
REVISED BY: SCC	

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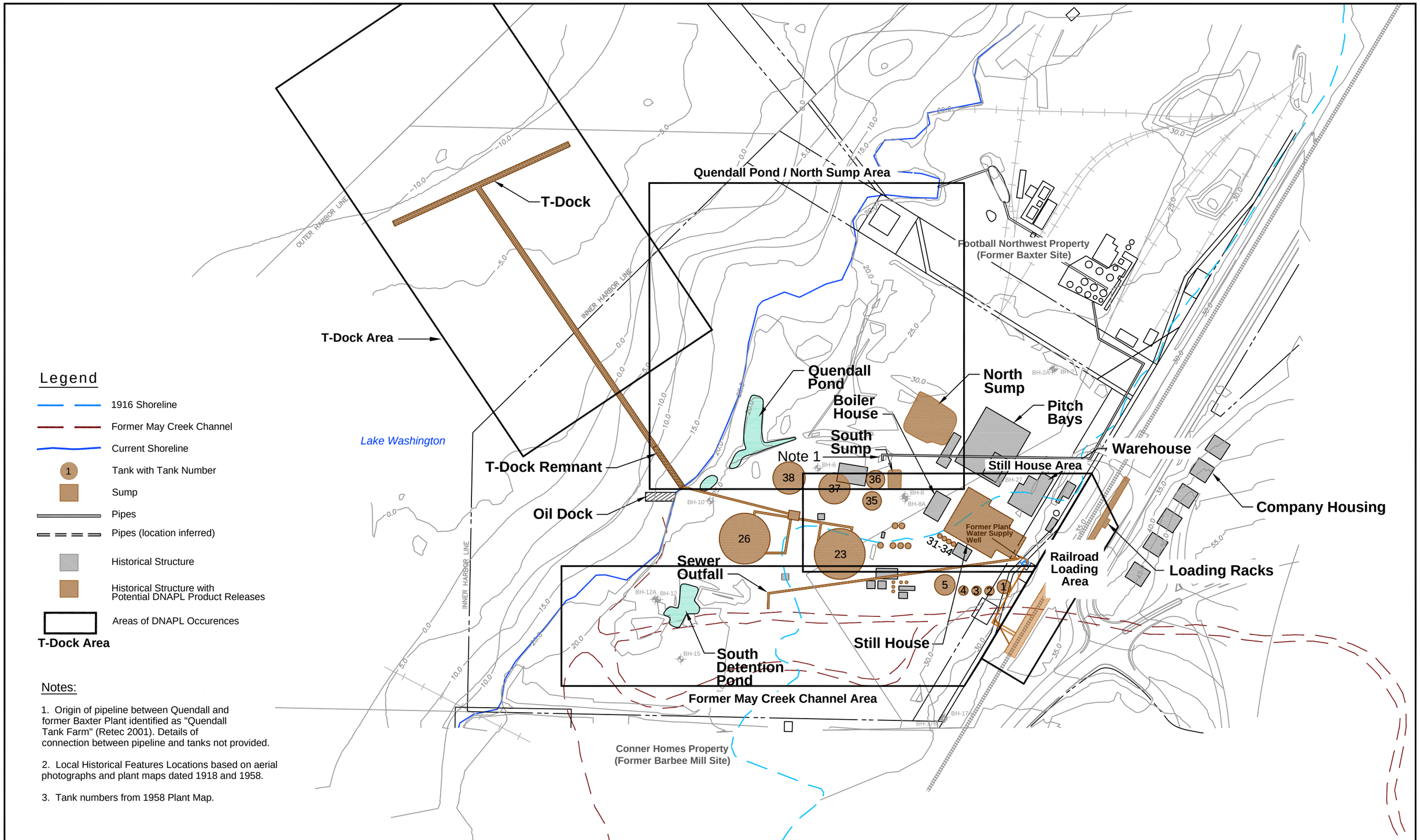

Notes:

1. Origin of pipeline between Quendall and former Baxter Plant identified as "Quendall Tank Farm" (Retec 2001). Details of connection between pipeline and tanks not provided.

2. Local Historical Features Locations based on aerial photographs and plant maps dated 1918 and 1958.

3. Tank numbers from 1958 Plant Map.

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Historical Quendall Site Features and Potential Sources of DNAPL

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. ES-2
REVISED BY: SCC	

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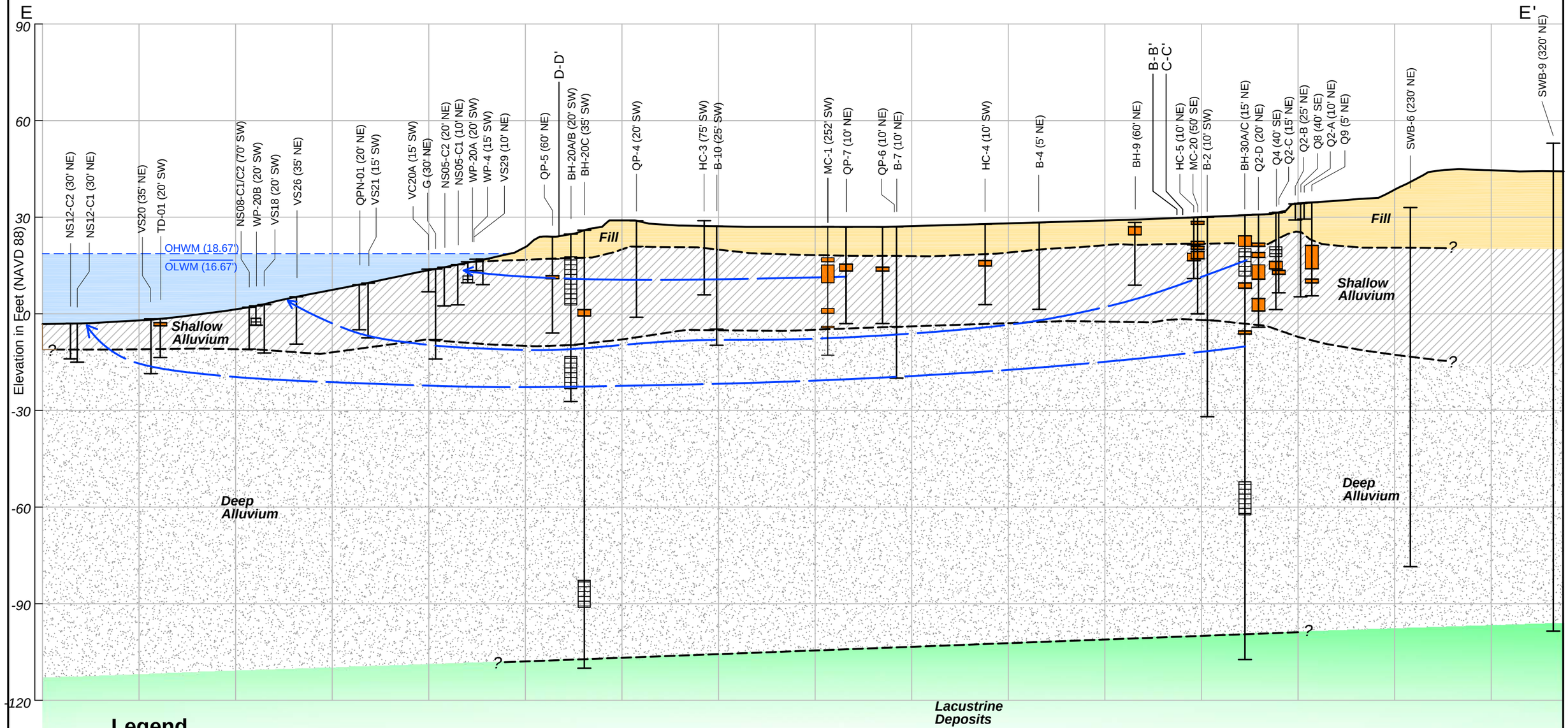

Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

Non-Aqueous Phase Liquid

Well Screen

FILL: Silt, Sand, Gravel, Wood and Mixed Debris

Shallow Alluvium: Stratified Organic Silt, Peat, Sand

Deep Alluvium: Sand and Gravels

Lacustrine Deposits: Silt and Clay

Model-Generated Groundwater Flow Lines

Horizontal Scale

0 100 200

Feet

Vertical Scale

0 30 60

Feet

Vertical Exaggeration 3.33X

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General Site Geology and Groundwater Flow

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH/TDC	
DRAWN BY: PMB	FIGURE NO. ES-3
REVISED BY: SCC	

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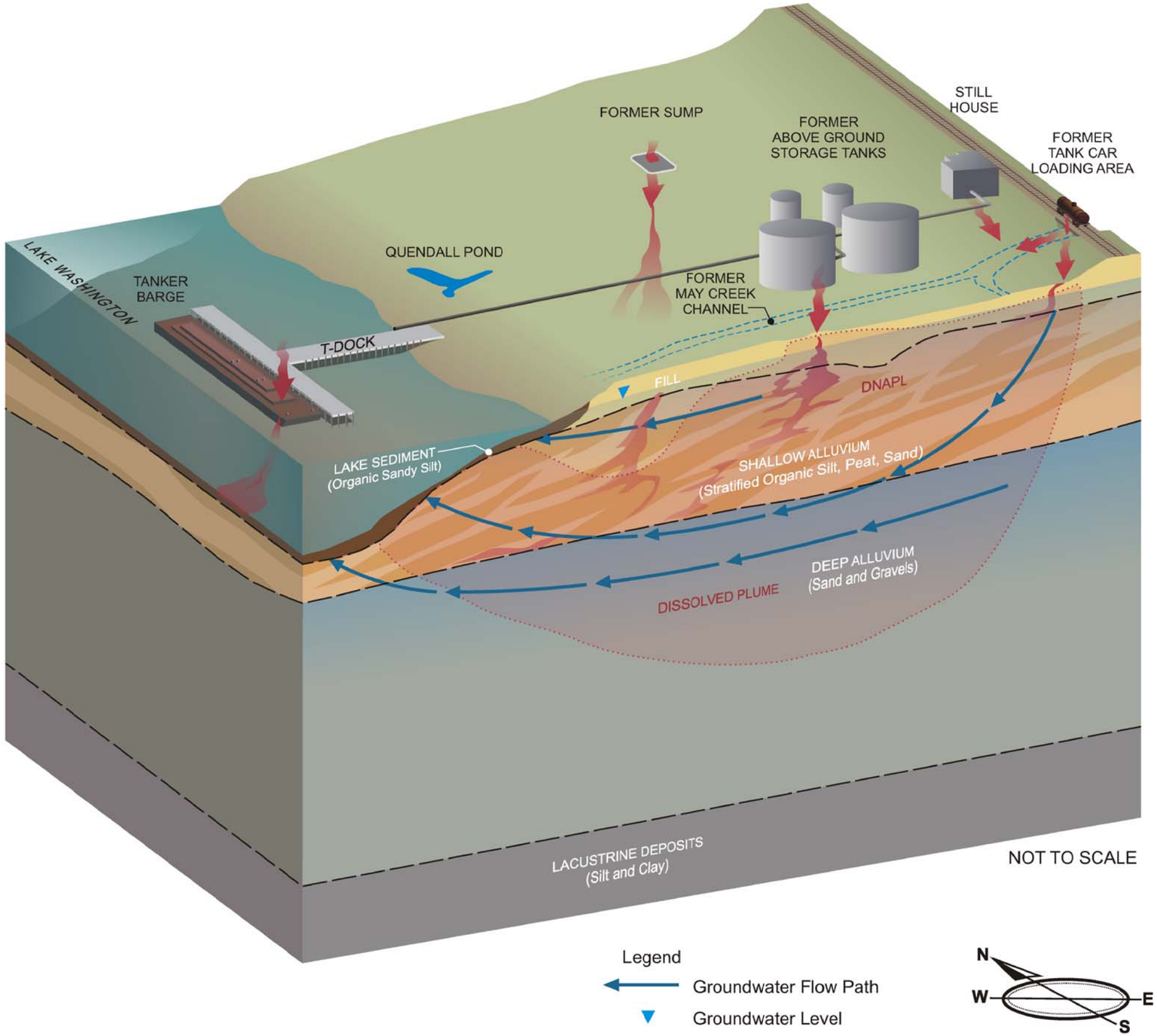

Graphic Illustration of the DNAPL Conceptual Site Model

Final Remedial Investigation, Quendall Terminals
Renton, Washington

Aspect CONSULTING	ANCHOR QEA	FIRM: ASPECT DRAWN BY: JJP/EG/SCC	FIGURE NO. ES-4

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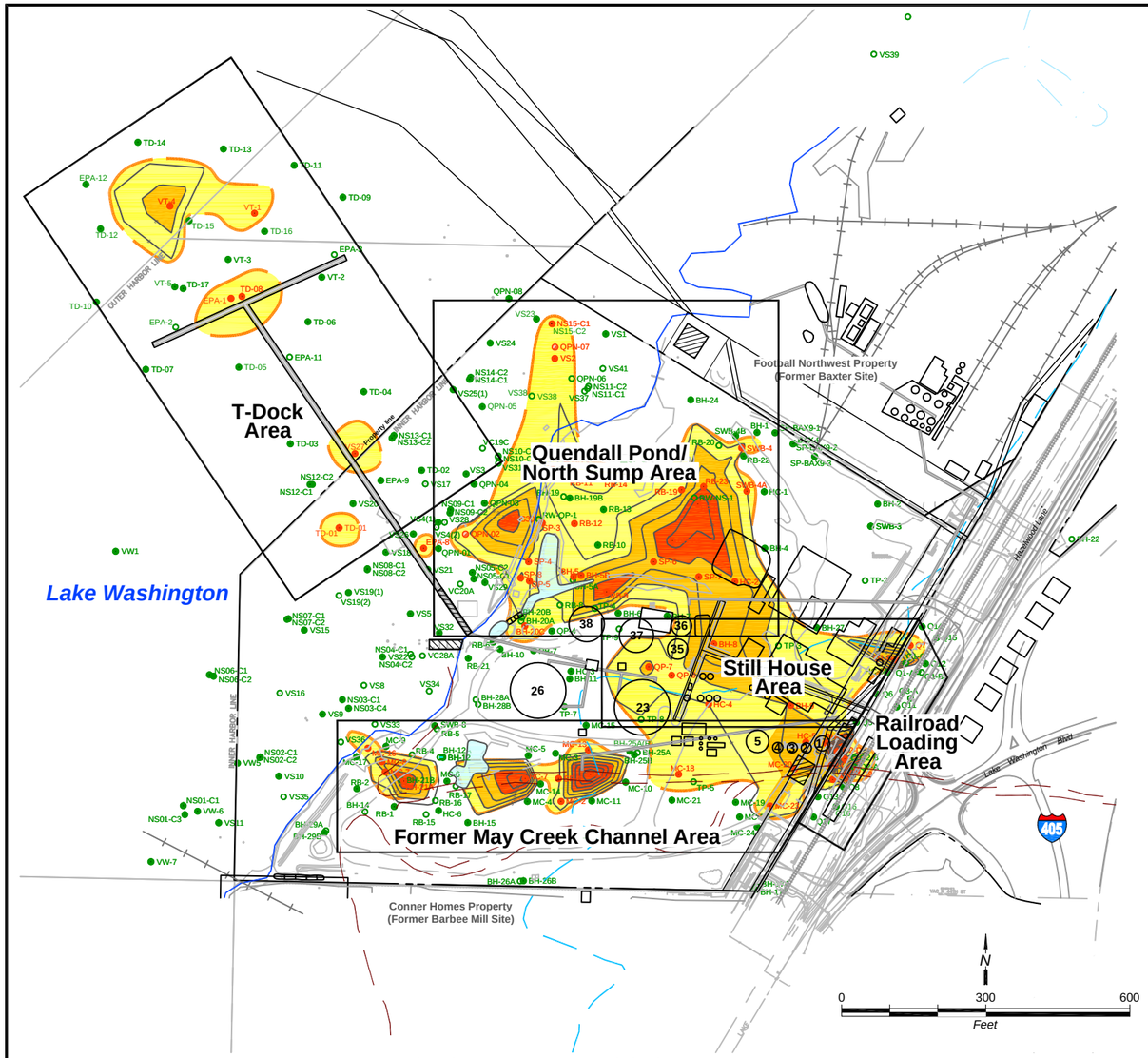
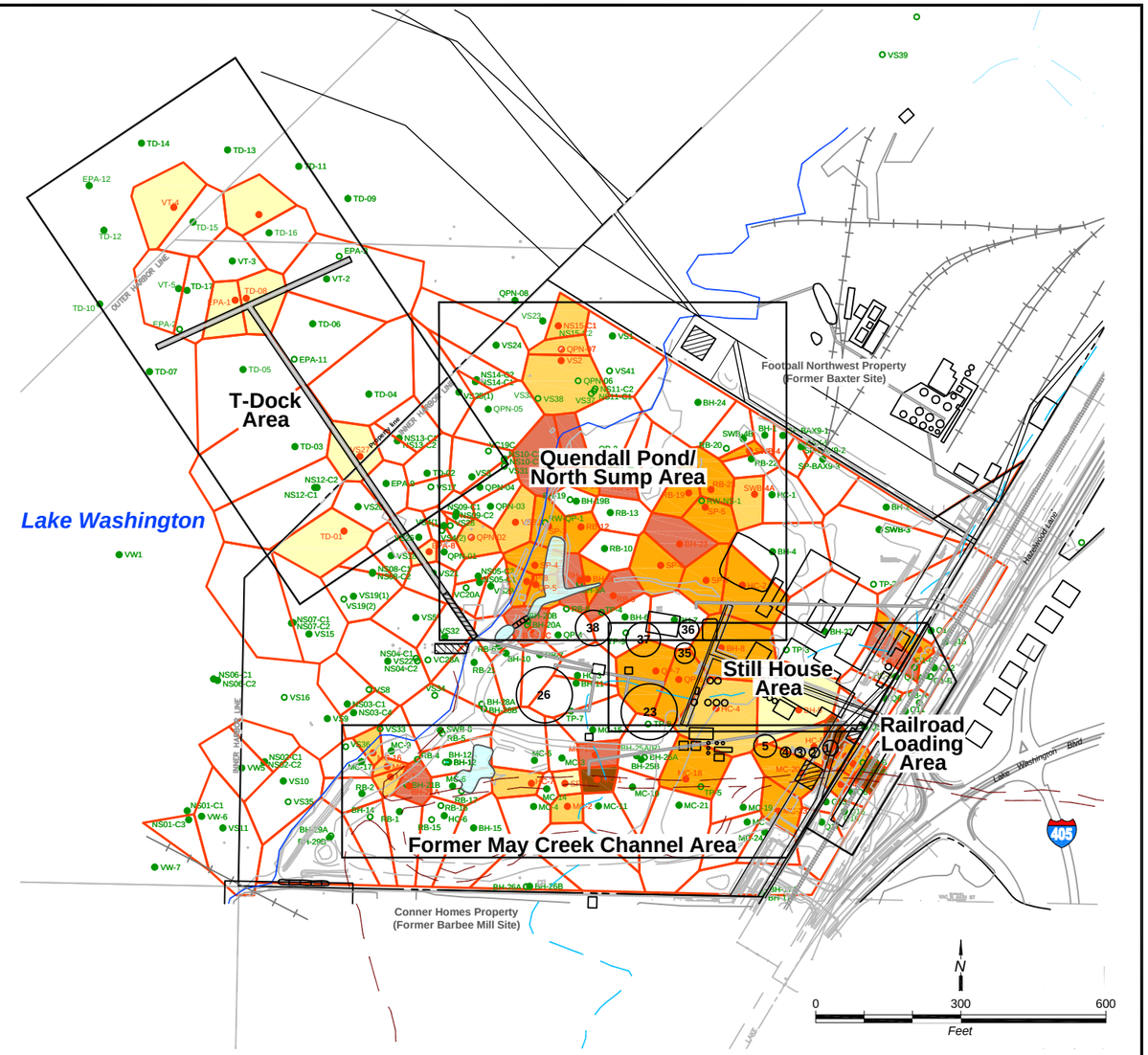


Cumulative DNAPL Thickness Contour Map



Maximum Depths of DNAPL Occurrences and Thiessen Polygon Areas

Notes

1. DNAPL occurrences based on observations of oil-coated or oil-wetted soil. Soil exhibiting only sheen or staining not identified as containing DNAPL. See Attachment A-11 of the Data Collection Work Plan (Anchor QEA & Aspect 2009a).

2. Boundaries generally based on midpoint between borings containing DNAPL and borings with no DNAPL (if sufficiently deep), adjusted to fit Surfer-generated contour intervals of DNAPL thickness (see Figure 4.4-4).

3. DNAPL occurrences at each boring are summarized in Tables G-1 through G-4 in Appendix G.

4. DNAPL thickness contours are the cumulative thickness of multiple layers (when present) at each boring. Contours generated using Surfer 8 (Golden Software Inc. 2002).

Legend

- Maximum Extents of DNAPL
- 5 — DNAPL Thickness contour
- DNAPL Thickness 0'-2'
- DNAPL Thickness 2'-4'
- DNAPL Thickness <4'
- TD-08 — Boring w/ DNAPL
- VT-3 — Boring w/ no DNAPL
- EPA-2 — Boring w/ no DNAPL but base is above adjacent occurances
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Current Shoreline
- 1916 Shoreline
- 1920 May Creek

Maximum DNAPL Depth (Ft)

- 0 - 6.0
- 6.1 - 12.0
- 12.1 - 18.0
- 18.1 - 24.0
- 24.1 - 33.0

- DNAPL Thiessen Polygons

Notes

1. Thiessen polygons based on midpoint between borings of adequate depth and characterization, truncated at property line.

2. See Appendix G, Figure G-1 and Table G-5 for maximum depth and area for each polygon.

3. DNAPL identified as oil-coated or oil-wetted soil. Sheen and stained soil not identified as DNAPL. See Section 4.3.1 for DNAPL definitions and Tables G-1 through G-4 in Appendix G for summaries of DNAPL characterization at each boring.

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Cumulative Thickness and Depth of DNAPL

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: TDC/JJP	
DRAWN BY: PMB	FIGURE NO. ES-5
REVISED BY: SCC	

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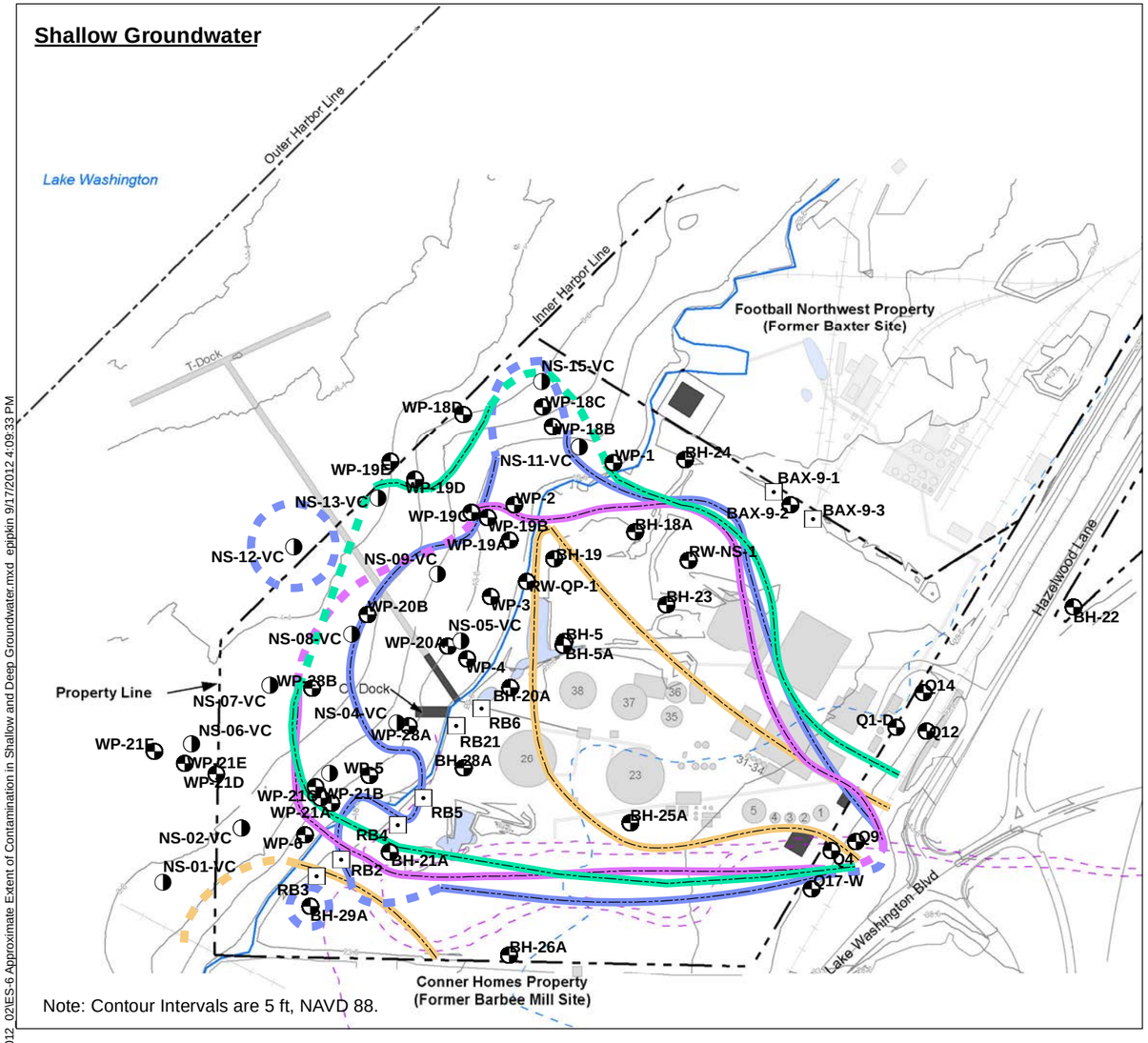

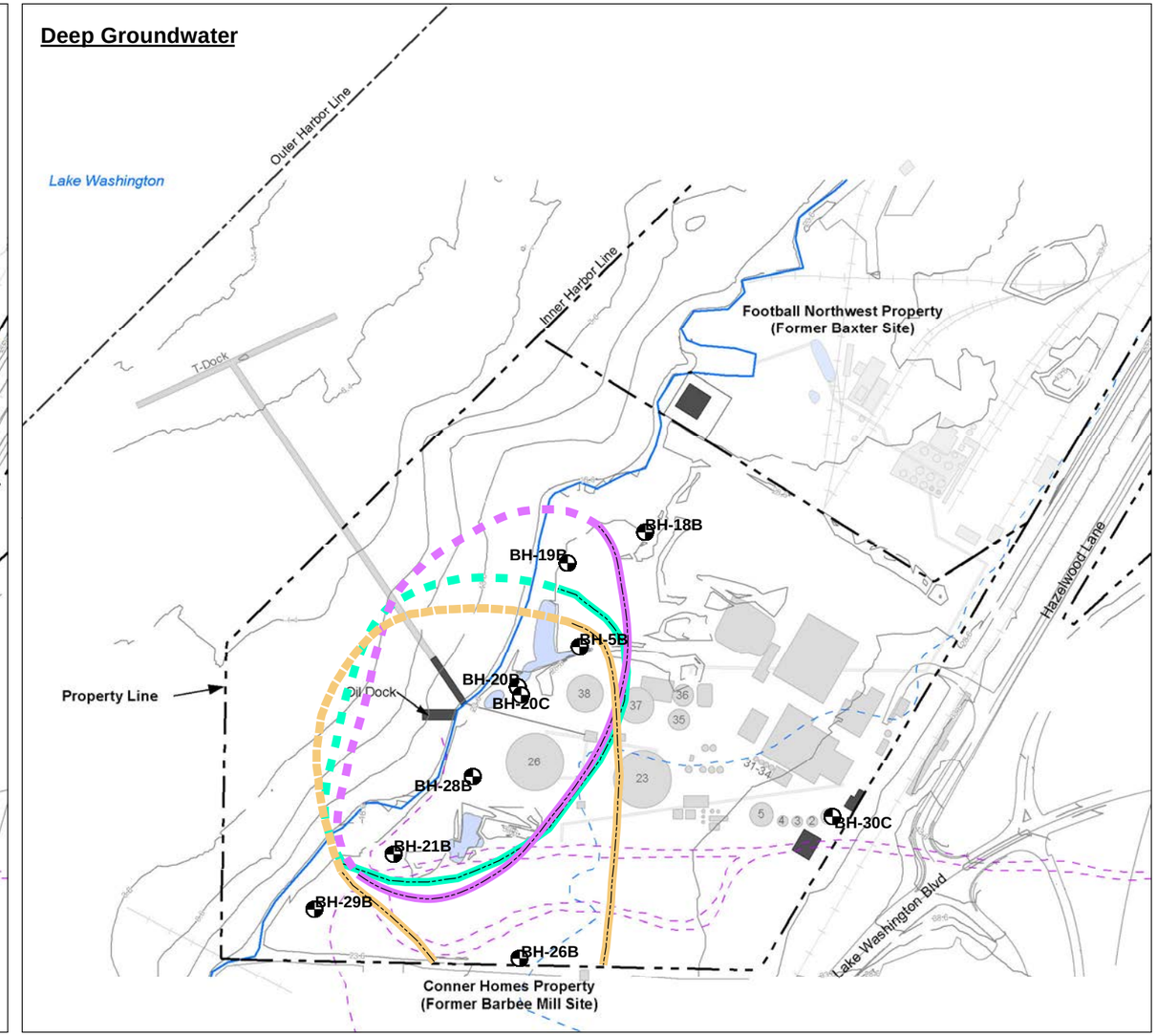

Legend

- Grab Sample Location
- Well Location
- Subsurface Core Location
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Benzene Detected
- Above MCL (5 µg/L)
- Inferred from Lines of Evidence other than Groundwater

Naphthalene Detected
- Above MTCA Method B Groundwater Cleanup Level (160 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

cPAHs (Benzo[a]Pyrene Equivalents) Detected
- Above MCL (0.2 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

Arsenic Detected
- Above MCL (10 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry

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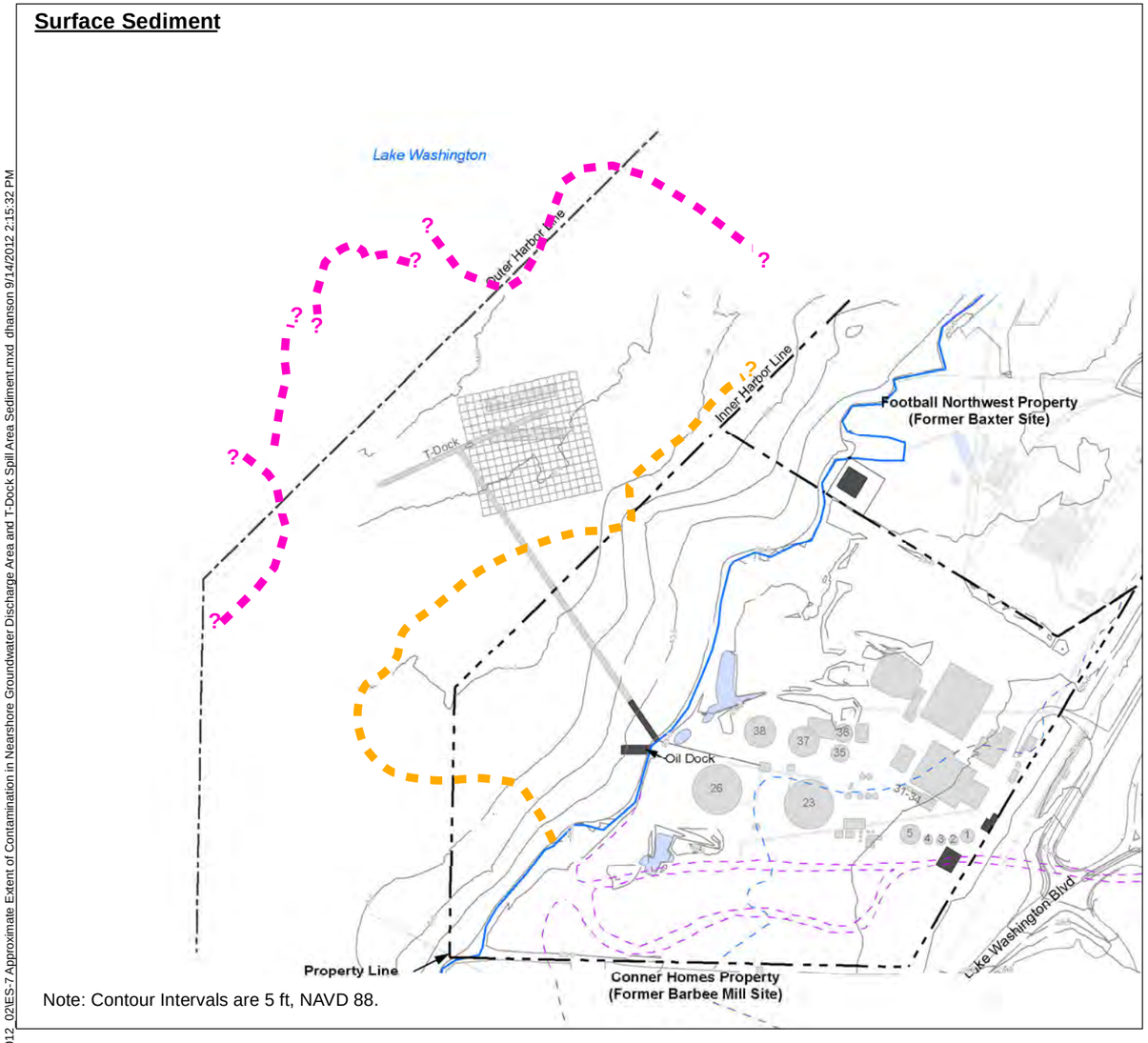
Feet
0 125 250 375 500

Figure ES-6
Approximate Extent of Contamination in Shallow and Deep Groundwater
Final Remedial Investigation, Quendall Terminals

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_02\ES-6 Approximate Extent of Contamination in Shallow and Deep Groundwater.mxd epipkin 9/17/2012 4:09:33 PM

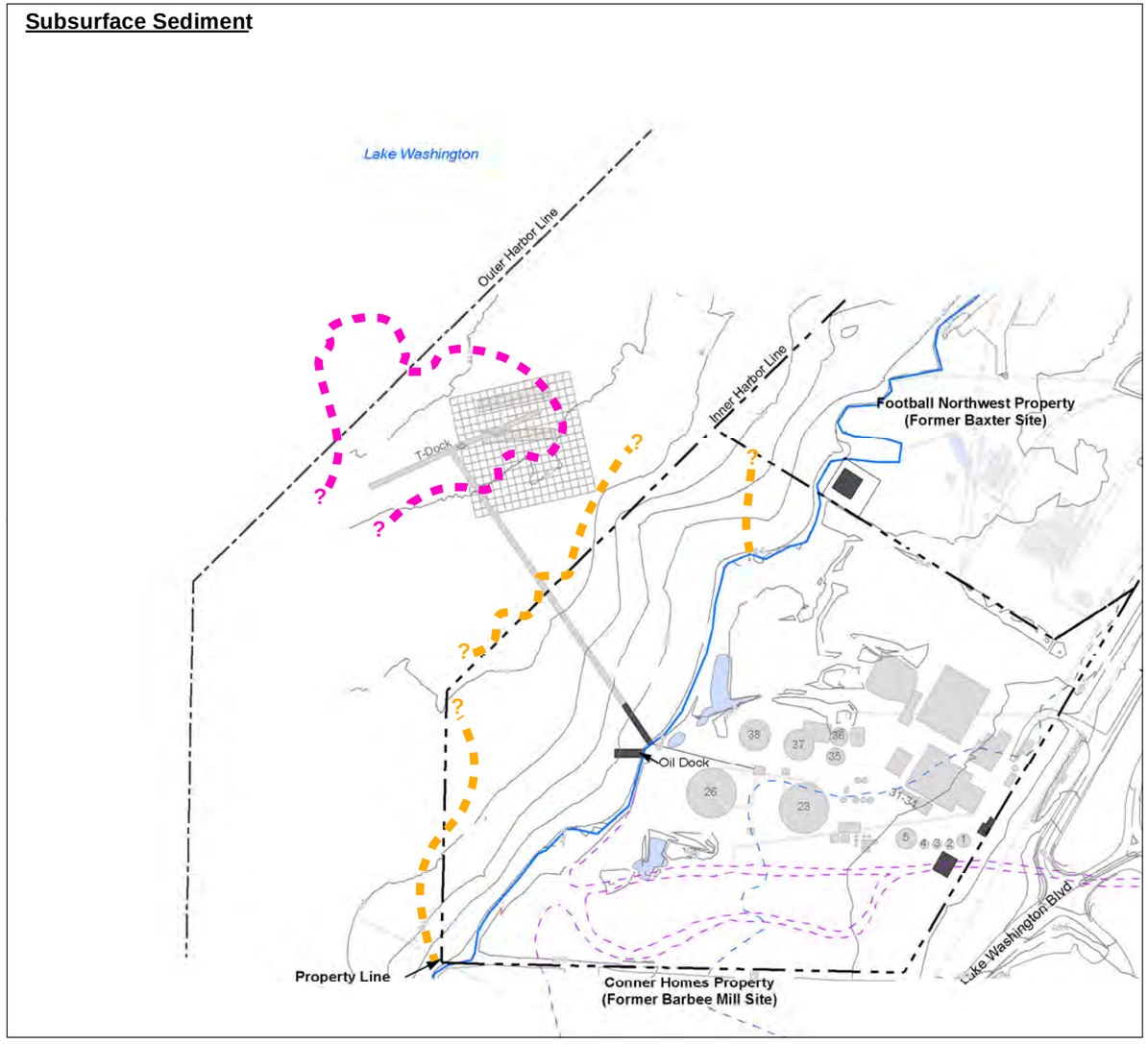
Q:\Jobs\020059_Quendall_Terminals\Maps\2012_02\ES-7 Approximate Extent of Contamination in Nearshore Groundwater Discharge Area and T-Dock Spill Area Sediment.mxd dhanson 9/14/2012 2:15:32 PM

Surface Sediment



Note: Contour Intervals are 5 ft, NAVD 88.

Subsurface Sediment



Legend

- Approximate Extent of Contaminant PRG Exceedance in T-Dock Spill Area
- Approximate Extent of Contaminant PRG Exceedance in Nearshore Area
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

ANCHOR QEA

Feet
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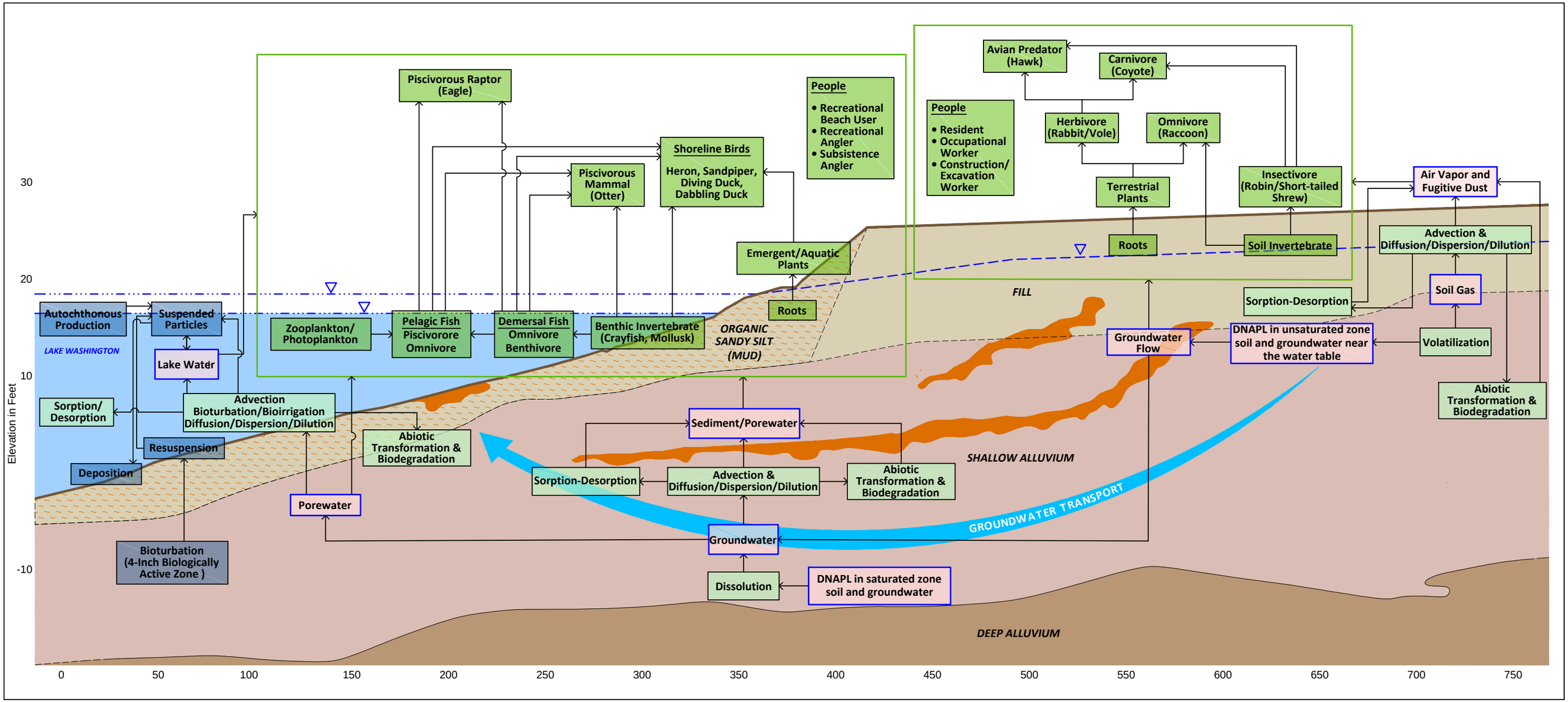
Figure ES-7
Approximate Extent of Contamination in Nearshore Groundwater Discharge Area and T-Dock Spill Area Sediment
Final Remedial Investigation, Quendall Terminals



LEGEND:

Geology

- Ground Surface
- Inferred Geologic Contact
- Fill
- Organic Sandy Silt (Mud)
- Shallow Alluvium
- Deep Alluvium
- DNAPL

Conceptual Site Model

- Hydrodynamics and Sediment Dynamics
- Biological Fate and Transport (Predation/Bioaccumulation/Biomagnification)
- Chemical Fate and Transport Media
- Chemical Fate and Transport Process

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ANCHOR QEA

Figure ES-8
Graphic Illustration of the Contaminant Fate and Transport Conceptual Site Model
Final Remedial Investigation, Quendall Terminals

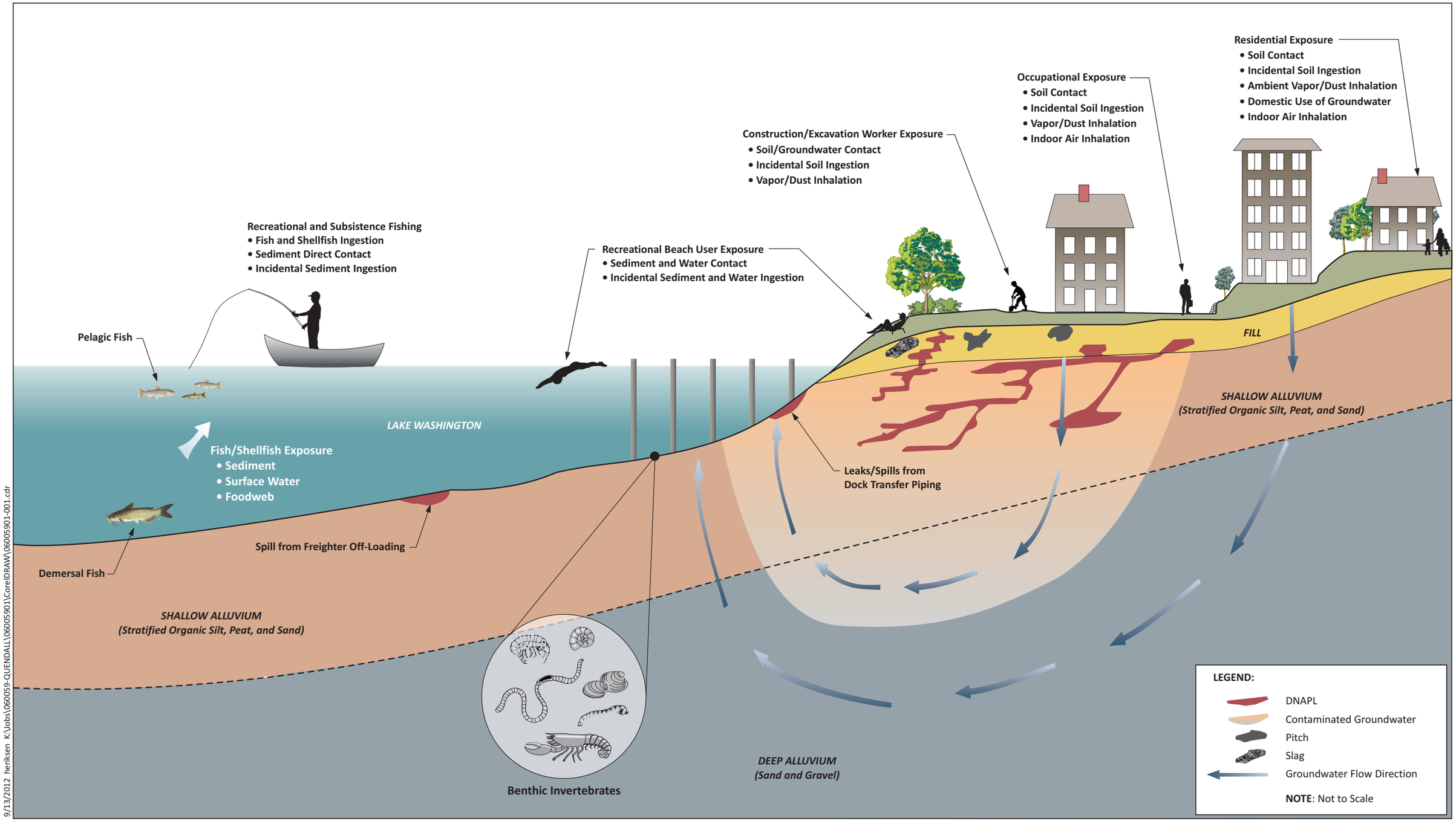

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Figure ES-9
Graphic Illustration of Human Health Conceptual Site Exposure Model
Final Remedial Investigation, Quendall Terminals

Table ES-1
Site-Specific Contaminants of Interest and Indicator Chemicals

Chemical	Environmental Medium at the Quendall Site			
	Groundwater	Soil	Bulk Sediment	Sediment Porewater/ Surface Water
Metals				
Arsenic	X	X		
Cadmium				
Chromium (III)[1]	X	X		
Copper	X	X		
Lead				
Nickel				
Iron				
Zinc				
Polynuclear Aromatic Hydrocarbons (PAHs)				
Acenaphthene				
Acenaphthylene				
Anthracene				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(k)fluoranthene				
Chrysene				
Dibenz(a,h)anthracene				
Indeno(1,2,3-c,d)pyrene				
Fluoranthene				
Fluorene				
Naphthalene	X	X	X	X
Phenanthrene				
Pyrene				
2-Methylnaphthalene				
Total cPAH TEQ (minimum 7, CAEPA 2009)	X	X	X	X
Total 10 of 16 HPAHs		X	X	
Total 6 of 16 LPAHs		X	X	
Total PAH ESBQ			X	X
Semivolatiles, Miscellaneous				
Bis(2-Ethylhexyl)phthalate				
Dibenzofuran				
n-Nitroso-diphenylamine				
Semivolatiles, Phenolic				
Phenol			X	
2-Methylphenol				
4-Methylphenol			X	
2,4-Dimethylphenol				
Semivolatiles, Chlorinated				
Total Polychlorinated Biphenyls (PCBs)	X	X		
Pentachlorophenol (PCP)	X	X		

Table ES-1
Site-Specific Contaminants of Interest and Indicator Chemicals

Chemical	Environmental Medium at the Quendall Site			
	Groundwater	Soil	Bulk Sediment	Sediment Porewater/ Surface Water
Volatiles, Aromatic and Halogenated				
Benzene	X	X		X
Ethylbenzene				
Toluene				
Dichloromethane				
Carbon Disulfide				
Xylenes				
Styrene				
Methylene Chloride				
Chloroform				
Other				
Total Organic Carbon			X	

Notes:

Indicator chemicals are shaded.

The media associated with each indicator chemical are denoted with an "X".

[1] Soil conditions at the Site are characterized by high organic content, supporting a reducing environment, and neutral pH. Because the oxidizing environment required to maintain chromium (VI) is not present at the Site, chromium (VI) was not retained as a contaminant of interest.

CAEPA - California Environmental Protection Agency
cPAH - carcinogenic PAH(s) (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h] anthracene, and indeno [1,2,3-c,d]pyrene)

ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient

HPAHs - high-molecular-weight PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3,-c,d]pyrene, fluoranthene, and pyrene)

LPAHs - low-molecular-weight PAHs (acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene)
TEQ - toxicity equivalency quotient

Table ES-2
Summary of DNAPL Thickness and Volume by Source Area

Source Area	Approximate Area in Acres	Cumulative Average/Maximum DNAPL Thickness in Feet	Average/ Maximum Depth of DNAPL in Feet	Volume of DNAPL-Contaminated Soil and/or Sediment in Cubic Yards	DNAPL Volume in Gallons	Percentage of DNAPL Logged as Oil-Wetted[1]
Former May Creek Channel Area (soil only)	1.5	2.9 / 8.8 (Max. at MC-1)	17 / 34 (Max. at BH-30C)	7,100	88,000	40%
Still House Area (soil only)	2.2	2.2 / 4 (Max. at BH-8)	11 / 14 (Max. at QP-7)	8,100	100,000	27%
Quendall Pond /North Sump Area (soil and sediment)	4.1	2.3 / 6 (Max. at SP-5)	16 / 27 (Max. at BH-20C)	16,000	200,000	36%
Railroad Loading Area (soil only)	0.23	4.9 / 11 (Max. at Q2-D)	22 / 30 (Max. at Q2-D)	1,700	21,000	20%
T-Dock Area (sediment only)	1.7	1.0 / 3.8 (Max. at VT-4)	1.5 / 3.8 (Max. at VT-4)	2,900	36,000	0%
Total	**9.7**	**--**	**--**	**36,000**	**445,000**	**--**

Notes:

DNAPL - dense non-aqueous phase liquid

[1]Cumulative thickness of DNAPL logged as oil-wetted divided by cumulative DNAPL thickness (including oil-coated, oil-wetted, and unknown [undifferentiated] DNAPL).

Table ES-3
Summary of Risk and Hazard Estimates for Human Exposure Scenarios

		Human Exposure Scenarios											
		Residential		Occupational Worker		Construction/ Excavation Worker		Recreational Beach User		Recreational Fishing		Subsistence Fishing	
Exposure Medium	**Exposure Route**	**HI**	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**	**HI**	**ELCR**
Soil (0 to 15 feet bgs)	Ingestion	**1**	**2E-02**	0.4	**1E-03**	**1**	**1E-04**	--	--	--	--	--	--
	Dermal	0.5	**7E-03**	0.3	**8E-04**	0.4	**5E-05**	--	--	--	--	--	--
	Inhalation	**6**	**3E-04**	**1**	**5E-05**	**1**	**2E-06**	--	--	--	--	--	--
	Total	**8**	**3E-02**	**2**	**2E-03**	**3**	**2E-04**	--	--	--	--	--	--
Groundwater	Ingestion	**602**	**8E-01**	--	--	--	--	--	--	--	--	--	--
	Dermal	**175**	**5E-04**	--	--	0.00001	**1E-05**	--	--	--	--	--	--
	Inhalation	**7,218**	**3E-01**	--	--	--	--	--	--	--	--	--	--
	Total	**7,995**	**>8E-01**[a]	--	--	0.00001	**1E-05**	--	--	--	--	--	--
Indoor Air	Inhalation	**280**	**2E-02**	--	--	--	--	--	--	--	--	--	--
Trench Vapor	Inhalation	--	--	--	--	486	**8E-04**	--	--	--	--	--	--
Nearshore Sediment	Ingestion	--	--	--	--	--	--	0.004	**2E-04**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.01	**9E-05**	--	--	--	--
	Total	--	--	--	--	--	--	0.02	**3E-04**	--	--	--	--
Site-Wide Sediment	Ingestion	--	--	--	--	--	--	--	--	0.008	**2E-05**	0.01	**4E-05**
	Dermal	--	--	--	--	--	--	--	--	0.005	**2E-05**	0.01	**3E-05**
	Total	--	--	--	--	--	--	--	--	0.01	**4E-05**	0.02	**6E-05**
Site Surface Water	Ingestion	--	--	--	--	--	--	0.007	**2E-06**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.02	**2E-06**	--	--	--	--
	Total	--	--	--	--	--	--	0.03	**3E-06**	--	--	--	--
Site Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.4	**2E-04**	**3**	**5E-03**
Background Sediment	Ingestion	--	--	--	--	--	--	0.001	**2E-06**	0.0002	7E-08	0.0003	1E-07
	Dermal	--	--	--	--	--	--	0.00005	7E-07	0.000001	5E-08	0.000002	8E-08
	Total	--	--	--	--	--	--	0.001	**3E-06**	0.0002	1E-07	0.0003	2E-07
Background Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.0004	**2E-06**	0.003	**4E-05**

Notes:

[a]Due to the very high concentrations found in well Q9 and the inherent limitations quantifying risk at these levels, the ELCR is reported as a "greater than" estimate.

Risks to future residents from exposure to groundwater and indoor air were estimated from the maximum single-well risk.

Risks to construction/excavation workers from exposure to groundwater and trench vapor were estimated from maximum detected concentrations from all wellpoints.

bgs - below ground surface

ELCR - excess lifetime cancer risk

HI - hazard index; HQ - hazard quotient

Boldface without highlighting - HQ greater than 1 or ELCR greater than 1E-06

Boldface with highlighting - HQ greater than 10 or ELCR greater than 1E-04

Table ES-4
Chemicals of Concern by Medium

Chemical of Concern[a]	Medium												
	Soil		Groundwater	Indoor Air	Trench Vapor	Surface Water/ Porewater		Nearshore Sediment		Site-Wide Sediment		Fish/ Shellfish[b]	Food/Prey Item
	HHRA[c]	ERA[d]	HHRA	HHRA	HHRA	HHRA	ERA	HHRA	ERA	HHRA	ERA	HHRA	ERA
2-Methylnaphthalene	X		X				X					X	
Acenaphthene		via LPAH	X				X		via LPAH		via LPAH		via LPAH
Anthracene		via LPAH					X		via LPAH		via LPAH		via LPAH
Arsenic	X		X										
Benzene			X	X	X	X							
Benzo(a)anthracene	X	via HPAH	X				X		via HPAH		via HPAH	X	via HPAH
Benzo(a)pyrene	X	X	X				X	X	X	X	X	X	X
Benzo(b)fluoranthene	X	via HPAH	X						via HPAH		via HPAH		via HPAH
Benzo(k)fluoranthene	X	via HPAH	X						via HPAH		via HPAH		via HPAH
Chromium		X											
Chrysene			X										
Dibenz(a,h)anthracene	X	via HPAH	X					X	via HPAH	X	via HPAH	X	via HPAH
Dibenzofuran			X										
Ethylbenzene	X		X	X	X								
Fluoranthene		via HPAH	X				X		via HPAH		via HPAH		via HPAH
Fluorene		via LPAH	X				X		via LPAH		via LPAH		via LPAH
Indeno(1,2,3-cd)pyrene	X	via HPAH	X						via HPAH		via HPAH		via HPAH
Lead		X											X
Naphthalene	X	X	X	X	X		X		via LPAH		via LPAH		via LPAH
PAH ESBQ TU							X						
Pentachlorophenol		X											X
Phenanthrene		via LPAH					X		via LPAH		via LPAH		via LPAH
Pyrene		via HPAH	X				X		via HPAH		via HPAH		via HPAH
Toluene							X						
Total 10 of 16 HPAHs (U=1/2)		X							X		X		X
Total 16 PAHs (U=1/2)									X		X		X
Total 6 of 16 LPAHs (U=1/2)		X									X		X
Total Xylenes			X	X	X								

Notes:

[a] Chemicals of concern identified as those associated with hazard quotients exceeding 1 or excess lifetime cancer risk exceeding 1×10^{6}.

[b] Based on modeled tissue concentrations from sediment, using biota-sediment accumulation factors.

[c] For the HHRA, soil from 0 to 15 feet below ground surface was evaluated.

[d] For the ERA, soil from 0 to 5 feet below ground surface was evaluated.

COC - chemical of concern
ERA - ecological risk assessment
ESBQ - equilibium partioning sediment benchmark quotient
HHRA - human health risk assessment
HPAHs - high-molecular-weight PAHs
LPAHs - low-molecular-weight PAHs
PAHs - polynuclear aromatic hydrocarbons
TU - toxic unit(s)
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit
via HPAH - Denotes that the COC is evaluated for sediment as part of the HPAH group
via LPAH - Denotes that the COC is evaluated for sediment as part of the LPAH group
X - indicates that the chemical is a COC for the specific medium.

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
1958 Plant Map	1958 Republic Creosoting Company "Seattle Plant Map"
ADAF	Age Dependent Adjustment Factor
ADD	average daily dose
AF	adherence factor
AFDW	ash-free dry weight
Anchor QEA	Anchor QEA, LLC
ANOVA	analysis of variance
AOC	Administrative Settlement Agreement and Order on Consent
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting, LLC
AST	aboveground storage tank
ASTM	American Standards for Testing and Materials
ATD	at time of drilling
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BCF	bioconcentration factor
bgs	below ground surface
BMP	best management practices
BNSF	Burlington Northern Santa Fe (Railroad)
BSAF	biota-sediment accumulation factor
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethylbenzene, and xylene(s)
BTV	background threshold value
CAEPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/d	centimeters per day
cm/hr	centimeters per hour
cm/s	centimeters per second

cm^2/s	square centimeters per second
cm/yr	centimeters per year
cm^2/yr	square centimeters per year
COC	chemical of concern
COI	contaminant of interest
COPC	chemical of potential concern
cp	centipoise
cPAHs	carcinogenic polynuclear aromatic hydrocarbons
CSM	conceptual site model
CT	central tendency
DNAPL	dense non-aqueous phase liquid
DNRP	King County Department of Natural Resources and Parks
DOH	Washington State Department of Health
DQO	data quality objective
DRET	dredging elutriate test
Ecology	Washington State Department of Ecology
Eco-SSL	ecological Soil Screening Level
Eh	oxidation-reduction potential
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESB	equilibrium-partitioning sediment benchmark
ESBQ	equilibrium-partitioning sediment benchmark quotient
ESL	Ecological Screening Level
FCV	final chronic value
FFS	Focused Feasibility Study
FOC	fraction organic carbon
FS	Feasibility Study
ft/day	feet per day
ft/ft	feet per foot
g/cm^3	gram(s) per cubic centimeter
H	Henry's Law constant

HEAST	Health Effects Assessment Summary Tables
HERA	human health and ecological risk assessment
HHRA	human health risk assessment
HI	hazard index
HPAH	high-molecular-weight polynuclear aromatic hydrocarbon
HQ	hazard quotient
HSDB	Hazardous Substance Data Bank
HVAC	heating, ventilation, and air conditioning
I-405	Interstate 405
IEUBK	Integrated Exposure Uptake Biokinetic (Model)
IRIS	Integrated Risk Information System
LAET	lowest apparent effects threshold
LC50	50 percent lethal concentration
L/kg	liter(s) per kilogram
LLC	Limited Liability Company
LNAPL	light non-aqueous phase liquid
LOAEL	lowest observed adverse effects level
LPAH	low-molecular-weight polynuclear aromatic hydrocarbon
MCL	maximum contaminant level
Metro	Municipality of Metropolitan Seattle
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MIW	mean individual weight
ml	milliliter(s)
MRL	Minimal Risk Level
MTCA	Washington State Model Toxics Control Act
MULTIMED	Multimedia Exposure Assessment Model
NAPL	non-aqueous phase liquid
NAS	Northwestern Aquatic Sciences
NAVD	North American Vertical Datum
NCP	National Contingency Plan
ND	not detected
NGVD	National Geodetic Vertical Datum

NOAEL	no observed adverse effects level
NPL	National Priorities List
NWQC	National Water Quality Criteria
OCN	organic carbon normalized
OGWDW	Office of Ground Water and Drinking Water
OHWM	ordinary high water mark
PAH	polynuclear aromatic hydrocarbon
PAZ	passive attenuation zone
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PEF	particulate emission factor
PEF	potency equivalency factor
PPRTV	Provisional Peer Reviewed Toxicity Value
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSE	Puget Sound Energy
PSS	palustrine scrub-shrub
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RA/FS	Risk Assessment/Feasibility Study
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
Respondents	Altino Properties, Inc., and J.H. Baxter & Company
Retec	Remediation Technologies, Inc.; the Retec Group
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
ROS	regression-on-order statistics
ROW	right-of-way
RSET	Regional Sediment Evaluation Team

RSL	regional screening level
SAP	Sampling and Analysis Plan
SCDM	Superfund Chemical Data Matrix
SF	slope factor
Site	Quendall Terminals Site
SPI	sediment profile imaging
SPME	solid-phase microextraction
SVOC	semivolatile organic compound
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
TRW	total replicate weight
TU	toxic unit
TVS	total volatile solids
U&A	Usual and Accustomed
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UT	University of Texas
Vdar	Darcy's Law velocity
VOC	volatile organic compound
WAC	Washington Administrative Code
WCC	Woodward Clyde Consultants
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WEFH	Wildlife Exposure Factors Handbook
WHO	World Health Organization
WP	wellpoint
WRIA	Water Resources Inventory Area
WSDOT	Washington State Department of Transportation

WSPCC	Washington State Pollution Control Commission

1 INTRODUCTION

Under the direction of the United States Environmental Protection Agency (EPA), the Quendall Terminals owners (Altino Properties, Inc., and J.H. Baxter & Company; the Respondents) are conducting a Remedial Investigation (RI) and Feasibility Study (FS) at the Quendall Terminals Site ("the Site", also referred to as "the Quendall Site") in Renton, Washington. The Site was placed on the National Priorities List (NPL) in 2006; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, prescribes a site characterization and remedy selection process for sites listed on the NPL. The work is being conducted under an Administrative Settlement Agreement and Order on Consent, as amended (referred to as "the AOC").

This RI Report contains background information and describes the RI field investigation conducted in 2009 at the Site consistent with the EPA-approved Data Collection Work Plan (Anchor QEA and Aspect 2009a),[1] along with the results of these investigations and associated baseline human health and ecological risk assessments. The report was prepared by Anchor QEA, LLC (Anchor QEA) and Aspect Consulting, LLC (Aspect) under the direction of EPA and the Respondents.

The purpose of the RI was to collect and evaluate sufficient information to determine whether cleanup actions at the Site are necessary. Because the Site includes upland areas and aquatic lands, the media investigated included soil, groundwater, and sediment. In addition to the 2009 RI field investigation conducted under EPA oversight, the scope and results of previous environmental investigations performed at the Site under the oversight of the Washington State Department of Ecology (Ecology) are described in this report to provide a comprehensive summary of Site conditions.

The Site is located on the southeast shore of Lake Washington (Figure 1.1-1). It encompasses approximately 22 acres of uplands and also includes contaminated areas offshore located on both private and State-owned aquatic lands. Shortly after the lowering of Lake Washington in 1916 to construct the Lake Washington Ship Canal, the Site, including newly exposed portions of the former May Creek delta, was developed into a creosote manufacturing

[1] Preliminary fieldwork for the 2009 RI field investigation was performed in 2008.

facility. Until 1969, creosote was manufactured on the Site by refining and processing coal tar and oil-gas tar residues. From 1969 to approximately 1983, some of the aboveground tanks (ASTs) at the Site were used intermittently for crude oil, waste oil, and diesel storage. From 1975 to 2009, the Site was used primarily for log sorting and storage. The Site is currently vacant. Aquatic lands adjacent to the facility managed by the Washington State Department of Natural Resources (WDNR) were historically leased for log rafting and vessel storage, but those leases were terminated in the 1990s.

The physical and chemical characteristics of the Quendall Site (i.e., within the property boundary) have been explored through more than 150 soil/sediment borings and test pits excavated for environmental and geotechnical investigations over the past 30 years. Areas within the Site that are located on the former Burlington Northern Santa Fe (BNSF) Railroad property were recently investigated through more than 23 soil borings by Pinnacle GeoSciences on behalf of the Port of Seattle, a potential purchaser of the Railroad property (Pinnacle 2009). The considerable characterization data previously available for the Quendall Site (e.g., Hart Crowser 1997; the Retec Group (Retec) 1997c; Exponent 1999; Anchor and Aspect 2004) were compiled and incorporated in an earlier RI/FS process overseen by Ecology under the Washington State Model Toxics Control Act (MTCA) and its implementing regulations (Chapter 173-340 Washington Administrative Code [WAC]; Chapter 70.105D Revised Code of Washington [RCW]). These earlier investigations revealed that polynuclear aromatic hydrocarbons (PAHs) and other organic chemicals such as benzene detected at the Quendall Site are present at concentrations that would likely trigger cleanup actions under MTCA.

Site investigations identified creosote-related contamination in soil, groundwater, and sediment at the Site. Previous investigation activities and results have been summarized in three documents previously prepared for EPA under the AOC. These documents are related to their respective tasks as identified in the AOC. Summaries of these three documents are provided below:

- **Task 2 – Summary of Existing Information and Data Quality Report** (Task 2 Report, Anchor and Aspect 2007a). The Task 2 Report includes a summary of background

information, a description of previous environmental investigations and studies, and a summary and data quality evaluation of previously collected data.

- **Task 3 – Preliminary Conceptual Site Model, Remedial Action Objectives, Remediation Goals, and Data Gaps** (Draft Task 3 Report, Anchor and Aspect 2007b). The Draft Task 3 Report describes the preliminary conceptual site model (CSM) of the Quendall Site, including its history and physical setting and the nature and extent of contamination at the Site. Consistent with EPA's September 19, 2008 follow-on comments on the Draft Task 3 Report, updates to the CSM have been provided in the Data Collection Work Plan (see below) and this RI Report.

- **Task 5 – Final Data Collection Work Plan** (Anchor QEA and Aspect 2009a*).* Based on its review of the existing data, EPA determined that additional data were necessary to complete the RI/FS for the Site. The Data Collection Work Plan describes the implementation of work efforts to fulfill information needs identified by EPA, and fulfills the requirements of RI/FS Task 5 as described in the AOC.

1.1 Purpose of this Report

The purpose of this RI Report is to compile and evaluate the findings and results of the comprehensive sampling and analysis conducted during the RI and other investigations to characterize the nature and extent and chemical fate and transport of hazardous substance contamination at the Site. At EPA's direction, previous CSMs and baseline ecological and human health risk assessments have been integrated into this RI Report to provide a comprehensive evaluation of Site conditions. A forthcoming FS Report will be prepared to document the development and detailed analysis of remedial alternatives and to provide a basis for remedy selection by EPA.

1.2 Site Description

The Quendall Site is located on Lake Washington in the northernmost limits of the City of Renton (Figure 1.1-1). The physical address is 4503 Lake Washington Boulevard North. The 22-acre upland portion of the Site is relatively flat and occupies the middle portion of a roughly 70-acre alluvial plain. The Site borders approximately 1,500 feet of Lake

Washington shoreline. Access to the Site is from Lake Washington Boulevard North, located along the eastern boundary of the property. Shoreline properties that are immediately adjacent to the Site include Conner Homes to the south (the former Barbee Mill site) and Football Northwest to the north (a former J.H. Baxter & Company property). Interstate 405 (I-405) is located approximately 500 feet to the east. Existing Site features and surrounding features are illustrated on Figure 1.2-1.

Previous Site activities, including the operation of log sorting yards, have resulted in the accumulation of wood chips and bark materials in the central and eastern portions of the property. The exposed Site soils are relatively fine-grained, which slows infiltration during rainy periods thus causing ponding in many areas. Site drainage is discussed in Section 3.1.1.

1.3 Report Organization

Following this Section 1, the text sections of this report are organized as follows:

- Section 2: Site History and Environmental Data
- Section 3: Environmental Setting
- Section 4: Nature and Extent of NAPL
- Section 5: Nature and Extent of Contamination in Site Media
- Section 6: Contaminant Fate and Transport
- Section 7: Baseline Risk Assessment
- Section 8: Conclusions and Recommendations
- Section 9: References

Figures and tables referenced in the above sections are provided in Volumes II and III of this RI Report. Technical appendices provide supplemental information and data, and include the following:

- Appendix A: Project Analytical Database and Supporting GIS and PAH Calculation Data
- Appendix B: Updated Screening of Contaminants of Interest
- Appendix C: Field Measurements
- Appendix D: Groundwater Modeling
- Appendix E: Field Logs

- Appendix F: Geotechnical Data
- Appendix G: DNAPL Volume Calculations
- Appendix H: Calculation of Site-Specific Background Concentrations of Carcinogenic PAHs in Surface Sediment
- Appendix I: Statistical Summaries of Available Analytical Data from the Quendall and Railroad Properties
- Appendix J: Risk Assessment Supporting Information

The above appendices are provided in Volumes IV and V of this RI Report.

2 SITE HISTORY AND ENVIRONMENTAL DATA

This section describes the history of the Quendall Site (Section 2.1) and provides summaries of the sources of contamination (Section 2.2), historical investigations (Section 2.3), the evaluation of historical data for use in the RI (Section 2.4), and data needs that defined the objectives and framework for the 2009 RI field investigation (Section 2.5).

2.1 Site History

This section describes historical Site ownership and operational activities. The locations of historical Site features are shown on Figure 2.1-1, and a timeline of Site operations is provided on Figure 2.1-2. The principal data sources for this historical summary include the following:

- 1958 Republic Creosoting Company "Seattle Plant Map" with revisions through 1969 (1958 and 1969 Plant Maps)
- Blueprints of the Reilly Plant, circa 1918 (1918 Plant Map)
- Aerial photography from 1936, 1946, 1956, 1968, and 1976
- Interviews with Walter (Ward) Roberts, a former employee of the Republic Creosoting Company/Reilly Tar Company during the 1950s and 1960s
- Interviews with Don Norman, a former Site manager for Quendall Terminals in the 1970s
- Historical Site photographs
- Historical records including government agency inspection reports, property tax records, leases, deeds, and historical Sanborn maps
- Previous environmental reports prepared for the Quendall Site

2.1.1 Site Ownership and Easements

Jeremiah Sullivan acquired the present-day Quendall Terminals property from the United States Government in 1873 for use as a homestead; it was subsequently conveyed to James Colman in 1875. During Colman's ownership, he sold timber on the land (starting in 1902) and in 1903 conveyed a right-of way to Burlington Northern Railroad. Colman sold the property to Peter Reilly in 1916.

The Reilly family founded Republic Creosoting Company in 1917, shortly after Lake Washington's levels were lowered by construction of the Ship Canal and the Montlake Cut. The Quendall Site was subsequently used for creosote manufacturing activities for more than 50 years, until 1969. (Creosote manufacturing and related historical Site features are discussed in more detail in the sections that follow.) In addition to the creosote manufacturing facilities, the company built family housing, bachelor quarters, and a barn for the plant's horses sometime in the 1920s. These housing quarters were located in the area that is now the I-405 Exit 7 interchange. Prior to connection to the municipal water supply, according to Roberts (undated), water for company housing was supplied by approximately four to five shallow wells less than 30 feet deep located northeast of the Still House on the west side of the railroad tracks; however, the 1918 Plant Map shows two wells, 50 and 75 feet deep, located just south of the Still House that appear connected to the company housing water supply. Drinking water for the plant was supplied by a 180-foot-deep artesian well located just west of the office (Ecology 1989). The artesian well (see Figure 1.2-1) was located during the 2009 RI field investigation. The other wells have not been located. King County tax assessor records indicate that by 1939, company housing and the plant site were connected to city water.

Quendall Terminals purchased the Site in 1971. Between 1969 and 1983, Quendall Terminals leased aboveground storage tanks (ASTs) that remained on the Site from the creosote manufacturing operations for the storage of Bunker C oil, waste oil, diesel, and lard. From approximately 1975 to 2009, the Quendall Site was used as a log sorting and storage yard.

A City of Renton utility easement for a sanitary sewer line is located just inside the eastern property boundary. A second City of Renton utility easement for a water line is located near the existing office. Puget Sound Energy (formerly Puget Power and Light) has an easement along the north property line for a pole line and for underwater cables, which connect electrical services to Mercer Island underneath Lake Washington. King County also has a utility easement along the northern property boundary for the South Mercer Force Main. According to plans from King County, the sewer main is located just north of the property boundary. Easement locations are shown on Figure 1.2-1.

2.1.2 Tar Refining and Distillate Manufacturing Activities

Reilly Tar & Chemical Company, formerly Republic Creosoting, operated on the Site from 1916 until 1969. The company distilled coal and oil-gas tar residues (collectively referred to as coal tar) from coal gasification plants into several fractions that were shipped off-Site for a variety of uses. The light distillate fraction was typically used as feedstock in chemical manufacturing. The middle distillate fraction, creosote, was used in the wood preserving industry. The bottom fraction, pitch, was used for applications such as roofing tar (Hart Crowser 1994). The identification of historical Site features that were part of the manufacturing process is based on historical aerial photographs and plant maps (1918 and 1969), and the features are illustrated on Figure 2.1-1.

The facility typically refined and processed coal tar from local sources such as Seattle (e.g., Lake Union Gas Works), Bellingham, and Tacoma. At the height of its productivity, the facility reportedly processed about 500,000 gallons of tar per month (CH2M HILL 1983). The typical chemical compositions of coal tar and creosote are summarized in Table 2.1-1. The composition of coal tar and creosote varies with the source, but in general, creosote consists of approximately 85 percent PAHs, 10 percent phenolic compounds, and 5 percent heterocyclic hydrocarbons (EPA 1995). Coal tar has a similar composition but also includes up to 5 percent light aromatic (e.g., benzene, toluene, ethylbenzene, and xylene [BTEX]) compounds (Cohen and Mercer 1993). Tars used at the Site were generally oil-gas tars that contained a relatively low fraction of light aromatics, except for tars imported from the Honolulu Gas Company from 1957 to 1965, which contained a higher proportion of light aromatics (Hart Crowser 1994). Pitch has a similar composition to creosote (no light aromatics) but contains more high-molecular-weight PAHs.

Tar feedstock was typically shipped to the Site and offloaded from tankers and barges along the T-Dock and the short pier offshore of the upland operation areas. Tax assessor records indicate that a 6-inch pipeline conveyed product from the T-Dock to two 2-million-gallon tanks (Tanks 23 and 26 shown on Figure 2.1-1). In 2005, during the installation of stormwater controls overseen by Aspect, a section of 6-inch pipe with tar residue on the inside of the pipe was unearthed just upland of the T-Dock Area.

The large, tar feedstock storage tanks contained heating elements that maintained product viscosity to facilitate product transfer from the tanks to the Still House. Aboveground pipelines were used to convey the tar feedstock to the Still House where it was distilled into the different product fractions (light distillates, creosote, and pitch) (Ecology 1989). Heat for distillation was provided by steam from the boiler house, located just west of the Still House. According to Roberts (Hart Crowser 1994), the boilers were oil-fired. A historical photograph also shows a heating oil barge moored to the Oil Dock.

Light distillates and creosote were stored in aboveground tanks prior to shipment. Aboveground tanks were installed west and south of the Still House for use in the creosote manufacturing operations, and each tank was assigned a number in chronological order as it was installed (Roberts undated). Figure 2.1-1 provides the locations of and, where available, the assigned numbers for tanks identified on the 1969 Plant Map and in historical photographs. A summary of how these tanks were used during light distillate and creosote manufacturing and subsequent Site use is provided in Section 2.2.2, Aboveground Storage Tanks.

Pitch was poured into the pitch bays located north of the Still House where it was allowed to solidify. Roberts described the pitch bays as having concrete bottoms with wood sides. The bays were approximately 40 feet wide, 150 feet long, and 4 feet deep (Ecology 1989).

Products were shipped off-Site via rail, tanker truck, or ship. Loading racks were located along the east side of the railroad tracks. The 1918 Plant Map shows product lines running between the Still House, Tanks 1 to 4, and the loading racks for transferring coal tar and creosote. The tank car loading rack appeared to be located on a trestle that crossed May Creek. The 1958 Plant Map also indicates that a pipeline was present between the ASTs west of the Still House and the property to the north of the Site (formerly occupied by J.H. Baxter & Company, which operated a wood treatment plant from 1955 until 1982). This pipeline was used to transport creosote used in the wood treatment process.

Wastes produced in the manufacturing process were disposed of on-Site. When the stills were cleaned, the waste pitch, also called Saturday Coke, was chiseled out of the stills (on Saturdays) and reportedly placed near the Site shoreline (Ecology 1989). Liquid waste from

the Still House cooling lines was reportedly disposed of in the north and south sumps. This effluent stream reportedly sometimes contained creosote and tars (Ecology 1989).

Roberts indicated that the condensers sometimes leaked, allowing creosote to enter the sanitary sewer (Ecology 1989). The sewer outfall discharged into the former May Creek Channel. The old bed of May Creek marked the southern boundary of improvements. A fence line along the channel alignment is shown on the 1958 Plant Map. Aerial photographs from 1936 through 1968 indicate that little to no activity occurred in the area immediately south of the former May Creek Channel.

The Reilly facility closed permanently in 1969. Subsequently the Still House, the boiler house, and many of the storage tanks were demolished (Ecology and Environment [E&E] 1990).

2.1.3 Later Site Uses

From 1971 to 1983, Quendall Terminals leased the remaining Site ASTs to various companies for storage of Bunker C oil, waste oil, diesel, and lard. Tanks 35 through 38 were the principal tanks used during this period, mostly for storage of diesel and waste oils (E&E 1990). Roberts indicated that Tanks 23 and 26 (2-million-gallon capacity) were only used for one brief period after Quendall Terminals purchased the property in 1971. These tanks were leased by Willamette Industries for 18 months to store Bunker C crude oil. The Bunker C crude oil was transported to the Site by truck. Tanks 35 through 38 were demolished in 1983 (E&E 1990).

An Ecology memorandum dated June 2, 1971 indicates that no containment dikes were present around the tanks until about 1971. An Ecology Site inspection in 1972 noted substantial oil and tar product residue in the area of the central tank farm.
From the late 1970s through 2009, the Site was used as a log sorting and storage yard with most of this activity occurring in the late 1970s and early 1980s. Wood chips and bark were scattered and mounded throughout the Quendall Site as a result of the log storage operations. Aquatic lands adjacent to the facility managed by WDNR were also historically leased for log rafting and vessel storage, but those leases were terminated in the 1990s.

In 2002, two World War II-era wooden dry docks with concrete bottoms were moved from Lake Union to Lake Washington and stored at Quendall Terminals, on private property. They remained there until 2005, when it was found that they had been moved off the property into state waters and had sunk. WDNR dismantled the dry docks in place. The dry dock work was completed on January 1, 2009, and included placement of a sand layer within the footprint of where the dry dock dismantling project took place. The concrete bases of the dry docks could not be removed; therefore, WDNR decided that they would be left in place and covered with clean sand.

2.2 Summary of Sources of Contamination

This section provides a discussion of potential primary contaminant source areas at the Quendall Terminals Site based on historical operational activities and land uses. Products released to the subsurface may act as ongoing secondary sources of contamination, which are discussed in Section 4 – Nature and Extent of NAPL and Section 5 – Nature and Extent of Contamination in Site Media.

Tar refining was conducted at the Quendall Site from 1916 through 1969. Releases of tars and distillate products to the environment have occurred at locations of the Quendall Site where transport, production, storage, and/or disposal of the products were performed. The release of waste products, including solids (e.g., still bottoms, Saturday Coke, and pitch) and liquids (e.g., steam condensate and spills), has also impacted Site media quality. After the plant was closed in 1969, all structures except for six of the ASTs and the office were demolished. After the tar refining facility was demolished, petroleum was stored at the Quendall Site using the remaining tanks from 1969 to 1982. Reported spills during this period may also have impacted Site media quality. Primary sources of potential contaminant releases are described below.

2.2.1 Historical Structures

T-Dock: Tar feedstock was typically shipped to the Quendall Site and transferred to ASTs through a transfer line located on the deck of the dock (Hart Crowser 1994). A large spill occurred sometime between 1930 and 1940 at the western end of the T-Dock.

Approximately 30,000 to 40,000 gallons of tar feedstock were reportedly released into Lake Washington during barge offloading (Ecology 1989).

In 1946, the Washington State Pollution Control Commission (WSPCC) noted that: "Upon reaching the end of the intake pipes, a large drip pan was observed completely filled with heavy crude oil. In fact, it was so full that it was overflowing… The entire end of this dock was saturated with oil…" (WSPCC 1946).

Still House: The Still House, where tar was refined to distillate products, reportedly did not have an impervious floor. Historical information suggests that spills onto the soil floor of the Still House occurred (CH2M HILL 1983 and Ecology 1989).

Boiler House: Although there were no reported releases from the boiler house, the boilers were fired by heating oil and likely required transfer and storage of this product. According to Roberts, tar distillates were sometimes also used as boiler fuel (Hart Crowser 1994). The boiler house was demolished when the plant closed in 1969.

Former Structure near Tanks 37 and 36: Chlorinated liquid tar distillates were reportedly used in a small volume in an experimental wood treating area located near Tanks 36 and 37 (Ecology 1989). According to Roberts, chlorine was added to tanks of creosote in an effort to improve the creosote mix, but the process was not successful in practice and was shortly discontinued (Hart Crowser 1994).

Railcar Loading Racks: In 1972, the Municipality of Metropolitan Seattle (Metro) indicated that loading areas at the railroad tracks "received heavy spilling over the years" (Metro 1972). Roberts indicated that areas close to the Still House and to the south were used for loading liquid products, and that areas east of the pitch bays were used for loading solid materials (Hart Crowser 1994).

2.2.2 Aboveground Storage Tanks

Historical AST locations and numbers, based on facility maps and aerial photographs, are shown on Figure 2.1-1. The smaller tanks were also numbered, but the numbers are illegible

on the 1958 facility map. Available information regarding tank installation and use is summarized below:

- Tanks 1 to 4: Installed in 1916, these tanks were primarily used to store creosote-related products. Product shipping via rail also occurred in this area of the Site.
- Tanks 23 and 26: The two largest tanks, installed in 1928, had an approximate capacity of 2 million gallons each. These tanks were primarily used to store raw tar and later used to store Bunker C oil. The tanks contained heating elements, which allowed for transfer of the raw tar to the Still House.
- Tanks 31 to 34: The installation date of these four 20,000-gallon tanks is unknown. They were dismantled and disposed of off-Site in 1974 (E&E 1990).
- Tanks 35 and 36: These 272,000-gallon tanks were installed in 1956. They were primarily used to store creosote-related products. After Reilly Tar operations ceased, the tanks were used to store waste oil. Historical documents do not specify what the waste oil contained; however, the source was thought to be automobile crankcase oil from service stations (E&E 1990).
- Tanks 37 and 38: These 1-million-gallon tanks were installed in 1956. They were primarily used to store creosote-related products. After Reilly Tar operations ceased, Tanks 37 and 38 were used to store Bunker C oil and later to store lard.

2.2.3 Waste Disposal

North and South Sumps: These sumps received effluent from still house cooling lines, and this effluent sometimes contained creosote and tars (Retec 1996). Roberts stated that steam condensate tubes in the stills would often corrode, resulting in distillates released into the steam (CH2M HILL 1983). This condensate would then be discharged to the sumps. The north and south sumps were located west of the process area (Figure 2.1-1). The south sump was reportedly filled in before 1950 (Hart Crowser 1994). Shortly after the plant was shut down, approximately 50 truckloads of material were excavated from the larger north sump and disposed of at the Coal Creek Landfill (CH2M HILL 1983).

Former May Creek Channel/Sanitary Sewer Outfall: Roberts stated that historical source areas may be located along the former May Creek Channel because residue from AST cleaning operations were placed there (Retec 1996). The sanitary sewer outfall also

discharged into the former channel (1969 Plant Map). Roberts indicated that the condensers sometimes leaked, allowing creosote to enter the sanitary sewer and ultimately reach the former channel (Hart Crowser 1997).

Waste Pitches and Tar Dumps: Roberts recounted that the waste pitch, or Saturday Coke, was chiseled out of the stills and placed near the shoreline on the northwest portion of the Site (CH2M HILL 1983).

Tank Bottoms: When tanks were cleaned, tank bottoms were reportedly placed on-Site near the tanks (CH2M HILL 1983).

2.2.4 Potentially Contaminated Fill Materials

Potentially contaminated materials used as fill at the Site include foundry slag and heavy tar distillates, such as pitch and Saturday Coke, that are solid or semi-solid (e.g., products of high viscosity that do not flow through porous media such as soil). Solid tar products of coal tar distillation were produced north of the Still House around the pitch bays, where pitch was cooled. A coal shed was also located in this area according to the 1918 Plant Map.

Roberts reported that PACCAR-foundry slag had been used as fill at the Quendall Site. In one interview, he reported that it had been placed northwest of the large tank farm in the area around Quendall Pond (CH2M HILL 1983); however, during two other interviews he reported that these materials had been placed southwest of the tank farm (Ecology 1989; Hart Crowser 1994).

2.2.5 Weed Control

Before 1950, sodium arsenate was reportedly sprayed at the Site every spring to control weeds (Hart Crowser 1994).

2.2.6 Summary of Sources, Release Mechanisms, and Exposure Media

The CSM for the Quendall Site, which describes primary and secondary sources and release mechanisms and exposure media, is illustrated on Figure 2.2-1. The nature and extent of the exposure media, non-aqueous phase liquid (NAPL), soil, groundwater, sediment, porewater,

and surface water, are detailed in Sections 4 and 5. Contaminant fate and transport considerations associated with secondary release mechanisms and additional exposure media important for risk evaluations (e.g., vapor and aquatic biota) are detailed in Section 6. Potential risks from exposure to Site media are detailed in the baseline human health and ecological risk assessments in Section 7.

2.3 Summary of Historical Investigations

This section summarizes the investigations that were conducted at the Quendall Site prior to the 2009 RI field investigation. Evaluation of the resulting historical data and selection of the data that were determined to be usable for the RI/FS are described in Section 2.4. Details regarding the application of the historical data and the data generated as part of the 2009 RI field investigation are presented in the sections of this report that describe the nature and extent of contamination (Sections 4 and 5), contaminant fate and transport (Section 6), and the baseline human health and ecological risk assessments (Section 7).

Numerous environmental investigations have been conducted at the Site since the 1970s, as detailed in the Task 2 Report (Anchor and Aspect 2007a). This section summarizes the investigations that generated physical, chemical, and/or biological data that are potentially relevant to the Site RI/FS. Table 2.3-1 summarizes the environmental media, investigation locations, numbers and types of samples collected, and chemicals analyzed for during the historical investigations. Figures 2.3-1 and 2.3-2 show the upland and offshore sample locations used in the historical investigations.

A list of historical Site investigations, organized by environmental media and specifying the date(s) performed, is provided below:

Soil

- Metro Study (1963)
- Twelker Oil Contamination Study (1971)
- Woodward Clyde Upland Investigations (1983, 1988, and 1990)
- Hart Crowser Upland Investigations (June 1995 and July 1996)
- Shannon & Wilson Geotechnical Investigation (November 1997)

- Retec Upland Investigations (December 2000 and April 2001)
- Aspect Geoprobe and Surface Soil Investigations (November 2003 and February 2004)

Groundwater

- Woodward Clyde Contamination Investigation (1983)
- Woodward Clyde Groundwater Investigations (January, June, and November 1989; March 1990; and May and June 1991)
- Hart Crowser Groundwater Investigations (January, June, and December 1996)
- Retec Upland Investigations (December 2000 and April 2001)
- Retec Lake Mudline Wellpoint Sampling (January 2001)
- Anchor Lake Mudline Wellpoint Sampling (September 2002 and February 2003)
- Aspect Deep Aquifer Sampling (August 2003)

Surface Water

- CH2M Hill Lake Current and Water Quality Studies (1979)
- Hart Crowser Surface Water Investigation (1996)
- Anchor Lake Mudline Wellpoint Sampling (September 2002 and February 2003)

Sediment and Porewater

- EPA Sediment Study (1983)
- Ecology Sediment Studies (May 1990 and February 1991)
- Retec Sediment Investigations (November 1996 and February 1997)
- Exponent Sediment Gray Zone Investigation (June 2000)
- Retec Lake Mudline Wellpoint Sampling (January 2001)
- Anchor Lake Mudline Wellpoint Sampling (September 2002 and February 2003)
- Anchor Sediment Natural Recovery Evaluation (September 2003)
- Aspect Sediment Hydraulic Properties Assessment (January 2004)
- Anchor Sediment Chemistry and Bioassay Sampling (February 2004)

2.4 Evaluation of Historical Data for Use in the RI/FS

This section summarizes the process by which the quality of the historical data collected during the investigations and studies listed in Section 2.3 was evaluated for use in the RI/FS

for the Quendall Site. The sections below summarize the quality assurance (QA) screening and corresponding data quality designations assigned to each dataset. The detailed data validation and assignment of QA categories are provided in the Task 2 Report (Anchor and Aspect 2007a). The Task 2 Report presents a summary of environmental sampling data available for different Site environmental media (surface water, groundwater, sediment, and surface and subsurface soil), along with other related information relevant to the RI/FS. The Task 2 Report reviews the quality of available sediment, surface water, groundwater, and soil data collected at the Site, and evaluates these data relative to their age, analytical methods employed, detection limits achieved, data validation methods and results, and other data limitations and/or strengths. The Task 2 Report was conditionally approved by EPA in August 2007.

The data screening for the RI/FS consisted of a two-step process that first identified datasets that were sufficiently recent (samples obtained in 1995 or later)[2] and for which adequate documentation of event-, station-, sample-, and result-level data was available. If the initial data screening parameters were met for a historical investigation or study, additional data quality indicators were applied that related specifically to the results and the availability of quality assurance/quality control (QA/QC) information and the manner in which this information was documented. Three levels of data validation were applied:

- Category QA2 was defined for this evaluation as a level of validation where full documentation was available and an independent third party performed a full validation. QA2 quality data are usable for all RI/FS purposes, including assessing boundaries of contamination at the Site and performing risk assessment exposure calculations.
- Category QA1 was defined for this evaluation as an abbreviated data review, where information such as method blanks, surrogates, or other quality control (QC) summary data were reviewed. QA1 results provided a more limited set of qualifiers than QA2 quality data. QA1 quality data were further categorized as QA1- or QA1+

[2] For sampling events conducted before 1995, only the physical information was potentially suitable for use in the RI/FS and is evaluated in the Draft Task 3 Report (Anchor and Aspect 2007b) and herein. While analytical data are available from earlier events, they may not be representative of current Site conditions because of their age.

indicating that certain non-critical data quality indicators were either missing (QA1-) or available (QA1+), to supplement the QA1 data validation. QA1 quality data are usable for evaluating the nature and extent of contamination, and can be used with QA2 quality data to assist in assessing boundaries of contamination. QA1 quality data are not as desirable as QA2 data for performing risk assessment exposure calculations, but may be used in cases where QA2 quality data are not available.

- Category QA0 was assigned to data that because of age, analytical method, or lack of complete laboratory report documentation, were determined to have too much uncertainty for use in assessing boundaries of contamination or risk assessment exposure concentrations. QA0 quality data include Woodward Clyde data collected from 1983 and from 1988 to 1991. Although complete laboratory reports were not obtained for these data, the work was performed under an Agreed Order with Ecology, and Ecology reviewed and accepted the data for use in the 1997 Uplands RI (Hart Crowser 1997). These data may be used in conjunction with higher-quality data and/or other lines of evidence to assist in identifying contaminants of interest (COIs), refining nature and extent determinations, and qualitatively evaluating historical trends in contaminant occurrences.

The analytical chemistry data for soil, groundwater, surface water, bulk sediment, and sediment porewater are contained in the project analytical database. The database includes all pertinent event, station, sample, and result information including qualifiers determined from initial and final reviews, and overall QA categories. The project analytical database is provided in Appendix A-1.

2.4.1 Historical Data Selected for Use in the RI/FS

Historical data that were retained for use in the RI/FS are identified below for soil, groundwater, bulk sediment, sediment porewater, and surface water. Figures 2.3-1 and 2.3-2 show the investigation event sample locations for upland and lake explorations meeting data quality requirements. As indicated in Table 2.3-1, the following datasets met necessary data quality indicators, the validated datasets were determined to be of QA1- quality or better, and the data were of sufficient quality to be retained for use in the RI/FS:

- Historical soil data generated for the Hart Crowser RI (1997), the Retec RI/Focused FS (FSS; 2002), and the Anchor and Aspect Risk Assessment/Feasibility Study (RA/FS;

2004).

- Historical groundwater data generated for the Hart Crowser RI (1997), the Retec RI/FFS (2002), and the Anchor and Aspect RA/FS (2004).
- Historical bulk sediment data generated for the Retec (1997a, 1997c) due diligence investigation (Sediment Quality Memorandum), the Exponent (2001) gray zone characterization , and the Anchor and Aspect RA/FS (2004).
- Historical sediment porewater data generated for the Retec RI/FFS (2002) and the Anchor and Aspect RA/FS (2004).
- Historical surface water data generated for the Hart Crowser RI (1997).

In addition, soil and groundwater data generated for the Port of Seattle Phase 1 and Phase 2 investigations by Pinnacle GeoSciences (2009) of the BNSF Eastside Rail Corridor adjacent to the Site were of high quality and are included in the RI/FS. These data are discussed in detail in this report and are included in the project analytical database (Appendix A-1).

2.5 Summary of RI/FS Data Needs and Data Collection

This section provides an overview of the selection of indicator chemicals for the Quendall Site, the identification of data needs, and the subsequent 2009 field data collection effort. The general discussion is framed around the three primary data collection data quality objectives (DQOs)—to assess the nature and extent of NAPL, the nature and extent of contamination in Site media, and contaminant fate and transport—that were detailed in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). Investigation activities for Site media included sampling of groundwater and sediment (bulk and porewater). Additional soil sampling was not performed because, based on cleanup actions implemented at similar sites and the fact that future Quendall property redevelopment will require at least several feet of fill to match the adjacent property grades and to install a gravity sewer system, it is expected that the final Site cleanup actions will include capping of almost the entire property. The purpose of this section, along with Section 2.4, is to provide a road map to the historical and 2009 RI Site investigations and the data included in the RI/FS. The details of how historical and 2009 data were applied in this RI and the associated baseline human health and ecological risk assessments are included in the sections below where applicable.

2.5.1 Contaminants of Interest and Indicator Chemicals

A screening process was developed and used during preparation of the Data Collection Work Plan (Anchor QEA and Aspect 2009a) to identify those hazardous substances associated with historical Site uses that have the potential to pose unacceptable risks to human health and/or the environment. The COI screening also provided a basis to identify indicator chemicals that could be used to more efficiently characterize the nature and extent of contamination at the Quendall Site. The COIs and indicator chemicals identified in the Data Collection Work Plan were used in evaluating existing Site data and guided the collection of supplemental data necessary to complete the RI/FS. The list of COIs and indicator chemicals identified in the Data Collection Work Plan is provided in Table 2.5-1.

During the COI screening, analytical data of QA1 and QA2 quality were compared to preliminary remediation goals (PRGs) for each environmental medium at the Site. Analytes detected above the PRGs in at least one medium were retained as Site COIs. For analytes not detected above the PRGs, a review was performed to determine whether: 1) the analyte may have been used or is a component of a product that was historically used at the Site or 2) the analyte has been identified at sites with similar historical uses and contamination. For chemicals with detection limits greater than the PRGs, the data were evaluated to determine whether the detection limits were elevated due to matrix interference or other analytical method limitations. The initial COI screening process is detailed in Section 2 of the Data Collection Work Plan (Anchor QEA and Aspect 2009a).

Media- and contaminant-specific PRGs were also used to help focus the 2009 RI field investigation based on a preliminary characterization of the nature and extent of Site hazardous substances in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). PRGs for groundwater, soil, bulk sediment, and sediment porewater (surface water) were developed using available federal and state applicable or relevant and appropriate requirements (ARARs) and risk-based criteria. Detailed tables of the PRGs evaluated during the initial COI screening are provided in Appendix B. Where multiple PRGs were identified, the most stringent PRG for each medium was selected as the basis for the initial screening. PRGs were selected as the most stringent values within the following hierarchy:

- Federal and Washington State ARARs (e.g., maximum contaminant levels [MCLs], EPA National Recommended Water Quality Criteria [NRWQC], and MTCA cleanup levels).
- External peer-reviewed EPA screening levels (e.g., Regional Screening Levels [RSLs] and ecological Soil Screening Levels [Eco-SSLs]).
- Other EPA screening levels (e.g., Region 5 Resource Conservation and Recovery Act [RCRA] ecological screening levels [ESLs]).

Because numerous hazardous substances have been detected at the Site at concentrations above the most stringent PRGs, a subset of the Site COIs, referred to as "indicator chemicals", were used to more efficiently characterize the nature and extent of contamination, particularly given that the hazardous substances not selected as COIs co-occur spatially at the Site with the indicator chemicals. To select the indicator chemicals, COIs were first categorized based on likely Site historical source(s) and chemical similarities. Within each indicator category, chemicals were then selected based on historical sources, fate and transport characteristics, and toxicity. Two general categories of Site indicator chemicals were identified: 1) chemicals associated with coal tar products and 2) chemicals associated with sources other than coal tar products (i.e., other potential sources). The indicator chemicals in each category are as follows:

- Coal Tar Products: benzene and PAHs (acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, indeno[1,2,3-c,d]pyrene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene).
- Other Potential Sources: arsenic, chromium (III)[3], copper, total PCBs, phenol, 4-methylphenol, pentachlorophenol (PCP), and total organic carbon (TOC).

Benzene and PAHs are associated with the dense non-aqueous phase liquid (DNAPL) present at the Site as the result of the production of coal tar and creosote. Arsenic is of interest because of its historical use at the former Barbee Mill (now the Conner Homes property, to the south of the Site), and PCP because of its potential association with the wood-treating

[3] Soil conditions at the Site are characterized by high organic carbon content, supporting a reducing environment and neutral pH. Because the oxidizing environment required to maintain chromium (VI) is not present at the Site, chromium (VI) was not retained as a COI.

activities at the former J. H. Baxter & Company Property (now Football Northwest, to the north of the Site). The other metals and PCBs are of interest because of the historical storage of waste oil at the Quendall Site. Phenol, 4-methylphenol, and TOC are included because they can be used to characterize the potential adverse effects of wood debris in the shallow sediment offshore from the Site.

The indicator chemicals identified in the Data Collection Work Plan (Anchor QEA and Aspect 2009a) and in Table 2.5-1 provide the basis for the discussion of contaminant nature and extent at the Site (Section 5 of this RI Report), and are discussed further in Section 5.1.

2.5.2 Nature and Extent of DNAPL

Based on the analysis presented in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), it was determined that additional information was needed to evaluate occurrences of DNAPL contamination at the Site. The objectives of the 2009 RI field investigation of DNAPL contamination were to:

- Determine lateral and vertical boundaries of DNAPL occurrences.
- Identify areas of DNAPL that may contribute most to groundwater contamination throughout the Site.
- Characterize soil stratigraphy surrounding DNAPL occurrences.
- Estimate volumes of DNAPL.

The 2009 RI field investigation applied a decision matrix for determining step-out locations for DNAPL explorations (see Figure 3-11 in the Data Collection Work Plan for details; (Anchor QEA and Aspect 2009a). If DNAPL was encountered in a new boring, the existing data points within 50 feet for the uplands or 150 feet for sediment were evaluated laterally and vertically to determine whether a step-out boring was needed. An expedited decision-making process was employed to ensure that step-out boring locations were reviewed and approved by EPA.

The 2009 RI field investigation included advancing soil borings and sediment cores to delineate the vertical extent of DNAPL in subsurface soil and sediment in three areas of the Site: 1) in the vicinity of Quendall Pond, 2) in the former May Creek Channel, and 3) in the

vicinity of the former T-Dock (main span and cross span). The locations of the borings and cores are described below and shown on Figures 2.3-1 and 2.3-2:

- Quendall Pond: Five direct-push soil borings (QP-1 through QP-5) to a maximum depth of 30 feet in the uplands to the south, west, and north of Quendall Pond, and eight continuous sediment vibracores (QPN-01 through QPN-08) to a maximum depth of 15 feet in sediment offshore to the west and north of Quendall Pond.
- Former May Creek Channel: Twenty-four direct-push soil borings (MC-1 through MC-24) to a maximum depth of 40 feet, and three trenches (T-5 through T-7) to a maximum depth of 10 feet in and to the north, south, and west of the former channel.
- Former T-Dock: Seventeen core samples to a maximum depth of 15 feet along the main span and cross span historical spill areas.

Five Quendall Pond and former May Creek Channel soil samples containing DNAPL and two tar samples were analyzed for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) to evaluate the composition of DNAPL in these areas.

Specific objectives, a description of the 2009 field activities, and data resulting from the DNAPL investigation are provided in the Data Report, Remedial Investigation/Feasibility Study, Quendall Terminals Site, Renton, Washington (RI/FS Data Report; Anchor QEA 2010).

2.5.3 Nature and Extent of Contamination in Groundwater

Based on the analysis presented in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), it was determined that additional information was necessary to evaluate the boundaries of the Site groundwater plume to complete the RI/FS. The goals of the 2009 RI field investigation of groundwater contamination were to:

- Confirm estimated boundaries of the horizontal and vertical extents of indicator chemicals in groundwater.
- Evaluate long-term trends for indicator chemicals in groundwater.
- Evaluate occurrences of metals and PCP in groundwater for chemicals of potential concern (COPCs) and remedial alternatives analysis.

- Evaluate seasonal variability in groundwater quality and gradients to estimate changes in contaminant flux along the shoreline and to assist fate and transport modeling and remedial alternatives analysis.

The 2009 RI field investigation included installing new monitoring wells, measuring water levels, and collecting groundwater samples from monitoring wells and direct-push borings. These activities were conducted at the locations shown on Figure 2.3-1, and included the following:

- Two wells (BH-29A and BH-29B) were installed in the southwestern corner of the Site to bound the extent of groundwater contamination south of the former May Creek Channel.
- One well (BH-5B) was installed next to existing wells BH-5A and BH-5 to delineate the extent of contamination at the top of the Deep Aquifer in the vicinity of Quendall Pond.
- Two wells (BH-20C and BH-30C) were installed near the base of the Deep Aquifer to delineate the vertical extent of groundwater contamination. Two borings (QP-6 and QP-7) were advanced as reconnaissance borings for locating well BH-30C.
- One well (BH-25A(R)) was installed to replace an existing, damaged well.
- Groundwater samples were collected from three direct-push borings (SP-BAX9-1 through 3) to delineate the northern extent of contamination.
- Water levels and DNAPL thickness (if present) were measured at all Site wells.
- Groundwater samples were collected from all Site wells and analyzed for VOCs, SVOCs, and metals.

Specific objectives, a description of the 2009 field activities, and data resulting from the groundwater investigation are provided in the RI/FS Data Report (Anchor QEA 2010).

2.5.4 Nature and Extent of Contamination in Sediment

Based on the analysis presented in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), it was determined that additional information was necessary to evaluate lateral and vertical boundaries of sediment contamination to complete the RI/FS. The goals of the 2009 RI field investigation of sediment contamination were to:

- Confirm estimated boundaries of the horizontal and vertical extent of indicator chemicals in surface sediment that exceed regulatory and risk-based criteria or background levels.
- Confirm estimated boundaries of the horizontal and vertical extent of wood debris in surface sediment and identify likely causes of potential toxicity to benthos.
- Supplement existing subsurface sediment quality data to determine current conditions of subsurface sediment contamination.

The 2009 RI field investigation included collecting surface sediment grab samples and subsurface core samples for analysis of bulk sediment and porewater. Work at the sediment stations shown on Figure 2.3-2 included the following:

- Forty-one surface grab samples were collected to characterize background contaminant concentrations in bulk sediment.
- Forty-six surface grab samples were obtained to characterize background contaminant concentrations in sediment porewater.
- Twenty additional surface grab samples were collected, ten of which were randomly selected for characterization of background PAHs in bulk sediment and sediment porewater.
- Seventeen subsurface cores were obtained in the T-Dock Area to bound the extent of contamination around historical spill areas and to characterize DNAPL.
- Fifteen subsurface cores were obtained in the nearshore area to bound the extent of contamination from groundwater discharge and to characterize the flowpath.[4]
- Three lake water samples were collected for use in characterizing lake water diffusion into surface sediment.

Specific objectives, a description of the 2009 field activities, and data resulting from the sediment investigation are provided in the RI/FS Data Report (Anchor QEA 2010).

The groundwater, surface and subsurface sediment porewater, and lake water samples were also used to address the fate and transport of contamination to Lake Washington, as detailed

[4] Note that in order to achieve sufficient sample volume, two co-located cores were collected at each nearshore location. Cores collected from the same location were processed and sampled at the same time, and the materials from corresponding depths were composited prior to submittal for chemical analysis.

in Section 6 of this report. Additionally, the data collected for Site media were used to quantify exposure to human and ecological receptors, as detailed in Section 7.

3 ENVIRONMENTAL SETTING

This section describes the physical characteristics of the Site (Section 3.1), natural resources at the Site and adjacent areas (Section 3.2), and surrounding land use characteristics (Section 3.3).

3.1 Physical Characteristics

The physical characteristics of the Quendall Site discussed in this section include topography and Site drainage, climatic conditions, geology and hydrogeology (both regional and Site-specific), bathymetry and sediment characteristics, and geotechnical characteristics. Each of these characteristics is discussed below based on Site investigations and available regional information.

3.1.1 Topography and Site Drainage

The Site is located in the Puget Lowlands on the southeast side of Lake Washington. The Site is relatively flat with hills rising to the east beyond I-405. Much of the property was formed by the lowering of Lake Washington in 1916, which exposed the alluvial delta of May Creek. The creek originates in the hills east of the Site. When the Site was first developed in the 1910s and 1920s, May Creek flowed across the southern portion of the property as illustrated on Figure 2.1-1. Based on review of aerial photographs, the creek had been diverted south of the property by 1936 and no longer crossed the Site.

Site topography has been modified over the past 90 years by filling and grading activities. The resulting topography is relatively flat, having a maximum relief of about 12 feet across the 22-acre upland area (Figure 3.1-1a). Upland elevations at the Site range from approximately 35 feet on the east side of the property to about 20 feet at the lake shore (all elevations reported in North American Vertical Datum [NAVD] 88). Site drainage is relatively poor because of the flat topography and the fine-grained nature of the shallow soil.

Recent changes in Site topography can be noted by comparing topographic maps generated over the past 30 years as part of specific environmental and geotechnical investigations. The

most current information on topography is based on a Site survey performed by Bush, Roed & Hitchings during the 2009 RI field investigation. Historical topographic surveys were also conducted in 1997 (Retec 1997c; included bathymetry; see Section 3.1.6) and in 1975 (Walker and Associates). The comparison of 2009 topographic contours with 1975 contours is shown on Figure 3.1-1a, and a comparison of 1997 contours with 1975 contours is shown on Figure 3.1-1b. The source of topographic contours on Site maps provided in Woodward Clyde's Technical Memorandum No. 1 (Woodward Clyde 1990) and the Hart Crowser RI Report (1997) is not referenced, but the maps appear identical to topographic maps based on aerial photography dated December 6, 1975.

Key differences between the 1975 and 1997 maps include the following:

- Generally lower elevations (typically 2 to 5 feet) were observed across the Site in 1975 compared with the 1997 topographic map, attributable to fill that was imported and placed on the Site in the 1980s.
- Berms in the center of the Site (around the ASTs) are shown on the 1975 map, but are absent on the 1997 topographic map.
- Several mounds are shown on the 1997 topographic map; these have been characterized as piles of wood debris from log yard operations.

No significant grading or filling activities have occurred since approximately 1997. Activities that have resulted in relatively minor changes to Site topography include the following:

- Under the Ecology Agreed Order, a stormwater control pilot study was implemented in 2004 to direct stormwater runoff away from Quendall Pond. A small detention basin was excavated south of the pond, and a berm was constructed between the log yard and the pond.
- In 2006, the former Site tenant did the following:
  - Increased the capacity of drainage ditches, including the installation of rock check dams and silt fencing, along the south property boundary.
  - Constructed a silt fence and sediment/debris trap between the access road and the southern property shoreline.

  - Constructed an earthen berm between a settling basin and the shoreline, improving drainage ditches with rock check dams to route Site runoff to Quendall Pond, and increased the capacity of a settling basin just upland of the dock area.

- In 2008, several stormwater best management practices (BMPs) were implemented at the Site to control runoff (Aspect 2008). Activities are documented in the Interim Stormwater Managment Closure Report (Aspect 2009a) and included installation of two shallow swales that directed stormwater away from Quendall Pond (Figure 1.2-1), installation and improvements of berms along the lake shore, and mulching and hydroseeding soil disturbed from former log yard operations.
- As part of the recent development of the Conner Homes property, Quendall Terminals dedicated the far southeastern corner of the Site right-of-way easement to the City of Renton, and the developer placed several feet of fill as sub-base for an access road in this location.
- As part of the recent development of the Football Northwest property, the developer placed quarry spalls and gravel in the northeastern corner of the Site, within a right-of-way easement, as a roadbed for construction access.

During the rainy season, much of the runoff in the center of the Site that is not diverted by the two shallow swales flows into two stormwater collection ponds on the west side of the Site (Quendall Pond and the South Detention Pond). Stormwater also accumulates in low-lying areas east of well BH-24, southwest of wells BH-21A/B, and south of wells BH-20A/B. (The locations of these wells are shown on Figure 2.3-1.)

The approximate locations of Site stormwater control swales and ditches are shown on Figure 1.2-1. Included on Figure 1.2-1 are generalized drainage patterns observed during inspections of the stormwater BMPs described above.

3.1.2 Site Climatic Conditions

The climate in the Site vicinity is characterized as Pacific Marine, typical of the Puget Sound area. Winters are generally mild and wet, and summers are usually dry. Based on data available for Seattle-Tacoma International Airport from 1931 to 2006, annual precipitation ranges between 23.8 and 55.1 inches with a mean of 38.1 inches. The majority of the

precipitation occurs between November and February. Monthly winter temperatures average between 35 and 49 degrees Fahrenheit while monthly summer temperatures range between 51 and 75 degrees Fahrenheit.

Wind direction, distribution frequency, and wind velocity data are available for the airport and are summarized on Figure 3.1-2. These data indicate that wind direction is most frequently from the south-southwest and north. Wind coming from the west across the Pacific Ocean is typically deflected around the Olympic range and enters the Puget Sound from either the north or south. This regional wind pattern is reinforced at the Site by its location on the shore of Lake Washington, where wind is likely to follow the water area between Mercer Island and the Renton shore.

3.1.3 Regional Hydrogeology

The Site is located in the southeastern part of the Puget Sound Lowland. The physiographic features of the lowland are dominated by repeated advances and recessions of glacial ice within the lowland. The hills to the east of the Site are composed of glacial and non-glacial soils with bedrock outcrops a mile east of the Site. A map of the regional geology is provided on Figure 3.1-3 and shows the bedrock outcrops to the east and southwest, forming the margins of the Cedar River drainage. A conceptual regional geologic cross section shown on Figure 3.1-4, extending east of the Site, illustrates a sequence of fine- and coarse-grained materials overlying bedrock as documented in area well and boring logs. The presence of bedrock and fine-grained deposits limits the lateral extent of aquifers encountered beneath the Site, isolating them from regional aquifers located to the south in the Cedar River valley.

The groundwater flow system is characterized primarily by recharge in the upland areas east of the Site and the May Creek drainage south/southeast of the Site, with flow towards the west and discharge to Lake Washington. Site groundwater likely originates from precipitation on and east of the Site and recharge from alluvial deposits in the May Creek drainage immediately south of the Site. The months of July through September constitute the low precipitation period when groundwater recharge is generally at its lowest. Conversely, the months of November through February are the rainy period when groundwater recharge is at its highest.

3.1.4 Site Geology

The geologic units beneath the Site consist of highly heterogeneous alluvial and lacustrine silts, sands, and peat underlain by a coarser sand-gravel alluvium. The alluvial deposits have been overlain by fill deposited over the years since the lake levels were lowered in 1916. The alluvium was deposited by May Creek and the Site is located within the creek's delta. The delta below lake level extends approximately 5,000 feet along the shoreline of Lake Washington and projects up to 3,000 feet offshore toward Mercer Island. Normal delta processes and periodic earthquake-induced landslides that occurred at the margin of the delta have resulted in a deposit with abruptly changing lithologies and little vertical or lateral continuity.

Detailed geologic cross sections along five alignments depict subsurface conditions and the relationship of the uplands portion of the Site to Lake Washington and underlying sediment. The locations of cross sections A-A' through E-E' are depicted on Figure 3.1-5, and the individual cross sections are shown on Figures 3.1-6 through 3.1-10. The geologic and hydrostratigraphic interpretation described below and on the referenced cross sections is based on identification and correlation of specific strata observed in the Site borings. Significant consideration was also given to the location of the Site within the context of regional and local topographic and physiographic features—including Lake Washington, May Creek, and the Renton uplands—and the geologic history of the Puget Sound region, including documented glacial and non-glacial depositional sequences (Troost and Booth 2008; Karlin et al. 2004; Pacific Northwest Center for Geologic Mapping Studies 2006). Note that cross sections A-A' through D-D' depict subsurface conditions up to approximately 60 feet bgs while cross section E-E' depicts subsurface conditions to approximately 170 feet bgs. Because the number of on-Site borings drilled to the 170-foot depth was limited, the geologic conditions inferred by cross section E-E' are necessarily simplified compared to the detail shown in cross sections A-A' through D-D'. A discussion of the major geologic units is provided below.

3.1.4.1 Fill and Fill History

Fill is found across the entire Site. Along the southern and eastern boundaries, fill ranges from 1 to 2 feet in thickness, while in other Site areas the fill ranges to more than 10 feet thick. Most commonly, the fill is a mix of silt, sand, and gravel with wood debris. Wood

chips and bark from the log sorting operations are common in the upper few feet. Where creosote and pitch-like material have been encountered in soil explorations, such materials have generally been observed at depths greater than 2 feet bgs. Specific areas of Site fill include the following (the locations of the referenced borings and test pits are shown on Figure 2.3-1):

- Northwest Quarter of Site: Fill may be as thick as 10 to 14 feet in this portion of the Site. Fill in this area includes abundant wood material, glass, brick, and pitch-like material.
- East of Quendall Pond: Fill is 7 to 9 feet in thickness with brick and pitch-like material observed in area explorations (borings BH-5/5A and test pits TP-4 and TP-9).
- Former May Creek Channel: Exploration logs from this area indicate that some of the fill includes tar, brick, wood, and metal fragments to depths of 6 to 7 feet.
- Former Tank Area: Tar and pitch were logged at a depth of 5 feet in borings BH-5, BH-6, and BH-25. This may represent a previous ground surface in the former tank area.
- West of South Detention Pond: In July 2007, slag-like material was observed in near-surface soil in the area of former well BH-12 (Anchor and Aspect 2007a).

Fill history is informed by geologic characteristics identified in subsurface explorations and historical records. Key episodes of Site fill placement are summarized below:

- The Lake Washington Ship Canal was completed in 1916, which resulted in the lowering of the lake level by about 9 feet. Not long after the lake was lowered, tar refining operations began at the Site. Both the existing shoreline and the historical (pre-1916) lake shoreline based on historical WDNR maps are shown on Figure 2.1-1.
- May Creek stream channels were located in the southern portion of the Site until the creek was rerouted sometime between 1920 and 1936. These channels have now been filled in. The former channel locations on the Site, indicated by early WDNR maps, are shown on Figure 2.1-1.
- Solidified tar products (pitch or Saturday Coke) were reportedly placed on the Site during the period of creosote manufacturing (CH2M HILL 1983). These materials, as well as other debris including brick, concrete, and metal, have been observed in the Fill Unit.

- Foundry slag from PACCAR, Inc. was reported by Roberts to have been placed as fill along the shoreline (CH2M HILL 1983; Ecology 1989; Hart Crowser 1994). Although geologic logs in this area generally have not identified slag, a few pieces of slag-like material were identified in a June 2007 well survey east of the former location of well BH-12 (Anchor and Aspect 2007a). In 1983, Quendall Terminals placed approximately 3 feet of fill consisting of sawdust and dirt over most of the Site.
- Log yard operations have resulted in the creation of several piles on the Site consisting largely of wood debris.

Fill is typically only seasonally saturated in isolated areas around the Site and does not substantially affect the Site-wide groundwater flow regime. Fill materials, like the Shallow Alluvium discussed below, are heterogeneous and could provide preferential flowpaths to groundwater when saturated; however, due to the heterogeneous nature of the material used, hydraulic effects are expected to be localized. Areas where the lower portion of the Fill Unit is seasonally saturated, such as in the northwest corner of the Site, do not appear to influence the Site-wide groundwater flow regime.

3.1.4.2 Shallow Alluvium

The Site Shallow Alluvium is part of the May Creek delta. The May Creek delta is best illustrated on the topographic map on Figure 3.1-11, where the deltaic fan is seen as a bulge in the topographic and bathymetric contours extending west into and beneath Lake Washington. The Quendall Site is located at the approximate center of that fan.

The deltaic deposits consist of interbedded sand, silt, clayey silt, organic silt, and peat beds. The Shallow Alluvium occurs to a depth of about 25 to 40 feet, with thinner deposits in the southeastern portion of the Site. Saturated conditions have been encountered at depths ranging from 2 to 10 feet depending on groundwater elevation and seasonal recharge.

The majority of the delta is composed of gently dipping foreset beds consisting of very soft peat and organic silts interbedded with very loose, silty, fine to medium sand. In a typical deltaic depositional environment, sediment is deposited on the delta slope at an angle that is marginally stable. The accumulated sediment periodically slumps or flows down the face of the delta. The process of alternating deposition of finer and coarser sedimentation continues

as the delta accumulates material over time. As the sediment built up a topographic mound around the mouth of May Creek, the stream would periodically jump its bank and shift laterally to a new position. Deposition of coarse-grained sedimentation then resumed elsewhere on the delta, and the former location of sandy deposition was blanketed with silt and clay. As the result of historical earthquake activity in the area, large portions of the delta slump into deeper water, contributing further to the discontinuous nature of these deltaic deposits.

The discontinuous layering observed at the Site borings and illustrated on the cross sections is consistent with a deltaic depositional environment. Cross sections A-A' and B-B' (Figures 3.1-6 and 3.1-7) illustrate the foreset beds deposited by the former May Creek Channel. Note that the angle of the beds appears exaggerated due to the vertical exaggeration of the cross sections. The lateral migration of the streambed is illustrated in cross sections C-C' and D-D' oriented north-south (Figures 3.1-8 and 3.1-9). The subsurface geology is based on the borings illustrated on the figures.

3.1.4.3 Deeper Alluvium

The Deeper Alluvium is generally coarser, consisting of medium-dense to dense sand and gravel. This unit occurs at a depth of 30 to 40 feet, with a shallower occurrence of about 25 feet at the southeast corner of the Site (boring BH-17B, adjacent to boring BH-17A shown on Figure 2.3-1). The sand and gravel most likely represent a historical continuation of the May Creek delta.

As inferred from geophysical explorations (Woodward Clyde 1988) and four deep borings at the Site, the base of this unit is estimated to be in the range of 90 to 137 feet bgs. Borings SWB-3 and SWB-4B were completed to depths of 121 and 151 feet, respectively (Shannon & Wilson 1997). In these borings, a fine to medium sand was encountered at approximately 90 feet, followed by a silty clay deposit at approximately 120 feet. The clay was interpreted to be a lacustrine deposit consisting of a very soft to medium-stiff silty clay (Figure 3.1-10 depicts the general occurrence of the deep alluvium and the lacustrine deposit.) A third deep boring (SWB-8) was completed to a depth of 121.5 feet near the lake shore and did not reach this fine-grained sequence. Most recently, two borings (BH-20C and BH-30C) were advanced to depths of 140 feet and 142 feet bgs, respectively. As shown on Figure 2.3-1, BH-

20C is located in the western portion of the Site, near Quendall Pond and the shoreline, while BH-30C is located near the southeastern boundary of the Site, adjacent to the Railroad property. Boring BH-20C encountered the silty clay at 137 feet bgs, while boring BH-30C encountered 10 feet of clay at 127 feet bgs. In addition, boring BH-30C encountered a sequence of interbedded clay and fine sand layers from approximately 105 to 127 feet bgs, and fine sand from 127 to 142 feet. A boring advanced several hundred feet east of the Site (SWB-9; Shannon & Wilson 2000) indicated that the clay is in excess of 40 feet thick at that location.

3.1.5 Site Groundwater Hydrology

Three aquifers have been identified beneath the Site and are described as the Shallow Aquifer, Deep Aquifer, and Artesian Aquifer. The groundwater flow system within the Shallow and Deep Aquifers is the primary focus of the RI/FS for the Quendall Site. The Shallow Aquifer occurs in the fill material and peat, silt, and sand deposits (Shallow Alluvium) from near ground surface to approximately 35 feet bgs. The Deep Aquifer occurs within the coarser alluvium (Deeper Alluvium) from approximately 35 to 140 feet bgs. The water table is typically encountered at depths of 6 to 8 feet in the Shallow Aquifer. Although the discontinuous lower-permeability silts, sandy silts, and peat layers of the Shallow Aquifer provide varying degrees of hydraulic separation between the Shallow and Deep Aquifers, there is no continuous aquitard between the two aquifers.

The presence of flowing conditions in the former plant water supply well located at the Site indicates a deeper confined aquifer, which for the purposes of the RI/FS is referred to as the Artesian Aquifer. The plant well was recently located in a field survey and is located north of boring BH-30C. Based on field observations, the well is constructed of 2-inch-diameter steel well casing. According to a former plant manager, the well is 180 feet deep (Hart Crowser 1994). The well exhibited flowing artesian pressures when the well cap was removed. Aside from the former plant well, no other wells are known to have been installed in this aquifer.

3.1.5.1 Seasonal Variability

Historical water level measurements collected from Site groundwater monitoring wells are summarized in Table 3.1-1. Measurements made in the 1995-1996 season were the most

complete for evaluating the seasonal variability in groundwater flow across the Site. In 1995-1996, Hart Crowser measured water levels bimonthly in on-Site monitoring wells, the Quendall Pond, the South Detention Pond, and Lake Washington. The elevation of Lake Washington is controlled by the U.S. Army Corps of Engineers (USACE) at the Hiram M. Chittenden Locks. The lake is at its maximum elevation of 18.7 feet (NAVD88) in June and early July and its minimum elevation of 16.7 feet in December, January, and early February. Water level data collected in years before and since the 1995-1996 monitoring program show little variation in seasonal groundwater patterns or minimum/maximum Site groundwater elevations.

Water level measurements were collected periodically in 2004-2005 in the vicinity of Quendall Pond. Measurements were collected from wells BH-5, BH-5A, BH-19A/B, BH-21A, RW-QP-1, and RW-NS-1, including the stage height of the pond. Transducers were deployed in well BH-5A and Quendall Pond. Water level measurements are provided in Table 3.1-1, and transducer data are included in Appendix C (which contains various field data referenced here and in other sections of the RI Report). This information was used to determine the local groundwater/surface water interaction. The conclusion was that the pond was connected to a seasonally perched groundwater unit observed at well BH-5A that, when filled during the winter months, resulted in seeps through the west bank of Quendall Pond to Lake Washington.

In June 2007, November 2008, and September 2009, water level measurements were collected from all available Site monitoring wells. September 2009 measurements were coordinated with water level measurements on the Conner Homes property to the south of the Site (Aspect 2010).

3.1.5.2 Vertical Gradients

During 1995-1996, water level measurements were collected from six shallow/deep Site well pairs. The shallow/deep well pairs were completed at depths that ranged from 20 to 41 feet apart. A consistent downward gradient ranging between -0.01 and -0.12 feet per foot (ft/ft) was recorded in well pairs located towards the center of the Site and eastward (BH-17A/B, BH-26A/B, and BH-25A/B). The highest downward gradients were typically observed during the winter months when recharge is greatest. Wells that were completed near the

shoreline (BH-18A/B, BH-20A/B, and BH-21A/B) exhibited consistently upward gradients ranging between 0.01 and 0.05 ft/ft, with the exception of BH-18A/B. The highest upward gradients in nearshore wells are typically observed in the fall, when recharge is low and the lake level is dropping. However, in the winter months at BH-18A/B, a downward gradient of up to -0.02 ft/ft has been recorded. This area of the Site, located at the edge of a wetland area, likely receives more recharge, and this well pair is also located farther from the shoreline relative to the other nearshore wells.

3.1.5.3 Hydraulic Conductivity Estimates

Hydraulic conductivities of the Shallow and Deep Aquifers and Lake Washington sediment were characterized in previous studies (Woodward Clyde 1992; Hart Crowser 1997; Anchor and Aspect 2004). Table 3.1-2 presents a compilation of estimates of hydraulic conductivity derived from aquifer testing (i.e., pumping or slug tests), grain size analysis, and sediment vertical permeability measurements using a piezo-seep meter. Pumping test, slug test, and grain size data were used to estimate hydraulic conductivities for the Shallow and the Deep Aquifers. Specific parameters used to characterize each of the aquifers are presented in Sections 3.1.5.4 and 3.1.5.5.

3.1.5.4 Shallow Aquifer

Water level data for the Shallow Aquifer are shown as groundwater elevation contours on Figures 3.1-12 and 3.1-13. These figures represent the seasonal hydraulic gradients observed in the Shallow Aquifer during September 2009 and November 2008, respectively. They illustrate the consistent flow of groundwater in the Shallow Aquifer to the west toward Lake Washington.

A horizontal hydraulic gradient of 0.005 ft/ft was measured in September 2009, when Lake Washington was near its maximum water level and groundwater elevations were on a decline. During the wetter month of November 2008, an average horizontal hydraulic gradient of 0.005 ft/ft was observed Site-wide; however, the gradient steepened to 0.01 ft/ft as groundwater neared discharge to Lake Washington. Higher gradients occur when Lake Washington water levels are at their minimum and Site groundwater levels are rising due to higher precipitation recharge to the shallow groundwater system.

Hydraulic conductivity data indicate at least a two-order-of-magnitude range in Shallow Aquifer materials from $1x10^{-2}$ to $1x10^{-4}$ centimeters/second (cm/s). Due to the highly interbedded nature of the Shallow Alluvium, the Shallow Aquifer is assumed to be highly anisotropic with respect to hydraulic conductivity, indicating that preferential groundwater flow pathways are near horizontal and impeding vertical movement of groundwater. The anisotropy value for this type of aquifer is typically greater than 100:1 horizontal to vertical conductivity (Freeze and Cherry 1979).

3.1.5.5 Deep Aquifer

Groundwater in the Deep Aquifer flows toward Lake Washington, as demonstrated by the measured water levels (Table 3.1-1). Water level data for the Deep Aquifer are shown as groundwater elevation contours on Figures 3.1-14 and 3.1-15. During the 1995-1996 season, flow gradients toward the lake ranged from 0.005 ft/ft (August 1995) to 0.04 ft/ft (December 1995). Like the Shallow Aquifer, water level data indicate that the Deep Aquifer is equally affected by lake levels and recharge with the maximum, wet-season gradient being more than double the minimum, dry-season gradient. More recent measurements show horizontal gradients of 0.003 ft/ft and 0.002 ft/ft for November 2008 and September 2009, respectively.[5]

The available hydraulic conductivity measurement for the Deep Aquifer is $2x10^{-2}$ cm/sec at well BH-18B. This measurement is consistent with literature values for sand and gravel (Freeze and Cherry 1979).

3.1.5.6 Groundwater Flow Conditions

Groundwater flow conditions at the Site were evaluated using groundwater hydraulic models. Several different models have been developed depicting the Site conceptual

[5] Note that the ability to develop groundwater elevation contours for November 2008 for the Deep Aquifer is limited because the deep wells existing at that time were primarily located close to the shoreline. A more comprehensive Site-wide characterization of Deep Aquifer elevation contours was performed in 1995 and 1996, as referenced in the text here. Some of the Deep Aquifer wells used to develop contour maps for the 1995-1996 season were damaged and have not been replaced. The 2009 map is more complete because four Deep Aquifer wells were installed for the 2009 RI field investigation.

groundwater flow regime. Hart Crowser (1997) initially used FLONET to conceptualize groundwater flowpaths across the Site, while Retec (1998) developed a groundwater flow model using Visual MODFLOW. In support of this RI/FS, a similar numerical groundwater flow model was developed using MODFLOW, incorporating the most recently collected stratigraphic and hydraulic data. A description of the construction, calibration, and results of this model is provided in Appendix D.

Based on this most recent modeling, Figures 3.1-16 and 3.1-17 show the pathways of Site groundwater flow. Groundwater flow between the Shallow and Deep Aquifers is influenced by the vertical gradients observed at the Site. As discussed in Section 3.1.5.2, vertical gradients are downward in the eastern portion of the Site, resulting in downward flow into the Deep Aquifer and transition to upward flow near the shoreline, resulting in discharge to Lake Washington. Groundwater enters the Site as underflow from the east and from infiltration of on-Site precipitation. As shown by the flow lines on Figures 3.1-16 and 3.1-17, groundwater moves through the Site from east to west. Through the anisotropic Shallow Aquifer, groundwater generally moves laterally to the west with a downward component in the eastern portion of the Site; primarily horizontally through the central Site area; and then upward at the shoreline before discharging to Lake Washington. Groundwater flow in the Deep Aquifer is predominantly horizontal until it nears Lake Washington, where flowpaths bend upward consistent with discharge into the lake.

3.1.5.7 Groundwater Discharge to Lake Washington

Groundwater in the Shallow and Deep Aquifers discharges into Lake Washington. The discharge rate of groundwater to Lake Washington through nearshore lake sediment has been estimated in several studies through a combination of empirical measurement and modeling. Results of these studies are summarized in Table 3.1-3.
Field studies have included the following:

- Aspect 2003. Seepage rates were estimated by measuring the vertical gradients through shallow sediment (upper 12 to 60 inches) and by the vertical hydraulic conductivity of shallow sediment (upper 12 inches) using a piezo-seep meter (summarized in Section 3.1.5.3 and discussed in Appendix F of the Draft RA/FS, Anchor and Aspect 2004). Estimated Darcy velocities (i.e., one-dimensional flux) ranged from 0.1 to 12 cm/day.

- EPA 2009. Seepage rates were estimated by deploying bucket-and-bag seepage meters at several locations in April and May 2009. Methods and results were documented in field reports (EPA 2009b and 2009c). Estimated Darcy velocities ranged from 0.05 to 3 cm/day.

The geometric mean of all field-estimated seepage rates measured at the Site is 0.83 cm/day. It should be noted that significant variation was noted in the field measurements, even between seepage meters collected at the same location on consecutive days (EPA 2009c). Field measurements of groundwater seepage, particularly in horizontally stratified deposits observed beneath the Site lakebed sediment, are prone to a high degree of variability. Although the stratified deposits beneath the lakebed include high-permeability sand lenses, vertical flow velocities are limited by the lower-permeability silt and peat layers that comprise the stratified delta deposit. Due to the limited depth of the seepage meter embedment, the higher end of the observed vertical flow velocities are generally not representative of flow rates across the entire stratified deposit.

For this RI, the groundwater hydraulic model described above and in Appendix D was used to estimate seepage rate through the sediment from 40 to 240 feet offshore along three transects. The model-predicted seepage rate varied across the sediment bed due to differences in the offshore thickness of the Shallow Alluvium (based on sediment core logs) and changes in the model-predicted gradient moving offshore. The arithmetic mean of seepage rates as Darcy flux was calculated to be 0.44 cm/day, with a standard deviation of ±0.13 cm/day.[6]

The hydraulic model does not account for local variations in the composition of the Shallow Alluvium. To estimate the variability that might result from local stratigraphic differences, the nearshore sediment core logs (NS-01 through NS-15, provided in Appendix E) were reviewed and the percentage of layers that primarily contained low-permeability materials (e.g., silt or peat) was calculated. The average percent thickness of low-permeability materials was calculated to be 47 percent, with a standard deviation of ±25 percent (see Table 3.1-4). Incorporating this variability into the estimated flux, the model-estimated

[6] An arithmetic mean was used because the range of model-calculated seepage rates was normally distributed. A geometric mean was used for field-measured seepage rates because these had wider variability.

seepage rate is therefore approximately 0.44 cm/day with a standard error of ±0.27 cm/day (160 ± 97 cm/year). These statistical parameters (i.e., mean ± 1 standard error) were used as input to the sediment porewater fate and transport modeling. Specifically, these Darcy velocity (flux) values will be used as input to the sediment porewater fate and transport model, briefly introduced in Section 6.4.3, that will be discussed and documented in the FS Report for the Quendall Site.

3.1.6 Bathymetry and Sediment Characteristics

Prior to the RI, as discussed in Section 3.1.1 and depicted on Figure 3.1-1b, topographic and bathymetric survey data were available for the years 1975 and 1997. Overall, Site bathymetry has been similar through the 22-year time span, and minor changes in mudline elevation that may have occurred over this period are likely the result of natural sediment transport processes. Surface sediment conditions were characterized in 1996 using sediment profile imaging (SPI), video transect surveys for determination of surface wood debris, side-scan sonar surveys to map large debris, beach surveys, and surface sediment grab sampling (Retec 1997b). Follow-on diver-operated video transect surveys were performed by EPA in 2009 and revealed similar distributions of submerged wood debris at the Site.

The primary bathymetric feature in the nearshore is the sand spit to the north of the former T-Dock. The lake bottom is relatively flat between the inner and outer harbor lines, with water depths at the outer harbor line ranging from 26 to 31 feet (as measured at normal high water line). The maximum water depth between the Site and Mercer Island is approximately 70 feet (Retec 1997b).

The lake bottom substrate is typically a fine silt/mud, although several areas with a sandier bottom were evident, including the Quendall Site sand spit and sediment near the outer harbor line south of the former T-Dock. With the exception of a wood debris area along the southern shoreline, aquatic vegetation is dominated by dense areas of Eurasian watermilfoil.

3.1.7 Geotechnical Characteristics

Site geotechnical studies have been conducted by Twelker (1973), CH2M HILL (1978), Hart Crowser (1997), and Shannon & Wilson (1997). In 2009, Aspect completed a preliminary geotechnical study compiling data from these previous studies and other geotechnical data

available for the Quendall Site (Aspect 2009b). A summary of the Aspect's geotechnical findings is provided below and selected geotechnical data are provided in Appendix F. For further details, refer to the reports referenced above.

In general, soils from 0 feet to approximately 25 feet deep (Fill and Shallow Alluvium) are relatively weak, with variable compressibility and permeability characteristics. Soils from approximately 25 feet to 135 feet (Lower Alluvium deposits) are moderately strong with low compressibility and high permeability. Below 120 feet, soils consist of lacustrine deposits with moderate strength, low to moderate compressibility, and low permeability and are presumed to overlie other glacial deposits and bedrock.

The near-surface soils (Fill and Shallow Alluvium) are considered to be compressible and weak; therefore, deep foundations (piles) would be required to support the buildings and any other heavily loaded and/or settlement-sensitive structures. Seismic hazards to consider for Site development include surface fault rupture due to the Site's proximity to the Seattle Fault Zone, amplification of strong shaking as a result of the soft soil profile, and liquefaction of the relatively weak granular soils beneath the Site. The Site is located in a moderately active seismic zone. The subsurface soils beneath the Site exhibit susceptibility to liquefaction to a depth of about 80 feet.

3.2 Natural Resources

This section briefly summarizes natural resources at the Site and adjacent areas and their management. More detailed information on natural resources is provided in the baseline human health and ecological risk assessments (Section 7) as it applies to the selection of receptors of concern.

3.2.1 Upland and Aquatic Habitat

The upland area is characterized by log handling and storage uses that have resulted in large deposits of wood debris covering access roads and storage areas. The Site vegetation consists primarily of early successional species and invasive species including large stands of Himalayan blackberry and Scot's broom. Site wetlands were most recently surveyed in 2009, including assessments of water quality, hydrologic, and habitat functional values (Anchor QEA 2009). Five current Site wetlands were previously constructed as depressions to control

spills and stormwater flows, and more recently to avoid disruption to log storage operations that have since ceased. Historical construction of each of these features influences the regulatory status of these wetlands as determined by municipal, state, and/or federal regulations. More detailed discussions of wetland delineation, lake ordinary high water mark (OHWM) delineation, and habitat assessments at the Site are provided in Anchor QEA (2009).

The shoreline can be divided into three sections. The northern area, including the sand spit, is low and sloping with upland vegetation, a sandy beach, and a marshy area behind the sand beach. The middle section is characterized by beaches with wood and other debris and shoreline with brush and small trees. The southern end of the property is partially bulkheaded and armored with riprap. There is no vegetation on the southern uplands because of the log handling activities. Beach and nearshore restoration was completed south of the Site (i.e., on aquatic lands adjacent to the Conner Homes property) in 2005, in accordance with federal, state, and local permits and a WDNR Right of Entry.

3.2.2 Riparian and Submerged Plants

Riparian vegetation is generally present across the Site shoreline, with the exception of the southern log handling area. Aquatic vegetation is mostly dense beds of Eurasian watermilfoil, which has choked out the majority of native plant growth (King County Department of Natural Resources and Parks [DNRP] 2003).

3.2.3 Benthic Organisms

Benthic invertebrates have been described for Lake Washington near the Site by EVS (1990) and identified and enumerated in surface sediment samples by Ecology (1991 and 1992). Chironomids constitute the majority of the benthic abundance and biomass. Other prevalent taxa include oligochaetes, bivalves, porifera, amphipods, and copepods.

3.2.4 Phytoplankton and Zooplankton

Phytoplankton populations are relatively uniform throughout Lake Washington. Dominant species vary seasonally. In winter and spring, the phytoplankton community is dominated by diatoms. In June, in response to nutrient depletion, diatom populations decline and

gelatinous green or blue-green algae dominate (EVS 1990). Zooplankton populations are distributed in random patches, with a relative constant composition of crustaceans and rotifers, dominated by *Daphnia* species (EVS 1990).

3.2.5 Fish

Based on a review of Lake Washington fish species information (EVS 1990; King County DNRP 2003; Washington Department of Fish and Wildlife [WDFW] 2009; Washington State Department of Health [DOH] 2004; and Wydoski and Whitney 2003), resident and migratory species were inventoried and are described here.

The fish community in Lake Washington is dominated by cutthroat trout (*Oncorhynchus clarki*), northern pikeminnow (*Ptychocheilus oregonensis*), yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieui*), and sockeye salmon (*O. nerka*). Other fish species include rainbow trout, steelhead (*O. mykiss*), coho and Chinook salmon (*O. tshawytscha*), lamprey, sculpin, carp, bull trout (*Salvelinus confluentus*), and threespine stickleback (*Gasterosteus aculeatus*). Longfin smelt (*Spirinchus thaleichthys*) are known to spawn in May Creek. The area of the lake adjacent to the Quendall Site is considered prime habitat for the rearing of juvenile salmonid stocks, including Chinook salmon, which are listed as threatened under the Endangered Species Act (ESA; see below).

The mouth of May Creek was historically relocated from its original delta position. Due to upstream development, the creek experiences elevated peak flows along with relatively large sediment loads that are detrimental to fish and wildlife habitat.

Additional information on fish species is provided in Appendix B of the Draft Task 3 Report (Anchor and Aspect 2007b).

3.2.6 Wildlife

Mammals observed in the Quendall Site vicinity include occasional coyotes (*Canis larans*) and red fox (*Vulpes vulpes*), deer, raccoons, skunks, river otters, beaver, weasels, opossums, and rodents including rabbits, squirrels, shrews, mice, voles, and bats.

Birds found at the Site may include seabirds such as great blue heron (*Ardea herodias*), common merganser (*Mergus merganser*), mallard (*Anas platyrhynchos*), spotted sandpiper (*Actitis macularius*), and osprey (*Pandion haliaetus*); bald eagle (*Haliaeetus leucocephalus*); and upland birds such as wrens, crows, woodpeckers, robins, sparrows, and finches.

Amphibians potentially using the Site include several salamander species, including the Pacific giant salamander (*Dicamptodon tenebrosus*), and several frog species, including the Oregon spotted frog (*Rana pretiosa*) and non-native bullfrogs. Reptiles include newts, lizards, turtles, and common garter snakes.

Additional information on wildlife species is provided in Appendix B of the Draft Task 3 Report (Anchor and Aspect 2007b).

3.2.7 Threatened and Endangered Species

Federal ESA-listed species that use the Quendall Site include:

- Chinook salmon
- Steelhead
- Bull trout

Juveniles of all three species may use the nearshore for rearing; however, steelhead are more likely to remain in their natal streams until they migrate directly to Puget Sound.

3.2.8 Resource Management

This section provides a discussion of water resource, Tribal and recreational fishery, and shoreline management. The Lake Washington fishery is co-managed by WDFW and the Muckleshoot, Suquamish, and Tulalip Tribes. Lake Washington is a Usual and Accustomed (U&A) fishing ground for these Tribes. Recreational fishing (catch and release) also occurs offshore from the Quendall Site.

The Hiram M. Chittenden Locks regulate water levels in the lake and are managed by USACE. King County DNRP administers the Shoreline Management Program for Water Resources Inventory Area (WRIA) 8. On behalf of the State of Washington, WDNR manages the aquatic land below the OHWM.

The Lake Washington/Cedar/Sammamish watershed is managed by the WRIA 8 Steering Committee, which consists of delegates from city governments (including the City of Renton and others), county governments (including King County), state and federal agencies, sewer, water, and conservation districts, and private entities, foundations, and councils.

3.3 Surrounding Land Use Characteristics

This section provides a discussion of surrounding land and drinking water uses.

3.3.1 Surrounding Land Uses

The Site and surrounding properties are zoned Commercial/Office/Residential. To the east, the property is bordered by the Burlington Northern Railroad right-of-way, which in turn is bordered on the east by Ripley Lane and Lake Washington Boulevard North. Adjacent to the south is the Conner Homes property, which is currently being developed for residential townhomes. The Football Northwest property to the north has been developed for office and recreational field use. Extensive environmental investigations have been performed on both the Conner Homes and Football Northwest properties. Soil, groundwater, and sediment cleanup actions were completed on these properties prior to recent redevelopment, as described below.

3.3.1.1 Conner Homes Property

The Conner Homes property was formerly operated as a lumber mill by Barbee Mill Marine Yards from 1943 to 1945, and by Barbee Mill Co., Inc. from 1945 to 2001 (Hart Crowser 2000). Environmental investigations indicated the presence of arsenic in soil and groundwater in the northern portion of the property where an experimental arsenic solution was used to treat wood in the late 1940s. Localized occurrences of PCP, which was used in small quantities in a spray for sap stain control prior to 1978, and petroleum hydrocarbons used to run mill equipment, were identified in the central portion (mill area) of the property.

The Conner Homes property is being addressed under an Ecology Agreed Order through a combination of soil source removal, groundwater treatment, and monitoring. Specific activities have included the following (Aspect 2006):

- Removal of soil containing PCP and total petroleum hydrocarbons (TPH) above MTCA (Chapter 173-340 WAC) unrestricted use cleanup levels.
- Removal of soil in the upper 15 feet containing arsenic above MTCA unrestricted use cleanup levels.
- Installation of a passive attenuation zone (PAZ) along the downgradient property boundary to intercept and remove arsenic from groundwater migrating towards Lake Washington above the MTCA cleanup level.
- Installation of a groundwater extraction and treatment system to remove the highest concentrations of arsenic-impacted groundwater upgradient of the PAZ.
- Placement of institutional controls on the property, including deed restrictions preventing groundwater withdrawal or disturbance of the PAZ.
- Monitoring arsenic concentrations in groundwater and sediment porewater upgradient and downgradient of the PAZ, including wellpoints in the southwestern corner of the Quendall Site.

The areas addressed by the cleanup action, the locations of existing compliance monitoring and extraction wells, and the arsenic concentrations measured at these wells in September 2009 are shown on Figure 3.3-1.

3.3.1.2 Football Northwest Property

The Football Northwest property was formerly owned by J.H. Baxter & Company, which operated a wood treatment plant from 1955 to 1981. Wood was treated using either creosote or PCP dissolved in an aromatic oil. Following several environmental investigations, PCP and PAHs were identified as chemicals of concern (COCs) in soil, groundwater, and sediment. Dioxins/furans were also identified as a chemical of concern, but because dioxin/furan occurrences were co-located with PCP, the indicator hazardous substance PCP was used as a surrogate for evaluating and addressing dioxin contamination (Retec 2000). During an RI conducted at the property (Woodward Clyde 1997), eight surface soil samples with the highest concentrations of PCP were submitted for dioxin analysis. Only dioxin congeners with six to eight chlorine substituents were detected, consistent with the components of commercial-grade PCP. Dioxin and furan congeners were detected at concentrations ranging from 0.033 to 2,770 micrograms per kilogram (µg/kg) in the eight samples.

A MTCA cleanup action that combined removal and containment technologies was completed at the Football Northwest property and included the following:

- Removal of DNAPL from one well.
- Focused removal of shallow hotspot soil containing light non-aqueous phase liquid (LNAPL).
- Focused removal of shallow hotspot sediment in Baxter Cove.
- In-situ stabilization of NAPL-impacted soil near the shoreline.
- Placement of a cap on upland soil across the property.
- Implementation of institutional controls to address contamination left in place, including prevention of groundwater withdrawal, groundwater compliance monitoring, and operations and maintenance requirements for the soil cap.

Areas addressed by the cleanup action and the locations of existing compliance monitoring wells are shown on Figure 3.3-2.

3.3.2 Drinking Water Use

Site facilities and all surrounding properties are served by City of Renton and Coal Creek Water District municipal water lines, which will continue to be used in the future. Coal Creek Water District is supplied with water from the City of Seattle system, which uses surface water from the Cedar River watershed. The City of Renton system is supplied by groundwater from wells located approximately 4 miles southeast of the Quendall Site, in downtown Renton. To protect its groundwater supply, the City of Renton has established an aquifer protection zone (Renton Municipal Code 4-3-050). The Site is located outside this zone (Figure 3.3-3).

A search of well records and water right certificates and permits was conducted to identify any possible water supply uses within a half mile of the Site, from either a groundwater source or Lake Washington. Table 3.3-1 provides well construction information available for water wells listed in the Ecology Well Logs database (shown on Figure 3.3-3). These wells are completed in aquifers upgradient the Site and cannot be impacted by Site contamination. A search of the Water Rights Tracking System identified two certificates for Lake Washington and no groundwater certificates or permits. The certificates for Lake

Washington were for the J.H. Baxter & Company to the north and Bellevue Sewer District for industrial sanitation use.

Lake Washington is no longer available for consumptive appropriation because it was closed in 1979 to further withdrawals under Chapter 173-508 WAC. It is highly unlikely that Lake Washington water will be used as drinking water in the future because of this closure. Furthermore, any use of the surface water would require some form of treatment for bacterial purification prior to use for drinking purposes. While Lake Washington is classified as a Suitable Source of Water Supply under Chapter 173-201A WAC, it is not currently used as such and is highly unlikely to be used as such in the future. Nevertheless, it is considered a potable water source and therefore subject to drinking water ARARs, including MCLs.

The surrounding community is serviced by public water systems, which have sources outside the Site area. The use of private wells in the area is limited and those wells are located upgradient of the Site. In accordance with the King County Comprehensive Plan, individual private water supply wells will not be permitted within municipal water supply service area boundaries, which include the Quendall Site.

4 NATURE AND EXTENT OF NAPL

The primary chemicals that have been processed or produced at the Quendall Site are coal tar, coal tar distillates (primarily creosote), and to a lesser degree petroleum hydrocarbons. These chemicals were generally in the form of NAPL. The occurrence of heavier distillate products and fuels that are solids at ambient conditions (e.g., pitch and coke) is discussed in Section 5.3.1.1.

NAPL released to the subsurface represents an ongoing source of contaminants to Site soil, groundwater, and sediment. This section describes the following:

- Sources of NAPL at the Site, including areas where NAPL was used, stored, and disposed of (Section 4.1).
- Properties of NAPL at the Site, including physical and chemical properties (density, viscosity, and composition) (Section 4.2).
- Characteristics by which NAPL is identified in Site explorations (Section 4.3).
- The occurrence of NAPL in the subsurface, including its lateral and vertical extent, its thickness and distribution, and the estimated volume of NAPL and NAPL-containing soil and sediment (Section 4.4). NAPL occurrences at the Site are discussed by Site area, with five general areas identified based on geography, particular operations, and potential sources. These NAPL source areas are the following:
  - Former May Creek Channel Area
  - Still House Area
  - Railroad Loading Area
  - Quendall Pond/North Sump Area
  - T-Dock Area

Mobility characteristics of NAPL in the subsurface are discussed as part of contaminant fate and transport mechanisms in Section 6.1.

4.1 NAPL Sources

NAPL is generally classified as light NAPL (LNAPL) if the density is less than that of water (i.e., it will float on water) or as dense NAPL (DNAPL) if the density is greater than that of

water (i.e., it will sink in water). Historical processes that stored, processed, or manufactured NAPL at the Quendall Site are described in Section 2.2. Areas of the Site that are potential sources of LNAPL and DNAPL are summarized in Sections 4.1.1 and 4.1.2, respectively. Section 4.1.3 provides further discussion of the distinction between LNAPL and DNAPL with specific reference to the Quendall Site.

4.1.1 Potential LNAPL Source Areas

LNAPL products associated with the Site include petroleum hydrocarbons and light-end distillates (e.g., BTEX) of coal tar. Processes and areas of the Site where LNAPL products were used include the following:

- **Petroleum Hydrocarbons:** Boiler house, Pier Dock (fuel oil), and ASTs used to store heating oil, diesel, waste oil, and Bunker C oil.
- **Light-end Distillates:** Still House, ASTs, railroad loading racks, north and south sumps, and former May Creek Channel.

These historical features are highlighted on Figure 4.1-1. Historical releases of LNAPL products have been reported. In historical interviews, Don Norman, Quendall Site manager in the 1970s, reported spills of petroleum around the central Site ASTs. In 1972, an Ecology site inspector described product that was displaced from the north sump when it was filled in; this product was intercepted at Quendall Pond, with the inspector noting light-end distillates "percolating through to the shallows" (Ecology 1972).

4.1.2 Potential DNAPL Source Areas

DNAPL products associated with the Site include coal tar and creosote. Potential source areas of coal tar and creosote include the following:

- **Coal Tar:** T-Dock, Tanks 23 and 26, Still House, piping between these areas, and potential liquid waste disposal areas (sumps, the area northwest of the ASTs, and the former May Creek Channel).
- **Creosote:** Other ASTs, Still House, piping, potential liquid disposal areas, and railroad loading racks.

These historical features are highlighted on Figure 4.1-2. Operator interviews and agency records document releases in all these areas, as discussed in Section 2.5 of the Draft Task 3 Report (Anchor and Aspect 2007b). Releases of wastes from the north sump area reportedly migrated west and northwest towards Lake Washington (via the Quendall Pond Area). One of these releases—which occurred when the north sump was filled in after the plant closed—was intercepted by creating Quendall Pond (Metro 1972).

4.1.3 Distinguishing Between LNAPL and DNAPL

Both LNAPL and DNAPL products can result in observations of sheens, stains, and strong odors during field screening. Characteristics that distinguish between LNAPL and DNAPL include the following:

- Evidence of NAPL at depths below the seasonal low water table generally indicates DNAPL because LNAPL floats and would stay at or above the water table.
- NAPL accumulation on top of the water table in a well (floating product) indicates LNAPL, while NAPL accumulating at the base of a well (sinking product) indicates DNAPL.
- If the chemical composition of soil contamination or NAPL is predominantly PAHs, then this typically indicates coal tar or creosote DNAPL. If the chemical composition is predominantly lighter hydrocarbons (e.g., BTEX) or the chromatogram is indicative of a petroleum hydrocarbon mixture, then this would suggest LNAPL.

Site investigations have not indicated the presence of free-phase LNAPL at the Quendall Site. Soil samples in the vicinity of the former ASTs were analyzed for petroleum hydrocarbons. Hydrocarbons were detected in several samples; however, the chromatograms were not consistent with a petroleum product and did not contain the aliphatic hydrocarbons that would indicate the presence of petroleum products (Hart Crowser 1997). The chemical composition of NAPL and NAPL-containing soil samples (discussed in Section 4.2) is primarily aromatic hydrocarbons, with a high proportion of PAHs to BTEX, and is consistent with coal tar and creosote DNAPL. Floating product has not been observed in Site monitoring wells, 14 of which are or were screened across the water table. Six of these wells (BH-5A, BH-6, BH-8, BH-20A, BH-25A, and BH-28A; see Figure 2.3-1) were screened across

the water table and were installed in and at the perimeter of the area of former tanks used to store petroleum products.

DNAPL has been observed in numerous explorations throughout the area extending east to west from the railroad to the shoreline, and north to south from the north sump to the former May Creek Channel. Offshore occurrences of DNAPL have been observed in sediment cores immediately west of Quendall Pond and along the T-Dock alignment. Further discussion of DNAPL occurrences in each Site area is provided in Section 4.4.

4.2 Physical and Chemical Properties of Site DNAPL

A total of five DNAPL samples have been collected from Site monitoring wells. Two samples were collected in 1996 (from BH-5 and BH-21A) and three samples were collected in 2003 (from BH-21A, RW-NS-1, and RW-QP-1). An additional five samples of DNAPL-containing soil (two from MC-1, and one each from MC-23, BH-30, and QP-1) and two tar samples (from trench T-7) were collected during the 2009 RI field investigation. The samples were analyzed for various physical and chemical properties, as presented in Table 4.2-1 and summarized below. The sample locations are shown on Figure 2.3-1.

4.2.1 Physical Properties

DNAPL samples from four Site wells (BH-5, BH-21A, RW-NS-1, and RW-QP-1) were analyzed for specific gravity, viscosity, and flash point. The specific gravity ranged between 1.04 and 1.09. Specific gravities of coal tar and creosote vary based on their composition and source, but are typically in the following ranges (Cohen and Mercer 1993, Table 3-1):

- Coal Tar: 1.01 to 1.18
- Creosote: typically 1.01 to 1.05, but may range up to 1.14

For DNAPL viscosity, analytical results measured in the laboratory were adjusted to the Site subsurface temperature (55 degrees Fahrenheit) using the viscosity-temperature correlation; adjusted results ranged between approximately 8 and 24 centistokes (Table 4.2-1). The viscosity of coal tar and creosote is typically in the range of 10 to 70 centipoise (cp) (Cohen and Mercer 1993, Table 3-1) or approximately 9 to 66 centistokes at an average specific

gravity of 1.06.[7] For comparison, the Site viscosity range is similar to that of diesel petroleum and is greater than the viscosity of water (1 cp). In general, the lower the viscosity of a liquid, the more mobile it is in the subsurface. High-viscosity liquids such as coal tar and creosote may only be mobile in permeable soil (e.g., sands or gravels). Very-high-viscosity liquids, such as the viscous tar that was observed in trench T-7 during the 2009 RI field investigation, may not be mobile in soil at all and may only flow when the soil is removed (i.e., along the wall of the test pit exploration). A photograph of very-high-viscosity tar at trench T-7 is shown on Figure 4.2-1.[8] For the purposes of this RI, very-high-viscosity liquids that do not flow through soil are not discussed as DNAPL in this section, but are described with solid tar products in Section 5.3.1.

Flash points were also measured in the 2003 DNAPL samples. Samples from wells BH-21A and RW-NS-1 were above 200 degrees Centigrade; the sample from RW-QP-1 had a flash point of 112 degrees Centigrade, which is consistent with higher concentrations of petroleum hydrocarbons (discussed below).

4.2.2 Chemical Composition

DNAPL samples from the same four Site wells were analyzed for TPH, BTEX, and SVOCs including PAHs and carbazole. The results are presented in Table 4.2-1 and are consistent with typical markers for coal tar and creosote (see Table 2.1-1), including:

- High concentrations of PAHs, including naphthalene composition ranging from 52,000 to 180,000 mg/kg (5.2 to 18 percent).
- The presence of carbazole, a heterocyclic compound, at concentrations ranging from 1,100 to 3,600 mg/kg (0.11 to 0.36 percent).
- The presence of light aromatics (total BTEX) at concentrations between 1,500 and 67,000 mg/kg (0.15 and 6.7 percent).

The typical chemical compositions of coal tar and creosote are summarized in Table 2.1-1. The compositions of coal tar and creosote vary with the source from which they are derived.

[7] Kinematic viscosity (reported in centistokes) and dynamic viscosity (reported in centipoise) are comparable when the specific gravity of the DNAPL is close to 1 (as it is at the Quendall Site).
[8] Samples from trench T-7 were not analyzed for physical properties, but were analyzed for chemical properties as discussed in Section 4.3.2.

Generally, creosote consists of approximately 85 percent PAHs, 10 percent phenolic compounds, and 5 percent heterocyclic hydrocarbons (EPA 1995). Coal tar has a similar composition but also includes up to 5 percent light aromatic (e.g., BTEX) compounds (Cohen and Mercer 1993). The naphthalene concentration in both products typically varies between 3 and 17 percent (see Table 2.1-1). Tars used at the Site were generally oil-gas tars that contained a relatively low fraction of light aromatics, except for tars imported from the Honolulu Gas Company from 1957 to 1965, which contained a higher proportion of light aromatics (Hart Crowser 1994). In general, DNAPL that has a greater proportion of lower-molecular-weight compounds will have a lower viscosity and greater potential mobility than DNAPL that primarily contains higher-molecular-weight compounds.

The following sections discuss methods used to identify DNAPL in the subsurface (Section 4.3) and the nature and extent of DNAPL in specific areas of the Site (Section 4.4), including discussion of how the physical and chemical composition of the DNAPL varies by area.

4.3 Identification of DNAPL in the Subsurface

Field data for DNAPL span a number of years, with varying details and descriptions regarding DNAPL presence. As discussed in Section 2.5.2, a significant focus of the 2009 RI field investigation was to more precisely define the lateral and vertical extent of DNAPL at the Site.

The nature and extent of DNAPL, or the potential for DNAPL presence, have been defined using field screening (observations from soil and sediment borings), measurement of DNAPL accumulation in wells, and soil and groundwater concentrations as indicators of the potential presence of DNAPL. These methods are described in the following sections.

4.3.1 Field Screening of Soil and Sediment Samples

During the 2009 RI field investigation, soil and sediment samples were logged and inspected for sheen, odor, and the presence of DNAPL in accordance with the procedures described in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). DNAPL was characterized based on the following descriptions:

- No visible evidence – No visible evidence of oil on sample.

- Sheen – Light to heavy and colorful film on sample (or as a result of a sheen test). Sheen as described by the sheen-testing nomenclature presented in Appendix A of the Data Collection Work Plan.
- Staining – Visible brown or black staining on sample. Can be visible as mottling or in bands. Typically associated with fine-grained materials.
- Oil-Coated (OC) – Visible brown or black oil coating on sample grains. Typically associated with coarse-grained materials.
- Oil-Wetted (OW) – Visible brown or black oil wetting the sample grains. Oil appears as a liquid and is not held by the sample grains. Soil oozing petroleum typically contains approximately 2 to 3 percent petroleum.

Soil and sediment that appeared oil-coated or oil-wetted were identified as containing DNAPL. In accordance with Appendix A of the Data Collection Work Plan (Anchor QEA and Aspect 2009a), if DNAPL was not bounded by a proposed exploration, additional "step-out" explorations were performed in accordance with the step-out boring decision matrix. Soil, sediment, and DNAPL characterization and decisions regarding step-out locations and depths were made in real time in the field by the Task Manager and by EPA representatives to ensure the completeness of the RI field investigation and the attainment of project objectives. Soil and sediment collection logs for the 2009 RI field investigation are provided in the RI/FS Data Report (Anchor QEA 2010).

For prior investigations, observations of DNAPL in soil or sediment borings were reviewed and categorized based on best professional judgment. Field notes that are interpreted as evidence of DNAPL presence include observations of oil, tar, and product. A summary of field notes for boring logs and their interpretation is presented in Appendix E. DNAPL occurrences were successfully identified by visual observations because the colors of coal tar and creosote products (ranging from yellow to brown to black) are easily identifiable in the field.

4.3.2 Measurement of DNAPL Accumulation in Wells

DNAPL accumulating in wells has been measured using a liquid measurement tape or probe that distinguishes between aqueous and non-aqueous liquids, and by visual identification of separate-phase liquids in well samples. Historical measurements of DNAPL thickness in

monitoring wells are summarized in Table 4.3-1.[9] Wells with historical accumulations of DNAPL are shown on Figure 4.3-1.

4.3.3 Analytical Data for Soil and Groundwater Samples

Unless associated with the occurrence of solid tar materials, concentrations of hydrocarbons in soil greater than 10,000 milligrams per kilogram (mg/kg) generally indicate the potential presence of coal tar or creosote DNAPL. For the purposes of this RI, if soil concentrations of hydrocarbons are greater than 10,000 mg/kg, it is assumed that DNAPL is present.

The concentration of a contaminant in groundwater greater than 10 percent of its solubility suggests that DNAPL may be present at or upgradient of that location (Cohen and Mercer, 1993, Table 7-4). The concentrations of hydrocarbons in groundwater that is in contact with DNAPL depend on several factors including the solubility of the DNAPL constituents, the DNAPL surface area in contact with the groundwater, and the rate of groundwater flow in the DNAPL area. As a result, the rule-of-thumb for groundwater concentrations that are indicative of DNAPL varies, but is typically from 1 to 10 percent of a constituent's solubility. For the purposes of this RI, groundwater concentrations less than 1 percent of a constituent's solubility are deemed unlikely to represent groundwater that is in contact with DNAPL, while concentrations greater than 10 percent of a constituent's solubility are deemed to likely represent groundwater that has been in contact with DNAPL (i.e., DNAPL is likely present at or upgradient of that location). Concentrations between 1 and 10 percent of a constituent's solubility are deemed to represent groundwater that may have been near a DNAPL source. When soil or groundwater concentrations indicate the presence of DNAPL, other lines of evidence are used to determine whether DNAPL is present.

4.4 DNAPL Occurrences and Characteristics by Site Area

The following sections describe DNAPL occurrences in the upland and offshore areas of the Quendall Site. Occurrences of coal tar and creosote DNAPL have been identified in these five general Site areas:

- **The Former May Creek Channel Area**, which includes an area west of a former sewer

[9] Additional product thickness data are provided in Appendix C.

outfall where wastes from the Still House were reportedly discharged and an area south of former ASTs (Tanks 1 through 5) where tank bottoms were reportedly placed.

- **The Still House Area** where coal tar was refined into creosote.
- **The Railroad Loading Area** where creosote was loaded onto railcars, coal tar was offloaded from railcars, and spills reportedly occurred.
- **The Quendall Pond/North Sump Area** where coal tar and creosote manufacturing wastes, such as contaminated condenser effluent (see Section 2.2.3), were reportedly discharged.
- **The T-Dock Area** where coal tar was offloaded from freighters and spills reportedly occurred.

Upland areas include the Former May Creek Channel Area, the Still House and Railroad Loading Areas, and most of the Quendall Pond/North Sump Area. Offshore areas include a portion of the Quendall Pond/North Sump Area, and the T-Dock Area.

A map showing the borings where DNAPL has been observed, and the estimated maximum areal extent of DNAPL occurrences, is provided on Figure 4.4-1. Enlargements of portions of this map are provided on Figures 4.4-1a (the Former May Creek Channel Area), 4.4-1b (the Still House and Railroad Loading Areas), and 4.4-1c (the Quendall Pond/North Sump Area). Borings with observed DNAPL are shown as solid red circles, and borings with no observed DNAPL are shown as either solid or open green circles. Solid green circles indicate the boring was of sufficient quality to be used to define a boundary; open green circles were not used to define a boundary due to the age of the boring or the lack of adequate soil descriptions, or because the boring was too shallow relative to the DNAPL depth at adjacent locations.

A three-dimensional map of DNAPL occurrences was developed using GIS to aid in understanding the DNAPL architecture beneath the Site. Two-dimensional views of the map that show DNAPL occurrences—a plan view and a cross-sectional view (looking from the south)—are provided on Figures 4.4-2 and 4.4-3, respectively. The GIS map includes layers for geologic units, groundwater concentrations of indicator chemicals, and historical and current Site features that can be turned on or off as desired to visualize DNAPL relative

to Site features. The GIS map files are provided in Appendix A-2. On Figures 4.4-2 and 4.4-3, groundwater concentrations and soil layers are turned off for readability purposes.

Tables 4.4-1 and 4.4-2 list the borings where DNAPL was encountered in soil and sediment, respectively. The tables include the depths and thicknesses of DNAPL, and the depths of the borings. The cumulative thickness of DNAPL at each boring (the sum of all individual layers) is shown in Table 4.4-3. In general, DNAPL is found within several discrete soil layers or thin lenses rather than in one continuous "pool". Details of DNAPL thickness calculations are provided in Appendix G.

Plan view maps showing the cumulative DNAPL thickness and the maximum depths of DNAPL occurrences at the Site are shown on Figures 4.4-4 and 4.4-5, respectively. Cumulative DNAPL thickness has been contoured on Figure 4.4-4 and maximum depths of DNAPL occurrence are depicted using Thiessen polygons.[10] Histograms showing the number of DNAPL layers at each boring and the layer thicknesses are shown on Figure 4.4-6.

Borings not used in the DNAPL evaluation because of their age or lack of complete soil observations include the following:

- Boring B-64(M) – Notes from a geotechnical boring advanced by Metro in the early 1960s for a sewer line study (Metro 1963) did not indicate potential contamination.
- Borings advanced by Twelker in 1971 (Twelker 1973) – In these geotechnical borings, only general evidence of contamination was noted; also, they were advanced 40 years ago, only 2 years after the plant was closed in 1969.
- Wells BH-19B and BH-28B and boring RB3, installed by Retec (in 2000 and 2001) for water quality monitoring – Only two samples were collected from BH-19B (one at 10 feet bgs and the other at 45 feet bgs) and there was no logging for BH-28B or RB-3. No DNAPL observations were noted.
- Offshore wellpoints for porewater sampling (which were generally installed by driving the points into sediment without sediment logging or sampling) – No DNAPL observations were noted.

[10] Thiessen polygons are constructed as perpendicular bisectors to lines joining each measuring station with those immediately surrounding it; the bisectors form a series of polygons, each polygon containing one station; the depth of DNAPL measured at the station is assigned to the whole area covered by the enclosing polygon.

Naphthalene concentrations in soil and groundwater are another indicator that DNAPL is present and provide information on the extent of NAPL as referenced in the discussions below. Naphthalene is the predominant component of both coal tar and creosote. Site DNAPL samples indicate naphthalene concentrations ranging from 5 to 18 percent; therefore, based on the DNAPL criterion of 10,000 mg/kg, naphthalene concentrations in soil of 500 to 1,800 mg/kg or greater may indicate DNAPL presence. As a general rule-of-thumb, concentrations in groundwater exceeding roughly 1 percent of a constituent's solubility limit may indicate the presence of separate-phase product at or upgradient of the location; therefore, naphthalene concentrations less than roughly 300 micrograms per liter (µg/L) suggest a boundary of DNAPL extent.

The evaluation of DNAPL presence based on soil chemistry is an order-of-magnitude evaluation because of the variability in product saturation levels for different soil types; therefore, high analytical precision is not necessary to evaluate the potential presence or absence of DNAPL, and soil and groundwater data used in the evaluation of DNAPL extent include QA0 quality data (see Section 2.4). Refer to Sections 5.3.2.2 and 5.4 for more detailed discussions of the naphthalene results in soil and sediment, respectively. Specific naphthalene data used in DNAPL delineation are referenced in this section.

DNAPL occurrences and characteristics in each Site area are discussed below. Data pertaining to the acreage and estimated volume of DNAPL are summarized in Table 4.4-4 by Site area. Overall, DNAPL encompasses approximately 9.7 acres at the Quendall Site. As indicated in Table 4.4-4, an estimated total of 36,000 cubic yards of DNAPL-containing soil and sediment and the equivalent of 445,000 gallons of DNAPL are present in the subsurface at the Quendall Site.

4.4.1 Former May Creek Channel Area

This area, shown on Figure 4.4-1a, refers to where the former channel of May Creek was located from 1917 until sometime before 1936. It includes a former northern branch and a former southern branch on the Quendall property; however, the southern branch appears to have been filled in shortly after the lake was lowered, according to the 1918 Plant Map. At that time, May Creek was rerouted along the straighter northern branch, with a weir

installed to reduce erosion. After May Creek was diverted to the property south of the Quendall property, sometime before 1936, the former channel (northern branch) existed as a low ditch along the southern edge of facility operations.

A sewer outfall from the plant discharged into the channel approximately 450 feet east of the Lake Washington shoreline. Five ASTs (Tanks 1 through 5) were located along the north edge of the former channel. According to an early Site map, the containment berm surrounded the tanks on three sides and the creek was located on the fourth side.

The former May Creek Channel was also located on the Railroad property east of the Quendall property. A former trestle crossed the former channel in the area where tank cars were loaded and unloaded. An aerial photograph from 1961, showing the former channel depression and tank cars on the trestle, is provided on Figure 4.4-7. DNAPL occurrences in that area are discussed as part of the Railroad Loading Area (Section 4.4.3).

A description of DNAPL occurrences in the Former May Creek Channel Area is provided below.

4.4.1.1 Horizontal and Vertical Extent of DNAPL

DNAPL has been observed in three areas within the former May Creek Channel footprint and near the perimeter of the former channel (see Figure 4.4-1a), as follows:

- In the eastern portion of the Quendall property at borings BH-30C, HC-5, MC-18, MC-20, and MC-23, near former Tanks 1 through 5. These occurrences appear contiguous with occurrences on the Railroad property to the east and the Still House Area to the north.
- At and west (downstream) of the former sewer outfall in the center of the Quendall Site, at borings MC-1, MC-2, MC-13, SP-1, and HC-7.
- Near the Lake Washington shoreline in the western portion of the Site, at borings BH-21A, MC-7, MC-8, and MC-16.

DNAPL occurrences have been generally within or very close to the estimated footprint of the former channel and encompass approximately 1.5 acres. Soil borings indicate silty clay

layers to the north and south of the channel, and it is assumed that the silty clay layers prevent migration in these directions. Stratigraphic layers are sloped slightly downwards towards Lake Washington, with the elevations of DNAPL occurrences along the channel alignment consistent with this observation. Some lateral movement of DNAPL from the former channel has occurred, as noted in three borings: MC-13 and MC-2 (located approximately 50 feet north and south, respectively, of the channel at the former sewer outfall), and MC-23 (located approximately 60 feet south of the channel and 120 feet south of former ASTs). In these areas, additional borings were advanced in the 2009 RI field investigation to define the northern and southern boundaries of DNAPL occurrences as follows (no DNAPL was encountered in these borings):

- MC-11, MC-12, and MC-4 were advanced east, south, and west, respectively, of MC-2.
- MC-3 and MC-15 were advanced west and north, respectively, of MC-13 (borings BH-25A, BH-25A(R), and BH-25B were previously located east of MC-13, providing a boundary).
- MC-19, MC-22, and MC-24 were located west, southwest, and south, respectively, of MC-23 (borings Q13 and Q17 were previously located east of MC-23, providing a boundary).

No DNAPL was identified at boring MC-6, located west of the former sewer outfall between BH-21A and HC-7. Because of subsurface heterogeneity, it is possible that the two areas of DNAPL west of the former sewer outfall are contiguous and may be connected by only a small lens allowing DNAPL to migrate along a thin permeable layer. The upper 25 feet of soil at MC-6 is primarily silt and peat (excluding recently placed wood debris at the surface), which would limit the extent of migration of releases to the Former May Creek Channel Area. The DNAPL at BH-21A may also have resulted from a separate surface release.

A thin sand layer containing DNAPL (approximately 7 inches) was identified at boring MC-16, located just west (offshore) of the OHWM for Lake Washington. The boundary of DNAPL extent to the west is defined by sediment cores VS-9 and NS-03.

The maximum depth of DNAPL observed in the Former May Creek Channel Area is 34 feet, located at boring BH-30C. DNAPL was also observed at boring MC-1 at a depth of 32 feet. DNAPL occurrences at other borings in this area were at depths less than 19 feet. All occurrences, with the exception of DNAPL at BH-30C, were within the fill or Shallow Alluvium. At BH-30C, a few inches of DNAPL were observed in the Deep Alluvium, approximately 1 foot beneath the base of the Shallow Alluvium.

The greatest DNAPL thickness in this area was near the former sewer outfall at borings MC-1 and HC-7. At MC-1, a cumulative DNAPL thickness of 8.25 feet was observed, with discrete occurrences identified in four soil layers ranging from 0.5 to 5.5 feet thick (Table 4.4-1). At HC-7, 6.5 feet of DNAPL was reported as one discrete layer.

Fourteen explorations in the Former May Creek Channel Area have been advanced to depths greater than the maximum depth of observed DNAPL (34 feet), and boundary explorations during the 2009 RI field investigation were advanced to a minimum of 5 feet below DNAPL occurrences at adjacent borings. The extent of DNAPL south of the former May Creek Channel is generally defined (from west to east) by borings MC-17, RB2, RB1, HC-6, BH-15, MC-4, MC-12, MC-11, MC-21, MC-22, and MC-24. The extent of DNAPL north of the former May Creek Channel is generally defined (from west to east) by borings MC-9, BH-12, MC-5, MC-3, MC-15, and BH-25B. East of BH-25B, DNAPL occurrences north of the channel appear contiguous with DNAPL occurrences in the Still House Area (discussed in Section 4.4.2).

In addition to physical observations, the estimated lateral and vertical boundaries of DNAPL are supported by historical soil and groundwater data. Naphthalene concentrations in groundwater samples from borings RB2 and RB3, located south of this area, and from RB4 and BH-12/12A to the north, were less than 1 percent of its solubility. Chemical sampling at BH-21B at several intervals in soil below 20 feet in depth indicated naphthalene concentrations less than 0.1 mg/kg, and naphthalene concentrations in groundwater at well BH-25B were less than 3 µg/L. These concentrations are well below levels indicative of potential DNAPL occurrences.

4.4.1.2 Physical and Chemical Properties of DNAPL

Chemical data and physical testing results from product collected from well BH-21A (near the former mouth of the May Creek Channel) are summarized in Table 4.2-1. These chemical and physical properties are consistent with creosote, containing non-detect concentrations of benzene and with a viscosity of 24 cp. Also included in Table 4.2-1 are chemical data from NAPL-containing soil samples collected during the 2009 RI field investigation from four other locations in or near the former channel: one sample from BH-30C (near the eastern portion of the former channel), one sample from MC-23 (south of BH-30C), and two samples (shallow and deep) from MC-1 (near the center of the former channel and near the former sewer outfall). The composition of all these samples is consistent with creosote, including a lack of detected benzene, and naphthalene that comprises 15 to 25 percent of detected hydrocarbons. Although the DNAPL identified in the Former May Creek Channel Area has generally shown a signature of creosote, some of the DNAPL in the former channel in the eastern portion of the Site may contain some coal tar based on the elevated concentrations of benzene (up to 920 µg/L) at well BH-25A.

4.4.1.3 DNAPL Mobility

Within the Former May Creek Channel Area, mobility characteristics vary based on location because of variations in local geology, soil architecture, and product characteristics. Adjacent to the sewer outfall, DNAPL saturating a 3-foot-thick sand layer at boring HC-7 was identified as "viscous black product". During a DNAPL recoverability study conducted by Aspect in 2003 (Anchor and Aspect 2007b), boring SP-1 was advanced nearby to determine whether this product was recoverable. A 1-foot layer of DNAPL was identified at SP-1 that was similarly viscous; DNAPL did not flow from the sample core and only yielded free liquid when the recovered soil sample was squeezed. At MC-1, much of the shallow DNAPL was identified as oil-coated (i.e., below residual saturation), while two deeper layers (from 25.5 to 27 feet and 31 to 31.5 feet deep) were identified as oil-wetted (i.e., above residual saturation). A summary table of DNAPL layers identified as oil-coated or oil-wetted during the 2009 RI field investigation is provided in Table G-1 in Appendix G. A photograph of the interval of oil-wetted soil from a depth of 25.5 to 27 feet at MC-1 is shown on Figure 4.4-8, and a photograph of the interval of oil-coated soil from a depth of 18 to 18.3 feet at MC-13 is shown on Figure 4.4-9. In borings advanced in the Former May Creek Channel Area during

the RI field investigation, the majority of DNAPL observed in soil (approximately 63 percent, based on the estimated total thicknesses of oil-coated and oil-wetted soil at borings MC-1 through MC-24, as listed in Table 4.4-1, where DNAPL was observed) was characterized as oil-coated.

At well BH-21A (located 250 feet west of SP-1), 5 feet of DNAPL has been measured in the well casing. Product recovery testing by Woodward Clyde (1992) and again by Aspect from 2003 to 2005 (Anchor and Aspect 2007b) indicated that DNAPL at this well recovers relatively quickly when pumped, returning to 80 percent of original thickness with 5 hours of purging.[11] This well yielded 8 gallons of DNAPL after 2 days of pumping by Woodward Clyde. Limited pumping between 2003 and 2005 recovered 34 gallons over a 2-year period (Figure 4.4-10).

DNAPL thicknesses in BH-21A (summarized in Table 4.3-1) have remained constant since first measured in 1989, suggesting that DNAPL is stratigraphically trapped. If a pathway were available for this product to flow, DNAPL levels would have changed during the past 20 years of monitoring unless a continuing DNAPL source to this area existed. Potential sources of DNAPL were removed from the Site more than 35 years ago and borings advanced in this area during the 2009 RI field investigation did not identify a connection of the DNAPL at BH-21A with a significant, mobile DNAPL source farther east. Because no continuing DNAPL sources to this area have been identified, the data suggest the DNAPL is stratigraphically trapped.

West of BH-21A, layers of oil-wetted sand were observed at borings MC-7 and MC-8, but not at MC-16 (located west of the OHWM) where only a thin layer of oil-coated sand was observed. The thickness of DNAPL at borings moving west from BH-21A also tapers out near the shore, decreasing from 5.5 feet at BH-21A to 2 to 3 feet at MC-7 and MC-8 and 0.2 feet at MC-16. This suggests that offshore DNAPL may have less potential mobility than DNAPL farther upland.

[11] DNAPL recovery test results are provided in Appendix C.

4.4.1.4 DNAPL Volume

The volume of DNAPL-impacted soil at the Site was estimated by multiplying the average DNAPL thickness by the area of DNAPL occurrences in each Site area. The mass of DNAPL contained in the estimated volume of DNAPL-containing soil was based on the analytical data from soil samples containing DNAPL that were analyzed during the 2009 RI field investigation. These included samples from the Former May Creek Channel and Quendall Pond/North Sump Areas. The average total hydrocarbon concentration was calculated to be 34,000 mg/kg, which was then used in estimating DNAPL mass for each Site area. The mass of DNAPL was then converted into an equivalent volume of DNAPL, based on the average density of DNAPL samples measured at the Site (see Section 4.2.1). Finally, the soil volume that includes DNAPL-containing soil and soil overlying DNAPL was calculated using the maximum depth of DNAPL observed at each boring and the area of DNAPL impacts.

Key assumptions and results of the calculations are provided in Table 4.4-4. Details of the calculations are provided in Appendix G. Based on these data, an estimated 7,100 cubic yards of DNAPL-containing soil and the equivalent of 88,000 gallons of DNAPL are present in the Former May Creek Channel Area.

4.4.2 Still House Area

This area includes the Still House, where creosote was refined, and ASTs located west of the Still House. The area is shown on Figure 4.4-1 and enlarged on Figure 4.4-1b. ASTs located south of the Still House, along the edge of the former May Creek Channel, are included in the Former May Creek Channel Area discussed in Section 4.4.1. The eastern boundary of the Still House Area is the Quendall Terminals property line; DNAPL occurrences east of this line, in the Railroad Loading Area on the Railroad property, are discussed in Section 4.4.3. A description of DNAPL occurrences in the Still House Area is provided below.

4.4.2.1 Horizontal and Vertical Extent of DNAPL

DNAPL has been observed in five borings in the Still House Area (BH-8, BH-9, HC-4, QP-6, and QP-7; see Figure 4.4-1b). DNAPL layer depths and thicknesses are summarized in Table 4.4-1 (with details provided in Appendix G). DNAPL has not been identified north of the Still House, where solid products were typically handled (e.g., the pitch bays). The DNAPL

extent is bounded to the north by boring BH-27, which was advanced to a depth of 25 feet. Naphthalene was also not detected in groundwater at this location (well screened 15 to 25 feet deep, last sampled in 1996). DNAPL occurrences to the south of the Still House appear contiguous with occurrences in the Former May Creek Channel Area, as discussed above.

The western extent of DNAPL in the Still House Area is bounded by the absence of DNAPL at BH-25A/B (installed just north of the former May Creek Channel), at MC-15, BH-11, and HC-3 (adjacent to the former large coal tar storage tanks), and at BH-7 (adjacent to the former medium-sized storage tanks; see Figure 4.4-1b). These borings were advanced to depths at or below the elevations of adjacent DNAPL occurrences.

DNAPL occurrences detected in the Still House Area at BH-8/8A, to the northwest, appear to co-mingle with DNAPL from the Quendall Pond/North Sump Area (discussed in Section 4.4.4). Similarly, DNAPL occurrences to the east of the Still House appear to co-mingle with occurrences beneath the former Railroad Loading Area (discussed in Section 4.4.3). DNAPL in the Still House Area encompasses approximately 2.2 acres.

DNAPL in the Still House Area has been observed to occur in 1- to 3-foot-thick layers. The majority of occurrences are shallow and likely resulted from surface spills from multiple sources during Site operations. The deepest DNAPL occurrence was noted at QP-7, at a depth of 13.8 feet. All five borings in the Still House Area in which DNAPL has been identified, including QP-7, have been advanced to depths below 13.8 feet. A thick sequence of low-permeability silt, sandy silt, and peat layers beneath the DNAPL layers appears to have inhibited vertical migration of DNAPL. Borings HC-4, HC-8, BH-8, BH-9, QP-6, and QP-7 were advanced to depths between 6 and 15 feet below the lowest observed DNAPL occurrence.

4.4.2.2 Physical and Chemical Properties of DNAPL

No product has been observed in wells in the Still House Area; therefore, no product samples from this area have been collected or analyzed. Soil samples from borings with DNAPL indicate the hydrocarbon product contained benzene at HC-4 (1.2 percent) in the west-central portion of this area. Given the historical use, storage, and processing of both coal tar

and its refined products in this area, DNAPL occurrences in this area may be products of coal tar, creosote, or a mixture of these products.

4.4.2.3 DNAPL Mobility

DNAPL in the Still House Area exhibits low mobility characteristics. DNAPL occurrences are generally shallow, in thin 1- to 2-foot layers. The thickest layer of DNAPL-containing soil, 4 feet at BH-8, was observed in a silty sand layer. Well BH-8A was installed with the screen placed at the depth interval where DNAPL was observed in soil, but no product was recorded in this well. Oil-wetted DNAPL was identified at QP-6 and QP-7 but within lower-permeability silty sand layers. A layer of tar was identified in BH-9 at a depth of 1.5 to 3.5 feet, at the top of a permeable sand layer with no product extending deeper into the sand. A photograph of viscous tar near the Still House at a similar depth is provided on Figure 4.4-11.

4.4.2.4 DNAPL Volume

The volumes of DNAPL and soil containing DNAPL were estimated as described in Section 4.4.1.4, with details provided in Appendix G. Assumptions and results are summarized in Table 4.4-4. Based on these data, approximately 8,100 cubic yards of DNAPL-containing soil and the equivalent of 100,000 gallons of DNAPL are present in the Still House Area.

4.4.3 Railroad Loading Area

The Railroad Loading Area, shown on Figure 4.4-1b, includes two sub-areas within the Site that are both located within the former BNSF Railroad property where products were formerly loaded and unloaded. The northern loading area (the Solid Material Loading Area) was reportedly primarily used for solid tar products such as pitch or coke, and the southern loading area (the Tank Car Loading Area) was reportedly used (and included pipelines to and from the plant) for loading and offloading liquid products such as coal tar and creosote. An environmental investigation performed by Pinnacle GeoSciences on behalf of the Port of Seattle, a potential purchaser of the Railroad property, identified DNAPL in both of these areas (Pinnacle 2009). A summary of DNAPL occurrences identified by Pinnacle GeoSciences in the Railroad Loading Area is provided below.

4.4.3.1 Horizontal and Vertical Extent of DNAPL

DNAPL has been observed in two borings around the Solid Material Loading Area and in four borings around the Tank Car Loading Area. The lateral extent of DNAPL occurrences on the Railroad property is bounded by borings to the north and south of each area and to the east of the Solid Material Loading Area that were advanced to depths at least as deep as where DNAPL had been observed. DNAPL occurrences to the east of the Tank Car Loading Area (east of boring Q9) were not bounded by the Pinnacle GeoSciences investigation.

DNAPL occurrences in both areas appear contiguous with occurrences to the west of these areas, located on the Quendall property. The Solid Material Loading Area is located east of the Still House Area. The Tank Car Loading Area, which was on a trestle above the former May Creek Channel, is located east of the Former May Creek Channel Area. DNAPL occurrences in these areas are discussed in Sections 4.4.2 and 4.4.1, respectively.

Soil and groundwater data, which are summarized in Sections 5.3 and 5.2, respectively, also support delineation of the vertical and lateral extent of DNAPL in this area. Naphthalene concentrations in soil samples from borings where no DNAPL was observed were generally very low, except where solid tar products were present in shallow soil. The maximum groundwater concentration of naphthalene at Q14 (north of the Solid Material Loading Area), Q12 (east of the Solid Material Loading Area), and Q17 (south of the Tank Car Loading Area) was 17 µg/L, well below the 1 percent solubility limit. DNAPL in the Railroad Loading Area encompasses approximately 0.2 acres.

4.4.3.2 Physical and Chemical Properties of DNAPL

No product samples from this area have been collected or analyzed. Chemical properties based on soil samples from borings with DNAPL indicate different characteristics as follows:

- In the Solid Material Loading Area, contamination had a higher proportion of high-molecular-weight PAHs (HPAHs) than elsewhere on the Site. Concentrations of several PAHs, including phenanthrene, fluoranthene, and acenaphthene, were higher than concentrations of naphthalene. No BTEX compounds were detected.
- In the Tank Car Loading Area, naphthalene and phenanthrene were the dominant PAHs. Total BTEX concentrations were approximately 0.1 percent of the total

hydrocarbon mass, with very little benzene (maximum concentration of 0.27 mg/kg).

4.4.3.3 DNAPL Mobility

Field observations indicated different DNAPL mobility characteristics in the two loading areas as follows:

- In the Solid Material Loading Area, DNAPL was generally noted as oil-coated (i.e., below residual saturation) except for a 1-foot-thick layer of oil-wetted soil noted at Q1-D.
- In the Tank Car Loading Area, several layers of oil-wetted soil were noted at borings Q2-D and Q9. DNAPL reportedly accumulated in well Q9, which was screened across two layers of oil-wetted soil. The thickness of DNAPL in this well was not measured by Pinnacle GeoSciences and the DNAPL was not purged to evaluate recovery. This well is shaded grey on Figure 4.3-1 to indicate that the recovery of product is unknown.

4.4.3.4 DNAPL Volume

The volumes of DNAPL and soil containing DNAPL were estimated as described in Section 4.4.1.4, with details provided in Appendix G. Assumptions and results are summarized in Table 4.4-4. Based on these data, an estimated 1,700 cubic yards of DNAPL-containing soil and the equivalent of 21,000 gallons of DNAPL are present in the Railroad Loading Area.

4.4.4 Quendall Pond/North Sump Area

This area, shown on Figure 4.4-1 and enlarged on Figure 4.4-1c, includes the former waste disposal areas of the Quendall Pond/North Sump Area. Quendall Pond was created in 1972 to prevent released product associated with filling of the north sump from reaching Lake Washington. DNAPL in this area is also present offshore from Quendall Pond. A description of DNAPL occurrences in this area is provided below.

4.4.4.1 Horizontal and Vertical Extent of DNAPL

DNAPL has been observed at 28 locations throughout this area, including 23 upland locations (including BH-8 to the south) and five offshore locations (Figure 4.4-1c). DNAPL

layer depths and thicknesses observed at upland borings are summarized in Table 4.4-1 (with details provided in Appendix G).

The northern extent of DNAPL is estimated to extend up to 150 feet north of the north sump and is generally bounded in the uplands as follows:

- DNAPL was not observed at borings BH-1, SWB-4B, BH-18A/B, QP-2, or QP-3, which were advanced deeper than depths where DNAPL was observed in nearby explorations.
- Naphthalene concentrations in groundwater at wells BAX-9 and BH-24 (located near the north property line) and at wellpoints WP-18A, WP-18B, and WP-19C (located in sediment north of this area; see Figure 5.2-8 accompanying Section 5) were either not detected or well below 1 percent of the solubility of naphthalene. In addition, during the 2009 RI field investigation, very low naphthalene concentrations (a maximum of 3 µg/L) were detected in three groundwater grab samples that were collected along the northern property line (SP-BAX9-1 through 3).

Thin DNAPL layers (approximately 1 to 3 inches thick) were observed offshore at QPN-07, VS-2, and NS-15-C1, north of upland borings SP-2 and QP-1. DNAPL was observed within a thin sand layer located between 10 and 15 feet deep that appears to slope gently to the north. Because this layer was very thin (less than 3 inches), consisted of oil-coated sand (i.e., no oil was present above residual saturation), and was not identified in sediment borings adjacent to the west or east, the extent of DNAPL in this area is believed to be limited. A photograph of the DNAPL layer encountered at a depth of 8.5 to 8.7 feet at QPN-07 is provided on Figure 4.4-12.

DNAPL extends to the east to between the north sump, where liquids were disposed of, and the pitch bays, where solid tar products were handled. The eastern extent of DNAPL in this area is bounded as follows:

- DNAPL has not been observed at borings BH-4 and BH-27, which were advanced deeper than the depths where DNAPL was observed in nearby explorations.
- Naphthalene has not been detected in groundwater at BH-27.

DNAPL extends to the south along the southern edge of Quendall Pond and the vicinity of the ASTs, and is bounded in this area as follows:

- DNAPL was not observed at borings QP-4, RB6, RB7, BH-10, BH-6, or BH-7, which were advanced deeper than the depths where DNAPL was observed in nearby explorations.

DNAPL extends to the west offshore of Quendall Pond and was identified in two sediment cores, VS-30 and QPN-02, at depths of approximately 4 to 9 feet and 3 to 7 feet below the mudline, indicating that the DNAPL at these locations has migrated from the uplands. Note that DNAPL at EPA-8 (discussed in Section 4.4.5 as part of the T-Dock Area) was observed in the upper 6 inches of the core, consistent with a localized surface spill.

The DNAPL extent from the uplands into Lake Washington is bounded to the west as follows:

- DNAPL was not observed at sediment cores NS05, QPN-01, NS09, QPN-03, QPN-04, QPN-05, VS-21, VS-4, VS-28, or VS-3, which were advanced deeper than the depths where DNAPL was observed in nearby explorations.
- Naphthalene concentrations in wellpoints WP-19C, WP-20A, WP-2, and WP-4 (see Figure 5.2-8 accompanying Section 5) were well below the 1 percent solubility of this compound.

DNAPL is typically encountered at greater depths near the Lake Washington shoreline. Soil stratigraphy layers are sloped slightly downwards towards Lake Washington and the elevation of DNAPL occurrences is lower toward the west, consistent with the slope of the stratigraphy. In the Quendall Pond Area along the shoreline, soil layers and DNAPL occurrences also slope slightly downwards to the north.

DNAPL is typically encountered within permeable sand layers. Based on review of adjacent boring logs, the sand layers are interpreted to be discontinuous lenses, resulting in NAPL pools in the subsurface that may not be continuous. DNAPL thickness typically corresponds with the thickness of the permeable sand layer where encountered. Near the north sump, DNAPL layers up to 5 feet thick have been observed, typically at depths between 10 and 16

feet, and thin DNAPL-saturated layers up to 1 foot thick have been observed at depths up to approximately 20 feet. Near Quendall Pond, DNAPL layers that are 2 to 4 feet thick have been observed at depths typically between 15 and 22 feet. DNAPL is also observed in shallow soil less than 15 feet deep immediately around Quendall Pond, likely a result of the use of the pond to intercept product in 1972. This DNAPL occurrence typically occurs in thin stringers less than 1 foot thick and is separated from deeper occurrences in the same area by low-permeability layers of silt and peat.

The vertical DNAPL boundary in the Quendall Pond Area was determined based on visual observations. Eighteen soil borings were completed to depths that were below the maximum depth of DNAPL observed in this area (24 feet bgs).

DNAPL in the Quendall Pond/North Sump Area encompasses approximately 4.1 acres, including both upland and offshore occurrences.

4.4.4.2 Physical and Chemical Properties of DNAPL

Chemical and physical testing results from DNAPL collected from BH-5, RW-QP-1, and RW-NS-1 are summarized in Table 4.2-1. DNAPL from BH-5 and RW-QP-1, located east and west (respectively) of Quendall Pond, had similar viscosity and density and contained a relatively high proportion of light-end (BTEX) constituents, consistent with coal tar. The chemical composition of soil or sediment samples containing DNAPL in the vicinity of Quendall Pond (including at QP-5 and VS-30) was consistent with the product observed at wells BH-5 and RW-QP-1.

DNAPL collected at RW-NS-1, in the Quendall Pond/North Sump Area, contained a lower fraction of BTEX constituents, although slightly higher than that observed in the Former May Creek Channel Area. DNAPL in both areas has a relatively low viscosity of around 9 cp, less than that of the creosote identified in the Former May Creek Channel Area. DNAPL in the Quendall Pond/North Sump Area likely represents a mixture of coal tar and creosote.

4.4.4.3 DNAPL Mobility

Within the Quendall Pond/North Sump Area, two different mobility characteristics were observed. In the area around the north sump, DNAPL has generally not been observed in wells in spite of relatively thick DNAPL layers in soil. A soil investigation in 2003 (Anchor and Aspect 2004) identified several locations near the north sump with several feet of DNAPL observed in soil. Well RW-NS-1 was installed at the location of the thickest DNAPL layer. This well contained 1 gallon of product immediately after installation, but no additional DNAPL was recovered in subsequent testing. Well BH-23, also located in this area, contained a few inches of DNAPL when first installed but, similarly, no DNAPL was observed in subsequent events. Well locations and DNAPL recovery characteristics are shown on Figure 4.3-1.

DNAPL observed in shallow soil around Quendall Pond exhibits different mobility/recoverability characteristics than the deeper DNAPL occurrences. DNAPL at depths shallower than 15 feet in the Quendall Pond Area appears to be below residual saturation, whereas DNAPL deeper than 15 feet is typically present above residual saturation as described below.

The shallower DNAPL occurrences near Quendall Pond are either identified as viscous, tar-like products, as observed at BH-5A and trench T-4, or as thin stringers of DNAPL within fairly permeable sands as observed in the upper 10 feet at SP-4. Shallow wells in this area include well BH-5A (screened 5 to 10 feet below grade) and BH-19 (screened 5 to 15 feet below grade). These wells are located adjacent to identified shallow DNAPL occurrences but, consistent with the soil observations of discontinuous and/or viscous products, no mobile product has accumulated in these wells. DNAPL at boring QP-5, noted at depths from 11 to 12 feet in the 2009 RI field investigation, was identified as oil-coated (below residual saturation). A photograph of this interval is provided on Figure 4.4-13.

DNAPL at depths below 15 feet in the Quendall Pond Area appears to have a higher potential mobility. In wells BH-5 and RW-QP-1, located around Quendall Pond and screened at depths to 20 feet, 3 to 5 feet of DNAPL have been measured. Recovery testing by Woodward Clyde (1992) and again by Aspect in 2003 and 2004 (Anchor and Aspect 2004) indicated that DNAPL at BH-5 recovers after being pumped to original levels within several

days. Periodic pumping by Aspect at these two wells recovered approximately 80 gallons over a 2-year period (Figure 4.4-10). DNAPL levels at BH-5 have remained constant since first measured in 1989, other than seasonal fluctuations due to changes in groundwater pressure and in response to DNAPL pumping. Because product in this area is of relatively low viscosity, and potential sources of DNAPL to the subsurface were removed almost 40 years ago, the relatively consistent DNAPL levels over time suggests that DNAPL pools in the subsurface are stratigraphically trapped and are likely not continuing to migrate. Observations at sediment cores VS-30 and QPN-02 suggest that product at these locations, which is at a similar elevation as the deeper upland occurrences, are above residual saturation. West of these sediment cores, no DNAPL has been observed; rather, at VS-3, VS-29, QPN-04, and NS-10 (see cross section A-A' on Figure 3.1-6 for a representative profile) low-permeability soil layers that would constrain further westward migration are located at the same elevation.

4.4.4.4 DNAPL Volume

The volumes of DNAPL and soil and sediment containing DNAPL were estimated as described in Section 4.4.1.4, with details provided in Appendix G. Assumptions and results are summarized in Table 4.4-4. Based on the available data, approximately 16,000 cubic yards of DNAPL-containing soil and sediment and the equivalent of 200,000 gallons of DNAPL are present in the Quendall Pond/North Sump Area.

4.4.5 T-Dock Area

The T-Dock Area is located entirely offshore. The T-Dock included a main span, which extended approximately 800 feet to the northwest from the shoreline, and a cross span, which was a 450-foot span at the north end of the main span. Historically, the T-Dock cross span was used to tie up large vessels that transported coal tar to the Site; transfer pipes were located in the center of the cross span. The main span contained piping used to transfer coal tar feedstock between transport vessels and the uplands area where the feedstock was stored and processed.

DNAPL occurrence in the T-Dock Area was assessed using historical data (e.g., EPA 1983; Retec 1997a; and Anchor and Aspect 2004) and RI field investigation data, and was described

qualitatively as visible product and oil-coated/wetted sediment. DNAPL layer depths and thicknesses observed at sediment borings are summarized in Table 4.4-2 (with details provided in Appendix G).

4.4.5.1 Horizontal and Vertical Extent of DNAPL

The discussion of the horizontal and vertical extent of DNAPL in sediment along the former T-Dock is divided into two areas: the main span, extending from the shoreline to the loading area, and the cross span, located at the end of the main span and extending approximately parallel to the shoreline. DNAPL occurrences in sediment in these areas are associated with leaks and spills from historical operations. Spills along the cross span were likely larger than those along the main span based on historical accounts (see Section 2.2.1).

Nearshore DNAPL occurrences in deeper sediment are associated with migration from the upland area around Quendall Pond. Refer to Section 4.4.4 for a discussion of these deeper DNAPL occurrences. Figure 4.4-5 shows the maximum depth of DNAPL occurrence in the vicinity of the former T-Dock.

DNAPL in the T-Dock Area encompasses approximately 1.7 acres.

4.4.5.1.1 Main Span DNAPL Occurrences

Along the former main span of the T-Dock, DNAPL product has been observed in three sediment cores: VS-27, TD-01, and EPA-8. DNAPL was not observed in cores EPA-9 and EPA-10 located northwest and southeast of VS-27, although sheen was observed in the surface sediment of core VS20A, located approximately 100 feet south of VS-27. Neither product nor sheen was observed in sediment from cores to the northwest of EPA-8. Surface sediment from cores VS-21 and VC20A, located south and southeast of EPA-8, contained visible sheen.

Sediment along the main span was historically impacted by leaks and spills based on the depth of observed DNAPL product and sheen. DNAPL has only been observed in the upper few feet of sediment in this area. DNAPL was observed at only one location outside the Site boundary of the former main span: core VS-27, where product occurs as a discontinuous

2-inch layer beneath a layer of wood debris at a depth of 2.5 feet below the mudline. No sheen or product was observed below this depth interval to the bottom of the core at 16.8 feet below the mudline. This unit lies beneath a unit composed of wood chips and overlies a unit of impermeable silty clay, which prevented downward migration. DNAPL was not observed in sediment collected at adjacent stations, indicating that lateral migration was negligible and that the extent of DNAPL is well bounded by locations NS-13-VC, EPA-9, NS-12-VC, TD-03, and TD-04. In core TD-01, product occurs as a discontinuous 1-inch layer within a 1.5-foot-thick silt layer, at a depth of 0.7 foot. No sheen or product was observed below the silt layer to the bottom of the core at 11.8 feet below the mudline. DNAPL was not observed in sediment collected at adjacent stations, indicating that lateral migration was negligible and that the extent of DNAPL is well bounded by locations NS-12-VC, NS-08, NS-07, and VS-19. In core EPA-8, within the property boundary, product was only encountered in the upper 6 inches of the core, although sheen extended to the base of the core at 3 feet below the mudline. In core VS-21, located just south of EPA-8, sheen was observed in the upper 3 feet of the 17-foot-deep core.

4.4.5.1.2 Cross Span DNAPL Occurrences

DNAPL was observed at four locations along and adjacent to the former cross span: cores EPA-1, TD-08, VT-1, and VT-4. These core locations lie in the presumed area of the large spill that occurred sometime between 1930 and 1940 (described in Section 2.2.1), which would have impacted sediment between the cross span and farther offshore due to wind-driven transport or migration along the slope of the lakebed. DNAPL occurrence observed in this sediment was shallow (less than 3 feet), consistent with the nature of the spill.

In sediment along the former cross span (e.g., at EPA-1 and TD-08), DNAPL was observed within the top 0.5 foot of sediment below the mudline in a unit of silt containing variable amounts of decomposed wood debris. The presence of wood debris in the silt can create preferential flowpaths through which DNAPL can migrate. This more permeable silt was vertically bound by deeper strata of silt, peat, and clay, which prevented further vertical migration. DNAPL was not observed in cores collected at adjacent stations toward the nearshore environment or the outer flanks of the cross span, indicating that the DNAPL extent is well bounded laterally by surrounding cores (e.g., EPA-2, EPA-3, TD-05, TD-06, TD-16, and TD-17). DNAPL occurrence along the former cross span is bounded to the west

by core EPA-2, advanced to a depth of 1 foot, and to the east by cores EPA-3 and VT-2, advanced to depths of 4 and 7 feet, respectively. Farther offshore, DNAPL was absent in core EPA-12 (3.7 feet below the mudline) located approximately 400 feet to the northwest of the cross span.

In cores collected adjacent to the former cross span in the offshore direction, DNAPL was observed in core VT-1, from 0 to 1 foot below the mudline, and core VT-4, from 0 to 3 feet below the mudline. In both cores, DNAPL was bound to a sand or silty sand unit overlying units of clay or interbedded silt and clay, which prevented vertical migration. The shallow sediment was observed to contain layers or droplets of product in three cores: VT-1 from 0 to 1 foot; VT-4 from 0 to 3 feet; and EPA-1 from 0 to 6 inches. No sheen was observed below the DNAPL occurrences in cores VT-1, advanced to a depth of 10.5 feet, and VT-4, advanced to a depth of 15.8 feet. In core EPA-1, advanced to a depth of 5.0 feet, sheen was noted to the bottom of the core. Sheen, but no product, was noted in cores VT-3 and VT-5 from depths of 0 to 1 foot and 0 to 3.5 feet, respectively. These two cores were completed to an approximate depth of 16 feet below the mudline. While DNAPL was not observed in core TD-15, which is located between cores VT-1 and VT-4, a heavy sheen with brown blebs was observed from the surface to 0.3 foot below the mudline, indicating the presence of contamination. Further discussion of the nature and extent of contamination of sediment in this area is provided in Section 5.4.1. The horizontal extent of DNAPL is bounded by cores TD-09 through TD-14 and EPA-12, where no DNAPL occurrences were observed.

The maximum horizontal extent of DNAPL, as defined by cores EPA-1, TD-08, VT-1, and VT-4, extends approximately 350 feet to the north of the cross span toward VT-4. Based on these data, the maximum depth of DNAPL in the T-Dock Area is approximately 3 feet below the mudline.

4.4.5.2 Physical and Chemical Properties of DNAPL

DNAPL in the T-Dock Area is likely related to coal tar feedstock that was offloaded in this area. Chemical analysis of subsurface sediment samples collected in this area has indicated PAH composition consistent with coal tar or creosote. However, analysis of sediment samples in the T-Dock Area has only involved limited analysis for BTEX compounds. In surface sediment samples collected by Retec in 1996, several surface sediment samples

collected near the former T-Dock cross span (S-51, S-60, and S-61) contained elevated PAH concentrations but relatively low naphthalene concentrations and no detectable benzene. Sediment sampled from cores with oil-coated sediment (e.g., TD-08) had naphthalene concentrations on the order of 6.7 mg/kg; however, the interval containing DNAPL was not analyzed. No oil-wetted sediment was observed during the 2009 RI field investigation. Further discussion of the nature and extent of contaminants in sediment is provided in Section 5.4.1.

4.4.5.3 DNAPL Mobility

DNAPL in the T-Dock Area generally exhibits low mobility characteristics due to its shallow occurrence and the prevalent distribution of low-permeability strata, such as silt, peat, and clay, which constrain its horizontal and vertical movement. A photograph of the oil-coated sediment from a depth of 0.3 to 0.4 foot at TD-08 is shown on Figure 4.4-14. At all four locations where DNAPL was observed (e.g., TD-08, EPA-1, VT-1, and VT-4), no evidence of vertical migration was noted (i.e., DNAPL was typically observed in the top foot of sediment, except for VT-4 where it was described in the log as being in the uppermost 3 feet of sediment).

4.4.5.4 DNAPL Volume

The volumes of DNAPL and sediment containing DNAPL were estimated as described in Section 4.4.1.4, with details provided in Appendix G. Assumptions and results are summarized in Table 4.4-4. Based on these data, an estimated 2,900 cubic yards of DNAPL-containing sediment and the equivalent of 36,000 gallons of DNAPL are present in the T-Dock Area.

4.5 Summary of the Nature and Extent of NAPL at the Quendall Site

It is estimated that approximately 445,000 gallons of DNAPL are present in the subsurface at the Quendall Site, impacting a total of 9.7 acres. The distribution and varied characteristics of DNAPL at the Site have a significant effect on the nature and extent of contamination present in Site groundwater, soil, and sediment (described in Section 5.0). Figure 4.5-1 shows a generalized CSM of DNAPL presence at the Site and how it affects other media. As indicated in the figure, DNAPL in the uplands at Quendall Site is generally found in shallow

stringers located in permeable soil, rather than in one or more continuous "pools". Of 57 borings where DNAPL was encountered, 44 had only one layer of DNAPL.

The majority of DNAPL in the uplands is found within the top 20 feet of the Shallow Aquifer. The deepest that DNAPL is found in the uplands is in the Railroad Loading Area at 30 feet and in the Former May Creek Channel Area at 34 feet. Upland DNAPL is found only within the Shallow Aquifer, with an exception of a thin layer of DNAPL within the top layer of the Deep Aquifer in the Former May Creek Channel Area. The highest cumulative thicknesses of DNAPL are found within the Former May Creek Channel Area (8.8 feet) and the Railroad Loading Area (11 feet). The Quendall Pond/North Sump Area contains the most DNAPL in terms of volume and affected acreage.

Offshore occurrences of DNAPL are sporadic. The maximum depth of DNAPL observed in the T-Dock Area is 3.8 feet, although most of the DNAPL along the T-Dock occurs very near the surface, indicating the DNAPL occurrences in sediment in this area are associated with leaks and spills from historical operations. DNAPL has also migrated from the uplands to nearshore sediment and has been found as deep as 16 feet immediately west of Quendall Pond.

5 NATURE AND EXTENT OF CONTAMINATION IN SITE MEDIA

This section describes the nature and extent of non-NAPL residual contamination in environmental media at the Quendall Site, building on information presented in previous sections, particularly information presented in Section 4 concerning the nature and extent of Site DNAPL contamination. Relevant information presented in Section 2 (e.g., Site history, data usability, and results of previous environmental Site investigations) and Section 3 (Environmental Setting), and data from the 2009 RI field investigation are also summarized and/or referenced in this section as appropriate. The nature and extent of non-NAPL contamination in Site media were assessed using both historical (pre-2009) data and RI field investigation data.

Site characterization data are presented sequentially for groundwater, soil, and sediment (and associated porewater), and each of the sections for these media is organized based on the areas of the Site where potential sources of contamination to the respective medium are present based on historical Site operations and associated hazardous substance releases. The distribution and varied characteristics of DNAPL at the Site (described in Section 4) have a significant effect on the nature and extent of contamination present in Site groundwater, soil, and sediment. Because the nature and extent of Site groundwater contamination help inform the contaminant distribution in soil and sediment, the groundwater contamination at the Site is discussed first.

The remainder of this section is organized as follows:

- Section 5.1 discusses the process used for identifying the PRG screening levels for the indicator chemicals that are evaluated in the subsequent sections.
- Section 5.2 discusses the nature and extent of contamination in shallow and deep groundwater.
- Section 5.3 discusses the nature and extent of contamination in surface and subsurface soil.
- Section 5.4 discusses the nature and extent of contamination and wood debris in surface and subsurface bulk sediment and associated sediment porewater.

5.1 Indicator Chemicals and Associated PRG Screening Levels

As described in Section 2.5.1, indicator chemicals were identified for the Site as part of the development of the RI Data Collection Work Plan (Anchor QEA and Aspect 2009a). These indicator chemicals have been used for the purpose of characterizing the nature and extent of Site contamination. They include: 1) chemicals associated with coal tar products and 2) chemicals associated with sources other than coal tar products (i.e., other potential sources). The indicator chemicals in each category are as follows:

- **Coal Tar Products:** benzene, naphthalene, and other PAHs
- **Other Potential Sources:** arsenic, chromium (III), copper, total PCBs, PCP, phenol, 4-methylphenol, and TOC

Of the PAHs, naphthalene is discussed separately as it is a key indicator of the extent of contamination associated with coal tar products. The remaining PAHs are described in terms of various risk-based metrics. These include the following:

- **Total carcinogenic PAHs (cPAHs) expressed as benzo(a)pyrene toxicity equivalency quotients (TEQs).** Total cPAH TEQs based on benzo(a)pyrene equivalent concentrations are calculated by multiplying concentrations of seven carcinogenic PAHs by toxicity equivalency factors (TEFs) per 2009 California EPA guidance (CAEPA 2009) and summing the results. When calculating a cPAH TEQ, one half (1/2) the detection limit is used for non-detects (U-flagged results); the maximum detection limit is used in cases where all seven cPAHs are non-detects. The seven cPAHs are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno (1,2,3-c,d)pyrene. These calculations are provided in Appendix A-3.
- **Total high-molecular-weight PAHs (HPAHs).** Total HPAHs are calculated by summing 10 HPAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3,-c,d)pyrene, fluoranthene, and pyrene. When calculating total HPAHs, 1/2 the detection limit is used for non-detects; the maximum detection limit is used in cases where all 10 HPAHs are non-detects. Calculated HPAHs are included in the project analytical database in Appendix A-1.
- **Total low-molecular-weight PAHs (LPAHs).** Total LPAHs are calculated by summing

six LPAHs: acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene. When calculating total LPAHs, 1/2 the detection limit is used for non-detects; the maximum detection limit is used in cases where all six LPAHs are non-detects. Calculated LPAHs are included in the project analytical database in Appendix A-1.

- **Total PAH equilibrium partitioning sediment benchmark quotients (ESBQs) expressed as toxic units (TUs).** Benthic organisms should be sufficiently protected from the narcotic effects of PAH mixtures in freshwater and saltwater sediment if the ESBQ is less than or equal to 1 TU. If the ESBQ is greater than 1 TU, sensitive benthic organisms may be adversely affected. ESBQ calculations are provided in Appendix A-4. More details on how total PAH ESBQ results are interpreted are provided in Section 7.2, Baseline Ecological Risk Assessment.

For the purpose of characterizing the nature and extent of Site contamination, PRG screening levels for indicator chemicals were selected based on the most relevant human health or ecological Site exposure pathway. For example, the development of the PRG screening levels prioritized: 1) MCLs above other ARARs or risk-based criteria, 2) groundwater criteria over surface water criteria for groundwater, and 3) surface water criteria over groundwater criteria for porewater. Regional background concentrations of metals in soil were considered when the PRG was lower than the regional background value (for arsenic, chromium, and copper in soil [Ecology 1994]). In addition, a Site-specific background value for total cPAH TEQs was developed for surface sediment during this RI; this was done because, based on preliminary evaluations, it was determined that risk-based human health sediment screening values for cPAHs in the fish consumption pathway would likely be below Lake Washington background concentrations (Anchor QEA and Aspect 2009a). The derivation of this Site-specific background value is described in Appendix H.

Table 5.1-1 lists the PRG screening levels (and provides links to their sources) for the indicator chemicals discussed in this nature and extent evaluation. Specifically:

- Shallow and deep groundwater data were primarily compared to MCLs, except for naphthalene data which were compared to the MTCA Method B groundwater cleanup level based on drinking water exposure.

- Surface and subsurface soil data were primarily compared either to EPA RSLs (for residents) for the protection of human health or to EPA ecological SSLs for protection of the environment.
- Surface and subsurface bulk sediment data were compared to EPA Region 3 Biological Technical Assistance Group (BTAG) freshwater sediment screening values, Site-specific cPAH background values, or Ecology freshwater sediment screening values (Ecology 2003). A TU value of 1 was used as the PRG screening level for total PAH ESBQs (EPA 2003b).
- Surface and subsurface sediment porewater data were compared to EPA National Recommended Water Quality Criteria (based on water and organism criteria), EPA Region 3 BTAG freshwater sediment screening values, and the EPA PAH ESBQ screening value of 1 TU.

The basis of the PRG screening level for each indicator chemical by environmental medium (groundwater, soil, and sediment/porewater) is shown on each applicable plan view figure that is referenced in Sections 5.2 through 5.4. A note on each figure indicates what the PRG screening level is (consistent with the screening level cited in the text), while the "Basis of Screening Level Intervals" portion of the legend on each figure is provided to explain the intervals that are shown for the detected and non-detected concentrations of the respective contaminants, which are used to delineate the extents and boundaries of contamination shown on various figures.

With the exception of Table 5.1-1, the tables supporting this section present summary statistics of Site indicator chemicals by medium and QA level, including the locations of the maximum detected concentrations, the PRG screening levels, and the number of detections and non-detects exceeding the PRG screening levels by chemical.[12] Where appropriate, background values are also included along with the numbers of detections and non-detects exceeding those values. Summary statistics for all chemicals are provided in Appendix I.

To provide a comprehensive characterization of Site sediment, general wood debris characterization parameters including surface sediment TOC, total volatile solids (TVS), and

[12] For groundwater and soil, the data are summarized separately for the Quendall and Railroad properties.

qualitative observations of percent wood by volume are also summarized in this RI Report. However, the potentially deleterious aspects of wood debris (e.g., physical habitat disturbances separate from the presence of hazardous substances) are not regulated under CERCLA and, as a result, are not subject to cleanup under CERCLA.

It is important to note that the baseline risk assessment (Section 7) was not limited by the COI or indicator chemical selection process, but included all data of sufficient quality to identify COPCs for human and ecological receptors.

5.2 Nature and Extent of Groundwater Contamination

Key Points for Groundwater Contamination:

- Groundwater at the Quendall Site is contaminated by soluble constituents of coal tar and coal tar distillates.
- Groundwater also represents a secondary source of contamination to soil and sediment.
- Indicator chemical distributions in groundwater define the hazardous-substance-impacted groundwater boundaries.
- Groundwater fate and transport pathways to sediment and surface water are presented in Section 6.
- Groundwater modeling results are presented in Appendix D.

Groundwater contamination at the Quendall Site has resulted from historical releases of aqueous wastes and from contaminant leaching/dissolution from DNAPL and soil (i.e., DNAPL-impacted soil). Site groundwater is encountered at relatively shallow depths (typically 6 to 8 feet bgs) and the Site is almost entirely covered by pervious surfaces, allowing precipitation and related stormwater to infiltrate into the subsurface. Therefore, contaminated soil (discussed in Section 5.3) and NAPL occurrences (discussed in Section 4) in both saturated and unsaturated soil are potential sources of groundwater contamination. In addition, the movement of contaminated groundwater across the Site represents a secondary source of contamination to soil and sediment, and thus the nature and extent of contamination in groundwater is a good indicator of the extent of impacts to these other media (i.e., soil and sediment discussed in Sections 5.3 and 5.4, respectively)

Groundwater contamination may also arise when chemicals leach from contaminated fill materials, such as solid tar and semi-solid (i.e., very viscous) tar products (discussed in detail

in Section 5.3.1.1). A detailed discussion of contaminant fate and transport characteristics related to solid tar and semi-solid tar products is presented in Section 6.2.2.

Groundwater samples were collected from Site monitoring wells and sediment wellpoints. The groundwater quality data resulting from analyses of these samples are supplemented where noted with data from groundwater grab samples collected from soil borings and porewater data from sediment stations. Most of the chemical data discussed below and displayed on the referenced figures are from the 2009 RI field investigation. Several Site wells (BH-12, BH-12A, BH-17A, and BH-17B) could not be sampled during the 2009 RI field effort and were last sampled in 1992; data at these locations are of QA0 quality due to the age of the data. On the applicable figures, QA0 quality data are differentiated by a pentagon symbol. QA1- or QA1 quality data include data from: 1) wellpoints WP-1 through WP-6 that were sampled in 1996 and 2) borings designated as "RB" that were sampled in 2001. Wellpoints designated as WP-19A, WP-19B, WP-20A, WP-20B, and WP-20C were sampled in 2001 or 2003, and data from these wellpoints are of QA2 quality. All remaining data were collected in 2008 or 2009 as part of either the RI field investigation or the Railroad property investigation (Pinnacle 2009); all these recent data are of QA2 quality. Statistical summaries of groundwater data collected on the Quendall and Railroad properties are provided in Appendix I. Statistical summaries limited to indicator chemicals in groundwater samples collected on the Quendall property are provided in Tables 5.2-1a (QA1 and QA2 data) and 5.2-1b (QA0 data). A statistical summary of indicator chemicals in groundwater samples collected on the Railroad property is provided in Table 5.2-2 (QA1 and QA2 data).

The most recent groundwater data collected between 2001 and 2009 were used as the primary basis for characterizing the nature and extent of Site groundwater contamination. However, the 2009 sampling and analytical data of QA2 quality were generally used to delineate the extent (i.e., estimated boundaries) of contamination relative to PRG screening levels, unless otherwise noted. The western groundwater contamination boundary in Lake Washington was also delineated based on the nearshore porewater data discussed in Section 5.4, using the deepest porewater sample collected at each station (i.e., groundwater unaffected by lake mixing and biodegradation processes that occur near the sediment surface; see Section 6.4.3). Data collected prior to 2001 were used only as needed to supplement the

characterization of Site groundwater contamination, including evaluation of seasonal and long-term trends in groundwater quality.[13]

Available sampling and analytical data are discussed below for two depth intervals: shallow and deep. The shallow interval is defined by groundwater sampling data collected at depths less than 30 feet bgs. This generally corresponds to the upper portion of the Shallow Alluvium geologic unit, though it also includes the lower portion of the Fill Unit, which may be seasonally saturated in some Site areas. The deep interval is defined by groundwater samples collected at depths greater than 30 feet bgs, and corresponds to the lower portion of the Shallow Alluvium and the Deep Alluvium.[14] Hydrologic and geologic units and associated characteristics are discussed in Sections 3.1.3 through 3.1.5. Most of the deep interval samples were collected from the top of the Deep Alluvium, with the exception of two deep wells that were screened closer to the base of the Deep Alluvium. To aid in interpreting groundwater sampling data, the monitoring well nomenclature used for this RI is as follows:

- Wells with no suffix after the well number (e.g., BH-5) or with an "A" suffix (BH-5A) are in the lower portion of the fill and/or the upper portion of the Shallow Alluvium. These wells are screened at depths less than 30 feet bgs.
- Wells with a "B" suffix are at the base of the Shallow Alluvium or the top of the Deep Alluvium. These wells are screened at depths greater than 30 and less than 50 feet bgs.
- Wells with a "C" suffix are deeper within the Deep Alluvium, above the deep lacustrine clay. Two C-level wells have been installed at the Site: BH-30C (screened at a depth of 85 to 95 feet bgs) and BH-20C (screened at a depth of 112 to 118 feet bgs).

Most of the figures beginning with Figure 5.2-1 and ending with 5.2-20 show the occurrence of individual contaminants in plan or profile views. Figures 5.2-7 and 5.2-13 are time-series

[13] Note that field parameters measured during groundwater sampling are provided in Appendix C.

[14] The deep interval approximately corresponds to the Deep Alluvium. The depth to the Deep Alluvium varies across the Site, but is typically encountered at depths between 30 and 35 feet (see Section 3.1.4). The screened intervals of several wells are located at depths greater than 30 feet but are across the interface of the Deep and Shallow Alluvium. For the purposes of this RI, data from these wells are categorized as from the deep interval.

plots that show historical concentrations of benzene and naphthalene, respectively, at nearshore Site wells. The estimated boundaries of contaminant occurrences are shown together for comparison purposes on Figures 5.2-21 and 5.2-22 for the shallow and deep groundwater intervals, respectively.

Estimated groundwater contaminant boundaries shown on applicable figures supporting this Section 5.2 are depicted using the following symbology: 1) a solid line means the boundary is based on a combination of QA1 and QA2 quality data and 2) a dashed line indicates that the boundary was inferred from secondary lines of evidence, such as porewater chemistry or modeled groundwater flow pathways.

The remainder of Section 5.2 addresses the nature and extent of indicator chemicals associated with coal tar products and other contaminant sources in groundwater. Section 5.2.1 discusses the nature and extent of coal-tar-related contamination in groundwater and addresses the indicator chemicals benzene, naphthalene, and total cPAHs as benzo(a)pyrene TEQs in shallow groundwater (up to 30 feet bgs) and deep groundwater (greater than 30 feet bgs). The areas of the Site where these chemicals are found are identified, and the temporal variability of each indicator chemical is also discussed. Section 5.2.2 discusses the nature and extent of contamination from other sources in groundwater and addresses the indicator chemicals arsenic, copper, chromium, and PCP.

5.2.1 Coal Tar Product Indicator Chemical Occurrences

As described in Section 4, DNAPL products (e.g., coal tar and creosote) were used or manufactured on-Site, and widespread occurrences of these products have been observed in the subsurface. DNAPL has been observed at a depth of 33 feet bgs (see Section 4.4). Coal tar product indicator chemicals (i.e., benzene, naphthalene, and cPAHs) are present in groundwater where DNAPL is present, either above or below the water table, because DNAPL is a groundwater contaminant source (see Section 6.2.2).

Characterization of the nature and extent of Site groundwater contamination is also supported by the groundwater flow modeling results (described in Section 3.1.5.6), particularly with respect to transport pathways downgradient of the DNAPL/source material

distributions described in Section 4.4. This groundwater flow pathway evaluation provides an additional line of evidence to supplement the groundwater sampling data. Groundwater flowpaths, as estimated by the particle-tracking hydraulic model (described in Section 3.1.5 and Appendix D) are included on cross section Figures 5.2-4 through 5.2-6 and 5.2-10 through 5.2-12 for reference. Note that these flowpaths do not account for contaminant plume "spreading" due to diffusion and dispersion processes (described in Sections 6.1.2 and 6.3.3, respectively). The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths. Contaminant fate and transport modeling incorporating diffusion and dispersion processes to estimate the vertical extent of the groundwater plume is discussed in Section 6.4.

The following sections discuss the rationale for assessing the extent of contamination for each coal-tar-related indicator substance in the shallow and deep groundwater intervals.

5.2.1.1 Benzene

Benzene analytical data from samples collected in the shallow and deep groundwater intervals are shown on Figures 5.2-1 and 5.2-2, respectively. Figure 5.2-3 shows the groundwater cross section locations. Vertical benzene concentration distributions in groundwater and soil along the groundwater flowpath in three east-west cross sections are shown on Figures 5.2-4 through 5.2-6.

The PRG screening level for benzene in groundwater at this Site is the MCL of 5 µg/L. The highest benzene concentrations in groundwater—up to 31,000 µg/L at well BH-5—were detected in the shallow interval near Quendall Pond and in wellpoints offshore of the Oil Dock within 150 feet of Quendall Pond. Detection limits for samples where benzene was not detected ranged between 0.4 and 1 µg/L, below the PRG screening level. Benzene distributions in the shallow and deeper groundwater intervals are discussed in further detail below.

5.2.1.1.1 Shallow Groundwater Occurrences

Benzene concentrations in the shallow groundwater interval are elevated over much of the Site, including in areas where DNAPL has been observed. As described in Section 4.2.2, Site

DNAPL may be coal tar, creosote, or a mixture of these products, with varying benzene concentrations. Coal tar DNAPL contains the highest benzene concentrations and creosote DNAPL contains little or no benzene. The benzene concentrations detected in shallow groundwater correspond closely with areas where benzene was detected in DNAPL products (e.g., coal tar), as follows:

- **Western Portion of the Former May Creek Channel Area.** In this area where creosote DNAPL is present (e.g., at well BH-21A), benzene concentrations are relatively low, ranging from non-detect (0.2 to 1 µg/L detection limit) to a maximum concentration at wellpoint WP-5 of 7.6 µg/L (see Figure 5.2-1), slightly above the PRG screening level of 5 µg/L. Corresponding to these very low benzene concentrations in groundwater, benzene was not detected (5 mg/kg detection limit) in DNAPL at well BH-21A in the same area (see Table 4.2-1).
- **Eastern Portion of the Former May Creek Channel/Railroad Loading Area.** In this area, moderate benzene concentrations have been detected, ranging up to a maximum concentration of 1,600 µg/L at well Q9 (on the Railroad property). Soil concentrations of benzene in this area are also moderately elevated (up to 0.75 mg/kg at well Q4; see Section 5.3, Figure 5.3-4). Given the soil chemistry and the historical loading and unloading of both creosote and coal tar in this area, a mixture of DNAPL products in this area is likely.
- **North Sump Area.** In this area, low to moderate benzene concentrations have been detected, ranging up to a maximum concentration of 350 µg/L at wells BH-18A and BH-23. DNAPL in this area, as characterized at well RW-NS-1, contains a detectable but low concentration of benzene (550 mg/kg; see Table 4.2-1) and may be a mixture of coal tar and creosote products.
- **Quendall Pond Area.** In this area where coal tar DNAPL is present, very high benzene concentrations have been detected, ranging up to 31,000 µg/L at well BH-5 on the east side of Quendall Pond. At this well, DNAPL contained 9,900 mg/kg benzene (see Table 4.2-1). The area of high benzene concentrations includes wells at the perimeter of Quendall Pond in all directions (BH-20A, BH-5A, and RW-QP-1), and wellpoints in Lake Washington (WP-19A and WP-19B).

The estimated extent of benzene contamination in shallow groundwater is shown on Figure 5.2-1. Lateral boundaries of benzene contamination exceeding the PRG screening level of 5 µg/L were estimated as follows:

- The southern extent of elevated benzene concentrations in the shallow groundwater interval was based on data from monitoring wells BH-29A (not detected with a 0.2 µg/L detection limit), BH-26A (not detected with a 0.2 µg/L detection limit), and Q17 (not detected with a 0.25 µg/L detection limit). In general, the boundary was estimated at approximately the midpoint between the elevated concentrations in the Former May Creek Channel Area and the non-detect concentrations at wells BH-29, BH-26A, and Q17, or in groundwater grab samples where available (RB3 and RB2; both not detected with a 1 µg/L detection limit). The boundary was adjusted southward in some areas to encompass the maximum DNAPL extent identified using the results of the 2009 RI field investigation. Note that groundwater flow in this area is to the northwest (away from the southern property boundary).
- The northern extent of elevated benzene concentrations in the shallow interval was based on groundwater concentrations below the PRG screening level, supplemented with QA1 quality well or grab sampling data where benzene and/or DNAPL were not detected. These locations include: well BH-27 located north of the Still House (QA1 data; not detected with a 1 µg/L detection limit); well BAX-9 (QA1 data; not detected with a 1 µg/L detection limit) and grab samples SP-BAX9-1 through 3 (not detected with a 0.2 µg/L detection limit), located north of the north sump; and well BH-24 located northeast of Quendall Pond (a 0.4 µg/L). The lack of groundwater contamination around the former pitch bays north of the former Still House is consistent with historical information on the material types—solid tar products (which do not contain benzene; see Section 5.3.1.1)—handled in this area.
- The western extent of elevated benzene concentrations in the shallow groundwater interval was based on three lines of evidence:
  - Benzene concentrations below the MCL at wellpoints WP-21D, WP-19D, and WP-18C (QA1 data).
  - Benzene concentrations below the MCL in porewater collected in subsurface sediment at stations NS-04, NS-07, and NS-12.

  - The predicted western extent of groundwater discharge from contaminated Site intervals (i.e., the Shallow Aquifer and top of the Deep Aquifer), which occurs in nearshore sediment within the Quendall property boundary as described in Section 6.4.2 and shown on Figure 6.4-1.

- The eastern extent of elevated benzene concentrations in the shallow groundwater interval was based on data from the Railroad property investigation (Pinnacle 2009). Benzene was not detected in the Solid Material Loading Area at wells Q12 and Q14 (0.25 µg/L detection limit). The extent of elevated benzene concentrations east of the Tank Car Loading Area was inferred based on the location of historical loading operations and the westerly groundwater flow direction.

5.2.1.1.2 Deep Groundwater Occurrences

Benzene concentrations in the deep groundwater interval exceeded the PRG screening level near the shoreline in an area extending from approximately the former May Creek Channel to Quendall Pond. The highest concentration—1,900 µg/L—was detected at well BH-20B at the southern end of Quendall Pond. Concentrations near the former May Creek Channel were lower (16 µg/L at BH-21B and 80 µg/L at BH-28B). The estimated extent of benzene contamination in deep groundwater is shown on Figure 5.2-2. Lateral boundaries of benzene contamination exceeding the PRG screening level of 5 µg/L were estimated as follows:

- The southern extent was based on non-detect concentrations at wells BH-29B and BH-26B (0.2 µg/L detection limit at each).
- The northern extent was based on benzene not being detected at wells BH-19B (1 µg/L detection limit) and BH-18B (0.2 µg/L detection limit).
- The eastern extent was based on interpolating the midpoint between wells along the shoreline where benzene was detected and well BH-25B, where no benzene was detected (QA1 quality; 1 µg/L detection limit).
- The western extent was based on the areal benzene occurrence in the shallow interval (see Section 5.2.1.1.1) and the estimated upward groundwater flowpath (discharging to Lake Washington) west of the shoreline, not accounting for diffusion or dispersion.

The vertical extent of benzene contamination in the deep groundwater interval was estimated to be less than 110 feet bgs near the shoreline. This vertical boundary was based on the following:

- Benzene was not detected at deep wells BH-20C or BH-30C. Well BH-20C, screened from 112 to 118 feet bgs, is located adjacent to the highest detected benzene concentration at the top of the Deep Aquifer (at BH-20B).
- Groundwater contaminant sources (DNAPL occurrences) are located in the upper 33 feet (see Section 4, including Figure 4.4-5). Extrapolating predicted contaminant flowpaths from contaminant source areas using the groundwater flow model indicates that contamination would remain near the top of the Deep Aquifer, as illustrated on Figures 5.2-4 through 5.2-6. However, spreading due to diffusion and dispersion is likely, and the contaminant fate and transport model (see Section 6.4.2) predicts the vertical extent of the benzene plume to be less than 100 feet bgs.

5.2.1.1.3 Temporal Variability

Since 1988, groundwater has been sampled and analyzed for benzene at many Site wells. Historical benzene concentrations at wells that do not contain DNAPL are shown on Figure 5.2-7. There is no discernible long-term trend in benzene concentrations from 1988 to 2009.

At most Site monitoring wells, significant seasonal variations in benzene concentrations have not been observed. Seasonal variability was evaluated by reviewing the results of sampling several wells in 1989 and 1990 and again during the RI in November 2008 and September 2009. Of the shoreline wells, only BH-18A exhibited a large difference between November 2008 and September 2009, with higher concentrations measured in September 2009; four other wells exhibited a slight decrease in concentration during the same period (Figure 5.2-7). In the sampling that occurred in 1989 and 1990, slightly higher concentrations were observed in June 1989 at three wells (BH-19, BH-21B, and BH-18A) than were observed in other quarters (January 1989, November 1989, and March 1990), and a much higher concentration was observed in June 1989 at one well (BH-20B) than in the other three quarters.

The lack of significant seasonal or long-term trends is likely the result of the presence and Site-wide distribution of DNAPL as the primary source of contamination to groundwater. As described in Section 4.4, DNAPL is largely present at depths greater than 6 feet bgs, and is therefore below the water table year-round. Under this condition, DNAPL is in constant contact with groundwater and leaching of contaminants therefore occurs at a fairly steady rate. Minor seasonal variations observed at the Site may be caused by seasonal differences in groundwater flow rates and dilution from infiltration. The observed trend of slightly higher concentrations in the early summer months could be a result of slower groundwater flow rates (because at that time, recharge is minimal and the lake level is highest, resulting in lower horizontal hydraulic gradients), which would allow more time for contaminants to dissolve into groundwater (i.e., get closer to concentrations in equilibrium between the DNAPL and groundwater). There would also be less dilution from infiltrating stormwater during the drier summer months.

5.2.1.2 Naphthalene

Naphthalene data from samples collected in the shallow and deep groundwater intervals are shown on Figures 5.2-8 and 5.2-9, respectively. Vertical naphthalene distributions in groundwater and soil in three east-west cross sections along the groundwater flowpath are shown on Figures 5.2-10 through 5.2-12.

The PRG screening level for naphthalene in groundwater at this Site is the MTCA Method B groundwater cleanup level of 160 µg/L based on drinking water exposure. (No MCL has been developed for naphthalene.) The highest naphthalene concentrations in groundwater—up to 45,000 µg/L at well Q9—have been detected in the shallow interval within the Tank Car Loading Area on the Railroad property. High concentrations have also been detected in the Former May Creek Channel Area and in the vicinity of Quendall Pond. Detection limits for samples where naphthalene was not detected ranged between 0.04 and 10 µg/L, well below the PRG screening level of 160 µg/L. Naphthalene distributions in the shallow and deep groundwater intervals are discussed below.

5.2.1.2.1 Shallow Groundwater Occurrences

Naphthalene concentrations in the shallow interval are elevated over much of the Site, including areas where DNAPL has been observed. As discussed in Section 4, naphthalene is the dominant component of both coal tar and creosote DNAPL, and areas containing DNAPL also contained naphthalene concentrations in groundwater that exceeded the PRG screening level. The naphthalene concentrations detected in shallow groundwater correspond closely with areas of DNAPL, as follows (Figure 4.4-1 shows the locations of these areas):

- **Western Portion of the Former May Creek Channel Area.** In this area, naphthalene concentrations are highest at well BH-21A (2,100 µg/L) where DNAPL has been observed and at wellpoint WP-21C (4,100 µg/L), immediately downgradient of where DNAPL has been observed. North and south (cross-gradient) of the DNAPL occurrence at well BH-21A, naphthalene concentrations are generally lower than the PRG screening level of 160 µg/L (see Figure 5.2-8), but one concentration (220 µg/L at wellpoint WP-5) slightly exceeded the screening level. WP-5 is located cross-gradient of BH-21A but downgradient of soil boring HC-7, where DNAPL was observed and high naphthalene concentrations (up to 11,000 mg/kg) were detected in soil (see Section 5.3, Figure 5.3-8).
- **Eastern Portion of the Former May Creek Channel/Railroad Loading Area.** In this area, naphthalene concentrations are highest at wells Q9 (45,000 µg/L), where DNAPL has been observed, and BH-25A (11,000 µg/L), immediately downgradient of where DNAPL has been observed. Concentrations of naphthalene in soil in this area are also high (up to 860 mg/kg at Q4, which is adjacent to Q9, and up to 590 mg/kg at TP-5, which is upgradient of BH-25A; see Section 5.3, Figure 5.3-8). Immediately south of the Tank Car Loading Area, at well Q17, the naphthalene concentration is 1.1 µg/L (see Figure 5.2-8). North of the Tank Car Loading Area, in and downgradient of the Solid Material Loading Area, naphthalene concentrations are very low at wells Q12, Q14, and BH-27. Within the Solid Material Loading Area, DNAPL has been observed but naphthalene concentrations are much lower than in other DNAPL areas. Products in this area appear to be higher-molecular-weight products that are less leachable into groundwater.
- **North Sump Area.** In this area, moderate naphthalene concentrations have been detected at wells where DNAPL has been observed (300 µg/L at well BH-23 and 760

µg/L at well RW-NS-1) and immediately downgradient of the observed DNAPL (460 µg/L at well BH-18A).

- **Quendall Pond Area.** Very high naphthalene concentrations have been detected in this area, ranging up to 16,000 µg/L at well BH-5 on the east side of Quendall Pond. At nearby well BH-5, DNAPL contained 180,000 mg/kg naphthalene (see Table 4.2-1). The area of high naphthalene concentrations includes wells at the perimeter of Quendall Pond (BH-20A, BH-5A, and RW-QP-1), and wellpoints in Lake Washington (WP-3, WP-19A, and WP-19B).

The estimated extent of naphthalene contamination in shallow groundwater is shown on Figure 5.2-8. Lateral boundaries of naphthalene contamination exceeding the PRG screening level of 160 µg/L were estimated as follows:

- The southern extent was based on data from wells BH-29A (18 µg/L), BH-26A (not detected with a 0.1 µg/L detection limit), and Q17 (1.1 µg/L). In general, the boundary was estimated at approximately the midpoint between the locations where elevated concentrations were detected in the Former May Creek Channel Area and the wells containing low or non-detect concentrations listed above. The boundary was adjusted southward in some areas to encompass the maximum DNAPL extent identified during the 2009 RI field investigation. Note that groundwater flow in this area is to the northwest (away from the southern property boundary).
- The northern extent was based on the locations of wells or grab samples where naphthalene was not detected above the PRG screening level, and adjusted based on the estimated DNAPL extent. Locations where naphthalene was not detected above the screening level included well BH-27 north of the Still House (not detected with a 10 µg/L detection limit), and wells BAX-9 (22 µg/L)[15] and BH-24 (2.1 µg/L) near the northern property boundary.
- The western extent was based on three lines of evidence:
  - Naphthalene concentrations equal to or below the PRG screening level at wellpoints WP-21D (not detected with a 0.04 µg/L detection limit), WP-28B (160 µg/L), WP-19C (6.1 µg/L), and WP-18B (0.35 µg/L).

[15] Note that grab samples SP-BAX9-1 through -3 north of the north sump had naphthalene detections ranging up to 3.3 µg/L.

  - Naphthalene concentrations below the screening level in porewater samples collected in subsurface sediment (36 to 40 inches below the mudline) at stations NS-04 (0.84 µg/L), NS-08 (8.4 µg/L), and NS-12 (not detected with a 0.83 µg/L detection limit).
  - The predicted western extent of groundwater discharge from contaminated Site intervals (i.e., the Shallow Aquifer and the top of the Deep Aquifer), which occurs in nearshore sediment within the Quendall property boundary as described in Section 6.4.2 and shown on Figure 6.4-1.

- The eastern extent was based on data from the Railroad property investigation (Pinnacle 2009). Very low naphthalene concentrations were detected in the Solid Material Loading Area at wells Q14 (2.7 µg/L) and Q12 (12 µg/L). The extent east of the Tank Car Loading Area was inferred based on the location of historical loading operations and the westerly groundwater flow direction.

5.2.1.2.2 Deep Groundwater Occurrences

Naphthalene concentrations in the deep groundwater interval are elevated near the shoreline in an area extending from approximately the former May Creek Channel to 200 feet north of Quendall Pond. The highest concentration—13,000 µg/L—was detected at well BH-5B on the east side of Quendall Pond. The estimated extent of naphthalene contamination in deep groundwater is shown on Figure 5.2-9. Lateral boundaries of naphthalene contamination exceeding the PRG screening level of 160 µg/L were estimated as follows:

- The southern extent was based on concentrations below the screening level at wells BH-29B (6.4 µg/L) and BH-26B (16 µg/L).
- The northern extent was based on the concentration at well BH-18B (12 µg/L).
- The eastern extent was based on interpolating the midpoint between wells along the shoreline where naphthalene was detected and BH-25B (0.52 µg/L).
- The western extent was based on the maximum areal naphthalene occurrence in the shallow interval (see Section 5.2.1.2.1) and the estimated upward groundwater flowpath (discharging to Lake Washington) west of the shoreline, not accounting for dispersion.

The vertical extent of elevated naphthalene concentrations in the deep groundwater interval is less than 110 feet bgs near the shoreline. This vertical boundary was based on the following:

- Naphthalene was not detected above the PRG screening level at the completion intervals of deep wells BH-20C (56 µg/L) or BH-30C (0.14 µg/L). Well BH-20C (screened 113 to 120 feet deep) is located along the flowpath from the area where the deepest DNAPL source has been identified (at 33 feet at well BH-30C) and the highest concentration of naphthalene has been detected in the shallow interval (45,000 µg/L at well Q9) in the eastern portion of the Site (near the Tank Car Loading Area). Well BH-20C is also located where contaminated groundwater flowing across the Site reaches its deepest extent before discharging upwards to Lake Washington (see Figure 5.2-12 and Section 6.4.2); therefore, this well is a conservative measure of the deepest extent of dissolved-phase Site contamination.
- Groundwater contaminant sources (DNAPL occurrences) are located in the upper 33 feet (see Section 4.4 and Figure 4.4-5). Extrapolating predicted contaminant flowpaths from contaminant source areas using the groundwater flow model indicates that most of the contamination would remain near the top of the Deep Aquifer, as illustrated on Figures 5.2-10 through 5.2-12.[16] However, spreading due to diffusion and dispersion is likely, and the contaminant fate and transport model (see Section 6.4.2) predicts the extent of the naphthalene plume to be less than 100 feet bgs.

5.2.1.2.3 Temporal Variability

Since 1988, groundwater samples from many Site wells have been analyzed for naphthalene. Historical naphthalene concentrations at wells that do not contain DNAPL are shown on Figure 5.2-13. Between 1989 and 1991, seasonal variability was evaluated by sampling during winter, spring, summer, and fall at a number of wells. Some seasonal variability was observed but was not consistent across the Site. The highest naphthalene concentrations at wells BH-20B, BH-21B, and BH18A were detected in a dry month (June), but the highest

[16] These flowlines do not take into account spreading of a contaminant plume via diffusion or dispersion, through which a portion of the contamination can migrate deeper into the Deep Aquifer, as observed by the low concentrations of naphthalene detected at well BH-30C. The potential magnitude of this effect is evaluated using fate and transport modeling in Section 6.4.2.

concentrations at wells BH-19, BH-20A, and BAX9 were detected during wet months (January or March). During the RI field investigation, concentrations at most wells (BH-20B, BH-18A, BH19, and BH-18B) were higher in the dry season (September 2009) than at the beginning of the wet season (November 2008). Naphthalene concentrations detected from 1988 to 2009 have not exhibited a discernible long-term trend.

As with benzene, the lack of significant seasonal or long-term trends for naphthalene in groundwater is likely the result of the widespread presence of DNAPL as the primary source of contamination to groundwater. Most DNAPL is located below the water table, in constant contact with groundwater, and thus leaching of contaminants occurs at a fairly steady rate. The large volume of DNAPL at the Site (see Table 4.4-4) is removed slowly by leaching; therefore, it takes a very long time to observe any appreciable changes in groundwater concentrations due to source degradation.

5.2.1.3 cPAHs

Analytical data for cPAHs (expressed as benzo[a]pyrene toxicity equivalent concentrations; see Section 7.1.2) in the shallow and deep groundwater intervals are shown on Figures 5.2-14 and 5.2-15, respectively.

The PRG screening level for cPAHs (based on benzo[a]pyrene) in groundwater at this Site is the MCL of 0.2 µg/L. cPAHs have been detected in groundwater at concentrations up to 2,800 µg/L (at well Q9) in data of QA1- or better quality.

5.2.1.3.1 Shallow Groundwater Occurrences

Detected cPAH concentrations in groundwater in the shallow interval are strongly correlated with areas where DNAPL has been observed. cPAHs are present in both coal tar and creosote DNAPL, and areas with DNAPL in shallow saturated soil generally also contain cPAHs in shallow groundwater. However, because cPAHs are relatively insoluble (see Section 6.4.2), cPAH mobility in groundwater is much less than that of naphthalene or benzene; therefore, cPAHs extend less distance downgradient of DNAPL source areas than the other indicator chemicals. cPAH concentrations detected in shallow groundwater

correspond closely with areas of DNAPL as follows (Figure 4.4-1 shows the locations of these areas):

- **Western Portion of the Former May Creek Channel Area**. In this area, the highest cPAH concentration was at well BH-21A (25 µg/L) where DNAPL has been observed. At locations where DNAPL has not been observed, cPAH concentrations were not detected or below the PRG screening level of 0.2 µg/L, with the highest concentration detected at wellpoint WP-21C (0.04 µg/L).
- **Eastern Portion of the Former May Creek Channel/Railroad Loading Area**. In this area, the highest cPAH concentration was at well Q9 (2,800 µg/L), where DNAPL has been observed.[17] A lower, but also elevated, cPAH concentration (86.3 µg/L) was detected at well Q4, where DNAPL has also been observed. The cPAH concentration at well BH-25A(R), located just outside and downgradient of the DNAPL area (see Figure 4.4-1), was not detected (at a detection limit of 30 µg/L).
- **North Sump Area.** In this area, cPAHs have been detected at well BH-18A (3 µg/L), just downgradient of the DNAPL in this area. cPAHs were not detected at well RW-NS-1, but detection limits were elevated (20 µg/L) due to the presence of high levels of other detected compounds (e.g., naphthalene).
- **Quendall Pond Area.** In this area, cPAHs were detected at several wells within the area of DNAPL, with the highest concentration of 361.7 µg/L at BH-5. cPAHs were not detected at several locations where high concentrations of other indicator chemicals were detected (RW-QP-1, WP-19A, and WP-19B), but detection limits were elevated (1 µg/L at WP-19A and WP-19B; 100 µg/L at RW-QP-1) due to the presence of other compounds.

The estimated extent of cPAHs in shallow groundwater is shown on Figure 5.2-14. Lateral boundaries of cPAHs exceeding the PRG screening level of 0.2 µg/L were estimated as follows:

- The southern extent was based on the midpoints between the elevated concentrations

[17] Based on the very high cPAH concentration, given that the naphthalene concentration detected was above the solubility limit for naphthalene, and that the well is constructed of small-diameter (0.75-inch) casing and screen, it is possible that the groundwater sample collected from this well contained some portion of DNAPL.

detected in the Former May Creek Channel Area at wellQ4 and BH-21A and non-detect concentrations at well BH-26A and in groundwater grab samples collected at borings RB2 and RB3. This estimated boundary is also consistent with the northwestern groundwater flow direction in this area and the estimated extent of naphthalene and benzene concentrations in shallow groundwater. Because naphthalene and benzene are much more mobile than cPAHs, the extent of these chemicals in groundwater is a conservative estimate of the extent of cPAHs in groundwater. A cPAH concentration of 0.3 µg/L (slightly above the PRG screening level) was detected at well BH-29A; this occurrence appears separate from the occurrence noted at BH-21A, based on analytical results for the groundwater grab samples from borings RB2 and RB3, located between BH-29A and BH-21A.

- The northern extent was based on interpolating between the locations where DNAPL is present and adjacent wells where DNAPL was not detected. These wells include Q14 north of the Solid Material Loading Area, BH-27 north of the Still House, and BAX-9 and BH-24 near the northern property boundary. The estimated boundary is beyond the estimated extent of DNAPL occurrences and similar to the estimated extent of naphthalene and benzene.
- The western extent was estimated based on data collected at wellpoints WP-21D, WP-28B, WP-28A, WP-20B, WP-19D, and WP-18B, and at well BH-28A. In general, cPAHs were not detected in shallow groundwater offshore (see Figure 5.2-14), although detection limits varied in this area.
- The eastern extent was based on data collected at wells Q12 and Q14 on the Railroad property; however, detection limits were elevated (approximately 1 µg/L) at these locations. The eastern extent of the Tank Car Loading Area is inferred based on potential source locations (historical loading operations) and the westerly groundwater flow direction.

5.2.1.3.2 Deep Groundwater Occurrences

The most recent cPAH concentrations detected in deep groundwater are shown on Figure 5.2-15. cPAHs were not detected in the deep groundwater interval during September 2008 and November 2009 sampling events. Detection limits were above 0.1 µg/L for samples

collected from several wells due to the presence of naphthalene, which limited laboratory instrument sensitivity.

5.2.1.3.3 Temporal Variability

Sampling and analysis for cPAHs have been conducted at many Site wells several times since 1989. cPAH concentrations appear to have decreased substantially since January 1989 when detected concentrations ranged from 1.2 to 1,952 µg/L. In January 2001, concentrations at the same wells were typically not detected at the 0.01 µg/L reporting limit and the highest detected concentration was 0.07 µg/L. Sampling events prior to 1996 had elevated detection limits, but those events were conducted using a bailer; this sampling technique often introduces solids into samples and, for chemicals such as cPAHs that adsorb strongly to soil, can result in a high bias (false positives) from contamination associated with suspended solids. Therefore, the cPAH data collected prior to 1996 are of limited use for assessing seasonal or long-term trends.

Since 1996, cPAH groundwater data have been collected using low-flow sampling techniques and are therefore more useful in determining seasonal and long-term trends. No significant seasonal fluctuations or long-term trends in cPAH concentrations in groundwater have been noted, though differences in detection limits between sampling events, and the infrequent detection of cPAHs, complicate assessments of temporal variability.

5.2.1.4 Summary of Coal Tar and Coal Tar Distillate Indicator Chemicals in Groundwater

The available data indicate that benzene, naphthalene, and cPAHs have been detected in groundwater above the PRG screening levels (5 µg/L for benzene, 160 µg/L for naphthalene, and 0.2 µg/L for cPAHs [based on the MCL for benzo(a)pyrene]). As shown on Figure 5.2-21, the extent of cPAHs in shallow groundwater is similar to the extent of DNAPL (see Figure 4.4-1); naphthalene extends slightly further offshore and benzene extends the farthest offshore beneath Lake Washington. The horizontal extents of benzene and naphthalene in deep groundwater are shown on Figure 5.2-22. The vertical extent of coal-tar-related contamination is estimated at less than 100 feet bgs for benzene and naphthalene, which are

mobile and have spread from the DNAPL sources located in the upper 33 feet at the Site. cPAHs have not been detected in the deep groundwater interval.

5.2.2 Indicator Chemical Occurrences for Other Contaminant Sources

Several potential sources of contaminants at the Quendall Site are not related to coal tar or creosote products. Historical contaminant sources are discussed in Section 2 and indicator chemicals for these sources are described in Section 5.1. Potential contaminant sources and associated indicator chemicals in groundwater for contaminants other than coal tar and creosote products include the following:

- Foundry slag (arsenic, chromium, and copper)
- Petroleum products including waste oil (PCBs and copper)
- Herbicides (arsenic)
- Chlorinated tar distillates (PCP)

The following sections discuss the occurrence of arsenic, chromium, copper, and PCP in groundwater at the Site. PCBs were only analyzed in groundwater samples collected in 1989 and 1990, and were not detected. Because PCBs are relatively insoluble in water, they are more likely to adsorb to soil and are discussed in Section 5.3.3.4.

5.2.2.1 Arsenic

Analytical data for arsenic in the shallow and deep groundwater intervals are presented on Figures 5.2-16 and 5.2-17, respectively. Arsenic concentrations in offshore wellpoints ranged from 1 to 6 µg/L, below the PRG screening level (the MCL of 10 µg/L) and consistent with the state-wide natural background level (5 µg/L; PTI 1989). Arsenic concentrations in most Site groundwater monitoring wells ranged from approximately 1 to 14 µg/L, again consistent with natural background concentrations, particularly for groundwater under moderately reducing conditions (as are found in the peaty deltaic soils of the Shallow Aquifer[18]). Higher arsenic concentrations exceeding the PRG screening level (between 21.5 and 389 µg/L) were detected at eight Site wells (BH-5, BH-5A, BH-19, BH-20B, BH-21B, BH-26B, BH-28B, and

[18] Arsenic concentrations in groundwater samples collected from peaty deltaic soils upgradient of the Conner Homes property have ranged up to 28 ug/L (Aspect 2006).

BH-29A), and the highest arsenic concentration in groundwater of 1,690 µg/L was detected on the Railroad property at well Q9. Seven of the nine wells with elevated groundwater arsenic concentrations either contained DNAPL or are located in the vicinity of DNAPL occurrences. Two of the wells with elevated arsenic concentrations, BH-26B and BH-29A, are discussed below.

Elevated arsenic concentrations are also present in shallow groundwater (at depths of less than 25 feet) on the adjacent Conner Homes property to the south. The groundwater arsenic plume at the Conner Homes property extends onto the southwestern corner of the Quendall Site due to the northwesterly direction of groundwater flow in this area. The high arsenic concentration at well BH-29A (389 µg/L) may be part of that plume. The Conner Homes property is being addressed under an Ecology Agreed Order through a combination of soil source removal, groundwater treatment, and monitoring; further information about the property is provided in Section 3.3.1.1.

The estimated extent of arsenic in shallow groundwater is shown on Figure 5.2-16, including the lateral boundaries of arsenic exceeding the PRG screening level of 10 µg/L. In general, the boundaries were based on QA2 quality data obtained from monitoring wells or at wellpoints installed offshore.

The western extent of arsenic in shallow and deep groundwater off the southern shoreline was based on the detected concentrations (6 µg/L) at two wellpoints in this area (WP-5 and WP-6), which were slightly lower than the PRG screening level.

The southern extent of deep arsenic occurrences above the PRG is bounded by well BH-29B to the southwest and BH-17B to the southeast. However, the southern extent is not bounded along the Conner Homes property boundary at well BH-26B, where 31.8 µg/L arsenic was detected. This concentration is less than the concentration detected at BH-21B (104 µg/L), located approximately 330 feet downgradient (northwest) of BH-26B. These exceedances may not be contiguous with the arsenic plumes in shallow groundwater on either the Quendall Terminals or Conner Homes properties, and therefore may be caused by localized

reducing conditions associated with peat deposits in the vicinity of both wells[19] and/or the presence of DNAPL in the vicinity of BH-21B. Groundwater data on and upgradient of the Conner Homes property were provided in the design and construction reports for the groundwater treatment system on the property (Aspect 2006 and Aspect 2007).

Elevated arsenic occurrences in deep groundwater (Figure 5.2-17) are likely due to the greater mobility of naturally occurring arsenic under reducing conditions, which occur in areas of DNAPL and dissolved-phase hydrocarbon contamination. The vertical extent of arsenic contamination at the northern and southern ends of the Site is less than 40 feet bgs, bounded by wells BH-19B (4.5 µg/L) and BH-29B (3 µg/L), respectively. The vertical extent of arsenic contamination is less than 85 feet in the center of the Site based on data from deep wells BH-20C (4.9 µg/L) and BH-30C (1.9 µg/L), where concentrations are lower than the PRG screening level.

5.2.2.2 Chromium

Eighteen groundwater samples collected in September 2009 and 32 samples collected between 1989 and 1991 were analyzed for chromium. The 2009 RI field investigation data are of QA2 quality and earlier data are of QA0 quality. All chromium concentrations were well below the PRG screening level (the MCL of 100 µg/L), and all detection limits were at or below the screening level. Sample locations and data from the most recent sampling event at each location are shown on Figure 5.2-18. The sample locations included wells BH-12 and BH-12A, located adjacent to the slag-like material identified in the 2007 well survey (Anchor and Aspect 2007a) and described in Section 5.3.1.2. Wells BH-20A and BH-20B are located downgradient of the former waste oil storage tanks, and BH-19 and BH-19B are located near the location of slag-like material identified at boring RB10 as described in Section 5.3.1.2.

5.2.2.3 Copper

Eighteen groundwater samples collected in September 2009 and 43 samples collected between 1989 and 1991 were analyzed for copper. The 2009 RI field investigation data

[19] The well log for BH-26B indicates the well is screened across the lower portion of the Shallow Alluvium and the upper portion of the Deeper Alluvium, and that seams of peat, organic silt, and wood were observed in the Shallow Alluvium within the screen interval depth.

collected are of QA2 quality and earlier data are of QA0 quality. All concentrations and all detection limits were well below the PRG screening level for copper (the MCL of 1,300µg/L). Sample locations and data from the most recent sampling event at each location are shown on Figure 5.2-19.

5.2.2.4 PCP

Ninety-six Site groundwater samples have been analyzed for PCP, and PCP has not been detected in Site groundwater. Samples analyzed for PCP have been collected from permanent monitoring wells screened in the shallow and deeper groundwater intervals and from six temporary wellpoints installed and sampled in 1995. Twenty-six groundwater samples of QA2 quality were collected in September 2009, 21 groundwater samples of QA1 quality were collected in 1996, and 49 samples of QA0 quality were collected before 1995. The detection limit for the 1995, 1996, and 2009 samples was generally 5 µg/L, slightly exceeding the PRG screening level (the MCL of 1 µg/L); however, detection limits were higher for samples from wells BH-5 (50 µg/L), BH-5A (25 µg/L), BH-5B (50 µg/L), BH-25A (100 µg/L, last sampled in 1996), BH-25A(R) (50 µg/L), BH-27 (50 µg/L, last sampled in 1995), and RW-QP-1 (15 µg/L) where high concentrations of other organic chemicals (e.g., PAHs) were detected. Sample locations and detection limits are shown on Figure 5.2-20. Wells sampled for PCP included six wells near the shoreline that are downgradient of the former chlorinated tar distillate area: BH-5, BH-5A, BH-5B, BH-20A, BH-20B, and BH-20C.

*5.2.2.5 **Summary of Indicator Chemical Occurrences for Other Contaminant Sources***

The available RI field investigation data indicate that with the exception of arsenic, indicator chemicals for contaminant sources other than coal tar and its products either have not been detected in groundwater (PCP and PCBs) or have been detected at concentrations below the PRG screening levels (100 µg/L for chromium and 1,300 µg/L for copper).

On the Quendall property, most arsenic concentrations were lower than the PRG screening level (10 µg/L) and consistent with the state-wide background level of 5 µg/L. As shown on Figure 5.2-21, the horizontal extent of arsenic contamination in shallow groundwater is in areas of the Site associated with, or immediately downgradient from, DNAPL occurrences.

Elevated arsenic concentrations are also present in shallow groundwater on the adjacent Conner Homes property to the south. The horizontal extent of arsenic (along with coal tar and coal tar distillate indicator chemicals) in deep groundwater is shown on Figure 5.2-22. The vertical extent of arsenic contamination is estimated at less than 40 feet bgs at the northern and southern ends of the Quendall Site and at less than 85 feet bgs in the center of the Site, based on concentrations in Site wells that were lower than the PRG screening level.

5.3 Nature and Extent of Soil Contamination

Site soil has been contaminated by historical fill materials, historical NAPL and/or aqueous waste releases, and as the result of contaminated groundwater migration. Historical contaminant sources are discussed in Section 2. Potential soil contamination sources and associated indicator chemicals include:

Key Points for Soil Contamination

- Soil at the Quendall Site has been contaminated by coal tar and coal tar distillates, among other sources.
- The extent of indicator chemicals exceeding PRG screening levels is consistent with observed DNAPL distribution.
- Soil contaminant boundaries are defined by soil quality data and the extent of groundwater contamination.
- Site soil is also a source of groundwater contamination (see Sections 5.2 and 6).

- Fill materials:
  - Solid tar products (cPAHs)
  - Foundry slag (arsenic, chromium, and copper)
- Coal tar and coal tar distillates (benzene, naphthalene, and cPAHs)
- Other potential sources:
  - Herbicides (arsenic)
  - Petroleum products including waste oil (PCBs and copper)
  - Chlorinated tar distillates (PCP)

The distribution of indicator chemicals in Site soil is summarized in this section. Historical soil sample locations are shown on Figure 5.3-1. As discussed in the introduction to Section 5, QA2 and QA1 quality chemical data were used to characterize the nature and extent of Site soil contamination, but QA0 quality data were only selectively used to qualitatively verify soil contaminant occurrences and trends. On the applicable figures referenced in this Section 5.3, data of QA0 quality are differentiated by a pentagon symbol.

Statistical summaries of soil data collected on the Quendall and Railroad properties are provided in Appendix I. Statistical summaries limited to indicator chemicals in surface and subsurface soil samples collected on the Quendall and Railroad properties are provided in Tables 5.3-1 through 5.3-4.

The spatial and temporal representativeness of Site soil characterization data is discussed below for each indicator chemical and its associated likely historical contaminant sources. In addition to soil quality data, the presence or absence of DNAPL and the distributions of groundwater contaminants are important indicators of the nature and extent of soil contamination. DNAPL distribution is discussed in Section 4, and groundwater contaminant distributions are discussed in Section 5.2. Relevant figures from those sections are referenced in this Section 5.3 where applicable.

For each indicator chemical, spatial distributions on the Quendall and Railroad properties are discussed separately because the two properties have been characterized in separate investigations and the future uses of these properties will also likely be different. Chemical distributions are also discussed separately for surface soil and subsurface soil. For the purposes of this RI, surface soil was defined as soil that is currently present from 0 to 5 feet bgs and subsurface soil was defined as soil at depths greater than 5 feet bgs. The 5-foot depth threshold for surface soil was based on an initial evaluation of the maximum depth of potential exposure for human or ecological receptors under current conditions, also recognizing that future Site development will likely result in additional fill material placement above the current grade (similar to the recent Conner Homes property development at the former Barbee Mill property to the south).

Extensive soil sampling was recently completed on the Railroad property as part of the Port of Seattle's due diligence to purchase the property; these data (Pinnacle 2009) have been incorporated into this RI. On the Quendall property, data from sampling performed during previous investigations are adequate for the purposes of this RI when used collectively with the extensive delineation of DNAPL, as described in Section 4, and the delineation of contaminated groundwater described in Section 5.2. Groundwater occurs at shallow depths and has been contaminated to levels exceeding PRG screening levels due to releases from DNAPL and DNAPL-impacted soil. Thus, the spatial extents of Site subsurface soil, DNAPL, and groundwater contamination are closely related.

The existing surface soil data were considered adequate for the purposes of this RI when considering the following:

- Limited soil sampling and analysis have shown that indicator chemicals exceed PRG screening levels in most areas of the Site.
- Future Quendall property redevelopment will require at least several feet of fill to match the adjacent property grades and install a gravity sewer system.
- Recent log sorting yard operations deposited a significant quantity of wood debris that is not representative of prior industrial activities. Redevelopment plans will likely require that this material be removed or graded prior to paved road construction, to minimize the potential for future settlement.
- Based on cleanup actions implemented at similar sites, it is expected that the final Site cleanup action will include capping of almost the entire Quendall property. In limited areas where a cap may not be placed (e.g., near the shoreline in aquatic habitat or wetland mitigation areas), additional focused surface soil sampling and any necessary corrective actions can be specified as part of the remedial design.

In addition to the indicator chemicals for soil listed previously, contaminant occurrences in soil are indicated by visual identification of tar products, slag, and DNAPL. DNAPL occurrences are discussed in Section 4. Solid and semi-solid tar product and slag occurrences are discussed below.

The remainder of Section 5.3 addresses soil contamination from fill materials (Section 5.3.1), coal tar and coal tar distillates (Section 5.3.2), and other potential sources (Section 5.3.3). The discussion of potentially contaminated fill materials (Section 5.3.1) addresses the occurrence and chemistry (if present) of solid tar products (containing cPAHs) and foundry slag. The discussion of soil contamination from coal tar and coal tar distillates (Section 5.3.2) addresses the indicator chemicals benzene, naphthalene, and cPAHs on the Quendall and Railroad properties in surface soil (up to 5 feet bgs) and subsurface soil (greater than 5 feet bgs). The discussion of contamination from other potential sources (Section 5.3.3) addresses the nature and extent of the indicator chemicals arsenic, chromium, PCBs, and PCP on the Quendall and Railroad properties.

5.3.1 Potentially Contaminated Fill Materials

Potentially contaminated materials historically used as Site fill include foundry slag and heavy tar distillates such as pitch and Saturday Coke that are solid or semi-solid. Semi-solid materials are very-high-viscosity products that do not flow through porous media such as soil (e.g., the highly viscous tar material that, during the RI field investigation, was observed slowly [over the course of an hour] flowing down the sidewall of trench T-7; see Figure 4.2-1). Because semi-solid tar products are too viscous to migrate in the subsurface through soil, they are discussed for the purposes of this RI with the solid-phase materials and not as DNAPL.

Contaminated fill materials have generally been identified in the subsurface based on visual identification during soil sampling. These fill materials occur as a separate phase (e.g., the thin [less than 1-inch thick] seam of very viscous tar material at trench T-7, or the "pitch fragments" observed at boring B-5). Contaminated fill material occurrences are described below.

5.3.1.1 Solid and Semi-Solid Tar Products

Solid- and semi-solid-phase contaminated fill materials related to creosote production (e.g., pitch and coke) contain primarily HPAHs. A sample containing solid tar products collected from near the pitch bays (at test pit TP-2 [see Figure 5.3-1] at a depth of 3.5 to 4 feet) revealed that cPAHs comprised approximately 90 percent of the total concentration of PAHs (compared with less than 10 percent cPAHs [as represented by chrysene in Table 2.1-1] for coal tar and creosote). The naphthalene content was less than 0.5 percent of the total PAHs, compared with the detected composition of 5 to 14 percent naphthalene in Site coal tar and creosote DNAPL samples (see Section 4.2.2).

Analysis of two semi-solid tar products from the former May Creek Channel indicated that the composition of these products correlated with their apparent viscosity. The most viscous (i.e., stiffest) product, in a tar sample from trench T-7 (T7 UKM; the location of the trench is shown in Figure 2.3-1) was composed primarily of HPAHs (of the total concentration for analyzed PAHs, approximately 75 percent were cPAHs) and contained only 0.36 percent naphthalene. A slightly less viscous, but still semi-solid, tar sample from trench T-7

(T7 TAR) contained higher concentrations of several LPAHs, including approximately 2 percent by weight naphthalene (see Table 4.2-1).

Locations where potentially contaminated fill materials have been identified are shown on Figure 5.3-2. Fill areas with the potential to contain solid tar products include the areas around the pitch bays where pitch was cooled, and areas west of the pitch bays toward the shoreline, where Saturday Coke (solid material chiseled out of the stills on Saturdays) was reportedly placed (CH2M HILL 1983; Hart Crowser 1994). These areas correspond to where the majority of the contaminated fill materials have been observed (see Figure 5.3-2). Semi-solid tar products have been observed in the former May Creek Channel, adjacent to the former storage tanks near the Railroad Loading Area, where the residues from tank bottoms were reportedly placed.

Because solid and semi-solid tar products are not mobile, their distribution is limited to the Site locations where they were placed. The vertical extent of Site solid and semi-solid tar products is limited to the shallow Fill Unit, which extends up to 10 feet in depth. Solid and semi-solid tar products are typically only present above the water table, but may occur within areas that are seasonally saturated; however, because of their low leachability, these products are not expected to be significant contributors to groundwater contamination (see Section 6.2.2).

5.3.1.2 Slag

Roberts originally reported that PACCAR-foundry slag was used as Site fill, indicating that these materials may have been placed northwest of the large tank farm in the vicinity of Quendall Pond (CH2M HILL 1983); however, during two other interviews, Roberts reported that these materials were placed southwest of the tank farm (Ecology 1989; Hart Crowser 1994). With very limited exceptions, previous environmental explorations in these areas did not identify any potential slag materials, either visually or in chemical analysis; however, slag-like material was noted in the Fill Unit from a depth of 3.2 to 4 feet at one soil boring (RB10) near Quendall Pond. Also, during the 2007 well survey, three pieces of slag-like material were identified in near-surface soil southwest of the former tank farm, near the former location of boring BH-12 (Anchor and Aspect 2007a).

5.3.2 Coal Tar and Coal Tar Distillate Indicator Chemical Occurrences

As discussed above, coal tar and creosote indicator chemicals include benzene, naphthalene, and cPAHs. These chemicals have been identified in soil (as well as other media) over much of the Site. Data for each indicator chemical and an assessment of data usability for characterizing the nature and extent of contaminants are presented below. Indicator chemical distributions in soil are presented separately for the Quendall property and Railroad property. Significant surface soil disturbances have occurred on the Quendall property since plant shutdown, including fill placement and wood debris deposition from a log operation. These changes likely affected the distribution of indicator chemicals in surface soil. Comparatively few surface soil disturbances have occurred on the Railroad property near the loading docks.

5.3.2.1 Benzene

Benzene concentrations in soil are shown on Figures 5.3-3 through 5.3-6 for depth intervals of 0 to 5 feet bgs (surface soil) and 5 to 15 feet, 15 to 25 feet, and greater than 25 feet bgs (subsurface soil), respectively. The PRG screening level for benzene in soil at this Site is the EPA RSL for Resident Soil of 1.1 mg/kg. The distributions of benzene in surface soil and subsurface soil on the Quendall and Railroad properties are discussed below.

5.3.2.1.1 Surface Soil

Benzene was analyzed for in 17 surface soil samples from the Quendall property (Table 5.3-1a). Benzene was not analyzed for in surface soil samples from the Railroad property.

Benzene was detected in one of 17 soil samples from the 0-to-5-foot depth interval, at a concentration of 1.8 mg/kg (Figure 5.3-3). This 1995 QA1 quality sample, collected at boring HC-5, was obtained from a depth of 2.5 to 4 feet bgs. A QA2 quality sample was collected at approximately the same location in 2004 at a depth of 1.5 feet, although benzene was not detected in this sample (detection limit 0.0067 mg/kg). During that 2004 sampling event, a total of 11 QA2 quality surface soil samples from a depth of 1.5 feet were collected for benzene analysis. Benzene was not detected in any of those samples (detection limits ranged from 0.0057 to 0.14 mg/kg), and all 11 samples had detection limits below the PRG screening

level of 1.1 mg/kg. In Site areas where former log yard operations caused surface soil disturbances, the 2004 data are considered most representative of current surface soil conditions. Benzene concentrations in surface soil (less than 5 feet bgs) are low and generally non-detect (see Figure 5.3-3), likely due to Site fill placement in 1983 after the plant was shut down (see Section 3.1.4.1).

5.3.2.1.2 Subsurface Soil

Benzene was analyzed for in 25 subsurface soil samples from the Quendall property (Table 5.3-3a) and 29 subsurface soil samples from the Railroad property (Table 5.3-4). A summary of the data quality and the occurrence of benzene in subsurface soil at the Quendall and Railroad properties is presented below.

Quendall Property

Soil data for benzene collected at the Quendall property in 1995 and 2001 at depths greater than 5 feet are of either QA1 or QA1- quality. These data conservatively represent current conditions because although this soil has not been disturbed, weathering of the volatile fractions may have occurred.

In general, benzene concentrations in subsurface soil are highest at depths between 5 and 25 feet bgs, as shown on Figures 5.3-4 and 5.3-5. This is the interval where the majority of DNAPL occurs (see Section 4.4 and Figure 4.4-5). The highest benzene concentration in soil (4.8 mg/kg at a depth of 18 feet at boring RB9; see Figure 5.3-5) was located near Quendall Pond, which is the Site area where the highest benzene concentrations have been detected in both groundwater (see Figure 5.2.1) and DNAPL (see Table 4.2-1). Lower benzene concentrations have been observed in soil in the eastern portion of the property, at borings HC-2 and HC-4, which also corresponds to areas of lower benzene concentrations in groundwater (see Figure 5.2.1).

The extent of benzene in subsurface soil is generally delineated by the extent of DNAPL (see Section 4.4) and groundwater contamination (see Section 5.2). The extent of subsurface soil benzene contamination is delineated by the extent of benzene in groundwater (discussed in Section 5.2.1.1 and illustrated on Figures 5.2-1 and 5.2-2). Relatively high benzene

concentrations in soil are also correlated with the presence of DNAPL products (e.g., the sample at boring RB9 noted above or at HC-7, where 4.4 mg/kg benzene was detected in the 5-to-15-foot depth interval; see Figure 5.3-4). Lower benzene concentrations in soil, still exceeding the PRG screening level, have been detected at locations where DNAPL is not present (e.g., at boring RB21, where 0.5 mg/kg benzene was detected at 42 to 44 feet deep; see Figure 5.3-6), but are located within the deep groundwater plume (see Figure 5.2-2).

Railroad Property

Soil data for benzene collected at the Railroad property in 2009 are of QA2 quality. The highest detected benzene concentration in this area was less than the PRG screening level of 1.1 mg/kg (0.75 mg/kg), at a depth of 15 feet at boring Q4 (Figure 5.3-4).

5.3.2.2 Naphthalene

Naphthalene concentrations in soil at depth intervals of 0 to 5 feet, 5 to 15 feet, 15 to 25 feet, and greater than 25 feet bgs are shown on Figures 5.3-7 through 5.3-10, respectively. The PRG screening level for naphthalene in soil at this Site is the EPA RSL for Resident Soil of 3.6 mg/kg. The distributions of naphthalene in surface and subsurface soil on the Quendall and Railroad properties are discussed below.

5.3.2.2.1 Surface Soil

Naphthalene was analyzed for in 39 surface soil samples from the Quendall property (Tables 5.3-1a and 5.3-1b) and 44 surface soil samples from the Railroad property (Table 5.3-2). A summary of the data quality and the occurrence of naphthalene in surface soil at the Quendall and Railroad properties is presented below.

Quendall Property

Naphthalene was detected above the PRG screening level (3.6 mg/kg) in the 0-to-5-foot depth interval at three of 15 locations where QA1- or better-quality data were collected. Two locations, SS-BH-9 and HC-5, were adjacent to the former Still House in the eastern portion of the Site, and the third, TP-2, was located east of the former pitch bays (Figure 5.3-7). The highest concentration detected in surface soil was 2,900 mg/kg, collected at HC-5 from the 2.5-to-4-foot depth interval in 1995 (QA1 quality). A sample was collected from

approximately the same location in 2004 at the 0-to-3-foot depth interval and exceeded the PRG screening level at a lower concentration (37 mg/kg; QA2 quality). During that 2004 sampling event, a total of 11 QA2 quality samples collected from the 0-to-3-foot depth interval were analyzed for naphthalene. In areas that were subject to surface soil disturbance from former tenant operations, the 2004 data are most representative of current surface soil conditions.

Very few naphthalene concentrations in surface soil exceeded the PRG screening level, probably because relatively clean fill was placed on the Site in 1983 after the plant was shut down (see Section 3.1.4.1).

Railroad Property

The highest naphthalene concentration in surface soil on the Railroad property (260 mg/kg) was detected in two samples, collected at a depth of 1 foot at borings Q1-A and Q1-B in the Solid Material Loading Area. These samples were collected from soil containing solid tar products. Naphthalene concentrations in eight additional surface soil samples from the Railroad property exceeded the PRG screening level of 3.6 mg/kg. In contrast to the Quendall property, where considerable surface soil changes (e.g., fill placement and wood debris deposition) have occurred since industrial operations ceased, there has been little surface soil disturbance on the adjoining Railroad property.

5.3.2.2.2 Subsurface Soil

Naphthalene was analyzed for in 72 subsurface soil samples from the Quendall property (Tables 5.3-3a and 5.3-3b) and 51 subsurface soil samples from the Railroad property (Table 5.3-4). A summary of the data quality and the occurrence of naphthalene in subsurface soil at the Quendall and Railroad properties is presented below.

Quendall Property

Data for naphthalene concentrations in soil collected at depths greater than 5 feet are of QA0, QA1, or QA1- quality and were collected from 1988 to 1991 by Woodward Clyde, in 1995 by Hart Crowser, and in 2001 by Retec. The QA1- or better-quality soil data are representative of current conditions because: 1) this soil has not been disturbed, and DNAPL

presence provides a long-term naphthalene source; and 2) QA0 quality data collected from 1988 to 1991 correlates well with field observations, with the high naphthalene concentrations detected at borings where DNAPL was observed (e.g., BH-23). As discussed in Section 4.4, QA0 quality data were used as a line of evidence in identifying DNAPL occurrences but were not used to define boundaries when assessing the nature and extent of chemical contamination.

Similar to benzene, the highest concentrations of naphthalene in soil on the Quendall property are consistent with the presence of DNAPL, both vertically and laterally, and are highest at depths between 5 and 25 feet. The areal and vertical DNAPL distributions are illustrated on Figures 4.4-1 and 4.4-5, respectively. The highest concentration (11,000 mg/kg, at boring HC-7 at a depth of 12.5 to 14 feet; Figure 5.3-8) was in a sample containing DNAPL from the former May Creek Channel.

Lower concentrations of naphthalene in soil have been detected at locations where DNAPL is not present (e.g., at boring RB21, where 0.46 mg/kg was detected at 42 to 44 feet deep; see Figure 5.3-10) within the deep groundwater plume (see Figure 5.2-9). As discussed in Section 5.2.1, the vertical extent of naphthalene in subsurface soil is delineated by its vertical extent in groundwater. Naphthalene concentrations in soil located outside areas of DNAPL occurrences (including all five samples collected at depths below 25 feet) were below the PRG screening level of 3.6 mg/kg (Figure 5.3-10).

Railroad Property

Naphthalene was detected in 35 of 51 subsurface soil samples of QA2 quality from the Railroad property. Naphthalene concentrations exceeding the PRG screening level are summarized as follows:

- At four borings in the Tank Car Loading Area: Q2-C (180 mg/kg at 13 feet); Q2-D (50 mg/kg at 10 feet, 17 mg/kg at 13 feet, and 190 mg/kg at 18 feet); Q4 (860 mg/kg at 15 feet); and Q9 (860 mg/kg at 18 feet and 58 mg/kg at 25 feet). At each location (except Q9) where the PRG screening level was exceeded, at least one deeper sample was collected that did not exceed the screening level.[20]

[20] Naphthalene was detected at 28 feet in Q9, just above the PRG screening level of 3.6 mg/kg.

- At five borings in the Solid Material Loading Area: Q1-D (16 mg/kg at 9 feet and 20 mg/kg at 15 feet); Q6 (960 mg/kg at 18 feet); Q7 (160 mg/kg at 5.5 feet and 66 mg/kg at 9 feet); Q14 (32 mg/kg at 6.5 feet); and Q11 (48 mg/kg at 11.5 feet). At each location where the PRG screening level was exceeded, a deeper sample was collected that did not exceed the screening level.

Elevated subsurface soil naphthalene concentrations correlated with locations and depth intervals where DNAPL was observed and were generally limited to the 5-to-15-foot depth interval in the Solid Material Loading Area and the 5-to-25-foot depth interval in the Tank Car Loading Area. These are consistent with the depth intervals where DNAPL was observed in these areas (see Figure 4.4-5).

5.3.2.3 cPAHs

cPAH concentrations in soil (as benzo[a]pyrene equivalents) at depth intervals of 0 to 5 feet, 5 to 15 feet, 15 to 25 feet, and greater than 25 feet bgs are shown on Figures 5.3-11 through 5.3-14, respectively. The PRG screening level for cPAHs in soil at this Site is the EPA RSL for Resident Soil of 0.015 mg/kg (based on benzo[a]pyrene). The distributions of cPAHs in surface and subsurface soil on the Quendall and Railroad properties are discussed below.

5.3.2.3.1 Surface Soil

cPAHs were analyzed for in 28 surface soil samples from the Quendall property (Tables 5.3-1a and 5.3-1b) and 44 surface soil samples from the Railroad property (Table 5.3-2). A summary of the data quality and the occurrence of cPAHs in surface soil at the Quendall and Railroad properties is presented below.

Quendall Property

cPAHs were detected above the PRG screening level of 0.015 mg/kg in the 0-to-5-foot depth interval at 12 of 13 locations where QA1- or better-quality data were collected. The highest cPAH concentration (benzo[a]pyrene equivalent) in surface soil was 200 mg/kg, collected at TP-2 from the 3.5 to 4-foot depth interval in 1995 (QA1- quality). A sample was collected from the 0-to-3-foot depth interval at approximately the same location in 2004 and exceeded the PRG screening level at a lower concentration (3.9 mg/kg; QA2 quality). During that

2004 sampling event, a total of 11 surface soil samples of QA2 quality collected from the 0-to-3-foot depth interval were analyzed for cPAHs, and the highest cPAH concentration was 48 mg/kg at SS-BH-9. In areas that were subject to surface soil disturbance from former tenant operations, the 2004 data are most representative of current surface soil conditions.

Railroad Property

Forty-four surface soil samples (from the 0-to-5-foot depth interval) of QA2 quality collected from the Railroad property were analyzed for cPAHs. The highest concentration (850 mg/kg benzo[a]pyrene equivalent) was detected at boring Q1-A in the Solid Material Loading Area. The highest concentration detected in the Tank Car Loading Area was 300 mg/kg at boring Q2-D. The highest cPAH concentrations appear to be associated with solid tar products observed in surface soil throughout the Solid Material Loading Area. cPAHs exceeded the PRG screening level in Railroad property surface soil samples collected more than 1,000 feet north of the Site, indicating that surficial PAH contamination may be common along the former railroad alignment.

5.3.2.3.2 Subsurface Soil

cPAHs were analyzed for in 77 subsurface soil samples from the Quendall property (Tables 5.3-3a and 5.3-3b) and 51 surface soil samples from the Railroad property (Table 5.3-4). A summary of the data quality and the occurrence of cPAHs in subsurface soil at the Quendall and Railroad properties is presented below.

Quendall Property

Similar to naphthalene occurrences, the highest cPAH concentrations (up to 970 mg/kg benzo[a]pyrene equivalent at boring HC-7, 12.5 to 14 feet deep) were located in areas and depth ranges where DNAPL has been observed, such as in the former May Creek Channel, around the former Still House, near the north sump, and near Quendall Pond.

Detected cPAH concentrations and detection limits for non-detect samples generally exceeded the PRG screening level of 0.015 mg/kg. Two exceptions, where cPAHs were not detected and detection limits were below the screening level, were in samples from borings

RB6 (depth of 44 feet; Figure 5.3-14) and RB21 (depth of 42 to 44 feet; Figure 5.3-14). These borings were located along the shoreline just south of Quendall Pond.

Similar to the benzene and naphthalene distributions summarized above, cPAH concentrations in soil on the Quendall property were highest at depths between 5 and 25 feet bgs where DNAPL has been observed. Concentrations at depths less than 5 feet bgs were lower but still significantly exceeded the PRG screening level. No cPAHs were detected in nine soil samples collected from depths greater than 25 feet bgs.

Railroad Property

Fifty-one subsurface soil samples (from greater than 5 feet bgs) of QA2 quality were analyzed for cPAHs. The highest detected concentration was 190 mg/kg at boring Q6 (18 feet) between the Solid Material and Tank Car Loading Areas. In the Solid Material Loading Area, cPAH concentrations in soil decreased with depth and, except for one sample (at Q1-D), did not exceed the PRG screening level at depths greater than 15 feet. All samples in the Solid Material Loading Area were below the PRG screening level at depths greater than 25 feet. In general, the highest cPAH concentrations in the Solid Material Loading Area subsurface soil correspond to intervals of observed DNAPL shown in Figure 4.4-5.

In the Tank Car Loading Area, concentrations exceeding the PRG screening level were detected at several locations to a depth of 25 feet bgs. cPAHs were not detected in six samples collected at depths greater than 25 feet bgs, although the detection limits (up to 0.06 mg/kg) slightly exceeded the screening level (0.015 mg/kg). The highest concentration of 130 mg/kg was detected at a depth of 18 feet bgs in boring Q9. Concentrations decreased significantly at depths below 25 feet bgs. In general, the highest cPAH concentrations in the Tank Car Loading Area correspond to intervals of observed DNAPL shown in Figure 4.4-5.

5.3.2.4 Summary of Coal Tar and Coal Tar Distillate Indicator Chemicals in Soil

High soil concentrations of benzene, naphthalene, and cPAHs have been detected in the former May Creek Channel, near the Still House, near Quendall Pond, and in the Railroad Loading Area and are strongly correlated with DNAPL or solid tar products. In areas of solid

tar products, benzene concentrations were typically low or non-detect and cPAH concentrations were typically higher than naphthalene concentrations. At some locations with DNAPL occurrences, benzene was not detected or was detected at very low concentrations. These results are consistent with the composition of creosote compared with coal tar, as discussed in Section 4.2.

Concentrations of coal tar and creosote constituents typically exceeded PRG screening levels in soil where DNAPL or solid tar products were present. Outside these areas, the extent of elevated benzene and/or naphthalene concentrations in soil corresponds to areas of groundwater contamination (see Section 5.2). Indicator chemical concentrations were relatively low or non-detect south of the former May Creek Channel, north of the Quendall Pond/North Sump Area (beyond the DNAPL extent), and in soil deeper than 30 feet bgs. The extent of soil contamination from coal tar and creosote constituents is based on multiple lines of evidence, and the lateral and vertical extents are summarized as follows:

- Coal tar and creosote constituents in soil at the Quendall property extend west to the Lake Washington shoreline. These compounds extend beyond the shoreline in sediment, as discussed in Section 5.4.
- The extent of coal tar and creosote constituents in subsurface soil does not extend onto the neighboring properties north and south of the Quendall property based on the boundaries of groundwater contamination, as discussed in Section 5.2.1.
- Contamination that may be present in surface soil on adjacent properties to the north and south has been addressed by cleanup actions implemented under Ecology oversight in accordance with current uses. Remediation activities at the former Barbee Mill site (now the Conner Homes property) to the south included excavation of contaminated soil and installation of a groundwater treatment wall, and activities at the Football Northwest property to the north included excavation and in-situ stabilization of contaminated soil. Integrated cleanup and redevelopment actions at both of these properties resulted in capping or covering of contaminated soil with several feet of clean fill, along with institutional controls such as recorded covenants restricting subsurface work and groundwater extraction.
- Coal tar and creosote constituents are present in Railroad property surface and subsurface soil, as follows:

- In surface soil, some constituents (primarily cPAHs) extend far north of the Site and are likely present as a result of general railroad operations, based on the results of the Railroad property investigation (Pinnacle 2009). The highest constituent concentrations on the portion of the Railroad property adjacent to the Quendall property have been detected in the vicinity of former loading areas, and the highest cPAH concentrations are associated with solid tar products observed in surface soil. Because of their low mobility, the solid tar product boundaries are assumed to be close to the identified loading areas.
- In subsurface soil, elevated concentrations are typically associated with DNAPL or tar products observed in the vicinity of the former railcar loading racks, and sampling data collected in these areas generally bound the contamination area exceeding the PRG screening levels. The estimated eastern extent of soil contamination is similar to the estimated extent of DNAPL because potential migration pathways of contaminants from DNAPL-impacted soil are to the west (i.e., transport of contamination through groundwater would occur in the direction of groundwater flow, which is to the west towards the Quendall property).

- The maximum vertical extent of coal tar and creosote constituents in soil was delineated based on the vertical extent of these constituents measured in groundwater. These constituents are below the PRG screening levels at deep wells BH-20C (located on the western side of the Site, screened 113 to 120 feet bgs) and BH-30C (located on the eastern side of the Site, screened 85 to 95 feet bgs). Consistent with these empirical data, the contaminant fate and transport model (see Section 6.4.2) also predicts the extent of the dissolved-phase plume to be less than 100 feet bgs.

5.3.3 Other Potential Source Indicator Chemical Occurrences

Indicator chemical occurrences for potential sources not related to coal tar or coal tar products are discussed in the following sections. In contrast to coal tar product indicator chemicals, indicator chemicals for other potential sources have generally not been detected on the Quendall Site or, in the case of naturally occurring substances such as metals, have been detected at concentrations below PRG screening levels or close to natural background

concentrations. Section 5.1 describes the indicator chemical PRG screening levels for assessing the nature and extent of contamination. Data for each indicator chemical (arsenic, chromium, copper, PCBs, and PCP) and an assessment of data usability for assessing the extent of occurrences are presented below. Summaries of soil data statistics for QA0, QA1, and QA2 quality data on the Quendall and Railroad properties are provided in Tables 5.3-1 through 5.3-4.

5.3.3.1 Arsenic

Arsenic is a potential indicator chemical for the herbicide sodium arsenate and for foundry slag. Sodium arsenate was reportedly used at the Site for weed control and foundry slag was reportedly placed as fill near the shoreline southwest and/or northwest of Tank 26. Data for arsenic in soil on the Quendall and Railroad properties are summarized below.

5.3.3.1.1 Surface Soil

Arsenic was analyzed for in eight surface soil samples from the Quendall property (Table 5.3-1a) and 44 surface soil samples from the Railroad property (Table 5.3-2). A summary of the data quality and the occurrence of arsenic in surface soil at the Quendall and Railroad properties is presented below.

Quendall Property

All available arsenic surface soil data were collected in 1995 and are characterized as QA1-quality. Of the eight samples, four contained concentrations at or below the Puget Sound area 90th percentile background concentration of 7.3 mg/kg (Ecology 1994) and seven contained concentrations at or below the MTCA Method A residential cleanup level of 20 mg/kg) (Chapter 173-340 WAC). The highest arsenic concentration (31 mg/kg) was detected at boring HC-5.

The average arsenic concentration in surface soil samples (from less than 5 feet bgs) was 8.8 mg/kg. The concentrations ranged from 0.2 to 31 mg/kg. Most of the surface soil samples were collected from depth intervals of 1 to 3 feet or 2.5 to 4 feet. Because approximately 1 to

3 feet of fill was placed across the Site after facility operations ceased,[21] these sample intervals may represent soil that was at or near the surface when the facility was operational and thus is most likely to have been impacted by herbicide application.

Focused soil sampling for arsenic was performed in areas of suspected slag occurrences. In 1995, two samples (of QA1 quality) were collected in the southern area at boring BH-28 (approximately 100 feet north of the location near BH-12 where slag was noted during the 2007 well survey [Anchor and Aspect 2007a]). Two additional samples (of QA1 quality) were collected in 1995 in the northern area: one at TP-4 and one at TP-1. These locations are approximately 50 and 150 feet south, respectively, of boring RB10, in which slag was noted during an investigation in 2001 (Retec 2001). These soil samples were collected at shallow depths within the fill materials. Arsenic concentrations in these samples ranged from 3.3 to 12.9 mg/kg, with an average concentration of 7 mg/kg. These values are consistent with the Site-wide average and range of arsenic concentrations.

Railroad Property

Forty-four surface soil samples (of QA2 quality) collected from the Railroad property were analyzed for arsenic. Of those, 15 samples exceeded the Ecology background concentration of 7.3 mg/kg. The highest concentration of 110 mg/kg was detected at boring Q1A at a depth of 1 foot bgs. Two other samples exceeded the MTCA Method A cleanup level of 20 mg/kg: from borings B1-B at a 1-foot depth (30 mg/kg) and Q12 at a 4.5-foot depth (25 mg/kg). These elevated arsenic concentrations were also co-located with elevated lead concentrations. Moreover, the sample from boring B1-B was collected on the Railroad property approximately 1,000 feet north of the Quendall property. Thus, elevated arsenic concentrations in soil within the Railroad property appear distinct from contamination resulting from operations associated with the Quendall property (i.e., they are potentially associated with railroad ballast fill or historical spraying of lead arsenate by the railroad to control weeds).

[21] Ground surface elevation contours in 1975 compared to the present day (see Figure 3.1-1a) indicate a similar fill thickness. In 1975 a number of tanks were still present and it is assumed that the surface elevation over much of the Site at that time was similar to the grade during Site operations. Aerial photographs from 1936 onward do not indicate evidence of significant fill activities.

5.3.3.1.2 Subsurface Soil

Arsenic was analyzed for in 15 subsurface soil samples from the Quendall property (Table 5.3-3a) and 48 subsurface soil samples from the Railroad property (Table 5.3-4). A summary of the data quality and the occurrence of arsenic in subsurface soil at the Quendall and Railroad properties is presented below.

Quendall Property

All available arsenic subsurface soil data were collected in 1995 and are characterized as QA1- quality. All of the 15 samples contained arsenic concentrations near or below the Puget Sound area 90th percentile background concentration of 7.3 mg/kg (Ecology 1994). The average arsenic concentration in subsurface soil samples (from greater than 5 feet bgs) was 4.2 mg/kg. The concentrations ranged from 1.5 to 7.5 mg/kg.

Railroad Property

Forty-eight subsurface soil samples (of QA2 quality) collected from the Railroad property have been analyzed for arsenic. Three samples contained detections of arsenic ranging from 7 to 10 mg/kg, with an average concentration of 6.4 mg/kg. All detection limits were below the PRG screening level.

5.3.3.2 Chromium

Chromium is a potential indicator chemical for waste oil and foundry slag. Waste oil was stored in Tanks 35 and 36 located east of Quendall Pond and foundry slag was reportedly placed as fill near the shoreline southwest and/or northwest of Tank 26. Data for chromium in surface and subsurface soil on the Quendall and Railroad properties are summarized below.

5.3.3.2.1 Surface Soil

Chromium was analyzed for in seven surface soil samples from the Quendall property (Tables 5.3-1a and 5.3-1b) and four surface soil samples from the Railroad property (Table 5.3-2). A summary of the data quality and the occurrence of chromium in surface soil at the Quendall and Railroad properties is presented below.

Quendall Property

Three of the seven surface soil samples collected in 1990 have been characterized as of QA0 quality and the four samples collected in 1995 have been characterized as of QA1- quality. Of the seven soil samples, five contained chromium concentrations at or below the Puget Sound area background level of 48.2 mg/kg (Ecology 1994). The highest chromium concentration (65 mg/kg) was detected in a shallow soil sample from boring BH-28.

Chromium soil samples of QA1- quality were collected from shallow depths between 1 and 4 feet bgs and included three sample locations approximately 200 feet north, west, and southwest of the waste oil storage area (Tanks 35 and 36). At these locations, approximately 1 to 3 feet of fill was placed after waste oil storage activities ceased. The sample collected closest to Tanks 35 and 36, at test pit TP-4, was approximately 150 feet west of these tanks. These samples were collected to characterize areas of suspected slag fill, which were located northwest and southwest of the waste oil storage area. No samples collected close to the tanks were analyzed for chromium; however, non-chemical indicators (i.e., visual observations for LNAPL) have not identified potential waste oil occurrences in the subsurface at these locations.

Focused soil sampling for chromium was performed in areas of suspected slag occurrences. One sample was collected in the southern area at boring BH-28 (approximately 100 feet north of a noted occurrence near BH-12). Two samples were collected in the northern area: one at test pit TP-4 (approximately 50 feet south of a noted occurrence at boring RB10) and one at TP-1 (approximately 150 feet north of RB10). These soil samples were collected at shallow depths within the fill material and had chromium concentrations ranging from 29 to 65 mg/kg, with an average concentration of 46 mg/kg. These values are consistent with the Puget Sound area background concentration of 48.2 mg/kg. No samples of identified slag material have been analyzed for chromium.

Railroad Property

Four surface soil samples (of QA2 quality) collected at the Railroad property were analyzed for chromium: two samples from boring Q1-D in the Solid Material Loading Area and two from boring Q2-D in the Tank Car Loading Area. Chromium concentrations in all these samples were below the Puget Sound area background concentration of 48.2 mg/kg.

5.3.3.2.2 Subsurface Soil

Chromium was analyzed for in six subsurface soil samples from the Quendall property (Tables 5.3-3a and 5.3-3b). Five subsurface soil samples collected in 1990 have been characterized as of QA0 quality and the one sample collected in 1995 has been characterized as of QA1 quality. All the subsurface soil samples contained chromium concentrations below the Puget Sound area background level of 48.2 mg/kg (Ecology 1994).

No subsurface soil samples from the Railroad property were analyzed for chromium.

5.3.3.3 Copper

Like chromium, copper is a potential indicator chemical for waste oil and foundry slag. Data for copper in surface and subsurface soil on the Quendall and Railroad properties are summarized below.

5.3.3.3.1 Surface Soil

Copper was analyzed for in three surface soil samples from the Quendall property (Table 5.3-1b) and five surface soil samples from the Railroad property (Table 5.3-2). A summary of the data quality and the occurrence of copper in surface soil at the Quendall and Railroad properties is presented below.

Quendall Property

The three surface soil samples collected in 1990 have been characterized as of QA0 quality and are all below the Puget Sound area background level of 36.4 mg/kg (Ecology 1994). The highest copper concentration (30 mg/kg) was detected in a shallow soil sample from boring BH-26A.

Railroad Property

Four surface soil samples (of QA2 quality) collected at the Railroad property were analyzed for copper: two samples from boring Q1-D in the Solid Material Loading Area and two samples from boring Q2-D in the Tank Car Loading Area. The highest copper concentration (52 mg/kg) was detected at 3.5 feet bgs in boring Q2, exceeding the Puget Sound area

background concentration of 36.4 mg/kg. All other copper concentrations were below the background concentration.

5.3.3.3.2 Subsurface Soil

Copper was analyzed for in five subsurface soil samples from the Quendall property collected in 1990. The data have been characterized as of QA0 quality (Table 5.3-3b). All the subsurface soil samples contained chromium concentrations below the PRG screening level of 28 mg/kg and the Puget Sound area background level of 36.4 mg/kg (Ecology 1994).

No subsurface soil samples from the Railroad property were analyzed for copper.

5.3.3.4 PCBs

PCBs are indicator chemicals for evaluating the potential presence of waste oil at the Site. PCBs were identified as a COI because waste oil was reportedly transported to and from the Site in the 1970s and stored in Tanks 35 and 36. It is not known if these operations resulted in waste oil releases to the Site.

PCBs have not been detected in any surface soil samples from the Site. PCBs have not been analyzed in subsurface soil, but no PCBs have been detected in groundwater. While only a limited number of soil samples have been analyzed, the potential historical use of products containing PCBs (primarily waste oil transported in the 1970s) is limited, and no evidence of waste oil (or other LNAPL petroleum products; see Section 4.1.3) that would potentially contain PCBs has been observed. Furthermore, as described in Section 4.1.3.2 of the Data Collection Work Plan (Anchor QEA and Aspect 2009a), waste oil was stored in a Site area more than 400 feet from Lake Washington. The characterization of PCBs is sufficient to support this RI because: 1) any occurrences of PCBs in soil would be co-located with, and present over a more localized area than other contaminants and 2) future Site use will involve soil capping and controls to prevent exposure to other contaminants left in place in Site soil.

Data for PCBs in surface soil on the Quendall and Railroad properties are summarized below.

Quendall Property

Four surface soil samples (of QA1 quality) were collected and analyzed for PCBs (Aroclors: 1016, 1242, 1248, 1254, and 1260) at locations HC-3, BH-28, TP-1, and TP-4, from between 1 and 4 feet bgs (Table 5.3-1a). No PCBs were detected in these samples and none of the detection limits exceeded the PRG screening level of 0.22 mg/kg[22], with the maximum detection limit being 0.042 mg/kg at boring BH-28. No subsurface soil samples were analyzed for PCBs. In addition (to support limited available soil data), 31 groundwater samples (of QA0 quality) were collected and analyzed for PCBs.[23] PCBs were also not detected in any of these samples. The detection limits in all 31 groundwater samples (typically 0.1 µg/L, but ranging up to 1 µg/L at borings BH-18A and BH-20A and 13 µg/L at BH-23) exceeded the groundwater PRG screening level for total PCBs (0.5 µg/L). The highest detection limits were present in samples containing high concentrations of other SVOCs.

Railroad Property

Four surface soil samples were collected from borings in the Solid Material Loading Area (Q1-D) and Tank Car Loading Area (Q2-D) and analyzed for PCBs. PCBs were not detected in any of these samples (detection limits were 0.03 mg/kg, below the PRG screening level of 0.22 mg/kg). No subsurface soil samples were analyzed for PCBs.

5.3.3.5 PCP

PCP is an indicator chemical for evaluating the potential Site presence of chlorinated tar distillates. PCP was identified as a COI because an experimental process whereby chlorine was added to creosote to improve its wood preserving properties was reportedly attempted in an area near Tanks 36 and 37. It is not known if the process was successful, or if any resulting products were released at the Site. PCP has not been detected in Site groundwater

[22] The EPA Region 5 Eco-SSLs were the most stringent screening levels for PCBs and most pesticides. The Region 5 ecological soil screening was based on the meadow vole; the derivation was not provided in available online documentation (http://www.epa.gov/reg5rcra/ca/edql.htm). For context, the MTCA Ecological Indicator Soil Concentrations for the Protection of Terrestrial Plants and Animals have a protective total PCB concentration of 0.65 mg/kg for the meadow vole. The EPA RSL for Resident Soil is 0.22 mg/kg total PCBs. Similar order-of-magnitude ranges exist for the pesticide PRG screening levels.

[23] See Appendix I for a complete statistical summary of chemicals analyzed for in groundwater.

or soil. Results for PCP in soil on the Quendall and Railroad properties are summarized below.

Quendall Property

Forty-six soil samples (17 surface and 29 subsurface) were analyzed for PCP. Twenty-eight of these samples (4 surface and 24 subsurface) were collected in 1995 and are of QA1 quality, and four surface soil samples (SS-TP-5, SS-TP-4, SS-TP-2, and SS-HC-8) were collected in 2004 and are of QA2 quality.

The soil samples analyzed for PCP were collected from surface and subsurface soil across the Quendall property. Sample locations included areas of former operations and waste disposal including the north sump (HC-2 and BH-23), storage tanks (TP-4, HC-3, and HC-4), and the former May Creek Channel (TP-5, HC-7, and BH-21A/B), as well as locations of limited historical operations north (HC-1 and BH-24), south (BH-26A and BH-17B), and west (BH-28 and BH-19) of those locations. PCP was not detected in any of the soil samples analyzed, although for eight samples (two surface and six subsurface) detection limits exceeded the soil PRG screening level, based the EPA RSL for Resident Soil of 0.89 mg/kg. The maximum detection limits in surface soil were 30 mg/kg at HC-5 (2.5-to-4-foot depth) and 42 mg/kg at BH-27 (5-to-6-foot depth). Elevated detection limits corresponded to samples that contained relatively high concentrations of other SVOCs and/or in which DNAPL or solid tar products were observed. PCP was also not detected in any of the 96 groundwater samples analyzed (see Section 5.2.2.4).

Railroad Property

Twenty-five surface soil samples and 14 subsurface soil samples (of QA2 quality) collected from throughout the Railroad property were analyzed for PCP. PCP was not detected in any of these samples. Detection limits ranged from 0.3 to 70 mg/kg, with the highest detection limit detected at boring Q3-A at a depth of 1 foot bgs. Detection limits exceeded the PRG screening level of 0.89 mg/kg in seven samples (twelve surface and three subsurface). The higher detection limits occurred in samples with observed DNAPL or solid tar products.

5.3.3.6 Summary of Other Potential Source Indicator Chemical Occurrences in Soil

The available RI field investigation data indicate that indicator chemicals for contaminant sources other than coal tar and its products have either not been detected in soil (PCP and PCBs) or have been detected at concentrations close to their regional background concentrations (7.3 mg/kg for arsenic and 48.2 mg/kg for chromium) (Ecology 1994).

On the Quendall property, arsenic and chromium slightly exceeded background levels and may be associated with historical activities, but the sample locations were within the soil footprint where coal tar products were also located. Limited soil sampling has been performed for several potential soil contaminants, particularly chromium and PCBs, but visual Site observations indicate that potential contaminant sources related to slag (see Section 5.3.1.2) and petroleum products (see the discussion of LNAPL in Section 4.1.3) are limited. The available physical and chemical data do not indicate that these chemicals are widespread or present at high concentrations in Site soil and, with the exception of arsenic, the chemicals have not been detected in groundwater above PRG screening levels (see Section 5.2.2). Arsenic occurrences in groundwater exceeding the PRG screening level appear to be due to natural background conditions or are co-located with DNAPL or highly elevated concentrations of coal tar constituents. Potential sources of these products (i.e., waste oil, slag, and pesticides) are relatively immobile in the subsurface and, if present, are unlikely to migrate in the future. In contrast, coal-tar-related chemicals described in Section 5.3.2 are more widespread in the subsurface and exceed PRG screening levels to a greater degree than contaminants from other sources.

On the Railroad property, PCP and PCBs have not been detected and chromium has not been detected above the regional background level of 48.2 mg/kg. Arsenic was detected in three surface soil samples but is likely related to railroad operations independent of the Quendall property because similar concentrations were observed in Railroad property surface soil 1,000 feet north of the Quendall property.

5.4 Nature and Extent of Sediment Contamination

Key Points for Sediment Contamination

- Sediment has been impacted by spills and leaks of coal tar and fuel oils along the former T-Dock and by ongoing contaminated groundwater discharge from upland sources.
- Indicator chemical distributions in bulk sediment (Section 5.4.1) and sediment porewater (Section 5.4.2) from surface grab and subsurface core samples define hazardous-substance-impacted sediment boundaries and wood debris areas.
- Groundwater fate and transport pathways to sediment and surface water are presented in Section 6.
- Sediment bioassays are discussed with analytical chemistry and other lines of evidence to delineate the nature and extent of sediment contamination in the baseline risk assessment (Section 7).

Historical releases of coal tar and fuel oil products directly into Lake Washington have occurred along the former T-Dock, including the historical main span of the T-Dock that extended from the shoreline into Lake Washington and the historical cross span that was used to berth vessels. In addition, groundwater transport of soluble coal tar product constituents from the upland portion of the Site has contributed contaminants to sediment in nearshore areas. Surface and subsurface sediment contaminant sources at the Site include historical spills and leaks from ships, barges, and overwater conveyances, and groundwater transport of dissolved constituents from areas of upland NAPL or contaminated soil. Site history, including sources, is discussed in Section 2.2 and a more detailed discussion of contaminant fate and transport is presented in Section 6. Two sediment areas impacted by hazardous substance releases are shown on Figure 5.4-1:[24]

- **Nearshore Groundwater Discharge Area**: Located adjacent to Quendall Pond, this area currently receives contaminated groundwater loading from upland sources; this area was also the location of historical spills and leaks that discharged directly to surface water.
- **T-Dock Spill Area**: This area in the vicinity of the former T-Dock received historical releases of coal tar and fuel oil products directly to surface water and sediment from leaks and spills.

[24] Note that the chemical data discussed in this section represent the most recent sediment data of QA2 quality collected between 2002 and 2009. Historical data of QA1 quality collected in 1996 and 1997 were used to supplement the QA2 quality data, where warranted. Historical sample locations are shown on Figure 2.3-2.

In addition to these two areas, contamination in a Wood Debris Area located south of the former T-Dock main span, near the location of historical log storage and handling operations, has altered aquatic habitat at the Site and is also addressed in this section. This area is also shown on Figure 5.4-1. Similar wood debris deposits were previously present at the former Barbee Mill site (now the Conner Homes property) to the south, but were removed in 1999 and 2002.

The Nearshore Groundwater Discharge Area (represented by "NS-" and "QPN-" sediment stations where sampling was conducted during the 2009 RI field investigation) includes aquatic lands generally inside the inner harbor line that have been impacted by migration of DNAPL and dissolved constituents. (The inner harbor line represents the limit of the portion of the Quendall Site that, as shown on figures in this report, extends into Lake Washington.) The western portion of the Nearshore Groundwater Discharge Area overlaps with the shoreward portion of the T-Dock Spill Area along the former main span. Some areas of groundwater discharge and leaks and spills from the T-Dock also overlap (see below and Figure 5.4-1). Because vibracore sampling results in disturbance of the surface layer, surface sediment porewater was characterized using surface grab samples. Figures depicting subsurface vibracore samples include the sample collected from the 0- to 4-inch interval to assist in characterizing contaminant transport through sediments in the nearshore area.

The T-Dock Spill Area is represented by "TD-" and "SS-" sediment stations where sampling was also conducted during the 2009 RI field investigation. Primary sources of contamination in the T-Dock Spill Area are historical spills and leaks associated with the transfer of tar feedstock. The most significant was a large spill that occurred between 1930 and 1940 at the western end of the T-Dock (cross span), during which approximately 30,000 to 40,000 gallons of tar feedstock were reportedly released during barge offloading (Ecology 1989).

Historical sources to the Wood Debris Area (represented by "WD-" sediment stations) include areas of log sorting and storage operations, which largely ceased during the 1980s and 1990s (Anchor and Aspect 2007a). The Wood Debris Area is located south of the T-Dock and was originally delineated based on previous video surveys, SPI, and confirmatory chemical and bioassay analyses (Anchor QEA and Aspect 2009a). The Wood

Debris Area boundaries were refined using 2009 diver surveys, sediment sampling data, and bioassay data.

Sediment characterization data include data obtained from surface samples (0 to 4 inches below the mudline) and subsurface samples (greater than 4 inches below the mudline) of bulk sediment and sediment porewater. The chemical data discussed below and displayed in the referenced figures represent both the most recent sediment data of QA2 quality collected between 2002 and 2009 and historical data of QA1 quality from 1996 and 1997 (for surface and subsurface bulk sediment). The historical data were used to supplement the QA2 quality data, where warranted, and are identified on Figures 5.4-2 through 5.4-8 by different symbols. Statistical summaries of QA1 and QA2 quality sediment data for indicator chemicals are provided for surface and subsurface bulk sediment in Tables 5.4-1 and 5.4-2, respectively, and for surface and subsurface sediment porewater in Tables 5.4-3 and 5.4-4, respectively.

The 2009 RI field investigation data were used as the primary basis to characterize the nature and extent of sediment contamination and were also used to delineate the boundaries of contamination relative to PRG screening levels. Lines depicting the extent of contamination on figures referenced in this section were estimated as the midpoint between samples exceeding or not exceeding the screening levels. The lines were drawn between adjacent stations or, if at the edge of the lateral extent of the data, with a 200-foot buffer.

In addition to comparisons of Site data with PRG screening levels, other lines of evidence to characterize the nature and extent of impacted sediment include Site-specific bioassays. Bioassays address overall toxicity from both identified and unmeasured chemicals (e.g., breakdown products). Because bioassay data provide key lines of evidence in the overall characterization of the nature and extent of Site sediment contaminants, the data are introduced in this section. Bioassay results as they relate to risk to benthic communities are discussed in more detail in Section 7.2.

The remainder of Section 5.4 addresses coal tar product indicator chemical occurrences in bulk sediment (Section 5.4.1) and sediment porewater (Section 5.4.2), and wood debris indicator chemical occurrences in bulk sediment and porewater (Section 5.4.3). Lastly, a

broad overview of sediment toxicity testing in the context of characterizing the nature and extent of sediment contamination is presented in Section 5.4.4. More detailed discussions of the sediment toxicity testing data are presented in Section 7.2.

5.4.1 Coal Tar Product Indicator Chemical Occurrences in Bulk Sediment

The indicator chemicals found in Site bulk sediment samples are those associated with coal tar product leaks and spills along the T-Dock and soluble DNAPL constituents transported by groundwater from upland source areas to the nearshore. The distributions of indicator chemicals in surface and subsurface bulk sediment have been characterized using 2009 RI field investigation sediment data (of QA2 quality) to identify contaminant boundaries; these data were supplemented as appropriate with other reliable datasets (of QA1- or better quality). Statistical data summaries of QA1 and QA2 quality bulk sediment data for indicator chemicals from surface and subsurface samples are provided in Tables 5.4-1 and 5.4-2, respectively.

The primary indicator chemicals for the Nearshore Groundwater Discharge Area and the T-Dock Spill Area are PAHs, which are primary components of tar feedstock and creosote. Specifically, naphthalene, cPAHs (expressed as benzo[a]pyrene equivalents), and PAH ESBQs (expressed as toxic units [TUs]) were used to delineate contamination in the nearshore and T-Dock areas. Bulk sediment samples from these two areas were not analyzed for benzene because benzene has high volatility and a relatively low affinity for solids. Characterization of benzene distributions in sediment at the Site is more appropriately performed based on porewater sampling results, discussed in Section 5.4.2.1.

The chemical testing results for surface bulk sediment samples (collected from 0 to 4 inches below the mudline) and subsurface bulk sediment samples (collected from 1 to 2 feet, 4 to 5 feet, and 7 to 8 feet below the mudline) are discussed below for each indicator chemical, including comparisons to PRG screening levels and delineation of the lateral and vertical extent of sediment contaminant boundaries. Except in cases where pre-2009 historical data are discussed, the results presented in these sections represent data of QA2 quality. The two areas impacted by hazardous substances, the Nearshore Groundwater Discharge Area and the

T-Dock Spill Area, are also discussed individually in these sections; refer to Figure 5.4-1 for the approximate boundaries of these areas.

5.4.1.1 Naphthalene

Figures 5.4-2 and 5.4-3 show naphthalene data from surface and subsurface bulk sediment samples, respectively, collected from the Nearshore Groundwater Discharge Area and the T-Dock Spill Area. The highest naphthalene concentrations in bulk sediment were detected in subsurface samples within the inner harbor line near Quendall Pond. Elevated concentrations were also detected in the spill area at the end of the former T-Dock. Detection limits for samples where naphthalene was not detected ranged from 0.0047 to 0.028 mg/kg, well below the PRG screening level (the EPA Region 3 BTAG sediment screening benchmark of 0.176 mg/kg).

5.4.1.1.1 Surface Bulk Sediment

The estimated lateral extent of naphthalene PRG screening level exceedances in surface bulk sediment is shown on Figure 5.4-2. In addition, the estimated extents of surface bulk sediment exceeding Ecology's most recent freshwater lowest apparent effects threshold (LAET) of 0.529 mg/kg and second lowest AET (2LAET) of 1.31 mg/kg (Ecology 2003) are shown on Figure 5.4-2.

Naphthalene concentrations in surface bulk sediment samples exceeded the PRG screening level in two localized areas associated with: 1) groundwater transport to the nearshore and 2) spills along the former T-Dock, particularly at the cross span. The naphthalene concentrations in surface bulk sediment samples that exceeded the PRG screening level and the extent of contamination for each area defined by the exceedances, as shown on Figure 5.4-2, were as follows:

- **Nearshore Groundwater Discharge Area.** In this area, naphthalene concentrations were highest at historical stations WP-19A (12 mg/kg) and WP-20A (2.6 mg/kg), located immediately offshore of Quendall Pond and northwest of WP-19A at historical station S-49 (1.1 mg/kg; QA1- quality data collected in 1996). Samples from nine other historical stations also exceeded the PRG screening level. In addition, an exceedance of 1.4 mg/kg occurred in a sample collected in 2009 from station

NS-12-SS, which is located adjacent to the former T-Dock main span in a likely spill area near the inner harbor line. The extent of PRG screening level exceedances in this area is defined by 2009 RI data from the following stations (moving clockwise from the southwest): NS-03-SS (0.066 mg/kg), NS-07-SS (0.11 mg/kg), SS-03-SS (0.018 mg/kg), SS-04-SS and SS-05-SS (both 0.052 mg/kg), SS-06-SS (0.048 mg/kg), NS-16-SS (0.036 mg/kg), and NS-11-SS (0.17 mg/kg).

- **T-Dock Spill Area.** In this area, naphthalene concentrations were highest at historical stations TD-08-SS (2.2 mg/kg) and TD-15-SS (0.94 mg/kg), located at the historical T-Dock cross span and immediately to the northwest. The highest detected naphthalene concentrations in surface bulk sediment in this area correspond to the coal tar spill sources described earlier in Section 5.4. The extent of PRG screening level exceedances in this area is defined by data from the following stations (moving clockwise from the southwest): 2009 RI data from stations TD-07-SS (0.0088 mg/kg), TD-10-SS (0.016 mg/kg), TD-12-SS (0.018 mg/kg), TD-14-SS (0.069 mg/kg), TD-13-SS (0.033 mg/kg), and TD-11-SS (0.072 mg/kg); pre-2009 historical data (of QA2 quality) from station QB-4 (0.07 mg/kg); and 2009 RI data from stations SS-05-SS and SS-04-SS (both 0.052 mg/kg).

5.4.1.1.2 Subsurface Bulk Sediment

Naphthalene concentrations in subsurface bulk sediment samples exceeded the PRG screening level in two localized areas associated with: 1) groundwater transport to the nearshore and 2) spills at the end of the former T-Dock. The naphthalene concentrations in subsurface bulk sediment samples that exceeded the PRG screening level of 0.176 mg/kg, as shown on Figure 5.4-3, were as follows:

- **Nearshore Groundwater Discharge Area.** In this area, the highest naphthalene concentration (7,800 mg/kg) occurred at historical station VS-30, located offshore of Quendall Pond, in the 4.5-to-5.5-foot interval (the deepest interval sampled at that location). Concentrations of 790 mg/kg and 740 mg/kg occurred at historical stations VS-29 (in the 10-to-11-foot interval) and VS-2 (in the 1-to-2-foot interval). At 2009 RI stations, the highest naphthalene concentration (230 mg/kg) occurred at station TD-02-VC in the 7-to-8-foot depth interval. Concentrations decreased to 17 mg/kg in the 4-to-5-foot interval and 8.7 mg/kg in the 1-to-2-foot interval. At station

TD-01-VC, the highest concentration was 14 mg/kg in the 4-to-5-foot interval. The vertical distribution of naphthalene at TD-02-VC is consistent with a groundwater source. The extent of PRG screening level exceedances in this area is defined by the elevated naphthalene concentrations in the samples from stations VS-36, VS-18, VS-21, WP-20B, and TD-01 (southwest of the former T-Dock) and in samples from stations located throughout the Nearshore Groundwater Discharge Area northeast of the former T-Dock. The fact that sediment concentrations are higher at depth indicates that these exceedances are the result of upwelling contaminated groundwater, and less likely associated with spills along the T-Dock. The extent of PRG screening level exceedances is also defined using the subsurface sediment porewater data, which are the primary line of evidence for assessing the nature and extent of naphthalene in subsurface sediment in the Nearshore Groundwater Discharge Area. See Section 5.4.2.2.2 for additional discussion and details.

- **T-Dock Spill Area.** In this area, naphthalene concentrations were highest at the center of the former cross span of the T-Dock, but in general were substantially lower than those observed in the Nearshore Groundwater Discharge Area. The highest naphthalene concentration (6.7 mg/kg) was observed at station TD-08-VC in the 1-to-2-foot interval; the deeper intervals showed a progressive decrease in concentrations with depth (1.9 mg/kg at 4 to 5 feet and 0.69 mg/kg at 7 to 8 feet). This decrease with depth is consistent with the surface spill source at this location. The extent of PRG screening level exceedances in this area is defined by the stations surrounding TD-08-VC (i.e., stations TD-07-VC, TD-10-VC, TD-15-VC, TD-11-VC, and TD-09-VC, where all depth intervals had naphthalene detection limits lower than 0.005 mg/kg).

5.4.1.2 cPAHs

In this section, cPAH data in bulk sediment are presented and discussed in a variety of forms to help relate the results to the baseline risk assessment (Section 7). Surface bulk sediment sample cPAH concentrations are presented as both dry-weight benzo(a)pyrene equivalents and organic carbon normalized (OCN) benzo(a)pyrene equivalents, as shown on Figures 5.4-4 and 5.4-5, respectively. OCN results are used to calculate inputs needed for evaluating potential risk resulting from consumption of aquatic organisms. cPAH concentrations in

subsurface bulk sediment samples are presented as dry-weight benzo(a)pyrene equivalents only, as shown on Figure 5.4-6.

The highest concentrations in bulk sediment are associated with historical spills along the former T-Dock, along both the main span and the cross span areas. However, because cPAHs are relatively insoluble (see Section 6.4.2), their mobility in groundwater is much less than that of naphthalene or benzene; therefore, their mobility in groundwater is relatively low and cPAH contributions from groundwater transport to the Nearshore Groundwater Discharge Area are assumed to be small.

For cPAHs in bulk sediment, there is no PRG screening value; therefore, the value used for comparison is the 90 percent upper confidence limit (UCL) on the mean of Site-specific background samples collected during the 2009 RI field investigation. Using the 90 percent UCL approach, a background screening level of 0.15 mg/kg dry weight or 6.2 mg/kg-OC was calculated (see Appendix H). Additional discussions of cPAH distributions, including population-based statistical comparisons, are provided in Appendix H and the baseline risk assessment (Section 7).

5.4.1.2.1 Surface Bulk Sediment

The estimated lateral extent of cPAH PRG screening level exceedances in surface bulk sediment is shown on Figures 5.4-4 and 5.4-5 for dry weight and OCN results, respectively. In order to highlight the areas with greater factors of exceedances, the estimated extents of surface bulk sediment exceeding 8 and 100 times the PRG screening levels are shown on these figures.

cPAH concentrations in surface bulk sediment samples exceeded the PRG screening level of 0.15 mg/kg dry weight or 6.2 mg/kg-OC across the Nearshore Groundwater Discharge Area and the T-Dock Spill Area. The cPAH concentrations in surface bulk sediment samples that exceeded the PRG screening levels and the extent of contamination defined by those exceedances, as shown on Figures 5.4-4 and 5.4-5, were as follows:

- **Nearshore Groundwater Discharge Area**. In this area, the highest cPAH concentrations in surface bulk sediment occurred in the vicinity the former T-Dock

main span at historical stations WP-20B (178 mg/kg; 2,910 mg/kg-OC), WP-20A (21 mg/kg; 580 mg/kg-OC), and NS-12 (14.9 mg/kg; 278 mg/kg-OC). The extent of PRG screening level exceedances in the Nearshore Groundwater Discharge Area is defined by both 2009 RI data and pre-RI historical data. Based on a PRG screening level of 0.15 mg/kg dry weight (see Figure 5.4-4), the screening level for cPAHs is exceeded across the entire Nearshore Groundwater Discharge Area and beyond into the T-Dock Spill Area to the west and southwest. Based on a PRG screening level of 6.2 mg/kg-OC (see Figure 5.4-5), the screening level for OCN cPAHs is also exceeded across the entire Nearshore Groundwater Discharge Area with the exception of the extreme southern part of the area. Within the Nearshore Groundwater Discharge Area, sediment within 100 to 200 feet of the former main span of the T-Dock is contaminated with cPAHs in excess of 100 times the PRG screening level, based on cPAH data expressed on both a dry weight and an OCN basis.

- **T-Dock Spill Area.** In this area, the highest cPAH concentrations in surface bulk sediment were at stations TD-08-SS (167 mg/kg, 1,770 mg/kg-OC; and TD-15-SS (101 mg/kg, 2,370 mg/kg-OC). The extent of PRG screening level exceedances in the T-Dock Spill Area is generally undefined to the north and east of the T-Dock. Both 2009 RI data and pre-RI historical data obtained roughly 500 feet to the west of the T-Dock indicate cPAHs below the screening levels of 0.15 mg/kg dry weight and 6.2 mg/kg-OC (see Figures 5.4-5 and 5.4-5). Samples collected at the northern and eastern limits of the T-Dock Spill Area consistently show cPAHs that are on the order of 2 to 8 times the screening level (as measured on both a dry weight and an OCN basis). Samples collected within 100 to 300 feet of the former cross span area indicate cPAH concentrations exceeding the PRG screening level by 100 times (as measured on both a dry weight and an OCN basis).

5.4.1.2.2 Subsurface Bulk Sediment

The estimated extent of cPAHs in subsurface bulk sediment is shown on Figure 5.4-6. The cPAH concentrations in subsurface bulk sediment samples that exceeded the PRG screening level of 0.15 mg/kg, and the extent of contamination defined by those exceedances, are as follows:

- **Nearshore Groundwater Discharge Area.** In this area, the highest cPAH

concentration (878 mg/kg) occurred at historical station VS-30, located offshore of Quendall Pond, in the 4.5-to-5.5-foot interval (the deepest interval sampled at that location). Concentrations of 157 mg/kg and 69.3 mg/kg occurred at historical stations WP-20B (in the 1-to-1.5-foot interval) and VS-29 (in the 10-to-11-foot interval). At 2009 RI stations, the highest cPAH concentration (40.2 mg/kg) was detected at station TD-02-VC in the 1-to-2-foot depth interval; concentrations decreased to below the PRG screening level in the 4-to-5-foot and 7-to-8-foot intervals, and were also below the screening level at station TD-01-VC. In the area of TD-01-VC, subsurface sediment porewater data provide the primary line of evidence for assessing the nature and extent of cPAHs in subsurface sediment in the Nearshore Groundwater Discharge Area (see Section 5.4.2.3.2 for additional discussion and details).

- **T-Dock Spill Area.** In this area, the highest cPAH concentrations occurred in samples from historical stations S-51 (72.1 mg/kg) and S-45 (45.7 mg/kg), both in the approximate 4-to-8-inch-interval. At 2009 RI stations, the highest cPAH concentration (2.4 mg/kg) was detected at the former cross span at station TD-08-VC in the 1-to-2-foot interval; concentrations were below the PRG screening level at the 4-to-5-foot depth interval, and then exceeded the screening level again at the 7-to-8-foot interval (0.31 mg/kg). The vertical distribution of cPAHs is consistent with the surface spill source at this location. In this area, the extent of screening level exceedances is defined by data from the 2009 RI stations surrounding station TC-08-VC, which is located at the former cross span of the T-Dock. None of the samples collected around station TC-08-VC at any depth indicate cPAH detection limits or concentrations greater than the screening level.

5.4.1.3 PAH ESBQs

PAH ESBQ results for surface and subsurface bulk sediment samples are shown on Figures 5.4-7 and 5.4-8, respectively. PAH ESBQ results were calculated using one-half the detection limit in the case where an individual PAH value was not detected. The highest PAH ESBQ values (expressed as TUs) in bulk sediment were from surface samples collected in the spill area at the end of the former T-Dock. Elevated values also occurred along the main span of the former T-Dock within the Nearshore Groundwater Discharge Area.

The PRG screening level for PAH ESBQs is 1 TU. EPA guidance (2003b, 2007a) on the application of PAH ESBQs was applied. Additional information on PAH ESBQ distributions is provided in the baseline ecological risk assessment (Section 7.2).

5.4.1.3.1 Surface Bulk Sediment

The estimated extent of PAH ESBQs exceeding the PRG screening level of 1 TU in surface bulk sediment is shown on Figure 5.4-7. PAH ESBQ values in surface bulk sediment samples exceeded the screening level in two areas associated with: 1) groundwater transport to the nearshore and 2) spills along the former T-Dock, particularly at the cross span. The surface bulk sediment distribution of PAH ESBQs in these areas is similar to that in surface sediment porewater (as described in Section 5.4.2.4.1) and provides an additional line of evidence for assessing the nature and extent of PAH ESBQs in surface sediment. The PAH ESBQ values in surface bulk sediment samples that exceeded the PRG screening level of 1 TU and the extent of contamination for each area defined by those exceedances, as shown on Figure 5.4-7, were as follows:

- **Nearshore Groundwater Discharge Area.** In this area, the highest PAH ESBQ value (8.6 TUs) was at historical station WP-20A. Station NS-12-SS (2.4 TUs) is near the former T-Dock and in a likely spill area. PAH ESBQ results from 10 other stations in this area exceeded the PRG screening level, but were generally less than 2 TUs. As shown on Figure 5.4-7, the extent of screening level exceedances includes nearly the entire Nearshore Groundwater Discharge Area, with the exception of the extreme southern part of the area (defined by NS-03-SS and NS-07-SS).
- **T-Dock Spill Area.** In this area, PAH ESBQ values were highest at stations TD-08-SS (59.3 TUs) and TD-15-SS (121 TUs). Farther offshore, Station TD-14-SS had a PAH ESBQ of 5.89 TUs. These three stations are located at the historical cross span and directly to the northwest. The highest PAH ESBQ values in this area correspond with the coal tar spill sources noted in the introduction to Section 5.4.

5.4.1.3.2 Subsurface Bulk Sediment

PAH ESBQ values in subsurface bulk sediment samples exceeded the PRG screening level in two localized areas associated with spills along the former T-Dock: the former cross span area and along the former main span just inside the inner harbor line. The subsurface bulk

sediment distribution of PAH ESBQs in these areas is similar to that in subsurface sediment porewater (as described in Section 5.4.2.4.2) and provides an additional line of evidence for assessing the nature and extent of PAH ESBQs in subsurface sediment. The PAH ESBQ values in subsurface bulk sediment samples that exceeded the PRG screening level of 1 TU and the extent of contamination for each area defined by those exceedances, as shown on Figure 5.4-8, were as follows:

- **Nearshore Groundwater Discharge Area.** In this area, the highest PAH ESBQ value (576 TUs) occurred at historical station VS-30, located offshore of Quendall Pond, in the 4.5-to-5.5-foot interval (the deepest interval sampled at that location). Eleven additional historical stations had PAH ESBQ values exceeding 20 TUs. The historical locations offshore of Quendall Pond show patterns of vertical contamination consistent with upwelling groundwater contamination. At 2009 RI stations, the highest PAH ESBQ value (9.7 TUs) occurred at station TD-02-VC in the 1-to-2-foot interval. PAH ESBQ values decreased to 1.8 in the 4-to-5-foot interval and 1.7 mg/kg in the 7-to-8-foot interval. This vertical distribution is consistent with a surface spill source at this location. At station TD-01-VC, the PAH ESBQ value was 2.6 TUs in the 1-to-2-foot interval. PAH ESBQ values at depth at this location were less than the PRG screening level. As shown in Figure 5.4-8, the extent of PRG screening level exceedances in this area is defined by the elevated ESBQ values in the samples from stations VS-36, VS-18, VS-21, WP-20B, and TD-01 (southwest of the former T-Dock) and in samples from stations located throughout the Nearshore Groundwater Discharge Area northeast of the former T-Dock. The extent of screening level exceedances is also defined using the subsurface sediment porewater data, which are the primary line of evidence for assessing the nature and extent of PAH ESBQs in subsurface sediment in the Nearshore Groundwater Discharge Area. See Section 5.4.2.4.2 for additional discussion and details.
- **T-Dock Spill Area.** In this area, PAH ESBQ values were highest in samples from historical stations S-51 (78.5 TUs) and S-45 (24.6 TUs), both in the 4-to-8-inch interval. At 2009 RI stations, PAH ESBQ values were highest at the former cross span of the T-Dock (station TD-08-VC). The highest value (5.5 TUs) was in the 1-to-2-foot interval. The PRG screening level of 1 TU was not exceeded at 4 to 5 feet. The PAH TU value was 2.8 at 7 to 8 feet. This vertical distribution is consistent with the

surface spill source at this location. One other exceedance occurred in a sample located just south of the southwestern end of the former cross span. At this location, a result of 1.4 TUs was reported for the 7-to-8-foot interval at station TD-07-VC. As shown in Figure 5.4-8, the PRG screening level is exceeded in one area located along the former T-Dock cross span. The limit of the hot spot is well defined by surrounding 2009 RI stations where PAH TU results are consistently below the screening level.

5.4.1.4 Summary of Coal Tar Product Indicator Chemicals in Bulk Sediment

Surface bulk sediment contamination at the Site was delineated in two areas using both historical data and 2009 RI data: the Nearshore Groundwater Discharge Area and the T-Dock Spill Area. The nature and extent of contamination in these areas was assessed based on the distribution of naphthalene, cPAHs (expressed as benzo[a]pyrene equivalents), and PAH ESBQs (expressed as TUs). In nearshore surface bulk sediment, naphthalene was detected at the highest concentrations in samples collected adjacent to Quendall Pond. Naphthalene concentrations declined further offshore consistent with the distribution of naphthalene concentrations in groundwater along the east-to-west groundwater flowpath, but are still elevated in the T-Dock Spill Area, near the intersection of the former main span and cross-span. PAH contamination in surface sediment is present in both the Nearshore Groundwater Discharge Area and the T-Dock Spill Area, with the highest concentrations generally in the vicinity of the former T-Dock, but also offshore of Quendall Pond. Areas along the former T-Dock and within the inner harbor line show evidence of both groundwater and spill sources.

Subsurface bulk sediment PAH contamination at the Site was delineated using historical data and 2009 RI data in the Nearshore Groundwater Discharge Area (along the former main span of the T-Dock) and in the T-Dock Spill Area. However, sediment porewater data (discussed in the next section) is considered the primary means for assessing subsurface contamination in nearshore sediment. Subsurface sediment data in the Nearshore Groundwater Discharge Area suggest that naphthalene concentrations increase with depth, indicating a groundwater source in that area. Conversely, areas along the former T-Dock main span within and

beyond the inner harbor line are characterized by decreasing cPAHs and PAH ESBQs with depth, indicating the contamination in these areas is more likely surface-spill-related.

The detected concentrations of PAHs in the bulk surface and subsurface sediment are further evaluated in the baseline risk assessment (Section 7).

5.4.2 Coal Tar Product Indicator Chemical Occurrences in Sediment Porewater

The indicator chemicals found in Site sediment porewater samples are those associated with: 1) coal tar product leaks and spills along the T-Dock and 2) transport of soluble DNAPL constituents in groundwater. The distributions of indicator chemicals in surface sediment porewater (0 to 4 inches below the mudline) and subsurface sediment porewater (8 to 12 inches, 20 to 24 inches, and 36 to 40 inches below the mudline) were characterized using 2009 RI field investigation sediment data of QA2 quality to assess contaminant boundaries. Statistical summaries of QA2 sediment porewater data for indicator chemicals from surface and subsurface samples are provided in Tables 5.4-3 and 5.4-4, respectively.

The primary indicator chemicals for the Nearshore Groundwater Discharge Area and the T-Dock Spill Area are PAHs, which are primary components of tar feedstock and creosote. Specifically, naphthalene, cPAHs (expressed as benzo[a]pyrene equivalents), and PAH ESBQs (expressed as TUs) were used to delineate contamination in surface sediment porewater in the nearshore and T-Dock areas and in subsurface sediment porewater in the nearshore area. Benzene was used to delineate contamination in surface and subsurface sediment porewater in the Nearshore Groundwater Discharge Area only because benzene is the most soluble indicator chemical and can be readily transported along the groundwater flowpath to the nearshore area (see Section 6.4.2 for details). Chemical analytical results for surface and subsurface sediment porewater and comparisons to PRG screening levels are discussed below, including delineation of the lateral and vertical extent of contaminant boundaries in Site sediment. The following sections also discuss the rationale for assessing the extent of contamination for each coal tar product indicator chemical in porewater.

The lithology at the Site is heterogeneous, and some sample locations were too sandy to extract sufficient porewater for chemical analysis. Sample locations where sufficient porewater could not be recovered are denoted with "NA" on the figures accompanying this section. For more details of sediment porewater sampling and analysis, see the RI/FS Data Report (Anchor QEA 2010).

5.4.2.1 Benzene

Benzene data for samples collected from the Nearshore Groundwater Discharge Area are shown on Figures 5.4-9 and 5.4-10 for surface and subsurface sediment porewater, respectively. (As noted above, samples for benzene analysis were not collected from stations in the T-Dock Spill Area.) The PRG screening level for benzene in sediment porewater is 2.2 µg/L (based on the EPA National Recommended Water Quality Criterion for Human Health [for the Consumption of Water + Organism]). The estimated extent of subsurface sediment porewater exceeding the MCL of 5 µg/L is also shown on Figure 5.4-10. Detection limits for samples in which benzene was not detected were well below the screening level in all cases. The highest benzene concentrations in sediment porewater were detected in subsurface samples within the inner harbor line near Quendall Pond.

5.4.2.1.1 Surface Sediment Porewater

No benzene concentrations in surface sediment porewater samples from the Nearshore Groundwater Discharge Area exceeded the PRG screening level (Figure 5.4-9). The highest benzene concentration of 2.1 µg/L, detected at station NS-08-SS, corresponded with the highest benzene concentrations in subsurface sediment porewater that were detected at the same location (discussed below).

5.4.2.1.2 Subsurface Sediment Porewater

Benzene concentrations in subsurface sediment porewater samples from the Nearshore Groundwater Discharge Area exceeded the PRG screening level in the area associated with groundwater transport to the nearshore. The highest concentrations were detected offshore of Quendall Pond (Figure 5.4-10).

The benzene concentrations in subsurface sediment porewater that exceeded the PRG screening level of 2.2 µg/L are summarized as follows (refer to Figure 5.4-10):

- In the area south of the former T-Dock, the highest benzene concentrations were detected at station NS-08-VC (1,200 µg/L in the 8-to-12-inch interval and 1,000 µg/L in the 20-to-24-inch interval, decreasing to 5.7 µg/L in the 0-to-4-inch interval). The sample collected closest to the shoreline, at station NS-04-VC, had a maximum concentration of 4 µg/L in the 20-to-24-inch interval and another screening level exceedance of 2.6 µg/L in the 36-to-40-inch interval.
- Benzene concentrations were over an order of magnitude lower on the north side of the main span of the T-Dock, but still exceeded the PRG screening level at stations NS-09-VC (140 µg/L in the 0-to-4-inch interval), NS-13-VC (48 µg/L in the 20-to-24-inch interval), and NS-05-VC (19 µg/L in the 20-to-24-inch interval).
- North of Quendall Pond, sediment porewater samples were not obtained for benzene analysis from any intervals at stations NS-10-VC and NS-14-VC due to poor porewater recovery from the sandy substrate. Benzene concentrations at station NS-15-VC, where the PRG screening level was exceeded in the 36-to-40-inch interval (20 µg/L), are consistent with the presence of a small stringer of DNAPL observed in the sample recovered from this location.

The benzene distribution shown in Figure 5.4-10 is consistent with benzene concentrations measured in groundwater in shoreline wells and wellpoints; further discussions of the groundwater concentrations and the groundwater-to-sediment flowpath are provided in Sections 5.2 and 6, respectively.

5.4.2.2 Naphthalene

Naphthalene data for samples collected from the Nearshore Groundwater Discharge Area and the T-Dock Spill Area are shown on Figures 5.4-11 and 5.4-12 for surface and subsurface sediment porewater, respectively. The PRG screening level for naphthalene in sediment porewater is 1.1 µg/L (based on the EPA Region 3 BTAG Surface Water Screening Value). Detection limits for samples where naphthalene was not detected were well below the screening level in all cases. The highest naphthalene concentrations in sediment porewater

were detected in subsurface samples within the inner harbor line near Quendall Pond. An elevated concentration was also detected in the spill area at the end of the former T-Dock.

5.4.2.2.1 Surface Sediment Porewater

The estimated lateral extent of naphthalene PRG exceedances in sediment porewater is shown on Figure 5.4-11. Naphthalene concentrations in surface sediment porewater exceeded the PRG screening level in two localized areas associated with: 1) groundwater transport to the nearshore and 2) spills at and near the former T-Dock cross span. The surface sediment porewater distribution of naphthalene in these areas is similar to that in surface bulk sediment (as described in Section 5.4.1.1.1), which provides an additional line of evidence for assessing the nature and extent of naphthalene contamination in surface sediment.

The naphthalene concentrations in surface sediment porewater that exceeded the PRG screening level and the extent of contamination for each area defined by those exceedances, as shown on Figure 5.4-11, were as follows:

- **Nearshore Groundwater Discharge Area**. In this area, naphthalene concentrations exceeded the PRG screening level at stations NS-08-SS (4.2 µg/L), NS-09-SS (2.3 µg/L), and NS-10-SS (18 µg/L) located offshore from Quendall Pond, and station NS-15-SS (3.9 µg/L) to the northeast. These detected naphthalene concentrations are consistent with the groundwater flowpath as described in Section 6.4.2. As shown on Figure 5.4-11, the estimated extent of exceedances of the PRG screening level for naphthalene is well defined by 2009 RI data. Surface sediment porewater exceeds the screening level of 1.1 µg/L over much of the central and northeastern portions of the Nearshore Groundwater Discharge Area.
- **T-Dock Spill Area.** In this area, naphthalene concentrations exceeded the PRG screening level at stations TD-08-SS (9.9 µg/L) and TD-15-SS (1.9 µg/L), which are located at the historical T-Dock cross span and immediately to the northwest, respectively. The locations of these detected naphthalene concentrations in surface sediment porewater are consistent with the location of coal tar spill sources described earlier in Section 5.4. As shown on Figure 5.4-11, the estimated extent of exceedances of the PRG screening level for naphthalene is well defined by 2009 RI

data. An area exceeding the screening level of 1.1 µg/L is centered on the former T-Dock cross span and extends to the northwest for several hundred feet. The area where naphthalene exceeds the PRG screening level is well defined by a number of stations where naphthalene in surface sediment porewater did not exceed the screening level.

5.4.2.2.2 Subsurface Sediment Porewater

Naphthalene concentrations in subsurface sediment porewater were characterized for the Nearshore Groundwater Discharge Area only (i.e., no sampling was conducted in the T-Dock Spill Area to characterize cPAHs in subsurface sediment porewater). The estimated extent of naphthalene in subsurface sediment porewater exceeding the PRG screening level of 1.1 µg/L is shown on Figure 5.4-12. In addition, the estimated extent of subsurface porewater exceeding the MTCA Method B drinking water criterion of 160 µg/L is shown on this figure.

In the Nearshore Groundwater Discharge Area, naphthalene samples collected at two stations located just offshore of Quendall Pond exceeded both the PRG screening level of 1.1 µg/L and the 160 µg/L MTCA Method B drinking water criterion. Naphthalene was detected at 1,150 µg/L in the 20-to-24-inch interval at station NS-10-VC. Naphthalene concentrations ranged from 7.01 µg/L (25-to-40-inch interval) to 844 µg/L (8-to-12-inch interval) at station NS-05-VC. At other offshore stations in the Nearshore Groundwater Discharge Area, the location of naphthalene detections exceeding the PRG screening level were consistent with groundwater discharge but the detections were an order of magnitude lower than the highest concentrations detected at stations NS-10-VC and NS-05-VC (ranging from 52 µg/L at NS-03-VC in the 36-to-40-inch interval to 2.02 µg/L at NS-15-VC in the 8-to-12-inch interval). At station NS-12-VC, the detected concentration of 1.5 µg/L in the 0-to-4-inch interval with no detections above the PRG screening level in deeper intervals is consistent with a surface spill source.

The estimated boundary is defined in the southwestern portion of the area by data from stations NS-02-VC, NS-06-VC, and NS-07-VC; in the northwestern portion of the area by data from stations NS-13-VC and NS-14-VC; and in the northeastern portion of the area by data from station NS-11-VC. None of these stations had naphthalene concentrations or

detection limits greater than the PRG screening level. The portions of the area near stations NS-12-VC and NS-15-VC cannot be bounded by available subsurface sediment porewater data; however, none of the surface sediment porewater samples collected from stations NS-12-SS, NS-13-SS, NS-16-SS, and TD-SO-1 (all shown on Figure 5.4-11) had naphthalene concentrations or detection limits greater than the screening level.

The distribution of naphthalene in subsurface sediment porewater is similar to that for subsurface bulk sediment (as described in Section 5.4.1.1.2) and provides an additional line of evidence for assessing the nature and extent of naphthalene contamination in subsurface sediment. The naphthalene distribution is also consistent with naphthalene concentrations in groundwater measured in shoreline wells and wellpoints; further discussions of the groundwater concentrations and the groundwater-to-sediment flowpath are provided in Sections 5.2 and 6, respectively.

5.4.2.3 cPAHs

Figures 5.4-13 and 5.4-14 show cPAH data (as benzo[a]pyrene equivalents) calculated from surface and subsurface sediment porewater samples, respectively. Subsurface sediment porewater cPAH data were only collected from sediment sample stations located in the Nearshore Groundwater Discharge Area (i.e., no sampling was conducted in the T-Dock Spill Area to characterize cPAHs in subsurface sediment porewater). The PRG screening level for cPAHs in sediment porewater is 0.0038 µg/L, based on the EPA National Recommended Water Quality Criterion for Human Health (for Consumption of Water + Organism). The estimated extent of subsurface sediment porewater exceeding the groundwater PRG screening level (based on the MCL) of 0.2 µg/L is also shown on Figure 5.4-14. The highest cPAH concentrations in subsurface sediment porewater were detected in samples collected from within the inner harbor line near Quendall Pond.

5.4.2.3.1 Surface Sediment Porewater

As shown on Figure 5.4-13, cPAHs detected in surface sediment porewater exceeded the PRG screening level at all sample locations. In those samples where cPAHs were not detected, the detection limits were greater than the screening level in all cases. For the RI field investigation dataset, sediment porewater and bulk sediment total cPAH concentrations

were strongly correlated (R^2 = 0.63; see the RI/FS Data Report [Anchor QEA 2010]), supporting the use of bulk sediment cPAH data to characterize nature and extent.[25] The concentrations of cPAHs in surface sediment porewater that exceeded the PRG screening level were as follows:

- **Nearshore Groundwater Discharge Area.** Similar to the bulk sediment total cPAH distributions, the highest surface sediment porewater concentrations were observed in areas adjacent to Quendall Pond at historical stations (sampled in 2003) WP-20A (3.0 µg/L) and WP-20B (40.1 µg/L). RI field investigation samples collected in the Nearshore Groundwater Discharge Area contained detected porewater sediment cPAH concentrations that ranged from 0.018 µg/L at station NS-06-SS to 0.103 µg/L at station NS-09-SS.
- **T-Dock Spill Area.** The highest detected surface sediment porewater cPAH concentrations in the T-Dock Spill Area were associated with the historical spill area at stations TD-08 (0.21 µg/L), TD-15 (0.28 µg/L), and TD-14 (0.07 µg/L). The remainder of surface sediment porewater samples with detectable amounts of cPAHs indicated concentrations ranging from 0.03 µg/L at station TD-04 to 0.018 µg/L at station TD-SO-09.

5.4.2.3.2 Subsurface Sediment Porewater

cPAH concentrations in subsurface sediment porewater were characterized for the Nearshore Groundwater Discharge Area only (i.e., no sampling was conducted in the T-Dock Spill Area to characterize cPAHs in subsurface sediment porewater). The estimated extent of cPAHs in subsurface sediment porewater is shown on Figure 5.4-14. Where detected, total cPAH concentrations exceeded the PRG screening level in all cases. In those samples where cPAHs were not detected, the detection limits were greater than the screening level in all cases.

The highest subsurface sediment porewater cPAH concentrations were clustered around the nearshore portion of the historical T-Dock main span (e.g., stations NS-04-VC, NS-05-VC, and NS-08-VC), with the highest concentrations measured in the 8-to-12-inch interval at

[25] Additional discussion of the relationship between porewater and bulk sediment is provided in Section 6 .

station NS-05-VC (0.65 µg/L) located adjacent to Quendall Pond. Concentrations generally declined with distance from Quendall Pond, as illustrated by samples from stations NS-03-VC (highest concentration 0.045 µg/L in the 36-to-40-inch interval), NS-08-VC (highest concentration 0.077 µg/L in the 20-to-24-inch interval), and NS-09-VC (highest concentration 0.18 µg/L in the 0-to-4-inch interval).

Stations NS-01-VC to the south and NS-15-VC to the north did not have cPAH detections, with detection limits ranging from 0.025 to 0.056 µg/L. Although the detection limits exceeded the PRG screening level, they are below the MCL of 5 µg/L, and these undetected values provide a secondary line of evidence to laterally define the footprint of cPAH contamination in subsurface sediment porewater.

5.4.2.4 PAH ESBQs

PAH ESBQ results (expressed in TUs) for surface and subsurface sediment porewater samples are shown on Figures 5.4-15 through 5.4-18. PAH ESBQ calculations for sediment porewater were sensitive to the treatment of detection limits (see the RI/FS Data Report [Anchor QEA 2010] and the baseline risk assessment [Section 7]). Therefore, the distributions of PAH ESBQs in sediment porewater were calculated two ways relative to non-detect values: they were calculated using non-detect results at: 1) one-half the detection limit (depicted as U=1/2) and 2) zero (depicted as U=0). The resulting PAH ESBQ data calculated on the basis of U=1/2 and U=0 are illustrated on Figures 5.4-15 and 5.4-16 (surface sediment porewater) and Figures 5.4-17 and 5.4-18 (subsurface sediment porewater). Detection limits for the PAH ESBQs ranged from 1.7 to 2.1 TUs for the U=1/2 treatment. For the purpose of assessing nature and extent, the TU data based on U=0 are used. The U=1/2 TU data are included to illustrate the sensitivity of this endpoint.

The PRG screening level for PAH ESBQs is 1 TU. EPA guidance (2003b, 2007a) on the application of PAH ESBQs was applied. The highest PAH TUs in sediment porewater were detected in surface samples from the T-Dock cross span area (70 TUs) and in subsurface samples from the Nearshore Groundwater Discharge Area (96 TUs). The EPA PAH ESBQ guidance was also used to select the color scale relating to 1, 2, 4, and 8 times the TU to illustrate the distribution of sediment porewater PAH TU results on Figures 5.4-15 through

5.4-18. Additional discussion of PAH ESBQ distributions is provided in the baseline ecological risk assessment (Section 7.2).

5.4.2.4.1 Surface Sediment Porewater

PAH ESBQ values exceeded the PRG screening level of 1 TU in surface sediment porewater in two areas. These are associated with: 1) groundwater transport to the nearshore and 2) spills along the former T-Dock, particularly at the cross span. The bulk sediment distribution of PAH ESBQ values in these areas is similar to that in bulk sediment porewater (as described in Section 5.4.1.3.1) and provides an additional line of evidence for assessing the nature and extent of PAH ESBQs in surface sediment. Again, for the purpose of assessing nature and extent, the TU data based on U=0 are used. The PAH ESBQ values in surface bulk sediment that exceeded the PRG screening level, as shown on Figure 5.4-16, are as follows:

- **Nearshore Groundwater Discharge Area.** In this area, PAH ESBQ (U=0) values were highest at stations NS-04-SS and NS-05-SS (both 2 TUs). Offshore from these stations, PAH TU values slightly exceeded the PRG screening level at NS-08-SS (1.6 TUs), NS-09-SS (1.4 TUs), and NS-15-SS (1.2 TUs). The highest detected PAH ESBQ values correspond with the groundwater-to-sediment flowpath, as detailed in Section 6.4.2. Based on the PAH ESBQ (U=0) data shown on Figure 5.4-16, stations where the PAH TU exceeded the PRG screening level occur in two areas: 1) on either side of the T-Dock and 2) the far northeast end of the Nearshore Groundwater Discharge Area. The exceedances along the T-Dock are likely attributable to historical spills, with possible contribution from upland sources via the groundwater-to-sediment flowpath. The limits of the two hot spots are defined by surrounding stations where PAH ESBQ results are consistently below the PRG screening level.
- **T-Dock Spill Area.** In this area, PAH ESBQ values were highest at and near the T-Dock cross span at stations TD-08-SS (42 TUs) and TD-15-SS (70 TUs). Station TD-14-SS, located approximately 450 feet northwest of the cross span, had a PAH ESBQ value of 7.7 TUs. These PAH ESBQ results are consistent with the highest detected surface bulk sediment PAH ESBQ values in this area (see Figure 5.4-7) and correspond with the coal tar spill sources described in Section 5.4. Based on the PAH ESBQ (U=0) data shown on Figure 5.4-16, stations where the PAH ESBQ exceeded the PRG screening level occur in a northwest-southeast trending area that is

approximately 250 feet wide and extends from the T-Dock cross span to approximately 450 feet northwest of the cross span. The exceedances in this area are attributable to historical spills at the former T-Dock cross span. The limit of the hot spot is defined by surrounding stations where PAH ESBQ results are consistently below the PRG screening level.

5.4.2.4.2 Subsurface Sediment Porewater

PAH ESBQ values in subsurface sediment porewater were characterized for the Nearshore Groundwater Discharge Area only (i.e., no sampling was conducted in the T-Dock Spill Area to characterize PAHs in subsurface sediment porewater). PAH ESBQ results exceeded the PRG screening level of 1 TU in the Nearshore Groundwater Discharge Area. These exceedances may be associated with groundwater transport of PAHs from upland areas of the Site to the nearshore and/or with the presence of DNAPL beneath the lakebed in the nearshore. The distribution of PAHs in subsurface sediment porewater is similar to that for subsurface bulk sediment (as described in Section 5.4.1.3.2) and provides an additional line of evidence for assessing the nature and extent of PAH ESBQs in subsurface sediment. PAH ESBQ results are shown in Figure 5.4-17 (U=1/2) and Figure 5.4-18 (U=0). For the purpose of discussing PRG screening level exceedances, the U=0 ESBQs are used.

As shown in Figure 5.4-18, PAH ESBQ (U=0) values were highest at stations NS-04-VC (96 TUs in the 20-to-24-inch interval) and NS-05-VC (65 TUs in the 0-to-4-inch interval and 64 TUs in the 8-to-12-inch interval). Farther offshore from these stations, PAH ESBQ values generally decreased but still exceeded the PRG screening level by more than eight times at stations NS-08-VC (11 TUs in the 8-to-12-inch interval); NS-12-VC (20 TUs in the surface interval); and NS-10-VC (8.2 TUs in the 20-to-24-inch interval). Stations NS-03-VC (3.9 TUs in the 30-to-36-inch interval), NS-02-VC (1.7 TUs in the 20-to-24-inch interval), and NS-07-VC (1.5 TUs in the 8-to-12-inch interval) exceeded the PRG screening level by less than four times.

As indicated in Figure 5.4-18, the PRG screening level was exceeded at all stations sampled in the central and southwestern portions of the Nearshore Groundwater Discharge Area. Samples collected from four stations in the west-central portion (NS-13-VC) and the

northeast portion (NS-11-VC, NS-14-VC, and NS-15-VC) of the Nearshore Groundwater Discharge Area all indicate PAH ESBQ results below the PRG screening level. The distribution of PAH ESBQ results is consistent with historical spills along the main T-Dock and also with groundwater-to-sediment transport of PAHs from upland source areas, particularly from the vicinity of Quendall Pond. The area west and northwest of station NS-12-VC is not bounded with subsurface porewater results; however, subsurface bulk sediment results for station TD-03-VC indicate that PAH concentrations decrease in this area beyond the inner harbor line (see Figure 5.4-8).

5.4.2.5 Summary of Coal Tar Product Indicator Chemicals in Sediment Porewater

Surface sediment porewater contamination at the Site was delineated in two areas: the Nearshore Groundwater Discharge Area and the T-Dock Spill Area. The nature and extent of contamination in the Nearshore Groundwater Discharge Area was assessed using the distribution of benzene, naphthalene, cPAHs (expressed as benzo[a]pyrene equivalents), and PAH ESBQs (expressed as TUs). Benzene was not detected above its PRG screening level in any surface sediment porewater sample collected in the Nearshore Groundwater Discharge Area. Naphthalene was detected at the highest concentrations in samples collected in the Nearshore Groundwater Discharge Area adjacent to Quendall Pond. Naphthalene concentrations generally declined with distance from shore, consistent with the distribution of naphthalene concentrations in groundwater along the east-to-west groundwater flowpath. The nature and extent of contamination in surface sediment porewater in the T-Dock Spill Area was delineated by the distribution of naphthalene, cPAHs, and PAH ESBQs (surface sediment porewater samples collected in the T-Dock Spill Area were not analyzed for benzene). The distributions of these indicator chemicals were similar, and PRG screening level exceedances were generally localized to the vicinity of the former T-dock cross span and sediment located immediately to the northwest of the cross span. Areas along the former T-Dock and within the inner harbor line show evidence of both groundwater and spill sources.

Subsurface sediment porewater concentrations exceeding PRG screening levels were delineated only in the Nearshore Groundwater Discharge Area, including the area adjacent

to the former main span of the T-Dock. The nature and extent of sediment contamination were assessed using the distributions of benzene, naphthalene, cPAHs, and PAH ESBQs. The distributions of these indicator chemicals are similar, with the highest concentrations and PRG screening level exceedances typically occurring in the vicinity of the former T-Dock main span and area immediately offshore of the Quendall Pond. The vertical distribution of contamination is generally consistent with transport of contaminants from upland sources or from DNAPL beneath the lakebed via a groundwater-to-sediment flowpath. As such, porewater samples collected from depth often show higher concentrations than those collected from shallow depths.

The detected concentrations of PAHs in surface and subsurface sediment porewater are further evaluated in the baseline risk assessment (Section 7).

5.4.3 Wood Debris Indicator Chemical and Parameter Occurrences in Surface Bulk Sediment

Indicator chemicals and parameters specific to wood debris were measured in surface bulk sediment samples collected during the RI field investigation to provide information regarding the nature of the wood debris located south of the main span of the former T-Dock (Figure 5.4-1) and its associated toxicity (or lack thereof). The distribution of indicator chemicals in surface bulk sediment (0 to 4 inches) was characterized using 2009 RI field investigation sediment data (of QA2 quality) to identify wood debris and related contamination boundaries. A statistical data summary of data of QA1 and QA2 quality collected from surface bulk sediment samples is provided in Table 5.4-1.

The wood debris chemicals measured at the Site included bulk sediment phenols, resin acids, and guaiacols.[26] Of these analytes, PRG screening levels are only available for phenol (0.42 mg/kg) and 4-methyphenol (0.67 mg/kg) based on EPA Region 3 BTAG Sediment Screening Values. Data for the indicator parameters TOC, percent wood by volume, and TVS were also obtained to assess the deleterious nature of wood debris in surface sediment. The following

[26] Ammonia and sulfide were also measured in surface sediment porewater samples collected during the 2009 RI field investigation to provide additional lines of evidence regarding the nature of the wood debris and its associated toxicity (bioassay) evaluations. The results are discussed in the context of the baseline ecological risk assessment in Section 7.2.

sections discuss the rationale for assessing the extent of wood debris as a hazardous substance (as determined by concentrations of associated wood-debris-related chemicals) or as a potentially deleterious substance (as assessed by TOC, percent wood by volume, and TVS).

5.4.3.1 Hazardous Substances

The highest detected Site concentrations of phenol (0.14 mg/kg) and 4-methylphenol (0.15 mg/kg) in surface bulk sediment occurred at stations WD-06 and WD-03, respectively. The PRG screening levels for neither of these chemicals were exceeded in Site surface sediment samples. The estimated lateral extent of phenol and 4-methylphenol exceedances in surface bulk sediment is shown on Figure 5.4-19. The PRG screening levels for neither of these chemicals were exceeded in Site surface sediment samples. The highest detected Site concentrations of phenol (0.14 mg/kg) and 4-methylphenol (0.15 mg/kg) occurred at stations WD-06 and WD-03, respectively. The highest concentration of 4-methylphenol was detected at background station BG-03 (0.75 mg/kg), slightly exceeding the PRG screening level of 0.67 mg/kg (see Appendix H for figures depicting background sample locations).

5.4.3.2 Deleterious Substances

General wood debris characterization indicator parameters, including surface bulk sediment TOC and TVS percentages, and qualitative observations of percent wood by volume are summarized in this section to enable a comprehensive Site sediment characterization in conjunction with the information previously provided in Section 5.4. It should be noted, however, that the potentially deleterious aspects of wood debris (e.g., physical habitat disturbances) are not regulated under CERCLA and, as a result, are not specifically subject to cleanup under CERCLA.

A summary of the bulk sediment TOC and TVS data and qualitative percent wood debris observations from the 2009 RI field investigation are presented on Figure 5.4-19. The extent of wood debris was initially defined using a TOC content of 9.82 percent (by dry weight), based on the most recent Ecology update of the freshwater LAET sediment screening value (Ecology 2003). As discussed in Anchor and Lloyd (2003) and the Data Collection Work Plan (Anchor QEA and Aspect 2009a), surface sediment bioassay data collected from the

Quendall Site were previously used by Ecology to develop Site-specific MTCA cleanup levels of 13.5 percent (by dry weight) for TOC and 50 percent (by volume) for wood debris.

Figure 5.4-19 shows three areas of surface bulk sediment containing wood debris exceeding the TOC criterion of 9.82 percent or the 50 percent (by volume) wood debris criterion. As expected from historical investigations, the area found to contain the most substantial volume of wood debris is located offshore of the southwestern portion of the Site (Figure 5.4-1), extending southwest into the area offshore of the former Barbee Mill site (now the Conner Homes property). The limits of this area are generally defined by stations TD-SO-6 to the north (approximately 1,100 feet offshore), NS-02-SS just offshore of the South Detention Pond, and WD-03-SS located approximately 600 feet west of the southwest corner of the Site. All the samples collected from this area were observed to contain greater than 50 percent wood debris by volume and/or a TOC value exceeding 9.82 percent (by dry weight). The highest surface bulk sediment TOC value (24 percent) in this area was measured at station TD-SO-9. Outside this larger area of wood debris, two other areas indicated sediment exceeding the TOC LAET of 9.82 percent and/or containing wood debris exceeding 50 percent by volume. The area offshore of the former Baxter site (now the Football Northwest property) contained sediment with TOC values greater than the LAET of 9.82 percent (11.5 percent at station TD-SO-2 and 13.3 percent at TD-SO-1). A sediment sample collected from station SS-06-SS contained 50 to 60 percent wood waste and represents the third area of sediment exceeding the wood debris by volume criterion. The TOC analytical data and volumetric wood debris observations were further corroborated with TVS/organic matter data (also shown on Figure 5.4-19).

Confirmatory sediment bioassays were performed on samples containing wood debris and revealed a lack of toxicity. A full discussion of the bioassay results and potential ecological risk is presented in the baseline ecological risk assessment (Section 7.2).

5.4.4 Sediment Toxicity Testing

Bioassay testing is an important component of defining the nature and extent of sediment-associated COIs and indicator chemicals that are potentially toxic to benthic infauna. Four series of laboratory bioassays were conducted with Site and reference sediment for the

purpose of evaluating impacts to the benthic invertebrate community and to support the development of Site-specific cleanup levels (Anchor QEA and Aspect 2009a). Specifically, bioassay testing was conducted for this RI to address potential toxicity associated with: 1) hydrocarbons in the T-Dock Spill Area and the Nearshore Groundwater Discharge Area, and 2) wood debris along the southwestern shoreline. Within the context of this RI, the bioassay results are evaluated in the baseline ecological risk assessment (Section 7.2), which establishes the relationship between bioassay and analytical chemistry results to define the nature and extent of impacts to the benthic community. Test results, statistical analyses comparing test and reference samples, and discussion of the use of bioassays as a line of evidence in evaluating risks to the benthic community are provided in the ecological risk assessment for aquatic-dependent receptors (Section 7.2.5.2).

6 CONTAMINANT FATE AND TRANSPORT

Contaminants present in Site media can migrate from one location to another via advection (bulk flow) or diffusion (chemical gradient) processes. Contaminants can also be transferred among air, water, and soil media via various partitioning mechanisms during migration (e.g., volatilization, dissolution, and sorption), thereby modifying the rate of movement through the subsurface. In addition, contaminant concentrations can be reduced or attenuated by various combinations of chemical (e.g., diffusion and abiotic transformation), biological (e.g., biodegradation), or physical (e.g., dispersion and dilution) processes, as well as by the partitioning mechanisms listed above. Therefore, understanding contaminant transport, partitioning, and attenuation processes across the Site is an important element of evaluating potential exposure pathways, anticipating how the nature and extent of contamination may change over time, and assessing the potential effectiveness of alternative remedial actions in the forthcoming FS for the Quendall Site. In this RI Report, Site contaminant fate and transport processes have been characterized through a weight-of-evidence evaluation combining field observations, empirical measurements (data collection), and focused fate and transport modeling.

This Section 6 describes the primary Site contaminant transport mechanisms (Section 6.1), contaminant partitioning (Section 6.2), and other contaminant concentration attenuation processes (Section 6.3), and how these influence contaminant transport pathways and migration from Site source areas to potential human and environmental receptors (Section 6.4). Additional groundwater flow and quality model refinement and scenario-specific development will be completed and documented during the FS to support the evaluation of remedial alternatives. Fate and transport modeling in the transition zone between groundwater and surface water near the mudline beneath Lake Washington will also be completed and documented during the FS to support contaminant flux estimates to surface water and evaluation of "sediment" remedial alternatives.

6.1 Contaminant Transport Mechanisms

Contaminants may be transported through the subsurface by the processes of advection and diffusion. These mechanisms and their occurrence at the Quendall Site are depicted graphically on Figure 6.1-1 and described below.

6.1.1 Advection

Advection is the bulk movement of a fluid or gas (DNAPL, water, or air) in response to a pressure gradient. Under advective transport, a contaminant present in a fluid (e.g., dissolved in groundwater) is carried at the same velocity as the fluid. Advective transport in groundwater is often the primary transport mechanism controlling the migration of contaminants. In the absence of partitioning processes, contaminant migration is equivalent to the rate of groundwater flow; however, for many of the Site COIs such as benzene and naphthalene, partitioning processes retard contaminant migration, thus altering the rate of migration relative to that of groundwater (see Sections 6.2 through 6.4).

Advective transport is proportional to the driving force (i.e., the pressure or hydraulic head difference between two locations) and the permeability or hydraulic conductivity of the material between the same two locations, and is inversely proportional to the effective porosity of this material. The viscosity of the migrating fluid also affects advective transport, as more viscous fluids will migrate more slowly through the same porous medium compared to less viscous fluids.

Examples of contaminants undergoing advective transport at the Site include volatilized contaminants in soil vapor, dissolved contaminants in groundwater, and DNAPL components moving in the subsurface. Advective transport within these Site media is described below.

6.1.1.1 Soil Vapor

Advective transport of soil vapor is typically caused by changes in atmospheric pressure or aboveground wind flow that result in a pressure gradient between subsurface soil vapor and air. This pressure gradient can be altered on a local scale by structures with functioning heating, ventilation, and air conditioning (HVAC) systems which may alter the local pressure gradient, creating a localized low-pressure zone that can lead to preferential vapor transport into the HVAC system. Structures with functioning HVAC systems are not currently present on the Site but may be constructed as part of future redevelopment. (Protection of human health and the environment under future redevelopment scenarios will be evaluated in the FS for the Quendall Site.)

The rate of soil vapor advective transport is influenced by the soil matrix permeability, which is a function of the soil type (e.g., silt, sand, or gravel) and the moisture content of the soil. Soil vapor will not move through soil if the pore space is saturated with water (i.e., below the water table or in the lower capillary zone).

Pressure changes created by atmospheric fluctuations and HVAC systems (analogous to hydraulic head), soil type, and soil moisture content can be incorporated into analytical models to quantify potential vapor intrusion rates and resulting concentrations. Soil type and soil moisture content are Site-specific values; soil types were recorded in Site boring logs and moisture content was measured in soil samples, as discussed in the Draft Task 3 Report (Anchor and Aspect 2007b).

6.1.1.2 Groundwater

In the absence of mechanisms that retard contaminant movement relative to that of water, the advective transport of contaminants in groundwater is dependent on the average linear groundwater velocity. The average linear groundwater velocity is a function of the hydraulic conductivity, the hydraulic gradient, and porosity of the media, as defined by Darcy's Law.

Hydraulic gradient and hydraulic conductivity Site data are summarized in Section 3.1.5.

6.1.1.3 DNAPL

Advective transport of DNAPL is caused by density differences between DNAPL and the surrounding fluid. DNAPL is denser than both air and water and, if sufficient volume of DNAPL is present, gravity will cause DNAPL to move through porous media until it encounters a lower-permeability layer—such as the silt and peat deposits within the Shallow Alluvium (see Section 3.1.4). The rate of flow depends on fluid viscosity, the difference in fluid densities, and the permeability of the porous medium.

As DNAPL migrates through soil, it leaves behind a residual coating of product on the soil grains (referred to as "residual DNAPL" or "oil-coated" soil), diminishing the available

volume of mobile DNAPL. The sections below describe several key factors affecting DNAPL movement in the subsurface:

- Physical characteristics of subsurface soil, including stratigraphy and preferential pathways.
- Hydraulic conditions, including horizontal and vertical hydraulic gradients.
- The presence of DNAPL relative to residual saturation levels.
- Characteristics affecting DNAPL mobility in sediment and surface water.

6.1.1.3.1 Soil Characteristics Affecting DNAPL Mobility

Lower-permeability soil layers of silt, organic silt, clay, and peat inhibit vertical DNAPL migration. DNAPL will collect on top of lower-permeability layers and migrate laterally through seams of higher permeability until becoming trapped by other intersecting lower-permeability layers or reaching residual saturation. Thick accumulations of creosote or coal tar (greater than 20 feet thick) can penetrate into silt layers (Cohen and Mercer 1993, p. 5 to 16); however, this thickness of DNAPL has not been observed at the Quendall Site.

The Shallow Alluvium consists of many interbedded silt, sand, and peat layers that are sloped several degrees downward towards the west (see Figures 3.1-6 through 3.1-9). DNAPL released to the subsurface generally migrates downward via gravity through layers of higher-permeability materials (e.g., sand). The sloping layers of the Shallow Alluvium direct DNAPL migration at the Site towards the west until either: 1) a lower-permeability layer prevents further migration or 2) the volume of DNAPL is sufficiently diminished by the residual coating of soil grains along the transport pathway. DNAPL will tend to accumulate on top of lower-permeability layers (Cohen and Mercer 1993, p. 5 to 16) and migrate laterally through seams of higher permeability until becoming trapped by other intersecting lower-permeability layers. The discontinuity of permeable soil layers creates isolated layers and saturated seams of DNAPL in the subsurface. For example, at soil boring MC-1, four discrete layers (with thicknesses varying from 6 inches to 5 feet) of oil-coated or oil-wetted soil, separated by lower-permeability silt or peat layers, were observed at depths between 10 and 31.5 feet (see Figure 3.1-7). A photograph of representative DNAPL layers at boring MC-1 is provided on Figure 4.4-8.

6.1.1.3.2 Hydraulic Characteristics Affecting DNAPL Mobility

Site hydraulic conditions influence the mobility of DNAPL in the subsurface. Downward vertical migration of coal tar and creosote below the water table can be retarded or eliminated when upward groundwater flow (driven by an upward gradient) is present. The flow rate necessary to halt vertical DNAPL migration is a function of the product density and soil capillarity (Cohen and Mercer 1993, p. 5 to 20). As a result, in areas of the Site where an upward flow gradient is consistently observed (such as on the western side of the Site near Lake Washington), layers that prevent downward movement of DNAPL may include permeable soil layers that, in the absence of an upward gradient, would otherwise not be an adequate flow barrier.

In certain cases, product that is present below residual saturation under normal conditions may become mobilized due to elevated hydraulic pressure. For example, sheen has been observed intermittently along the Lake Washington shoreline adjacent to Quendall Pond. A hydraulic study by Aspect in 2005 (described in the Task 2 Report, Anchor and Aspect 2007a) evaluated sheen occurrences and found that sheen was correlated to very high water level elevations in Quendall Pond resulting from stormwater inputs from heavy rain events and seasonally lower winter lake levels, which together created a steep hydraulic gradient between water levels in Quendall Pond and Lake Washington. During these peak stormwater inflow events, sheen was observed discharging through the earthen berm forming the western (shoreline) edge of Quendall Pond. Discharge during these earlier events occurred as preferential flow "piping" through the base of the berm. Sheen discharge was reduced between 2005 and 2008 following implementation of a series of stormwater controls initially constructed in the immediate vicinity of Quendall Pond, and later across the entire Site. Field observations following the implementation of the Site-wide stormwater controls (see the Stormwater Best Management Practice Construction Report, Aspect 2008) confirmed that reducing stormwater inflow into Quendall Pond reduced sheen discharge.

Improperly abandoned wells, if located in DNAPL areas and screened at and below the depth of DNAPL occurrences, have the potential to act as vertical conduits that allow deeper DNAPL migration. Several former Site water supply wells and monitoring wells may not have been properly abandoned, but it is not believed that these wells have allowed deeper migration; these wells are discussed in the following:

- Several water supply wells approximately 20 to 30 feet deep were located north of the Still House. Potentially mobile DNAPL has not been identified in this area; therefore, improper abandonment of these wells is unlikely to have contributed to DNAPL migration.
- Two wells were located just north of Tank 2 on the 1918 Plant Map—one identified as 4 inches in diameter and 70 feet deep, and the other as 3 inches in diameter and 50 feet deep. Deep monitoring well BH-30C was installed cross-gradient approximately 20 feet north of the former locations of these wells and contamination was not detected at the screen depth (85 to 95 feet), indicating that a significant volume of DNAPL has not likely migrated through these former wells.
- Monitoring wells BH-2, BH-2A, BH-10, BH-12, BH-12A, and BH-15 were installed in 1983 but now cannot be located and are believed to have been destroyed during subsequent log yard activities. No DNAPL was noted in the boring logs of these wells. The wells were located outside identified DNAPL areas and are unlikely to have contributed to DNAPL migration.
- Monitoring wells BH-6, BH-8, and BH-8A, which were also installed in 1983, are also believed to have been destroyed during subsequent log yard activities. These wells were installed in or very close to DNAPL occurrences south of the north sump (occurrences in this area are described in Section 4.4.3, and the well locations relative to DNAPL occurrences are shown on Figure 4.3-1); however, mobile DNAPL was not observed in these wells after installation (and no accumulation of product was reported). Furthermore, these wells were screened at depths of 20 feet or less. Because the wells were not screened below the depth of observed DNAPL occurrences in these areas, improper abandonment of these wells is unlikely to have contributed significantly to the vertical migration of DNAPL.

One water supply well approximately 180 feet deep was located near the former facility office. This well was identified in a field survey in September 2009, as discussed in Section 3, and was confirmed to still be flowing when uncapped. As discussed below, this area is outside the area of identified DNAPL impacted soils, indicating that DNAPL migration along this well is unlikely.

As discussed above and in Section 3.1.5, there were a number of historical monitoring and drinking water wells at the Site for which proper abandonment was not performed or documented. The majority of these wells were screened in the Shallow Aquifer at depths less than 30 feet. The locations of these wells were within the areas of identified soil and groundwater contamination discussed in Section 5. Based on the observed vertical hydraulic gradients, dissolved-phase contamination along these potential preferential flowpaths is not expected to promote or enhance the potential for downward contaminant migration. The historical water supply well was installed much deeper (180 feet bgs) into a confined aquifer below the Deep Aquifer, separated by an intervening low-permeability aquitard. The confined aquifer exhibits a higher groundwater elevation than groundwater in the Shallow Aquifer (indicating an upward vertical gradient and upward flow potential) and therefore the deep historical water supply well is unlikely to be a pathway of downward groundwater or associated dissolved-phase contamination. Two historical wells located in the eastern portion of the Site were installed at depths of 50 and 75 feet bgs which are deeper than the identified contamination in this area; however, the predicted groundwater flowpaths in this area are primarily horizontal, indicating that these wells are unlikely to be pathways of downward groundwater or dissolved contaminant migration.

6.1.1.3.3 Residual Saturation Levels

A key characteristic that represents the potential mobility of DNAPL is the residual saturation level, defined as the fraction of pore space saturation at which DNAPL would begin to flow downward through the soil matrix. Residual saturation is a function of the product's physical characteristics (density, viscosity) and the soil type. DNAPL that no longer flows through a permeable layer is defined as being at or below residual saturation (non-mobile DNAPL). DNAPL that can migrate due to gravity, or which would migrate but for a lower-permeability layer, is defined as being above residual saturation (potentially mobile DNAPL).

Observations of DNAPL characteristics and its spatial distribution in the context of soil stratigraphy (type) can be used in a weight-of-evidence evaluation to assess whether DNAPL is likely present below or above residual saturation. Characteristics that indicate that DNAPL may be below residual saturation (i.e., is non-mobile) are as follows:

- DNAPL is present only as relatively thin, discontinuous layers within a homogeneous soil layer.
- DNAPL is present in permeable soil, but its downward migration is not limited by a low-permeability soil layer. For example, at boring SP-4, relatively thin, vertically discontinuous layers of DNAPL were observed within a sand layer without silty sand, silt, or peat layers separating the occurrences (see Figure 3.1-9).
- DNAPL has high viscosity (i.e., is not readily "flowable").
- Soil is not "oil-wetted" (i.e., the soil grains appear "coated", but oil does not separate from the soil). The majority of DNAPL-containing soil observed at the Site has been characterized as oil-coated rather than oil-wetted (see Section 4.4 and Tables G-1 through G-4 in Appendix G).

The presence or absence of DNAPL in monitoring wells can also be used to assess whether DNAPL is likely present below or above residual saturation (i.e., is potentially mobile), as follows:

- DNAPL that accumulates in the bottom of a well after the well is purged is likely present above residual saturation in the soil adjacent to the screen interval. Three wells at the Site exhibit this characteristic: BH-21A, BH-5, and RW-QP-1 (see Figure 4.3-1).
- DNAPL that is initially observed in a well after installation or development but does not recover after being removed is likely present below residual saturation. Three wells exhibit this characteristic: RW-NS-1, BH-23, and BH-20A (see Figure 4.3-1).
- If no DNAPL is observed in a well that is screened at an interval containing DNAPL, then the DNAPL is likely present below residual saturation. Three wells exhibit this characteristic: BH-5A, BH-8A, and Q4 (see Figure 4.3-1).

The variability of residual saturation in the subsurface is demonstrated by wells BH-5 (showing above residual saturation behavior) and BH-5A (located a few feet from BH-5, but showing below residual saturation behavior).

In some Site areas, DNAPL may be present above residual saturation levels but is prevented from further migration (i.e., is trapped) by lower-permeability soil, as discussed above.

Multiple lines of evidence can be used to assess whether DNAPL above residual saturation is trapped; these include the following:

- Long-term monitoring of product thickness in monitoring wells completed within areas of observed DNAPL accumulation: A decreasing product level in a monitoring well suggests that there is an available pathway for DNAPL migration. Product level thicknesses that are stable over a long period of time (i.e., years or decades) would suggest that the DNAPL accumulation is contained and not moving (assuming there is no continuing source of DNAPL to the well area). A Site map showing historical and existing monitoring wells, with wells in which DNAPL accumulates (indicating product is above residual saturation) highlighted in orange, is provided on Figure 4.3-1. DNAPL thickness measurements at Site wells are provided in Table 4.3-1.
- Long-term groundwater quality trends near observed areas of DNAPL accumulation: These trends enable evaluation of whether the area of impact changes in response to DNAPL migration in a particular direction over time. Increases in groundwater contaminant concentrations may be indicative of migration. Groundwater monitoring data at Site monitoring wells, discussed in Section 5.2 and tabulated in Appendix A, indicate generally stable levels of DNAPL constituents over the last 20 years.

Because of the uncertainty resulting from the relatively high heterogeneity of the Site subsurface, it is appropriate to use multiple lines of evidence to demonstrate DNAPL stability in a particular area.

6.1.1.3.4 Characteristics Affecting DNAPL Mobility in Sediment and Surface Water

DNAPL mobility in sediment is affected by the same parameters as mobility in soil; however, additional parameters affect the mobility of DNAPL released to surface water (e.g., Lake Washington). In these cases, DNAPL mobility as a result of spilled or leaked material is a function of the spill event (i.e., location, volume, and rate), the nature of the material, and physical conditions including weather and currents. The short-term fate and transport of the spilled or leaked product may include the following:

- Lighter fractions spreading across the lake surface and dissolving and evaporating.
- Some fractions becoming adsorbed on suspended material and deposited on the lake bottom.
- Denser fractions sinking to the sediment surface and migrating along the slope of the lake bottom.

Near-neutral density fractions would remain primarily within the sediment surface layer and would be subject to bioturbation and biodegradation over time. Dense fractions (i.e., DNAPL) would move down through the sediment and, depending on the sediment characteristics, would tend to flow until the concentrations were below residual saturation levels or the material was trapped by low-permeability layers, such as silty clay or silty peat, or by upward-discharging groundwater flow.

6.1.2 Diffusion

Diffusion is the migration, on a molecular scale, of a chemical within a fluid from an area of higher concentration to an area of lower concentration. Diffusion is often a minor contributor to contaminant transport relative to advection, but it may be significant in low-permeability soil and for movement of contaminants through soil gas. The rate of diffusion is proportional to the driving force (i.e., the concentration gradient between two locations) and the diffusivity of the fluid. The diffusivity depends primarily on the properties of the fluid, with much higher rates of diffusion of a particular chemical through gas than through a liquid. The diffusivity also depends on the particular chemical, with low-molecular-weight compounds typically migrating faster than high-molecular-weight compounds through the same fluid. Concentration gradients for Site COIs between two locations (separated vertically and/or horizontally) were characterized based on the results of chemical analyses at those locations.

Spreading of the groundwater dissolved contaminant plume at the Site also occurs by diffusion, but is typically minor in comparison with spreading by dispersion. Dispersion is discussed in Section 6.3.3. The major role played by diffusion at the Site is that over time, some of the dissolved contaminants have diffused into the fine grain layers of the Shallow

Aquifer and will slowly "bleed" back out, thus creating a secondary source of contaminants even if the contaminants are flushed from the coarser-grained units of the Shallow Aquifer.

6.2 Contaminant Partitioning between DNAPL, Water, Soil, and Air

Site contaminants can be transferred among DNAPL, water, soil, and air via various partitioning mechanisms (i.e., volatilization, dissolution, and sorption) during migration, thereby modifying the rate of movement through the subsurface. These mechanisms and their occurrence at the Quendall Site are depicted graphically on Figure 6.1-1 and described below.

6.2.1 Volatilization

Chemicals that are adsorbed onto soil particles, dissolved in water, or a component of DNAPL may volatilize (i.e., evaporate) into soil vapor. The tendency for a chemical to volatilize depends on its vapor pressure and, when partitioning from water, on its water solubility, and is generally greater for low-molecular-weight organic compounds (e.g., VOCs) than for metals or high-molecular-weight organic compounds. Partitioning between water and gaseous phases is described by Henry's Law. The higher the Henry's Law constant is for a chemical, the greater the tendency for that chemical to volatilize. Henry's Law constants for Site COIs are provided in Table 6.2-1.

6.2.2 Dissolution

Chemicals present in DNAPL or adsorbed onto soil particles may dissolve in water. Dissolution may occur in the unsaturated zone as infiltrating recharge migrating downward leaches chemicals from contaminated soil or DNAPL. Dissolution may also occur in the saturated zone as groundwater moving through the Site contacts contaminated soil or DNAPL.

The tendency of a chemical to dissolve into groundwater is represented by its aqueous solubility. The aqueous solubilities for the pure compounds present in creosote and coal tar are listed in Table 2.1-1. Pure phases of many PAHs are solids at room temperature; the theoretical solubility of these compounds as NAPL would, however, be somewhat higher.

For a NAPL mixture, the aqueous-phase concentration of each component of the mixture that is in equilibrium with groundwater can be approximated using Raoult's Law.

Typical chemical fractions in creosote and coal tar based on literature values and analysis of Site DNAPL products are discussed in Section 4.2.

The solubilities of non-ionic organic compounds are relatively stable under a typical range of groundwater conditions. In general, the solubility of organic compounds decreases with increasing molecular weight. Ionic organic compounds are typically much more soluble than non-ionic organic compounds. The solubility of some weakly acidic ionic compounds such as phenols can depend on the solution pH, resulting in a range of solubilities. The solubilities of inorganic chemicals such as metals depend on several factors, including the chemical's valence state, solution pH, and oxidation-reduction potential (Eh).

Groundwater at the Site may come into contact with DNAPL or contaminated soil in either the unsaturated or the saturated zone. In the unsaturated zone, rainwater infiltrating from the surface and percolating down through the unsaturated zone leaches chemicals from contaminated soil or DNAPL. In the saturated zone, groundwater flowing through the Site also comes into contact with DNAPL or contaminated soil below the water table.

Groundwater flowing past globules or stringers of DNAPL will typically become contaminated with DNAPL constituents according to the partitioning mechanisms described above. In areas of thicker DNAPL accumulation where soil pore spaces are oil-saturated, groundwater will tend to move around the DNAPL, resulting in less contact area and potentially slower mass transfer of contaminants to groundwater (i.e., lower aqueous concentrations). The more soluble Site COIs such as benzene and naphthalene will tend to preferentially dissolve from DNAPL into groundwater.

Groundwater or infiltrating stormwater may also leach chemicals from solid or semi-solid tar products; however, the contribution of dissolved-phase contaminants from these sources is expected to be much less than from DNAPL occurrences, as indicated by the following:

- Solid tar products are primarily composed of HPAHs that are relatively insoluble in groundwater and contain low concentrations of LPAHs such as naphthalene. A sample of soil containing solid tar fragments from test pit TP-2 (located east of the pitch bays; see Figure 3.1-5) contained a relatively low concentration of naphthalene (less than 0.5 percent), in contrast to the relatively high concentration of naphthalene present in Site DNAPL (5.2 to 18 percent: see Table 4.2-1). Products with low concentrations of naphthalene have a lower potential to leach this chemical, according to Raoult's Law.
- PAHs were not detected in well BH-27, located adjacent to the pitch bays in an area where solid tar materials are present in soil.
- Semi-solid tar containing a slightly higher concentration of naphthalene (2 percent) was detected in the former May Creek Channel; however, DNAPL was located in the same area, over a much larger area and at a greater depth. Site DNAPL products (coal tar and creosote) contain much higher concentrations of naphthalene (5.2 to 18 percent; see Table 4.2-1) and other LPAHs. Because of their wider distribution and higher proportions of leachable compounds, DNAPL products are a much more likely significant contributor to groundwater contamination than semi-solid tar products.
- Solid and semi-solid tar products are typically present above the water table (see Section 5.3), although some occurrences may occur within areas that are seasonally saturated. Limited contact with groundwater provides limited opportunity for leaching.
- Because solid and semi-solid tar products do not flow through soil and therefore do not "coat" soil grains, the available surface area for leaching into groundwater is much less than with DNAPL-impacted soil.

6.2.3 Sorption

Sorption is a process in which dissolved contaminants are removed from groundwater when they chemically or physically bind to soil particles. Sorption includes physical adsorption as well as chemical precipitation or co-precipitation. Sorption on some substrates may be irreversible or reversible depending on the mechanism. Reversible sorption, which is typical for organic chemicals sorbing onto aquifer or sediment material, results in desorption of the contaminant from the soil/sediment particles if the dissolved concentration of the surrounding water decreases or more sorption if the dissolved concentration increases up to

the sorptive capacity of the soil/sediment. The process of sorption/desorption slows the rate of movement of the contaminant relative to that of water and, as the plume moves into "clean" areas, helps reduce the dissolved contaminant concentration. For reversible reactions, the tendency of a chemical to adhere to soil/sediment is described by the soil-water partitioning coefficient.

Similar to the solubility characteristics summarized above, sorption of inorganic constituents such as metals varies depending on the ionic characteristics of the soil (e.g., its cation exchange capacity) and the pH of the solution. Organic constituents typically adsorb onto the organic matter present in soil, and the degree of partitioning (K_d) is equal to the soil organic content times the octanol-carbon partitioning coefficient (K_{OC}).

K_{OC} is strongly correlated to the octanol-water partitioning coefficient (K_{OW}), which is commonly measured for different chemicals under laboratory conditions. K_d and K_{OW} for Site indicator chemicals are indicated in Table 6.2-1. Fractional organic carbon data for soil are included in the Site project analytical database (Appendix A in this RI Report).

At the Quendall Site, near-surface Site soil and sediment contain relatively high fractions of organic carbon, particularly in the Shallow Aquifer layers containing peat; therefore, the K_d of these matrices is higher than the Deep Aquifer soil and nearshore beach sediment with somewhat lower carbon contents. Many Site COIs, including PAHs, have a strong affinity for soil organic matter, with the higher-molecular-weight compounds (e.g., benzo[a]pyrene and other cPAHs) being the most strongly adsorbed. Therefore, because cPAHs are relatively immobile in Site groundwater, sediment that is located farther from a contaminant source may accumulate only the more mobile compounds migrating from the source.

Contaminants that are adsorbed onto soil or sediment can later desorb back into groundwater if there is a decline in contaminant concentrations in groundwater. The rate of desorption can be relatively slow, particularly from low-permeability materials where the rate is limited by chemical diffusion through the fine-grained matrix.

6.3 Other Contaminant Concentration Attenuation Processes

In addition to diffusion and sorption discussed above, contaminant concentrations may be reduced or contaminants may be transformed into other chemicals by a variety of processes, including chemically (abiotic) and biologically mediated reactions and physical processes such as dispersion and dilution. These attenuation mechanisms for Site COIs are depicted graphically on Figure 6.1-1 and discussed below.

6.3.1 Abiotic Transformation

Abiotic transformation reactions that may affect contaminant transport at the Site include hydrolysis, photodegradation, and oxidation-reduction reactions. In hydrolysis, a chemical is destroyed in reaction with water, although hydrolysis is generally considered not to be a significant degradation process for coal tar constituents (World Health Organization [WHO] 2004). In photodegradation, ultraviolet light causes the organic compound to break down (a.k.a. photolysis). Photolysis may be a significant degradation process for coal tar constituents (WHO 2004) but only in media with exposure to sunlight (e.g., in air or shallow surface water).

In oxidation-reduction reactions, electron transfer reactions can change the valence state and chemical form of elements such as metals, which can affect their toxicity and mobility. For example, under reducing conditions, iron is typically present as ferrous (Fe^{2+}) iron, which is more soluble in groundwater than ferric (Fe^{3+}) iron. Reducing conditions can also cause naturally elevated arsenic concentrations in groundwater, as arsenic is more mobile under reducing conditions. Conversely, chromium is more soluble (i.e., mobile) in groundwater under oxidizing conditions, in the Cr(VI) valence state, than in the more commonly encountered Cr(III) valence state.

At the Quendall Site, groundwater conditions (particularly in the Shallow Aquifer) are generally reducing due to the presence of naturally occurring organic material (e.g., peat) and anthropogenic substances such as petrogenic hydrocarbons (including creosote), which form the primary carbon source for microorganisms that consume dissolved oxygen. A majority of the field parameter measurements collected during Site groundwater monitoring indicate low dissolved-oxygen concentrations and low Eh (see Appendix C). Analytical

measurements of iron concentrations indicate relatively high concentrations of dissolved iron in Site groundwater, verifying that reducing conditions are present (Retec 1997c).

In natural water, inorganic arsenic can occur in two common oxidation-reduction valence states: As(V) and As(III), with As(III)-containing compounds generally being more soluble. If geochemical conditions in groundwater become reducing, ferric iron (which limits the mobility of arsenic by sorption) reduces to more soluble and mobile ferrous iron (Krauskopf 1979), thus liberating more mobile As(III) compounds. Therefore, the reducing geochemical conditions in groundwater at the Quendall Site increase the mobility of arsenic, which results in increased concentrations of arsenic in Site groundwater.

6.3.2 Biodegradation

Indigenous microorganisms break down and eliminate organic contaminants through metabolic and enzymatic processes. These processes, both aerobic and anaerobic, transform contaminants into smaller compounds, with the final products commonly being carbon dioxide, methane, and water.

COIs related to coal tar DNAPL (particularly the lower-molecular-weight and more mobile contaminants) are generally biodegradable under both aerobic and anaerobic conditions, although anaerobic degradation is typically slower for these contaminants. As discussed above, low dissolved-oxygen and Eh levels, along with high ferrous iron and organic carbon, suggest that Site subsurface conditions are generally anaerobic (Retec 1997d).

The rate at which a compound is degraded is commonly expressed as a half-life, which is the time required for a compound to degrade to half its initial mass. Table D-5 in Appendix D presents literature values of anaerobic degradation rates for the indicator chemicals benzene and naphthalene. The rates cited in Table D-5 for groundwater transport are based on conservative literature values from Howard et al. (1991). The literature values are also reported in Retec (1998) and are more conservative than laboratory estimates developed from the Site-specific treatability study conducted by Retec (1997d).

Recent advances in soil/sediment column technologies have supported improved assessments of biological decay rates under conditions that more directly simulate field conditions. For example, recent column-based half-lives of benzene and naphthalene measured in anaerobic sediment collected from Onondaga Lake, New York averaged approximately 24 and 12 days, respectively, consistent with the range of literature values based on batch slurry experiments (D. Reible, University of Texas, in press). Site-specific evaluations at the Quendall property have verified that degradation (undifferentiated chemical and biological concentration attenuation mechanisms) is very active in the transition zone between groundwater and surface water beneath Lake Washington (see Section 6.4.3), and thus is an important process affecting the fate and transport of many of the COIs identified at the Site.

6.3.3 Dispersion

Mechanical dispersion is a physical (mechanical) process driven by advection resulting from fluid-flow irregularities that cause contaminants to follow an indirect path from their point of origin and result in a contaminant plume spreading in three dimensions rather than following a strictly linear groundwater flowpath. The spreading of the contaminant plume also reduces the contaminant concentrations by spreading the contaminant mass into a greater volume of groundwater. Dispersion is an important process influencing contaminant migration and concentrations in groundwater and sediment porewater, and is generally proportional to the average groundwater velocity and soil/sediment dispersivity. (Note: Some contaminant molecules will travel faster than the average groundwater velocity and some slower via dispersion.) Highly heterogeneous soil and sediment such as those present at the Quendall Site typically have higher dispersivities.

Dispersivity values often vary based on the dimension relative to groundwater flow (i.e., longitudinally, transversely, and vertically).[27] Dispersivity is typically not directly measurable on a Site-specific scale. Rather, dispersivity for use in groundwater flow models is estimated using Site characteristics and empirical methods. Near the mudline, dispersivity processes in sediment porewater can be difficult to distinguish from co-occurring bioturbation/bioirrigation processes and dilution from mixing with surface water. The

[27] Longitudinal means in the direction of groundwater flow. Transverse means horizontally perpendicular to the direction of groundwater flow. Vertical means vertically perpendicular to the direction of groundwater flow.

combined effects of these processes are often evaluated together in sediment fate and transport assessments.

Contaminants dissolved in groundwater at the Quendall Site are transported as the groundwater flows from the uplands west toward Lake Washington. Based on the results of fate and transport assessments and supporting modeling, summarized in the sections below and in Appendix D, advective transport is the primary transport mechanism for dissolved contaminants in Site groundwater. In addition, as dissolved contaminants move along a groundwater flowpath, mechanical dispersion results in vertical/lateral spreading of the dissolved contaminant plume well beyond the groundwater advective flowpath.

6.3.4 Dilution

Simple mixing of contaminated Site groundwater with clean direct precipitation recharge and with clean upgradient groundwater underflow into the Shallow and Deep Aquifers will directly reduce the concentrations of dissolved contaminants in Site groundwater. Moreover, when contaminated groundwater discharges into the Lake Washington surface water, contaminant concentrations can be lower as the result of the mixing of surface water in the aquifer/sediment transition zone between pure groundwater and surface water above the sediment interface; this is discussed further in Section 6.4.3.

Simple dilution of contaminated Site soil gas with clean air can reduce the concentrations of Site soil gas contaminants; this is discussed further in Section 6.4.1.

6.4 Contaminant Transport Pathways

Contaminant occurrences in multiple Site media may be linked through the transport, partitioning, and attenuation/transformation mechanisms described in Sections 6.1 through 6.3. In the evaluation of Site conditions, three pathways are of particular importance in evaluating potential COI exposures under current and future conditions:

- The DNAPL/soil/groundwater to air pathway (Section 6.4.1)
- The DNAPL/soil to groundwater to sediment/porewater pathway (Section 6.4.2)
- The groundwater to lake pathway (Section 6.4.3)

For the DNAPL to air and DNAPL to porewater pathways, computer model simulations that incorporate the transport, partitioning, and attenuation/transformation mechanisms described above were used to evaluate COI migration. These model predictions were used along with the measured Site characterization data (described in Section 5) to develop an overall weight-of-evidence evaluation of contaminant fate and transport at the Site and to support the Site CSM. The sections below describe the primary assumptions incorporated into the fate and transport modeling, the key results of the modeling, and how these results were used in the overall weight-of-evidence evaluation along with the Site characterization data to develop the CSM of contaminant fate and transport at the Site. Additional details of the modeling efforts, including model construction, sensitivity analyses, and outputs, are provided in Appendix D (Groundwater Modeling). Note: Additional groundwater flow and quality model refinement and scenario-specific development will be completed and documented during the FS to support the evaluation of remedial alternatives.

Fate and transport modeling of the Site COIs in the groundwater to lake pathway, representing the transition zone between groundwater and Lake Washington, will also be completed and documented during the FS to support evaluation of sediment-specific remedial alternatives.

6.4.1 DNAPL/Soil/Groundwater to Air Pathway

In this pathway, also called the vapor intrusion pathway, contaminants present in the subsurface are transported via soil gas into the aboveground air. Contaminants present in DNAPL and soil in the unsaturated zone, and in groundwater near the water table, volatilize into soil gas according to the partitioning relationships described above. Contaminants in soil gas can migrate through the unsaturated zone via diffusion and advection. Diffusive transport will generally result in a net movement from the source of contamination (where the concentration is highest) towards the ground surface (where the contaminant concentration is substantially diluted in ambient air). Advective transport will vary in direction depending on whether atmospheric pressure is rising or falling; falling atmospheric pressure conditions typically increase advective transport into the aboveground air. Depending on the pressure differential and the soil properties, either advection or diffusion may be the more important transport mechanism for soil gas migration. In soil with high

water content, particularly saturated and capillary-zone soil, diffusion through water-filled pores is often the dominant transport mechanism.

Contaminant migration in soil vapor may be retarded by sorption onto soil, and contaminants may be removed by biodegradation. Biodegradation of hydrocarbons can significantly reduce concentrations in soil gas, particularly in shallow soil where atmospheric air contributes oxygen to the subsurface (Interstate Technology and Regulatory Council [ITRC] 2007). Contaminant concentrations in soil gas migrating aboveground will be diluted by ambient air. Some dilution may also occur in the subsurface when atmospheric pressure is increasing (i.e., forcing ambient air into the ground).

Site air monitoring by Hart Crowser (1997, summarized in Section 2.7.1 of the Draft Task 3 Report [Anchor and Aspect 2007b]) did not identify potential exposure concerns for outside air. In that study, vapor samples were collected in flux chambers at five locations in areas of shallow subsurface contamination and VOC concentrations were all below PRGs. However, future Site uses may include the construction of heated, enclosed structures and associated HVAC systems for which vapor intrusion is a potential concern. A screening-level analysis using the most commonly applied model for vapor intrusion, the Johnson-Ettinger Model (1991), was performed by EPA during its review of the Draft Task 3 Report (see Bailey 2008). This screening-level analysis used Site-specific data for soil and contaminant characteristics, and generally used default model assumptions for the characteristics of a hypothetical building (see Environmental Quality Management [EQM] 2004 for discussion of default assumptions for the Johnson-Ettinger model). Application of the Johnson-Ettinger model to the Site indicated that exceedances of air PRGs for benzene and naphthalene are possible for future structures.

Based on the widespread occurrence of volatile contaminants in shallow Site soil and groundwater, and the results of the screening-level evaluation performed by EPA, it is anticipated that the design of future Site redevelopment structures will need to include an evaluation of vapor intrusion and will likely require some form of vapor intrusion mitigation, either passive or active, be incorporated into the design. The details of the evaluation and mitigation would depend on future development details such as the depth and type of fill placed on the Site, building locations and footprints, and building HVAC designs (e.g.,

negative or positive pressure systems and air exchange rates). A variety of mitigation techniques such as vapor barriers and sub-slab ventilation systems are available and are commonly applied at redeveloped sites, usually for a small fraction of the overall building cost (ITRC 2007). These considerations will be explored further in the FS.

6.4.2 DNAPL/Soil to Groundwater to Sediment/Porewater Pathway

In this pathway, contaminants present in Site DNAPL or soil dissolve into groundwater and are transported in groundwater toward Lake Washington, where they are either discharged to the lake or, prior to discharge, are transformed or sorbed onto sediment. This pathway is of particular concern because it represents the primary mechanism for Site DNAPL and soil contaminants to migrate through groundwater into Lake Washington sediment or porewater, where they may become available to lake biota.

This pathway results from the following mechanisms that affect Site contaminants:

- Dissolution from DNAPL or soil into groundwater
- Transport in groundwater via advection, with lateral/vertical spreading of the contaminant plume in groundwater due primarily to dispersion
- Reduction of contaminant concentrations in groundwater and porewater along the flowpath due to dispersion, sorption, and degradation from chemical and biological reactions in the aquifer and lakebed sediment

6.4.2.1 Groundwater Flow and Contaminant Fate and Transport Modeling

Because of the complexity of contaminant transport mechanisms, groundwater models are particularly useful in fate and transport evaluations to: 1) define contaminant transport pathways based on groundwater flow hydraulics and 2) evaluate contaminant migration and attenuation along those pathways due to advection, dispersion, diffusion, sorption, and chemical and biological degradation. Models can provide a further line of evidence to corroborate empirical data and are particularly useful in helping evaluate the relative differences among multiple remediation scenarios.

Contaminant fate and transport in the groundwater flow system were evaluated in previous Site studies using one-dimensional computer models, as follows:

- Hart Crowser (1997) used the Multimedia Exposure Assessment Model (MULTIMED) (Salhotra et al. 1990), which accounts for dilution and sorption processes but not transformation processes. MULTIMED was applied along flowpaths simulated by a two-dimensional steady-state flownet generator (FLOWNET).
- Retec (1998) used an analytical contaminant transport model based on the Domenico solution (Domenico 1987) that accounted for dilution, sorption, and biodegradation (incorporating literature biodegradation rates). Retec adapted three-dimensional flowpaths simulated by the numerical finite difference code MODPATH.

Both of these evaluations concluded that significant attenuation of COIs (including benzene, naphthalene, and cPAHs) occurs at the Site, leading to corresponding decreases in dissolved-phase contaminant concentrations in groundwater downgradient of DNAPL and soil source areas.

For this RI, the numerical groundwater flow model MODFLOW (described in Section 3 and Appendix D) was used to characterize groundwater flowpaths in three dimensions across the Site using particle tracking techniques and to estimate groundwater discharge into Lake Washington. Fate and transport of Site indicator chemicals were evaluated using the three-dimensional numerical contaminant transport model MT3D (Zheng 1990; Zheng and Wang 1999, described in Appendix D) to provide a preliminary evaluation of groundwater fate and transport on a Site-wide scale from representative contaminant sources to Lake Washington. Note: More detailed and remedial-alternative-specific contaminant transport modeling will be performed as part of the evaluation of Site remedial alternatives during the FS.

Contaminant transport along the DNAPL/soil to groundwater to sediment/porewater pathway is discussed in the following sections for the Shallow Aquifer and Deep Aquifer pathways.

6.4.2.2 Groundwater Pathway – Shallow Aquifer

This section discusses contaminant fate and transport in the Shallow Aquifer. The mechanisms controlling contaminant transport include: 1) groundwater transport processes that dictate the primary direction of contaminant migration, 2) sorption/retardation processes that affect the rate of contaminant migration relative to water, and 3) the presence of concentration-attenuating mechanisms such as dispersion and biodegradation. As discussed earlier, the transport and attenuation mechanisms of diffusion and dispersion may reduce contaminant concentrations, but also broaden the area of contamination beyond that predicted by groundwater hydraulic flowpath models. Characteristics of contaminant fate and transport in the Shallow Aquifer, as predicted by the groundwater models and observed in the empirical data, are described below.

6.4.2.3 Groundwater Transport in the Shallow Aquifer

Advection of contaminants through the Shallow Aquifer groundwater pathway is illustrated by particle flowpaths on Figures 6.4-1 through 6.4-4. Based on evaluations of measured groundwater characteristics at the Site (e.g., water levels and hydraulic conductivity) using the numerical groundwater flow model MODFLOW, groundwater flow within the Shallow Aquifer is predominantly horizontal with a downward component in the eastern portion of the Site. Horizontal groundwater flow dominates the central Site area, and then slowly transitions upward near the shoreline before discharging to Lake Washington. Throughout the Shallow Aquifer, the vertical component of advection is small relative to the horizontal direction of groundwater flow due to anisotropy (the ratio of horizontal to vertical hydraulic conductivity). The high anisotropic nature of the Shallow Aquifer is characteristic of the many interbedded layers of the silt, peat, and sand (see Section 3.1.4.2).

The groundwater flow model was calibrated using the measured Site groundwater levels, resulting in similar groundwater gradients to those measured on-Site. The groundwater flow model simulates a downward hydraulic gradient (0.015 ft/ft) between the Shallow and Deep Aquifers in the eastern portion of the Site, consistent with the measured value of 0.019 ft/ft at the BH-30A/C well pair, and an upward gradient of 0.02 ft/ft (compared to 0.040 ft/ft measured at the BH-19/BH-19B well pair) in the western portion of the Site near Lake Washington. A summary of the model calibration is presented in Table D-2 in Appendix D.

Hydraulic interaction between the Shallow and Deep Aquifer pathways is limited by the horizontal stratification of the Shallow Alluvium and the relatively small vertical gradients across the Site, and varies depending on where the groundwater flowlines originate. Groundwater flow at the Site is east-to-west towards Lake Washington, with a vertical flow component that varies across the Site.

To help bound the maximum western extent of advective groundwater flow transport (excluding dispersion/diffusion), a particle tracking analysis was conducted. A series of "particles" were placed along the eastern Site boundary at two depths (15 and 33 feet bgs). The groundwater model was run and the locations of the particles were tracked at 1-year intervals until they exited the modeled area into the surface water beneath Lake Washington. Figure 6.4-1 shows a plan view of groundwater discharge points for the particles originating along the eastern boundary of the Site at depths the following depths:

- 15 feet, which represents groundwater in the Shallow Aquifer that is near the water table and where DNAPL has been observed in numerous borings. Groundwater at this depth in the eastern portion of the Site travels west and downward into the top of the Deep Aquifer, as illustrated by the model-generated flowpaths depicted on Figures 6.4-2 through 6.4-4. Groundwater along this pathway remains close to the top of the Deep Aquifer and, as the vertical gradient transitions from downward in the eastern portion of the Site to upward near the lake, groundwater re-enters the Shallow Aquifer close to the shoreline. Groundwater present at a depth of 15 feet along the eastern boundary of the Site is predicted to discharge approximately 150 to 200 feet offshore, as illustrated on Figure 6.4-1.
- 33 feet, which represents groundwater at the top of the Deep Aquifer where the deepest occurrence of DNAPL has been observed at well BH-30C (Figure 6.4-2). Groundwater at this depth in the eastern portion of the Site flows primarily horizontally, to the west, with a small downward component as shown on Figures 6.4-2 through 6.4-4. Groundwater originating at this depth remains in the Deep Aquifer for most of the flowpath, transitioning upward and entering the Shallow Aquifer just before discharging to Lake Washington, approximately 300 feet offshore (Figure 6.4-1).

As illustrated by the cross-sectional particle tracking results on Figures 6.4-2 through 6.4-4, groundwater infiltrating into the eastern portion of the Site flows downward through the entire thickness of the Shallow Aquifer and reaches the upper portion of the Deep Aquifer. Within the central Site areas, groundwater flowlines are predominantly horizontal and likely do not transition between the aquifers. Near the shoreline, groundwater flowlines in the Deep Aquifer transition upward, transecting the Shallow Aquifer before discharging to Lake Washington.

Although particle tracking is useful in predicting advective transport, the paths of contaminants usually diverge from groundwater flowpaths due to dispersion and the concentration attenuation processes such as dispersion, sorption, and degradation tend to lower the contaminant concentrations. To assess the effects of these additional processes on the two primary Site indicator chemicals (naphthalene and benzene), the MT3D model was used. Site-specific data and literature-reported values used in previous modeling were reviewed and used where appropriate for parameters affecting chemical processes. A description of the contaminant transport model is presented in Appendix D.

For a preliminary assessment, contaminant transport downgradient from three representative locations of dissolved-phase DNAPL contamination was evaluated. The three locations are as follows:

- Well BH-30C, representing a DNAPL source in the eastern portion of the Site where the deepest Site DNAPL has been observed and where groundwater flow includes a downward component. This Shallow Aquifer/top of Deep Aquifer source was represented in the model with a hypothetical constant naphthalene source groundwater concentration of 16 mg/L to a depth of 33 feet.
- Boring MC-1, representing a DNAPL source in the Shallow Aquifer in the center of the Site at the location where the second-deepest Site occurrence of DNAPL was observed. This Shallow Aquifer source was represented in the model with a hypothetical constant naphthalene source groundwater concentration of 16 mg/L to a depth of 28 feet.
- Well pair BH-20A/B, representing a source in the Shallow Aquifer containing significant benzene, located adjacent to Lake Washington. This Shallow Aquifer

source was represented in the model with a hypothetical constant benzene source groundwater concentration of 8 mg/L to a depth of 49 feet because concentrations of benzene were elevated at both wells BH-20A and BH-20B.

Note: The constant representative source concentrations at well BH-30C, boring MC-1, and well pair BH-20A/B were based on the highest reported Site groundwater contaminant concentrations detected in September 2009 of 8 mg/L (8,000 μg/L) benzene at well BH-20A and 16 mg/L (16,000 μg/L) naphthalene at well BH-5.

The model results are shown on Figures 6.4-2 through 6.4-4. The results of the three representative contaminant-release scenarios clearly demonstrate that naphthalene and benzene concentrations rapidly attenuate with distance from potential sources and are transported relatively deep into the Deep Aquifer in contrast to the advective particle tracking results.

These preliminary contaminant transport model scenarios were not intended to simulate transport from all Site sources; rather, they were used to assess contaminant migration and concentration attenuation for indicator chemicals downgradient from representative source areas. More detailed and remedial-alternative-specific contaminant transport modeling will be performed as part of the evaluations of Site remedial alternatives during the FS.

6.4.2.4 Contaminant Migration Rates in the Shallow Aquifer

Sorption of contaminants to soil particles causes contaminant travel times to be slower than those predicted by advective transport. Historical Site data and typical literature values of parameters affecting sorption (Hart Crowser 1997; Retec 1998) suggest an average Site-specific retardation factor (i.e., ratio of advective groundwater velocity to retarded contaminant velocity) in the Shallow Aquifer of approximately 2.2 for benzene and 13.2 for naphthalene. Transport for HPAHs is much slower than for naphthalene. For example, the retardation factor for benzo(a)pyrene in the Shallow Aquifer is approximately 18,000. Longer travel times allow for greater mass attenuation through chemical and biological degradation along flowpaths. As summarized in Table 6.4-1, the calculated advective flow travel times to the Lake Washington mudline from a DNAPL source located at a depth of 15

feet at boring MC-1 (in the central portion of the Site) are approximately 3 years for groundwater, 7 years for dissolved benzene, and 40 years for dissolved naphthalene. The travel times for HPAHs are much longer because of much higher retardation rates relative to that of naphthalene. For example, the estimated travel time for benzo(a)pyrene in the Shallow Aquifer is 54,000 years.

6.4.2.5 Contaminant Attenuation in Shallow-Aquifer Groundwater

The contaminant transport modeling indicated that significant contaminant concentration attenuation occurs at the Site downgradient from the representative source areas in the Shallow Aquifer due to a combination of dispersion, sorption, degradation, and dilution from precipitation recharge. The results of the representative contaminant release scenarios discussed above show that the simulated reductions in naphthalene concentrations downgradient from two locations of maximum groundwater concentrations to the Lake Washington mudline (see Figures 6.4-2 and 6.4-3) are on the order of 99.95 percent (maximum estimated concentration of 0.008 mg/L [8 µg/L] at the mudline) from well BH-30C along an approximate 900-foot flowpath, and 98.5 percent (maximum estimated concentration of 0.24 mg/L [240 µg/L] at the mudline) from boring MC-1 along an approximate 400-foot flowpath. The simulated reduction in benzene concentrations downgradient from well pair BH-20A/B along an approximate 100-foot flowpath to the Lake Washington mudline, as shown on Figure 6.4-4, is on the order of 65 percent (maximum estimated concentration of 2.78 mg/L [2,780 µg/L] at the mudline). See Table D-7 in Appendix D for additional details.

These preliminary model predictions of significant contaminant concentration reductions along the flowpath downgradient from representative source areas are consistent with data collected in Site areas that do not contain DNAPL but are downgradient of DNAPL sources, such as at well BH-28A. BH-28A is located approximately 350 feet downgradient of well BH-25A(R), which in turn is located at the edge of a DNAPL area. Groundwater at BH-25A(R) contained a naphthalene concentration of 11,000 µg/L, but at downgradient well BH-28A, concentrations of naphthalene are very low (1.1 µg/L). (The well locations and naphthalene concentrations are shown on Figure 5.2-8.) The measured reductions in concentrations along the flowpath from BH-25A(R) to BH-28A (greater than 99.98 percent)

are greater than those predicted by the model, suggesting that the model assumptions may be conservative or that well BH-28A is not exactly downgradient of the source and thus has a lower concentration.

In contrast to the decreasing concentrations observed along flowpaths downgradient of DNAPL sources in many Site areas, relatively high dissolved-phase concentrations persist in the Shallow Aquifer along the groundwater flowpaths. For example, along the 800-foot-long flowpath from the Tank Car Loading Area (well Q9) to near Lake Washington (well BH-20A), naphthalene concentrations are highly elevated at both wells (45,000 µg/L at Q9 and 10,000 µg/L at BH-20A; see Figures 5.2-8 and 5.2-12). However, as shown on Figure 5.2-12, numerous DNAPL sources are present along this flowpath (for example, at borings BH-30C, BH-9, HC-4, and QP-6), including within the immediate vicinity of well BH-20A. In this case, elevated contaminant concentrations likely persist along the flowpath because of the multiple DNAPL sources in the Shallow Aquifer that are encountered along this flowpath.

6.4.2.6 Groundwater Pathway – Deep Aquifer

This section discusses contaminant fate and transport in the Deep Aquifer. The mechanisms controlling contaminant transport are the same as in the Shallow Aquifer and include: 1) groundwater transport processes that dictate the primary direction of contaminant migration, 2) sorption/retardation processes that affect the rate of contaminant migration relative to water, and 3) the presence of concentration-attenuating mechanisms such as dispersion and biodegradation. As discussed earlier, the transport and attenuation mechanisms of diffusion and dispersion may reduce contaminant concentrations, but also may broaden the area of contamination beyond that predicted by groundwater hydraulic flowpath models. Characteristics of contaminant fate and transport in the Deep Aquifer, as predicted by the groundwater models and observed in the empirical data, are described below.

6.4.2.7 Groundwater Transport in the Deep Aquifer

Although sources of dissolved contaminants at the Site primarily[28] originate within the Shallow Aquifer and at the interface between the Shallow and Deep Aquifers, groundwater concentration data collected during the RI field investigation indicate that COIs extend throughout most of the thickness of the Deep Aquifer near the shoreline, consistent with the groundwater flow and transport modeling. Dissolved contaminants enter the Deep Aquifer groundwater pathway through westward Shallow Aquifer advection with downward vertical gradients enhanced by lateral/vertical dispersion, especially in the eastern portion of the Site. Where contaminants enter the Deep Aquifer the groundwater flowpath is predominantly horizontal with the highest dissolved concentrations observed in the upper portion of the Deep Aquifer, ultimately discharging to Lake Washington. However, dispersion causes contaminants to spread downward throughout much of the Deep Aquifer thickness (see Figures 6.4-2 through 6.4-4), making dispersion a significant contaminant transport mechanism in the Deep Aquifer.

The model-predicted results of the three representative contaminant-release scenarios discussed above show the depth of contamination in the Deep Aquifer to be greatest near the shoreline, where vertical gradients start to transition upward. These results are consistent with the 56 µg/L of naphthalene observed in well BH-20C screened in the lower portion of the Deep Aquifer near the shoreline (Figure 5.2-9).

6.4.2.8 Contaminant Migration Rates in the Deep Aquifer

Retardation of contaminant migration relative to the advective groundwater flow velocity occurs within the Deep Aquifer as it does in the Shallow Aquifer. Retardation, however, is lower (see Table D-5 in Appendix D), due to the lower organic carbon fraction of the alluvium comprising the Deep Aquifer (Hart Crowser 1997). The calculated retardation factors in the Deep Aquifer are approximately 1.4 and 4.7 for benzene and naphthalene, respectively. The calculated benzo(a)pyrene retardation factor in the Deep Aquifer is approximately 5,500. These factors equate to estimated advective contaminant travel times

[28] DNAPL has mostly been observed in the Shallow Aquifer, except for a 6-inch layer of DNAPL observed in the uppermost part of the Deep Aquifer at well BH-30C (approximately 1 foot beneath the base of the Shallow Alluvium).

to the lake from the eastern property boundary near the location of BH-30C through the Deep Aquifer of 5 years for groundwater, 8 years for benzene, and 28 years for naphthalene. The travel times for HPAHs in the Deep Aquifer, including benzo(a)pyrene, are much longer, estimated to be 28,000 years. Retardation factors and estimated travel times in the Deep Aquifer are summarized in Table 6.4-1.

6.4.2.9 Contaminant Attenuation in Deep-Aquifer Groundwater

The same contaminant concentration attenuation mechanisms present in the Shallow Aquifer also occur in the Deep Aquifer, but faster estimated travel times in the Deep Aquifer result in less concentration attenuation over similar flowpath lengths; this is demonstrated by the model-predicted concentration contours of naphthalene associated with the BH-30C representative constant source area (Figure 6.4-2), in which the plume extends farther downgradient in the Deep Aquifer than in the Shallow Aquifer. Groundwater sampling data generally support the model prediction: naphthalene concentrations downgradient of the eastern portion of the former May Creek Channel decreased more than 99.9 percent in the Shallow Aquifer over 400 feet (from 11,000 µg/L at well BH-25A(R) to 6.2 µg/L at BH-28A) but decreased only 94 percent at the top of the Deep Aquifer (to 700 µg/L at well BH-28B). (Note: The magnitude of these observed decreases may be affected by the upgradient and downgradient wells not being located or screened exactly on the same groundwater flowline.)

In contrast to the multiple DNAPL sources impacting the full vertical extent of the Shallow Aquifer, the highest concentrations of dissolved-phase contaminants in the Deep Aquifer from DNAPL sources are primarily limited to the upper portion of the Deep Aquifer. Once in the Deep Aquifer the contaminants are “carried down” by dispersion, reaching their greatest depths near the shoreline (see Figures 6.4-2 and 6.4-3). Contaminant migration extending deeper into the Deep Aquifer occurs primarily from sources in the eastern portion of the Site in response to downward vertical gradients and dispersion, and is deepest near the shoreline. As a result, well BH-30C (screened deep in the Deep Aquifer near the eastern Site boundary, and horizontally downgradient of DNAPL sources) had non-detect benzene and 0.14 µg/L of naphthalene. Well BH-20C (located horizontally downgradient of BH-30C) had non-detect benzene and 56 µg/L of naphthalene (see Figures 5.2-6 and 5.2-12, respectively).

6.4.3 Groundwater to Lake Pathway

The results of the groundwater flow and fate and transport modeling discussed above are not anticipated to be representative of Site conditions in the transition zone between groundwater and the surface water of Lake Washington because contaminant fate and transport mechanisms near the mudline are more numerous and variable, and thus are more complex. However, analytical models can be very useful in evaluating these processes in this transition zone. Using the groundwater/sediment porewater data collected from the Site and building on the groundwater flow modeling results summarized in Section 6.4.2, a one-dimensional contaminant transport model will be developed to help refine the fate and transport CSM within the nearshore groundwater discharge area and evaluate potential lake sediment/porewater remediation alternatives. The modeling framework for this effort will be the University of Texas (UT) one-dimensional steady-state model that is widely used at other Superfund sediment sites (Lampert and Reible 2009). Although the UT model was originally developed to simulate sediment caps, it can easily be used simulate uncapped conditions as well. The UT model simulates chemical (dissolved and sorbed phase) fate and transport under the processes of advection, diffusion/dispersion, undifferentiated chemical/biodegradation processes, bioturbation/bioirrigation, and exchange with the overlying surface water (dilution). Details of the model structure and underlying theory and equations are provided in Lampert and Reible (2009). Details of the UT model, remediation scenarios, and model output will be presented in the FS Report.

To support the UT model evaluation during the FS, detailed sampling and analysis of groundwater and sediment porewater concentration gradients were performed for the upper 4 feet of sediment in the nearshore area of the Site, as described in Section 5.4. In addition to porewater analysis for representative Site COIs (e.g., benzene and naphthalene), the nearshore sediment porewater samples were also analyzed for several relatively non-reactive "tracer" cations (sodium, potassium, calcium, and magnesium) to help differentiate between chemical/biological concentration attenuation processes that affect Site COIs and simple dilution with surface water.

To differentiate the chemical/biological concentration attenuation processes from simple dilution with surface water, the vertical concentration profiles of the "tracer" cations were compared with those of benzene and naphthalene. The comparison approach assumed that the cation concentrations were unaffected by the chemical/biological attenuation processes that affect benzene and naphthalene, and that all the other concentration attenuation processes such as dilution, dispersion, and other similar processes affect all the analytes similarly. Concentration attenuations of benzene and naphthalene that are greater than those of the "tracer" cations would demonstrate the presence of attenuation processes in excess of dilution in the last few feet of contaminant migration to the mudline. Data preparation and results are discussed below.

Because of similarities in groundwater discharge velocities (flux rates) and groundwater concentrations entering the nearshore discharge area, all porewater data collected from core sampling stations NS-04, -05, -08, -09, and -10 and wellpoint stations WP-19A, -19B, -19C, -20A, and -20B were pooled for this evaluation. (The data and the station locations are shown on Figures 5.2-1 and 5.2-8.) The variability in porewater concentrations measured at these locations was addressed through evaluations of the mean ± standard error of each parameter.

It is assumed that the overlying surface water contaminant concentrations are negligible. While this assumption is appropriate for benzene and naphthalene (given their low surface water concentrations), the cation data exhibit non-zero concentrations in Site surface water (Table 6.4-2). In order to appropriately evaluate the cation data profiles given their non-zero concentrations in the surface water, concentrations measured within the porewater were normalized by first subtracting the surface water concentration from the porewater cation data, and then dividing them by the maximum cation concentration collected from the 4-foot depth within each profile. For benzene and naphthalene, only the second step was used to normalize the data (Table 6.4-3).

Data plots of the normalized cation, benzene, and naphthalene concentrations (C/C_o) versus depth are presented on Figures 6.4-5, 6.4-6, and 6.4-7, respectively. These figures show that significant undifferentiated chemical/biological concentration attenuation processes are occurring near the mudline. The normalized C/C_o values for the "tracer" cations in the 0-10 cm depth interval range from approximately 0.25 to 0.65, indicating that some dilution with

surface water occurs. However, the normalized C/C_o values for benzene and naphthalene in the same 0-10 cm depth interval range from approximately 0.00018 to 0.0015, respectively, demonstrating that there is more than two to three orders of magnitude more concentration attenuation of benzene and naphthalene than for the "tracer" cations. This indicates the existence of undifferentiated chemical/biological attenuation processes in the transition zone.

7 BASELINE RISK ASSESSMENT

This section characterizes potential Site-related risks to human health and ecological receptors resulting from the presence of hazardous substance in environmental media at the Quendall Site. The baseline risk assessment was generally conducted in accordance with the Final Work Plan, Human Health and Ecological Risk Assessment (HERA Work Plan, Anchor QEA and Aspect 2009b), as approved by EPA, which outlined the approach and methods for use in all screening and baseline risk assessments for human and ecological receptors. Supporting information documenting details of the human health risk assessment (HHRA) and the ecological risk assessment (ERA) performed as part of the RI/FS for the Quendall Site, including deviations from the HERA Work Plan, is provided in Appendix J.

The HHRA is presented in Section 7.1 and the ERA in Section 7.2.

7.1 Baseline Human Health Risk Assessment

This section describes the methodology and presents the results of the baseline HHRA performed for the Quendall Site. A baseline HHRA represents an analysis of potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate those releases. The assessment identifies and characterizes the toxicity of the COPCs for the Site, the potential exposure pathways, the potential human receptors, and the likelihood of adverse health effects under current and reasonably anticipated future land and water use conditions.

The procedures and assumptions used for the baseline HHRA for the Quendall Site are as described in the HERA Work Plan (Anchor QEA and Aspect 2009b), with several deviations based on comments provided by EPA on a draft version of this RI Report. These deviations are documented in Appendix J-1.

The results of the baseline HHRA will be used to assist in risk management decision-making and to refine remedial action objectives for the Quendall Site.

7.1.1 Organization of this Baseline HHRA

This baseline HHRA includes the following components:

- **Section 7.1.2, Human Health Risk Assessment Guidance,** lists the guidance documents that were followed as this baseline HHRA was performed and Site risks were characterized.
- **Section 7.1.3, Selection of Chemicals of Potential Concern,** describes the process for identifying which data are the focus of the baseline HHRA and identifies the COPCs considered for the risk characterization processes.
- **Section 7.1.4, Exposure Assessment,** identifies the pathways by which potential human exposures to COPCs could occur; describes how the pathways are evaluated; and evaluates the magnitude, frequency, and duration of the potential exposures.
- **Section 7.1.5, Toxicity Assessment,** summarizes the toxicity of the selected COPCs and the relationship between the magnitude of exposure and the occurrence of adverse health effects.
- **Section 7.1.6, Risk Characterization,** integrates information from the exposure and toxicity assessments to characterize the risks posed to human health from potential exposure to chemicals in environmental media.
- **Section 7.1.7, Uncertainties Associated with this Baseline HHRA,** discusses the sources and nature of uncertainties that are associated with this assessment.

In addition to tables and figures supporting the sections above, further details of the baseline HHRA are provided in the following appendices:

- Appendix J-1, Deviations from the HERA Work Plan
- Appendix J-2, Updated Screening of Chemicals of Potential Concern (COPCs) for the Baseline Human Health Risk Assessment
- Appendix J-3, Analytical Data Used in the Baseline Risk Assessment
- Appendix J-4, ProUCL Program Output
- Appendix J-5, Biota-Sediment Accumulation Factor (BSAF) Derivation and Application
- Appendix J-6, Trench Vapor Model Documentation
- Appendix J-7, Human Health Risk Calculation Data Sheets

7.1.2 Human Health Risk Assessment Guidance

Guidance documents used in the preparation of the HHRA included the following:

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A), Interim Final (EPA 1989)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors (EPA 1991)
- Soil Screening Guidance: Users Guide, Second Edition (EPA 1996)
- Exposure Factors Handbook (EPA 1997d)
- Estimated Per Capita Fish Consumption in the United States (EPA 2002b)
- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final (EPA 2004)
- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final (EPA 2009a)

7.1.3 Selection of Chemicals of Potential Concern

The COPCs for human health at the Quendall Site are those chemicals that are carried through the risk quantification process. This section summarizes the chemicals detected in environmental media at the Site and identifies the COPCs for media that are potentially accessible for human exposures. During the course of the baseline HHRA (which is generally referred to as "the HHRA" in the remainder of this Section 7.1), the COPCs were evaluated to identify and eliminate from further consideration those contaminants that are unlikely to contribute substantially to overall risks at the Site.

7.1.3.1 Data Used in the HHRA

As discussed in Section 2.4 of this RI Report, historical analytical data were evaluated in the Task 2 and Draft Task 3 Reports (Anchor and Aspect 2007a and 2007b, respectively) to determine the usability of those data for risk assessment purposes. Based on the earlier evaluations, additional data collection was deemed necessary to adequately characterize the nature and extent of contamination and to support this HHRA. A summary of the data used

for the HHRA is provided in Table 7.1-1. While most data are of QA2 quality, data of QA1 quality were also selectively used for performing HHRA exposure calculations.[29]
The analytical data used in this HHRA include data obtained for the following environmental media:

- Soil (from 0 to 15 feet bgs)
- Groundwater
- Sediment (nearshore, offshore, and background sediment, all from 0 to 4 inches bgs)
- Surface water

The investigations listed in Table 7.1-1 are described in Sections 2, 3, and 4 of this report. Samples used in the HHRA are listed by exposure medium, sample location, sampling date, sample ID, sample type, and sampling depth interval in Table 7.1-2 along with the exposure scenarios that are evaluated later in this HHRA. Information about the samples used in the HHRA is provided by medium in the sections below.

7.1.3.1.1 Soil Samples

The locations of soil samples used in the HHRA are shown on Figure 7.1-1. A total of 98 samples were collected between 0 and 15 feet bgs.

7.1.3.1.2 Groundwater Samples

Groundwater data used in the HHRA included shallow and deep well data from 44 samples (including three field duplicates) collected from 30 wellpoints during the RI field investigation. The locations of groundwater samples used in the HHRA are shown on Figure 7.1-2.

7.1.3.1.3 Sediment Samples

The locations of sediment samples used in the HHRA are shown on Figures 7.1-3 and 7.1-4. The numbers of different kinds of sediment samples used in the HHRA were as follows:

- Nearshore sediment: Six samples collected between 0 and 4 inches or 0 and 10

[29] The QA categories used to designate the quality of the historical analytical data obtained from the Quendall Site are described in Section 2.4 of this RI Report.

centimeters bgs.

- Offshore sediment: 51 samples (including three field duplicates) collected between 0 and 4 inches or 0 and 10 cm bgs.[30]

As described in Section 2.5.4, background surface sediment samples were collected in addition to Site samples during the RI field investigation in order to help delineate the boundary between Site and background PAH contamination, given that background PAH concentrations are expected to exceed risk-based PRGs. The 10 background samples (collected between 0 and 4 inches bgs) have been identified as a separate data group for evaluation in the HHRA. Risk estimates have been developed for background sediment primarily to provide context for future remedial decision-making (e.g., understanding the potential risks associated with a cleanup that might be consistent with background conditions), in accordance with EPA guidance (EPA 2002a and 2002c).

7.1.3.1.4 Surface Water Samples

Surface water samples used in the HHRA were collected from six locations, SW-1 through SW-6. These locations are shown on Figure 7.1-4.

7.1.3.2 Data Reduction Procedures

The following rules were applied to identify data for use in the HHRA:

- Estimated values (flagged with "J" qualifiers) were treated as detected concentrations.
- For duplicate samples, the following procedure was applied:
  - If there were two detections, the higher of the two concentrations was used.
  - If there was one detection and one non-detection, the detected value was used.
  - If there were two non-detections, the lowest detection limit was used.

7.1.3.3 Process for Selection of COPCs

Media-specific COPCs were selected for inclusion in this HHRA by comparing Site COIs to risk-based screening values. The HERA Work Plan (Anchor QEA and Aspect 2009b)

[30] Metals results from five offshore samples were also used to represent nearshore sediment.

specified that MTCA Method B cleanup levels would be used to identify COPCs. As noted in Appendix J-1, the final method used to screen for human health COPCs deviated from the HERA Work Plan in that it included comparing COIs that were excluded based on the MTCA Method B cleanup levels to EPA RSLs. For noncarcinogens, a hazard quotient (HQ) of 0.1 was applied for COPC screening per EPA Region 10 guidance (EPA 2007b). The human health COPC screening process is depicted in Figure 7.1-5 and described in detail in Appendix J-2.

7.1.3.4 COPCs Selected for the HHRA

This section provides a summary of the COPCs selected for soil, groundwater, sediment, and surface water at the Quendall Site. Summary statistics for each medium and data group considered in the HHRA are provided in Table 7.1-3. The analytical data used in the HHRA are described in Appendix J-3. The exposure scenarios for which COPCs were identified, as noted below, are discussed in detail in Section 7.1.4.1 and summarized in Table 7.1-2.

Soil - A total of 20 chemicals detected at least once in Site soil samples were identified as COPCs for the residential, occupational worker, and construction/excavation worker exposure scenarios.

Groundwater - A total of 27 chemicals detected at least once in groundwater were identified as COPCs for the residential and construction/excavation worker exposure scenarios. Of these 27 chemicals, 13 were identified as volatile (EPA 2011c) and were considered COPCs for the vapor intrusion and in-trench vapor evaluations.

Nearshore Sediment - A total of 19 chemicals detected at least once in nearshore sediment samples were identified as COPCs for the recreational beach user exposure scenario.

Site-Wide Sediment (Combined Offshore and Nearshore Sediment) - A total of 19 chemicals detected at least once in Site-wide sediment samples were identified as COPCs for the recreational fishing and subsistence fishing exposure scenarios.

Background Sediment - A total of 17 chemicals were detected at least once in background samples and were used to provide a background comparison for the recreational beach user, recreational fishing, and subsistence fishing exposure scenarios.

Surface Water - A total of 11 chemicals detected at least once in surface water were identified as COPCs for the recreational beach user exposure scenario.

7.1.4 Exposure Assessment

This section describes the means by which human receptors at or near the Quendall Site may come into contact with contaminants in exposure media. This section addresses exposures that may result under reasonably anticipated potential uses of the Site and the surrounding areas in the future.

An exposure pathway can be described as the physical course that a COPC takes from the point of release to a receptor. Chemical intake or route of exposure is the means by which a COPC enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A source;
- A mechanism of chemical release and transport;
- An environmental transport medium;
- An exposure point;
- An exposure route; and
- A receptor or an exposed population.

The primary sources of contamination have been documented for DNAPL in Section 4 of this RI Report, and the secondary sources of contamination present in soil, groundwater, sediment, and porewater/surface water are described in Section 5. Section 6 details release and transport mechanisms and media. Section 7.1.4.1 describes potentially complete human exposure pathways and receptors. Figure 7.1-6 combines these components and presents the conceptual site exposure model schematic for the Quendall Site. Figure 7.1-7 is a graphic illustration of the conceptual site exposure model. The remainder of Section 7.1.4 includes

the methods for estimating exposure point concentrations (EPCs; Section 7.1.4.2) and calculating chemical intake (Section 7.1.4.3).

7.1.4.1 Potentially Complete Human Exposure Pathways and Receptors

On the basis of the present understanding of current and anticipated future land uses and beneficial water uses at and near the Site, the most plausible exposure scenarios considered for characterizing human health risks include the following:

- **Future Residential Exposure Scenario.** The residential scenario is based on potential redevelopment of the Site for residential purposes and future Site use by adults and children. Exposure of future residents to contaminants in soil to a depth of 15 feet bgs was assumed, to account for uncertainties associated with the relocation of soil by heavy equipment during residential construction. Likely routes of exposure include incidental ingestion, dermal contact, and inhalation of fugitive dusts and vapors. The potential routes of exposure to contaminants in Site groundwater include ingestion, dermal contact, and inhalation of vapors resulting from domestic water uses (e.g., showering). Inhalation is a potential route of exposure to volatile chemicals migrating from subsurface shallow groundwater into indoor air. The residential receptor was assumed to be exposed for 350 days per year (50 weeks per year) for a duration of 30 years, which represents approximately the 90th percentile of the time spent at one residence in the U.S. population. Both adult and child receptors were evaluated (6 years for a child, 24 years for an adult) to account for certain childhood behavioral patterns (outdoor play activities and greater hand-to-mouth contact) that can result in greater relative childhood exposures than for adults. Further, because cancer risk is averaged over a lifetime, it is directly proportional to the exposure duration as well as the dose and the potency of the chemical.
- **Future Occupational Worker Exposure Scenario.** The occupational worker scenario is based on potential future Site use by adults. Workers could potentially be exposed to chemicals in soil (from 0 to 15 feet bgs) by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors. Although vapor intrusion into future non-residential buildings and exposure to groundwater by occupational workers are also possible, these pathways are addressed under the more health-conservative residential

exposure scenario. Occupational workers are assumed to work at the Site for 50 weeks (250 days) per year for a duration of 25 years.

- **Future Construction/Excavation Worker Exposure Scenario.** Under future Site conditions, construction/excavation workers could potentially be exposed to soil to a depth of 15 feet bgs during excavation activities at the Site. These activities could include placement or repair of utilities or other construction activities involving digging. Potential routes of exposure to soil for the construction/excavation worker include incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors generated during excavation activities. Potential routes of exposure to shallow groundwater for the construction/excavation worker include dermal contact and inhalation of ambient vapors generated during excavation activities. Construction/excavation workers are assumed to work at the Site for 50 weeks (250 days) over a duration of a 1-year construction event.
- **Current and Future Recreational Beach User Exposure Scenario.** The recreational beach user scenario addresses individuals engaged in recreation at the shoreline, gaining access either from Site uplands or via boat. Recreational beach users were presumed to have direct contact with beach surface sediment and with surface water while swimming or during other water activities. Potential exposures to nearshore sediment (from 0 to 4 inches bgs) were evaluated under this scenario, and potential exposure routes include incidental ingestion and dermal contact. Exposure to COPCs in water during water-related activities is likely via incidental ingestion and dermal contact. As with the residential exposure scenario, recreational beach users were evaluated as a combined child and adult, with an exposure frequency of 94 days per year for 30 years.
- **Current and Future Recreational Fishing Exposure Scenario.** The recreational fishing exposure scenario addresses recreational anglers gaining Site access by boat or land and harvesting fish or shellfish for personal consumption using hook and line, traps, digging, or other methods. The primary exposure media for this scenario include aquatic biota and Site-wide sediment (i.e., combined offshore and nearshore sediment). Adults are the receptors considered for the recreational fishing exposure scenario. Potential exposure routes include ingestion of contaminants that bioaccumulate in fish/shellfish tissue, and incidental ingestion of and dermal contact with sediment during angling activities. Recreational anglers were assumed to visit

the Site for fishing 39 days per year for a duration of 30 years. An annualized average consumption rate of 17.5 grams of fish/shellfish per day for 30 years was used, based on the 90th percentile consumption rate for the U.S. population (EPA 2002b).

Several relevant studies were used to inform the fish consumption human health conceptual site model. King County DNRP (2003) conducted a freshwater fish consumption survey to evaluate recreational fishing habits, event duration and frequency, and fish consumption patterns. The location nearest to the Site (approximately 0.5 mile to the south) was Kennydale Beach Park in Renton. Species caught there include bass (yellow and smallmouth), bluegill, bullhead, perch, salmon (coho and sockeye), and trout (including brown, cutthroat, and rainbow). Neither smallmouth bass nor bullhead are reported to be consumed. It was assumed that crayfish are also harvested.

- **Current and Future Subsistence Fishing Exposure Scenario.** Lake Washington is a Usual and Accustomed (U&A) fishing ground for the Muckleshoot, Suquamish, and Tulalip Tribes. The subsistence fishing exposure scenario addresses fish and shellfish harvesting (freshwater mollusks and crayfish) by boat using nets, hook and line, and traps. The primary exposure media for this scenario are aquatic biota and Site-wide sediment, and adults are the receptors considered. As is the case with recreational anglers, potential exposure routes under this scenario include ingestion of contaminants that bioaccumulate in fish/shellfish tissue, and incidental ingestion of and dermal contact with sediment during angling activities.

  Subsistence anglers were assumed to visit the Site 65 days per year for 30 years. Although regional subsistence angler consumption rates for freshwater are not available, a subsistence angler is assumed to consume an annualized average of 143.4 grams of fish per day over 70 years, based on the 99th percentile consumption rate for the U.S. population (EPA 2002b). As detailed in the HERA Work Plan (Anchor QEA and Aspect 2009b), if no risk is indicated from subsistence fishing using this default ingestion rate, regional Tribal consumption rates (which may be greater than the default subsistence rates) may need to be evaluated to ensure that Tribal and subsistence anglers are adequately protected.

7.1.4.2 Exposure Point Concentrations

An EPC is defined as the average concentration of a chemical contacted at identified exposure points over the duration of an exposure period (EPA 1992b). EPA recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (EPA 1989). Use of the average concentration is consistent with EPA toxicity criteria, which are also based on lifetime average exposures. Because it is generally not possible to know the true average, the 95 percent UCL of the mean is typically used in CERCLA risk assessments to represent the average concentration. The UCL is defined as a value that, when calculated repeatedly for randomly drawn subsets of data, equals or exceeds the true population mean 95 percent of the time. Use of the UCL can also help account for uncertainties that can result from limited sampling data and/or the uneven spatial distribution of contaminant concentrations. UCLs were calculated for each analyte using EPA's statistical program ProUCL, Version 4.1 (EPA 2011a) using concentrations directly measured in soil, groundwater, sediment, and surface water. The ProUCL output summaries are provided in Appendix J-4. EPCs in ambient and indoor air were estimated from soil and/or groundwater concentrations, and fish and shellfish tissue EPCs were estimated from surface sediment concentrations using the modeling approaches described in Section 7.1.4.3.

EPCs were calculated for each exposure medium as follows:

- EPCs in soil were calculated using detected concentrations in soil (from 0 to 15 feet bgs) at the Site.
- Groundwater EPCs for the residential exposure scenario were identified on a well-specific basis (i.e., maximum detected concentrations from the RI field investigation dataset at each wellpoint were used) rather than aggregating data spatially. Groundwater EPCs for the construction/excavation worker exposure scenario were the maximum detected Site-wide concentrations from the RI field investigation dataset.
- Indoor air EPCs for evaluation of residential vapor intrusion were calculated by adjusting the well-specific groundwater EPCs for VOCs using a groundwater-to-indoor-air attenuation factor (see Section 7.1.4.3.8). Trench vapor EPCs for the construction/excavation worker exposure scenario and household vapor EPCs for the

residential scenario were estimated from the maximum detected Site-wide VOC concentrations from the RI field investigation dataset using a generic volatilization factor (see Sections 7.1.4.3.6 and 7.1.4.3.7).

- Sediment EPCs for the recreational beach user exposure scenario were 95 percent UCLs calculated using detected concentrations in nearshore sediment (from 0 to 4 inches or 0 to 10 centimeters bgs). Sediment EPCs for the recreational and subsistence fishing exposure scenarios were 95 percent UCLs calculated using detected concentrations in both nearshore and offshore sediment (from 0 to 4 inches or 0 to 10 centimeters bgs).
- Surface water EPCs for the recreational beach user exposure scenario were conservatively assumed to be maximum detected concentrations in surface water at the Site.
- Fish tissue EPCs for the recreational and subsistence fishing exposure scenarios were calculated by adjusting the Site-wide sediment concentrations by a BSAF. Tissue EPCs were calculated for each organism group (mollusks, crustaceans, and bottom-feeding fish) using the 95 percent UCL of the organic-carbon-normalized Site surface sediment data, the BSAF, and the geometric mean of freshwater lipid data as reported for the BSAF data as further described in Appendix J-5 and Section 7.4.1.3.9. The average of the mollusk, crustacean, and bottom-feeding fish EPCs was used as the EPC for the risk assessment. The same approach was used for calculating EPCs based on background surface sediment concentrations.

The EPCs for soil, groundwater, sediment, and surface water are presented in Table 7.1-3 and the ProUCL output summaries are provided in Appendix J-4. EPCs for fish and shellfish tissue derived using the BSAF approach (Appendix J-5) are summarized in Table 7.1-4. Consistent with EPA guidance (EPA 1989), the maximum detected concentration is used as the EPC when the calculated 95 percent UCL is greater than the maximum detected value.

7.1.4.3 Estimation of Chemical Intake

The amount of each chemical incorporated into the body is referred to as the dose and is expressed in units of milligrams per kilogram per day (mg/kg-day). The dose is calculated

differently when evaluating carcinogenic effects than when evaluating noncarcinogenic effects. Each is described below:

Noncarcinogens: The dose is averaged over the estimated exposure period. This is done to be consistent with the assumption that adverse effects are not expected to occur after exposure has ceased. Thus, the average daily dose (ADD) is used to represent the potential for adverse noncancer health effects over the period of exposure.

Carcinogens: The dose is based on the estimated exposure duration, extrapolated over an estimated 70-year lifetime. This is consistent with cancer slope factors, which are based on lifetime exposures and on the assumptions that the risk of carcinogenic effects is cumulative and continues even after exposure has ceased.

The equations used to calculate chemical intake and exposure concentrations associated with the various human exposure scenarios for the Quendall Site are presented in the following sections.

7.1.4.3.1 Incidental Ingestion of Soil and Sediment

The following equation was used to calculate the intake (expressed as mg/kg-day) associated with the incidental ingestion of contaminants in soil or sediment for the occupational worker (soil only), construction/excavation worker (soil only), recreational fishing (sediment only), and subsistence fishing (sediment only) exposure scenarios:

$$Intake = \frac{C_s \times IRS_a \times 10^{-6}\, kg/mg \times EF \times ED_a}{BW_a \times AT}$$

The following age-weighted equation was used to calculate the intake associated with the incidental ingestion of contaminants in soil or sediment for the residential (soil only) and recreational beach user (sediment only) exposure scenarios:

$$Intake = \frac{C_s \times IFS_{adj} \times EF \times 10^{-6}\, kg/mg}{AT}$$

Where:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}$$

and where:

C_s	=	chemical concentration in soil or sediment (mg/kg)
IFS_{adj}	=	age-adjusted soil/sediment ingestion factor [(mg-year)/(kg-day)]
IRS_a	=	adult soil/sediment ingestion rate (mg/day)
IRS_c	=	child soil/sediment ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED_a	=	adult exposure duration (years)
ED_c	=	child exposure duration (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of chemicals in soil and sediment are provided in Table 7.1-5.

7.1.4.3.2 Dermal Contact with Soil or Sediment

The following equation was used to calculate the intake from dermal contact with contaminants in soil for the occupational worker (soil only), construction/excavation worker (soil only), recreational fishing (sediment only), and subsistence fishing (sediment only) exposure scenarios:

$$Intake = \frac{C_S \times ABS \times SA_a \times AF_a \times EF \times ED_a \times 10^{-6}\, kg/mg}{BW_a \times AT}$$

The following age-weighted equation was used to calculate the intake from dermal contact with contaminants in soil for the residential (soil only) and recreational beach user (sediment only) exposure scenarios:

$$Intake = \frac{C_S \times SFS_{adj} \times ABS \times EF \times 10^{-6} kg/mg}{AT}$$

Where:

$$SFS_{adj} = \frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}$$

and where:

C_s	=	chemical concentration in soil or sediment (mg/kg)
SFS_{adj}	=	age-adjusted dermal contact factor [(mg-year)/(kg-day)]
ABS	=	absorption efficiency
SA_a	=	adult exposed skin surface area (square centimeters [cm^2])
SA_c	=	child exposed skin surface area (cm^2)
AF_a	=	adult soil-to-skin adherence factor (mg/cm^2)
AF_c	=	child soil-to-skin adherence factor (mg/cm^2)
EF	=	exposure frequency (days/year)
ED_a	=	adult exposure duration (years)
ED_c	=	child exposure duration (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

The exposure assumptions for estimating exposure from dermal contact with soil and sediment are provided in Table 7.1-5. Dermal absorption factor values were obtained from the EPA dermal risk assessment guidance (EPA 2004).

7.1.4.3.3 Inhalation of Fugitive Dusts or Contaminants Volatilized from Soil

The following equation was used to calculate the exposure concentration of contaminants associated with inhalation of volatilized contaminants or fugitive dust emissions from soil for the occupational worker, construction/excavation worker, and residential exposure scenarios:

$$EC_a = \frac{C_s \times \left(\frac{1}{PEF} + \frac{1}{VF} \right) \times ET \times EF \times ED}{AT}$$

Where:

EC_a	=	exposure concentration in ambient air (mg/m^3)
C_s	=	chemical concentration in soil or sediment (mg/kg)
ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
ED	=	adult exposure duration (years)
PEF	=	particulate emission factor (m^3/kg)
VF	=	volatilization factor (m^3/kg)
AT	=	averaging time (days)

The volatilization factors (VFs) for VOCs identified as COPCs in soil are calculated using the Jury Model presented in the EPA soil screening guidance (EPA 1996). The exposure assumptions used to estimate exposure from inhalation of dust and vapors in ambient air are provided in Table 7.1-5.

7.1.4.3.4 Ingestion of Groundwater or Surface Water

The following age-weighted equation was used to calculate the intake of contaminants associated with the ingestion of groundwater or surface water under the residential (groundwater only) and recreational beach user (surface water only) exposure scenarios:

$$Intake = \frac{C_w \times IFW_{adj} \times EF}{AT}$$

Where:

$$IFW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{ED_a \times IRW_a}{BW_a}$$

and where:

C_W	=	chemical concentration in water (mg/L)
IFW_{adj}	=	age-adjusted water ingestion factor [(L-year)/(kg-day)]
IRW_a	=	adult groundwater ingestion rate (L/day)
IRW_c	=	child groundwater ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED_a	=	adult exposure duration (years)
ED_c	=	child exposure duration (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of groundwater or surface water are provided in Table 7.1-5.

7.1.4.3.5 Dermal Contact with Groundwater or Surface Water

The following equation was used to calculate the intake associated with dermal contact with contaminants in groundwater for the construction/excavation worker exposure scenario:

$$Intake = \frac{C_w \times SA_a \times ED_a \times K_p \times EF \times ET \times CF}{AT \times BW_a}$$

The following age-weighted equation was used to calculate the intake associated with dermal contact with contaminants in groundwater or surface water for the residential (groundwater only) and recreational beach user (surface water only) exposure scenarios:

$$Intake = \frac{C_w \times SFW_{adj} \times K_p \times EF \times ET \times CF}{AT}$$

Where:

$$SFW_{adj} = \frac{ED_c \times SA_c}{BW_c} + \frac{ED_a \times SA_a}{BW_a}$$

and where:

C_W	=	chemical concentration in water (mg/L)
SFW_{adj}	=	age-adjusted water dermal contact factor [(cm^2-year)/kg]
K_p	=	dermal permeability coefficient (cm/hour)
EF	=	exposure frequency (days/year)
ET	=	exposure time (hour)
CF	=	conversion factor (0.001 L/cubic centimeter)
ED_a	=	adult exposure duration (years)
ED_c	=	child exposure duration (years)
SA_a	=	adult exposed skin surface area (cm^2)
SA_c	=	child exposed skin surface area (cm^2)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

The exposure assumptions used to estimate exposure from dermal contact with groundwater or surface water are provided in Table 7.1-5. Chemical-specific dermal permeability coefficients (Kp) were obtained from the ORNL Risk Assessment Information System (ORNL 2011), calculated using EPA's Dermwin™ tool that is part of its Estimation Program Interface (EPI) Suite program. Note that potential risks associated with HPAHs were not quantified because the Kp values calculated for the Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final (EPA 2004) fall outside the predictive range of the model.

7.1.4.3.6 Inhalation of Trench Vapors Volatilized from Groundwater

The following equation was used to calculate the exposure concentrations of contaminants volatilizing from groundwater to trench air for the construction/excavation worker exposure scenario:

$$EC_a = \frac{C_w \times VF_t \times ET \times EF \times ED}{AT}$$

Where:

EC_a	=	exposure concentration in trench air (mg/m^3)
C_w	=	chemical concentration in trench water (mg/L)
VF_t	=	volatilization factor for trench groundwater to air (L/m^3)
ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
AT	=	averaging time (days)

The exposure assumptions used to estimate exposures from inhalation of volatile chemicals are listed in Table 7.1-5. Volatile chemicals considered for the inhalation pathway are operationally defined as those COPCs with a Henry's Law constant greater than 10^{-5} atm-m^3/mole (atmospheres-meters cubed per mole) and a molecular weight of less than 200 grams per mole (EPA 1991). The volatilization factor used to estimate the upper-bound EPC for workers in trenches flooded with groundwater off-gassing VOCs was derived using a method documented by EPA (Dawson 1999a) and provided in Appendix J-6. Assuming a maximum trench depth of 3 meters, the estimated volatilization factor is 0.133 L/m^3, which is considered conservative and appropriate for VOCs with Henry's Law constants greater than 1×10^{-4} atm·m^3/mole.

7.1.4.3.7 Inhalation of Vapors due to Household Groundwater Use

The following equation was used to calculate the exposure concentrations of contaminants associated with inhalation of vapors while showering or performing other household activities for the residential exposure scenario:

$$EC_a = \frac{C_w \times VF \times ET \times EF \times ED}{AT}$$

Where:

EC_a	=	exposure concentration in air (mg/m^3)
C_w	=	chemical concentration in groundwater (mg/L)
VF	=	volatilization factor for domestic use groundwater to air (L/m^3)
ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
AT	=	averaging time (days)

The exposure assumptions used to estimate exposures from the inhalation of volatile chemicals are listed in Table 7.1-5. The VF used for assessing vapor off-gassing from normal domestic uses of groundwater is from Andelman (1990).

7.1.4.3.8 Vapor Inhalation due to Subsurface Migration into Indoor Air

The following equation was used to calculate the exposure concentrations associated with the inhalation of vapors emanating from groundwater and migrating through the subsurface into indoor air for the residential exposure scenario:

$$EC_a = \frac{C_{source} \times ATF_{res} \times ET \times EF \times ED}{AT}$$

Where:

EC_a	=	exposure concentration in air (mg/m^3)
C_{source}	=	chemical concentration at the source in the vadose zone (mg/m^3)
ATF_{res}	=	groundwater to residential indoor air attenuation factor (unitless)
ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)

AT = averaging time (days)

The groundwater-to-indoor-air attenuation factor was derived from empirical attenuation factors contained in EPA's Vapor Intrusion Database (EPA 2008a), consisting of 596 data pairs representing 27 sites. The attenuation factor used for this HHRA was 0.001, which represents the 95th percentile of this dataset. Estimated subsurface source vapor concentrations (C_{source}) were calculated by multiplying the groundwater concentration by the chemical's dimensionless Henry's Law constant.

7.1.4.3.9 Consumption of Fish and Shellfish

To evaluate the potential for risk to human consumers of fish and shellfish (i.e., recreational anglers), Site-specific fish and shellfish tissue data were used. The following equation was used to estimate the chemical intake associated with the consumption of fish and shellfish:

$$Intake = \frac{C_t \times IR_t \times 10^{-3} \times EF \times ED}{BW \times AT}$$

Where:

C_t	=	Chemical concentration in fish/shellfish tissue (mg/kg, wet-weight basis)
IR_t	=	Fish ingestion rate (g/day, wet-weight basis)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

The exposure assumptions used to estimate exposure from fish and shellfish consumption are presented in Table 7.1-5.

Modeled tissue residue values were derived using chemical-specific BSAFs to estimate tissue concentrations from measured sediment concentrations:

$$C_{tissue} = C_{sed} \times BSAF \times F_{lipid}$$

Where:

C_{tissue}	=	Chemical concentration in fish/shellfish tissue (mg/kg, wet-weight basis)
C_{sed}	=	Chemical concentration in sediment (mg/kg dry weight, OC normalized)
BSAF	=	Biota-sediment accumulation factor
F_{lipid}	=	Fraction lipid in fish/shellfish tissue

Separate BSAF values were used to calculate tissue concentrations in shellfish, crustaceans, and bottom-feeding fish; the final tissue EPC represents the average of the three calculated tissue concentrations. A more detailed discussion of the methodology and the BSAF values used is presented in Appendix J-5.

7.1.4.3.10 Calculation of Intake for Mutagenic COPCs

Early-in-life susceptibility to carcinogens has been recognized by the scientific community as a public health concern. In its revised cancer assessment guidelines, EPA concluded that existing risk assessment approaches did not adequately address the possibility that exposures to a chemical in early life can result in higher lifetime cancer risks than a comparable duration adult exposure (EPA 2005b). In order to address this potential for increased risk, EPA recommends use of a potency adjustment to account for early-in-life exposures. When no chemical-specific data are available to directly assess cancer susceptibility from early-life exposure, the following default Age Dependent Adjustment Factors (ADAFs) are recommended for use when evaluating a carcinogen known to cause cancer through a mutagenic mode of action:

- 10-fold adjustment for exposures during the first two years of life;
- Three-fold adjustment for exposures from ages 2 to less than 16; and
- No adjustment for exposures after turning 16 years of age.

Of the COPCs evaluated in this HHRA, EPA considers that there is sufficient weight of evidence to conclude that the cPAHs cause cancer through a mutagenic mode of action.

Consideration of early-life stage exposure was limited to the residential and recreational beach user exposure scenarios.

Incidental Ingestion of Soil and Sediment

The following equation was used to calculate the intake in mg/kg-day for mutagenic COPCs associated with the incidental ingestion of contaminants in soil or sediment:

$$Intake = \frac{C_s \times \left(\frac{(ED_{0\text{-}2} \times IRS_c) \times 10}{BW_c} + \frac{(ED_{2\text{-}6} \times IRS_c) \times 3}{BW_c} + \frac{(ED_{6\text{-}16} \times IRS_a) \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times IRS_a) \times 1}{BW_a} \right) \times EF}{AT}$$

Where:

C_s	=	chemical concentration in soil or sediment (mg/kg)
IRS_a	=	adult soil/sediment ingestion rate (mg/day)
IRS_c	=	child soil/sediment ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$	=	exposure duration ages 16-30 (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

Dermal Contact with Soil or Sediment

The following equation was used to calculate the intake from dermal contact with contaminants in soil or sediment:

$$Intake = \frac{C_S \times \left(\frac{ED_{0\text{-}2} \times AF_c \times SA_c \times 10}{BW_c} + \frac{ED_{2\text{-}6} \times AF_c \times SA_c \times 3}{BW_c} + \frac{ED_{6\text{-}16} \times AF_a \times SA_a \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times AF_a \times SA_a \times 1}{BW_a} \right) \times ABS \times EF \times 10^{-6} kg/mg}{AT}$$

Where:

C_s	=	chemical concentration in soil or sediment (mg/kg)
ABS	=	absorption efficiency
SA_a	=	adult exposed skin surface area (square centimeters [cm^2])
SA_c	=	child exposed skin surface area (cm^2)
AF_a	=	adult soil-to-skin adherence factor (mg/cm^2)
AF_c	=	child soil-to-skin adherence factor (mg/cm^2)
EF=	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$	=	exposure duration ages 16-30 (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

Inhalation of Fugitive Dusts

The following equation was used to calculate the exposure concentrations of contaminants associated with inhalation of fugitive dust emissions from soil:

$$EC_a = \frac{C_s \times \frac{1}{PEF} \times ET \times EF \times \left[(ED_{0\text{-}2} \times 10) + (ED_{2\text{-}6} \times 3) + (ED_{6\text{-}16} \times 3) + (ED_{16\text{-}30} \times 1) \right]}{AT}$$

Where:

EC_a	=	exposure concentration in ambient air (mg/m^3)
C_s	=	chemical concentration in soil or sediment (mg/kg)

ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$	=	exposure duration ages 16-30 (years)
PEF	=	particulate emission factor (m^3/kg)
AT	=	averaging time (days)

Ingestion of Groundwater or Surface Water

The following equation was used to calculate the intake of chemicals associated with ingestion of groundwater or surface water:

$$Intake = \frac{C_w \times \left(\frac{(ED_{0\text{-}2} \times IRW_c) \times 10}{BW_c} + \frac{(ED_{2\text{-}6} \times IRW_c) \times 3}{BW_c} + \frac{(ED_{6\text{-}16} \times IRW_a) \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times IRW_a) \times 1}{BW_a} \right) \times EF}{AT}$$

Where:

C_W	=	chemical concentration in water (mg/L)
IRW_a	=	adult groundwater ingestion rate (L/day)
IRW_c	=	child groundwater ingestion rate (L/day)
EF	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$	=	exposure duration ages 16-30 (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)
AT	=	averaging time (days)

Vapor Inhalation due to Subsurface Migration into Indoor Air

The following equation was used to calculate the exposure concentrations associated with the inhalation of vapors emanating from groundwater and migrating through the subsurface into indoor air:

$$EC_a = \frac{C_{source} \times ATF_{res} \times ET \times EF \times \left[\left(ED_{0\text{-}2} \times 10 \right) + \left(ED_{2\text{-}6} \times 3 \right) + \left(ED_{6\text{-}16} \times 3 \right) + \left(ED_{16\text{-}30} \times 1 \right) \right]}{AT}$$

Where:

EC_a	=	exposure concentration in air (mg/m^3)
C_{source}	=	chemical concentration at the source in the vadose zone (mg/m^3)
ATF_{res}	=	groundwater to residential indoor air attenuation factor (unitless)
ET	=	exposure time (unitless fraction of day)
EF	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$	=	exposure duration ages 16-30 (years)
AT	=	averaging time (days)

Dermal contact while wading/swimming was not evaluated because Kp values for the cPAHs fall outside the predictive range of the model used for their derivation (EPA 2004).

7.1.5 Toxicity Assessment

The toxicity assessment is composed of two steps: 1) hazard identification and 2) dose-response assessment. Hazard identification is the process of determining whether exposure to a chemical may result in a deleterious health effect in humans. Hazard identification consists of characterizing the nature of the effect and the strength of the evidence that the chemical will cause the observed effect. Dose-response assessment characterizes the relationship between the dose and the incidence and/or severity of the adverse health effect in the exposed population.

For risk assessment purposes, chemicals are generally separated into categories based on their toxicological endpoints. The primary basis of this categorization is whether a chemical exhibits potentially carcinogenic or noncarcinogenic health effects. Because some chemicals that are suspected carcinogens may also give rise to noncarcinogenic effects, these must be evaluated separately for both effects.

7.1.5.1 Toxicity Values for Evaluating Noncancer Effects

The reference dose (RfD) and reference concentration (RfC) provide quantitative information for use in risk assessments for health effects known or assumed to be produced through a nonlinear (possibly threshold) mode of action. The RfD, expressed in units of milligrams of substance per kilogram body weight per day (mg/kg-day) is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The inhalation RfC, expressed in units of milligrams of substance per cubic meter of air (mg/m^3) is analogous to the oral RfD but provides a continuous inhalation exposure estimate and considers toxic effects for both the respiratory system (portal of entry) and effects peripheral to the respiratory system (systemic effects). The use of RfDs and RfCs is based on the concept that there is range of exposures that exist up to a finite value, or threshold, that can be tolerated without producing a toxic effect. This HHRA uses available chronic RfDs and RfCs for the oral and inhalation exposure routes, respectively. Because EPA has not derived toxicity values specific to skin contact, dermal RfDs were derived in accordance with EPA's Supplemental Guidance for Dermal Risk Assessment (EPA 2004). The RfD that reflects the absorbed dose was calculated by using the following equation:

$$RfD_{ABS} = RfD_o \times ABS_{GI}$$

Where:

RfD_{ABS} = absorbed reference dose

RfD_o = oral reference dose

ABS_{GI} = gastrointestinal (GI) absorption efficiencies

EPA recommends adjusting oral toxicity values only when evidence suggests that GI absorption is less than 50 percent. GI absorption efficiencies were also obtained from EPA's Supplemental Guidance for Dermal Risk Assessment (EPA 2004).

7.1.5.2 Toxicity Values for Evaluating Cancer Effects

Oral cancer slope factors and inhalation unit risks are used to estimate the risk of cancer associated with exposure to a carcinogen. The oral slope factor represents an upper bound, generally approximating a 95 percent confidence limit, on the increased cancer risk from a lifetime exposure by ingestion. Slope factors are expressed in units of proportion (of a population) affected per milligram of substance/kilogram body weight-day (mg/kg-day^{-1}). An inhalation unit risk is an upper-bound excess lifetime cancer risk estimated to result from continuous exposure at a concentration of 1 μg/m^3 in air.

In addition to the numerical estimates of carcinogenic potential, a cancer weight-of-evidence descriptor is used by EPA to describe a substance's potential to cause cancer in humans and the conditions under which the carcinogenic effects may be expressed. This judgment is independent of consideration of the agent's carcinogenic potency. Under EPA's 1986 Guidelines for Carcinogen Risk Assessment (EPA 1986a), the weight of evidence was described by categories "A" through "E"—Group A for known human carcinogens through Group E for agents with evidence of noncarcinogenicity. Under EPA's 2005 Guidelines for Carcinogen Risk Assessment (EPA 2005a), a narrative approach, rather than the alphanumeric categories, is used to characterize carcinogenicity. Five standard weight-of-evidence descriptors are used: *Carcinogenic to Humans, Likely to Be Carcinogenic to Humans, Suggestive Evidence of Carcinogenic Potential, Inadequate Information to Assess Carcinogenic Potential, and Not Likely to Be Carcinogenic to Humans.*

Because EPA has not derived toxicity values specific to skin contact, dermal slope factors were derived in accordance with the EPA's Supplemental Guidance for Dermal Risk Assessment (EPA 2004). The slope factor that reflects the absorbed dose was calculated by using the following equation:

$$SF_{ABS} = \frac{SF_o}{ABS_{GI}}$$

Where:

SF_{ABS} = absorbed slope factor
SF_o = oral slope factor
ABS_{GI} = GI absorption efficiencies

Oral toxicity values should be adjusted only when evidence suggests that GI absorption is less than 50 percent. GI absorption efficiencies were also obtained from EPA's Supplemental Guidance for Dermal Risk Assessment (EPA 2004).

7.1.5.3 Sources of Toxicity Values

In accordance with EPA guidance (EPA 2003c), the toxicity values used were obtained from the following sources in order of preference:

- The Integrated Risk Information System (IRIS) database available through the EPA Environmental Criteria and Assessments Office in Cincinnati, Ohio (EPA 2011c). IRIS, prepared and maintained by EPA, is an electronic database containing health risk and EPA regulatory information on specific chemicals.
- EPA Provisional Peer Reviewed Toxicity Values (PPRTVs), provided by the Office of Research and Development, National Center for Environmental Assessment, Superfund Health Risk Technical Support Center, which develops these values on a chemical-specific basis when requested under the EPA Superfund program.
- Other sources of information, with a preference for sources that: 1) provide toxicity information based on similar methods and procedures as those used for IRIS and PPRTV values and 2) contain values that are peer-reviewed, available to the public, and transparent with respect to the methods and processes used to develop the values. Examples of recommended sources include, but are not limited to, the California Environmental Protection Agency (CAEPA), available at http://www.oehha.ca.gov/tcdb/, and the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), which represent estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure.

The toxicity values used in this HHRA are listed in Table 7.1-6.

7.1.5.4 Use of Toxicity Equivalency Factors for PAHs

An assessment of the cancer risk from long-term human exposure to a particular PAH mixture is best conducted with quantitative information on the dose-response relationship from chronic exposure to the mixture of concern; however, such information exists only for a few specific complex mixtures. Alternatively, a component-based approach involving an analysis of the toxicity of each component of the mixture is recommended when components in the mixture are judged to act in a toxicologically similar manner. The doses of component chemicals that act in a toxicologically similar manner are added together and the potency of each component is scaled relative to the potency of an index chemical (EPA 2000c). For PAHs, benzo(a)pyrene is chosen as an index chemical because of the large amount of available toxicological data versus the relatively incomplete database for other PAHs. As specified in the HERA Work Plan (Anchor QEA and Aspect 2009b), this HHRA uses the toxicity equivalency factors (TEFs) developed by the California Environmental Protection Agency (CAEPA 2009) to assess the potency of individual PAHs relative to benzo(a)pyrene, as follows:

Compound	TEF
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	0.1
Indeno(1,2,3-cd)pyrene	0.1

7.1.6 Risk Characterization

This section summarizes the approach used to develop the human health risk estimates for the Quendall Site and presents the quantitative risk characterization results for the soil, groundwater, sediment, surface water, and fish/shellfish tissue samples used in the HHRA.

In this risk characterization step, quantification of risk is accomplished by combining the results of the exposure assessment (estimated chemical intakes and exposure concentrations) with the results of the dose-response assessment (toxicity values identified in the toxicity assessment) to provide numerical estimates of potential human health effects. The approach differs for potential cancer and noncancer effects, as described in the following sections.

Although this HHRA produces numerical estimates of risk, it should be recognized that these numbers are not predictive of actual health outcomes. Rather, they provide a frame of reference for risk management decision-making, and interpretation of the risk estimates provided should consider the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding them.

7.1.6.1 Cancer Risk Estimation Method

The potential for cancer effects is evaluated by estimating excess lifetime cancer risk (ELCR). This risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer (i.e., if no exposure to Site chemicals occurs). For example, an ELCR of 2×10^{-6} means that for every 1 million people exposed to the carcinogen throughout their lifetimes, the average incidence of cancer may increase by two cases of cancer. In the United States, the background probability of developing cancer for men is a little less than one in two and for women is a little more than one in three (American Cancer Society 2008). As previously noted, cancer slope factors developed by EPA represent upper-bound estimates; therefore, any cancer risks generated in this assessment should be regarded as an upper bound on the potential cancer risks. The actual cancer risk may be less than that predicted, and may be zero (EPA 1989).
ELCR is estimated by using the following formula:

$$Risk = Intake \times SF$$

Where:

Risk = excess lifetime cancer risk (unitless probability)
Intake = chronic daily intake averaged over a lifetime (mg/kg-day)
SF = cancer slope factor $(mg/kg\text{-}day)^{-1}$

However, this linear equation is valid only at risk levels below one in one hundred (1×10^{-2}). For cases where chemical intakes are higher than this, an alternative calculation equation was used. This "one-hit" equation is consistent with the linear low-dose model:

$$Risk = 1 - \exp(-Intake \times SF)$$

Where:

Risk = excess lifetime cancer risk (unitless probability)
exp = the exponential
Intake = chronic daily intake averaged over a lifetime (mg/kg-day)
SF = cancer slope factor $(mg/kg\text{-}day)^{-1}$

Inhalation risk is calculated by multiplying the exposure concentration by the inhalation unit risk (IUR). The IUR is expressed in different units than the cancer slope factor (above), and a conversion factor is necessary to normalize units between the IUR and exposure concentration values. Inhalation risk is estimated by using the following formula:

$$Risk_{inh} = EC_a \times IUR \times CF$$

Where:

$Risk_{inh}$ = excess lifetime cancer risk from inhalation (unitless probability)
EC_a = exposure concentration in air (mg/m^3)
IUR = inhalation unit risk $(\mu g/m^3)^{-1}$
CF = conversion factor (μg/mg)

Although synergistic or antagonistic interactions might occur between cancer-causing chemicals and other chemicals, information is generally lacking in the toxicological literature

to predict quantitatively the effects of these potential interactions; therefore, cancer risks are treated as additive within an exposure route in this assessment. This approach is consistent with the EPA guidelines for the health risk assessment of chemical mixtures (EPA 1986b). For estimating the cancer risks from exposure to multiple carcinogens from a single exposure route, the following equation is used:

$$Risk_T = \sum_1^N Risk_i$$

Where:

$Risk_T$	=	total cancer risk from route of exposure
$Risk_i$	=	cancer risk for the ith chemical
N	=	number of chemicals

7.1.6.2 Noncancer Risk Estimation Method

For noncancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular chemical with the highest level of exposure that is considered protective (that is, its RfD). The ratio of the intake divided by RfD is termed the HQ:

$$HQ = \frac{Intake}{RfD}$$

Where:

HQ	=	noncancer hazard quotient from route of exposure
Intake	=	chronic daily intake averaged over the exposure duration (mg/kg-day)
RfD	=	noncancer reference dose (mg/kg-day)

For noncancer effects by inhalation exposure, the following equation is used:

$$HQ_{inh} = \frac{EC}{RfC}$$

Where:

HQ_{inh} = noncancer hazard quotient from inhalation
EC = exposure concentration in air (mg/m^3)
RfC = noncancer reference concentration (mg/m^3)

When the HQ for a chemical exceeds 1 (i.e., exposure exceeds the RfD or RfC), there is a concern for potential noncancer health effects. To assess the potential for noncancer effects posed by exposure to multiple chemicals, a hazard index (HI) approach was used in accordance with EPA guidance (1989). This approach assumes that the noncancer hazard associated with exposure to more than one chemical is additive; therefore, synergistic or antagonistic interactions between chemicals are not accounted for. The HI may exceed 1 even if all the individual HQs are less than 1. In this case, the chemicals may be segregated by similar mechanisms of toxicity and toxicological effects. Separate HIs may then be derived based on mechanism and effect. The HI is calculated as follows:

$$HI = \frac{Intake_1}{RfD_1} + \frac{Intake_2}{RfD_2} + \ldots \frac{Intake_i}{RfD_i}$$

Where:

HI = hazard index
$Intake_i$ = daily intake of the ith chemical (mg/kg-day)
RfD_i = reference dose of the ith chemical (mg/kg-day)

Both intake and RfD (or in the case of inhalation, the exposure concentration and RfC) are expressed in the same units (mg/kg-day or mg/m^3) and represent the same exposure period (i.e., chronic exposure).

7.1.6.3 Risk Estimation Method for Lead

Potential adverse health effects from lead are evaluated using different methods than those conventionally used for other chemicals. This is because for lead most human health effects data are based on blood lead concentrations rather than on the external dose. The adverse

health outcomes, which include neurotoxic and developmental effects, may occur at exposures so low that they may be considered to have no threshold. EPA views it as inappropriate to develop noncarcinogenic "safe" exposure levels (RfDs) for lead. Instead, a biokinetic model is used that relates exposure to measured lead concentrations in the environmental media with an estimated blood-lead level.

For this HHRA, potential adverse health effects from lead were evaluated by comparing the EPC for lead in soil to the residential RSL of 400 mg/kg (EPA 2011b). The soil RSL for residential land use was derived by EPA using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model (EPA 2005c). The IEUBK model is designed to predict probable blood-lead concentrations for children between 6 months and 7 years of age who have been exposed to lead through various sources (e.g., air, water, soil, diet, and *in utero* contributions from the mother). A predicted blood-lead level of 10 micrograms/deciliter (µg/dL) in greater than 5 percent of the potentially exposed population is considered by EPA to be a level of concern. Blood lead levels above this are therefore considered to pose an unacceptable risk.

7.1.6.4 Summary of Risk Estimates by Exposure Scenario

This section summarizes the risk estimates for each of the exposure scenarios identified for the Quendall Site. As described previously, the exposure scenarios for the Site are as follows:

- Future residential exposure scenario
- Future occupational worker exposure scenario
- Future construction/excavation worker exposure scenario
- Current and future recreational beach user exposure scenario
- Current and future recreational and subsistence fishing exposure scenarios

For the purposes of this evaluation, the potential for unacceptable human health risk is identified in accordance with EPA guidance (EPA 1991), using the following risk thresholds:

- In interpreting estimates of ELCRs, EPA under the Superfund program generally considers action to be warranted when the multi-chemical aggregate cancer risk for all exposure routes within a specific exposure scenario exceeds 1×10^{-4}. Action generally is not required for risks falling within 1×10^{-6} and 1×10^{-4}; however, this is judged on a case-by-case basis.

- Under EPA guidance, unacceptable noncancer hazard exists if the multi-chemical aggregate noncancer hazard for all exposure routes within a specific exposure scenario exceeds a target noncancer HI of 1 for toxicants that have similar mechanisms of action.
- If lead concentrations in environmental media result in a predicted blood-lead level of 10 μg/dL in greater than 5 percent of the potentially exposed population,[31] lead is present at unacceptable levels.

For the current and future beach user and fishing scenarios, risk estimates were also developed using sediment samples from background locations in order to understand the contribution of background concentrations to Site risks and provide information that may be used for risk management decisions; this is consistent with EPA guidance (EPA 2002a and 2002c).

The cancer and noncancer risk estimates for soil, groundwater, sediment, surface water, and fish/shellfish tissue are summarized by exposure scenario in the following sections.

The risk calculation data sheets used to develop the risk summary tables for each exposure scenario described below are provided by scenario in Appendix J-7.

7.1.6.4.1 Future Residential Exposure Scenario

Future residents living at the Site were evaluated for potential exposure to COPCs detected in three exposure media:

- Soil (from 0 to 15 feet bgs)
- Groundwater used for domestic purposes (well-specific)
- Indoor air via volatilization of VOCs from groundwater (well-specific) and vapor intrusion

[31] For the purposes of this HHRA, a soil concentration equal to 400 mg/kg was used as a risk threshold level for a residential exposure scenario. This concentration meets the threshold of 10 μg/dL blood lead in greater than 5 percent of the potentially exposed population.

The risk and hazard estimates for each of these are summarized in Table 7.1-7 and described in the following subsections.

Direct Contact with Soil

A total of 98 samples were used to calculate EPCs in soil for the residential exposure scenario; the individual sample locations are listed in Table 7.1-2 and EPCs are provided in Table 7.1-3. The estimated noncarcinogenic HI for COPCs in soil samples is 8. The primary contributor to the HI is naphthalene, with an HQ of 7; no other COPC has an HQ greater than 1. The estimated ELCR is 3×10^{-2}.[32] The primary contributors to the estimated cancer risk are cPAHs including: benzo(a)pyrene (2×10^{-2}), benzo(b)fluoranthene (2×10^{-3}), benzo(a)anthracene (1×10^{-3}), benzo(k)fluoranthene (1×10^{-3}), indeno(1,2,3-cd)pyrene (1×10^{-3}), and naphthalene (3×10^{-4}). The HI and ELCR estimates for the residential exposure scenario are summarized in Table 7.1-7.

The EPC for lead in soil is 327.1 mg/kg, less than the residential RSL of 400 mg/kg, indicating that lead concentrations in soil are not expected to pose an adverse health risk under a residential land use scenario.

Domestic Use of Groundwater

Thirty wellpoints were included in the evaluation of domestic use of groundwater, and risks were estimated on a well-specific basis. Of the 30 wellpoints evaluated, the estimated HI for noncarcinogenic chemicals was greater than 1 in 21 wells, with a maximum HI of 7,995 at well Q9. The primary contributors to the HI are PAHs including naphthalene (HQ=7,291), 2-methylnaphthalene (HQ=225), pyrene (HQ=13), fluoranthene (HQ=9), fluorene (HQ=6), and acenaphthene (HQ=6). Additional COPCs with HQs greater than 1 include dibenzofuran (HQ=206), arsenic (HQ=197), benzene (HQ=41), and total xylenes (HQ=7).

The estimated ELCR was greater than 1×10^{-4} at 20 of the 30 wellpoints evaluated, with a maximum ELCR of greater than 8×10^{-1} at well Q9.[33] The primary risk contributors are

[32] In these sections, the notation used for presenting ELCR estimates is different in the tables than in the text (for brevity). For example, this ELCR of 2×10^{-2} is listed as 2E-02 in Table 7.1-7.

[33] Due to the very high concentrations found in this well and the inherent limitations in quantifying risk at these levels, the ELCR is reported as a "greater than" estimate.

cPAHs including benzo(a)pyrene (5×10^{-1}), naphthalene (3×10^{-1}), benzo(a)anthracene (1×10^{-1}), benzo(b)fluoranthene (6×10^{-2}), benzo(k)fluoranthene (5×10^{-2}), indeno(1,2,3-cd)pyrene (3×10^{-2}), chrysene (7×10^{-3}), and dibenz(a,h)anthracene (7×10^{-3}), as well as arsenic (4×10^{-2}), and VOCs (benzene, 4×10^{-3}; and ethylbenzene, 6×10^{-4}). The well-specific HI and ELCR estimates for domestic use of groundwater are provided in Table 7.1-8.

Vapor Intrusion into Indoor Air

Inhalation exposure to volatile COPCs in indoor air potentially originating from groundwater was evaluated independently for each of the 30 wells included in the HHRA. The HI was greater than 1 at 15 of the 30 wellpoints evaluated, with a maximum HI of 280 at well BH-5/BH-5A.[34] The primary contributors are benzene (HQ=180), naphthalene (HQ=81), and total xylenes (HQ=17). The well-specific HI and ELCR estimates for vapor intrusion into indoor air under the residential exposure scenario are summarized in Table 7.1-9.

The estimated ELCR was greater than 1×10^{-4} at 13 of the 30 wellpoints evaluated, with a maximum ELCR of 2×10^{-2} at well BH-5/BH-5A. The primary risk contributors are benzene (2×10^{-2}), naphthalene (4×10^{-3}), and ethylbenzene (7×10^{-4}).

7.1.6.4.2 Future Occupational Worker Exposure Scenario

Direct Contact with Soil

A total of 98 soil samples were used to calculate EPCs for the occupational worker scenario. The sample locations and EPCs in soil are listed in Tables 7.1-2 and Table 7.1-3, respectively. The estimated HI is 2. Naphthalene (HQ=2) is the only COPC with an individual HQ greater than 1, although the HQ for 2-methylnaphthalene, which would be expected to have a similar toxic endpoint, is 0.2.

The estimated ELCR is 2×10^{-3}. The primary contributors to the ELCR are cPAHs including benzo(a)pyrene (1×10^{-3}), benzo(b)fluoranthene (1×10^{-4}), benzo(a)anthracene (1×10^{-4}),

[34] Wells BH-5 and BH-5A are part of a well cluster and are located within 10 feet of each other. The maximum concentration for these two wells was applied as the BH-5/BH-5A maximum exposure concentration for the risk assessment.

benzo(k)fluoranthene (8 x 10^{-5}), indeno(1,2,3-cd)pyrene (8 x 10^{-5}), chrysene (2 x 10^{-5}), and dibenz(a,h)anthracene (2 x 10^{-5}). The ELCR from naphthalene is 5 x 10^{-5} and the ELCR from arsenic is 8 x 10^{-6}. These results are summarized in Table 7.1-10.

7.1.6.4.3 Future Construction/Excavation Worker Exposure Scenario

Future construction/excavation workers at the Site were evaluated for potential exposure to COPCs from the following media:

- Soil (from 0 to 15 feet bgs)
- Trench groundwater (via dermal contact)
- Groundwater vapors off-gassing to trench air

The risk and hazard estimates for each are described in the following subsections.

Direct Contact with Soil

A total of 98 soil samples were used to calculate EPCs for the construction/excavation worker exposure scenario. The sample locations are listed in Table 7.1-2 and EPCs are provided in Table 7.1-3.

The estimated HI for noncarcinogenic effects is 3, and the primary contributors are naphthalene (HQ=2) and 2-methylnaphthalene (HQ=0.6), which would be expected to have a similar toxic endpoint. The estimated ELCR is 2 x 10^{-4} and the primary contributors are benzo(a)pyrene (1 x 10^{-4}), benzo(b)fluoranthene (1 x 10^{-5}), benzo(a)anthracene (1 x 10^{-5}), benzo(k)fluoranthene (8 x 10^{-6}), indeno(1,2,3-cd)pyrene (8 x 10^{-6}), chrysene (2 x 10^{-6}), dibenz(a,h)anthracene (2 x 10^{-6}), and naphthalene (2 x 10^{-6}). The HI and ELCR estimates are summarized in Table 7.1-11.

Contact with Groundwater in Construction Trenches

The possibility of dermal contact with COPCs in standing water in construction trenches was evaluated using the maximum detected concentrations for each chemical from all 30 Site wells.

The estimated HI for noncarcinogenic effects is 33. The primary contributors are 2-methylnaphthalene (HQ=13), dibenzofuran (HQ=12), benzene (HQ=4), and naphthalene (HQ=3). The estimated ELCR is 1 x 10^{-5} and the primary contributors to the risk estimate are benzene (1 x 10^{-5}) and arsenic (2 x 10^{-6}). These results are summarized in Table 7.1-11.

Inhalation of Volatilized Chemicals in Construction Trenches

Inhalation exposures to volatile COPCs in groundwater via off-gassing into trench air were evaluated using the maximum detected concentrations for each VOC in the 30 Site wells. The estimated HI for noncarcinogenic effects is 486 and the primary contributors are naphthalene (HQ=451), benzene (HQ=31), and total xylenes (HQ=3). The estimated ELCR is 8 x 10^{-4} and the primary contributors to the estimated cancer risk are naphthalene (7 x 10^{-4}), benzene (1 x 10^{-4}), and ethylbenzene (3 x 10^{-6}). These results are summarized in Table 7.1-11.

7.1.6.4.4 Current and Future Recreational Beach User Scenario

Current and future recreational beach users at the Site were evaluated for potential exposure to COPCs detected in nearshore sediment (from 0 to 4 inches and 0 to 10 centimeters bgs) and surface water.

Direct Contact with Nearshore Sediment

Six nearshore sediment samples were used to calculate EPCs for the recreational beach user exposure scenario. Metals results from five offshore samples were also used to represent nearshore sediment. The individual sample locations used to calculate EPCs in sediment are listed in Table 7.1-2, and EPCs for nearshore sediment and surface water are provided in Table 7.1-3. The estimated HI for noncarcinogenic chemicals in nearshore sediment samples is 0.02 for this scenario. The estimated ELCR from exposure to nearshore sediment is 3 x 10^{-4} and the primary contributors to the risk estimates are the cPAHs benzo(a)pyrene (3 x 10^{-4}), benzo(a)anthracene (1 x 10^{-5}), indeno(1,2,3-c,d)pyrene (1 x 10^{-5}), dibenz(a,h)anthracene (5 x 10^{-6}), and chrysene (3 x 10^{-6}). These results are summarized in Table 7.1-12.

Table 7.1-12 also includes HI and ELCR estimates for direct contact with sediment using cPAH data collected from background locations. The background HI is 0.001 and the

background ELCR is 3 x 10^{-6} for this exposure scenario. The primary background risk contributor is benzo(a)pyrene (ELCR=2 x 10^{-6}).

Direct Contact with Surface Water

To estimate exposures to contaminants in surface water, the maximum detected concentration for each COPC from six surface water locations was used for the EPC.

The estimated HI for noncarcinogenic chemicals in surface water samples is 0.03. The estimated ELCR is 3 x 10^{-6} and the primary contributor to the ELCR estimate is benzene (2 x 10^{-6}). These results are summarized in Table 7.1-12.

7.1.6.4.5 Current and Future Recreational and Subsistence Fishing Scenarios

Potential exposures to contaminants in fish and shellfish tissue and sediment were evaluated for recreational and subsistence anglers. Data from 57 Site-wide sediment samples were used to estimate EPCs in sediment and, in conjunction with BSAFs, to estimate EPCs in fish and shellfish tissue. The specific samples used are listed in Table 7.1-2 and the EPCs for Site-wide sediment and fish and shellfish tissue are provided in Tables 7.1-3 and 7.1-4, respectively.

Consumption of Fish and Shellfish

The estimated HIs are 0.4 and 3 for the recreational and subsistence fishing exposure scenarios, respectively. The primary contributor to the subsistence fishing HI is 2-methylnaphthalene (HQ=2). The ELCRs are 2 x 10^{-4} and 5 x 10^{-3} for the recreational and subsistence fishing scenarios, respectively. The primary contributors to the ELCRs for both scenarios are the cPAHs benzo(a)pyrene, benzo(a)anthracene, dibenz(a,h)anthracene, chrysene, and indeno(1,2,3-c,d)pyrene. These results are summarized in Tables 7.1-13 and 7.1-14.

These tables also include HI and ELCR estimates for consumption of fish and shellfish using data collected from background locations. The estimated HIs are 0.0004 and 0.003 for the recreational and subsistence fishing exposure scenarios, respectively, both of which are well

below EPA risk thresholds. The ELCRs are 2 x 10^{-6} and 4 x 10^{-5} for the recreational and subsistence fishing exposure scenarios, respectively. The primary contributors to the ELCRs for both scenarios are the cPAHs benzo(a)pyrene, benzo(a)anthracene, indeno(1,2,3-c,d)pyrene, and dibenz(a,h)anthracene. The primary contributor to the ELCR for the subsistence fishing exposure scenario is benzo(a)pyrene (3 x 10^{-5}).

Direct Contact with Site-wide Sediment

The estimated HIs due to exposure to COPCs in Site-wide sediment are 0.01 and 0.02 for the recreational and subsistence fishing exposure scenarios, respectively.

The ELCRs are 4 x 10^{-5} and 6 x 10^{-5} for the recreational and subsistence fishing exposure scenarios, respectively, and the primary contributor to the risk estimates for both scenarios is benzo(a)pyrene. These results are summarized in Tables 7.1-13 and 7.1-14, respectively.

These tables also include HI and ELCR estimates for contact with sediment using cPAH data collected from background locations. The estimated HIs are 0.0002 and 0.0003 for the recreational and subsistence fishing exposure scenarios, respectively, both of which are well below EPA risk thresholds. The ELCRs are 1 x 10^{-7} and 2 x 10^{-7} for the recreational and subsistence fishing exposure scenarios, respectively.

7.1.6.5 Overview of Risk Estimates

Table 7.1-15 summarizes the risk and hazard estimates for the six human health exposure scenarios evaluated in the baseline HHRA; these scenarios are listed below:

- Future residential exposure scenario
- Future occupational worker exposure scenario
- Future construction/excavation worker exposure scenario
- Current and future recreational beach user exposure scenario
- Current and future recreational fishing exposure scenario
- Current and future subsistence fishing exposure scenario

Noncancer HIs exceed 1 for all but the recreational beach user and recreational fishing scenarios. HIs exceeding 1 range from 3 (subsistence fish ingestion) to 7,995 (groundwater

exposure for the future resident). ELCR estimates exceed 1 x 10^{-4} for all six scenarios using Site data, ranging from 2 x 10^{-4} (recreational fish ingestion) to 1 (groundwater exposure for the future resident). The primary COCs that pose risks to human health throughout the Site are PAHs, benzene, and arsenic.

Recreational beach user, recreational fishing, and subsistence fishing exposure scenarios were also evaluated using a background sediment dataset. HIs were less than 1 for all three scenarios and ELCR estimates for recreational and subsistence fish ingestion exceed 1 x 10^{-6}, but are less than 1 x 10^{-4}.

7.1.7 Uncertainties Associated with this Baseline HHRA

The presence of uncertainty is inherent in the risk assessment process. Estimates of risk should present not only point estimates, but also take into account the sources and magnitude of uncertainty associated with these estimates, provide characterizations of risk that are both qualitative and quantitative, consider the limits of scientific knowledge, and identify when there is a possibility of either overestimation or underestimation. Sources of uncertainty in risk assessment range from the assumptions and methodologies used in the evaluation of exposures and risks, to data gaps in the qualitative and quantitative information used to characterize the risks and hazards posed by Site contaminants.

Several sources of uncertainty can affect the overall estimates of human health risks presented in this assessment. The sources are generally associated with the following:

- Sampling, analysis, and data evaluation
- Chemical fate and transport estimation
- Exposure assessment
- Toxicity assessment
- Risk characterization

These sources of uncertainty are discussed in the following sections.

7.1.7.1 Sampling, Analysis, and Data Evaluation

Uncertainties associated with soil, groundwater, sediment, and surface water sampling and analysis include the inherent variability (standard error) in the analysis, the representativeness of the samples, sampling errors, and the heterogeneity of the sample matrix. The QA/QC programs used during Site investigations are intended to maintain acceptable precision and accuracy in the measurement of chemical concentrations, but they cannot eliminate all errors associated with sampling and analysis. The degree to which sample collection and analyses reflect real exposure concentrations will influence the reliability of the risk estimates.

While the majority of the data used in this HHRA were of QA2 quality, data of QA1 quality were selectively used for performing HHRA exposure calculations (for soil and surface water). In these cases, there may be more uncertainty associated with the corresponding risk estimates.

7.1.7.2 Chemical Fate and Transport Estimation

This HHRA assumes that no chemical loss or transformation has occurred since the sampling data were collected, or will occur over the course of the assessed exposure durations. In cases for which natural attenuation or other degradation processes are moderate or high, the analytical data chosen to represent exposure concentrations likely overstate actual long-term exposure levels. This uncertainty is likely to be more relevant for organic chemicals (e.g., PAHs) that can be expected to undergo some limited biodegradation over the assumed 30- to 70-year exposure duration than for those that are more environmentally stable (e.g., metals).

7.1.7.3 Exposure Assessment

The estimation of exposures in this HHRA required many assumptions. There are uncertainties regarding the likelihood of exposure, the frequency of contact with contaminated media, exposure point concentrations, the intake rates, and the total duration of exposure. In the absence of Site-specific information, the exposure assumptions used in this HHRA were selected to reduce the likelihood of underestimating actual risks and are thus are intended to be health-protective.

Uncertainties in exposure estimates also include potential bias from sampling targeted towards areas of the highest Site contamination and conservatively modeled inputs, such as for indoor air or fish and shellfish tissue.

Specific uncertainties and their potential effects on exposure calculations are described below:

- Soil data available to characterize the beach for nearshore wading were limited to two samples collected in a Site area with relatively high concentrations. In this case the maximum value was used.
- Surface soil samples collected from Railroad property locations Q1-A and Q1-B contained cPAH concentrations 2 to 3 orders of magnitude higher than other Site samples. These two locations are in the Solid Material Loading Area where pitch was one of the materials formerly loaded, and the area likely contains fragments of pitch. The calculated Site-wide concentrations may be substantially weighted towards the sample results from these two locations.
- Arsenic concentrations in groundwater measured at well Q9 in the Railroad property were an order of magnitude higher than the next highest concentrations, which were detected at boring BH-29A in the southwest corner of the Site. The concentrations detected at well Q9 contributed substantially to the overall calculated risk estimates.

7.1.7.4 Toxicity Assessment

Uncertainties in toxicological data can also influence the reliability of risk management decisions. The toxicity values used for quantifying risk in this HHRA have varying levels of confidence that may affect the confidence in the resulting risk estimates. The general sources of toxicological uncertainty include the following:

- Extrapolation of dose-response data derived from high-dose exposures to adverse health effects that may occur at the low levels seen in the environment.
- Extrapolation of dose-response data derived from short-term tests to predict effects of chronic exposures.
- Extrapolation of dose-response data derived from animal studies to predict effects on humans.

- Extrapolation of dose-response data from homogeneous populations used in laboratory studies to predict effects on heterogeneous human populations.

More specific areas of toxicological uncertainty associated with this HHRA are as follows:

- The HHRA used available chronic RfDs and RfCs. The use of chronic values may be conservative for the future construction/excavation worker because it is most likely that any exposure would be intermittent and of shorter-than-lifetime duration.
- Toxicity values were not available from the sources listed in Section 7.1.5.3 for several chemicals detected. Theoretically, exclusion of these chemicals from quantitative evaluation in the HHRA may result in some underestimation of risk at the Site. However, most of the Site contamination was derived from coal tar and creosote sources associated with historical facility operations. Toxicity values for chemicals associated with these sources are readily available and chemicals without toxicity values do not represent a significant uncertainty in this HHRA.
- The toxicity values available from EPA and other sources are intentionally health-conservative to ensure that actual risks are unlikely to be underestimated. For example, cancer slope factors are typically based on the 95 percent UCL of the slope of the dose-response curve.

7.1.7.5 Risk Characterization

In the risk characterization for the Quendall Site, the assumption was made that the total risk of developing cancer from exposure to Site chemicals is the sum of the risk attributed to each individual contaminant. Likewise, the potential for the development of noncancer adverse effects is the sum of the HQs estimated for exposure to each individual contaminant. This approach, in accordance with EPA guidance, does not account for the possibility that some chemicals may act synergistically or antagonistically. In the absence of specific information about the interaction, the default assumption of additivity is considered appropriate.

7.2 Baseline Ecological Risk Assessment

The baseline ERA was conducted following standard EPA guidance for ecological risk assessments, including the following:

- Framework for Ecological Risk Assessment (EPA 1992a)
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (EPA 1997a)
- Guidelines for Ecological Risk Assessment (EPA 1998)
- Relevant and appropriate updated EPA guidance material (e.g., EPA's Eco Updates)
- EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund (EPA 1997b)

State and other regional information was also consulted, as applicable.

EPA's ERA process (1997a) is comprised of eight steps which have been applied in previous Site documents and herein, as described below. The screening-level problem formulation and ecological effects evaluation (Steps 1 and 2 of the EPA framework) are part of the initial ecological risk screening assessment, which was completed along with portions of Steps 3 through 6 (revised problem formulation, study design and DQO process, field sampling planning, and Site investigation) in the Draft Task 3 Report (Anchor and Aspect 2007b) and the Data Collection Work Plan (Anchor QEA and Aspect 2009a). This baseline ERA addresses Step 7 (risk characterization) in EPA's risk assessment process and includes summaries of the previous steps, exposure and effects assessments, and an uncertainty analysis. Step 8 (risk management) is the stage where remedial actions are considered and will be included as part of the forthcoming FS for the Quendall Site.

The following sections summarize the problem formulation including the CSM and assessment endpoints (Section 7.2.1); the ERA dataset including data selection and reduction (Section 7.2.2); the exposure and effects assessments including toxicity evaluations for terrestrial and aquatic-dependent receptors (Sections 7.2.3 and 7.2.4, respectively); the risk characterization (Section 7.2.5); and the uncertainty analysis (Section 7.2.6). Additional details supporting the ERA are provided in the following appendices:[35]

- Appendix J-1, Deviations from the HERA Work Plan
- Appendix J-3, Analytical Data Used in the Baseline Risk Assessment
- Appendix J-4, ProUCL Program Output

[35] Appendices J-2, J-6, and J-7 are specific to the baseline HHRA (Section 7.1).

- Appendix J-5, Biota-Sediment Accumulation Factor (BSAF) Derivation and Application
- Appendix J-8, Updated Screening of Chemicals of Potential Concern (COPCs) for the Baseline Ecological Risk Assessment
- Appendix J-9, Ecological Risk Assessment Model Inputs
- Appendix J-10, Effects of Variable Detection Limits on PAH ESBQ Calculations

For the ecological receptors addressed in this ERA, risk from exposure to Site media is addressed using a weight-of-evidence approach. The types of lines of evidence are described in Section 7.2.1.6 and evaluated in the risk characterization (Section 7.2.5), which includes discussions of exposure and effects, data quality, spatial and temporal representativeness, endpoint sensitivity, and degrees of association between endpoints.

7.2.1 Problem Formulation

The HERA Work Plan (Anchor QEA and Aspect 2009b) presents a problem formulation framework that includes conceptual models for receptors of concern, CSM diagrams for terrestrial and aquatic-dependent receptor exposure scenarios, and an exposure analysis plan with sample-level exposure summaries for identified exposure pathways to Site media.

The CSM diagrams for terrestrial and aquatic-dependent receptor exposure scenarios are shown in Figures 7.2-1 and 7.2-2, respectively. Specific exposure pathways and their relation to Site media are summarized in Table 7.2-1. COPCs for ecological receptors are summarized in Table 7.2-2 and detailed in Appendix J-8. A summary of the rationale for the selection or exclusion of quantitative ecological pathways in the ERA is provided in Table 7.2-3. Ecological assessment and measurement endpoints are summarized in Table 7.2-4.

7.2.1.1 Ecological Setting

A summary of the Site environmental setting and natural resources is provided in the Section 3 of this report, and Section 2 discusses historical Site features. The Draft Task 3 Report (Anchor and Aspect 2007b) also presented a general discussion of ecological setting and habitat utilization. This portion of the problem formulation summarizes the Draft Task 3

Report and HERA Work Plan information, any relevant updates based on input received from EPA, and information identified through recent Site investigations.

7.2.1.1.1 Terrestrial

The land uses surrounding the Site are primarily residential and commercial, with residential development immediately to the south and a sports complex to the north. Until 2007, the upland area was used for log handling and storage, resulting in large deposits of wood debris covering access roads and storage areas. The Site has been heavily manipulated through the placement of fill, which is found across the entire Site. Fill thickness ranges from 1 to 2 feet along the southern and eastern boundaries, and up to 6 and 10 feet in the northern portions of the Site. Most commonly, the fill is a mix of silt, sand, and gravel with wood debris. Wood chips and bark from the log sorting operations are typical in the upper few feet.

The surface of the Site is currently covered either by wood debris or by a 0.25-to-1-foot-thick layer of gravel and wood debris mixed together by prior operations of log sorting equipment in wet areas. There is also a network of roads at the Site that was previously used for log sorting and storage, resulting in relatively compacted soil on much of the Site.

The on-Site vegetation consists primarily of early successional and invasive species, although shoreline areas have well-developed areas of cottonwood (*Populus balsamifera*) and other deciduous trees. The U.S. Fish and Wildlife Service (USFWS) Wetlands Mapper for National Wildlife Inventory map information identifies palustrine scrub-shrub habitat on the western border of the study area adjoining Lake Washington (USFWS 2009a). Wetland vegetation community types identified during the 2009 delineation include palustrine and lacustrine emergent, palustrine and lacustrine scrub-shrub, palustrine and lacustrine forested, and palustrine open water wetland systems. Site vegetation includes tree, shrub, grass, and herbaceous species typically found in upland, wetland, and riparian habitat associated with Lake Washington and the constructed stormwater features.

Current upland Site habitat is of low to moderate quality. Because the Site is undeveloped and in close proximity to Lake Washington, it is assumed that typical species filling urban

habitat niches would use the Site under current conditions. Selection of terrestrial receptors is described in Section 7.2.1.4.1.

7.2.1.1.2 Aquatic

General information regarding Lake Washington summarized in this section was obtained from King County's Water and Land website (http://green.kingcounty.gov/lakes/LakeWashington.aspx). The lake has two major inflows: the Cedar River at the southern end and the Sammamish River from the north. Approximately 63 percent of the immediate watershed is a fully developed urban environment.

Aquatic habitat at the Site consists of shoreline and nearshore areas where light can penetrate to the bottom (littoral zone) extending out to more open surface waters (limnetic zone) above the deeper sediment below the range of effective light penetration (profundal zone). The Lake Washington substrate is primarily a silty mud, with sandy substrate indicated along the beach near the former May Creek delta and north of the former T-Dock, extending from the shoreline out past the inner harbor line. (The inner harbor line represents the limit of the portion of the Quendall Site that, as shown in figures in this report, extends into Lake Washington.) Wood debris, including sunken and partially submerged logs, has accumulated on the beach adjacent to Quendall Pond and is prevalent in log rafting areas near the haul-out at the southern property line. Where aquatic macrophyte growth is supported, the dominant species is invasive Eurasian watermilfoil (*Myriophyllum spicatum)*. Selection of aquatic receptors is detailed in Section 7.2.1.4.2.

7.2.1.2 Chemicals of Potential Concern for Ecological Receptors

COPCs for ecological receptors were selected based on the screening process outlined in Figure 7.1-5. Maximum detected concentrations and detection limits from the risk assessment datasets as described in Section 7.2.2 were used to screen all chemicals identified as COIs through the updated COI screening described in Section 7.1.3.3. Selection of COPCs for ecological receptors is described in detail in Appendix J-8 and is summarized below and in Table 7.2-2. Because the COI screening used data of QA0 quality, certain chemicals were identified as COIs that have no usable data for risk assessment purposes; these chemicals are

discussed for each medium and are qualitatively evaluated in this ERA. COIs with no screening levels were conservatively retained as COPCs.

7.2.1.2.1 Soil

Maximum detected concentrations and detection limits from the surface soil risk dataset (Section 7.2.2.1) of all soil COIs were compared with screening values to identify ecological COPCs for soil. EPA Eco-SSLs (http://www.epa.gov/ecotox/ecossl/), EPA Region 5 Ecological Screening Levels (ESLs) for soil, and MTCA Unrestricted Terrestrial Ecological Evaluation Screening Levels were used in selecting ecological COPCs for soil. Several soil COIs do not have data of QA2 quality and were identified as COIs based on QA1 quality data (cadmium, chromium, nickel, total PCBs, and zinc). The maximum detected concentrations (or the maximum non-detected values for all non-detects) for each of these COIs were conservatively used for COPC screening.

The screening levels for the metals arsenic, cadmium, chromium, lead, nickel, and zinc were below the regional background values (Ecology 1994). The maximum detected cadmium concentration is below the regional background value; therefore, cadmium was not quantitatively assessed in the ERA. The maximum detected concentrations of the remaining metals in the ecological soil dataset are greater than the regional background values, and these metals are therefore considered ecological COPCs. PCP was not detected in the ecological risk soil dataset but was retained as an ecological COPC for soil due to detection limit exceedances.

7.2.1.2.2 Surface Water and Sediment Porewater

For determining ecological COPCs for water, data for groundwater, surface water, and undiluted sediment porewater were combined for all surface water COIs in order to ensure that the groundwater transport pathway is addressed. National Freshwater Aquatic Life Chronic Criteria and EPA Region 3 BTAG surface water screening benchmarks were compared to maximum detected concentrations and detection limits from the combined water dataset to select ecological COPCs for surface water. PCP was not detected in the ecological risk surface water dataset but was retained as an ecological COPC for surface water due to detection limit exceedances. Several ecological COPCs for surface water were

identified solely based on the inclusion of groundwater data (chloroform, dibenzofuran, dibromochloromethane, and styrene). No surface water or sediment porewater data are available for these COPCs for a quantitative assessment; therefore, they were not carried through into this baseline ERA.

7.2.1.2.3 Sediment

Maximum detected concentrations and detection limits from the surface sediment risk dataset (Section 7.2.2.2) of all sediment COIs were compared with screening values to identify ecological COPCs for sediment. ESBQs, EPA Region 3 BTAG screening benchmarks, and Ecology freshwater screening values were used in identifying these COPCs.

Ethylbenzene, carbon disulfide, and sulfide were identified as COIs based on QA1 quality data. The maximum detected concentrations of each of these COIs were conservatively used for COPC screening. A sediment COI was considered an ecological COPC for sediment bioaccumulation if the chemical was an ecological COPC for sediment and was identified as a potential, candidate, or primary bioaccumulative chemical of concern by the USACE Regional Sediment Evaluation Team (RSET) (USACE and other federal and state agencies, 2009).

7.2.1.3 Ecological Receptors Potentially at Risk

This section provides an overview of ecological resources that could potentially use the Site and be directly or indirectly exposed to contaminated media. EPA guidance is available to help identify receptors potentially at risk (EPA 1992a, 1997a, and 1998). Receptors potentially at risk include the following:

- Federal or state rare, threatened, or endangered species.
- Resident species or communities with the greatest exposure to chemicals in sediment and surface water.
- Species or functional groups that are essential to, or indicative of, the normal functioning of the affected habitat.

At the Quendall Site, the ecological receptors potentially at risk include the animals and plants that use terrestrial and/or aquatic habitats within the Site. These receptors can

generally be segregated into plants, invertebrates, reptiles and amphibians, fish and shellfish, and birds and mammals. Representative species from these groups were selected as receptors of concern and further evaluated to determine whether and to what degree they may be at risk from contaminated media at the Site. Additional information on these resources is provided in the Draft Task 3 Report (Anchor and Aspect 2007b).

7.2.1.3.1 Rare, Threatened, or Endangered Species

Based on a review of the USFWS list of special status species for Washington State (USFWS 2009b), only the following three federally listed species occur in King County:

- Chinook salmon (*Oncorhynchus tshawytscha*)
- Steelhead (*O. mykiss*)
- Bull trout (*Salvelinus confluentus*)

The bald eagle (*Haliaeetus leucocephalus*) has been federally delisted, but is still currently considered a sensitive species in the State of Washington (http://wdfw.wa.gov/wlm/diversty/soc/sensitiv.htm).

7.2.1.3.2 Plants

Both terrestrial and aquatic plants are important resources because they provide significant habitat for fish and wildlife. Riparian vegetation is generally present across the Site shoreline, with the exception of the southern log handling area. Aquatic vegetation mostly consists of dense beds of Eurasian watermilfoil, which has choked out the majority of native plant growth (King County DNRP 2003). Phytoplankton populations are relatively uniform throughout Lake Washington. Dominant species vary seasonally. In winter and spring, the phytoplankton community is dominated by diatoms (*Bacillariophyceae*). Around June, in response to nutrient depletion, diatom populations decline and gelatinous green or blue-green algae dominate (EVS 1990).

7.2.1.3.3 Invertebrates

The invertebrate community (both terrestrial and aquatic) is an important receptor group because soil and benthic invertebrates consume plants and detritus. These invertebrates are

active in critical nutrient cycling and represent a trophic link to other organisms that consume them. Because invertebrates are relatively sessile and are in direct contact with soil or sediment, they provide an integrated measure of toxicity. Benthic infauna were identified and enumerated in samples collected from Lake Washington by Ecology (1991 and 1992) and EVS (1990). Chironomids constitute the majority of the benthic abundance and biomass in the Site vicinity. Other prevalent taxa include oligochaetes, bivalves, porifera, amphipods, and copepods. Similar information on Site terrestrial invertebrates is not available. Zooplankton populations are distributed in random patches, with a relative constant composition of crustaceans and rotifers, dominated by *Daphnia* (EVS 1990).

7.2.1.3.4 Reptiles and Amphibians

Reptiles potentially using the Site include newts, lizards, turtles, and common garter snakes *(Thamnophis spp.).* Amphibians include several salamander species including the Pacific giant salamander *(Dicamptodon tenebrosus*), and several frog species including the Oregon spotted frog *(Rana pretiosa*), and non-native bullfrogs *(Rana catesbeiana).*

7.2.1.3.5 Fish and Shellfish

Based on a review of Lake Washington fish species information (EVS 1990; King County DNRP 2003; WDFW 2009; WDOH 2004; and Wydoski and Whitney 2003), resident and migratory species were inventoried, their life history needs were compared to available niches at the Site, and representative species were selected for this ERA.

The fish community in Lake Washington is dominated by cutthroat trout (*O. clarki*), northern pikeminnow *(Ptychocheilus oregonensis*), yellow perch *(Perca flavescens*), smallmouth bass (*Micropterus dolomieui),* and sockeye salmon *(O. nerka*). Other fish species include steelhead/rainbow trout, coho *(O. kisutch)* and Chinook salmon, lamprey *(Lampetra spp.)*, sculpin *(Cottus spp.)*, carp *(Cyprinus carpio)*, brown bullhead *(Ameiurus nebulosus),* bull trout, threespine stickleback *(Gasterosteus aculeatus*), and dace (*Leuciscus* spp.). Longfin smelt (*Spirinchus thaleichthys)* are known to spawn in May Creek. Salmon species likely use the nearshore area as juveniles. Additional information on fish species is provided in Appendix B of the Draft Task 3 Report (Anchor and Aspect 2007b).

The preliminary species guilds to be addressed for the ERA exposure pathway include piscivorous fish (e.g., pikeminnow or yellow perch), omnivorous fish (e.g., stickleback or salmonid fry), benthivorous fish (e.g., sculpin), and shellfish (e.g., crayfish *[Astacoidea spp.]*).

7.2.1.3.6 Birds

Birds found at the Site may include aquatic-dependent birds such as the great blue heron *(Ardea herodias)*, common merganser *(Mergus merganser)*, mallard *(Anas platyrhyncho)*, spotted sandpiper *(Actitis macularia)*, and osprey *(Pandion haliaetus)*; the bald eagle; and upland birds such as wrens *(Troglodytidae)*, crows *(Corvus spp.)*, woodpeckers *(Picidae)*, robins *(Turdus spp.)*, sparrows *(Emberizidae),* and finches *(Fringillidae)*. Like mammals, birds are grouped into terrestrial and aquatic-dependent receptors for this ERA. Primary terrestrial avian feeding guilds for the Site include avian predators and insectivorous birds. Aquatic-dependent species guilds include piscivorous raptors and other shorebirds, including the great blue heron, diving and dabbling ducks, and sediment-probing birds.

7.2.1.3.7 Mammals

Mammals observed in the Site vicinity include occasional coyotes *(Canis latrans)*, red fox *(Vulpes vulpes)*, deer *(Odocoileus spp.)*, raccoons *(Procyon lotor)*, skunks *(Mephitidae)*, river otters *(Lutra canadensis)*, beaver *(Castor canadensis)*, weasels *(Mustela spp.)*, opossums *(Didelphis virginianus)*, rabbits *(Sylvilagus spp.)*, shrews *(Sorex spp.)*, bats *(Vespertilionidae)*, and rodents including squirrels *(Sciuridae)*, mice, and voles *(Muridae).* Mammals were grouped into terrestrial and aquatic-dependent receptors for the ERA. Primary terrestrial mammal feeding guilds include herbivorous mammals, insectivorous mammals, omnivorous mammals, and carnivorous mammals.

Aquatic-dependent wildlife species potentially using the Site were evaluated based on a review of readily available information from the University of Washington, WDFW, WDNR, and the Audubon Society. The aquatic-dependent species guild includes the piscivorous mammal otter.

7.2.1.4 Selection of Representative Receptors

Preliminary receptor feeding guilds and potential receptors are discussed in the Draft Task 3 Report (Anchor and Aspect 2007b) and the Data Collection Work Plan (Anchor QEA and Aspect 2009a) as part of Steps 1 through 4 of EPA's 8-step ERA process (EPA 1997a). Representative receptors for the ERA were selected based on the following criteria:

- Ecological relevance
- Potential levels of exposure to COPCs
- Social or economic importance
- Sensitivity to COPCs
- Availability of sufficient natural history information to allow meaningful assessment of exposure and risk

Terrestrial and aquatic-dependent receptor selection is discussed separately in the next two sections. Assessment and measurement endpoints and the weight-of-evidence approach to risk characterization are described in Section 7.2.1.6.

7.2.1.4.1 Terrestrial Receptors

Terrestrial feeding guild categories include plants, invertebrates, birds, and mammals. Soil invertebrates and terrestrial plants were assessed on a community-level basis for direct effects and were also included as a food source to upper-trophic-level organisms, as discussed below.

Reptiles and amphibians were not directly assessed in this ERA because exposure models and toxicological data for reptiles and amphibians are limited. There is significant uncertainty associated with the exposure and sensitivity of this group of receptors to COPCs at the Site. Given the limited information available, a meaningful assessment of risk to this group of receptors is not possible; however, it is assumed that the risk characterization and risk-based management for other assessment endpoints (e.g., soil invertebrates, mammals, fish, and birds) will provide protection of reptiles and amphibians at the Site.

Terrestrial bird feeding guilds for this ERA include insectivorous birds and avian predators. The specific receptors selected for each feeding guild include the following:

- **Insectivorous bird:** The American robin (*T. migratorius)* is a common bird consuming plants, fruits, and insects. For this ERA, the robin represents birds that feed primarily on soil invertebrates.
- **Avian predator:** The red-tailed hawk (*Buteo jamaicensis*) is an upper-trophic-level terrestrial predator that preys on small birds, ground-dwelling rodents, and small mammals. For this ERA, the hawk represents birds that feed primarily on small mammals.

Terrestrial mammal feeding guilds for this ERA include herbivorous mammals, insectivorous mammals, omnivorous mammals, and carnivorous mammals. The following species were selected as specific receptors for each feeding guild:

- **Herbivorous mammal:** The eastern cottontail rabbit (*S. floridanus*) is a small mammal that is common throughout the eastern, midwestern, and southwestern United States and is an introduced species of Washington. The meadow vole (*Microtus pennsylvanicus*) is a common small mammal with a smaller body size than the rabbit. The vole consumes shoots, grasses, and bark and is prey for hawks and foxes. The rabbit and the vole represent mammals feeding solely on plants.
- **Insectivorous mammal:** The mole was initially selected to represent mammals that feed primarily on earthworms and soil invertebrates. Due to the lack of availability of natural history information in the standard literature for the mole, the short-tailed shrew *(Blarina brevicauda)* was assessed for this guild that feeds on earthworms and other soil invertebrates.
- **Omnivorous Mammal:** The raccoon is a common, medium-sized, opportunistic feeder with a varied diet depending on season and location. The raccoon was selected to represent mammals feeding primarily on soil invertebrates and plants.
- **Carnivorous Mammal**: The coyote is an upper-trophic-level terrestrial predator present throughout the United States and Canada and common in Washington. Coyotes prey primarily on small mammals but also feed on carrion and fruit. The coyote was selected to represent a mammal feeding solely on small mammals.

7.2.1.4.2 Aquatic-Dependent Receptors

Aquatic feeding guild categories include plants, invertebrates, fish and shellfish, birds, and mammals. Aquatic macrophytes (plants) and benthic invertebrates were assessed as general communities and, for benthos, using surrogate test species.

Detailed information on Lake Washington fish species is presented in the Draft Task 3 Report (Anchor and Aspect 2007b) and is summarized in the HERA Work Plan (Anchor QEA and Aspect 2009b). The representative fish receptors selected for each feeding guild included the following:

- **Piscivorous Fish:** Yellow perch represent piscivorous fish. This guild also includes the pikeminnow. Both perch and pikeminnows are known inhabitants of Lake Washington.
- **Omnivorous Fish:** Salmonid fry conservatively represent omnivorous fish such as the stickleback that may use the nearshore portion of the Site for at least a portion of their lives. Both Chinook and sockeye salmon are known to occur in Lake Washington, in addition to other salmonids.
- **Benthivorous Fish and Shellfish:** The brown bullhead *(Ameiurus nebulosus)* represents both fish and crayfish having high direct exposure to surface sediment. This guild also includes sculpins.

The above fish guilds were also included as prey to both fish and wildlife.

The feeding guilds for aquatic-dependent birds include piscivorous raptors, shorebirds, sediment-probing birds, dabbling ducks, and diving ducks. The specific receptors selected for each feeding guild included the following:

- **Piscivorous Raptor:** The bald eagle represents birds that feed primarily on pelagic fish with some demersal fish, including osprey.
- **Shorebird:** The great blue heron represents birds that feed primarily on demersal fish with some pelagic fish and crustaceans.
- **Sediment-Probing Bird:** The spotted sandpiper represents birds that feed on aquatic worms, mollusks, and crustaceans.
- **Dabbling Duck**: The mallard duck represent birds that feed primarily on aquatic

vegetation with some crustaceans.

- **Diving Duck:** The lesser scaup *(Aythya affinis)* represents birds that feed primarily on crustaceans with some plants, mollusks, and demersal fish.

The piscivorous mammal feeding guild was selected for aquatic-dependent mammals. The river otter was selected to represent mammals with primarily aquatic diets feeding mostly on demersal and pelagic fish with some crustaceans and mollusks. Otter tracks have been noted on-Site.

The bald eagle and salmon fry are representative threatened or endangered species for this ERA. Though federally delisted in most of the United States, the eagle is still a sensitive species in the State of Washington, as noted previously, and is still protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act.

7.2.1.5 Ecological Conceptual Site Model

The nature and extent of NAPL and non-NAPL contamination in Site media are detailed in Sections 4 and 5, respectively. In general, the highest levels of contamination in Site media are associated with occurrences of creosote and coal tar DNAPL. The ecological CSM is shown in Figure 7.2-1 for terrestrial receptors and Figure 7.2-2 for aquatic-dependent receptors. The following sections briefly summarize the sources, pathways, and exposure media to ecological receptors.

7.2.1.5.1 Sources

The Site sources, release mechanisms, and transport media are summarized in Section 2.2 and depicted in Figure 2.2-1. As described in Section 2.2, the primary historical sources of COPCs to upland areas are tars and distillate products along with the release of waste products including solids and liquids. Primary sources to aquatic areas include historical spills and leaks of tars and fuel oils.

7.2.1.5.2 Pathways

Transport pathways may be within a mobile medium such as DNAPL or groundwater, or between media, such as dissolution from soil into groundwater. Details on the fate and transport of COPCs at the Site are provided in Section 6.

Chemical pathways to soil include direct discharge and DNAPL migration through soil. Contaminants in soil and DNAPL can dissolve into Site groundwater and be transported with groundwater flow. The resulting contaminant plume follows the direction of groundwater flow toward Lake Washington. Pathways to sediment include groundwater migration and direct discharge from spills. Contaminant pathways to surface water at the Site occur through physically, chemically, and biologically mediated exchange of sediment porewater across the sediment/surface water interface and upward advection of groundwater through the sediment and associated chemical diffusion of sediment porewater.

7.2.1.5.3 Exposure Media

Exposure media for ecological receptors include soil, surface water, bulk sediment, and sediment porewater (Figure 2.2-1). Using the above-described species information, the CSM shown in Figure 2.2-1 was used to develop assessment endpoints and measures of effect and exposure, described in Section 7.2.1.6.

7.2.1.6 Assessment and Measurement Endpoints and Lines of Evidence

Assessment endpoints are the valued attributes of ecological entities upon which risk management actions are focused. More specifically, assessment endpoints are "*an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes*" (EPA 1998). The selection criteria for assessment endpoints include ecological relevance, susceptibility (exposure plus sensitivity), and relevance to management goals (EPA 2004).

Unless an ecological receptor is listed as a threatened and endangered species, assessment endpoints are generally selected that are relevant to population- or community-level rather than individual effects. For evaluation of threatened, endangered, or rare species (i.e., bald

eagle) that may have exposure to Site COPCs, assessment endpoints are based on protecting individual organisms rather than populations or communities.

Assessment endpoints for receptors of concern (e.g., those identified in Table 7.2-4) evaluate survival, growth, and reproduction. The selection of assessment endpoints is based on the available information and the criteria listed previously. In this ERA, endpoints were selected that would likely result in protection of other valued entities and were amenable to assessment through existing data for exposure pathways quantitatively assessed in the ERA. Certain pathways were not quantitatively evaluated in the ERA (Table 7.2-3) and generally include direct contact with soil and direct contact with/ingestion of surface water.

Measurement endpoints associated with these assessment endpoints are further discussed in the exposures and effects assessments for terrestrial and aquatic-dependent receptors, in Sections 7.2.3 and 7.2.4 respectively. Those sections describe the measures of effect and exposure, lines of evidence, and study design for each of the assessment endpoints in the ERA. A measurement endpoint is described as "*a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint*" (EPA 1992a). Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity tests results, contaminant concentrations in sediment) and include measures of exposure and measures of effect. Evaluation of overall ecological risk is based on a weight-of-evidence approach that combines multiple assessment endpoints.

7.2.1.6.1 Weight-of-Evidence Approach

Where possible, more than one line of evidence was evaluated to determine the potential for risk and the sensitivity of risk estimates for the various exposure scenarios and receptors. The assessment and measurement endpoints available (Table 7.2-4) provide the basis of the lines of evidence described below for each of the receptors:

- **Soil Invertebrates and Terrestrial Plants**
  - Comparison of Site data with soil screening values for single chemicals or chemical groups.

- **Terrestrial Birds and Mammals**
  - Comparison of Site data with soil screening values for single chemicals or chemical groups.
  - Multi-media exposure model calculations and comparisons with single-chemical toxicity data.
- **Aquatic Macrophytes**
  - Comparison of Site data with surface water screening values for single chemicals or chemical groups.
- **Benthic Invertebrates**
  - Comparison of Site data with sediment porewater screening values or benchmarks for single chemicals or chemical groups.
  - Comparison of Site data with bulk sediment screening values or benchmarks for single chemicals or chemical groups.
  - Site-specific sediment bioassays using amphipods and midges with Site and statistical comparisons with reference sediment tests.
- **Fish and Shellfish**
  - Comparison of Site data with surface water and sediment porewater screening values or benchmarks for single chemicals or chemical groups.
  - Modeled tissue residue values for single chemicals or chemical groups.
  - Dietary exposure model calculations and comparisons with single- chemical toxicity data.
- **Aquatic-Dependent Birds and Mammals**
  - Multi-media exposure model calculations and single-chemical toxicity data.

There are four types of lines of evidence, and their strengths and weaknesses are described below. Specific applications of the lines of evidence are presented in the receptor-specific sections within the Risk Characterization (Section 7.2.5); uncertainties associated with specific endpoints are discussed in the uncertainty analysis (Section 7.2.6).

Comparison of Site Data with Screening Values or Benchmarks for Single Chemicals or Chemical Groups

Screening values and benchmarks are differentiated by their intended uses and derivation. Single-chemical or chemical group screening values (e.g., EPA Region 5 ESLs for soil, EPA Eco-SSLs, and EPA Region 3 BTAG surface water screening benchmarks) were applied to evaluate Site media and associated receptors including terrestrial plants, invertebrates, birds and mammals, and aquatic macrophytes, benthos, and fish/shellfish. These generic screening values are not Site-specific and were derived based on conservative exposure and toxicity assumptions. For soil invertebrates/ terrestrial plants and aquatic macrophytes, this screening approach was the sole line of evidence. Risk from soil exposure to terrestrial birds and mammals was addressed using additional lines of evidence as described below. Risk assessment methods and suitable data for evaluating aquatic macrophytes were limited, although other aquatic-dependent receptors with direct sediment/porewater contact, including fish/shellfish and benthic invertebrates, were addressed using multiple lines of evidence.

In addition to the sediment screening values for total PAHs, EPA's equilibrium partitioning sediment benchmark (ESB) approach for PAHs (EPA 2003b) was applied as an additional line of evidence for estimating risk to benthic communities. The PAH ESB approach is a method to estimate potential narcotic toxicity to benthic invertebrates based on sediment porewater exposure to dissolved PAHs. Because PAHs share the same toxic mode of action, a toxic unit (TU) approach is used. A TU is calculated as a quotient, i.e., the sum of the ratio of each individual PAH concentration in sediment porewater divided by a final chronic value (FCV) for that PAH. The model can be used on a sediment porewater basis by calculating a porewater PAH TU based on direct comparison of porewater to the FCV, or on a bulk sediment basis by calculating a PAH ESB quotient (ESBQ, expressed in TUs) based on the equilibrium partitioning estimate of porewater PAH concentrations.

Modeled Tissue Residue Values for Single Chemicals or Chemical Groups

Modeled tissue residue values were derived using the BSAF approach (Appendix J-5) and compared to available tissue-based toxicity reference values (TRVs) for fish and shellfish. The derivation of TRVs is described in Appendix J-9. Tissue residue effects data are limited to a subset of bioaccumulative compounds and are not Site-specific in terms of test organisms

and exposure methods. Overall, this line of evidence was limited in its usefulness for evaluating potential risk to fish and shellfish.

Multi-media Exposure Models

Multi-media exposure models were applied to calculate total daily intake (TDI) of contaminants by terrestrial and aquatic-dependent birds and mammals. These exposure models address multiple media including modeled prey, soil, sediment, and water and, therefore, provide more realistic exposure estimates. In addition, the database of diet-based TRVs is robust (see Appendix J-9).[36] The multi-media exposure models for wildlife are well developed and supported by EPA guidance and literature. This was the primary line of evidence for evaluating risk to wildlife.

Bioassays

Sediment bioassays tests using amphipods and midges were used as the primary line of evidence to evaluate risk to benthic communities. Survival and growth following a chronic exposure (i.e., 28 days) to sediment samples, compared to reference locations, provided a direct measure of the incidence and magnitude of toxicity at the Site. The bioassays used standardized methods to provide a sensitive, representative, and high-quality line of evidence to evaluate risk to benthos. In addition, synoptic bulk sediment and porewater chemistry measurements of the bioassay samples provided a dataset that allows risk to benthic communities to be characterized across the Site with a high degree of confidence.

7.2.2 Data Availability and Selection

This section describes the ERA data selection methods that were used to calculate EPCs. As discussed in Section 2, the usability of historical analytical data was evaluated in previous Site documents, including the Task 2 Report (Anchor and Aspect 2007a), the Draft Task 3 Report (Anchor and Aspect 2007b), and the Data Collection Work Plan (Anchor QEA and Aspect 2009a).

The usability evaluations were conducted to determine the quality of data for delineating the nature and extent of contamination and to determine whether the available dataset for each

[36] Appendix J-9 also includes soil uptake factors used to calculate TDI for terrestrial receptors.

exposure medium was adequate to conduct the ERA. Based on the data needs identified in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), supplemental sampling for select media was performed as necessary to adequately characterize the nature and extent of contamination. The additional RI field investigation data, along with the historical data that met usability requirements, were determined to be adequate for conducting the baseline risk assessment. The samples selected for use in the ERA are identified in Table 7.2-1. The primary data used in the ERA for risk characterization were QA2 quality data. QA1 and QA1- quality data were used for determining indicator chemicals where no QA2 data existed (i.e., selected metals and total PCBs in soil, and selected metals in sediment). The dataset quality meets the DQOs identified in the Data Collection Work Plan and the HERA Work Plan (Anchor QEA and Aspect 2009b), ensuring adequate data coverage for the ERA. No data suitability concerns were identified with any of the ERA datasets.

The following sections describe the data for the specific exposure media and Figures 7.1-1, 7.1-3, and 7.1-4 show the sample locations for soil, sediment, and surface water/sediment porewater, respectively, from which data used in the ERA were collected. Note that these sample locations were the same for both the HHRA and the ERA.

7.2.2.1 Soil Data

No additional risk-assessment-specific soil sample data collection was determined to be necessary to conduct the baseline ERA. The ERA soil dataset includes all surface soil data from the same locations as the HHRA. These include data from previous Quendall Site investigations and the Railroad property investigation (Pinnacle 2009). While most data are of QA2 quality, data of QA1 quality were also selectively used for the ERA.[37] Surface soil was conservatively defined as samples with depths within the interval of 0 to 5 feet bgs. The surface soil sample locations where data used in the ERA were collected are shown on Figure 7.1-1.

[37] The QA categories used to designate the quality of the historical analytical data obtained from the Quendall Site are described in Section 2.4 of this RI Report.

7.2.2.2 Bulk and Porewater Sediment Data

The RI field investigation provided bulk and porewater sediment data of QA2 quality with which to estimate direct contact, incidental ingestion, and bioaccumulation exposures to wildlife. Additionally, the bulk and porewater sediment data of QA2 quality were used to assess the risk to freshwater benthos using the ESB approach for PAHs (EPA 2003b) and other chemical endpoints including TPH, wood-debris-related chemicals, and conventional parameters (TOC and TVS).

The ERA bulk and porewater sediment dataset includes data from all surface samples (collected from 0 to 4 inches) with a QA2 or better quality designation from previous Site investigations, and also includes data from all surface bulk sediment and porewater samples collected during the RI field investigation. The bulk sediment and sediment porewater sample locations where data used in the ERA were collected are shown on Figures 7.1-3 and 7.1-4, respectively.

7.2.2.3 Surface Water Data

Selected RI surface sediment porewater data were used in conjunction with historical data of QA1 quality from surface water samples collected from locations SW-1 through SW-6 (shown on Figure 7.1-4) to evaluate water contact and ingestion by ecological receptors. Surface water exposure was estimated for sediment porewater data by applying a dilution factor of 10 to the porewater data. Because of the limited areas of upland surface water, it was assumed that water in Lake Washington is the primary surface water source of exposure, as described in the next section for specific receptors. Quendall Pond, the largest existing wetland on the Site, was evaluated qualitatively as a source of surface water exposure to ecological receptors because prospective Site cleanup actions will remove future exposures to this pond (Anchor QEA 2009).

7.2.2.4 Bioassay Data

The data from RI field investigation sediment bioassays were used in the ERA to assess risk to benthic communities. Two sets of bioassay tests were run to evaluate risk from hydrocarbons and to assess the deleterious properties of wood debris. For each bioassay sample, 28-day amphipod (*Hyalella azteca)* and 20-day midge (*Chironomus dilutus)* tests

were run. For both tests, the endpoints were end-of-test survival and growth. Growth endpoints were expressed as mean individual weight (MIW) of surviving individuals or total replicate weight (TRW) of surviving individuals. Synoptic bioassay and analytical chemistry sample data from the hydrocarbon tests allowed for Site-specific evaluation of several chemical endpoints including total PAHs and PAH ESBQs (expressed in TUs) in bulk sediment and sediment porewater, as described in Section 7.2.4.2. Wood debris bioassays included synoptic chemistry measurements of conventional parameters and selected wood-debris-related chemicals. Figure 7.2-3 shows the locations where the bioassay samples were collected.

7.2.2.5 Data Reduction

The methods used to address field duplicates in the ERA were the same as described for the HHRA in Section 7.1.3.2. Chemical totals were calculated as described in Section 5.1. For example, ESBQs for PAHs (expressed in TUs) were calculated according to EPA procedures (EPA 2003b) using the appropriate set of 34 PAHs for bulk sediment and porewater (see Appendix A-4). EPC calculations for 95 percent UCLs were performed using EPA's ProUCL statistical program (see Appendix J-4). ProUCL input files included the full reporting limits and associated detection flags. The ProUCL-recommended results were applied as the EPCs.

Due to the frequency of non-detects in the porewater dataset, PAH ESBQs for sediment porewater were calculated as a range assuming U=0 and U=1/2 of the solid-phase microextraction (SPME) reporting limits to assess the impact of the left-censored data on the sensitivity of the TU calculations. Because of the variability in these initial bounding calculations, and consistent with guidance provided by EPA, PAH ESBQs for sediment porewater were also calculated using ProUCL regression-on-order statistics (ROS) detection limit estimates. An evaluation of porewater detection limits and their impact on the calculation of PAH ESBQs was performed with four methods of accounting for the undetected values as follows:

- Undetected chemicals were included as zero (U=0).
- Undetected chemicals were included as one-half the detection limit (U=1/2).
- Undetected chemicals were included as the ROS estimated value and, for chemicals where the distribution could not be estimated, at U=0.

- Undetected chemicals were included as the ROS estimated value and, for chemicals where the distribution could not be estimated, at U=1/2.

Calculation summary tables are provided in Appendix J-10 along with the ProUCL distribution summaries. The results of the ROS-derived PAH ESBQ calculation evaluation are discussed in the uncertainty analysis (Section 7.2.6). As noted above, for the purpose of calculating UCLs, the laboratory detection limits were used, consistent with ProUCL guidance. Because the analysis of benthic toxicity did not use screening or TDI exposure estimates, 95 UCLs were not calculated for PAH ESBQs.

7.2.3 Exposure and Effects Assessment for Terrestrial Receptors

The following sections describe the exposure and effects assessment for terrestrial receptors including soil invertebrates, plants, and terrestrial wildlife. As described in Section 7.2.1.4.1, one primary wildlife receptor was identified for each general feeding guild. Table 7.2-1 summarizes exposure media for selected terrestrial receptors. For terrestrial birds and mammals, the primary line of evidence for characterizing risk was a multi-media exposure model comparing TDI of COPCs to dietary TRVs, while Site soil concentrations were compared to soil screening values as an additional line of evidence. Comparison of Site data with soil screening values was the sole line of evidence for characterizing risk to soil invertebrates and terrestrial plants.

The potential risks to the wildlife receptor groups were evaluated using modeled COPC concentrations in prey tissue and measured COPC concentrations in Site soil. Foraging strategies, the home range, dietary composition, and allometric information—such as body weight and ingestion rates for the representative receptor(s)—chosen for each receptor group were used to assess exposure. More specifically, the ingested dose received by each representative receptor was estimated by multiplying species-specific food and incidental soil ingestion rates (normalized to body weight) by the concentrations of COPCs in prey species and soil. Estimated ingested doses were compared to appropriate TRV values for survival, growth, and reproduction.

If the ingested dose of one or more COPC was in excess of the respective TRV for a representative receptor, (i.e., the HQ was greater than 1), or if the soil EPC exceeded the respective soil screening value, members of the receptor group were considered to be potentially at risk. HQs shown in the tables supporting this section are presented at two significant figures, reflecting the maximum precision of the TRVs and screening levels.

7.2.3.1 Soil Invertebrates and Terrestrial Plants

The COPC screening (Section 7.2.1.2) applied conservative screening values to identify the list of chemicals carried forward to the baseline risk assessment. The ability to further refine risk to soil invertebrates and terrestrial plants was limited due to the small number of chemicals addressed by benchmark-level Eco-SSLs. Because soil COPCs were evaluated using other receptors (i.e., terrestrial birds and mammals) and lines of evidence (TDI), less stringent screening levels, such as the ORNL bulk soil screening values for plants (Efroymson et al. 1997), were not applied to evaluate terrestrial soil invertebrates and plants. As summarized in Table 7.2-5, the assessment of soil invertebrates and terrestrial plants was conducted through a screening assessment using EPA Eco-SSLs and a UCL of the mean (95 UCL) of Site surface soil data. The UCLs were calculated using EPA's ProUCL software and were compared to screening levels using an HQ approach.

7.2.3.2 Terrestrial Wildlife

Terrestrial wildlife was evaluated using bulk soil screening and the TDI/TRV measure of exposure and effects. The TDI equations used to estimate exposure to terrestrial wildlife (Equations 7.2-1 and 7.2-2; see below) are standard multi-media dietary dose equations, as detailed in the HERA Work Plan (Anchor QEA and Aspect 2009b).

7.2.3.2.1 Exposure Assessment for Terrestrial Wildlife

Although wildlife can be exposed to COPCs through dermal contact with contaminated surface water or sediment and through ingestion of surface water, the primary exposure pathway for terrestrial wildlife identified in the problem formulation is through the ingestion of contaminated soil/sediment and/or biota. Two measurement endpoints were evaluated for terrestrial wildlife in the ERA (Table 7.2-4):

1. Bulk soil concentrations were compared to ecological soil screening guidelines.
2. TDI was estimated based on modeled plant, soil invertebrate, and small mammal data and incidental soil and surface water uptake.

Bulk Soil Screening

Bulk soil screening was conducted similar to the screening performed for soil invertebrates and plants, by calculating the 95 UCL soil concentrations to estimate the exposure point concentrations (Table 7.2-5).

TDI Assessment

Upper-trophic-level receptor exposures via food webs to constituents present in surface soil and sediment were determined using estimated constituent concentrations in each relevant dietary component for each receptor. Incidental ingestion of soil or sediment was included when calculating the total exposure.

Dietary intakes for each upper-trophic-level receptor were calculated using the following formula (modified from EPA [1993b]):

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

(Equation 7.2-1)

Where:

TDI_x	=	dietary intake for constituent x (mg constituent/kg body weight/day)
SUF	=	site use factor (fraction of time spent at Site)
FIR	=	food ingestion rate (kg/day, wet weight)
FC_{xi}	=	concentration of constituent x in food item i (mg/kg, wet weight)
PDF_i	=	proportion of diet composed of food item i (wet-weight basis)
WIR	=	water ingestion rate (L/day)
WCx	=	concentration of constituent x in water (mg/L)
SC_x	=	concentration of constituent x in soil/sediment (mg/kg, wet weight)

PDS	=	proportion of diet composed of soil/sediment (wet-weight basis)
BW	=	body weight (kg, wet weight)

Incidental ingestion of soil/sediment as a dietary component was modeled rather than using a separate soil/sediment ingestion rate. The exposure parameters were obtained from the literature for each receptor, using Site-specific assumptions as summarized in Table 7.2-6.

As discussed above, a conservative dilution factor of 10 was applied to sediment porewater data prior to calculating the surface water EPC. Incidental sediment ingestion rates were calculated as a specified percentage of the food ingestion rate for each receptor.

Dietary fractions (Table 7.2-7) were estimated using life history information provided in the literature (EPA 1993b), professional judgment based on Site habitat, and consideration of each feeding guild.

Prey items for terrestrial receptors evaluated in the ERA included plants, small mammals, earthworms, and other soil invertebrates. Estimation of COPC concentrations for each terrestrial prey item used the following general equation and soil bioaccumulation factors:

$$FCxi = (AFx \times CSx \times CFi) \qquad \text{(Equation 7.2-2)}$$

Where:

FCxi	=	concentration of constituent x in food item i (mg/kg, wet weight)
AFx	=	soil to food accumulation factor for constituent x (dw)
CSx	=	concentration of constituent x in soil (mg COPC/kg dry weight [dw])
CFi	=	dw/ww conversion factor for food item i (dw/wet weight [ww])

For the upper-bound threshold TDI evaluation, the 95 UCL was calculated for surface soil for estimation of prey item concentrations using EPA's ProUCL software program. An arithmetic mean was used for the lower-bound threshold TDI evaluation. Equation 7.2-2 simplifies the actual calculations for some prey items/COPC combinations. Bioaccumulation factors (BAFs) were obtained from EPA's Eco-SSLs, EPA's Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities – Volume One (EPA

1999b), the work of Baes et al. (1984), and professional judgment, and are summarized in Appendix J-9. Surrogates were selected for soil COPCs with similar chemical characteristics. As summarized in Table J-9-3, some prey item concentrations can be estimated by the linear application of an accumulation factor, but most soil-to-prey-item relationships (from Eco-SSL guidance) are not direct linear relationships with soil concentrations.

7.2.3.2.2 Effects Assessment for Terrestrial Wildlife

Results of the effects assessments for the two measurement endpoints used in evaluating terrestrial wildlife—bulk soil screening and TDI/TRV comparisons—are discussed in this section.

Bulk Soil Screening

Bulk soil concentrations were compared to EPA Eco-SSL values for avian and mammalian terrestrial receptors. The effects measures for the EPA Eco-SSLs are based on peer-reviewed literature and a formal data evaluation process. Data with which to derive the SSLs are limited; therefore, these screening values were only available for a limited number of chemicals, as indicated in Table 7.2-8.

TDI Assessment

In addition to the more generic bulk soil screening described above, a multi-media exposure model approach was also applied to compare estimated TDIs with literature TRVs. Measures of effect for both terrestrial and aquatic-dependent wildlife included comparison of TDIs with upper-bound (i.e., no observed adverse effects level [NOAEL]) and lower-bound (i.e., lowest observed adverse effects level [LOAEL]) dietary-based threshold effect concentrations for COPCs using an HQ approach. To develop threshold effect concentrations, the toxicity literature was reviewed and single-chemical toxicity data for wildlife receptors were compiled. The selection of wildlife TRVs for avian and mammalian receptors was detailed in the HERA Work Plan (Anchor QEA and Aspect 2009b). Identification of threshold effect concentrations focused on ecologically relevant effects such as survival, reproduction, and growth. All COPCs were conservatively assumed to have the same bioavailability in the field as in the laboratory toxicity study that provides the basis for the TRV in all media. Selected avian and mammalian TRVs are discussed in Section 7.2.4.4.2. Additional details

regarding TRV derivation, including TRVs from all studies reviewed, are presented in Appendix J-9.

Effects data can be characterized and summarized in a variety of ways, ranging from benchmarks designed to be protective of most species to dose-response curves for the receptor group of interest. In this assessment, measures of effect preferentially relied on dose-response curves. Toxicity studies published in the scientific literature were found in review sources or electronic databases (e.g., BIOSIS, ECOTOX, TOXNET, Science Citation Index). Review sources included the following:

- USFWS Contaminant Hazard Review series (e.g., Eisler 1988)
- ATSDR toxicological profiles for NPL sites
- Toxicological Benchmarks for Wildlife, 1996 Revision (Sample et al. 1996)

Food-web risk calculations for terrestrial wildlife species are presented in Tables 7.2-9 through 7.2-22, and the risk characterization results are summarized in Section 7.2.5.1.

7.2.4 Exposure and Effects Assessment for Aquatic-Dependent Receptors

The following sections describe the exposure and effects assessment and the risk analysis and estimation approach used for aquatic-dependent receptors: aquatic macrophytes, benthic invertebrates, fish and shellfish, and aquatic-dependent wildlife.

7.2.4.1 Aquatic Macrophytes

Aquatic macrophytes were assessed by comparing a combined dataset of measured porewater and modeled surface water data (considered to be the surface water dataset in the ERA) to EPA Region 3 BTAG screening values using an HQ approach. A conservative dilution factor of 10 was applied to the porewater data prior to inclusion with the surface water data in order to calculate surface water EPCs.

7.2.4.2 Benthic Invertebrates

Risk to the benthic invertebrate community was assessed using synoptic Site-specific bioassays and porewater sediment chemistry data as the primary and secondary lines of

evidence to determine the risk. A tertiary line of evidence was provided by comparing bulk sediment chemistry data to established sediment quality guidelines for indicator chemicals including naphthalene, 4-methylphenol, and phenol. For all bioassay samples, a 28-day survival and growth amphipod (*Hyalella azteca*) test and a 20-day survival and growth midge (*Chironomus dilutus*) test were performed according to American Standards for Testing and Materials (ASTM) and EPA guidelines (modification of EPA/600/R-99/064 [EPA 2000a] Methods 100.4, 100.5). The application of these lines of evidence was also consistent with EPA guidance on the application of PAH ESBQs (EPA 2003b and 2007a).

Four series of laboratory bulk sediment bioassays were conducted with Site and reference sediment for the purpose of evaluating impacts to the benthic invertebrate community and to support the development of Site-specific cleanup levels (Anchor QEA and Aspect 2009a). Figure 7.2-3 shows the locations where the bioassay samples were collected. Test results and statistical analyses comparing test and reference samples are presented in Section 7.2.4.2.1. Performance standards are shown in Table 7.2-23. Results are presented in Tables 7.2-24 through 7.2-26 and Figures 7.2-4 and 7.2-5, and are summarized in the sections below. The bioassays were categorized as hydrocarbon and wood debris tests, based on the type of analytical chemistry performed.

7.2.4.2.1 Sediment Toxicity Testing

This section addresses the test results and statistical analyses comparing test and reference samples. The first test series (referred to as the hydrocarbon tests) included 10 test sediment samples and three reference samples to characterize potential hydrocarbon impacts to benthos. The second test series (referred to as Wood Debris Test 1) included nine test samples and another three reference samples to evaluate the impacts to benthos from wood debris. The third test series (referred to as Wood Debris Test 2) was also run to evaluate wood debris impacts and consisted of three test samples, two reference samples, and an additional control sample of silica sand. The fourth laboratory toxicity test series was conducted with a composite of Site sediment to assess the toxicity of exposure to dredge elutriates and is referred to as the dredging elutriate test (DRET) (see the RI/FS Data Report [Anchor QEA 2010] for details). The DRET test is used to evaluate water quality impacts

during dredging; therefore, the data may be useful for evaluating alternatives in the forthcoming FS for the Quendall Site.

All tests were performed by Northwestern Aquatic Sciences (NAS), Newport, Oregon, and included an amphipod test, a midge test, and a 48-hour cladoceran (*Ceriodaphnia dubia*) survival test. Test procedures are detailed in the Quality Assurance Project Plan (QAPP) in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). The laboratory reports from NAS are provided in Attachment 4 to the RI/FS Data Report (Anchor QEA 2010).

As described in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), bioassay reference samples for the hydrocarbon and wood debris tests were selected from the area background samples (BG samples) to encompass a range of sediment grain sizes. To account for potential grain-size effects, initial statistical comparisons between the test and reference samples were paired based on the closest match of percent fine-grained (total silt and clay) material.

Because the performance of some test reference sediment samples was relatively low (i.e., reduced survival) compared to control and test samples, a further evaluation of reference samples was conducted. These additional evaluations included statistical comparisons of control and reference sample performance using analysis of variance (ANOVA) and post-hoc multiple comparisons of means including the Tukey-Kramer test and t-tests (alpha 0.05). Also considered were the performance criteria specified by the USACE RSET (2009) for freshwater bioassays in dredge material suitability determinations. Both an initial and a final reference sample evaluation were conducted and the specific outcomes are discussed below by test.

Bioassay test control and reference sample performance standards are summarized in Table 7.2-23. Results are discussed below by test series and organism. The initial evaluations were performed by NAS and included the mortality and MIW endpoints. The final evaluations were performed by Anchor QEA and included the mortality, MIW, and TRW endpoints. The NAS bioassay reports and final statistical evaluation output files are provided in the RI/FS Data Report (Anchor QEA 2010).

Hydrocarbon Tests

This subsection presents the amphipod and midge hydrocarbon test results. Survival and growth test endpoints were evaluated for statistical differences compared to reference samples and on the basis of magnitude of effect. For the purpose of determining magnitude of effect in amphipod and midge tests, all reference samples from the hydrocarbon and wood debris test series were considered to develop three levels of magnitude of effects: not toxic, moderately toxic, and toxic. First, reference and control data were evaluated statistically to determine whether any of the lower-performing reference samples were statistically lower than the control or other reference samples. The lower-performing reference samples included BG-04 and BG-06 from the hydrocarbon series for both the amphipod and midge tests, and BG-03 from the first wood debris test for midges. The magnitude levels were based on the control-adjusted survival endpoints. A magnitude level for growth endpoints was not developed because of the confounding growth effects in low survival treatments. The toxic level of magnitude was set based on the minimum value of the lower-performing reference sample group. These values were 56 percent survival for midges based on BG-03 and 63 percent survival for amphipods based on BG-04. The non-toxic threshold was based on the minimum control-adjusted survival in remaining reference samples, which was 77 percent for both amphipods and midges.

28-Day Amphipod (*Hyalella azteca*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to amphipods using a 28-day exposure. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.4 (EPA 2000a), as detailed in the QAPP in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). Eight replicate test vessels were run for each test sediment sample including reference samples and a negative control sample. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on June 19, 2009, and the test was initiated on July 2, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival (83.75 percent) and individual weight (0.56 mg/individual) (Table 7.2-24) met the performance standards of greater than or equal to 80 percent survival and greater than or equal to 0.15 mg/individual, respectively. All water quality parameters were within

acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant (positive control) 50 percent lethal concentration (LC50) was within the laboratory's control chart limits. Based on the negative and positive control sample performance, the test data were determined to be suitable for supporting management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-03, NS-07, NS-11, NS-12, NS-16, SS-04, SS-05, TD-08, TD-09, and TD-15. Reference sediment included samples from stations BG-04, BG-06, and BG-19. The negative control sediment sample was collected from an area approximately 1 mile east (upstream) of the Highway 101 bridge at Beaver Creek, approximately 8 miles south of Newport, Oregon. The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-24.

At the conclusion of this 28-day test, the mean mortality of amphipods in the negative control sediment sample was 16.25 percent and the mean mortalities in the reference samples ranged from 31.25 to 47.5 percent. The mean mortality in the test samples ranged from 20 to 100 percent. TRW was 4.30 mg in the control sample and ranged from 2.62 to 2.70 mg in the reference samples. In the test samples, TRW ranged from 0 to 4.27 mg. MIW was 0.56 mg in the control sample and ranged from 0.45 to 0.67 mg in the reference samples. MIW in the test samples ranged from 0 to 0.74 mg.

MIW was negatively correlated with percent survival ($R^2 = 0.32$), demonstrating that competition for food resources in replicates with high survival resulted in lower individual growth. TRW was positively correlated with percent survival ($R^2 = 0.21$), indicating that replicate biomass may be a more appropriate test endpoint than individual growth. For this reason, both MIW and TRW were evaluated as measurement endpoints.

Reference samples BG-04 and BG-06 had 47.5 and 41.25 percent mortality, respectively. These mortality levels were more than 10 percent greater than the recommended performance standard of greater than or equal to 30 percent. Reference sample BG-19 had 31.25 percent mortality. For the initial statistical evaluation, the 10 test samples most closely

matched BG-04 and BG-06 (Table 7.2-24); however, because of the mortality levels in BG-04 and BG-06, BG-19 was used for the final statistical evaluation.

The following final statistical outcomes for the hydrocarbon test with amphipods were determined (Table 7.2-24, Figure 7.2-4):

- Mortality in test samples TD-08 and TD-15 at 100 and 98.75 percent, respectively, was significantly higher than in reference sample BG-19 (31.25 percent). These two stations were classified as toxic to amphipods. Stations NS-11 and NS-12 had control-adjusted survival lower than the moderately toxic threshold, but were not statistically different based on mortality.
- TRW in test samples NS-11, TD-08, and TD-15 at 1.77, 0, and 0.03 mg, respectively, was significantly lower than in reference sample BG-19 (2.70 mg). Because NS-11 had significantly lower TRW than the reference sample and survival lower than the moderately toxic threshold, NS-11 was classified as moderately toxic to amphipods. NS-12 was not significantly different.
- MIW in samples TD-08 and TD-15 at 0 and 0.25 mg/individual, respectively, was significantly lower than in reference sample BG-19 (0.45 mg/individual). While TD-09 was statistically different from BG-04 in the initial comparison, this was likely due to elevated MIW in BG-04 as a result of less competition for food resources in surviving organisms. In the final evaluation, MIW in TD-09 was similar to the MIW in reference sample BG-19.

20-Day Midge (*Chironomus dilutus*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to midges using a 20-day exposure. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.5 (EPA 2000a), as detailed in the QAPP in the Data Collection Work Plan. Eight replicates plus a reference sample and a negative control sample were run for each test. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on June 19, 2009, and the test was initiated on July 3, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival

(82.5 percent) and individual weight (1.59 mg/individual) (Table 7.2-24) met the performance standards of greater than or equal to 68 percent survival and greater than or equal to 0.48 mg/individual, respectively. All water quality parameters were within acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant (positive control) LC50 was within the laboratory's control chart limits. Based on the negative and positive control sample performance, the test data were determined to be suitable for supporting management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-03, NS-07, NS-11, NS-12, NS-16, SS-04, SS-05, TD-08, TD-09, and TD-15. Reference sediment included samples from stations BG-04, BG-06, and BG-19. The negative control sediment sample was collected from Beaver Creek. The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-24.

At the conclusion of this 20-day test, the mean mortality of midges in the negative control sediment sample was 17.5 percent and the mean mortalities in the reference samples ranged from 36.25 to 47.5 percent. The mean test sample mortality ranged from 40 to 100 percent. TRW was 12.35 mg in the control sample and ranged from 6.46 to 11.24 mg in the reference samples. In the test samples, TRW ranged from 0 to 11.14 mg. MIW was 1.59 mg in the control sample and ranged from 1.02 to 2.07 mg in the reference samples. MIW in the test samples ranged from 0 to 1.86 mg.

Reference samples BG-04 and BG-06 had 43.75 and 47.5 percent mortality, respectively. These mortality levels were greater than the recommended performance standard of less than or equal to 35 percent. Reference sample BG-19 had 36.25 percent mortality. For the initial statistical evaluation, the 10 test samples most closely matched BG-04 and BG-06 (Table 7.2-24); however, because of the mortality levels in BG-04 and BG-06, BG-19 was used for the final evaluation.

The following final statistical outcomes for the hydrocarbon test with midges were determined (Table 7.2-24, Figure 7.2-5):

- Mortality in test samples NS-07, NS-11, and NS-12 at 65, 68.75, and 71.25 percent,

respectively, was significantly lower than in reference sample BG-19 (36.25 percent). TD-08 and TD-15 had complete mortality. All of the above stations were designated as toxic. NS-03, SS-05, and TD-09 had control-adjusted survival less than the moderately toxic threshold, but were not statistically different based on mortality. Because NS-03 and TD-09 had significantly lower TRW than the reference sample and survival lower than the moderately toxic threshold, these samples were classified as moderately toxic to midges.

- TRW in samples NS-03, NS-07, NS-11, NS-12, TD-08, TD-09, and TD-15 at 5.87, 5.10, 3.13, 3.75, 0, 4.13, and 0 mg, respectively, was significantly lower than in reference sample BG-19 (11.24 mg).
- MIW in samples NS-03, NS-07, NS-11, NS-12, TD-08, TD-09, and TD-15, at 0.95, 1.12, 0.47, 1.13, 0, 0.86, and 0 mg/individual, respectively, was significantly lower than in reference sample BG-19 (1.77 mg/individual). While NS-16 was statistically different from BG-19 in the initial comparison, this was likely due to elevated MIW in BG-19 as a result of less competition for food resources in surviving organisms. In the final evaluation, MIW in NS-16 was similar to MIW in the reference sample BG-19.

Wood Debris Tests

Two test series were conducted to characterize sediment toxicity in areas where sediment includes wood debris. A second wood debris test was conducted following the results of the first, in order to further refine the characterization for wood debris at the Site and also to evaluate questions about the quality of the results from the first test series. The results of the two test series are discussed in the following subsections.

Wood Debris Test 1

28-Day Amphipod (*Hyalella azteca*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to amphipods using a 28-day exposure. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.4 (EPA 2000a), as detailed in the QAPP in the Data Collection Work Plan (Anchor QEA and Aspect, 2009a). Eight replicates plus a reference sample and a

negative control sample were run for each test. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on June 19, 2009, and the test was initiated on July 17, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival (97.5 percent) and individual weight (0.41 mg/individual) (Table 7.2-25) met the performance standards of greater than or equal to 80 percent survival and greater than or equal to 0.15 mg/individual, respectively. All water quality parameters were within acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant was within the laboratory's control chart limits. Based on the negative and positive control sample performance, the test data were determined to be suitable for making management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-06, NS-07, SS-01, SS-02, WD-03, WD-06, WD-07, WD-08, and WD-09 (Figure 7.2-4). Reference sediment included samples from stations BG-02, BG-03, and BG-13. The negative control sediment sample was collected at the same time and location (Beaver Creek) as for the hydrocarbon test series. The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-25.

At the conclusion of this 28-day test, the mean mortality of amphipods in the negative control sediment sample was 2.5 percent and the mean mortalities in the reference samples ranged from 1.25 to 25 percent. The mean test sample mortality ranged from 0 to 10 percent. TRW was 3.99 mg in the control sample and ranged from 2.56 to 4.27 mg in the reference samples. In the test samples, TRW ranged from 3.69 to 4.66 mg. MIW was 0.41 mg in the control sample and ranged from 0.28 to 0.43 mg in the reference samples. MIW in the test samples ranged from 0.38 to 0.48 mg.

Ammonia toxicity tests were performed and compared to ammonia values in sediment porewater to evaluate potential test sediment toxicity due to ammonia exposure in wood debris bioassays. The ammonia reference toxicity test was conducted with ammonium chloride (NH_4Cl). The 96-hour LC50 was 59 milligrams per liter (mg/L) total ammonia-N.

Ammonia in sediment porewater was measured on days 2, 4, 10, and 28. The maximum porewater ammonia result was 7.4 mg/L, which was well below the LC50 value. Based on this evaluation, ammonia exposure was not a confounding factor for amphipods in wood debris bioassays.

All the reference samples met the recommended performance standard of greater than or equal to 60 percent survival. Test samples were matched at the laboratory according to the closest matching grain size. No test stations were statistically different from their paired reference stations for this test.

20-Day Midge (*Chironomus dilutus*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to midges using a 20-day exposure. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.5 (EPA 2000a), as detailed in the QAPP in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). Eight replicates plus a reference sample and a negative control sample were run for each test. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on June 19, 2009, and the test was initiated on July 17, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival (90 percent) and individual weight (2.36 mg/individual) (Table 7-2-25) met the performance standards of greater than or equal to 68 percent survival and greater than or equal to 0.48 mg/individual, respectively. All water quality parameters were within acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant (positive control) LC50 was within the laboratory's control chart limits. Based on the negative and positive control sample performance, the test data were determined to be suitable for making management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-06, NS-07, SS-01, SS-02, WD-03, WD-06, WD-07, WD-08, and WD-09 (Figure 7.2-5). Reference sediment included samples from stations BG-02, BG-03, and BG-13. The negative control sediment sample was collected at the same time

and location (Beaver Creek) as for the hydrocarbon test series. The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-25.

At the conclusion of this 20-day test, the mean mortality of midges in the negative control sediment sample was 10 percent and the mean mortalities in the reference samples ranged from 18.75 to 50 percent. The mean test sample mortality ranged from 17.5 to 50 percent. TRW was 15.0 mg in the control sample and ranged from 8.03 to 12.74 mg in the reference samples. In the test samples, TRW ranged from 7.71 to 14.90 mg. MIW was 2.36 mg in the control sample and ranged from 1.64 to 2.56 mg in the reference samples. MIW in the test samples ranged from 1.44 to 1.86 mg.

Ammonia toxicity tests were performed and compared to ammonia values in sediment porewater to evaluate potential test sediment toxicity due to ammonia exposure in wood debris bioassays. The ammonia reference toxicity test was conducted using ammonium chloride (NH_4Cl). The 96-hour LC50 was 63 mg/L total ammonia-N. Ammonia in sediment porewater was measured on days 2, 4, 10, and 28. The maximum porewater ammonia result was less than 8 mg/L, which was well below the LC50 value. Based on this evaluation, ammonia exposure was not a confounding factor for midge in wood debris bioassays.

Reference sample BG-03 had 50 percent mortality, which was greater than the recommended control performance standard of 35 percent. For the initial statistical evaluation, the nine test samples were matched with the sample most similar in terms of percent fines; however, because of the mortality level in BG-03, only samples BG-02 and BG-13 were used for the final evaluation.

The following final statistical outcomes for the first wood debris test with midges were determined (Table 7.2-25, Figure 7.2-5):

- Mortality in sample NS-07, at 50 percent, was significantly higher than in reference sample BG-13 (25 percent). As in the hydrocarbon test, this sample was classified as toxic.
- TRW in sample NS-07, at 7.71 mg, was significantly lower than in reference sample BG-13 (11.71 mg).
- MIW at all stations was not significantly different from matching reference samples.

While stations SS-01, WD-03, WD-06, and WD-07 were statistically different from BG-03 in the initial comparison, this was likely due to elevated MIW in BG-03 as a result of less competition for food resources in surviving organisms. In the final evaluation, no station's MIW was different than in reference samples.

Wood Debris Test 2

The second wood debris test series provided supplemental characterization for three Site stations (NS-01, NS-02, and WD-01) and two reference samples (BG-12 and BG-13) using bioassays and chemical analyses. The three Site stations are located in the main Wood Debris Area and were not tested previously. Figures 7.2-4 and 7.2-5 show the locations of these stations. In addition to refining the wood debris characterization for the Site, this test series was also used to evaluate questions about the quality of results from the previous test series (i.e., Wood Debris Test 1).

EPA raised concerns about the variability and performance of the hydrocarbon and first-round wood debris bioassays and suggested that a potential reason is that the NAS laboratory freshwater supply, which is carbon-filtered City of Newport municipal tap water, may be deficient in chloride. EPA's working premise was that chloride-deficient overlying water used for amphipod and midge exposures may have resulted in reduced test performance and greater variability in survival and growth endpoints due to organism stress from insufficient concentrations of chloride, an essential nutrient. NAS uses sand collected from Beaver Creek for negative control samples for freshwater tests. Because each Beaver Creek control sample is collected from an area of minor tidal influence, the potential saltwater intrusion may have provided sufficient chloride in the control samples while the test samples from an entirely freshwater environment, such as Lake Washington, would not have this additional chloride source. To ensure that overall test quality was adequate, a clean silica-sand control sample using medium-fine sand (ASTM #40) was run along with the Beaver Creek control sample. The purpose of this additional control sample was to document that control acceptability standards could be met in a silica-sand control sample; this is particularly the case for the amphipods, which were expected to be more sensitive to potential chloride ion deficiency than midges based on observations that amphipods are sensitive to low hardness and because of the longer exposure duration—28 days for amphipods versus 20 days for midges (EPA 2000a).

The results of the test showed no difference between the Beaver Creek and silica sand control samples for amphipods at 3.8 and 5 percent mortality, respectively. For midges, the mortality in the Beaver Creek control sample (3.8 percent) was significantly lower than in the silica sand control sample (67.5 percent); however, the reason is grain-size effects on the first instar larvae, which were unable to build tubes in the silica sand substrate. Overall, the results indicated no dilution water impacts.

28-Day Amphipod (*Hyalella azteca*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to amphipods using a 28-day exposure for samples in the Wood Debris Area that were not previously tested. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.4 (EPA 2000a), in accordance with the QAPP in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). Eight replicates plus a reference sample and a negative control sample were run for each test. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on December 2, 2009, and the test was initiated on December 15, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival (96.2 percent) and individual weight (0.63 mg/individual) met the performance standards of greater than or equal to 80 percent survival and greater than or equal to 0.15 mg/individual, respectively. All water quality parameters were within acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant was within the laboratory's control chart limits. Based on the negative and positive control sample performance, the test data were determined to be suitable for making management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-01, NS-02, and WD-01 (Figure 7.2-4). Reference sediment included samples from stations BG-12 and BG-13. The negative control sediment sample was collected on November 24, 2009, at the same location (Beaver Creek) as for the hydrocarbon test series and Wood Debris Test 1. The positive control sample consisted of

clean, medium-fine silica sand (ASTM #40). The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-26.

At the conclusion of this 28-day test, the mean mortality of amphipods in the negative control sediment sample was 3.8 percent and the mean mortalities in the reference samples ranged from 8.8 to 10 percent. The mean test sample mortality ranged from 2.5 to 3.8 percent. TRW was 6.00 mg in the control sample and ranged from 3.92 to 4.22 mg in the reference samples. In the test samples, TRW ranged from 4.14 to 6.03 mg. MIW was 0.63 mg in the control sample and ranged from 0.45 to 0.46 mg in the reference samples. MIW in the test samples ranged from 0.43 to 0.63 mg.

All the reference samples met the control performance standard of less than or equal to 30 percent mortality, and the test samples were matched according to the closest matching grain size. No test stations were statistically different from their paired reference stations for this test.

20-Day Midge (*Chironomus dilutus*) Survival and Growth Test

The purpose of this test was to characterize chronic sediment toxicity to midges using a 20-day exposure for samples in the Wood Debris Area that were not previously tested. Test protocols were based on ASTM Method E1706-00 (ASTM 2002) and modified EPA Method 100.5 (EPA 2000a), as detailed in the QAPP in the Data Collection Work Plan (Anchor QEA and Aspect 2009a). Eight replicates plus a reference sample and a negative control sample were run for each test. The measurement endpoints for each replicate were survival and organism weight.

Test samples were received on December 2, 2009, and the test was initiated on December 15, 2009, which was within the specified maximum 56-day holding time. Samples were collected and stored in accordance with the QAPP. The negative control sample average 28-day survival (96.2 percent) and individual weight (1.86 mg/individual) exceeded the performance standards of greater than 68 percent survival and greater than 0.48 mg/individual, respectively. All water quality parameters were within acceptable limits. The reference toxicant test was conducted using potassium chloride. The reference toxicant (positive control) LC50 was within the laboratory's control chart limits. Based on the

negative and positive control sample performance, the test data were determined to be suitable for making management decisions.

The test and reference sediment samples were collected from the surface interval (0 to 4 inches). Test stations included NS-01, NS-02, and WD-01 (Figure 7.2-5). Reference sediment included samples from stations BG-12 and BG-13. The negative control sediment sample was collected on November 24, 2009, at the same location (Beaver Creek) as for the hydrocarbon test series and Wood Debris Test 1. The means and standard errors of percent mortality, TRW, and MIW are listed by sample in Table 7.2-26.

At the conclusion of this 20-day test, the mean mortality of midges in the negative control sediment sample was 3.8 percent and the mean mortalities in the reference samples ranged from 23.8 to 25 percent (Table 7.2-26). The mean test sample mortality ranged from 8.8 to 21.3 percent. TRW was 28.5 mg in the control sample and ranged from 15.07 to 16.88 mg in the reference samples. In the test samples, TRW ranged from 16.03 to 19.05 mg. MIW was 1.86 mg in the control sample and ranged from 1.62 to 1.64 mg in the reference samples. MIW in the test samples ranged from 1.42 to 1.76 mg.

All the reference samples met the control performance standard of less than or equal to 30 percent mortality, and the test samples were matched according to the closest matching grain size. No test stations were statistically different from their paired reference stations for this test.

7.2.4.2.2 Hazardous Substances

As detailed in the Data Collection Work Plan (Anchor QEA and Aspect 2009a), limitations in the PRGs and other interpretative criteria for addressing risk to benthos from petroleum hydrocarbons warranted collection of additional bioassay and analytical chemistry data. These data were used to support the application of EPA's PAH ESB approach (EPA 2003b and 2007a) and to evaluate other effects from hydrocarbons, such as physical oiling. In addition, TPH measurements (i.e., TPH-diesel and TPH-oil) were included to investigate the potential for physical effects of oil (Mount et al. 2009). Together, the synoptic bioassays and

PAH ESBQ and TPH measurements are consistent with the best available science for assessing hydrocarbon impacts to benthos, as detailed in the following:

- Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures (EPA 2003b)
- Evaluating Ecological Risk to Invertebrate Receptors from PAHs in Sediment at Hazardous Waste Sites (EPA 2007a)
- Are PAHs the Right Metric for Assessing Toxicity Related to Oils, Tars, Creosote, and Similar Contaminants in Sediments? (Mount et al. 2009)

Bulk sediment PAH ESBQs are based on the use of conservative equilibrium partitioning coefficients to account for the bioavailability of chemicals in sediment porewater. Because of the uncertainty associated with bulk-sediment-based estimates in predicting PAH toxicity, direct measurements of PAHs in sediment porewater provide a more robust and accurate tool with which to implement the polar narcosis toxicity model. As described below, direct sediment porewater measurements were collected using the SPME porewater measurement method and applied for this RI in general and for the baseline risk assessment in particular. The SPME porewater measurement method is detailed in the Data Collection Work Plan (Anchor QEA and Aspect 2009a).

The PAH ESBQ calculation is the sum of the quotients of the concentrations of each of the 34 individual PAHs and PAH homologues in bulk sediment or porewater divided by the respective FCV for each individual PAH. If all 34 PAHs and PAH homologues are not measured, the ESBQ calculation applies an uncertainty factor to the sample. Consistent with EPA guidance, the available historical bulk sediment dataset was assigned an uncertainty factor of 11.5 to account for potential underestimates in the dataset if only 13 of the 34 PAHs were analyzed (EPA 2003b).

To illustrate the relationships between bioassay endpoints and chemical measurements, "scatterplot" figures were prepared showing the amphipod and midge survival and growth endpoints (MIW and TRW) versus PAH ESBQs in surface bulk sediment and sediment porewater, total PAH concentrations, and total TPH concentrations (see Figures 7.2-6 and 7.2-7, each of which contains separate sets of scatterplots for survival, MIW, and TRW). A summary of regression coefficients for the above comparisons is provided in Table 7.2-27.

7.2.4.2.3 Wood Debris

In the Data Collection Work Plan (Anchor QEA and Aspect 2009a), a decision framework for the evaluation of wood debris was presented (Figure 7.2-8). Two test series were conducted, as described in Section 7.2.4.2.1. For Wood Debris Test 1, nine Site sediment wood debris samples and three reference samples were submitted for bioassay analyses. For Wood Debris Test 2, three Site samples and two reference samples were tested along with an additional silica sand control sample (see Section 7.2.4.2.1 for details).

7.2.4.3 Fish and Shellfish

Three types of toxicity data were used to evaluate risk to fish and shellfish: surface water benchmarks, estimated tissue body burdens, and estimated dietary intake. First, 95 UCL concentrations in the modeled surface water dataset were screened against appropriate benchmarks including aquatic life chronic water quality criteria, the FCVs recommended for use in the ESB PAH model (EPA 2003b), and EPA Region 3 ESLs for surface water. Second, tissue body burdens were estimated using BSAFs and compared to tissue TRVs. Third, for piscivorous and omnivorous fish and where dietary concentration TRV data were available for COPCs, BSAF-estimated COPCs for prey shellfish, crustaceans, and fish were evaluated. The following exposure and effects measures for each feeding guild were evaluated in the ERA.

7.2.4.3.1 Surface Water Toxicity Screening

95 UCL concentrations in the modeled surface water dataset were compared to screening benchmarks using an HQ approach to evaluate all fish (Table 7.2-28). The benthivore guild includes benthivorous fish and crayfish. As the sensitivities of sediment-dwelling organisms to COPCs has been shown to be similar to those of water column species (i.e., fish; Di Toro et al. 1991), it is not unreasonable to conclude that COPCs at levels that adversely affect the survival, growth, and reproduction of benthic invertebrates would have similar effects on the benthic fish community exposed to contaminated sediment. For this reason, Site-specific porewater calculations of PAH ESBQs were also used for evaluating risk to benthivorous fish. This evaluation was also used to evaluate aquatic macrophytes as discussed in Section 7.2.4.1, and the results are also shown in Table 7.2-28.

7.2.4.3.2 Tissue Residue Evaluation

Both a tissue residue and a dietary approach were used in the ERA to assess potential risks to benthivorous fish and shellfish, omnivorous fish (salmon fry), and piscivorous fish (yellow perch). Tissue-residue TRVs were available for a limited number of bioaccumulative COPCs. Tissue- and diet-based TRVs are listed in Table 7.2-29. Summaries of the sediment and fish/shellfish tissue EPCs selected for use in modeling tissue exposure to ecological receptors and prey items are presented in Tables 7.2-30 and 7.2-31. Details of the BSAF derivation are provided in Appendix J-5. PAHs are the only sediment COPCs identified as bioaccumulatives that have BSAFs in the identified database sources. However, fish readily metabolize PAHs, and tissue-residue TRVs have not been derived; therefore, risk to fish using tissue measurements cannot be readily determined. Uncertainty associated with tissue residue evaluation is discussed in Section 7.2.6.

7.2.4.3.3 Dietary Evaluation

Contaminant concentrations in the diet of fish/shellfish receptors were estimated using Site-wide sediment data and BSAFs as one of the lines of evidence to evaluate Site risk to piscivorous, omnivorous, and benthivorous fish and crayfish. Sediment COPC concentrations in prey items and dietary fraction assumptions are presented in Table 7.2-32. Total concentrations in diet (in mg/kg dw) were compared to dietary-based TRVs for each fish receptor.

7.2.4.4 Aquatic-Dependent Wildlife

Aquatic-dependent wildlife was evaluated by the TDI/TRV measure of exposure and effects, similar to the approach for terrestrial wildlife detailed in Section 7.2.3.2. The TDI equation applied to estimate exposure to aquatic-dependent wildlife (Equation 7.2-1) is identical to the one used for terrestrial receptors. The accumulation factor for the aquatic-dependent receptor evaluation is a BSAF, the derivation of which is detailed in Appendix J-5.

7.2.4.4.1 Exposure Assessment for Aquatic-Dependent Wildlife

Concentrations in prey items were calculated using the Site sediment dataset, while direct exposure to sediment was assessed using both the nearshore sediment dataset (for the otter) and the avifauna sediment dataset (for aquatic-dependent birds), as detailed in Table 7.2-1 for each receptor. The sample locations from which sediment data were collected are shown on Figures 7.1-3 and 7.1-4.

7.2.4.4.2 Effects Assessment for Aquatic-Dependent Wildlife

As described in Section 7.2.3, measures of effect for both terrestrial and aquatic-dependent wildlife included comparison of TDIs with upper- and lower-bound dietary-based threshold effect concentrations. The development of threshold effect concentrations and the selection of wildlife TRVs for avian and mammalian receptors were described in the HERA Work Plan (Anchor QEA and Aspect 2009b). Selected avian and mammalian TRVs are summarized in Tables 7.2-33 and 7.2-34, respectively. Additional details regarding TRV derivation, including all studies reviewed, are presented in Appendix J-9.

7.2.5 Risk Characterization

The following sections describe the risk characterization for terrestrial and aquatic-dependent ecological receptors. The lines of evidence described in Section 7.2.1.6.1 were applied as part of the weight-of-evidence approach for assessing risk. As noted where applicable, some of the lines of evidence had greater usefulness or were based on higher-quality data derived from established methods. Thus, the best line of evidence is identified for a given receptor guild.

7.2.5.1 Terrestrial Receptors

As described in Section 7.2.1.1.1, the Quendall Site provides moderate to low-quality habitat supporting species typically found in an urban area in western Washington. Previous screening-level ERAs (Anchor and Aspect 2004) documented that risk to humans and ecological receptors was likely across the Site uplands. In addition, prospective future developments, like those on the adjacent properties, will likely include capping (Section 3.3). Under the assumption that the uplands would be capped, the HERA Work Plan (Anchor

QEA and Aspect 2009b) established a focused approach for documenting risk to terrestrial receptors. Terrestrial receptors evaluated in this baseline ERA included soil invertebrates, plants, and birds and mammals representing carnivores, herbivores, omnivores, insectivores, and predators. The risk characterizations for these receptors using the lines of evidence discussed previously are described in the following sections.

7.2.5.1.1 Soil Invertebrates and Terrestrial Plants

The sole line of evidence for evaluating risk to soil invertebrates and terrestrial plants was the comparison of Site EPCs with Eco-SSLs. As noted above, the Eco-SSLs are derived using a rigorous QA process and represent the best available science for such screening values. As such, Eco-SSLs for soil only include values for: 1) arsenic, lead, and PCP for plants; and 2) lead, PCP, LPAHs, and HPAHs for invertebrates. The results of the soil invertebrate and terrestrial plant soil screening assessment are presented in Table 7.2-5. For the soil COPCs with plant and/or invertebrate Eco-SSLs, the 95 UCLs for lead, HPAHs, and LPAHs exceeded Eco-SSLs. Invertebrate Eco-SSLs were exceeded for HPAHs (HQ of 226) and LPAHs (HQ of 47), and plant Eco-SSLs were exceeded for lead (HQ of 5). The samples with the highest concentrations of lead, HPAHs, and LPAHs were collected on the Railroad property.

7.2.5.1.2 Terrestrial Wildlife

The lines of evidence for evaluating risk to terrestrial birds and mammals included: 1) the comparison of Site EPCs with Eco-SSLs for birds and mammals and 2) comparison of modeled TDI to TRVs, as discussed in the following subsections.

Bulk Soil Screening Approach

The results of the terrestrial wildlife bulk soil screening assessment are presented in Table 7.2-8. Available Soil Eco-SSLs include arsenic, chromium, lead, and PCP for birds and mammals; and LPAHs and HPAHs for mammals only. For the soil COPCs with avian and/or mammalian Eco-SSLs, the 95 UCLs for chromium (as chromium III), lead, PCP, HPAHs, and LPAHs exceeded Eco-SSLs. Avian Eco-SSLs were exceeded for chromium (HQ of 2.2), lead (HQ of 58), and PCP (HQ of 34 based on non-detect). For mammals, Eco-SSLs were exceeded for chromium (HQ of 1.7), lead (HQ of 11.4), PCP (HQ of 25.4 based on non-detect), HPAHs (HQ of 3,692), and LPAHs (HQ of 14).

The low-level chromium HQ exceedances were conservatively based on QA1 quality data because no QA2 quality data are available in the risk dataset. The PCP data for soil included 38 samples with no detections; therefore, PCP is not considered a risk driver. For the samples in which chromium exceeded the Eco-SSL (from locations BH-28 and HC-3), HPAHs were also elevated above the Eco-SSL. The majority of risk posed by HPAHs and LPAHs is associated with two soil samples from the Railroad property dataset (Q1A-1 and Q1B-1).

Although the soil screening line of evidence for terrestrial birds and mammals is limited because of its generic nature and limited dataset, the risk attributed to PAHs is consistent with the Site CSM. Because the more robust line of evidence provided under the TDI approach also captures the risk attributed to terrestrial birds and mammals from soil exposure, the TDI approach is the best line of evidence for terrestrial wildlife.

TDI Approach

The results of the TDI assessment for terrestrial wildlife are presented in Tables 7.2-9 through 7.2-22, and the terrestrial wildlife TDI HQ results are summarized in Table 7.2-35. Benzo(a)pyrene, chromium, lead, PCP, HPAHs, and, LPAHs had NOAEL HQs greater than 1 for at least one terrestrial receptor. NOAEL HQs for benzo(a)pyrene and total HPAHs, total LPAHs, PCP, and lead exceeded 1 for the majority of terrestrial receptors, primarily due to ingestion of soil and ingestion of earthworms and/or other soil invertebrates. HPAHs were the primary risk driver chemicals. The terrestrial receptors with the highest NOAEL HQs for HPAHs were the raccoon (HQ of 1,101) and the shrew (HQ of 1,084).

Benzo(a)pyrene, lead, and HPAHs had LOAEL HQs greater than 1 for at least one terrestrial receptor. LOAEL HQs for HPAHs exceeded 1 for the majority of terrestrial receptors. The potential risk from surface water exposure is minimal. The majority of soil-related risk is associated with two soil samples from the Railroad property dataset (Q1A-1 and Q1B-1).

Potential risks (NOAEL HQs) are summarized in Table 7.2-35 for the receptors selected for this ERA. As anticipated, this baseline ERA indicates that upland soil poses an unacceptable risk to terrestrial ecological receptors. The primary risk drivers are PAHs. HQs for chromium

and total PCBs in soil were based on QA1- quality data, and conclusions are therefore uncertain. PCP exposure was based on non-detect data and, although HQs exceeded 1, PCP is not considered to pose a risk to terrestrial receptors.

7.2.5.2 Aquatic-Dependent Receptors

Aquatic-dependent receptors evaluated in the ERA included aquatic macrophytes, benthic invertebrates, fish and shellfish, and birds and mammals including piscivorous raptors and shorebirds, diving and dabbling ducks, and sediment-probing birds. As described in Section 7.2.1.1.2, the aquatic portion of the Site provides a diverse range habitat ranging from shallow nearshore areas with dense Eurasian watermilfoil beds to deeper profundal zone sediment. Because of the complex nature of the aquatic portions of the Site, the HERA Work Plan (Anchor QEA and Aspect 2009b) established a detailed approach for documenting risk to aquatic-dependent receptors using multiple lines of evidence.

7.2.5.2.1 Aquatic Macrophytes

The results of the aquatic macrophyte screening were identical to those of the fish and shellfish surface water screening presented in Section 7.2.4.3.1 and Table 7.2-28. Surface water data were represented both by Site surface water data and surface sediment porewater data. For all but the PAH ESBQ calculations, sediment porewater concentrations were diluted by a factor of 10 and combined with Site surface water data.

Although the screening-level line of evidence for aquatic macrophytes is limited due to its generic nature, the risk attributed to benzo(a)pyrene, benzo(a)anthracene, and anthracene is consistent with the Site CSM and coal-tar-related sources to sediment. Because the benthic invertebrate sediment assessment endpoints address mudline-scale risk using more robust lines of evidence, including comparing SPME porewater measurements to FCVs developed for PAHs using the polar narcosis toxicity model, the overall risk to aquatic macrophytes can be addressed using the PAH ESB model (EPA 2003b).

7.2.5.2.2 Benthic Invertebrates

Risk to benthic invertebrates was characterized primarily using Site-specific bioassay results along with corroborative sediment porewater chemistry and, to a lesser degree, bulk

sediment chemistry. As described in Section 7.2.4.2, two bioassay test series were conducted (consisting of hydrocarbon and wood debris tests). The results of the bioassays are presented in combination with porewater sediment chemistry to aid in the risk characterization. Figures 7.2-6 and 7.2-7 contain scatterplots showing the correlation between various bioassay endpoints and hydrocarbon measures (PAH ESBQs [expressed in TUs] in surface bulk sediment and sediment porewater, total PAH concentrations, and total TPH concentrations). Final combined bioassay results and surface sediment porewater results for naphthalene are depicted on Figure 7.2-9. Bioassay results and sediment porewater PAH ESBQ results are depicted on Figures 7.2-10 and 7.2-11 (for U=1/2 and U=0, respectively). Exceedances of PRG screening levels and the approximate extents of those exceedances, previously shown on figures supporting Section 5, are also shown on Figures 7.2-9 through 7.2-11. Bioassay results and Wood Debris Area sampling results for TOC, TVS, and percent wood by volume are depicted on Figure 7.2-12.[38] The bioassay results are described below and summarized in Tables 7.2-24 through 7.2-26.

In the hydrocarbon test series, amphipod and midge survival and growth were strongly associated with PAH ESBQs in surface sediment porewater and with bulk sediment PAH ESBQs, total PAH concentrations, and total TPH concentrations (Figures 7.2-6 and 7.2-7). Risk to benthos was evaluated using the most sensitive endpoint from both tests across the survival and growth endpoints. Although midge survival and growth endpoints were more sensitive in statistical comparisons to reference samples, amphipod survival and growth endpoints had higher regression correlation coefficients than those for midges. Amphipods typically burrow a few millimeters into the surface of the sediment to provide cover. Midges are tube builders and may have a greater porewater exposure at depths up to a few centimeters below the mudline. PAH ESBQs for porewater had somewhat stronger association to test endpoints than the bulk sediment PAH ESBQs, but the differences are not significant. Generally, bulk sediment total PAH and total TPH measurements had stronger association with bioassay endpoints than porewater or bulk sediment PAH ESBQs. Overall, the use of the sediment porewater PAH ESBQ endpoint provides greater usefulness than bulk sediment chemistry as a line of evidence, given that: 1) the SPME analysis method provides

[38] These results are discussed in Section 5.4.3.

the most direct measure of exposure to bioavailable PAHs and 2) the polar narcosis toxicity model is a well-developed exposure-response relationship.

As discussed above, the midge was the most sensitive bioassay test organism and all stations with significant reductions in amphipod survival or growth were also significantly reduced for midges. The most significant reductions in growth and survival for both test species occurred at T-Dock locations TD-08 and TD-15, with nearly complete mortality for both test species at these two locations. As indicated on Figure 7.2-9, naphthalene concentrations in surface sediment porewater exceed the EPA Region 3 BTAG surface water screening level of 1.1 µg/L at stations TD-08 (9.9 µg/L) and TD-15 (1.9 µg/L). Figures 7.2-10 and 7.2-11 show that sediment porewater ESBQ TUs (both U=1/2 and U=0) for stations TD-08 and TD-15 were 42 and 70, respectively. Other stations with reductions in survival and growth that were classified as toxic to midges were TD-09, NS-03, NS-07, NS-11, and NS-12. Surface sediment porewater naphthalene concentrations were less than the BTAG screening level of 1.1 µg/L at these stations; however the uppermost vibracore sample collected at NS-12 slightly exceeded the screening level, with a naphthalene concentration of 1.2 µg/L. Sediment porewater ESBQ TUs (U=0) for these stations were all less than 1. The other hydrocarbon stations—SS-04, SS-05, and NS-16—were non-toxic and had naphthalene concentrations less than the BTAG screening level and porewater ESBQ TUs less than 1.

Stations NS-3, NS-7, NS-11, and NS-12 are located within the nearshore groundwater discharge area (Section 5.4; Figure 5.4-1). While surface sediment porewater PAH ESBQ TUs were generally less than 1 for these stations (Figures 5.4-15 through 5.4-18), subsurface sediment porewater PAH ESBQ TUs in the 1-to-2-foot interval were elevated. Based on the surface and subsurface chemistry, as well as the midge test performance, the weight of evidence indicates that these nearshore stations pose a risk to benthos.

Based on the Site-specific correlation between toxicity and TUs in porewater, a TU of 1 was retained as the threshold for predicting the toxicity of PAHs at the Site, consistent with EPA's PAH ESB guidance (EPA 2003b). Locations not tested with bioassays but with sediment porewater PAH ESBQ TUs greater than 1 included the areas depicted on Figures 7.2-10 and 7.2-11. While most TUs inside the T-Dock main span did not exceed 4, station

TD-14 had a porewater TU of 7.7 (U=0). The approximate extent of Site sediment that poses a PAH-related risk to benthic invertebrates is depicted on Figures 7.2-10 and 7.2-11.

Potential risk to benthic invertebrates from wood debris was evaluated with sediment and porewater chemistry measurements and bioassays. Bioassay growth and survival in all Site surface sediment samples collected within the Wood Debris Area (defined as samples with greater than 9.8 percent TOC or 50 percent wood by volume) were not significantly different from those in appropriately matched reference samples (Tables 7.2-25 and 7.2-26 and Figure 7.2-12). Further, bulk sediment concentrations were all below the sediment screening values for the wood-debris-associated chemicals 4-methylphenol and phenol. Thus, there is no identified wood-debris-related risk to Site benthic invertebrates. Potential habitat improvements in this Wood Debris Area are being considered outside the CERCLA cleanup process.

7.2.5.2.3 Fish and Shellfish

Risk to fish and shellfish was addressed using screening-level comparisons (i.e., a dietary evaluation). As noted above, because PAHs are readily metabolized by fish, the tissue residue line of evidence was not carried forward to the risk characterization. Surface water screening HQs for PAHs (HQ of 53 for benzo(a)pyrene) and PAH ESBQs (HQ of 15) (Table 7.2-28) exceeded 1, which is consistent with the evaluation of benthos described above. For the dietary line of evidence, NOAEL and LOAEL HQs for all sediment bioaccumulative COPCs were below 1 for the piscivorous fish. The HPAH NOAEL HQs for omnivorous and benthivorous fish were just above 1 (Table 7.2-32), but the LOAEL HQs did not exceed 1. Therefore, potential risk to omnivorous and benthivorous fish and shellfish via the dietary screening evaluation (Section 7.2.4.3) is low. Overall, the fish and shellfish lines of evidence are consistent with those used to characterize risk to benthos.

7.2.5.2.4 Aquatic-Dependent Wildlife

The sole line of evidence for evaluating risk to aquatic-dependent birds and mammals was the comparison of modeled TDIs to TRVs. Detailed risk calculation results from the TDI assessment for aquatic-dependent wildlife are presented by individual species in Tables 7.2.36 through 7.2-47 and summarized in Table 7.2-48. NOAEL HQs for benzo(a)pyrene,

chromium, HPAHs, LPAHs, and total PAHs exceeded 1 for at least one receptor, with the largest HQs estimated for the spotted sandpiper and the river otter. The total PAH NOAEL HQ for the sandpiper (consuming sediment, crustaceans, mollusks, and surface water) was 10, while the corresponding LOAEL was less than 1. The total PAH NOAEL HQ for the river otter (consuming sediment, demersal fish, pelagic fish, crustaceans, mollusks, and surface water) was 9, while the corresponding LOAEL was less than 1. No dibenzofuran data are available in the dataset used for assessing direct exposure to aquatic-dependent wildlife.

The NOAEL HQs for the bald eagle (representing rare, threatened, and endangered receptors) were all less than 1. Because the NOAEL HQs for the eagle and the LOAEL HQs (excluding totals for all chemicals) for all aquatic-dependent wildlife receptors were less than 1, it is concluded that contaminant concentrations in sediment at the Quendall Site do not pose a significant risk to this group of receptors.

7.2.5.3 Overview of Risk Estimates

A summary of the hazard estimates for ecological receptors is provided in Table 7.2-49. HQs are shown for bulk soil screening results, for TDI results based on NOAEL TRVs (for the terrestrial and aquatic-dependent bird and mammal species with the maximum HQs), surface water screening results, and fish diet HQs. The results for each group of receptors are summarized by line of evidence in Table 7.2.50. In general, the results are as follows:

- Ecological Site risk for terrestrial and aquatic-dependent wildlife receptors exceeded an HQ of 1. The primary risk drivers to ecological receptors throughout the Site are PAHs.
- Site sediment that poses a PAH-related risk to benthic macroinvertebrates was associated with hydrocarbon releases (delineated in the T-Dock Area and nearshore Site areas adjacent to Quendall Pond).
- Benthic toxicity measured in sediment bioassays correlated closely with porewater PAH concentrations, consistent with EPA's current PAH toxicity model.

7.2.6 Uncertainties Associated with this Baseline ERA

The uncertainty analysis is an important step in the risk assessment process (EPA 1998). Table 7.2-51 includes the uncertainty analysis completed for this ERA.

Sources of uncertainty in an ERA can be generally classified in the following four categories:

- Measurement errors – associated with the measurement of physical, chemical, and/or biological parameters.
- Extrapolation errors – associated with the extrapolation that is necessary to characterize or describe a parameter or an effect when collection of specific data is not achievable.
- Modeling errors – associated with how well a model approximates true relationships between Site-specific environmental conditions.
- Data gaps – resulting from a lack of information that could conceivably be addressed through additional measurement, extrapolation, or modeling of conditions.

Uncertainty in EPCs, wildlife exposure factors, dietary fractions, uptake factors, BSAFs, and TRVs all contribute to the overall uncertainty associated with this ERA. For the assumptions where alternate values are possible (e.g., ingestion rates and TRVs), these values were selected to be consistent with EPA guidance and other ERAs conducted in EPA Region 10.

Table 7.2-51 includes major categories for uncertainties associated with the ERA dataset and COPC screening and those associated with the exposure and effects assessments. For each parameter that introduces uncertainty (e.g., the inclusion of COPCs based on non-detect data), the table presents the following:

- The level of uncertainty;
- The effect of the uncertainty on the risk estimate;
- An alternative parameter basis to reduce uncertainty (e.g., achieve lower detection limits);
- The effect of the alternative parameter on the risk assessment;
- Whether or not the alternative parameter basis was quantified for comparison; and
- Comments pertaining to the parameter.

The majority of the alternative parameters, whether qualitatively or quantitatively assessed, were considered to have a low likelihood for affecting threshold exceedances, pathway identifications, and/or risk decisions.

8 CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions of the RI and recommendations for further action at the Quendall Site. Section 8.1 presents the conclusions with emphasis on the nature and extent of coal tar and creosote DNAPL, the distribution of indicator chemicals in other affected Site media, and related human health and ecological risks. Section 8.2 presents recommendations regarding the need for further action at this Site.

8.1 Conclusions

DNAPL originating as creosote and coal tar products is the primary source of contamination at the Site. Creosote and other coal tar products were released into the subsurface in the historical processing, storage, and offloading areas located in the upland portion of the Site. Releases of coal tar also occurred offshore in Lake Washington along the T-Dock during product offloading operations, directly impacting sediments. Although petroleum hydrocarbons (e.g., fuel oil) and light-end distillates were used or processed at the Site, LNAPL has not been observed in the subsurface.

Occurrences of DNAPL have been identified in the shallow subsurface in much of the upland area, extending beneath Lake Washington offshore of Quendall Pond, and in surface sediment offshore along the former location of the T-Dock. The DNAPL tends to occur within discrete layers or thin lenses in the shallow alluvium rather than in continuous "pools". The movement of DNAPL in the subsurface is influenced by the prevailing east-to-west groundwater flow, but the deltaic nature of the shallow alluvium (e.g., sloping and interbedded silt, sand, and peat layers) also plays a significant role in how DNAPL migrates in the subsurface. Boring and test pit logs indicate that DNAPL impacts approximately 9.7 acres of the Site and is present up to a depth of 34 feet bgs, but is most typically observed in the upper 15-20 feet bgs. A total of approximately 445,000 gallons of DNAPL is estimated to be present in the subsurface at the Site.

Coal tar and creosote product indicator chemicals (i.e., benzene, naphthalene, and cPAHs) are present above PRGs in groundwater where DNAPL is present, with impacted groundwater generally extending downgradient (both horizontally and vertically) from DNAPL-impacted areas. The migration of dissolved indicator chemicals in groundwater is

primarily controlled by the east-to-west groundwater flow direction and contaminant-specific mobility. Benzene and naphthalene are relatively mobile and, based on both empirical data and groundwater modeling, have migrated deeper (up to 110 feet bgs, impacting groundwater in the deeper alluvium) and further downgradient (i.e., towards Lake Washington) from DNAPL source areas compared to the less mobile cPAHs. Groundwater transport of soluble coal tar product constituents from the upland portion of the Site has also contributed contaminants to sediment in nearshore areas. The migration of contaminated groundwater from DNAPL source areas represents a secondary source of contamination to soil and sediment; therefore, the horizontal and vertical extent of contamination in groundwater is a good indicator of the extent of impacts to these other media. Arsenic concentrations in groundwater also exceed the PRG in both the shallow and the deeper alluvium. This may be due, at least in part, to the greater mobility of naturally occurring arsenic under reducing conditions, which occur in areas of peat, DNAPL, and dissolved-phase hydrocarbon contamination.

Baseline human health and ecological risk assessments were conducted as part of the RI in accordance with EPA guidance. The results of the baseline human health risk assessment indicate that risks posed to all of the receptors evaluated exceed EPA's acceptable levels of 1×10^{-4} for cancer risk and/or an HQ of 1 for noncancer risk. The exposure scenarios that were evaluated included future residential, worker, recreational beach user, and recreational and subsistence fishing scenarios. The primary contributors to unacceptable risk are cPAHs, naphthalene, benzene, and arsenic.

The results of the baseline ecological risk assessment indicate that risks to terrestrial invertebrates, plants, and wildlife (birds and mammals), as well as to benthic invertebrates, aquatic plants, and aquatic-dependent wildlife, exceed an HQ of 1. The primary contributors to unacceptable risk are PAHs, represented as both individual chemicals and as totals (LPAHs, HPAHs, total PAHs, and PAH ESBQs).

8.2 Recommendations

Based on the nature and extent of contamination present at the Quendall Site and the baseline risk assessment findings, it is recommended that:

- Identification and evaluation of remedial alternatives that address DNAPL and other affected Site media with contaminants exceeding PRGs should be pursued in the forthcoming FS.
- Groundwater flow and fate/transport modeling tools should continue to be updated as new groundwater monitoring data become available; the models should be enhanced in anticipation of their value in assessing candidate remedial alternatives developed during the FS.
- Groundwater monitoring should continue to support ongoing analysis of groundwater quality trends and the horizontal and vertical migration of DNAPL over time.
- Until the selected remedy is fully functional, public access to the Site should be restricted by use of upland fencing and signs prohibiting access to Lake Washington sediment and collection of shellfish for human consumption.

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FINAL REMEDIAL INVESTIGATION REPORT QUENDALL TERMINALS SITE, RENTON, WASHINGTON

Volume II:
Figures

Prepared for
U.S. Environmental Protection Agency, Region 10

On behalf of
Altino Properties, Inc. and
J.H. Baxter & Co.

Prepared by
Anchor QEA, LLC and
Aspect Consulting, LLC
Incorporates revisions provided by EPA Region 10

September 2012

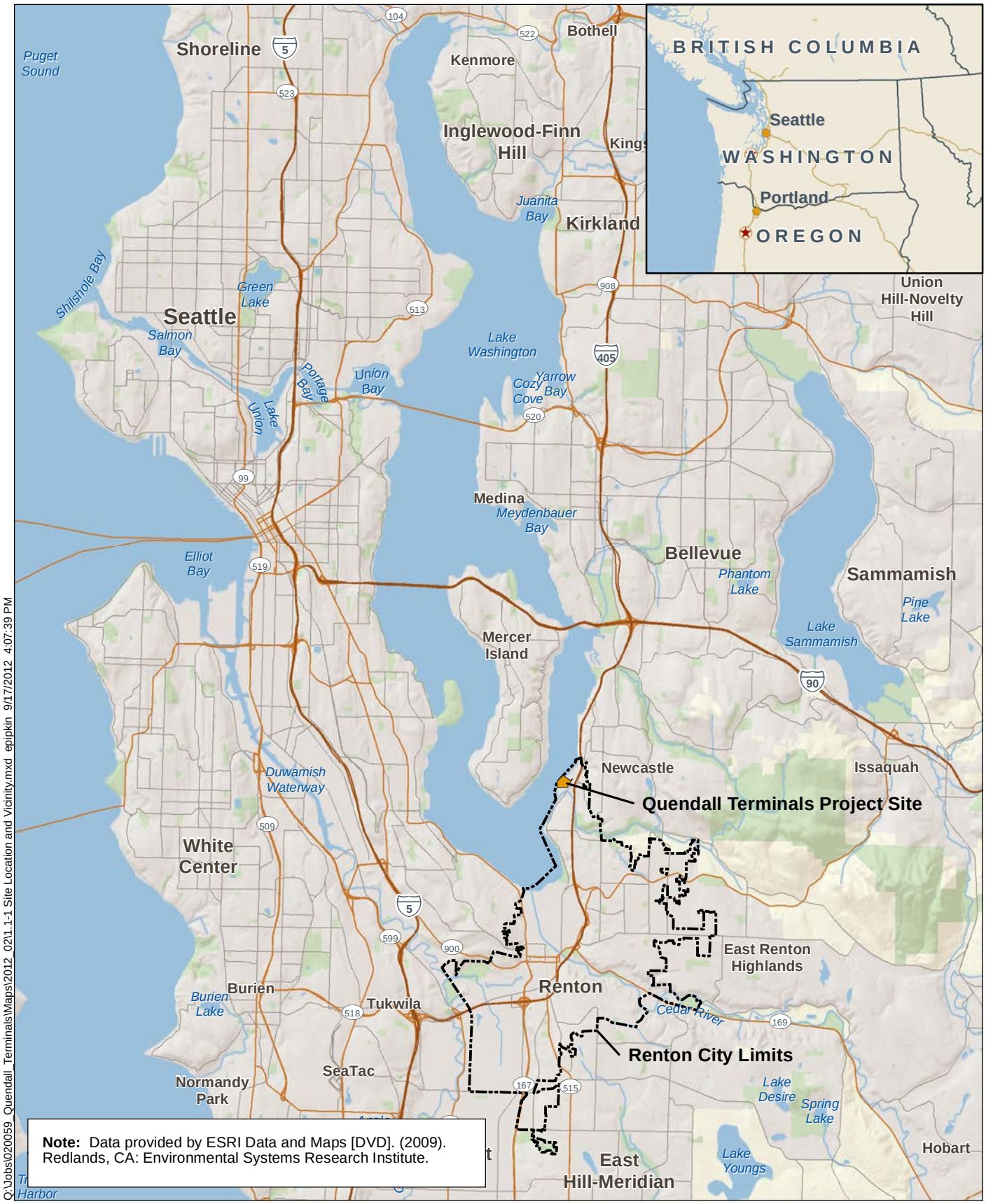

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Figure 1.1-1
Quendall Terminals Site Location and Vicinity
Final Remedial Investigation, Quendall Terminals

ANCHOR QEA

Legend

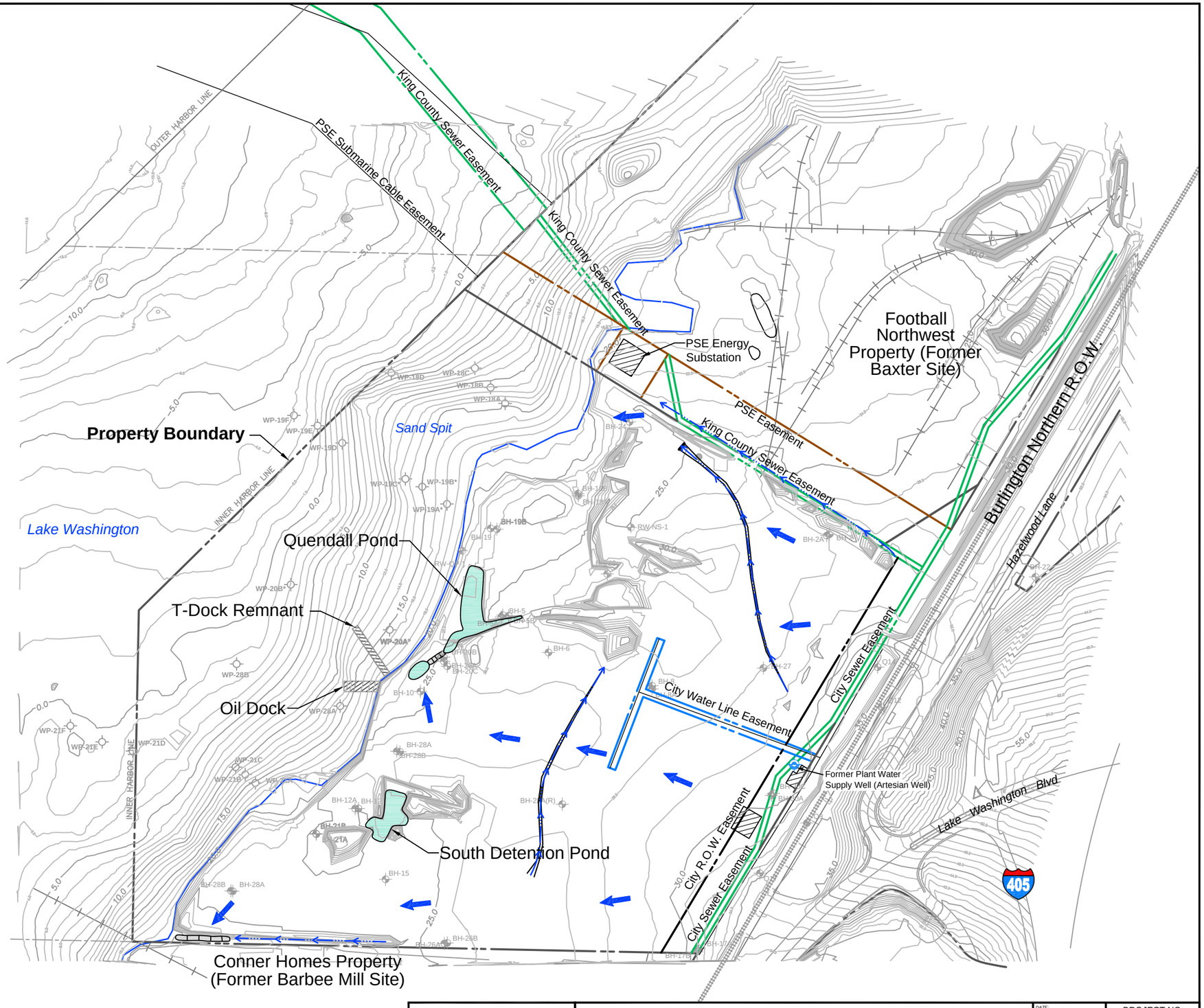
- Current Shoreline
- Existing Monitoring Wells
- Former Plant Water Supply Well (Artesian Well)
- Existing Wellpoints
- Existing Structures
- Puget Sound Energy (PSE) Easement Boundary
- City Right-of-Way (R.O.W.) Easement
- Sewer Easement Boundary
- Water Line Easement Boundary

Surface Water Features and Stormwater Control Structures

- Detention pond
- Stormwater drainage ditch with silt fence and/or rock check dams (approximate location)
- Overland drainage flow direction
- Ditch flow direction
- Shallow interceptor swale

Notes:

1) Wellpoints with *'s, WP-19 A/B/C and WP-20 A/B, were confirmed to still exist in September 2002. WP-21C could not be located at that time. Attempts to locate remaining wellpoints have not been made since Retec last sampled them in 2001.
2) "City" refers to City of Renton in easement labels.
3) The southern boundary of the PSE Easement is the northern boundary of the Quendall Site.



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0 200 400

Feet

Aspect CONSULTING

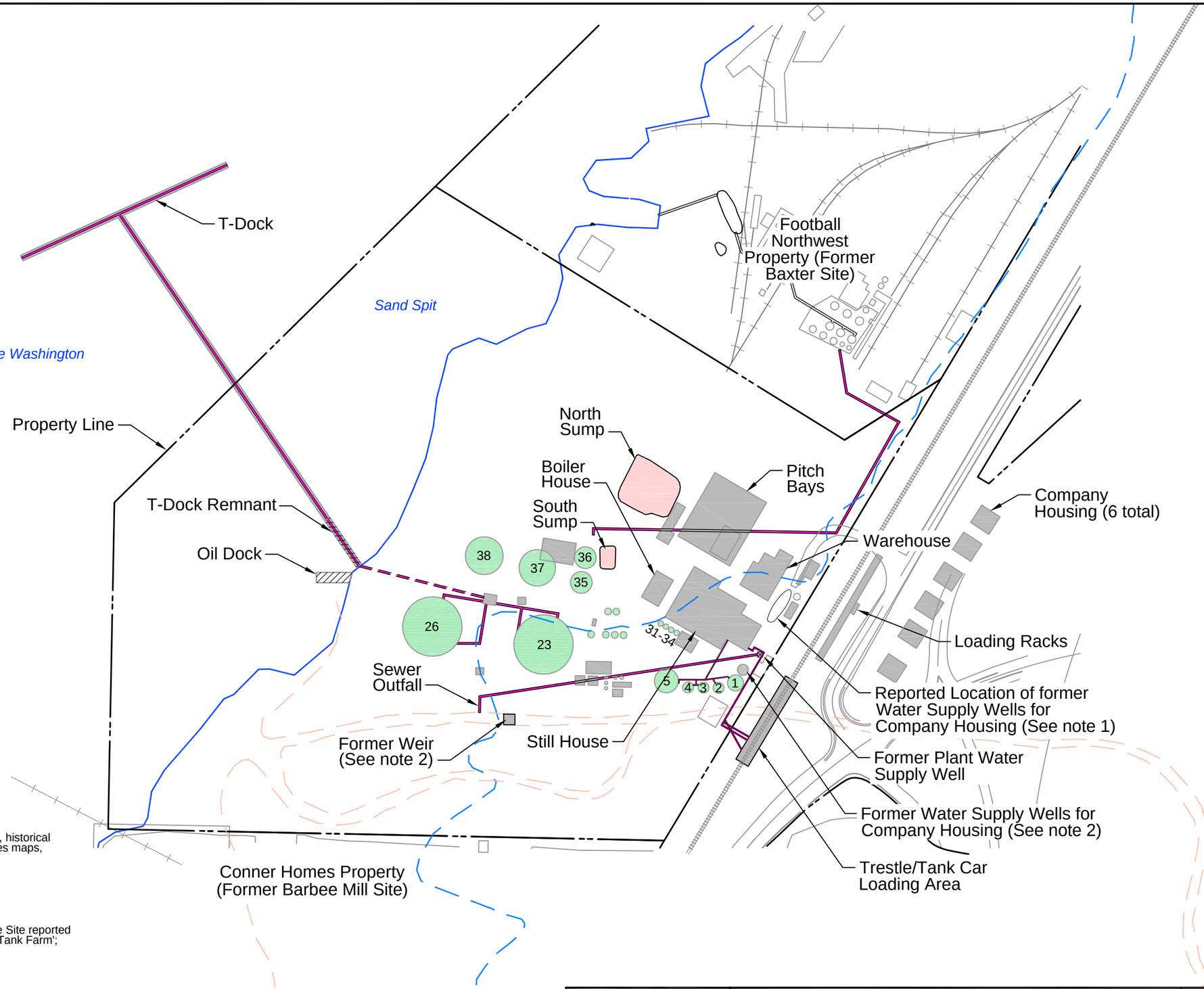
Summary of Current Site Features

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO.
DESIGNED BY: DLC/JJP/TDC	020027
DRAWN BY: PMB	FIGURE NO.
REVISED BY: SCC	1.2-1

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-121.dwg Figure 1.2-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 11:12am || User: scudd



Legend

- 1916 Shoreline
- Former May Creek Channel
- Current Shoreline
- (1) Tank with Tank Number
- Sump
- Pipes
- Pipes (location inferred)
- Other Historical Structures

Notes:

Site feature locations based on aerial photographs, historical Washington State Department of Natural Resources maps, and 1918 and 1958 Plant Maps, except as noted.

1. Reported by Ward Roberts (Ecology 1989).
2. Based on 1918 Plant Map.
3. Piping to the former Baxter property north of the Site reported by Retec (2001). Origin identified as 'Quendall Tank Farm'; details of connection not provided.
4. Tank Numbers from 1958 Plant Map.

N

0 200 400

Feet

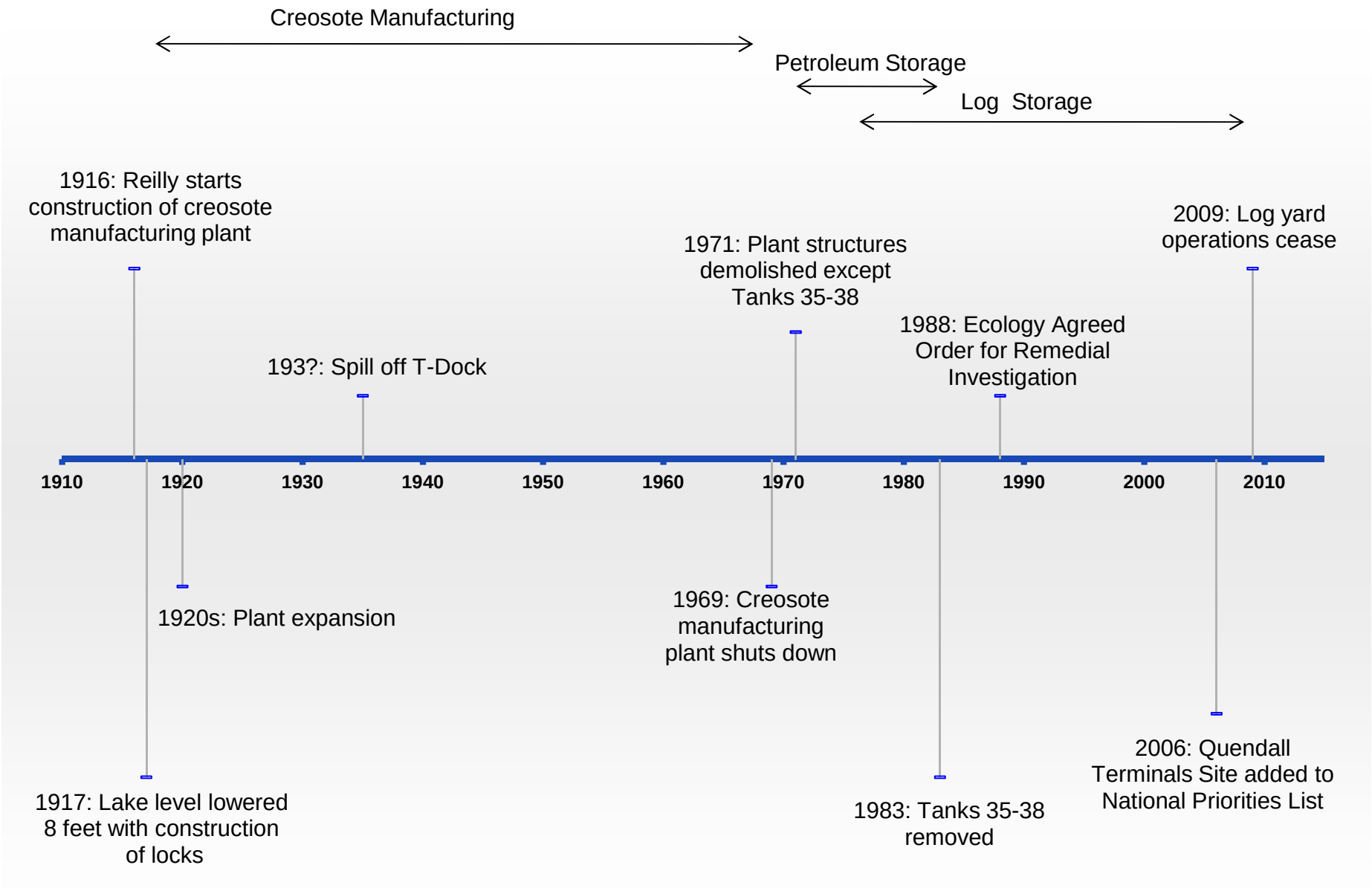
Aspect CONSULTING

Summary of Historical Site Features

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP/TDC	
DRAWN BY: LAL/PMB	FIGURE NO. 2.1-1
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-211.dwg Figure 2.1-1 (11x17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 11:23am || User: scudd



Aspect Consulting
September 2012

Figure 2.1-2
Timeline of Site Operation
Final Remedial Investigation, Quendall Terminals

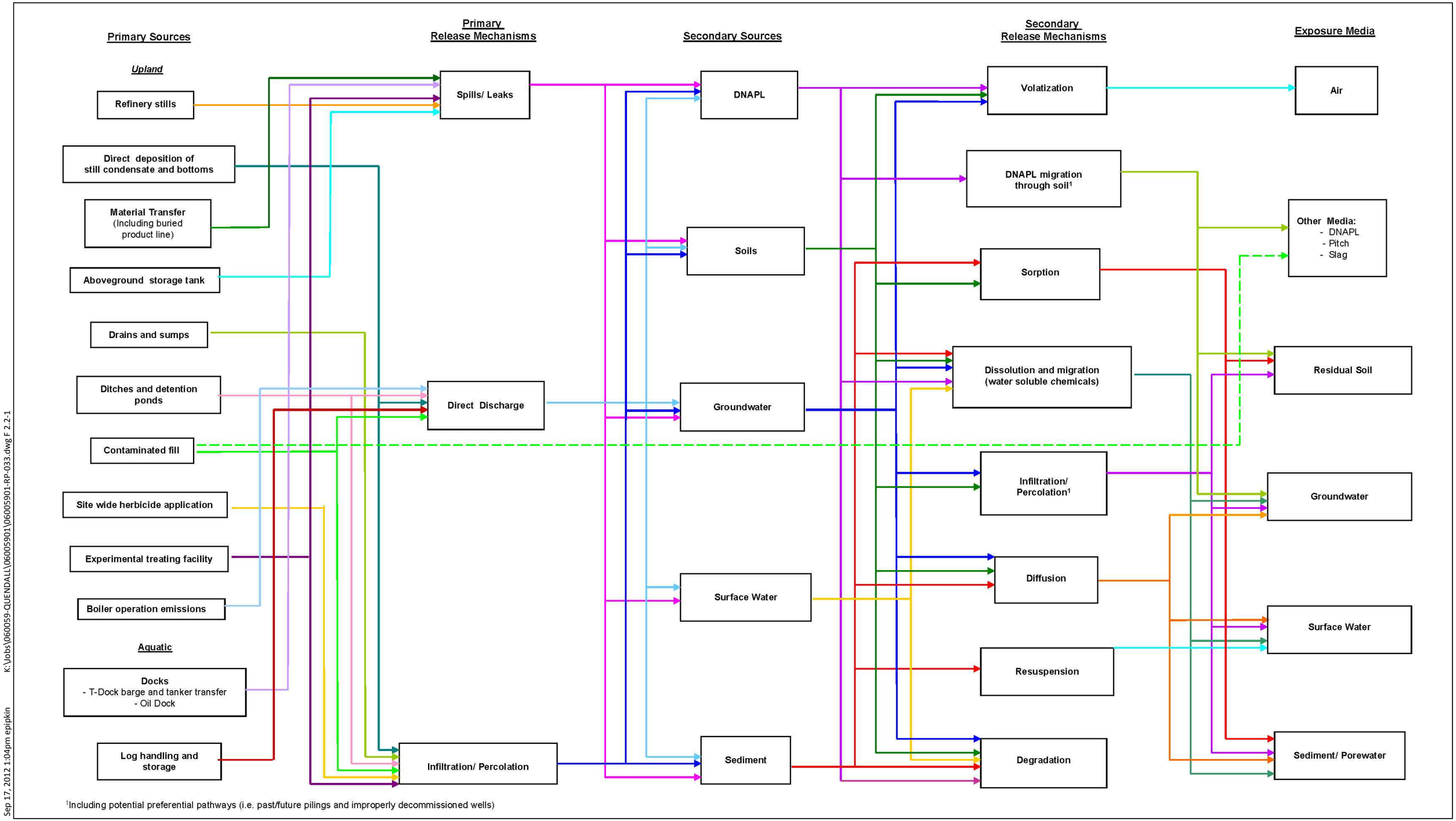


Figure 2.2-1
Conceptual Site Model of Quendall Terminals Contaminant Sources and Release Mechanisms
Final Remedial Investigation, Quendall Terminals

ANCHOR QEA

Summary of Explorations by Consultant

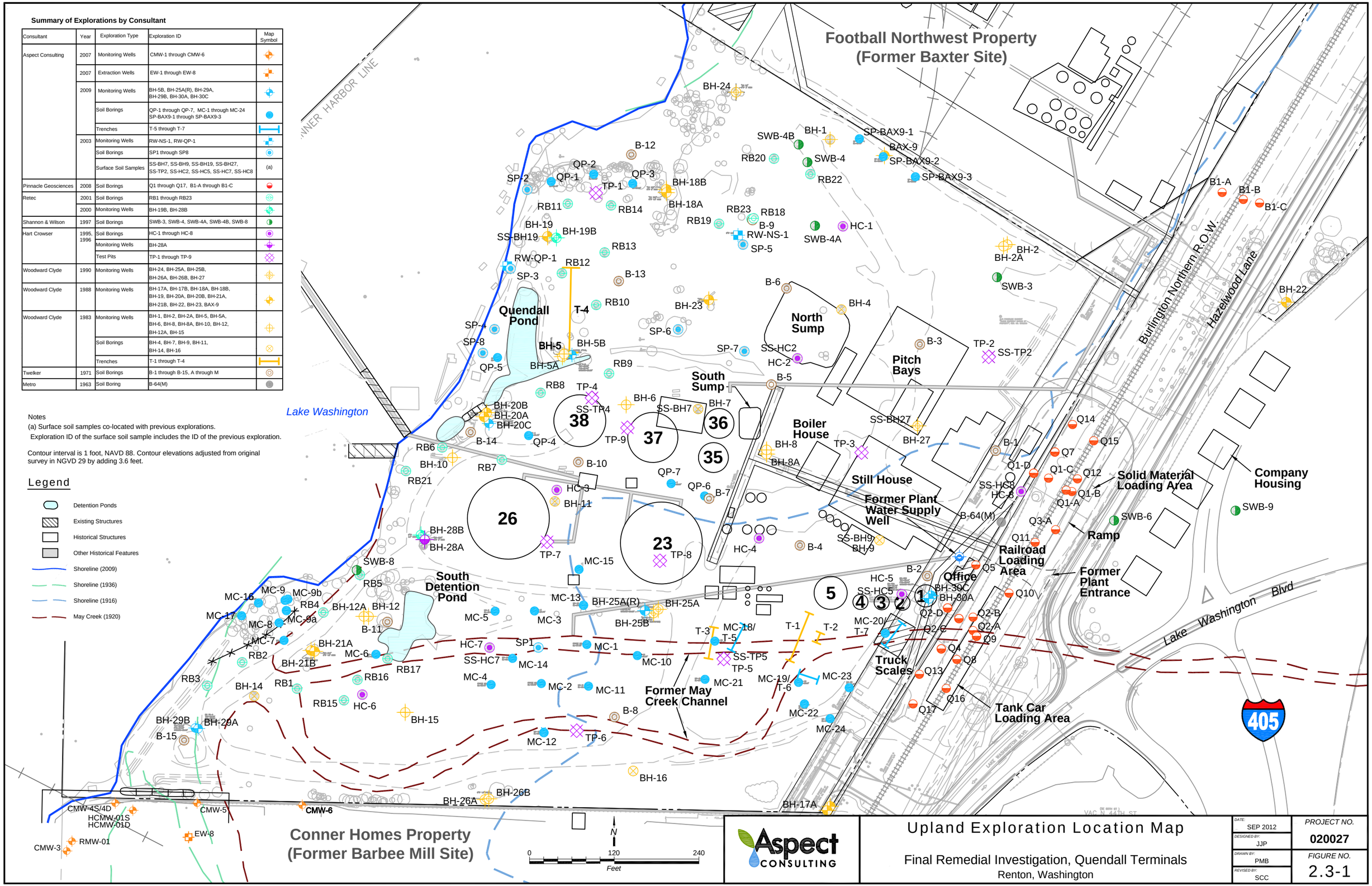
Consultant	Year	Exploration Type	Exploration ID	Map Symbol
Aspect Consulting	2007	Monitoring Wells	CMW-1 through CMW-6	
	2007	Extraction Wells	EW-1 through EW-8	
	2009	Monitoring Wells	BH-5B, BH-25A(R), BH-29A, BH-29B, BH-30A, BH-30C	
		Soil Borings	QP-1 through QP-7, MC-1 through MC-24 SP-BAX9-1 through SP-BAX9-3	
		Trenches	T-5 through T-7	
	2003	Monitoring Wells	RW-NS-1, RW-QP-1	
		Soil Borings	SP1 through SP8	
		Surface Soil Samples	SS-BH7, SS-BH9, SS-BH19, SS-BH27, SS-TP2, SS-HC2, SS-HC5, SS-HC7, SS-HC8	(a)
Pinnacle Geosciences	2008	Soil Borings	Q1 through Q17, B1-A through B1-C	
Retec	2001	Soil Borings	RB1 through RB23	
	2000	Monitoring Wells	BH-19B, BH-28B	
Shannon & Wilson	1997	Soil Borings	SWB-3, SWB-4, SWB-4A, SWB-4B, SWB-8	
Hart Crowser	1995, 1996	Soil Borings	HC-1 through HC-8	
		Monitoring Wells	BH-28A	
		Test Pits	TP-1 through TP-9	
Woodward Clyde	1990	Monitoring Wells	BH-24, BH-25A, BH-25B, BH-26A, BH-26B, BH-27	
Woodward Clyde	1988	Monitoring Wells	BH-17A, BH-17B, BH-18A, BH-18B, BH-19, BH-20A, BH-20B, BH-21A, BH-21B, BH-22, BH-23, BAX-9	
Woodward Clyde	1983	Monitoring Wells	BH-1, BH-2, BH-2A, BH-5, BH-5A, BH-6, BH-8, BH-8A, BH-10, BH-12, BH-12A, BH-15	
		Soil Borings	BH-4, BH-7, BH-9, BH-11, BH-14, BH-16	
		Trenches	T-1 through T-4	
Twelker	1971	Soil Borings	B-1 through B-15, A through M	
Metro	1963	Soil Boring	B-64(M)	

Notes
(a) Surface soil samples co-located with previous explorations.
Exploration ID of the surface soil sample includes the ID of the previous exploration.

Contour interval is 1 foot, NAVD 88. Contour elevations adjusted from original survey in NGVD 29 by adding 3.6 feet.

Legend

- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Shoreline (2009)
- Shoreline (1936)
- Shoreline (1916)
- May Creek (1920)



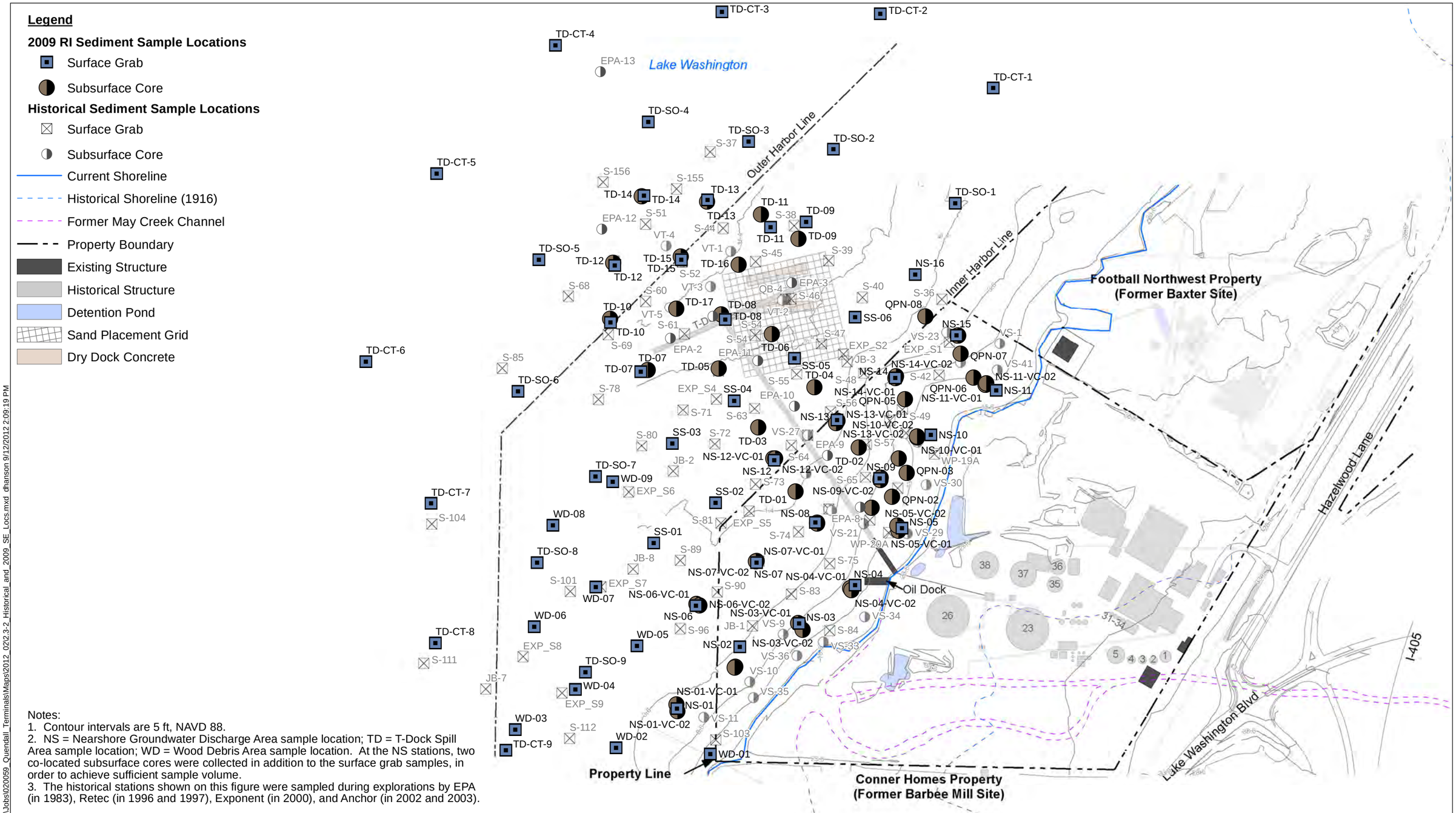
Aspect CONSULTING

Upland Exploration Location Map

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 2.3-1
REVISED BY: SCC	

CAD Path: C:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report 01\020027-231.dwg Figure 2.3-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 17, 2012 12:57pm || User: scudd



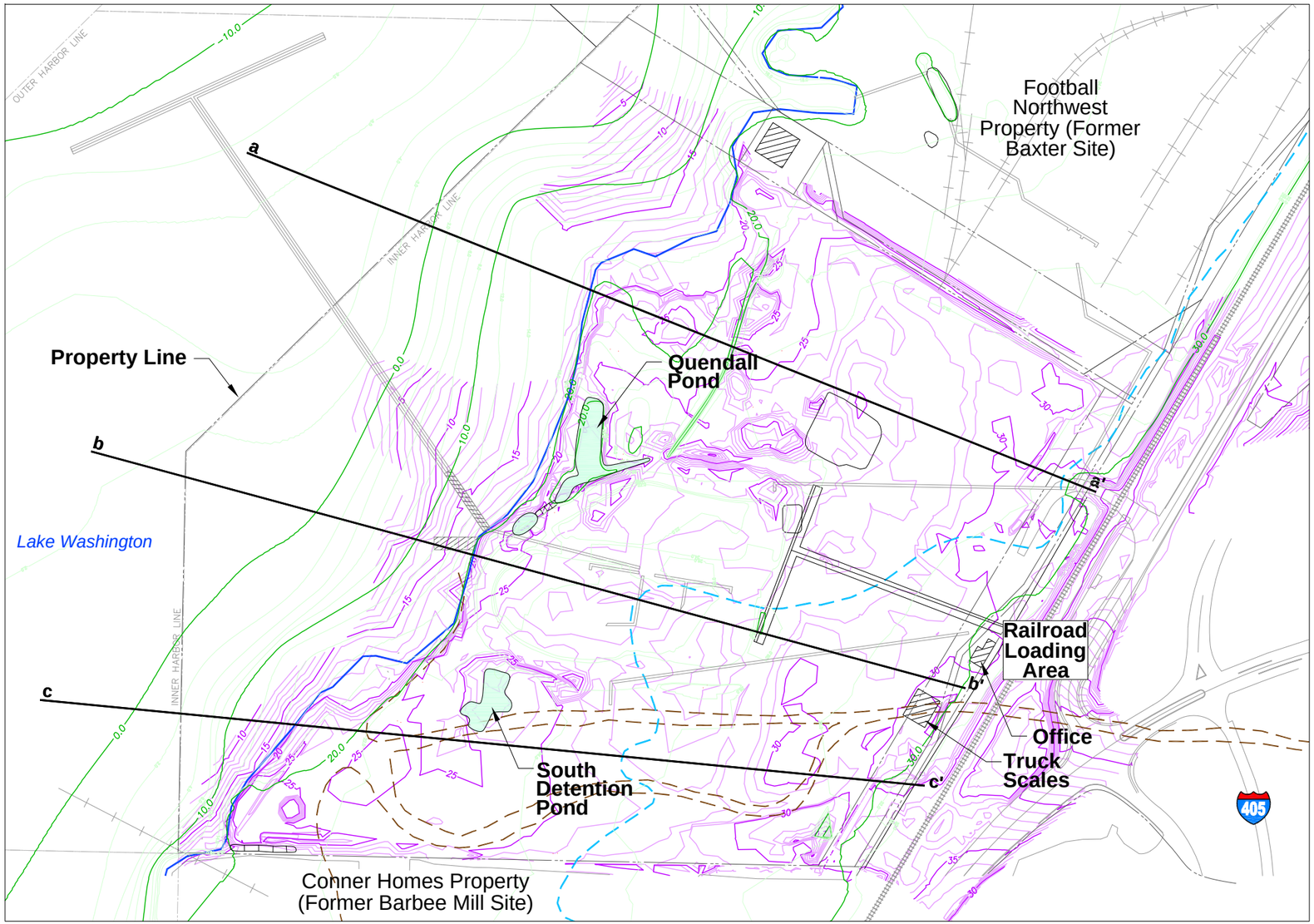
Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. NS = Nearshore Groundwater Discharge Area sample location; TD = T-Dock Spill Area sample location; WD = Wood Debris Area sample location. At the NS stations, two co-located subsurface cores were collected in addition to the surface grab samples, in order to achieve sufficient sample volume.
3. The historical stations shown on this figure were sampled during explorations by EPA (in 1983), Retec (in 1996 and 1997), Exponent (in 2000), and Anchor (in 2002 and 2003).

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_02\2.3-2_Historical_and_2009_SE_Locs.mxd dhanson 9/12/2012 2:09:19 PM

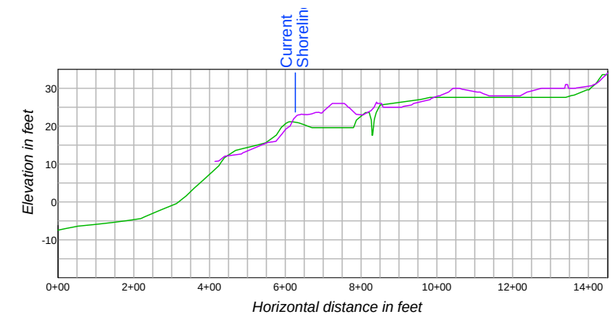
ANCHOR QEA

Feet
0 110 220 330 440

Figure 2.3-2
Offshore Exploration Location Map
Final Remedial Investigation, Quendall Terminals

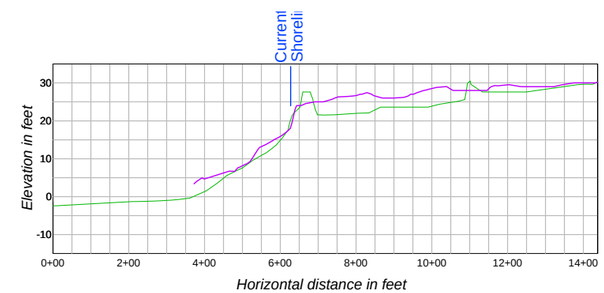


Note: Contour intervals are 1 foot, NAVD 88.



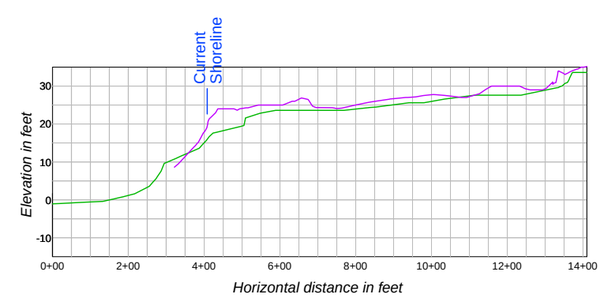
Cross Section a-a'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical



Cross Section b-b'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical



Cross Section c-c'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical

Legend

- Current Shoreline
- Existing Structure
- Detention Pond
- 25 — 1975 Major Contour (Walker and Associates)
- 1975 Minor Contour (Walker and Associates)
- 25 — 2009 Major Contour (Bush, Roed and Hitchings)
- 2009 Minor Contour (Bush, Roed and Hitchings)
- 1916 Shoreline
- Former May Creek Channel

N

0 100 200 400
Feet

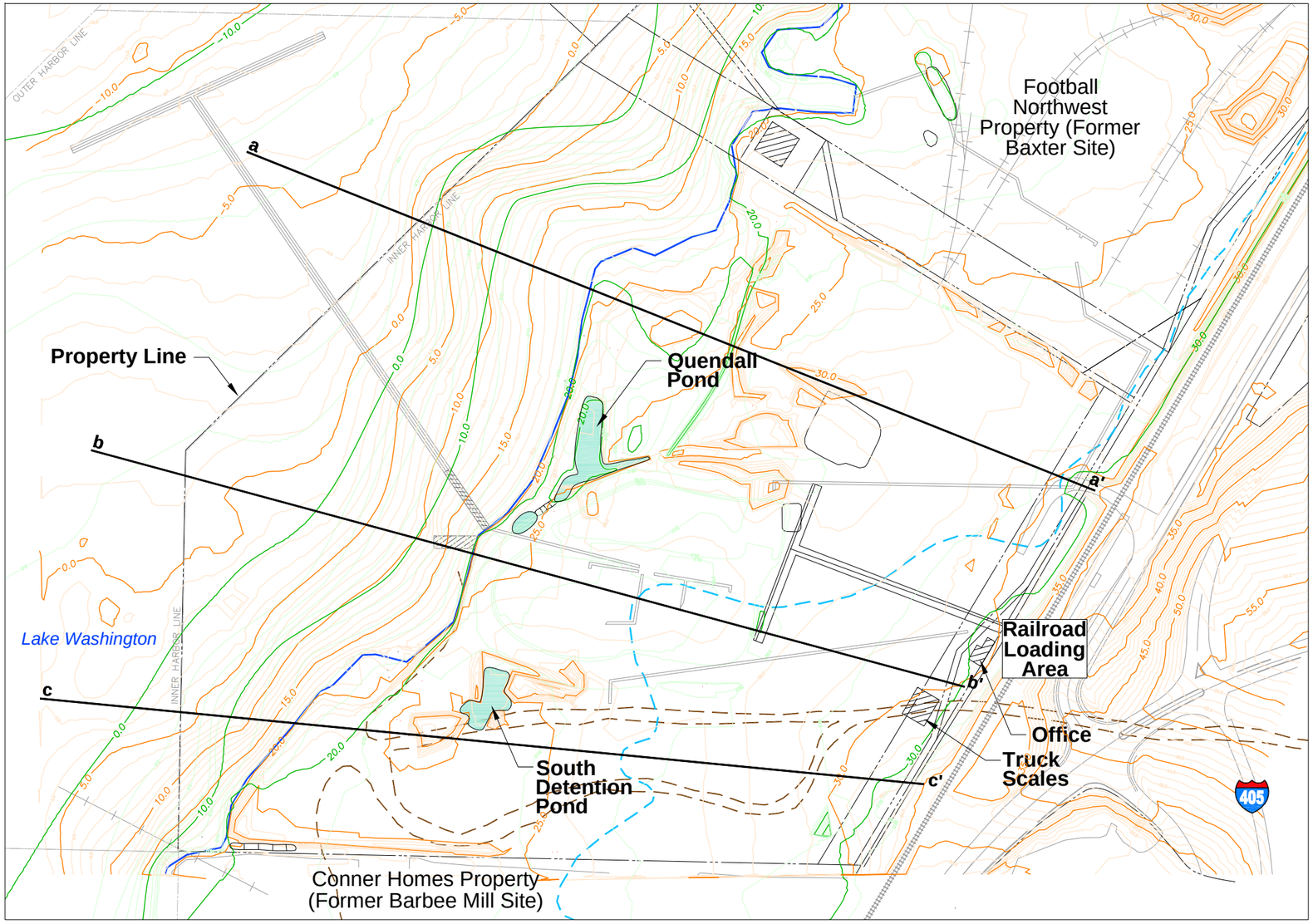
Aspect CONSULTING

Comparison of 1975 and 2009 Topographic Contours

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO.
DESIGNED BY: JJP	020027
DRAWN BY: PMB	FIGURE NO.
REVISED BY: SCC	3.1-1a

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-311a.dwg Figure 3.1-1a (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 12:36pm || User: scudd



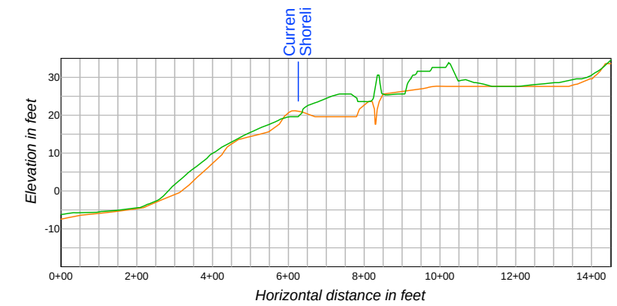
Note: Contour intervals are 1 foot, NAVD 88.

Legend

- Current Shoreline
- Existing Structure
- Detention Pond
- 1975 Major Contour (Walker and Associates)
- 1975 Minor Contour (Walker and Associates)
- 1997 Major Contour (Retec)
- 1997 Minor Contour (Retec)
- 1916 Shoreline
- Former May Creek Channel

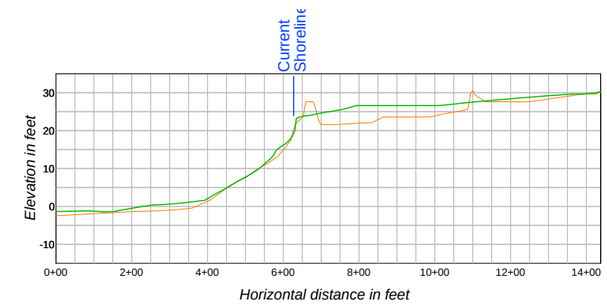
N

0 100 200 400
Feet



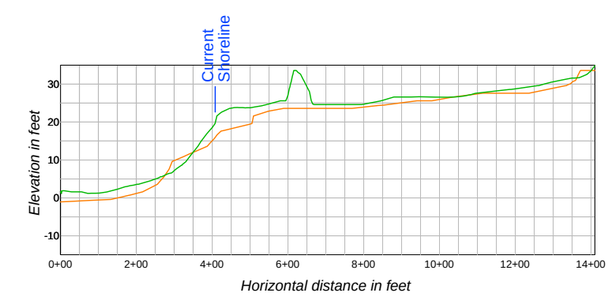
Cross Section a-a'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical



Cross Section b-b'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical



Cross Section c-c'

Scale: 1" = 200'-0" Horizontal
1" = 20'-0" Vertical

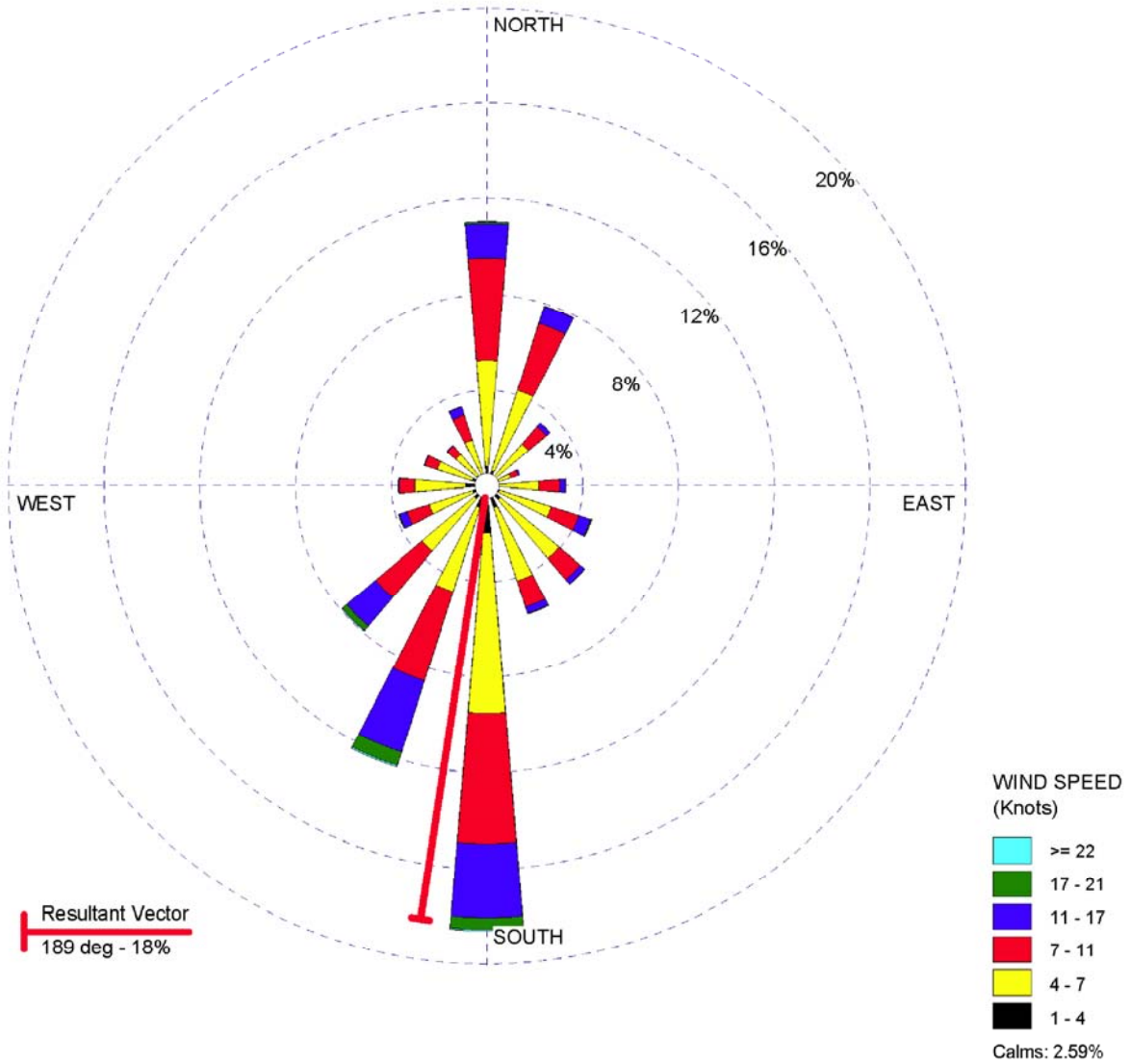
Aspect CONSULTING

Comparison of 1975 and 1997 Topographic Contours

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO.
DESIGNED BY: JJP	020027
DRAWN BY: PMB	FIGURE NO.
REVISED BY: SCC	3.1-1b

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3.1-1b.dwg Figure 3.1-1b (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 12:42pm || User: scudd



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Data source: WebMET and National Climatic Data Center (NCDC)	**1971-1989 1990-1995 1996-2000 Jan 1 - Dec 31 00:00 - 23:00**	**Office of the Washington State Climatologist**	
	CALM WINDS: **2.59%**	TOTAL COUNT: **248465 hrs.**	
	AVG. WIND SPEED: **7.46 Knots**	DATE: **6/10/2005**	PROJECT NO.:

Aspect CONSULTING

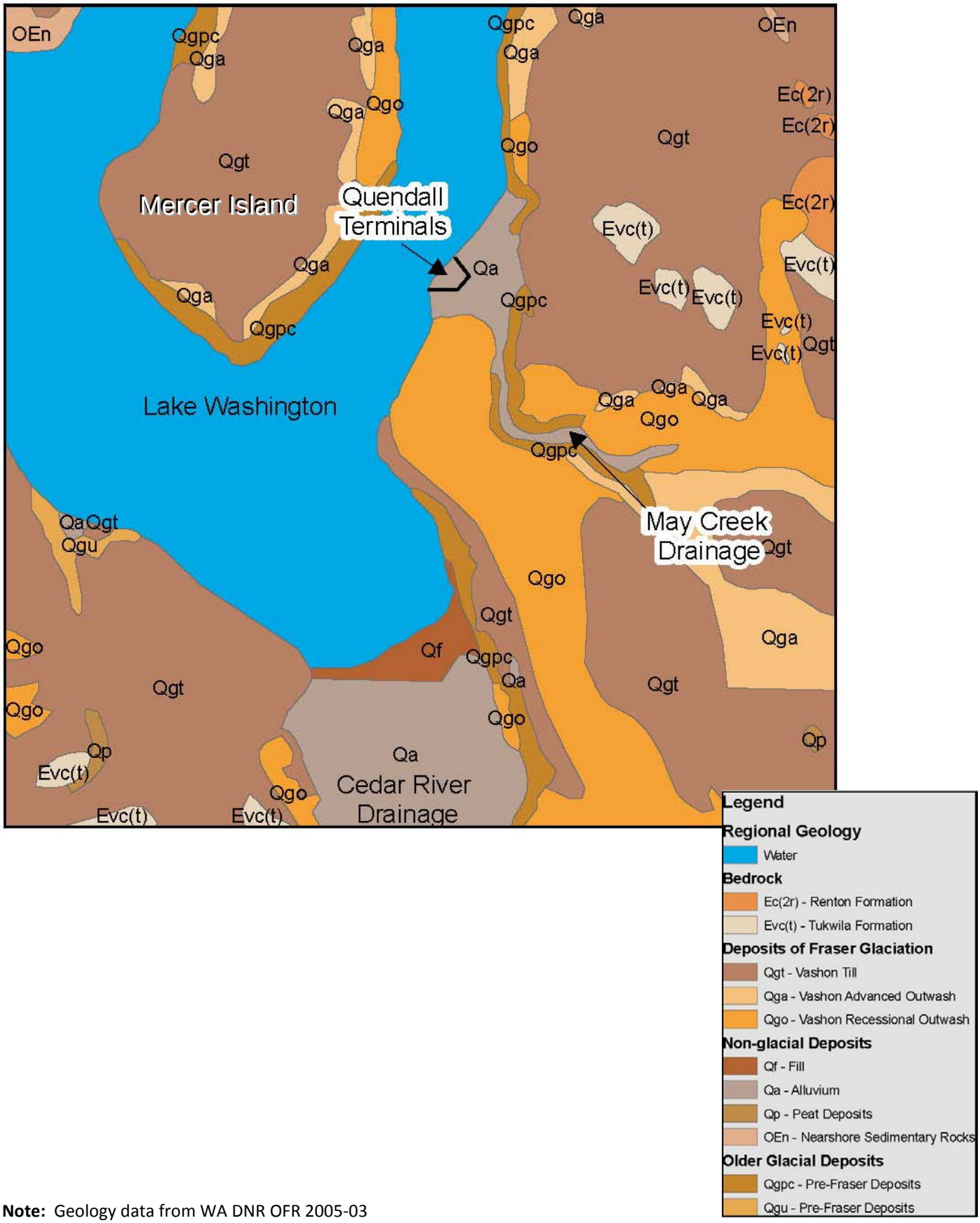
Wind-Rose Diagram for Seattle-Tacoma International Airport

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 3.1-2
REVISED BY: SCC	

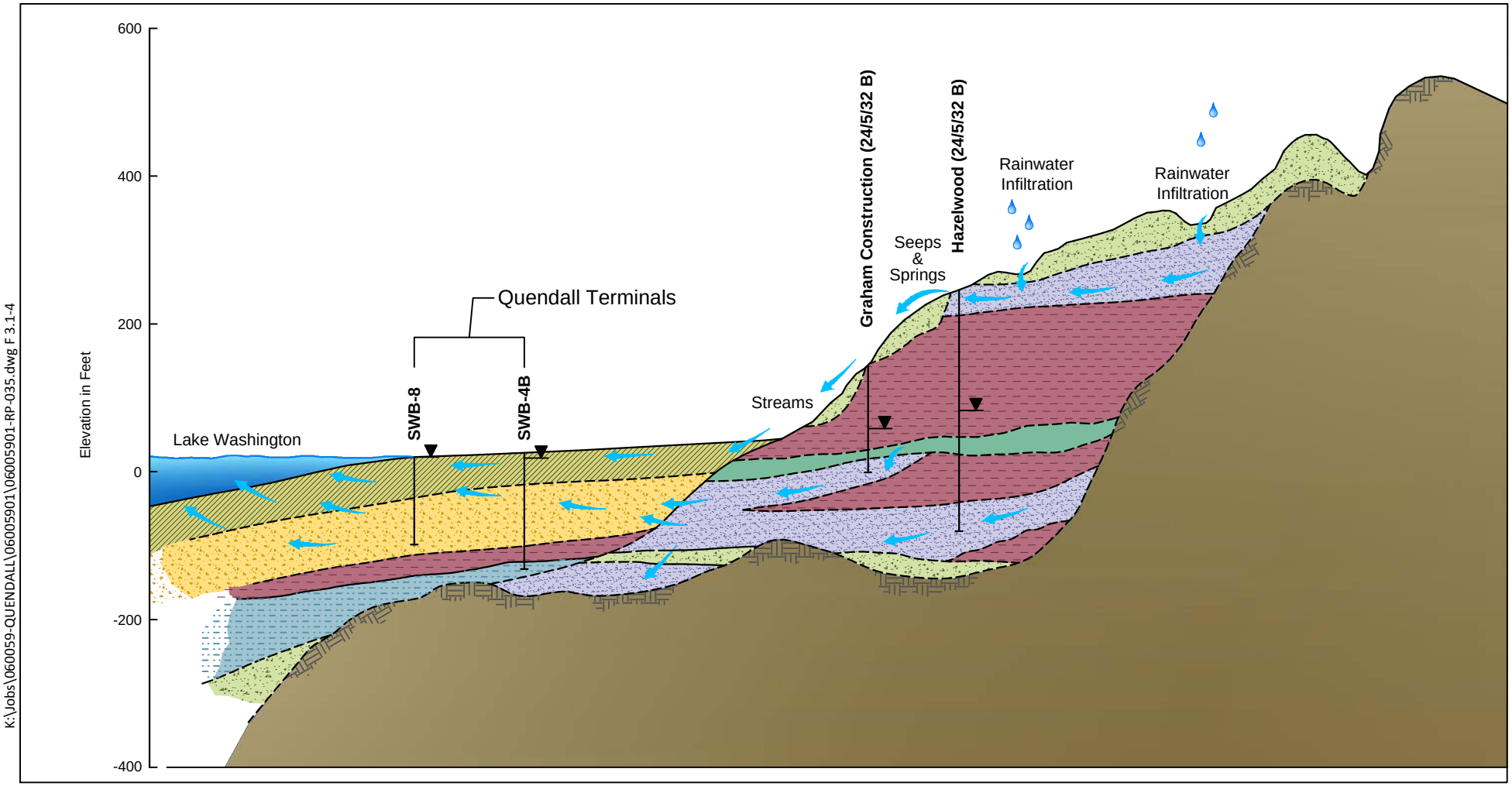
CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-312.dwg Figure 3.1-2 (8.5 x 11) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 12:54pm || User: scudd



Note: Geology data from WA DNR OFR 2005-03

ANCHOR QEA

Figure 3.1-3
Regional Geology
Final Remedial Investigation, Quendall Terminals



Glacial Till
Glacial Sand
Glacial Clay
Silt and Sand
Silt, Sand, Clay, Peat, and Alluvium
Sand and Gravel
Mud-Flow Deposits
Bedrock
Groundwater and Surface Water Flow Direction
Geologic Contact
SWB-4B
Well (Township/Range/Section)
Water Level in Well (Indicated in Historical Well Logs)

0 1000
Scale in Feet
Vertical Exaggeration x5

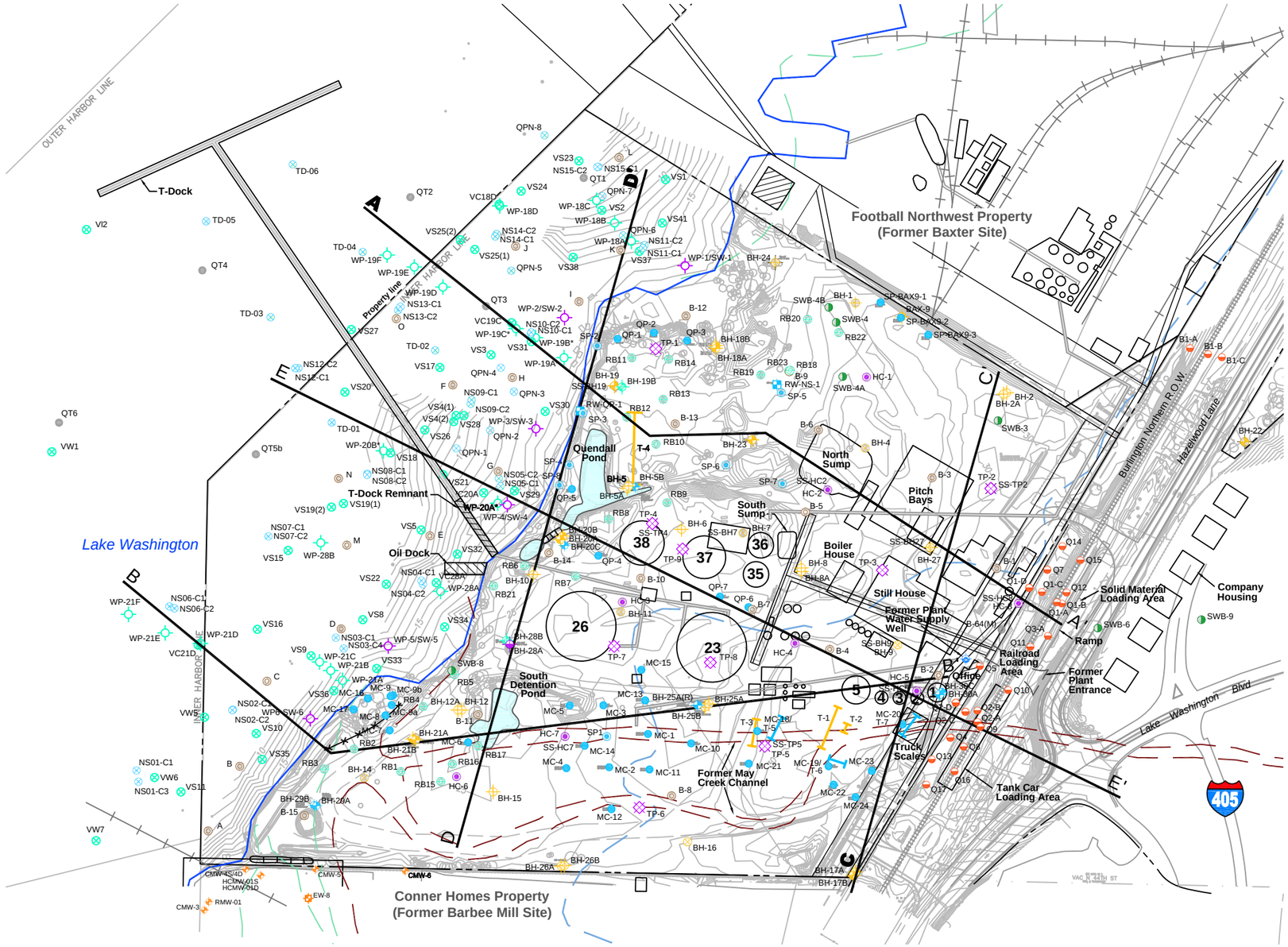
NOTE: Shannon & WIlson (1997) soil borings (SWB-8 and SWB-4B) are near the western and northern boundaries of the site, respectively.

K:\Jobs\060059-QUENDALL\06005901\06005901-RP-035.dwg F 3.1-4

Sep 20, 2012 2:11pm epipkin

ANCHOR QEA

Figure 3.1-4
Conceptual Cross Section of Regional Geology
Final Remedial Investigation, Quendall Terminals



Summary of Explorations by Consultant

Consultant	Year	Exploration Type	Exploration ID	Map Symbol
Aspect Consulting	2007	Monitoring Wells	CMW-1 through CMW-6	
	2007	Extraction Wells	EW-1 through EW-8	
	2009	Monitoring Wells	BH-5B, BH-25A(R), BH-29A, BH-29B, BH-30A, BH-30C	
		Soil Borings	QP-1 through QP-7, MC-1 through MC-24 SP-BAX9-1 through SP-BAX9-3	
		Trenches	T-5 through T-7	
	2003	Monitoring Wells	RW-NS-1, RW-QP-1	
		Soil Borings	SP1 through SP8	
		Surface Soil Samples	SS-BH7, SS-BH9, SS-BH19, SS-BH27, SS-TP2, SS-HC2, SS-HC5, SS-HC7, SS-HC8	(a)
Pinnacle Geosciences	2008	Soil Borings	Q1 through Q17, B1-A through B1-C	
Retec	2001	Soil Borings	RB1 through RB23	
	2000	Monitoring Wells	BH-19B, BH-28B	
Shannon & Wilson	1997	Soil Borings	SWB-3, SWB-4, SWB-4A, SWB-4B, SWB-8	
Hart Crowser	1995, 1996	Soil Borings	HC-1 through HC-8	
		Monitoring Wells	BH-28A	
		Test Pits	TP-1 through TP-9	
Woodward Clyde	1990	Monitoring Wells	BH-24, BH-25A, BH-25B, BH-26A, BH-26B, BH-27	
Woodward Clyde	1988	Monitoring Wells	BH-17A, BH-17B, BH-18A, BH-18B, BH-19, BH-20A, BH-20B, BH-21A, BH-21B, BH-22, BH-23, BAX-9	
Woodward Clyde	1983	Monitoring Wells	BH-1, BH-2, BH-2A, BH-5, BH-5A, BH-6, BH-8, BH-8A, BH-10, BH-12, BH-12A, BH-15	
		Soil Borings	BH-4, BH-7, BH-9, BH-11, BH-14, BH-16	
		Trenches	T-1 through T-4	
Twelker	1971	Soil Borings	B-1 through B-15, A through M	
Metro	1963	Soil Borings	B-64(M)	

Notes
(a) Surface soil samples co-located with previous explorations.
Exploration ID of the surface soil sample includes the ID of the previous exploration.

Contour interval is 1 foot, NAVD 88. Contour elevations adjusted from original survey in NGVD 29 by adding 3.6 feet.

Legend

- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Shoreline (2009)
- Shoreline (1936)
- Shoreline (1916)
- May Creek (1920)
- A — A' Cross Section Location and Designator

N

0 200 400
Feet

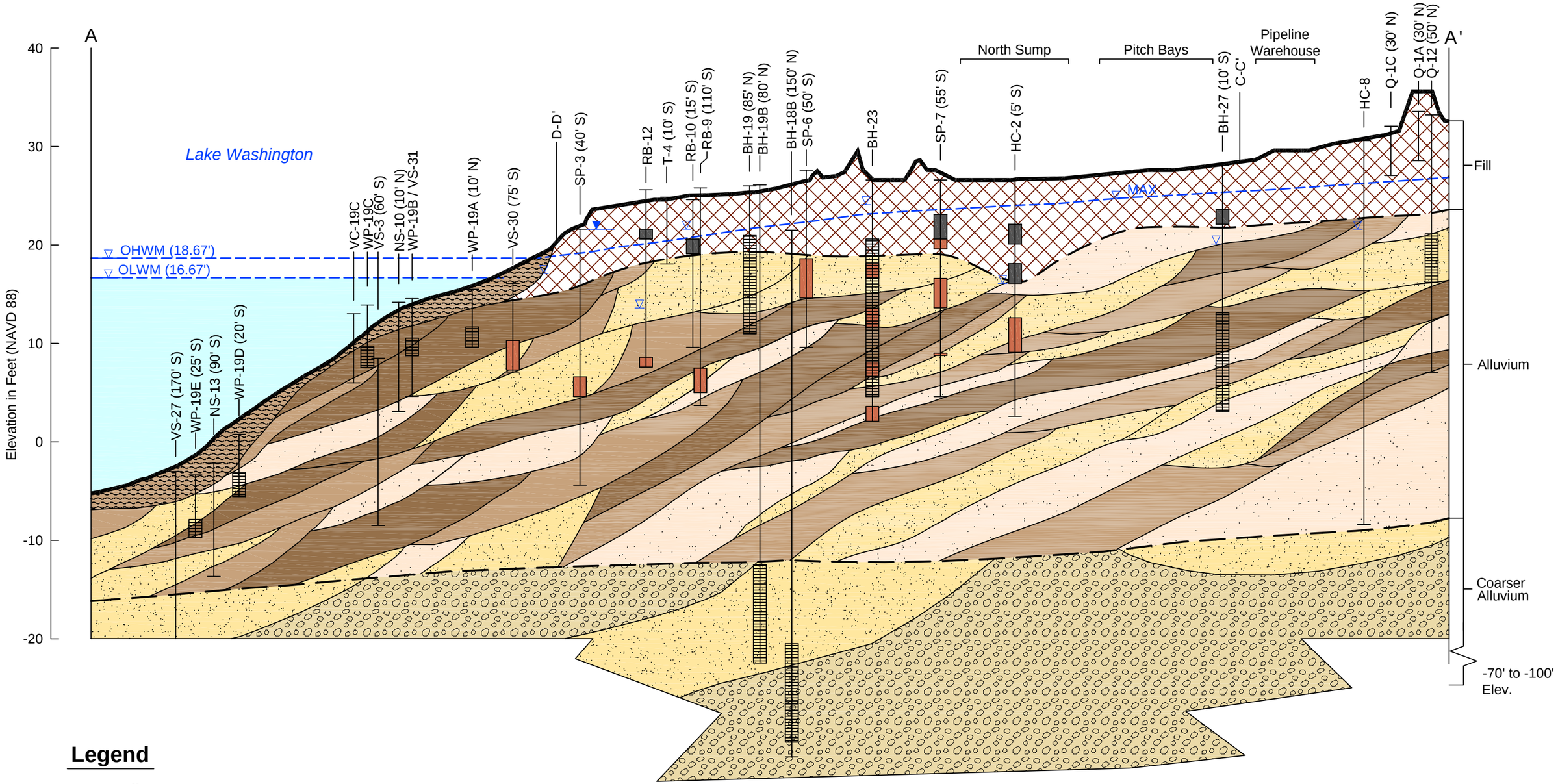
Aspect CONSULTING

Cross Section Location Map

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 3.1-5
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-315.dwg Figure 3.1-5 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 1:14pm || User: scudd



Legend

BH-27 (10' S) — Well ID and Offset from Cross Section

Water Level ATD

Solidified Tar Products

Non-Aqueous Phase Liquids

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Horizontal Scale

0 100 200

Feet

Vertical Scale

0 10 20

Feet

Vertical Exaggeration 10X

Aspect CONSULTING

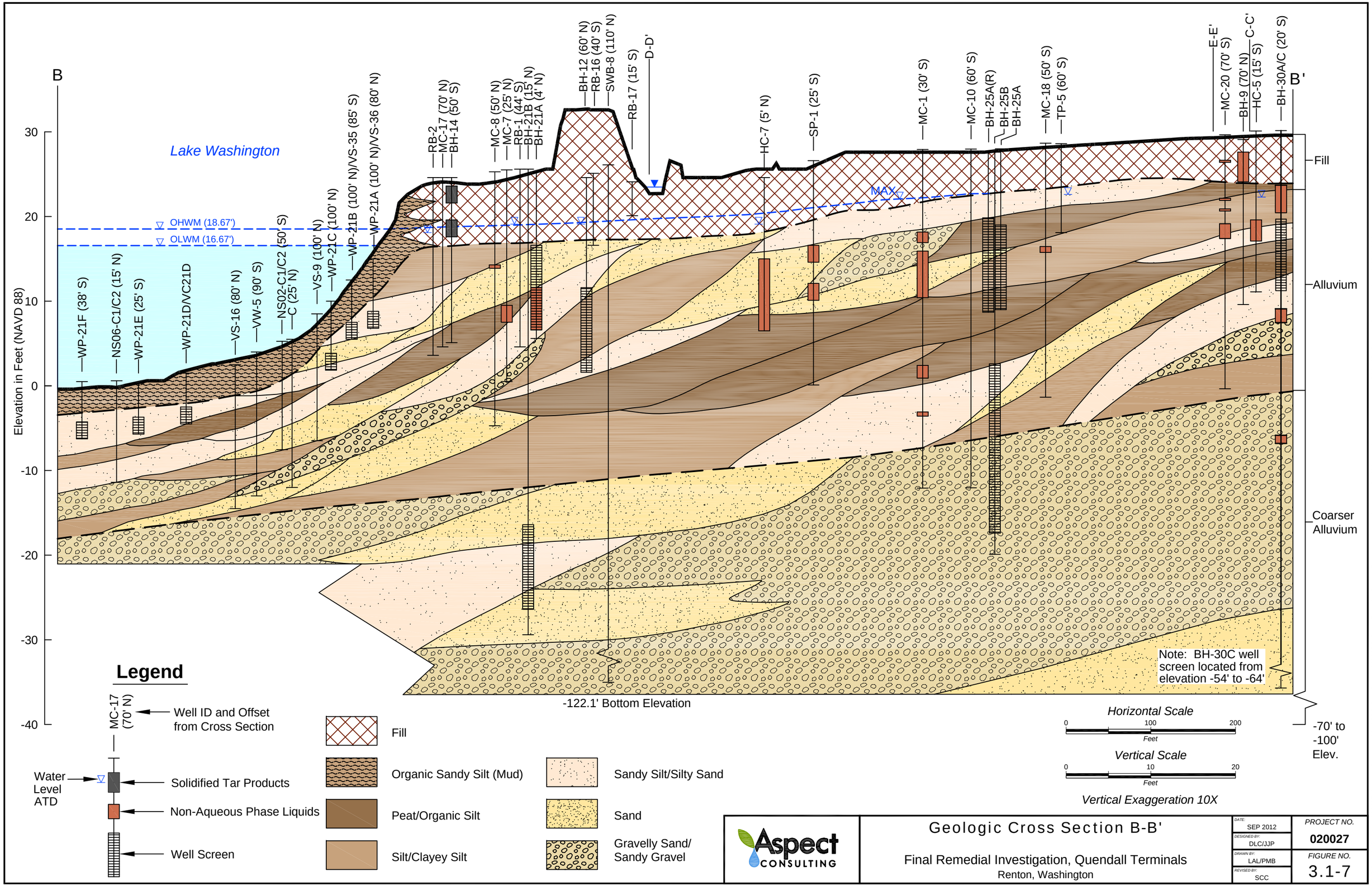
Geologic Cross Section A-A'

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.1-6
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-316.dwg Figure 3.1-6 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 2:31pm || User: scudd



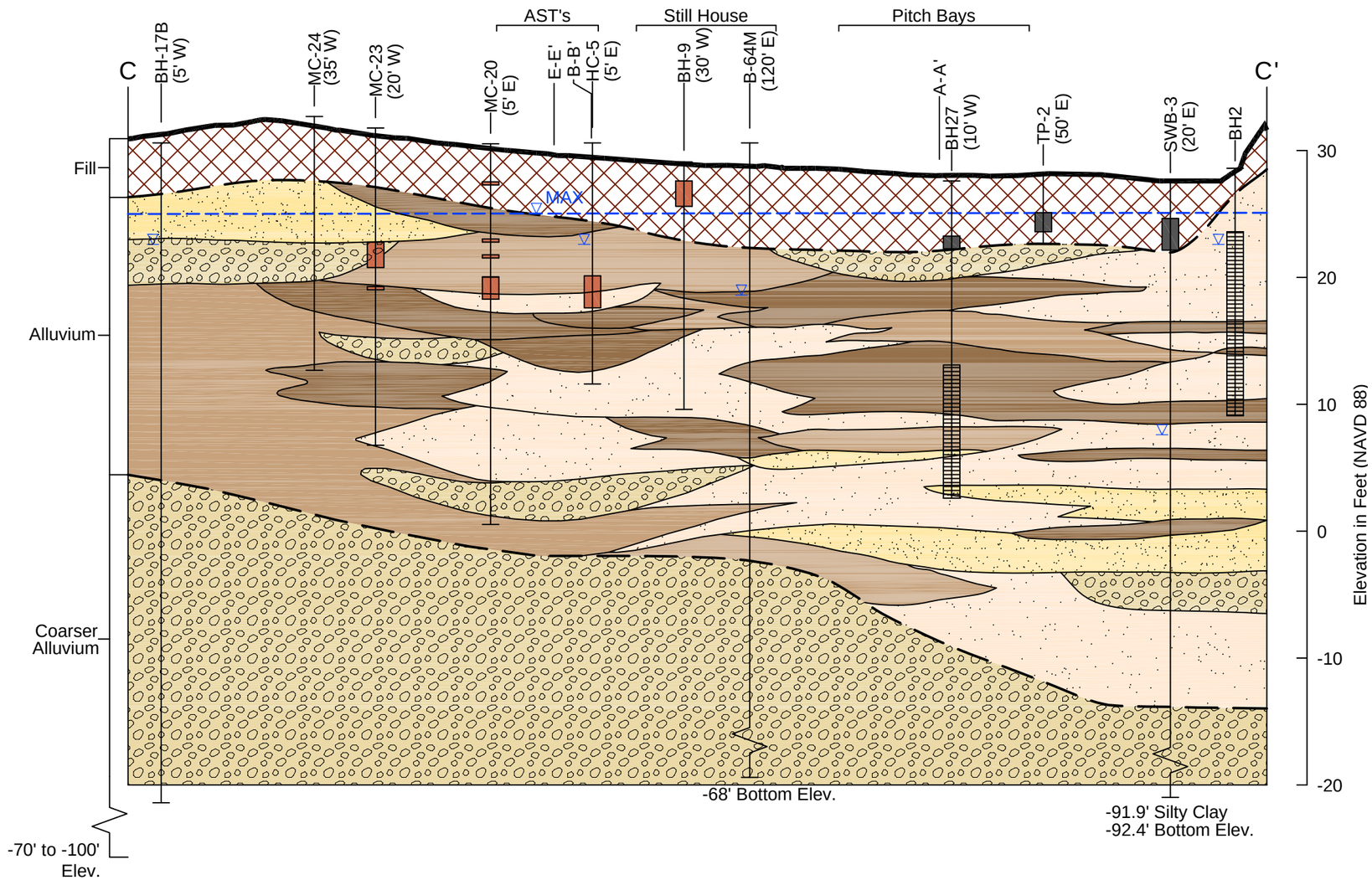
Aspect CONSULTING

Geologic Cross Section B-B'

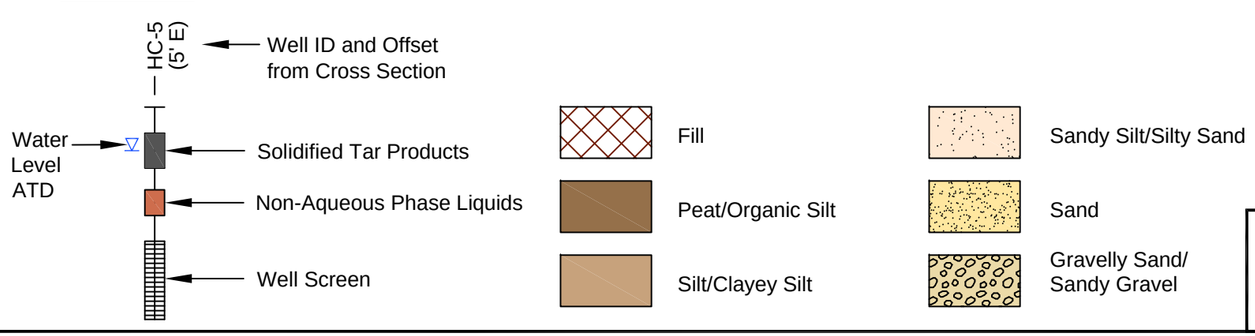
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.1-7
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-317.dwg Figure 3.1-7 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 2:33pm || User: scudd



Legend



Horizontal Scale

0 100 200

Feet

Vertical Scale

0 10 20

Feet

Vertical Exaggeration 10X

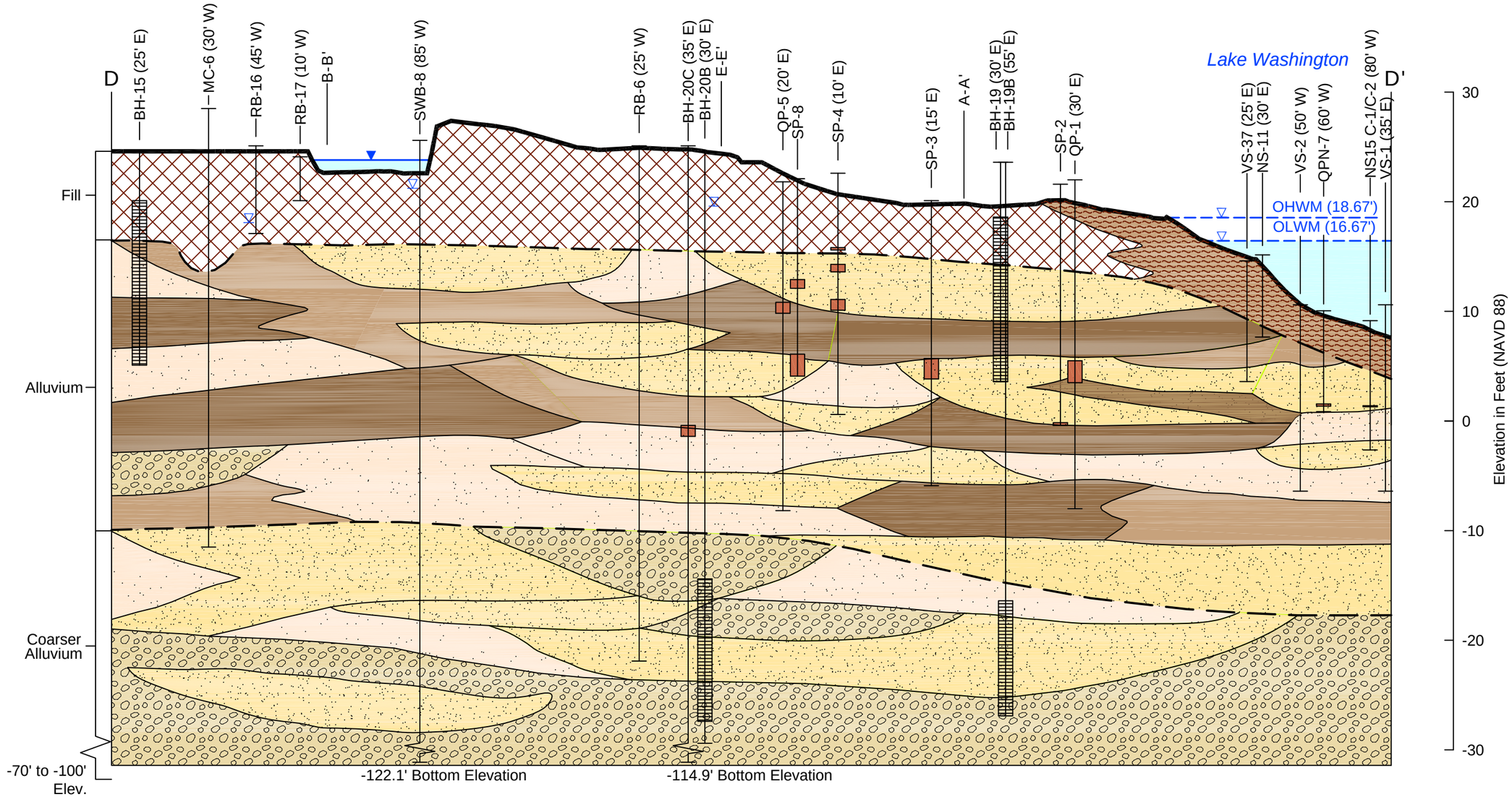
Aspect CONSULTING

Geologic Cross Section C-C'

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.1-8
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-318.dwg Figure 3.1-8 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 2:28pm || User: scudd



Legend

BH-15 (25' E) — Well ID and Offset from Cross Section

Water Level ATD — Solidified Tar Products

Non-Aqueous Phase Liquids

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Horizontal Scale

0 100 200

Feet

Vertical Scale

0 10 20

Feet

Vertical Exaggeration 10X

Aspect CONSULTING

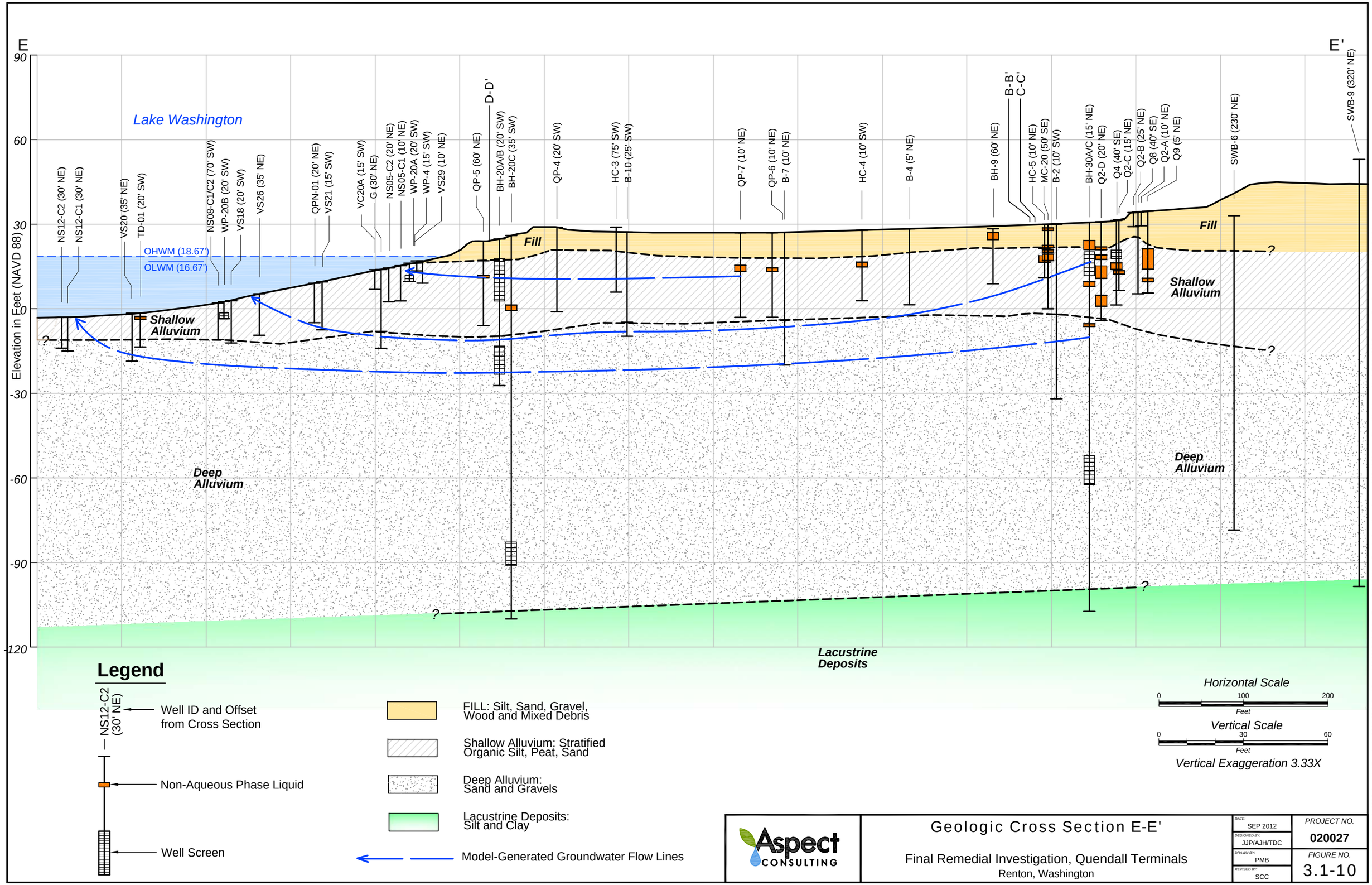
Geologic Cross Section D-D'

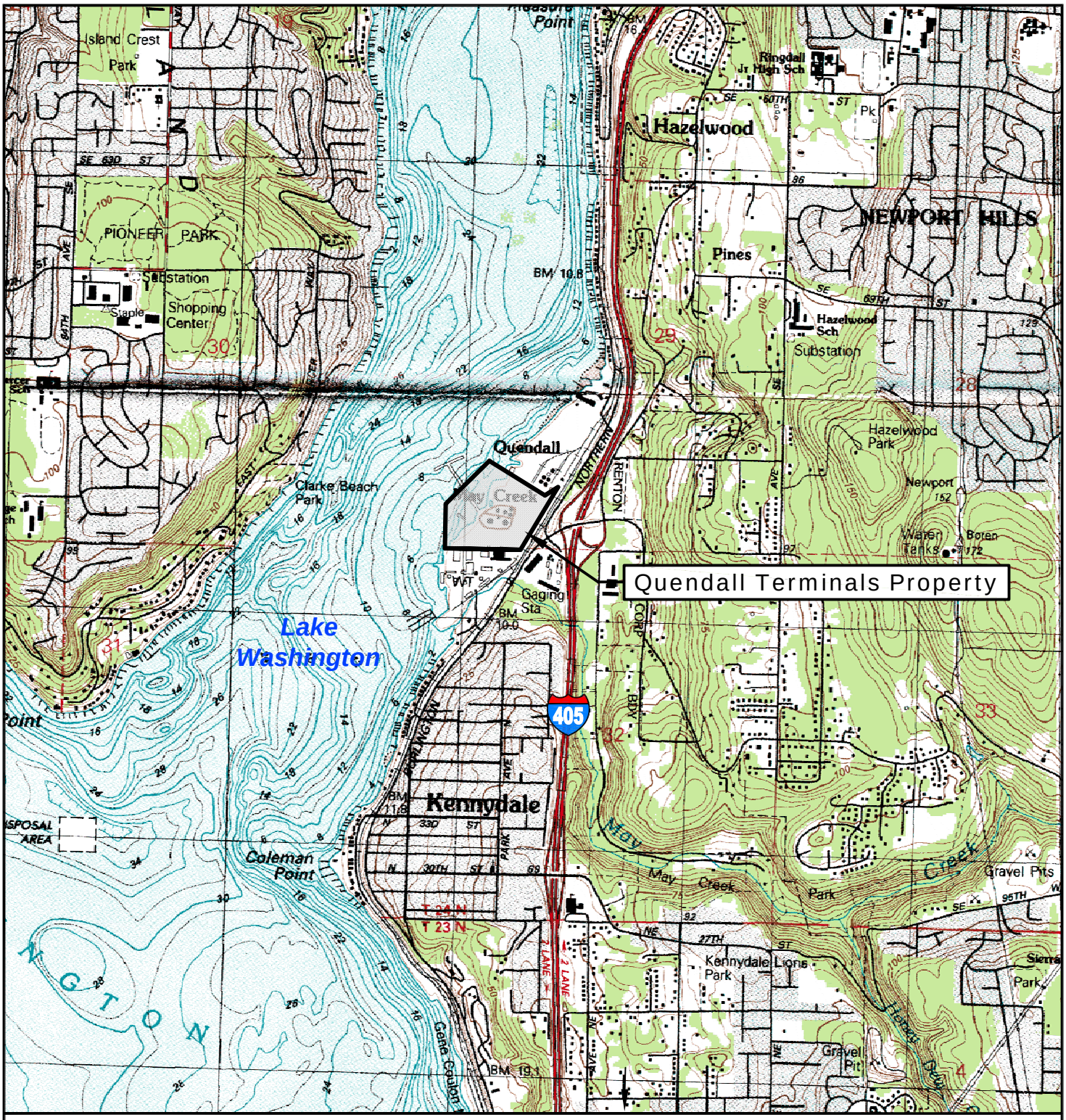
Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.1-9
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-319.dwg Figure 3.1-9 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 2:45pm || User: scudd


E
E'
Elevation in Feet (NAVD 88)
90
60
30
0
-30
-60
-90
-120
Lake Washington
OHWM (18.67')
OLWM (16.67')
NS12-C2 (30' NE)
NS12-C1 (30' NE)
VS20 (35' NE)
TD-01 (20' SW)
NS08-C1/C2 (70' SW)
WP-20B (20' SW)
VS18 (20' SW)
VS26 (35' NE)
QPN-01 (20' NE)
VS21 (15' SW)
VC20A (15' SW)
G (30' NE)
NS05-C2 (20' NE)
NS05-C1 (10' NE)
WP-20A (20' SW)
WP-4 (15' SW)
VS29 (10' NE)
QP-5 (60' NE)
D-D'
BH-20A/B (20' SW)
BH-20C (35' SW)
QP-4 (20' SW)
HC-3 (75' SW)
B-10 (25' SW)
QP-7 (10' NE)
QP-6 (10' NE)
B-7 (10' NE)
HC-4 (10' SW)
B-4 (5' NE)
BH-9 (60' NE)
B-B'
C-C'
HC-5 (10' NE)
MC-20 (50' SE)
B-2 (10' SW)
BH-30A/C (15' NE)
Q2-D (20' NE)
Q4 (40' SE)
Q2-C (15' NE)
Q2-B (25' NE)
Q8 (40' SE)
Q2-A (10' NE)
Q9 (5' NE)
SWB-6 (230' NE)
SWB-9 (320' NE)
Fill
Shallow Alluvium
Deep Alluvium
Lacustrine Deposits
?
Legend
NS12-C2 (30' NE)
Well ID and Offset from Cross Section
Non-Aqueous Phase Liquid
Well Screen
FILL: Silt, Sand, Gravel, Wood and Mixed Debris
Shallow Alluvium: Stratified Organic Silt, Peat, Sand
Deep Alluvium: Sand and Gravels
Lacustrine Deposits: Silt and Clay
Model-Generated Groundwater Flow Lines
Horizontal Scale
0
100
200
Feet
Vertical Scale
0
30
60
Feet
Vertical Exaggeration 3.33X
Aspect CONSULTING
Geologic Cross Section E-E'
Final Remedial Investigation, Quendall Terminals
Renton, Washington
DATE: SEP 2012
DESIGNED BY: JJP/AJH/TDC
DRAWN BY: PMB
REVISED BY: SCC
PROJECT NO. 020027
FIGURE NO. 3.1-10
CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3110.dwg Figure 3.1-10 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 4:04pm || User: scudd



Base map USGS Bellevue South Quadrangle. Contour interval is 5 meters.

Aspect CONSULTING

Topographic Map of Site Vicinity

Final Remedial Investigation, Quendall Terminals
Renton, Washington

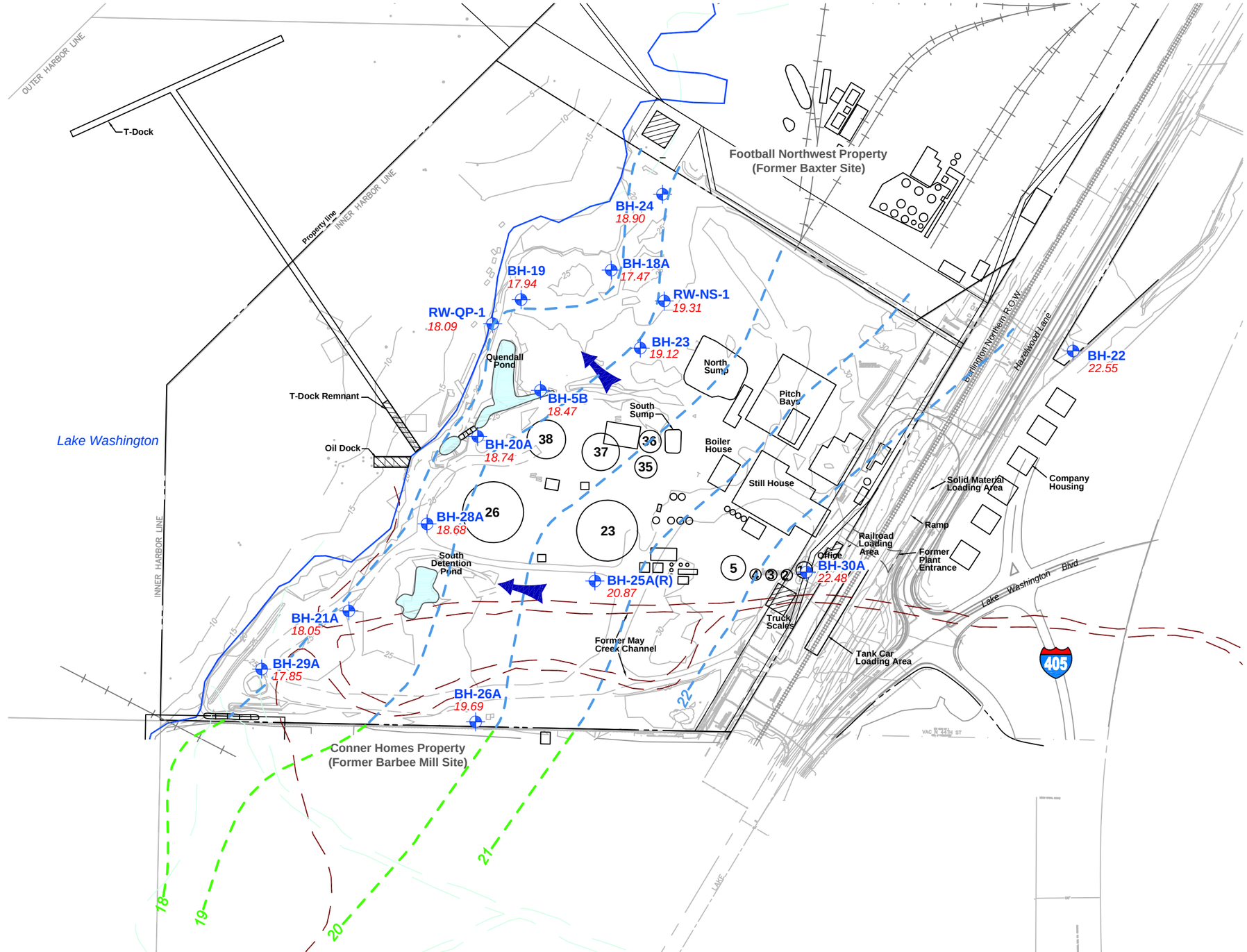
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 3.1-11
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012 09 RI Final Report\020027-3111.dwg Figure 3.1-11 (8.5 x 11) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 3:11pm || User: soudd

Legend

- BH-22 / 22.55 — Monitoring Well with Data from September 2009 (Aspect)
- 20 — Groundwater Elevation Contour (September 2009)
- Inferred Direction of Groundwater Flow
- 20 — Groundwater Elevation Contour for adjacent Connor Homes Property (former Barbee Mill Site)
- Detention Ponds
- Existing Structures
- Historical Structures

Note: Elevations in feet (NAVD 88)



Aspect CONSULTING

September 2009 Groundwater Elevation Contour Map
Shallow Aquifer

Final Remedial Investigation, Quendall Terminals
Renton, Washington

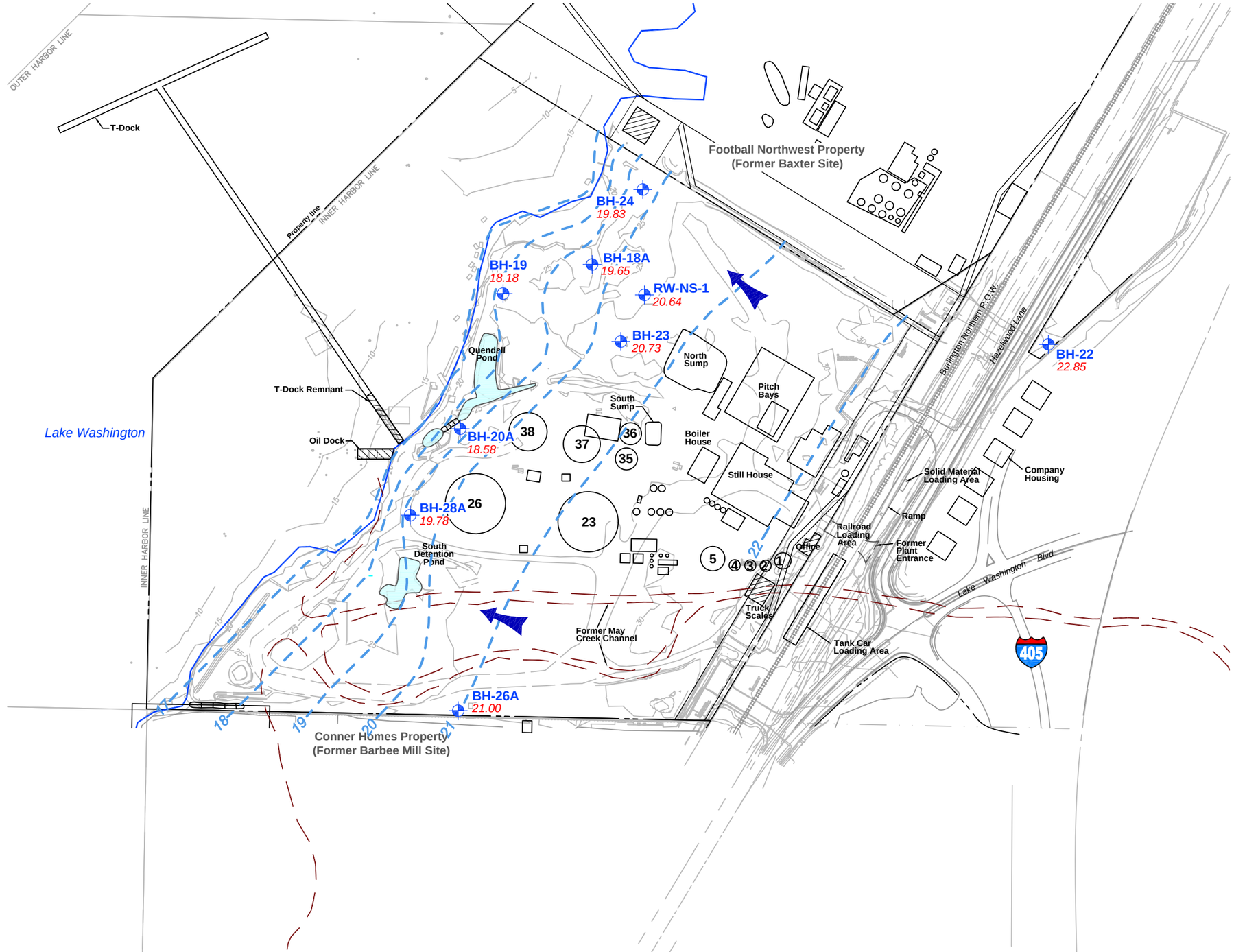
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM/JJS	
DRAWN BY: PMB	FIGURE NO. 3.1-12
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3112.dwg Figure 3.1-12 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 4:13pm || User: scudd

Legend

- BH-24 / 19.83 — Monitoring Well with Data from November 2008 (Aspect)
- 19 — Groundwater Elevation Contour (November 2008)
- Inferred Direction of Groundwater Flow
- Detention Ponds
- Existing Structures
- Historical Structures

Note: Elevations in feet (NAVD 88)



Aspect CONSULTING

November 2008 Groundwater Elevation Contour Map
Shallow Aquifer

Final Remedial Investigation, Quendall Terminals
Renton, Washington

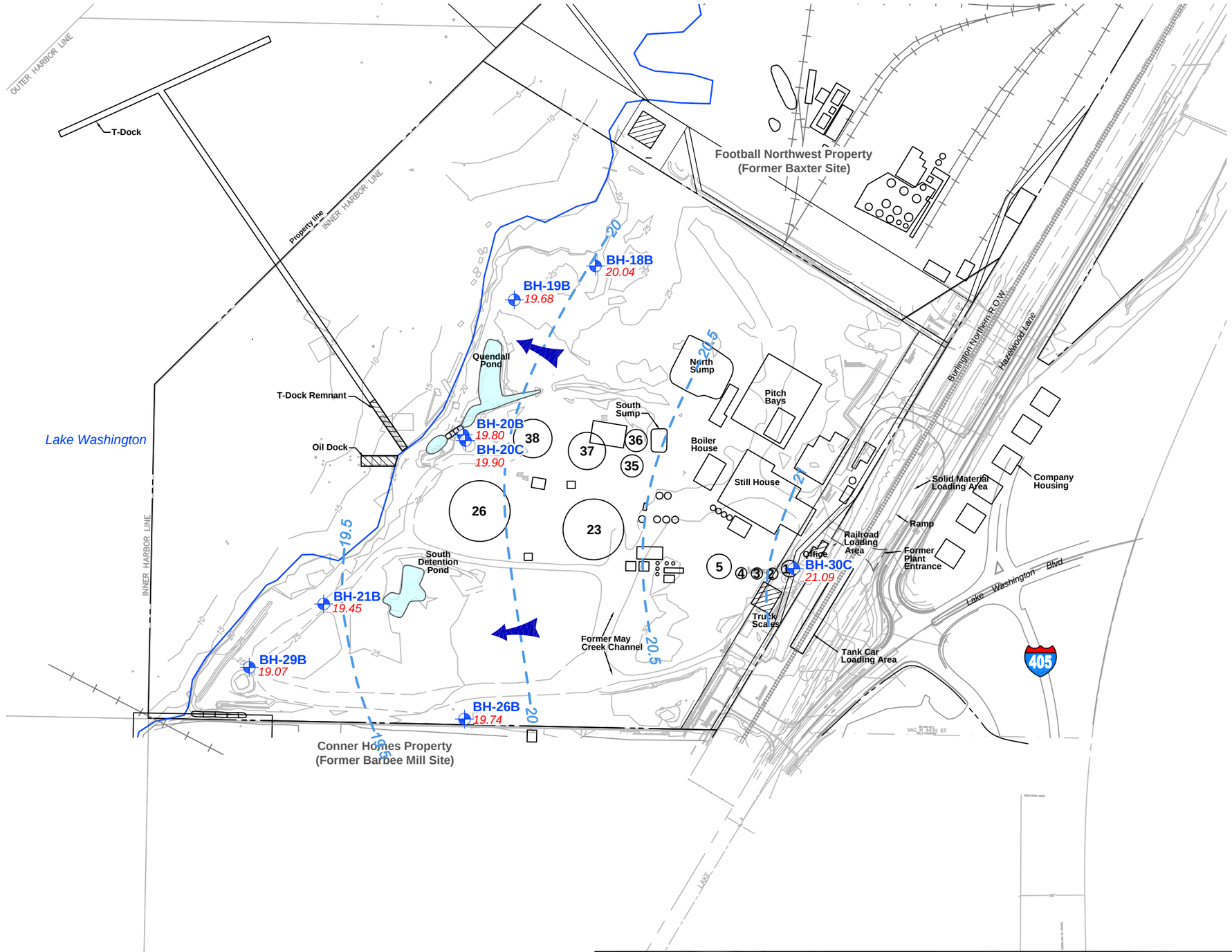
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM	
DRAWN BY: PMB	FIGURE NO. 3.1-13
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3113.dwg Figure 3.1-13 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 4:18pm || User: scudd

Legend

- BH-19B 19.68 — Monitoring Well with Data from September 2009 (Aspect)
- 20 — Groundwater Elevation Contour (September 2009)
- Inferred Direction of Groundwater Flow
- Detention Ponds
- Existing Structures
- Historical Structures

Note: Elevations in feet (NAVD 88).



Aspect CONSULTING

September 2009 Groundwater Elevation Contour Map
Deep Aquifer

Final Remedial Investigation, Quendall Terminals
Renton, Washington

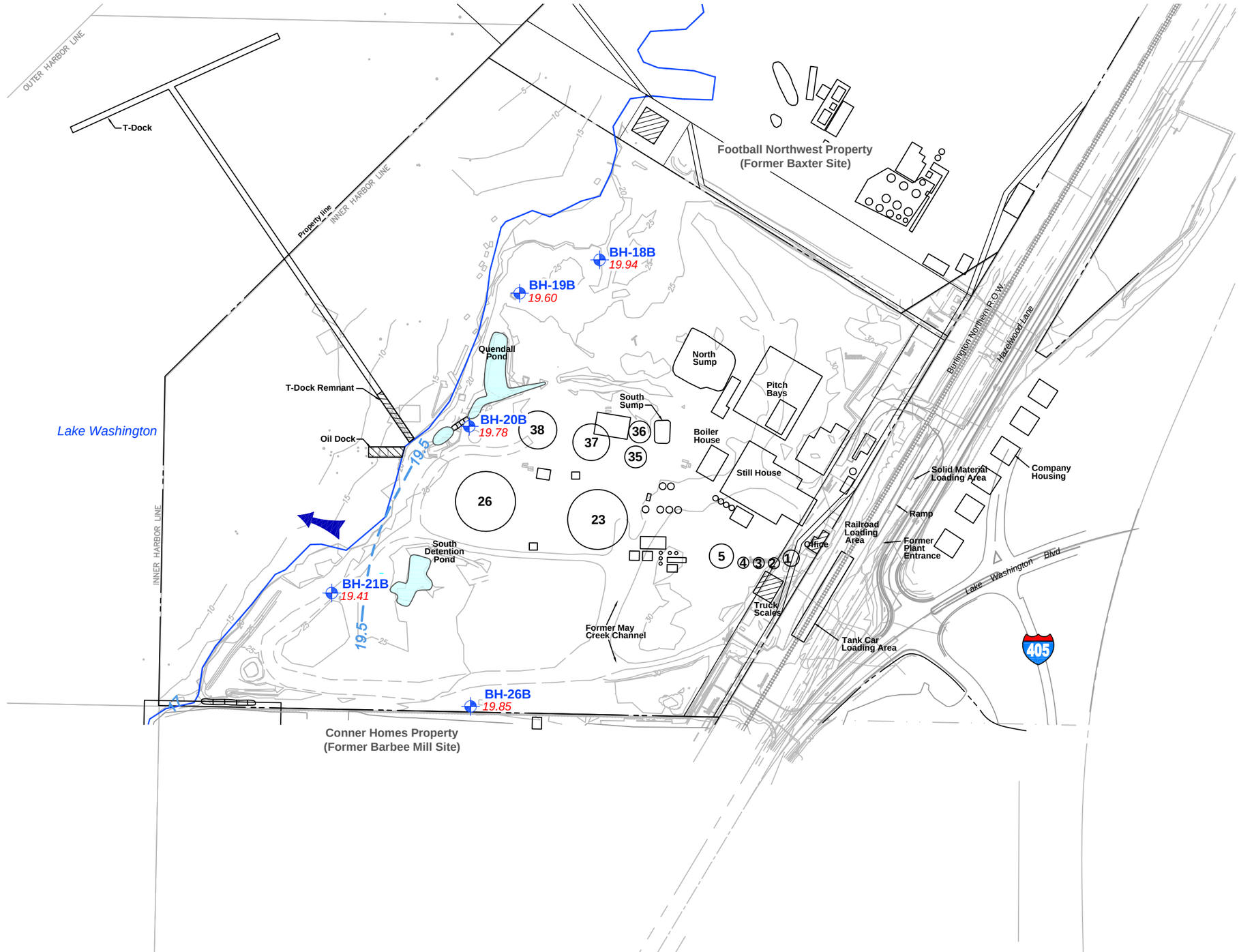
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM/JJS	
DRAWN BY: PMB	FIGURE NO. 3.1-14
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3114.dwg Figure 3.1-14 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 4:23pm || User: scudd

Legend

- **BH-19B** *19.60* — Monitoring Well with Data from November 2008 (Aspect)
- *19.5* — Groundwater Elevation Contour (November 2008)
- Inferred Direction of Groundwater Flow
- Detention Ponds
- Existing Structures
- Historical Structures

Note: Elevations in feet (NAVD 88)



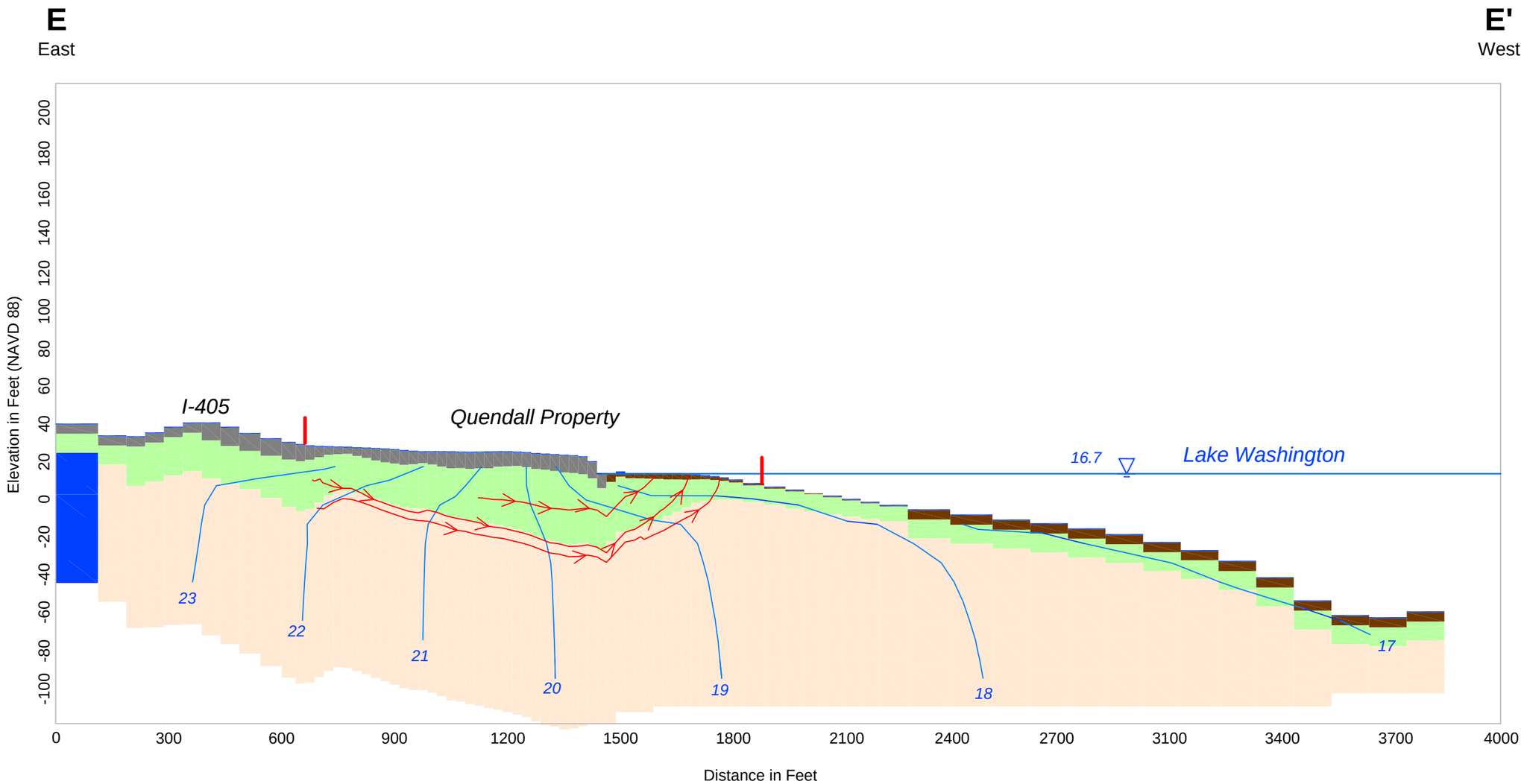
Aspect CONSULTING

November 2008 Groundwater Elevation Contour Map
Deep Aquifer

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM/JJS	
DRAWN BY: PMB	FIGURE NO. 3.1-15
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3115.dwg Figure 3.1-15 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 10, 2012 4:27pm || User: scudd



Legend

- Fill
- Shallow Aquifer
- Deep Aquifer
- Lake Washington Sediments
- Constant Head Boundary Cell
- Quendall Property Boundary
- Contours of Hydraulic Head in Feet
- Particle Traces (Arrows Represent 1 Year of Particle Travel Time)

0 300 600
Feet

5x Vertical Exaggeration

All elevations are in feet NAVD 88.

Aspect CONSULTING

Groundwater Particle Tracking,
Cross Section E-E'
Final Remedial Investigation, Quendall Terminals
Renton, Washington

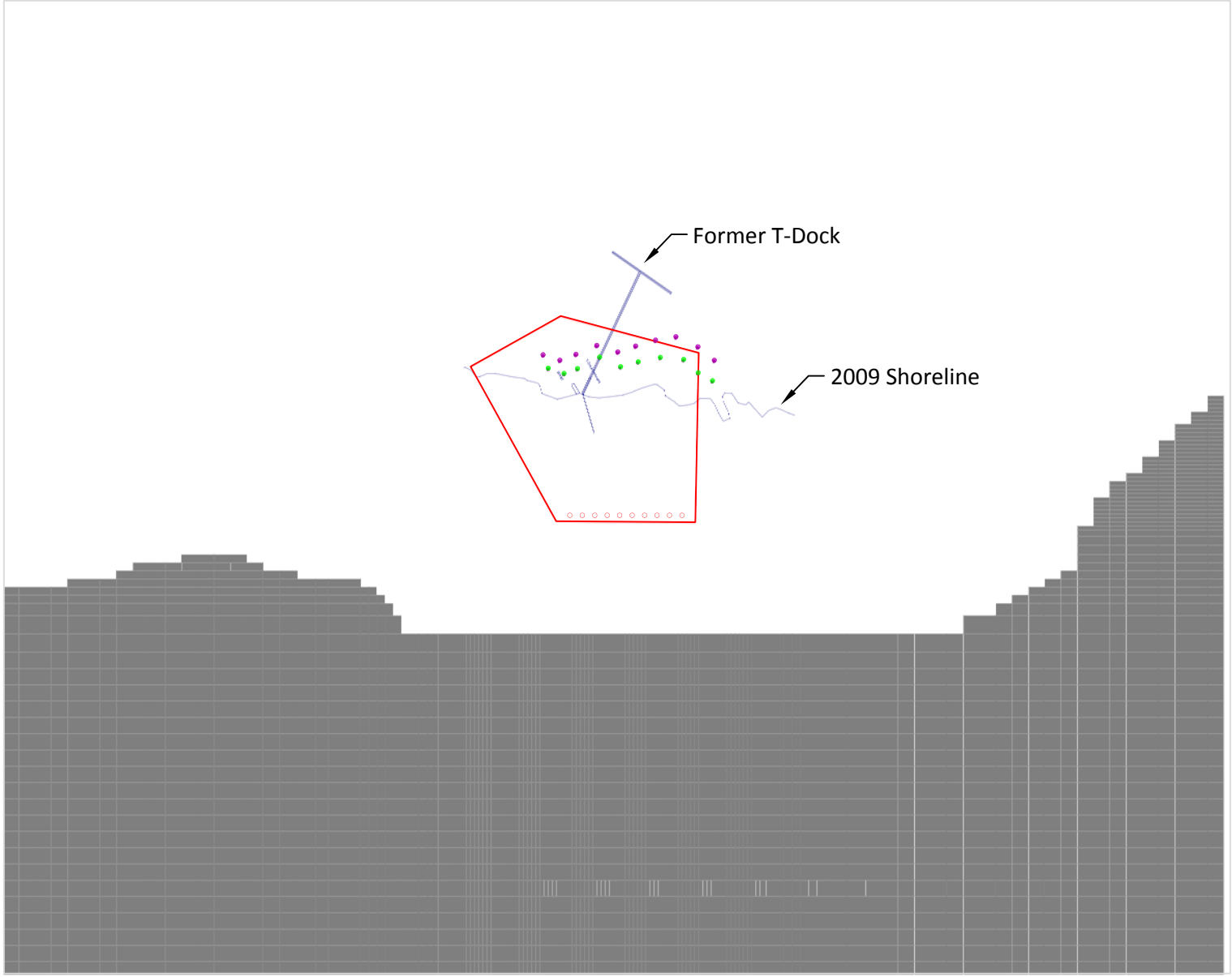
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM	
DRAWN BY: SCC/PMB	FIGURE NO. 3.1-16
REVISED BY: SCC	

Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3116.dwg Figure 3.1-16

Sep 10, 2012 4:38pm scudd

Legend

- No-Flow Boundary
- Quendall Property Boundary
- Discharge Point of Particles Released from 15 Feet Below Ground Surface
- Discharge Point of Particles Released from 33 Feet Below Ground Surface
- Release Point of Particles



N

0 1000 2000
Feet

Aspect CONSULTING

Groundwater Particle Tracking Plan View, Shallow and Deep Aquifer

Final Remedial Investigation, Quendall Terminals

Renton, Washington

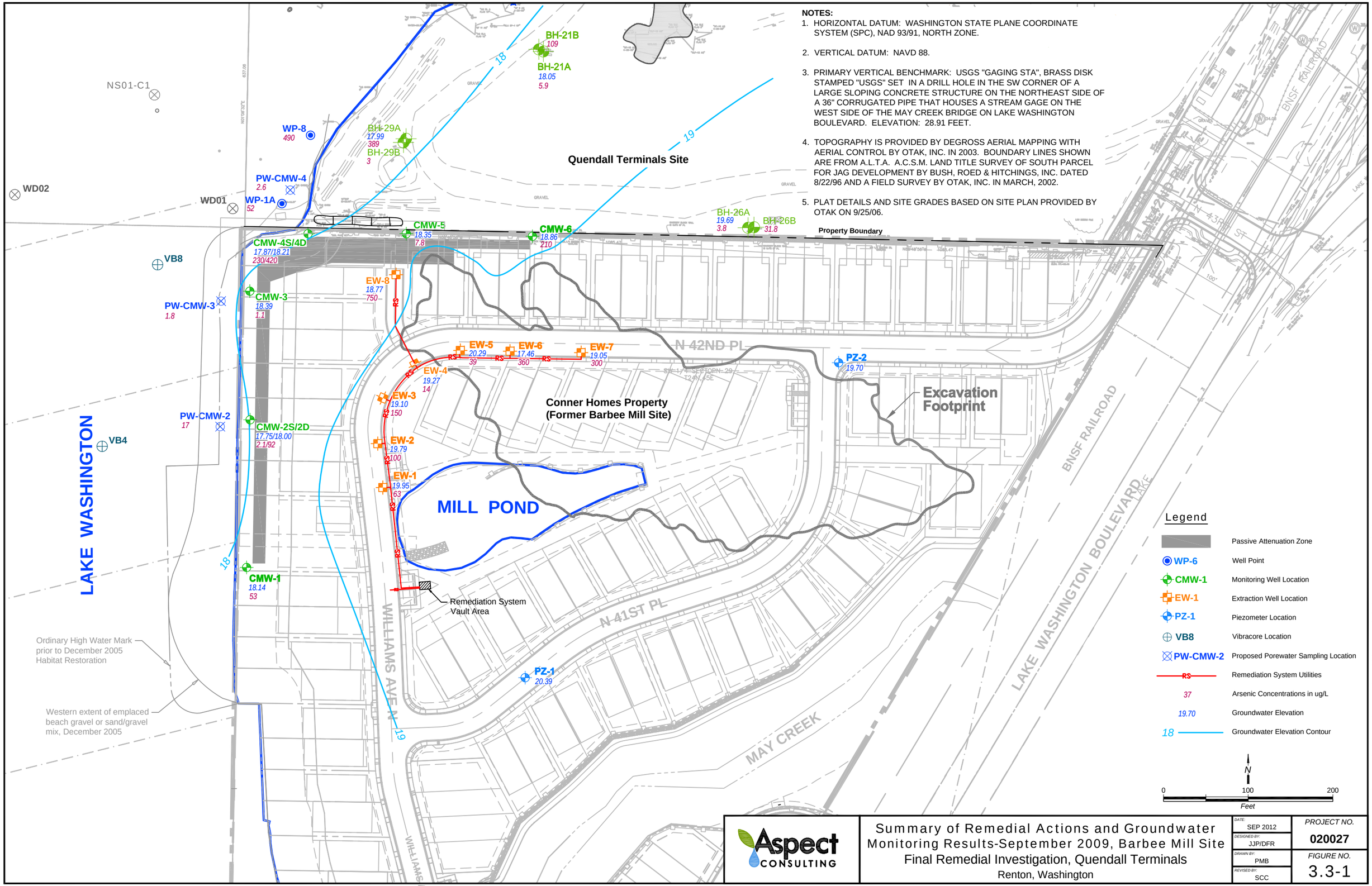
DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM	
DRAWN BY: SCC/PMB	FIGURE NO. 3.1-17
REVISED BY: SCC	

Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-3117.dwg Figure 3.1-17 (8.5 x 11)

Sep 10, 2012 4:43pm scudd

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE COORDINATE SYSTEM (SPC), NAD 93/91, NORTH ZONE.
2. VERTICAL DATUM: NAVD 88.
3. PRIMARY VERTICAL BENCHMARK: USGS "GAGING STA", BRASS DISK STAMPED "USGS" SET IN A DRILL HOLE IN THE SW CORNER OF A LARGE SLOPING CONCRETE STRUCTURE ON THE NORTHEAST SIDE OF A 36" CORRUGATED PIPE THAT HOUSES A STREAM GAGE ON THE WEST SIDE OF THE MAY CREEK BRIDGE ON LAKE WASHINGTON BOULEVARD. ELEVATION: 28.91 FEET.
4. TOPOGRAPHY IS PROVIDED BY DEGROSS AERIAL MAPPING WITH AERIAL CONTROL BY OTAK, INC. IN 2003. BOUNDARY LINES SHOWN ARE FROM A.L.T.A. A.C.S.M. LAND TITLE SURVEY OF SOUTH PARCEL FOR JAG DEVELOPMENT BY BUSH, ROED & HITCHINGS, INC. DATED 8/22/96 AND A FIELD SURVEY BY OTAK, INC. IN MARCH, 2002.
5. PLAT DETAILS AND SITE GRADES BASED ON SITE PLAN PROVIDED BY OTAK ON 9/25/06.

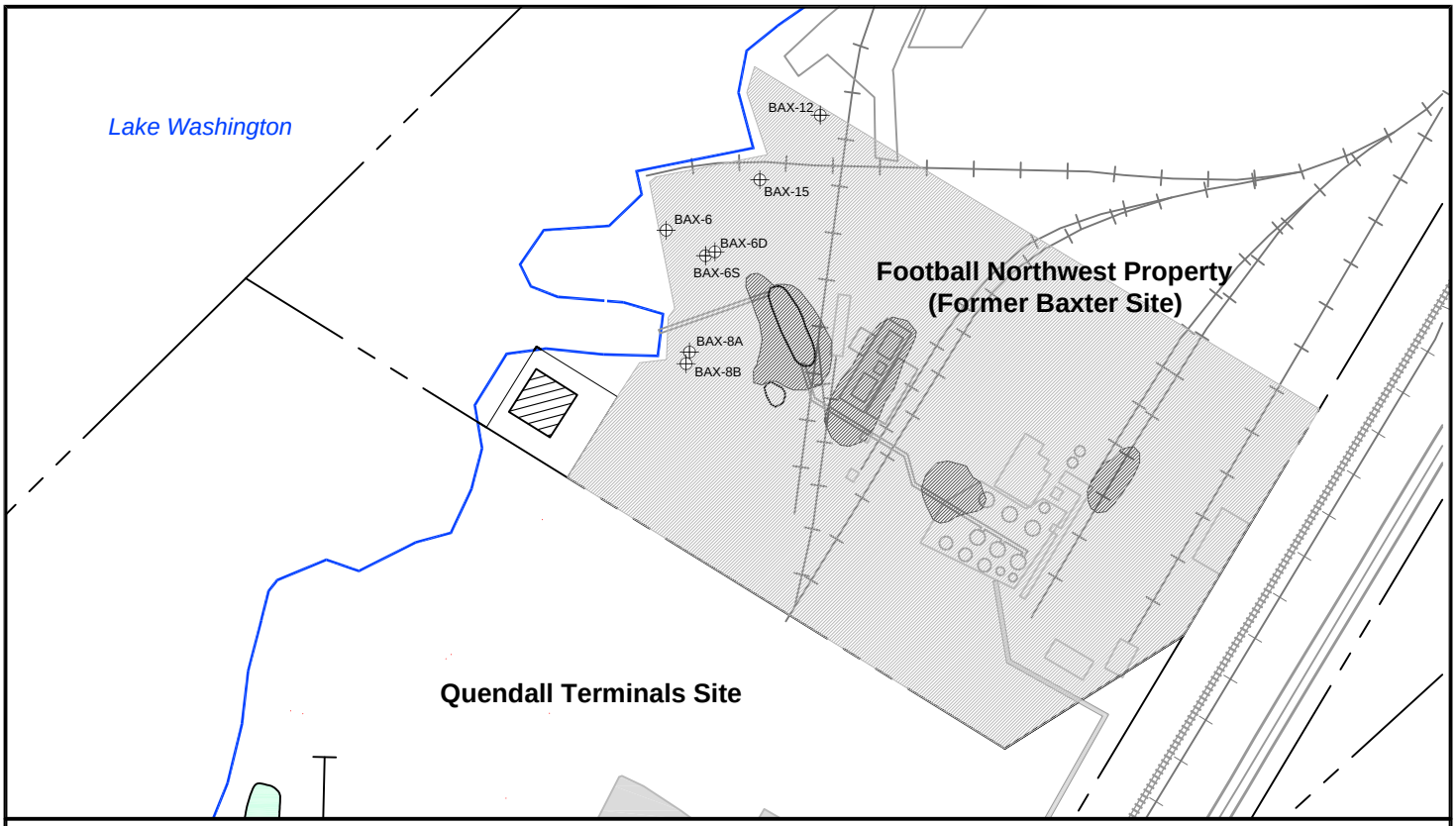


Aspect CONSULTING

Summary of Remedial Actions and Groundwater Monitoring Results-September 2009, Barbee Mill Site
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/DFR	
DRAWN BY: PMB	FIGURE NO. 3.3-1
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report 01\020027-331.dwg Figure 3.3-1 (11x17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 24, 2012 1:48pm || User: scudd



Legend

- Environmental Cap
- Areas of Excavation or In-situ Stabilization
- Compliance Monitoring Well

N

0 200 400

Feet

Note:
Information compiled from Cleanup Action Plan, J.H. Baxter South Property, Renton, WA. (Retec 2000)

Aspect CONSULTING

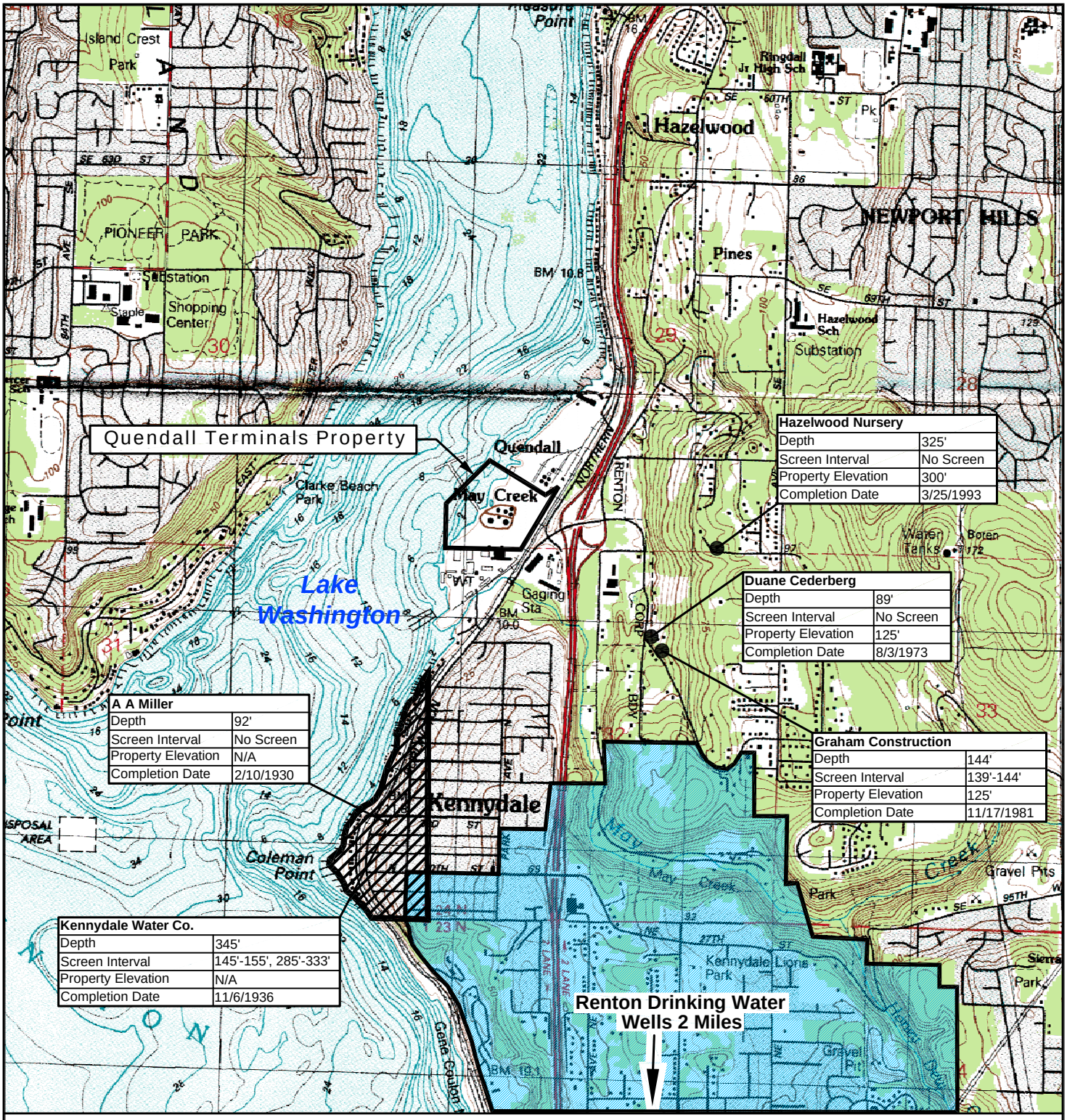
Summary of Environmental Conditions and Remedial Actions, Football Northwest Property

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.3-2
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-332.dwg Figure 3.3-2 (8.5 x 11) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 10:59am || User: scudd



Legend

- Water Well
- Wells listed under AA Miller and Kennydale Water Co. are located within hatched area (Section 31, T24N, R5E). Exact location not provided on well log.
- Renton Aquifer Protection Zone

Notes:

1) Well information based on well log database at Washington State Department of Ecology website. Refer to Table 3.3-1 for complete well information, including a list of abandoned water wells.
2) Base map USGS Bellevue South Quadrangle. Contour interval is 5 meters.

N

0 2000 4000
Feet

Aspect CONSULTING

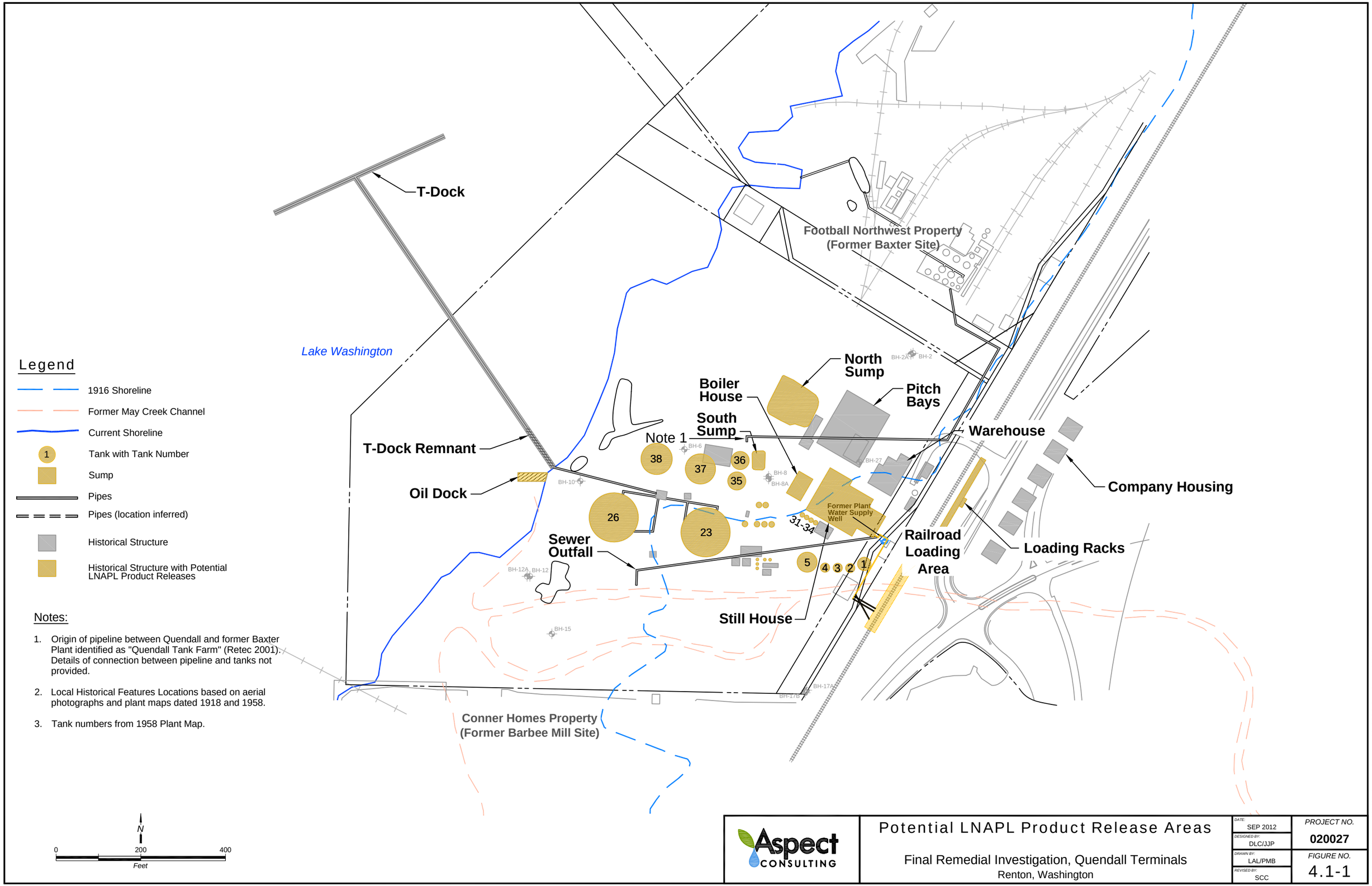
Locations of Water Wells Within 0.5 Mile of Quendall Terminals Site

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 3.3-3
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-333.dwg Figure 3.3-3 (8.5x11) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 11:22am || User: scudd



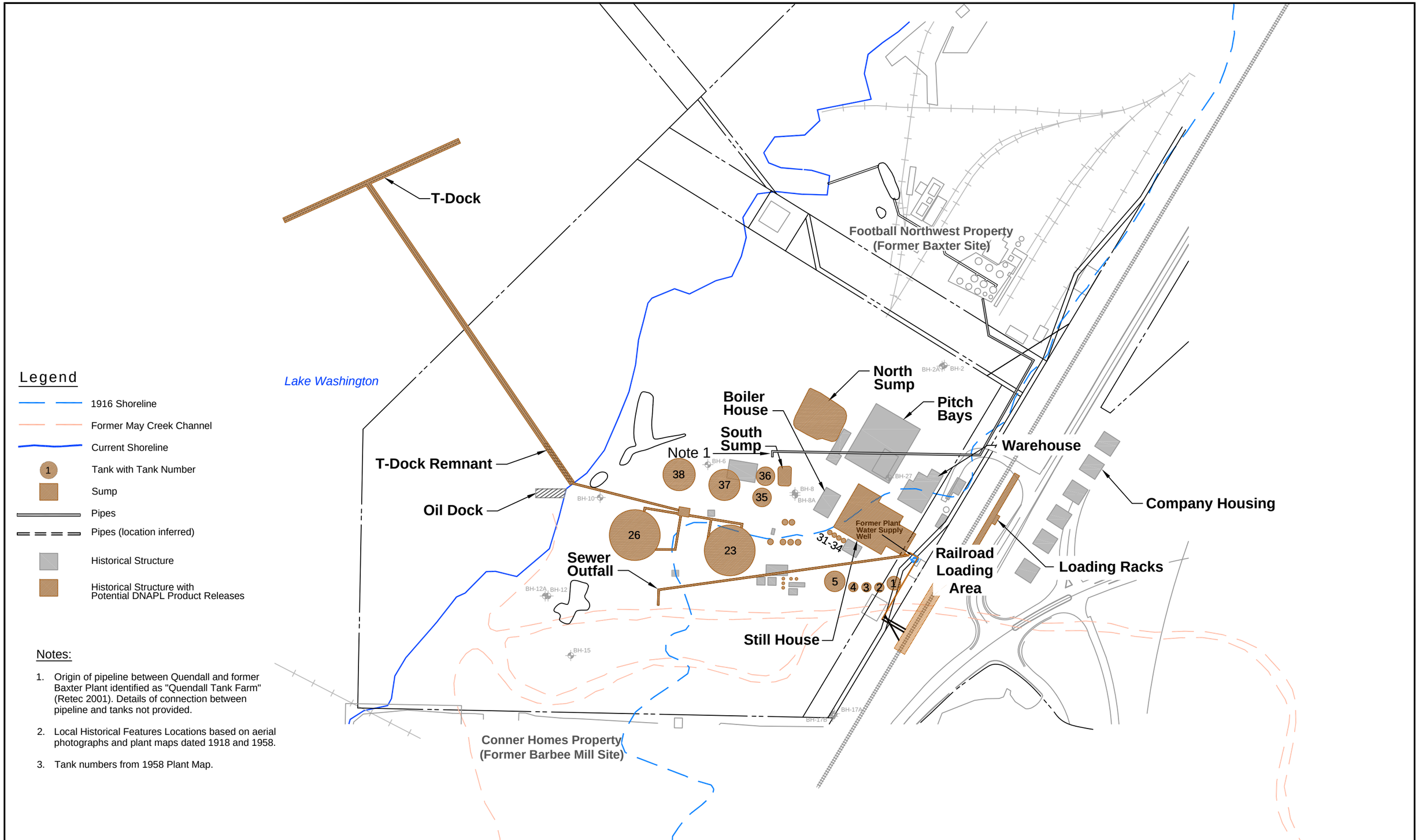
Aspect CONSULTING

Potential LNAPL Product Release Areas

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 4.1-1
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-411.dwg Figure 4.1-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 11:50am || User: scudd



Legend

- 1916 Shoreline
- Former May Creek Channel
- Current Shoreline
- Tank with Tank Number
- Sump
- Pipes
- Pipes (location inferred)
- Historical Structure
- Historical Structure with Potential DNAPL Product Releases

Notes:

1. Origin of pipeline between Quendall and former Baxter Plant identified as "Quendall Tank Farm" (Retec 2001). Details of connection between pipeline and tanks not provided.
2. Local Historical Features Locations based on aerial photographs and plant maps dated 1918 and 1958.
3. Tank numbers from 1958 Plant Map.

N

0 200 400
Feet

Aspect CONSULTING

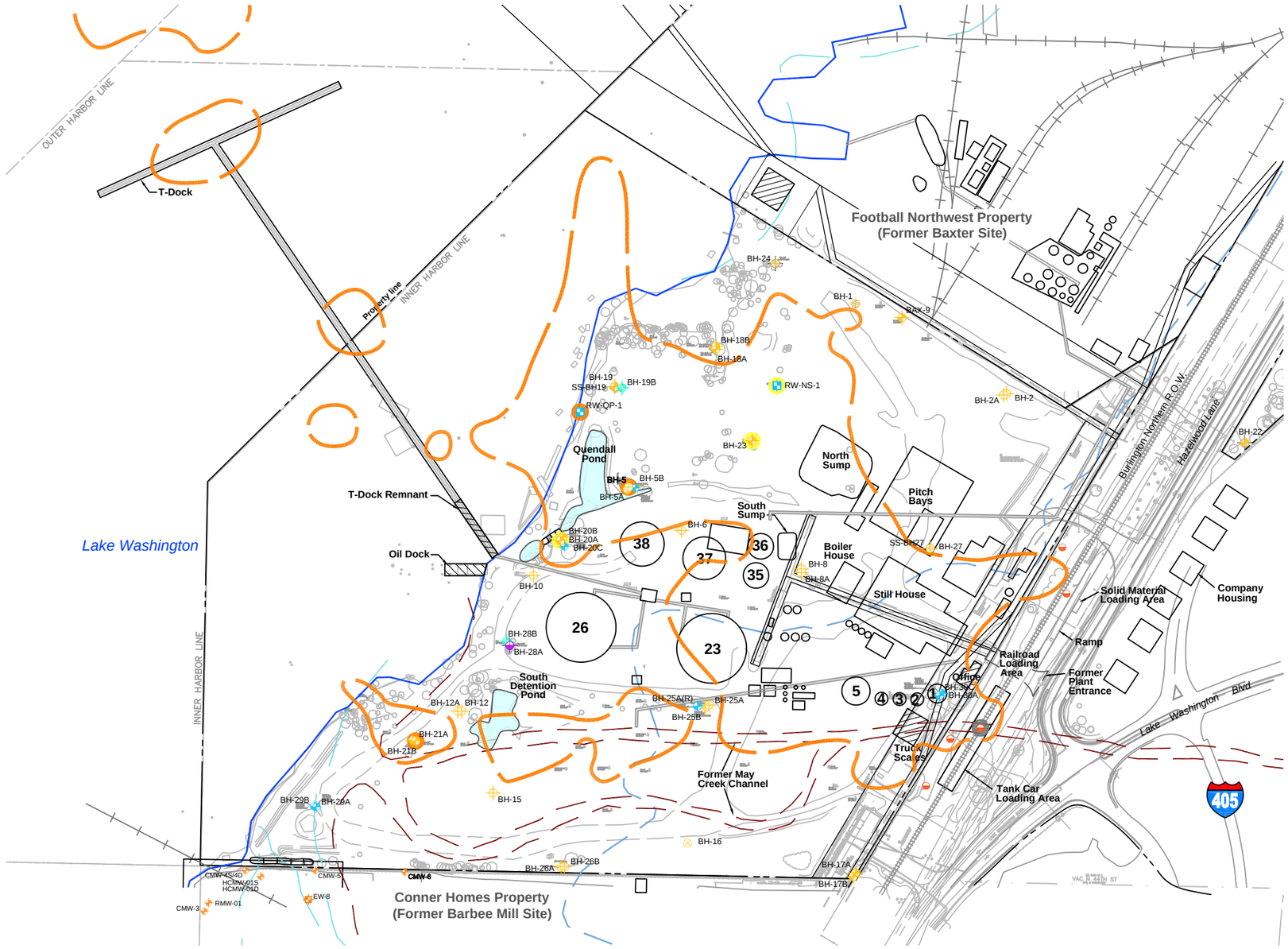
Potential DNAPL Product Release Areas

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: LAL/PMB	FIGURE NO. 4.1-2
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-412.dwg Figure 4.1-2 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 11:53am || User: scudd

Figure 4.2-1
Tar on Sidewall of Trench T-7
Final Remedial Investigation, Quendall Terminals



Summary of Explorations by Consultant

Consultant	Year	Exploration Type	Exploration ID	Map Symbol
Aspect Consulting	2007	Monitoring Wells	CMW-1 through CMW-6	
	2007	Extraction Wells	EW-1 through EW-8	
	2009	Monitoring Wells	BH-5B, BH-25A(R), BH-29A, BH-29B, BH-30A, BH-30C	
	2003	Monitoring Wells	RW-NS-1, RW-QP-1	
Pinnacle Geosciences	2008	Monitoring Wells	Q4, Q9, Q12, Q14, Q17	
Retec	2000	Monitoring Wells	BH-19B, BH-28B	
Hart Crowser	1995, 1996	Monitoring Wells	BH-28A	
Woodward Clyde	1990	Monitoring Wells	BH-24, BH-25A, BH-25B, BH-26A, BH-26B, BH-27	
Woodward Clyde	1988	Monitoring Wells	BH-17A, BH-17B, BH-18A, BH-18B, BH-19, BH-20A, BH-20B, BH-21A, BH-21B, BH-22, BH-23, BAX-9	
Woodward Clyde	1983	Monitoring Wells	BH-1, BH-2, BH-2A, BH-5, BH-5A, BH-6, BH-8, BH-8A, BH-10, BH-12, BH-12A, BH-15	

Estimated Extent of DNAPL (see figure 4.4-1)

Orange indicates well contains product that recovers after purging

Yellow indicates well contained product at initial installation but product did not recover after purging

Gray indicates product is present, but has not been purged to evaluate recovery

Legend

- Shoreline (2009)
- Shoreline (1936)
- Shoreline (1916)
- May Creek (1920)
- Existing structure
- Historical structure
- Other historical features

N

0 200 400
Feet

Aspect CONSULTING

Product Observations at Site Monitoring Wells

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: MS/PMB	FIGURE NO. 4.3-1
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-431.dwg Figure 4.3-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 12:00pm || User: scudd

Legend

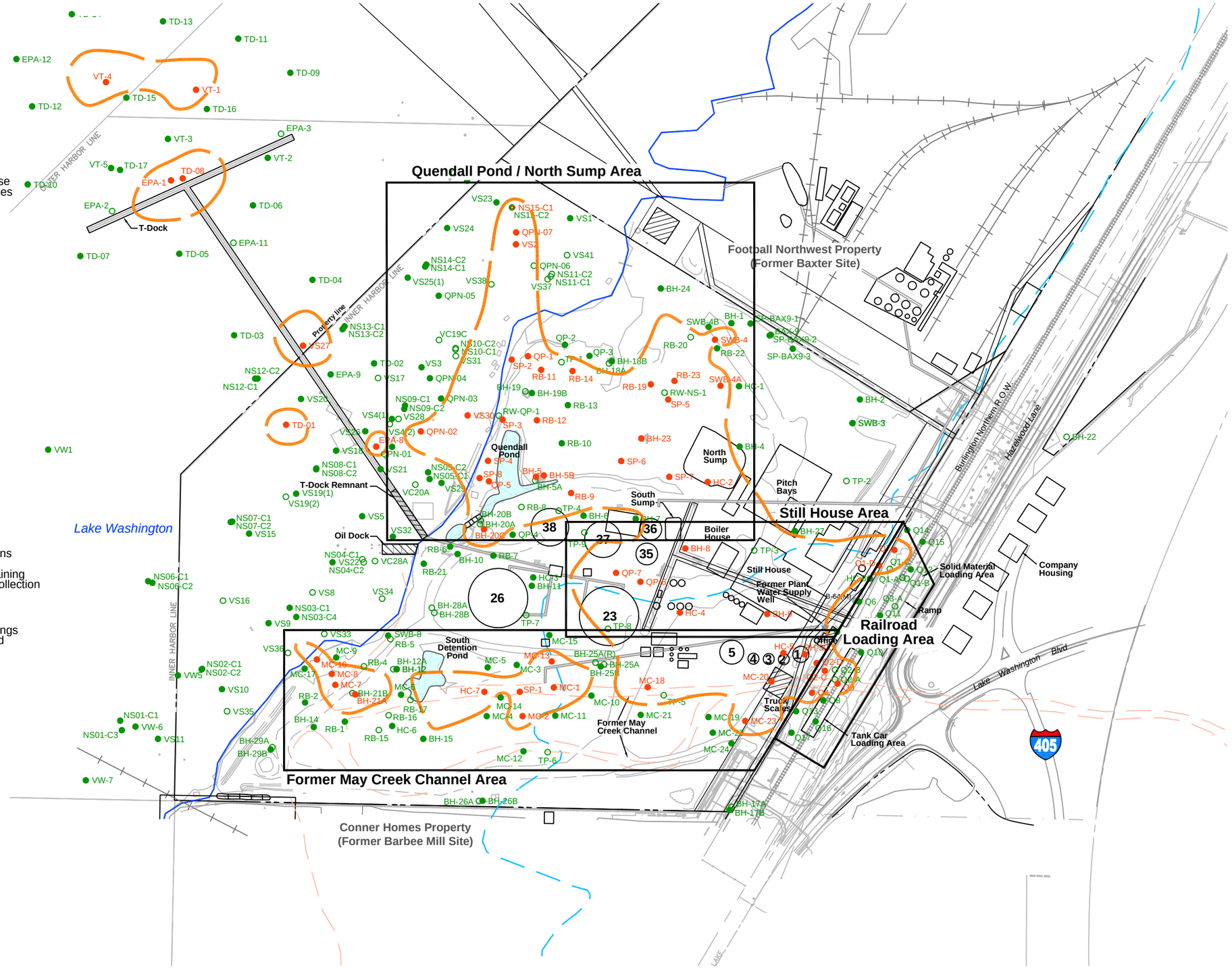
- TD-08 Boring w/ DNAPL
- VT-3 Boring w/ no DNAPL
- EPA-2 Boring w/ no DNAPL but base is above adjacent occurrences or no samples collected
- Maximum Extent of DNAPL
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Current Shoreline
- 1916 Shoreline
- Former May Creek Channel

Notes

1. DNAPL occurrences based on observations of oil-coated or oil-wetted soil. Soil exhibiting only sheen or staining not identified as containing DNAPL. See Attachment A-11 of the Data Collection Work Plan (Anchor QEA & Aspect 2009a).

2. Boundaries generally based on midpoint between borings containing DNAPL and borings with no DNAPL (if sufficiently deep), adjusted to fit Surfer-generated contour intervals of DNAPL thickness (see Figure 4.4-4).

3. DNAPL occurrences at each boring are summarized in Tables G-1 through G-4 in Appendix G.



N

0 200 400

Feet

Aspect CONSULTING

Site Plan Showing DNAPL Occurrences

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: RRR/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 4.4-1
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-441.dwg Figure 4.4-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 12:16pm || User: scudd

Notes

1. DNAPL occurrences based on observations of oil-coated or oil-wetted soil. Soil exhibiting only sheen or staining not identified as containing DNAPL. See Attachment A-11 of the Data Collection Work Plan (Anchor QEA and Aspect 2009a).

2. Boundaries generally based on midpoint between borings containing DNAPL and borings with no DNAPL (if sufficiently deep), adjusted to fit Surfer-generated contour intervals of DNAPL thickness (see Figure 4.4-4).

3. DNAPL occurrences at each boring are summarized in Tables G-1 through G-4 of Appendix G.

Legend

- TD-08 — Boring w/ DNAPL
- VT-3 — Boring w/ no DNAPL
- EPA-2 — Boring w/ no DNAPL but base is above adjacent occurrences or no samples collected
- Maximum Extent of DNAPL
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features

Quendall Pond
T-Dock Remnant
Oil Dock
Lake Washington
South Sump
North Sump
Boiler House
Still House
Former Plant Water Supply Well
Office
Truck Scales
Tank Car Loading Area
South Detention Pond
Former May Creek Channel
LAKE WASHINGTON BLVD.

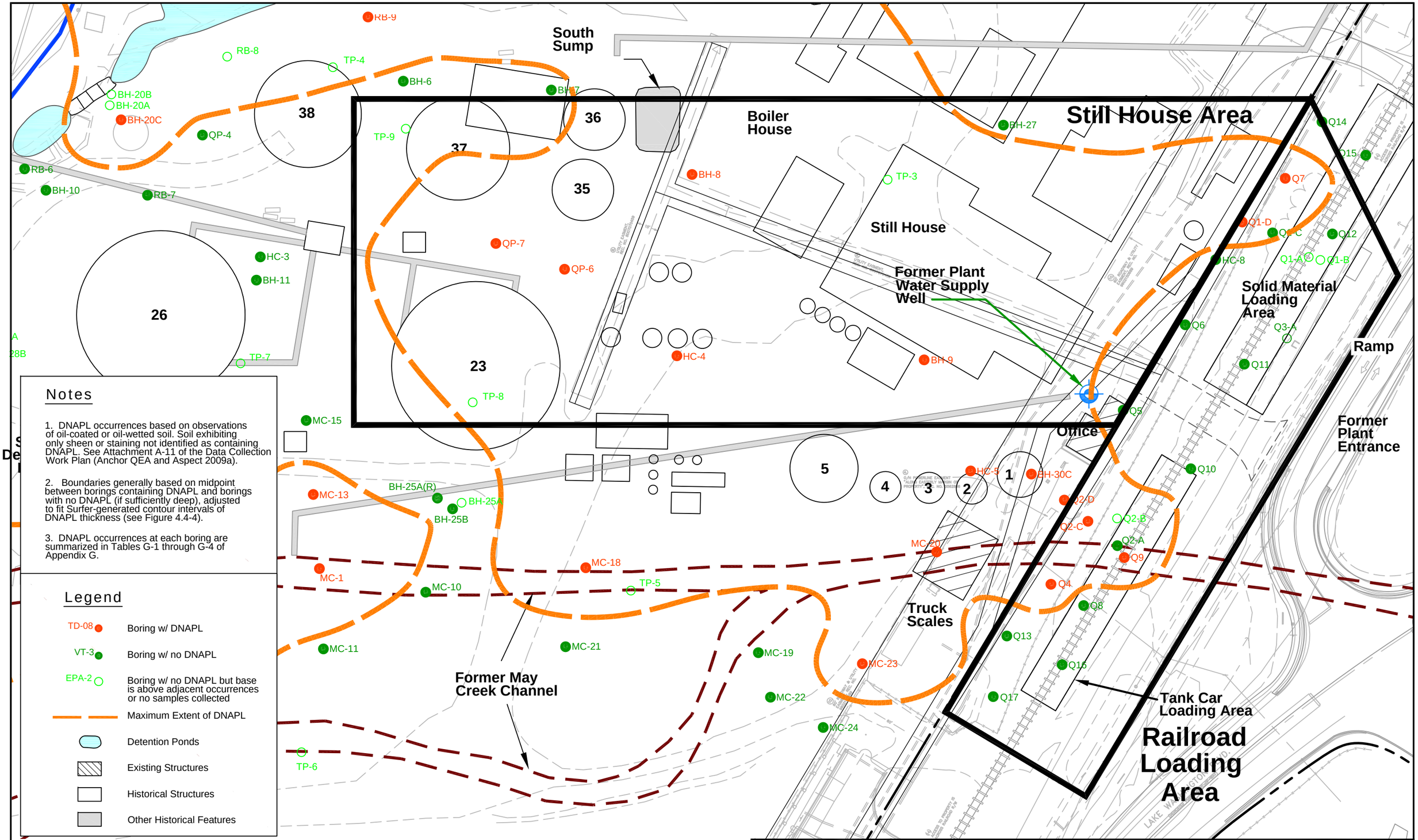
N
0 80 160
Feet

Aspect CONSULTING

DNAPL Occurrences in the Former May Creek Channel Area
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: RRR/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 4.4-1a
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report Keep Separate\020027-01-4.4-1abc.dwg Figure 4.4-1a May Creek || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 1:55pm || User: scudd



Aspect CONSULTING

DNAPL Occurrences in the Still House and Railroad Loading Areas

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: RRR/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 4.4-1b
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report Keep Separate\020027-01-441abc.dwg Figure 4.4-1b Still-Railroad || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 2:00pm || User: scudd

Notes

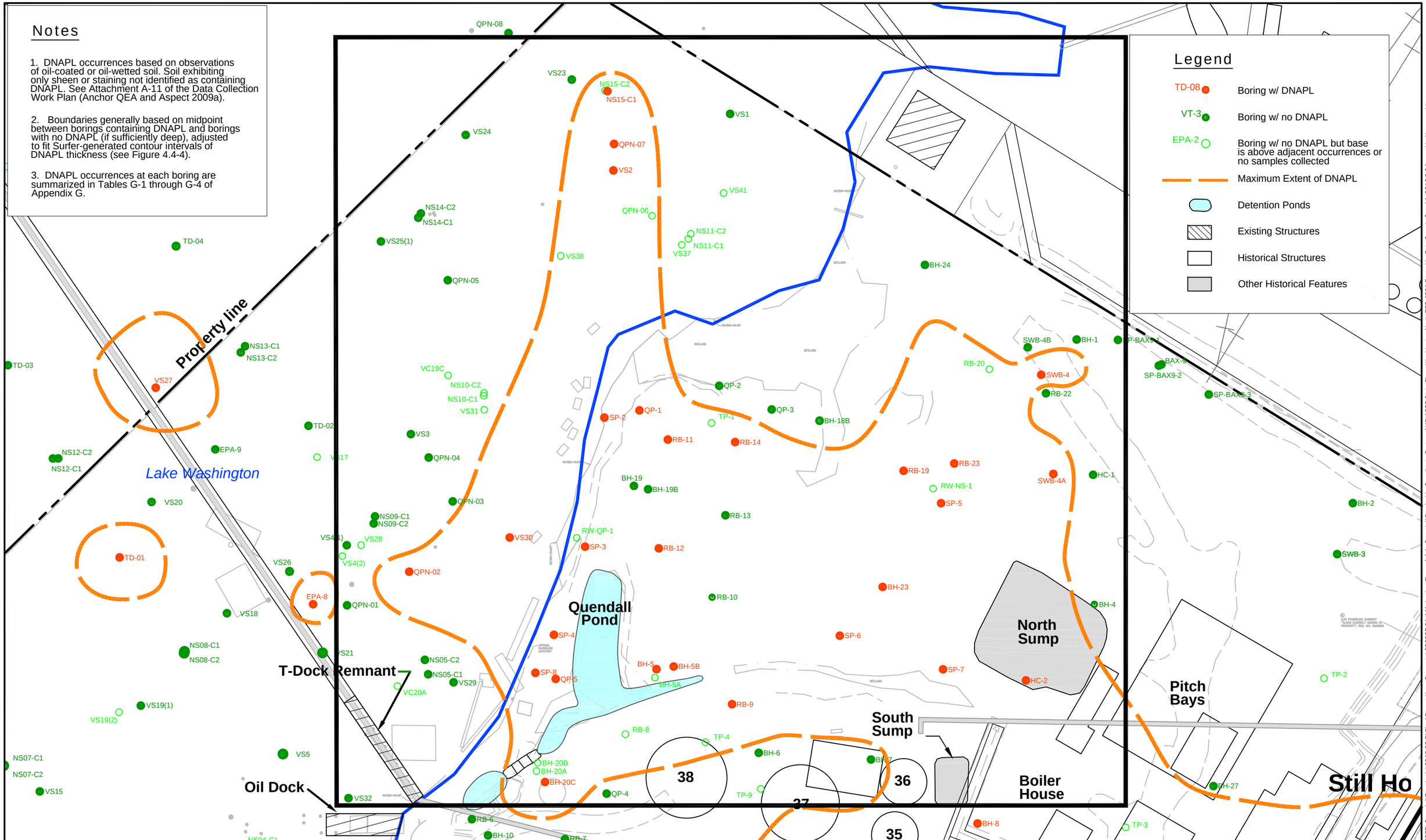
1. DNAPL occurrences based on observations of oil-coated or oil-wetted soil. Soil exhibiting only sheen or staining not identified as containing DNAPL. See Attachment A-11 of the Data Collection Work Plan (Anchor QEA and Aspect 2009a).

2. Boundaries generally based on midpoint between borings containing DNAPL and borings with no DNAPL (if sufficiently deep), adjusted to fit Surfer-generated contour intervals of DNAPL thickness (see Figure 4.4-4).

3. DNAPL occurrences at each boring are summarized in Tables G-1 through G-4 of Appendix G.

Legend

- TD-08 — Boring w/ DNAPL
- VT-3 — Boring w/ no DNAPL
- EPA-2 — Boring w/ no DNAPL but base is above adjacent occurrences or no samples collected
- Maximum Extent of DNAPL
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features



Aspect CONSULTING

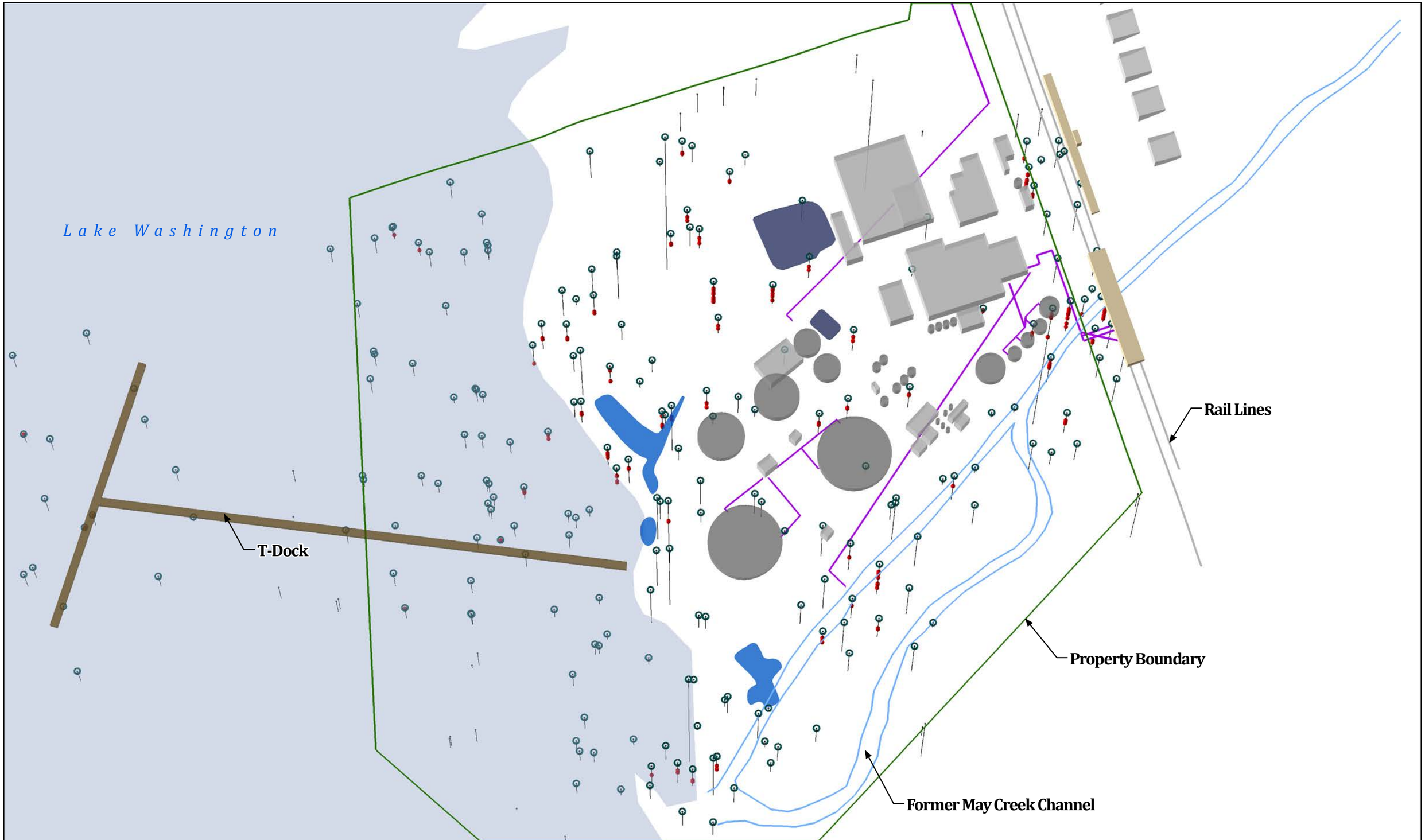
DNAPL Occurrences in the Quendall Pond/North Sump Area

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: RRR/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 4.4-1c
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report Keep Separate\020027-01-441abc.dwg, Figure 4.4-1c Quendall Pond || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 2:04pm || User: scudd



Buildings
Ponds
Tanks
Sumps
Loading Racks
Historical Pipes
Boring Location
DNAPL Upper and Lower Contacts

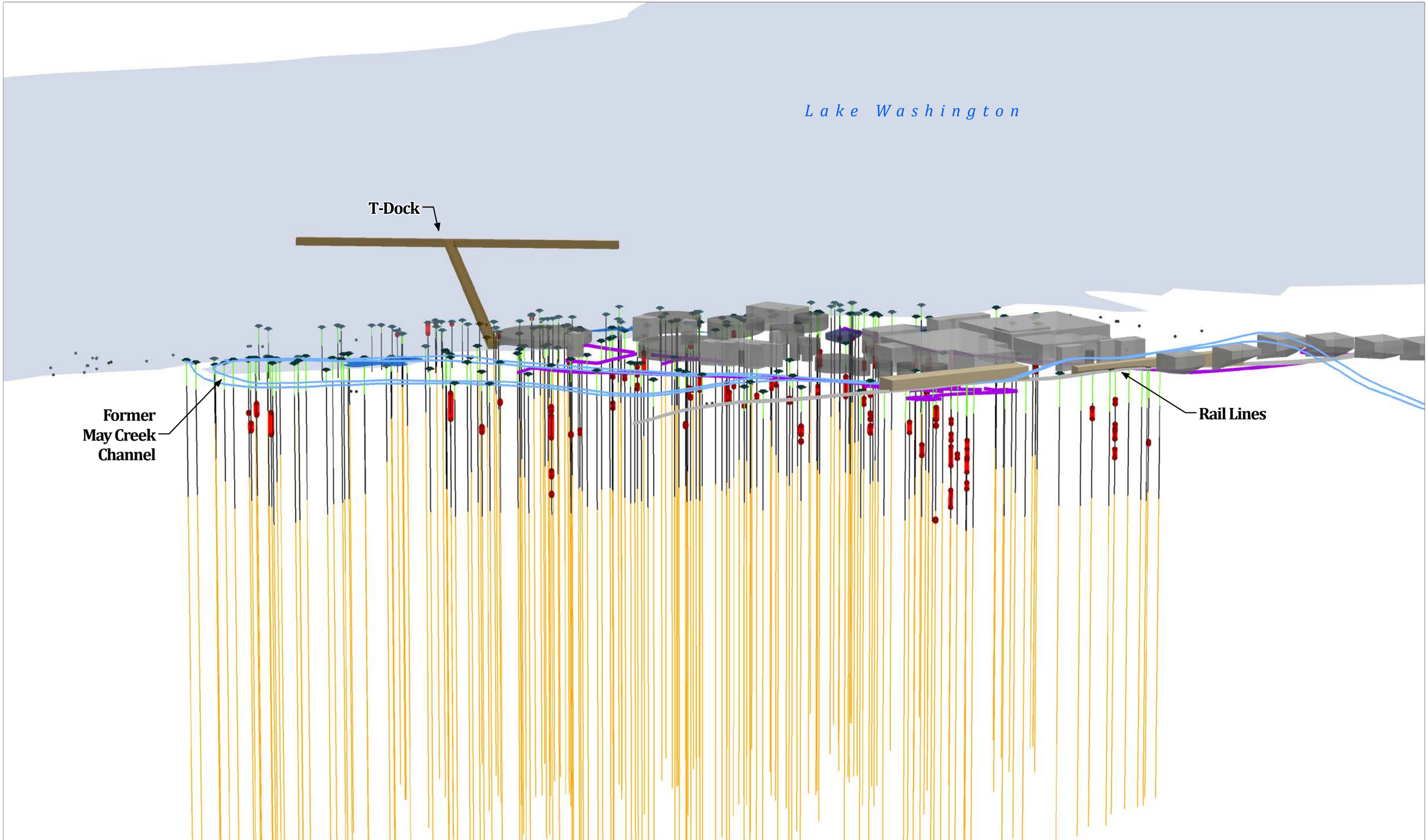
Aspect CONSULTING

3-D DNAPL Visualization - Plan View

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PPW	FIGURE NO. 4.4-2
REVISED BY: SCC	

GIS Path: T:\projects_8\Quendall\DNAPL\3D\2D Figures\2012-09 RI Final Report\4_4-2_PlanView.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/12/2012 || User: scudd || Print Date: 9/12/2012



Buildings
Tanks
Ponds
Sumps
Loading Racks
Historical Pipes
Boring Location
DNAPL Upper Contact
DNAPL Lower Contact
Modeled Aquifer Contacts
Fill
Silt
Gravel

Aspect CONSULTING

3-D DNAPL Visualization - Cross-Sectional View

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PPW	FIGURE NO. 4.4-3
REVISED BY: SCC	

GIS Path: T:\projects_8\Quendall\DNAPL\3D\2D Figures\2012-09 RI Final Report\4_4-3_CrossSectionView.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 9/12/2012 || User: scudd || Print Date: 9/12/2012

Legend

- TD-08 — Boring w/ DNAPL
- VT-3 — Boring w/ no DNAPL
- EPA-2 — Boring w/ no DNAPL but base is above adjacent occurances
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Maximum Extents of DNAPL
- 5 — DNAPL Thickness contour
- DNAPL Thickness 0'-2'
- DNAPL Thickness 2'-4'
- DNAPL Thickness >4'
- Current Shoreline
- 1916 Shoreline
- Former May Creek Channel

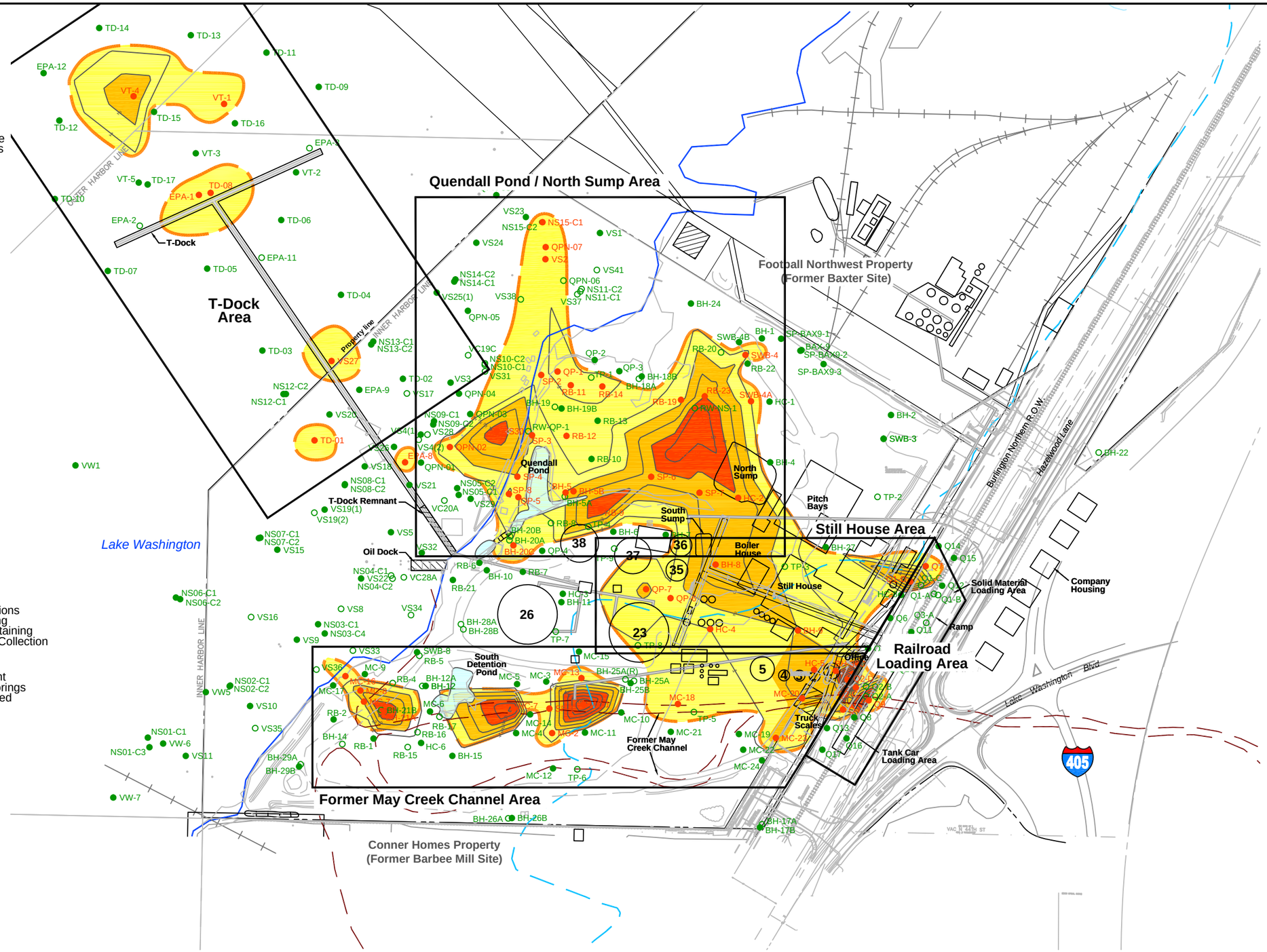
Notes

1. DNAPL occurrences based on observations of oil-coated or oil-wetted soil. Soil exhibiting only sheen or staining not identified as containing DNAPL. See Attachment A-11 of the Data Collection Work Plan (Anchor QEA & Aspect 2009a).

2. Boundaries generally based on midpoint between borings containing DNAPL and borings with no DNAPL (if sufficiently deep), adjusted to fit Surfer-generated contour intervals of DNAPL thickness.

3. DNAPL occurrences at each boring are summarized in Tables G-1 through G-4 in Appendix G.

4. DNAPL thickness contours are the cumulative thickness of multiple layers (when present) at each boring. Contours generated using Surfer 8 (Golden Software Inc. 2002).



N

0 200 400
Feet

Aspect CONSULTING

Cumulative DNAPL Thickness Contour Map

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 4.4-4
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-444.dwg Figure 4.4-4 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 2:17pm || User: scudd

Legend

- TD-08 Boring w/ DNAPL
- VT-3 Boring w/ no DNAPL
- EPA-2 Boring w/ no DNAPL but base is above adjacent occurrences or no samples collected
- DNAPL Thiessen Polygons
- Detention Ponds
- Existing Structures
- Historical Structures
- Other Historical Features
- Current Shoreline
- 1916 Shoreline
- Former May Creek Channel

Maximum DNAPL Depth (Ft)

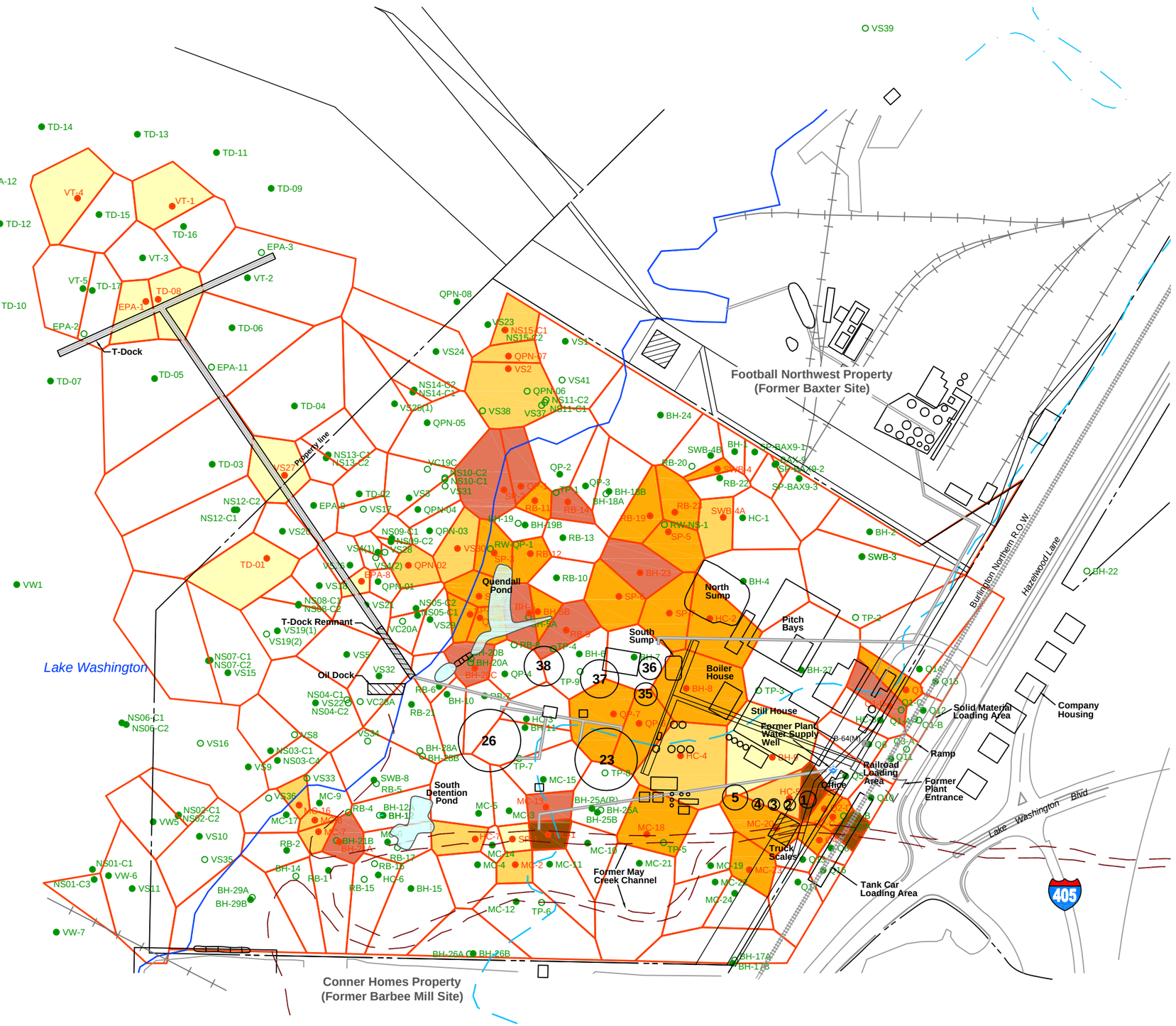
- 0 - 6.0
- 6.1 - 12.0
- 12.1 - 18.0
- 18.1 - 24.0
- 24.1 - 33.0

Notes

1. Thiessen polygons based on midpoint between borings of adequate depth and characterization, truncated at property line.

2. See Appendix G, Figure G-1 and Table G-5 for maximum depth and area for each polygon.

3. DNAPL identified as oil-coated or oil-wetted soil. Sheen and stained soil not identified as DNAPL. See Section 4.3.1 for DNAPL definitions and Tables G-1 through G-4 in Appendix G for summaries of DNAPL characterization at each boring.



N

0 200 400

Feet

Aspect CONSULTING

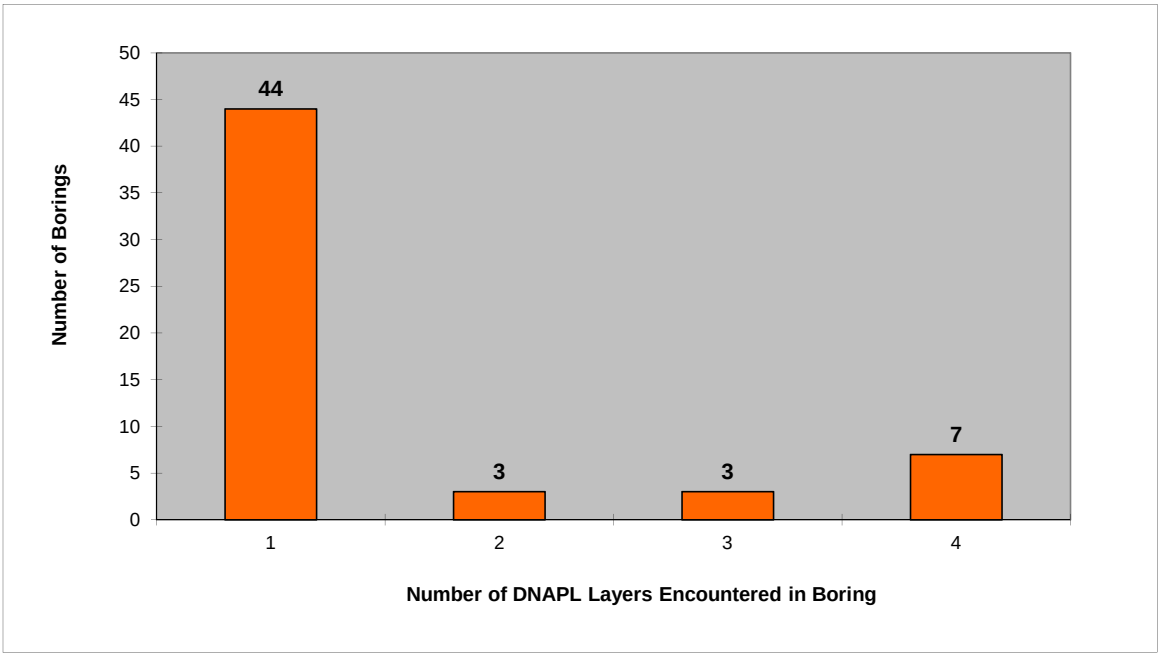
Maximum Depths of DNAPL Occurrences and Thiessen Polygon Areas

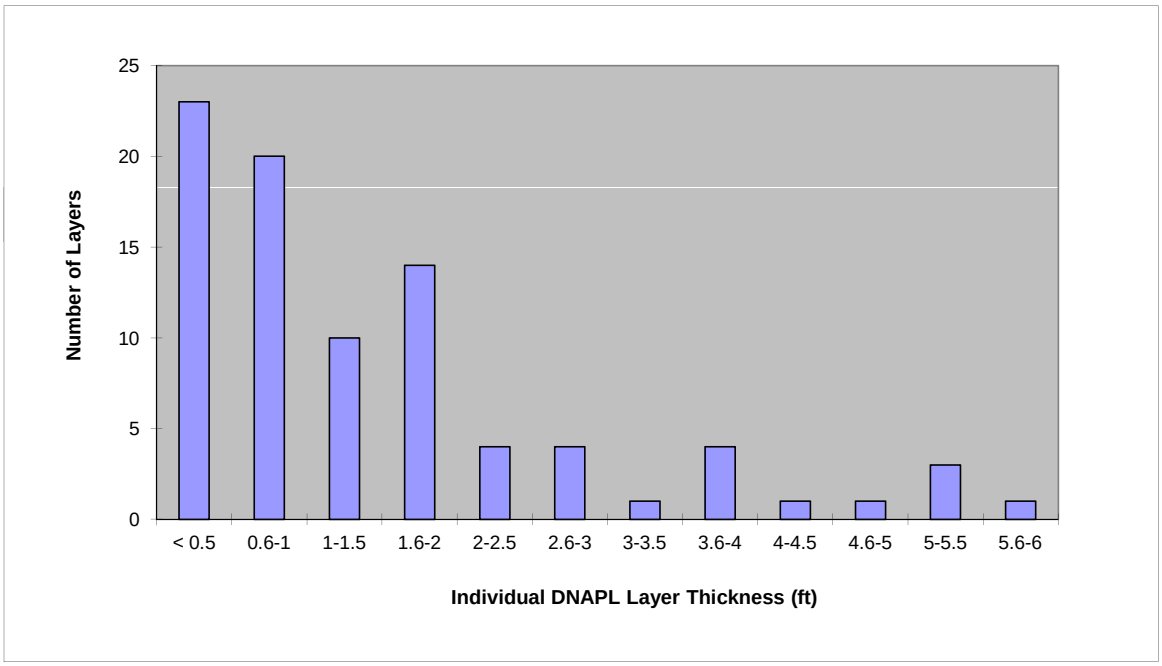
Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: RRR/JJP	
DRAWN BY: PMB	FIGURE NO. 4.4-5
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-445.dwg Figure 4.4-5 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:02pm || User: scudd

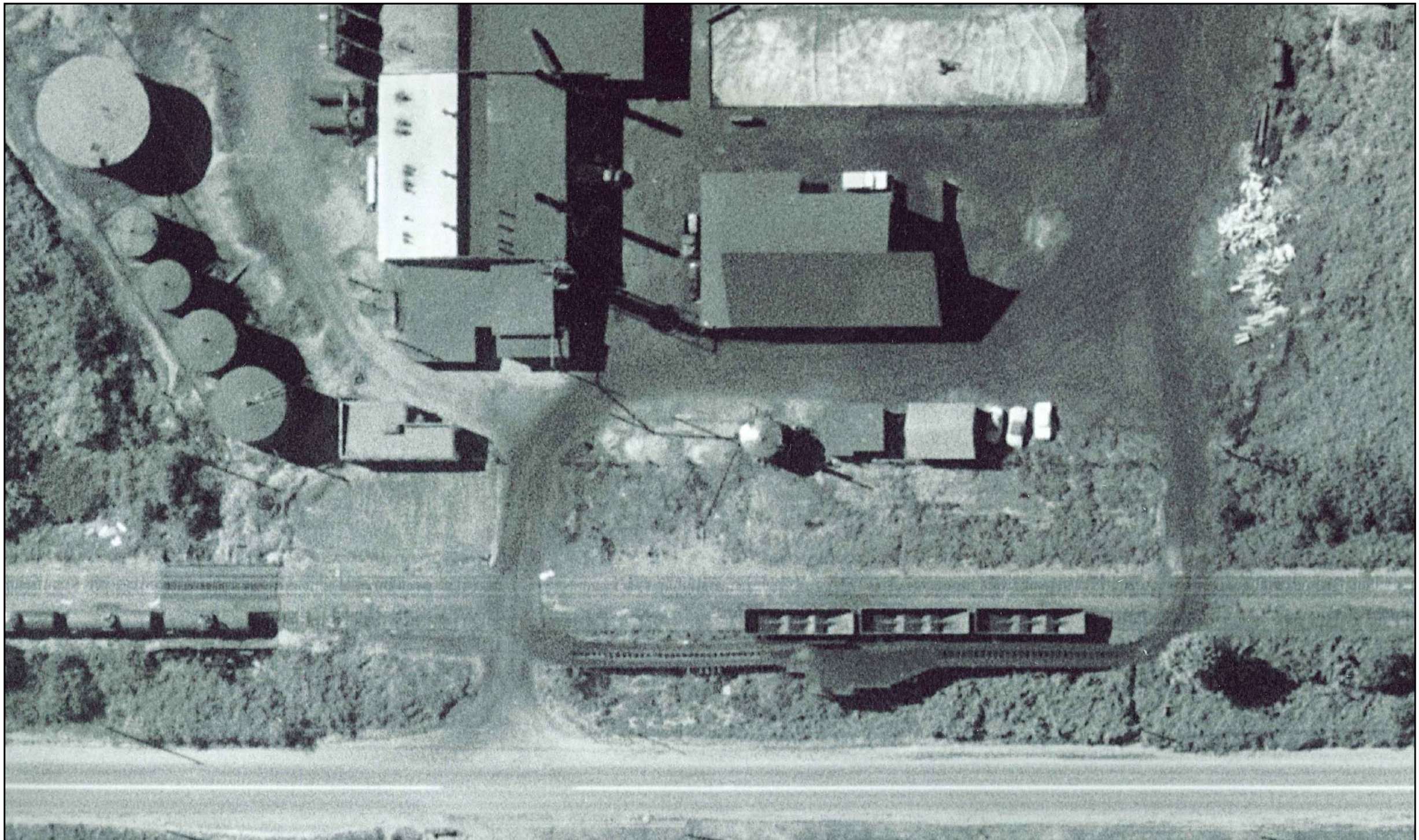




Notes:

1. Includes upland and sediment subsurface explorations on the Quendall Property, Railroad Property, and in sediment west of the Quendall Property. Does not include surface soil or surface sediment samples
2. DNAPL layers include soil that is oil-coated or oil-wetted as defined in the Field Data Collection Work Plan Soil that merely exhibits staining or sheen is not considered to contain DNAPL
3. Intervals of DNAPL at each boring and the type of DNAPL are shown in Tables G-1 through G-4 in Appendix G

Figure 4.4-6
Distribution of DNAPL Layers and Layer Thicknesses Observed at Site Borings
Final Remedial Investigation, Quendall Terminals



N

Aspect CONSULTING

Quendall Terminals Tank Car Loading Area, 1961

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 4.4-7
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-447.dwg Figure 4.4-7 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:10pm || User: scudd

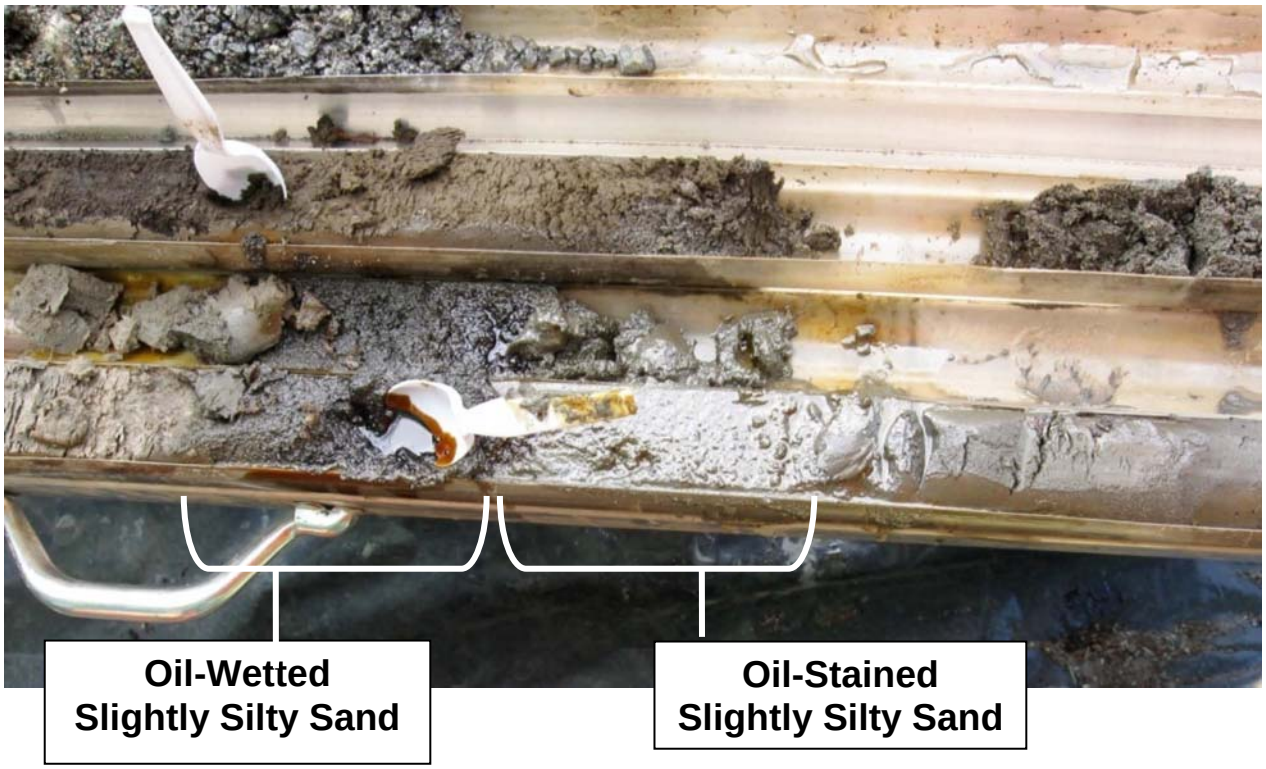
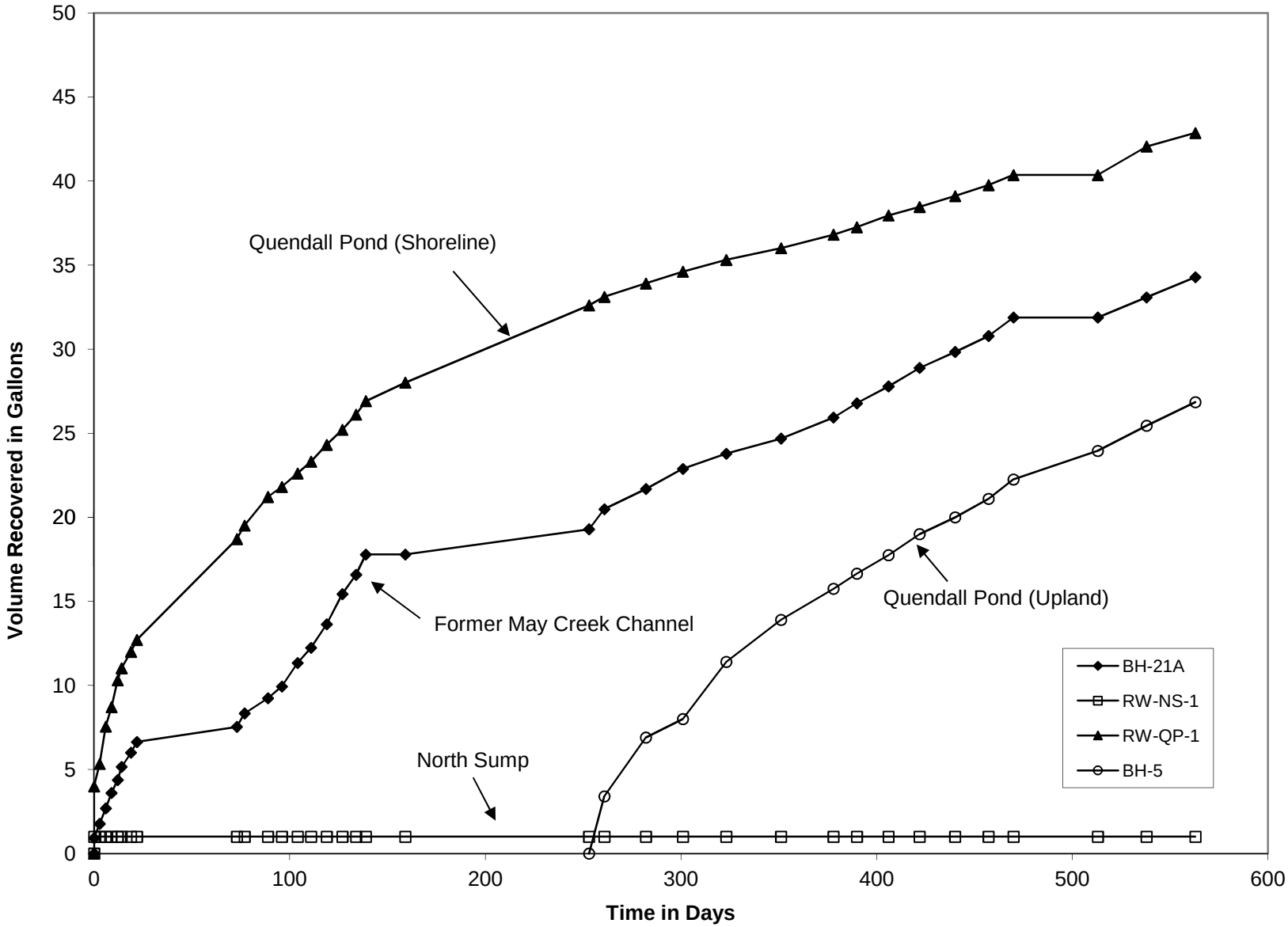


Figure 4.4-8
DNAPL at MC-1: Oil-Wetted Soil 25.5-27 Feet Deep
Final Remedial Investigation, Quendall Terminals

Figure 4.4-9
DNAPL at MC-13: Oil-Wetted Soil 18-18.3 Feet Deep
Final Remedial Investigation, Quendall Terminals



Aspect Consulting
September 2012

Figure 4.4-10
Product Recovery Pilot Test Results
Final Remedial Investigation, Quendall Terminals

Figure 4.4-11
DNAPL in The Still House Area adjacent to Former Transfer Pipe
Final Remedial Investigation, Quendall Terminals

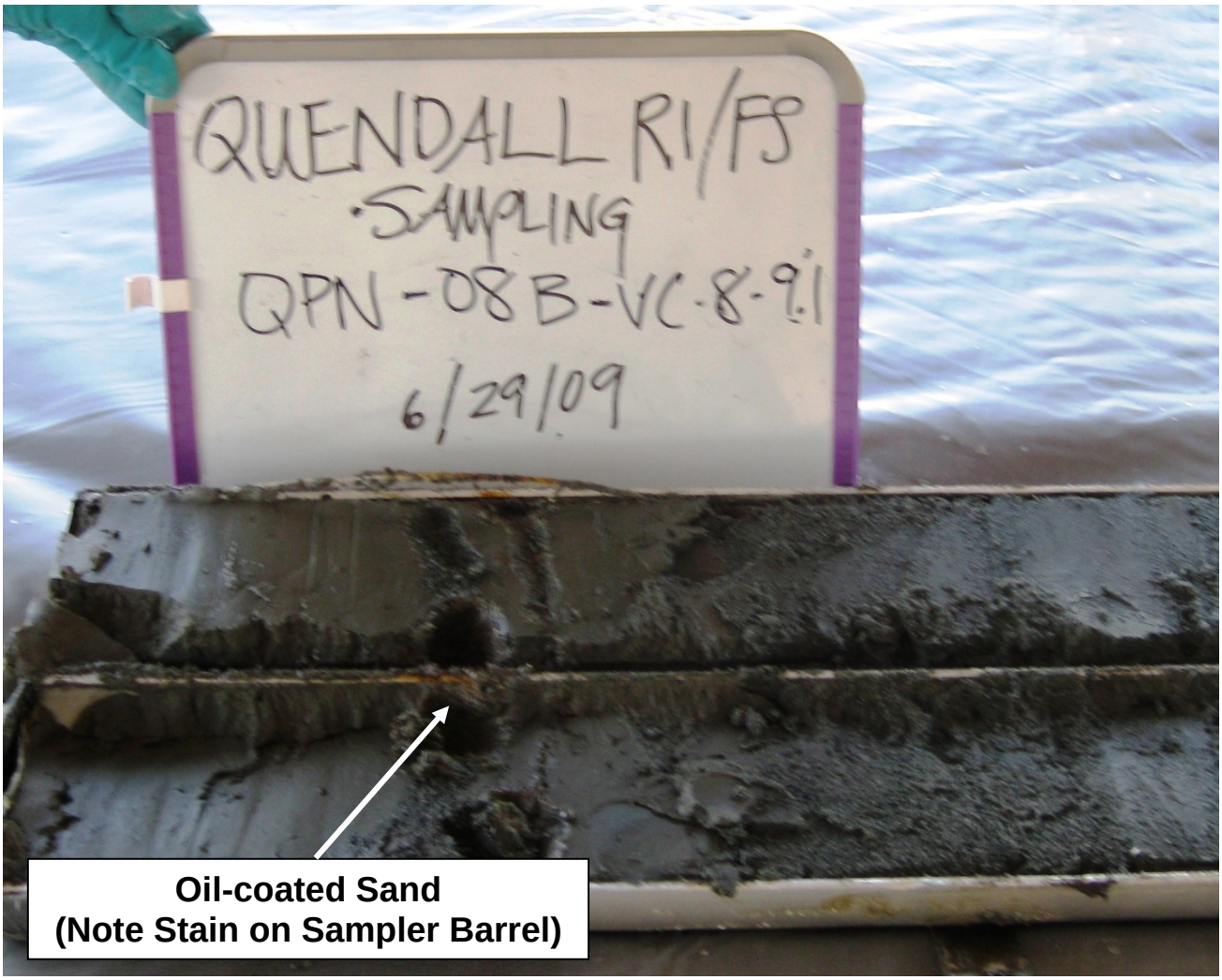


Figure 4.4-12
DNAPL at QPN-07 (formerly QPN-08B): Oil-Coated Sediment 8.5 - 8.7 Feet Deep
Final Remedial Investigation, Quendall Terminals

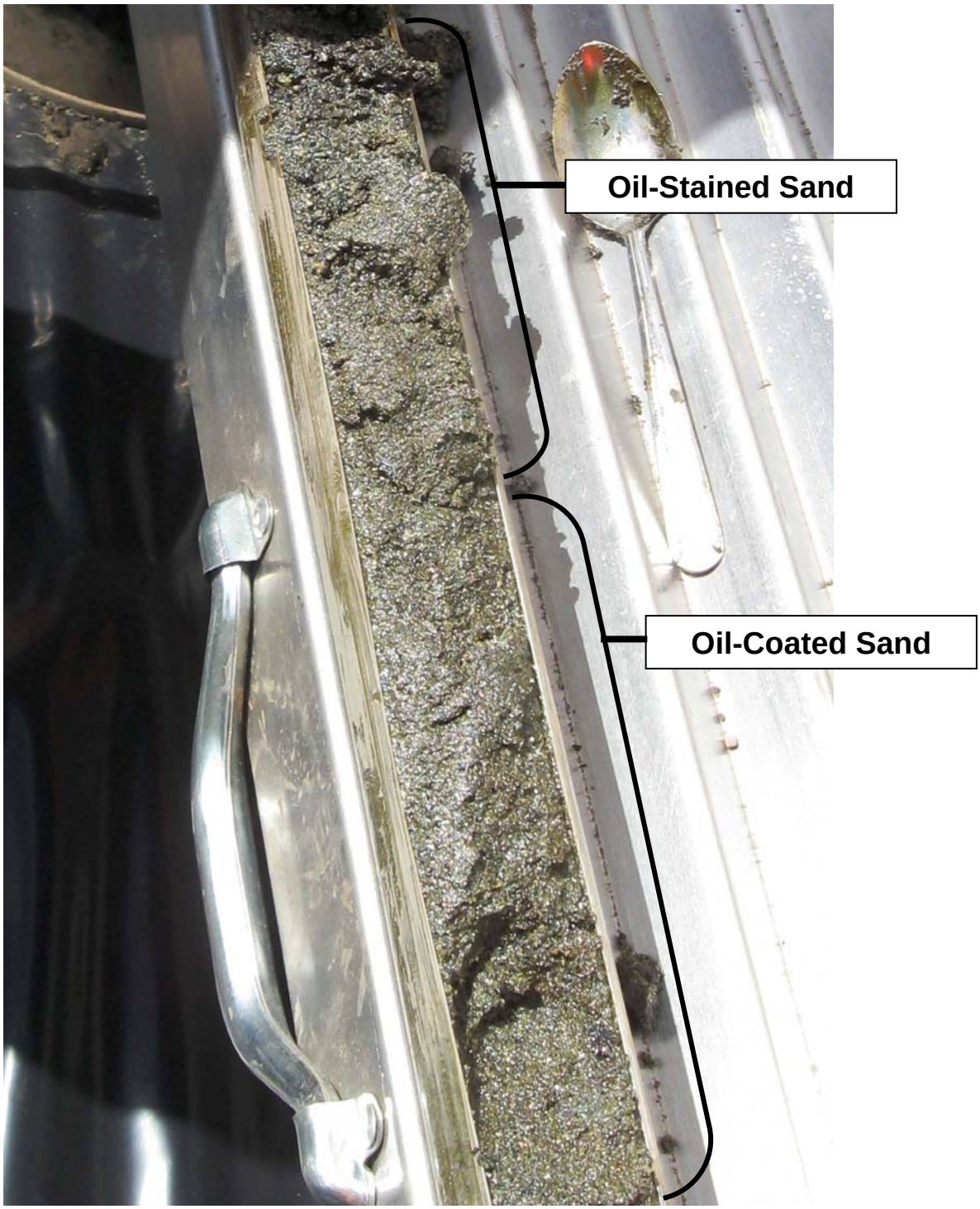


Figure 4.4-13
DNAPL at QP-5: Oil-Coated Soil 11 to 12 Feet Deep
Final Remedial Investigation, Quendall Terminals

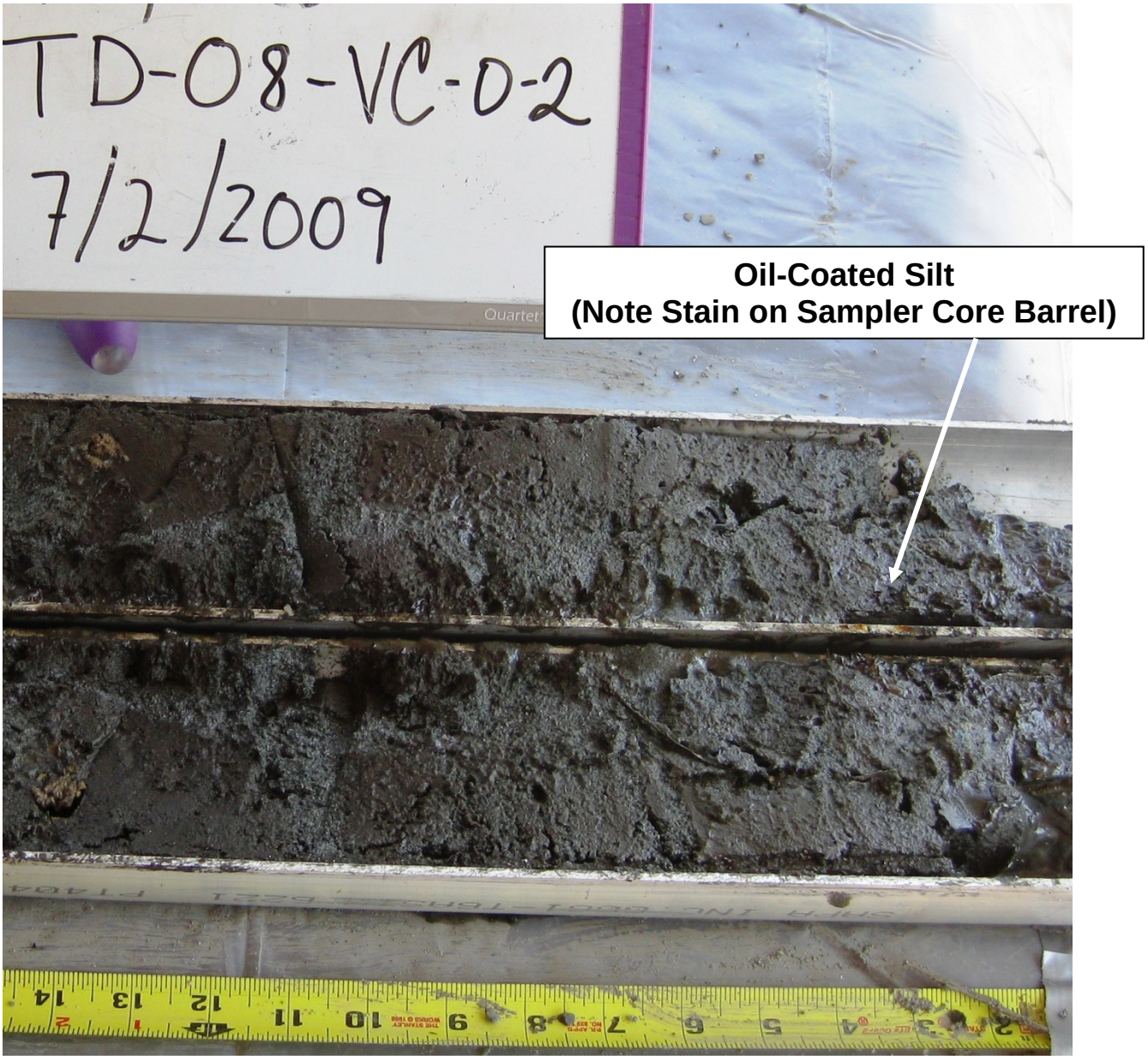
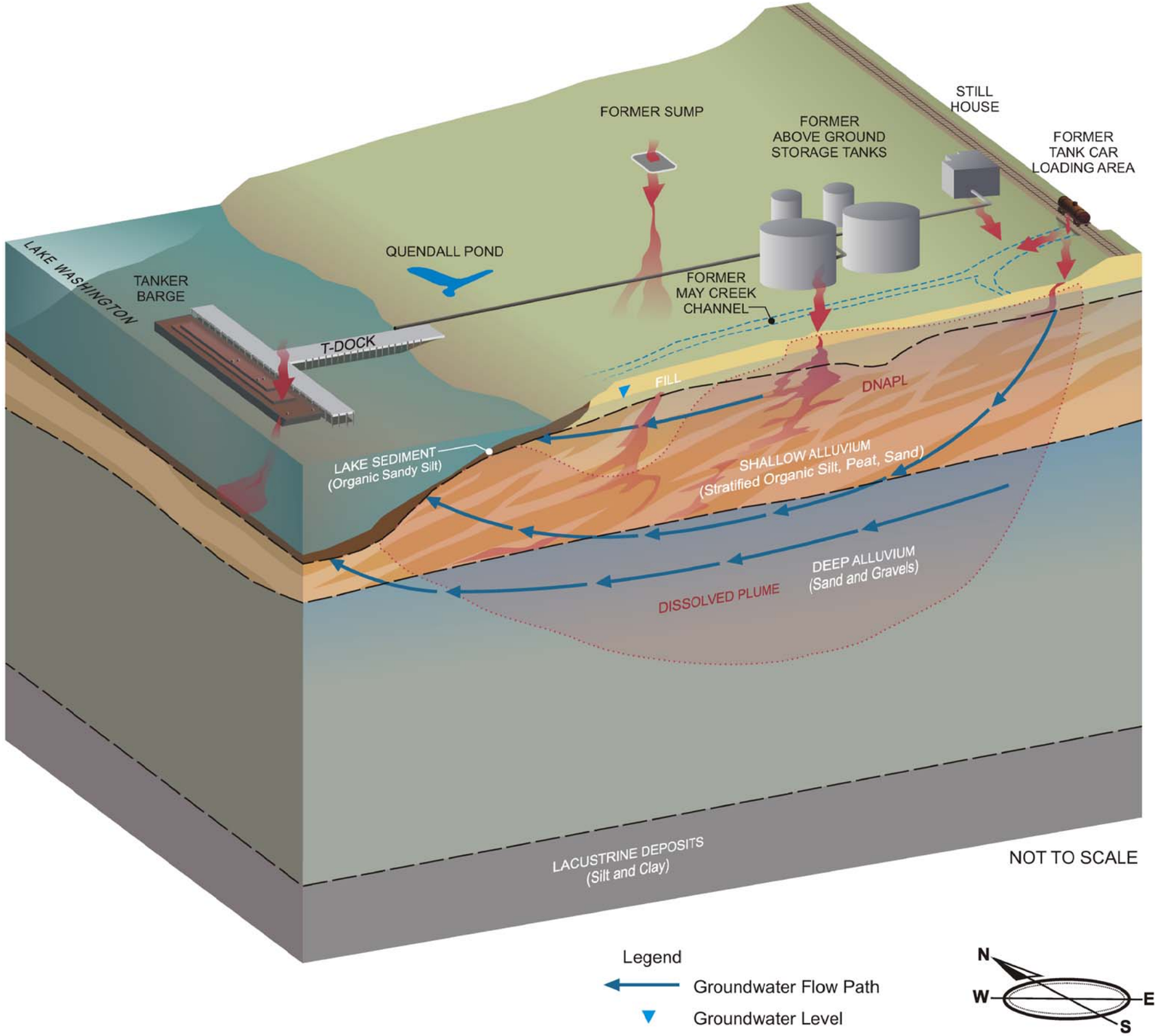


Figure 4.4-14
DNAPL at TD-08: Oil-Coated Soil 0.3 – 0.4 Feet Deep
Final Remedial Investigation, Quendall Terminals



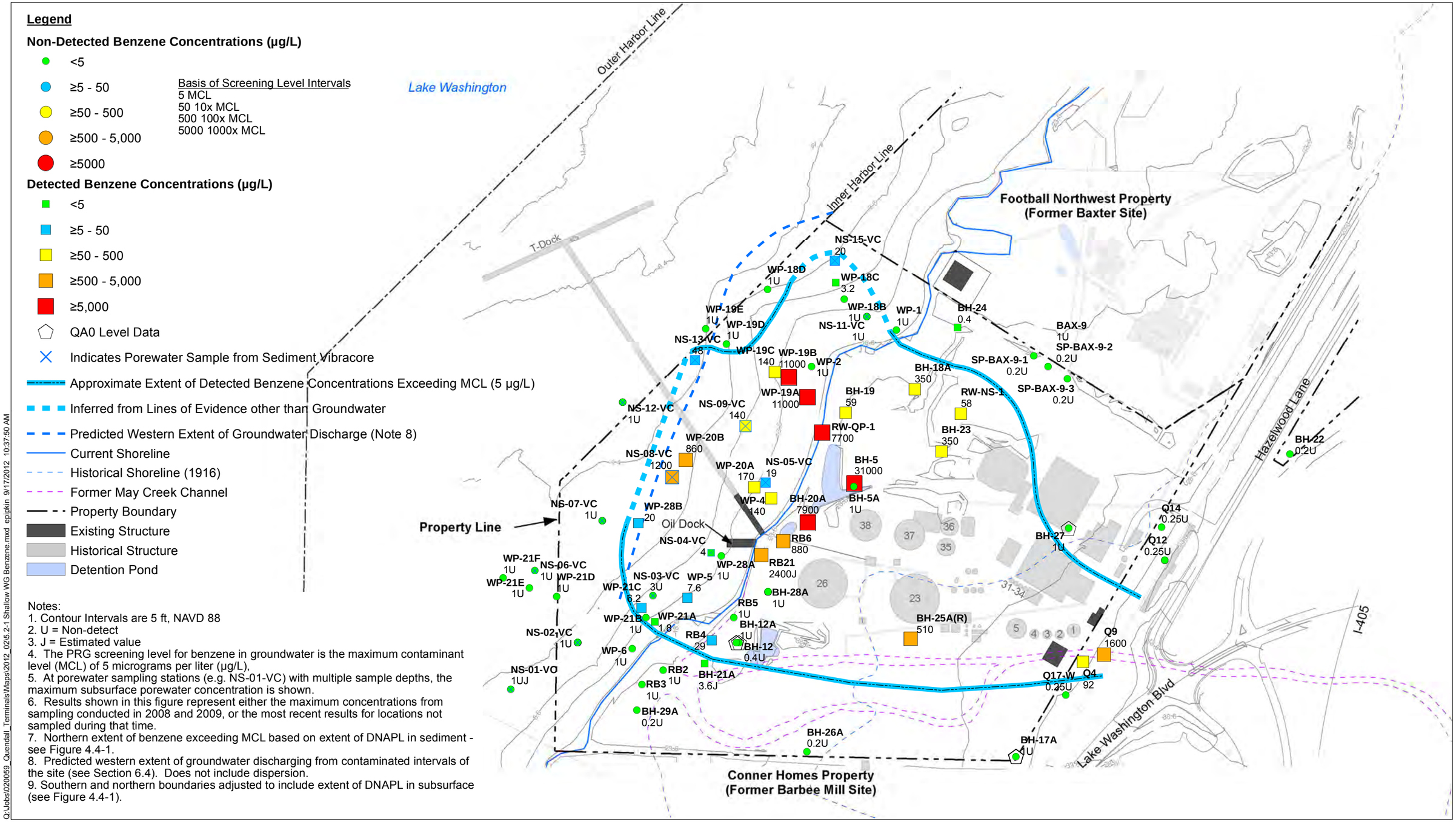
Graphic Illustration of the DNAPL Conceptual Site Model

Final Remedial Investigation, Quendall Terminals

Renton, Washington

Aspect CONSULTING	ANCHOR QEA	FIRM: ASPECT DRAWN BY: JJP/EG/SCC	FIGURE NO. 4.5-1

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report 01\020027-451.dwg 11x17 Landscape || Date Saved: Sep 17, 2012 12:25pm || User: soudd

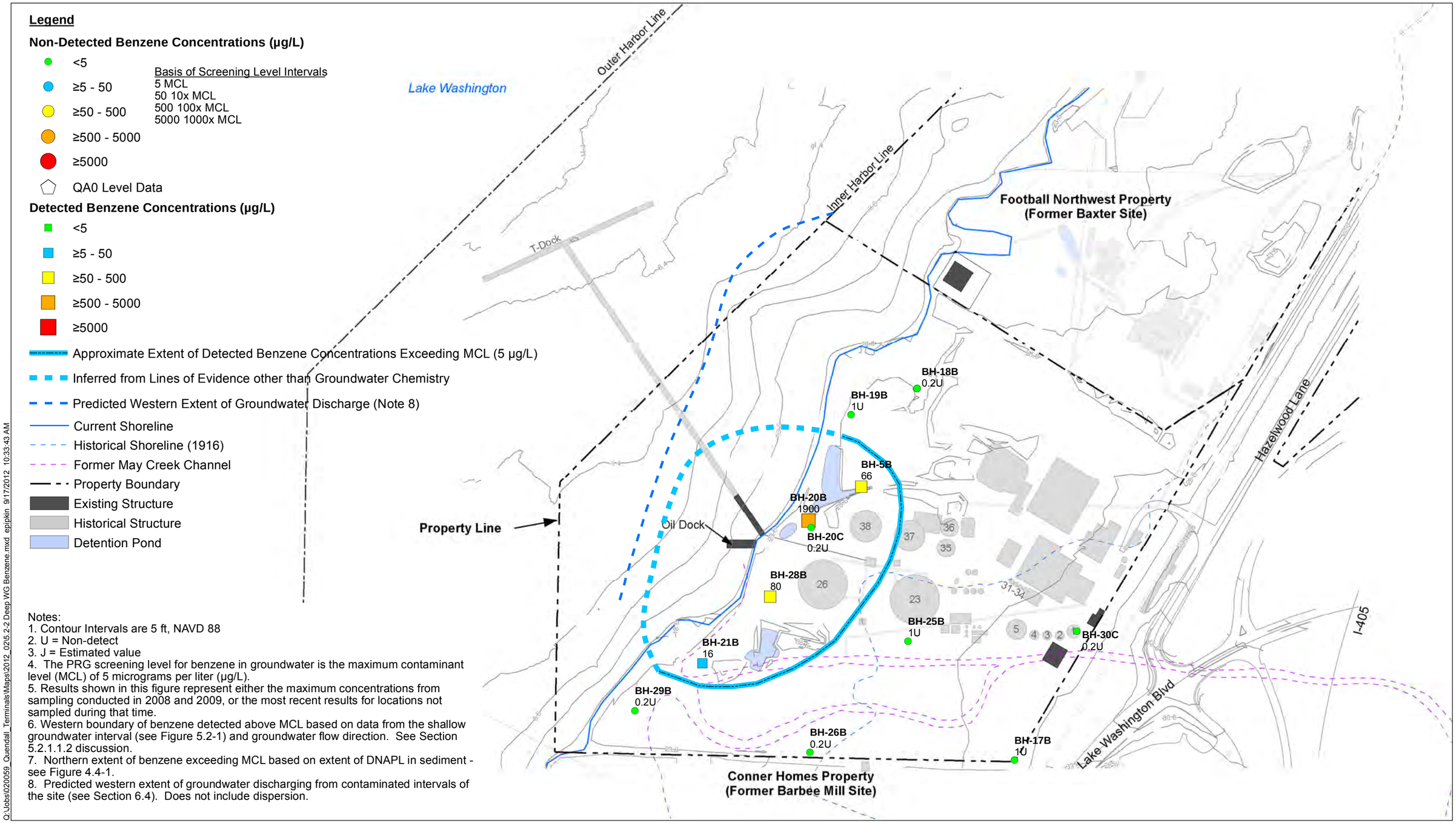


Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for benzene in groundwater is the maximum contaminant level (MCL) of 5 micrograms per liter (µg/L),
5. At porewater sampling stations (e.g. NS-01-VC) with multiple sample depths, the maximum subsurface porewater concentration is shown.
6. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
7. Northern extent of benzene exceeding MCL based on extent of DNAPL in sediment - see Figure 4.4-1.
8. Predicted western extent of groundwater discharging from contaminated intervals of the site (see Section 6.4). Does not include dispersion.
9. Southern and northern boundaries adjusted to include extent of DNAPL in subsurface (see Figure 4.4-1).

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0256.2-1 Shallow WG Benzene.mxd epipkin 9/17/2012 10:37:50 AM

ANCHOR QEA

Figure 5.2-1
Shallow Groundwater Benzene Concentrations
Final Remedial Investigation, Quendall Terminals



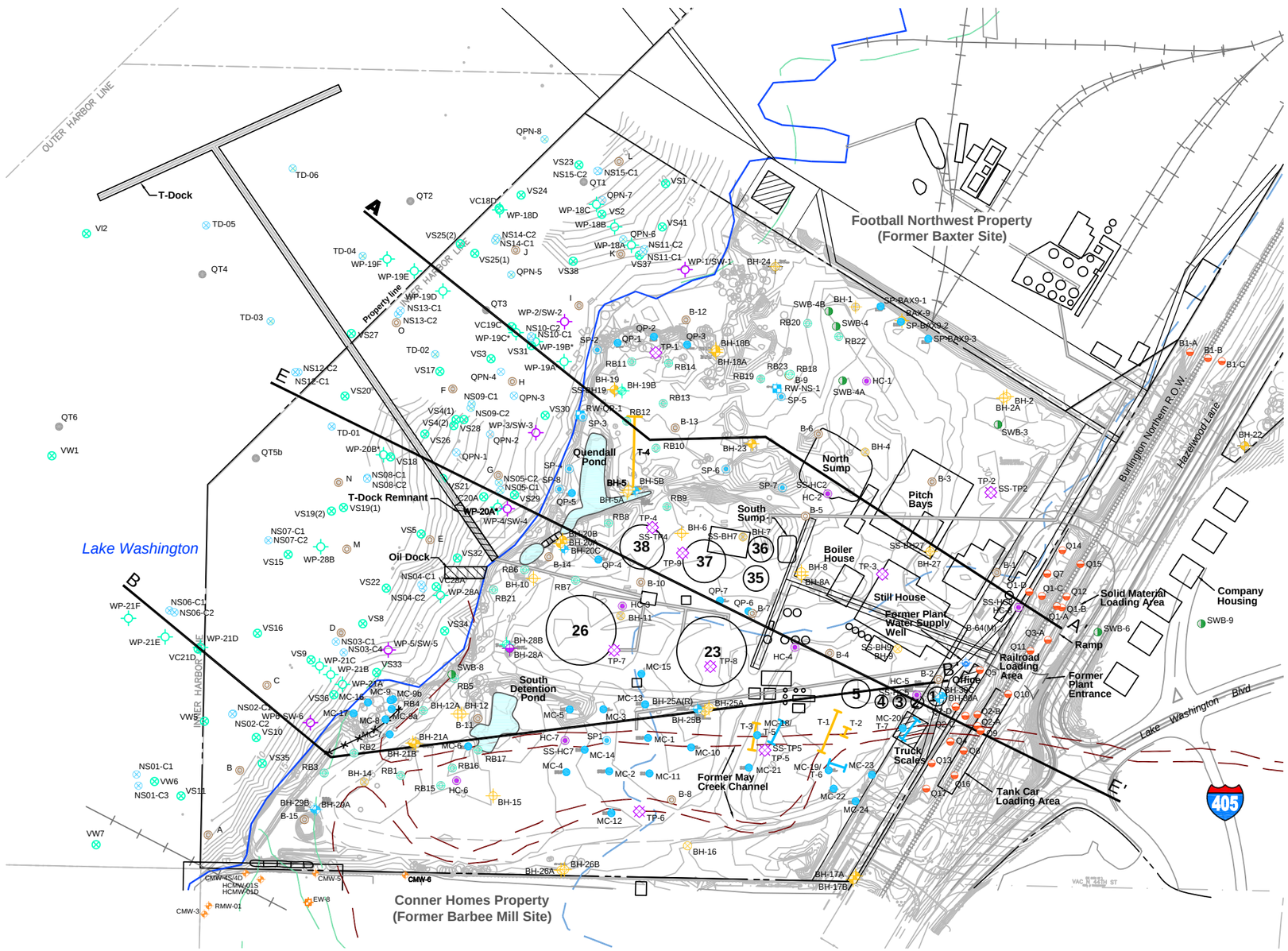
Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for benzene in groundwater is the maximum contaminant level (MCL) of 5 micrograms per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Western boundary of benzene detected above MCL based on data from the shallow groundwater interval (see Figure 5.2-1) and groundwater flow direction. See Section 5.2.1.1.2 discussion.
7. Northern extent of benzene exceeding MCL based on extent of DNAPL in sediment - see Figure 4.4-1.
8. Predicted western extent of groundwater discharging from contaminated intervals of the site (see Section 6.4). Does not include dispersion.

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215.2-2 Deep WG Benzene.mxd epipkin 9/17/2012 10:33:43 AM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-2
Deep Groundwater Benzene Concentrations
Final Remedial Investigation, Quendall Terminals



Summary of Explorations by Consultant

Consultant	Year	Exploration Type	Exploration ID	Map Symbol
Aspect Consulting	2007	Monitoring Wells	CMW-1 through CMW-6	
	2007	Extraction Wells	EW-1 through EW-8	
	2009	Monitoring Wells	BH-5B, BH-25A(R), BH-29A, BH-29B, BH-30A, BH-30C	
		Soil Borings	QP-1 through QP-7, MC-1 through MC-24 SP-BAX9-1 through SP-BAX9-3	
		Trenches	T-5 through T-7	
	2003	Monitoring Wells	RW-NS-1, RW-QP-1	
		Soil Borings	SP1 through SP8	
		Surface Soil Samples	SS-BH7, SS-BH9, SS-BH19, SS-BH27, SS-TP2, SS-HC2, SS-HC5, SS-HC7, SS-HC8	(a)
Pinnacle Geosciences	2008	Soil Borings	Q1 through Q17, B1-A through B1-C	
Retec	2001	Soil Borings	RB1 through RB23	
	2000	Monitoring Wells	BH-19B, BH-28B	
Shannon & Wilson	1997	Soil Borings	SWB-3, SWB-4, SWB-4A, SWB-4B, SWB-8	
Hart Crowser	1995, 1996	Soil Borings	HC-1 through HC-8	
		Monitoring Wells	BH-28A	
		Test Pits	TP-1 through TP-9	
Woodward Clyde	1990	Monitoring Wells	BH-24, BH-25A, BH-25B, BH-26A, BH-26B, BH-27	
Woodward Clyde	1988	Monitoring Wells	BH-17A, BH-17B, BH-18A, BH-18B, BH-19, BH-20A, BH-20B, BH-21A, BH-21B, BH-22, BH-23, BAX-9	
Woodward Clyde	1983	Monitoring Wells	BH-1, BH-2, BH-2A, BH-5, BH-5A, BH-6, BH-8, BH-8A, BH-10, BH-12, BH-12A, BH-15	
		Soil Borings	BH-4, BH-7, BH-9, BH-11, BH-14, BH-16	
		Trenches	T-1 through T-4	
Twelker	1971	Soil Borings	B-1 through B-15, A through M	
Metro	1963	Soil Borings	B-64(M)	

Notes
(a) Surface soil samples co-located with previous explorations.
Exploration ID of the surface soil sample includes the ID of the previous exploration.

Contour interval is 1 foot, NAVD 88. Contour elevations adjusted from original survey in NGVD 29 by adding 3.6 feet.

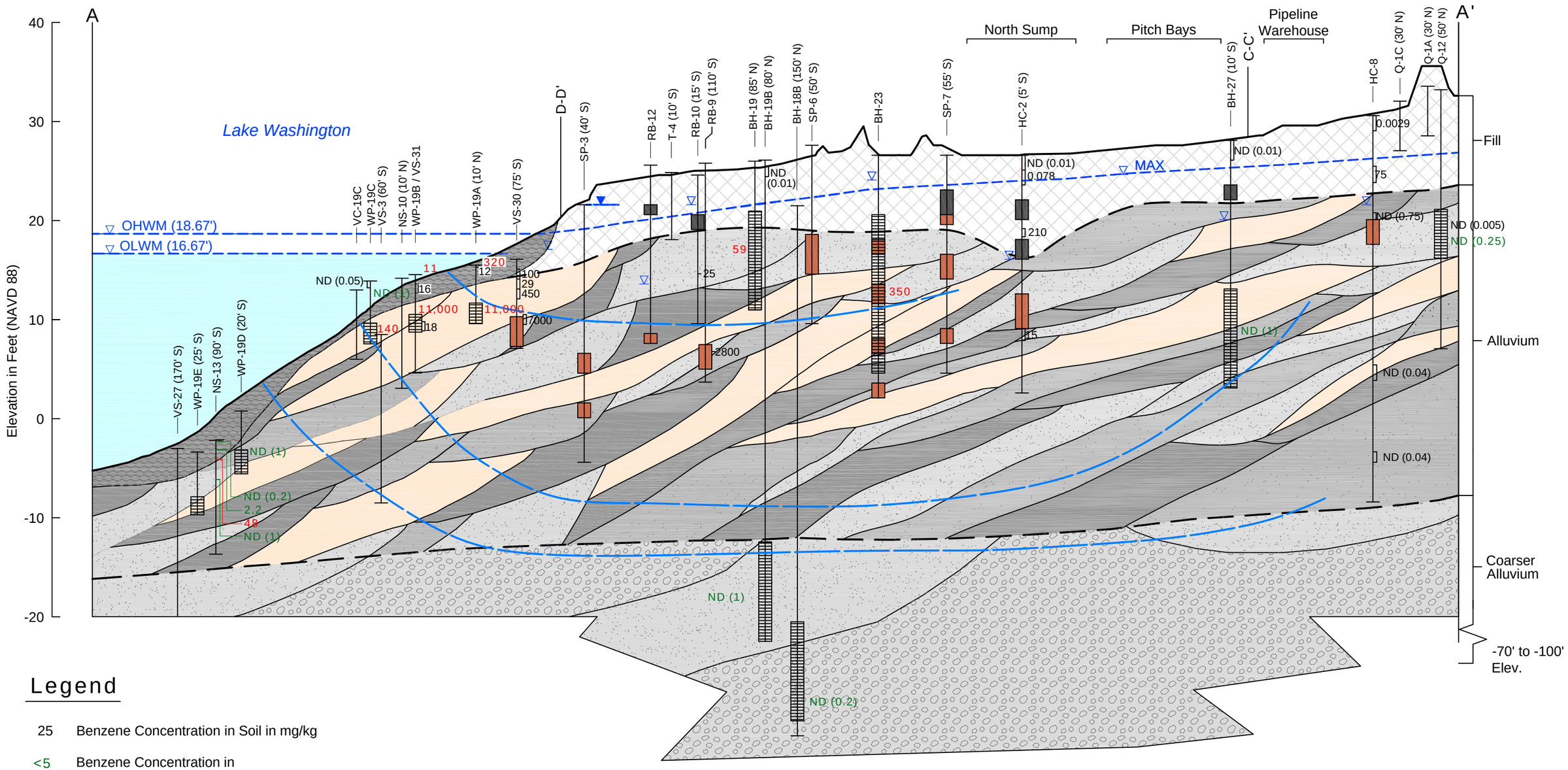
Aspect CONSULTING

Groundwater Cross Section Locations

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 5.2-3
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-523.dwg Figure 5.2-3 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:17pm || User: scudd



Legend

25 Benzene Concentration in Soil in mg/kg

<5 Benzene Concentration in
>5 Groundwater/Porewater in µg/L

WP-19D (20' S) — Well ID and Offset from Cross Section

Water Level — Solidified Tar Products

ATD — DNAPL

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 10 20
Feet

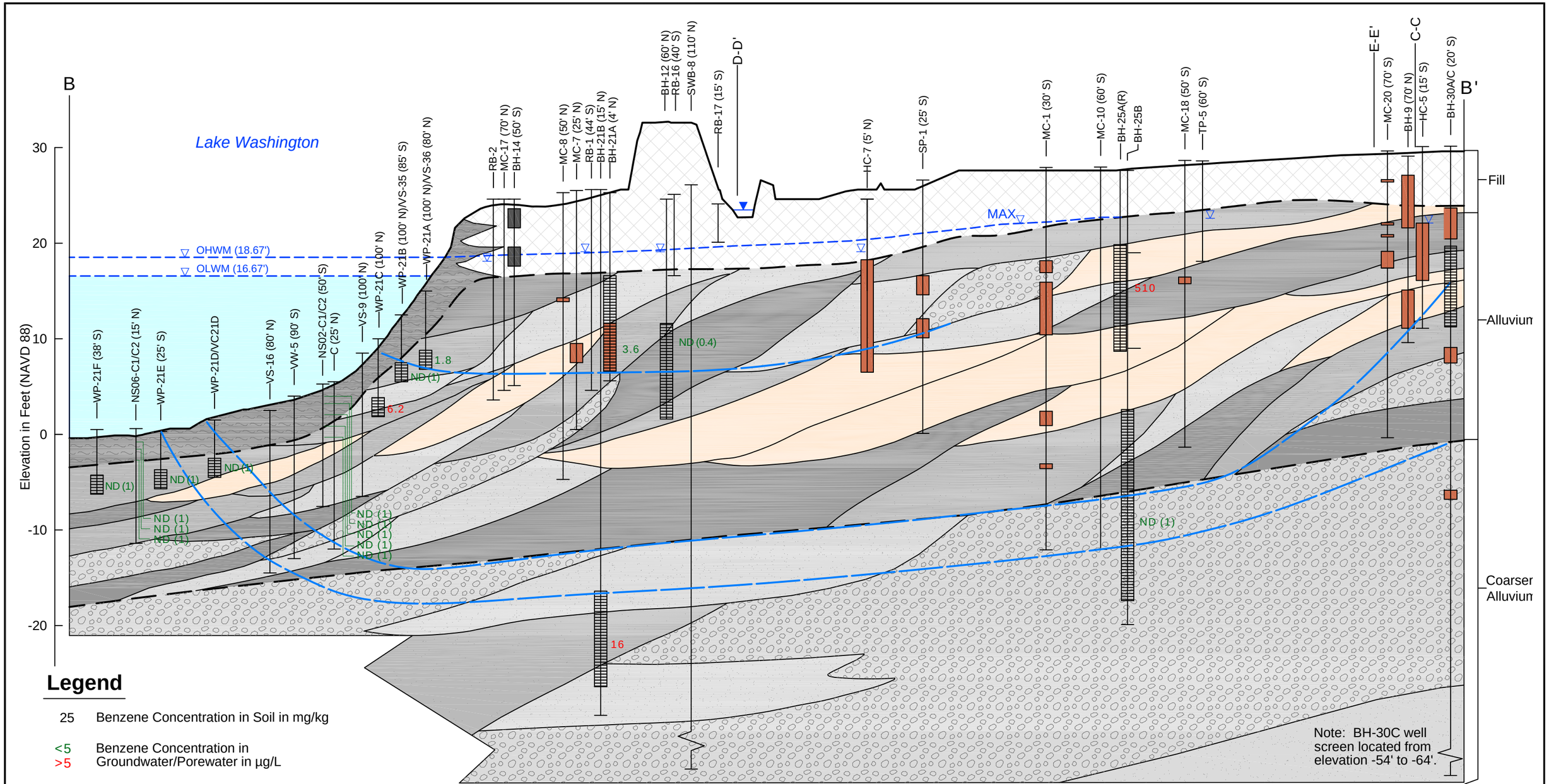
Vertical Exaggeration 10X

Aspect CONSULTING

Benzene Occurrences along Cross Section A-A'
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 5.2-4
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-524.dwg Figure 5.2-4 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:38pm || User: scudd



Legend

25 Benzene Concentration in Soil in mg/kg

<5 Benzene Concentration in Groundwater/Porewater in µg/L
>5 Groundwater/Porewater in µg/L

BH-27 (10' E) — Well ID and Offset from Cross Section

Water Level ATD

Solidified Tar Products

DNAPL

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 10 20
Feet

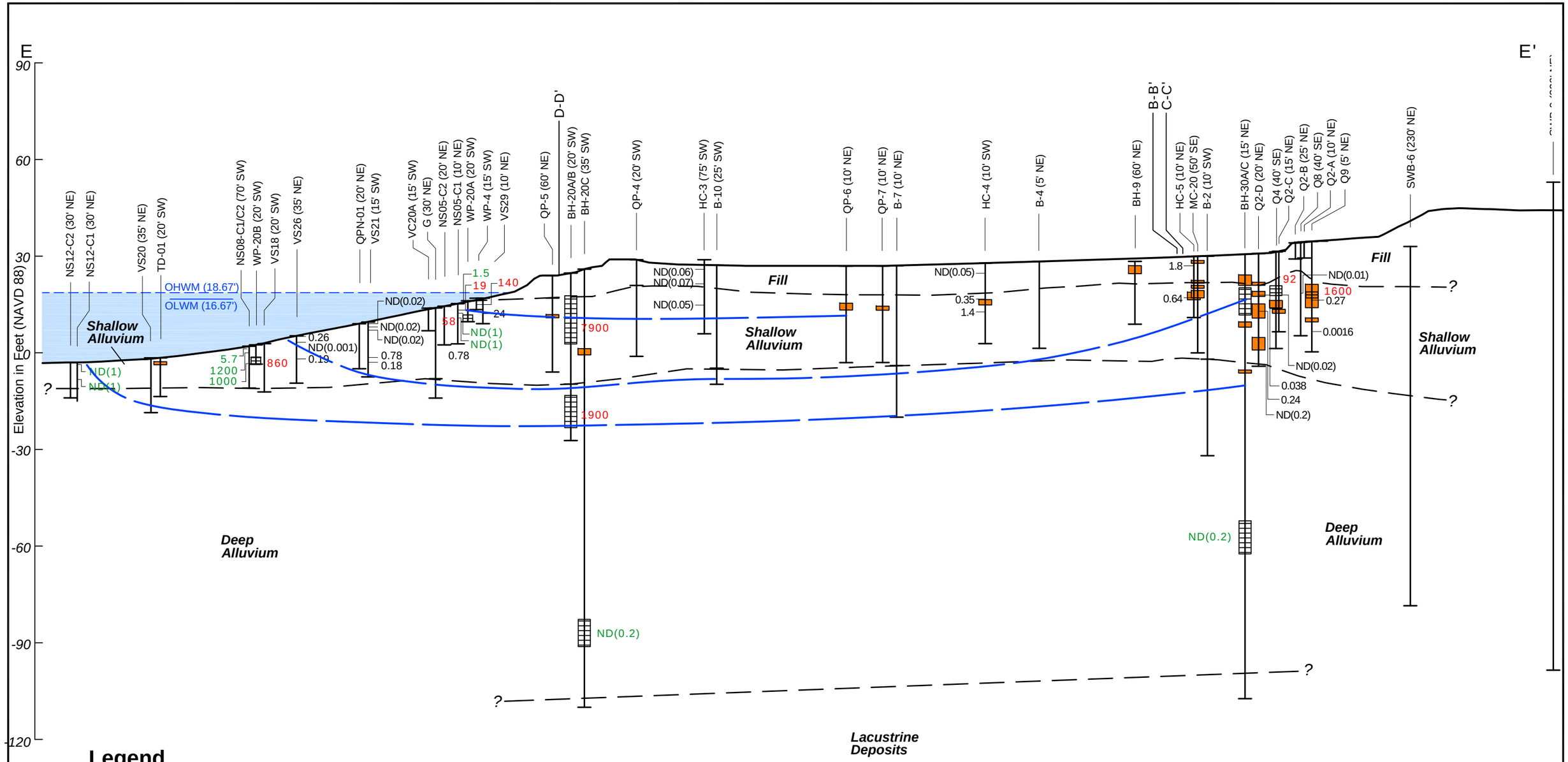
Vertical Exaggeration 10X

Aspect CONSULTING

Benzene Occurrences along Cross Section B-B'
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: DLC/JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 5.2-5
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-525.dwg Figure 5.2-5 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:27pm || User: scudd



Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

DNAPL

Well Screen

25 — Benzene Concentration in Soil in mg/kg

<5 / >5 — Benzene Concentration in Groundwater/Porewater in µg/L

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 30 60
Feet

Vertical Exaggeration 3.33X

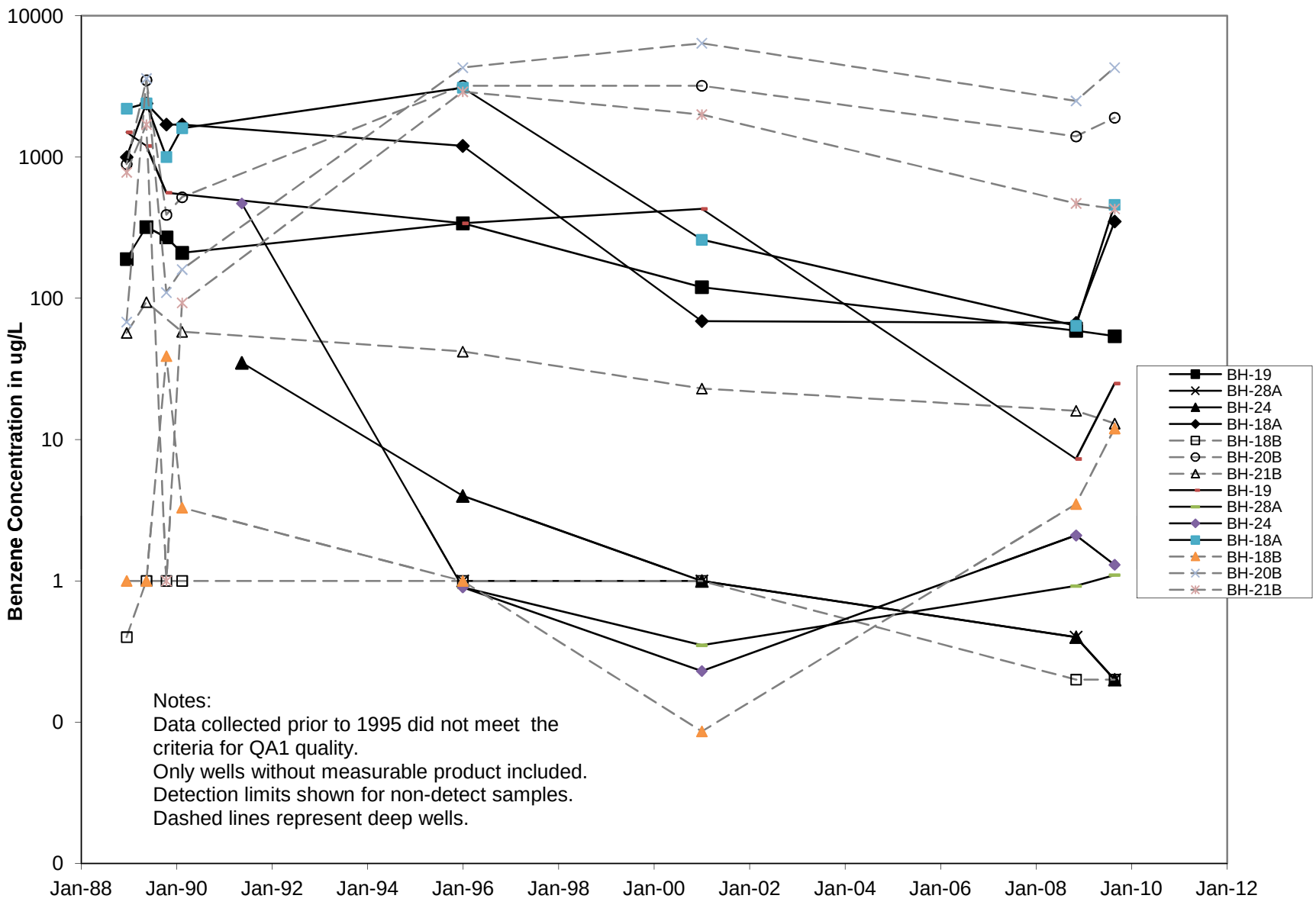
Aspect CONSULTING

Benzene Occurrences Along Cross Section E-E'

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH	
DRAWN BY: PMB/SCC	FIGURE NO. 5.2-6
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-526.dwg Section E-E' (Benzene) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 3:31pm || User: scudd



Aspect Consulting
September 2012

Figure 5.2-7
Historical Benzene Concentrations at Shoreline Wells
Final Remedial Investigation, Quendall Terminals

Legend

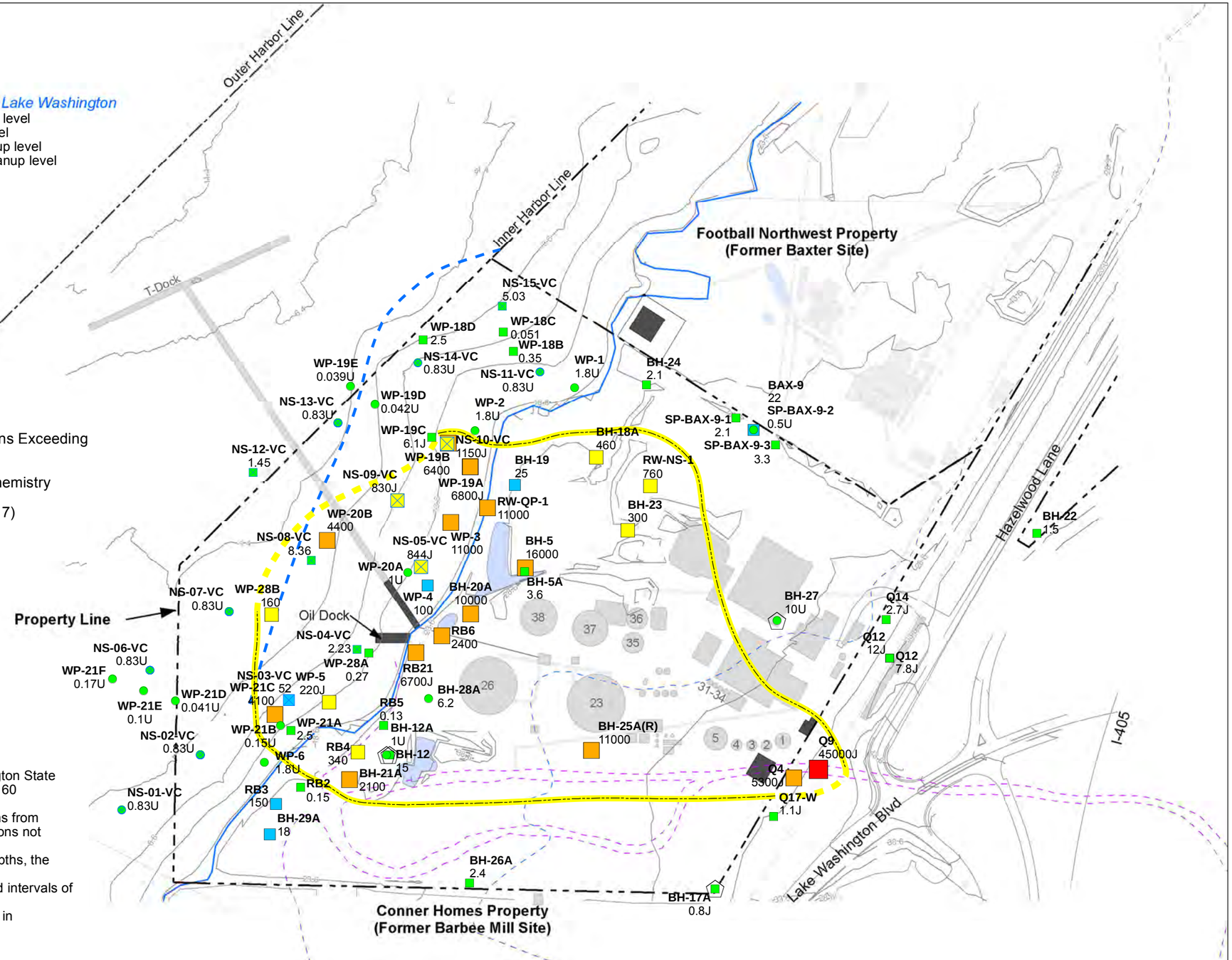
Non-Detected Naphthalene Concentrations (µg/L)

- <16
- ≥16 - 160
- ≥160 - 1,600
- ≥1,600 - 16,000
- >16,000

Basis of Screening Level Intervals
16 0.1x MTCA Method B groundwater cleanup level
160 MTCA Method B groundwater cleanup level
1600 10x MTCA Method B groundwater cleanup level
16000 100x MTCA Method B groundwater cleanup level

Detected Naphthalene Concentrations (µg/L)

- <16
- ≥16 – 160
- ≥160 – 1,600
- ≥1,600 – 16,000
- ≥16,000
- QA0 Level Data
- Indicates Porewater Sample from Sediment Vibracore
- Approximate Extent of Detected Naphthalene Concentrations Exceeding MTCA Method B Groundwater Cleanup Level (160 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry
- Predicted Western Extent of Groundwater Discharge (Note 7)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond



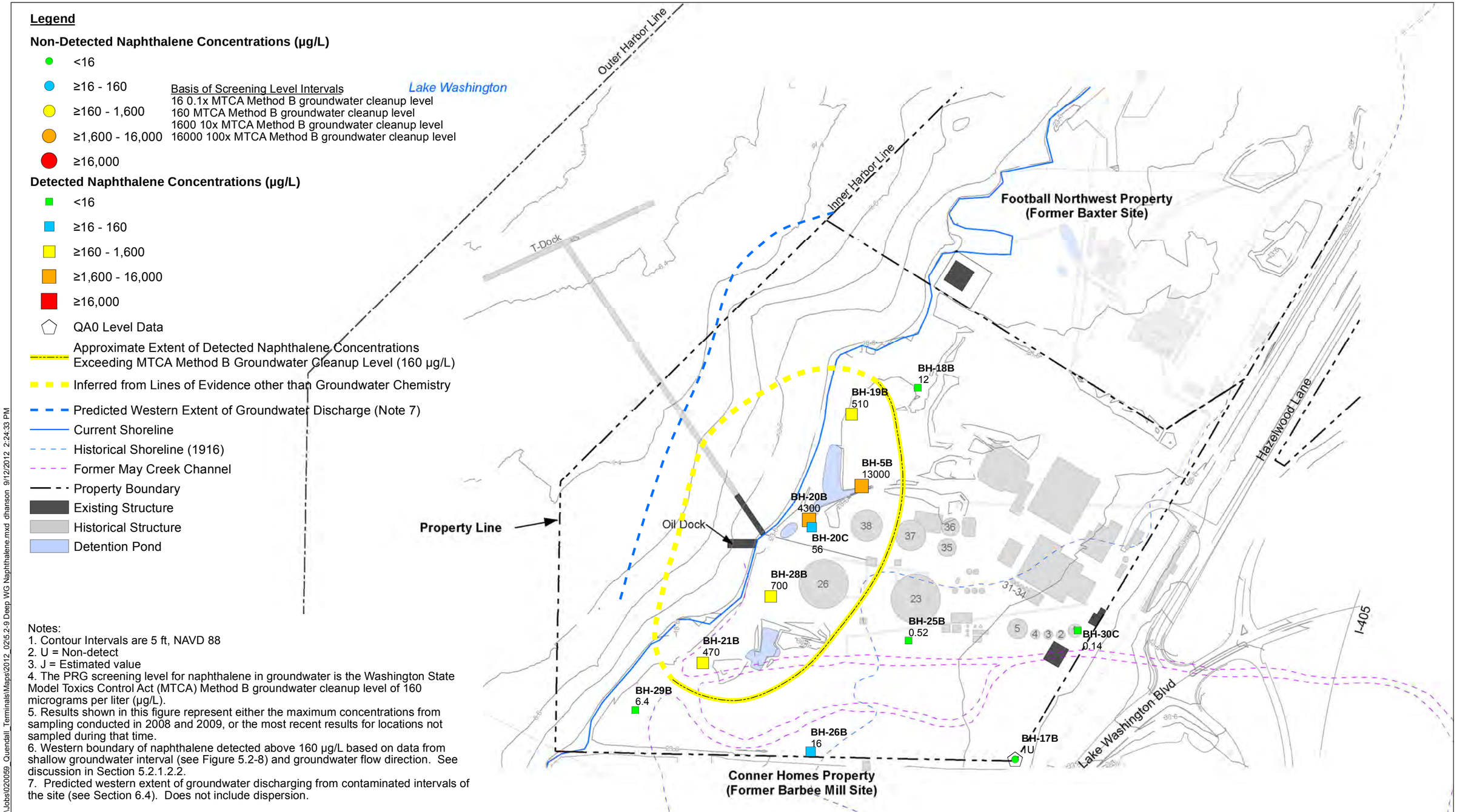
Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for naphthalene in groundwater is the Washington State Model Toxics Control Act (MTCA) Method B groundwater cleanup level of 160 micrograms per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. At porewater sampling stations (e.g. NS-01-VC) with multiple sample depths, the maximum subsurface porewater concentration is shown.
7. Predicted western extent of groundwater discharging from contaminated intervals of the site (see Section 6.4). Does not include dispersion.
8. Southern and northern boundaries adjusted to include extent of DNAPL in subsurface (see Figure 4.4-1).

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215_2-8 Shallow WG Naphthalene.mxd epipkin 9/17/2012 10:39:40 AM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-8
Shallow Groundwater Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals



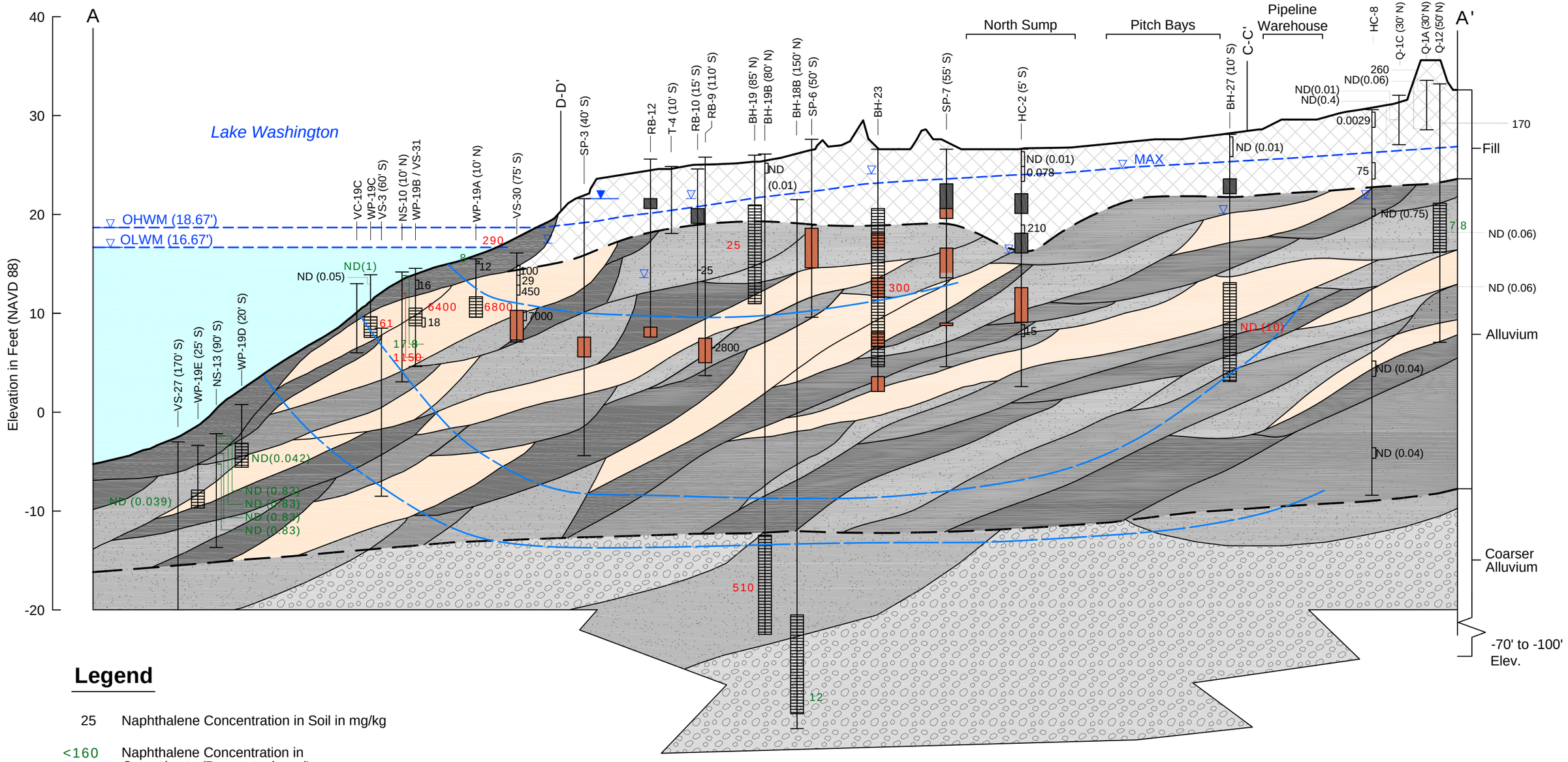
Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for naphthalene in groundwater is the Washington State Model Toxics Control Act (MTCA) Method B groundwater cleanup level of 160 micrograms per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Western boundary of naphthalene detected above 160 µg/L based on data from shallow groundwater interval (see Figure 5.2-8) and groundwater flow direction. See discussion in Section 5.2.1.2.2.
7. Predicted western extent of groundwater discharging from contaminated intervals of the site (see Section 6.4). Does not include dispersion.

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215\2-9 Deep WG Naphthalene.mxd dhanson 9/12/2012 2:24:33 PM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-9
Deep Groundwater Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals



Legend

25 Naphthalene Concentration in Soil in mg/kg

<160 Naphthalene Concentration in
>160 Groundwater/Porewater in µg/L

VS-27 (170' S) — Well ID and Offset from Cross Section

Water Level ATD

Solidified Tar Products

DNAPL

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 10 20
Feet

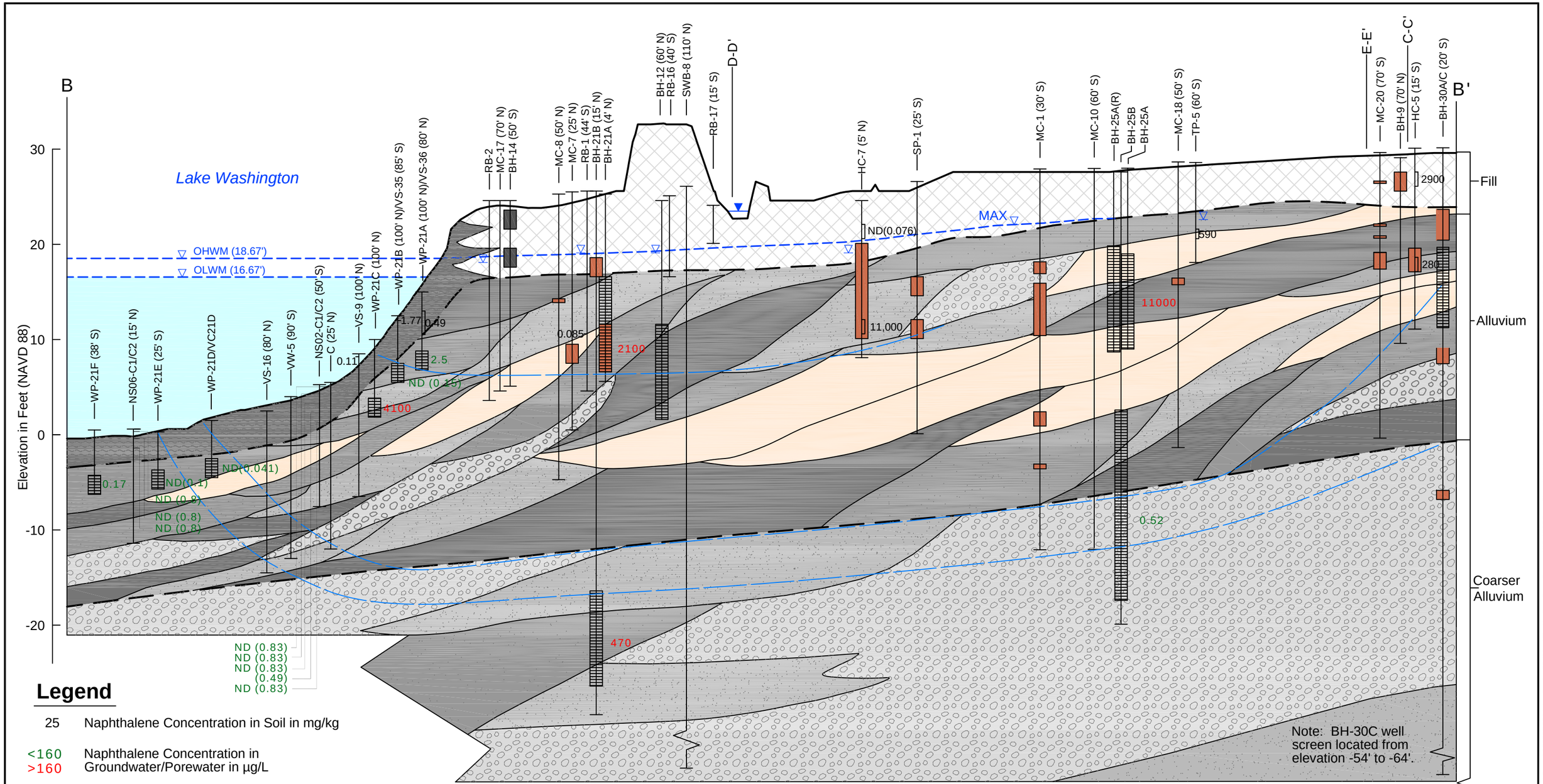
Vertical Exaggeration 10X

Aspect CONSULTING

Naphthalene Occurrences along Cross Section A-A'
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB/SCC	FIGURE NO. 5.2-10
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-5.2-10.dwg Figure 5.2-10 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:04pm || User: scudd



Legend

25 Naphthalene Concentration in Soil in mg/kg

<160 Naphthalene Concentration in
>160 Groundwater/Porewater in µg/L

RB-17 (15' S) — Well ID and Offset from Cross Section

Water Level ATD

Solidified Tar Products

DNAPL

Well Screen

Fill

Organic Sandy Silt (Mud)

Peat/Organic Silt

Silt/Clayey Silt

Sandy Silt/Silty Sand

Sand

Gravelly Sand/ Sandy Gravel

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 10 20
Feet

Vertical Exaggeration 10X

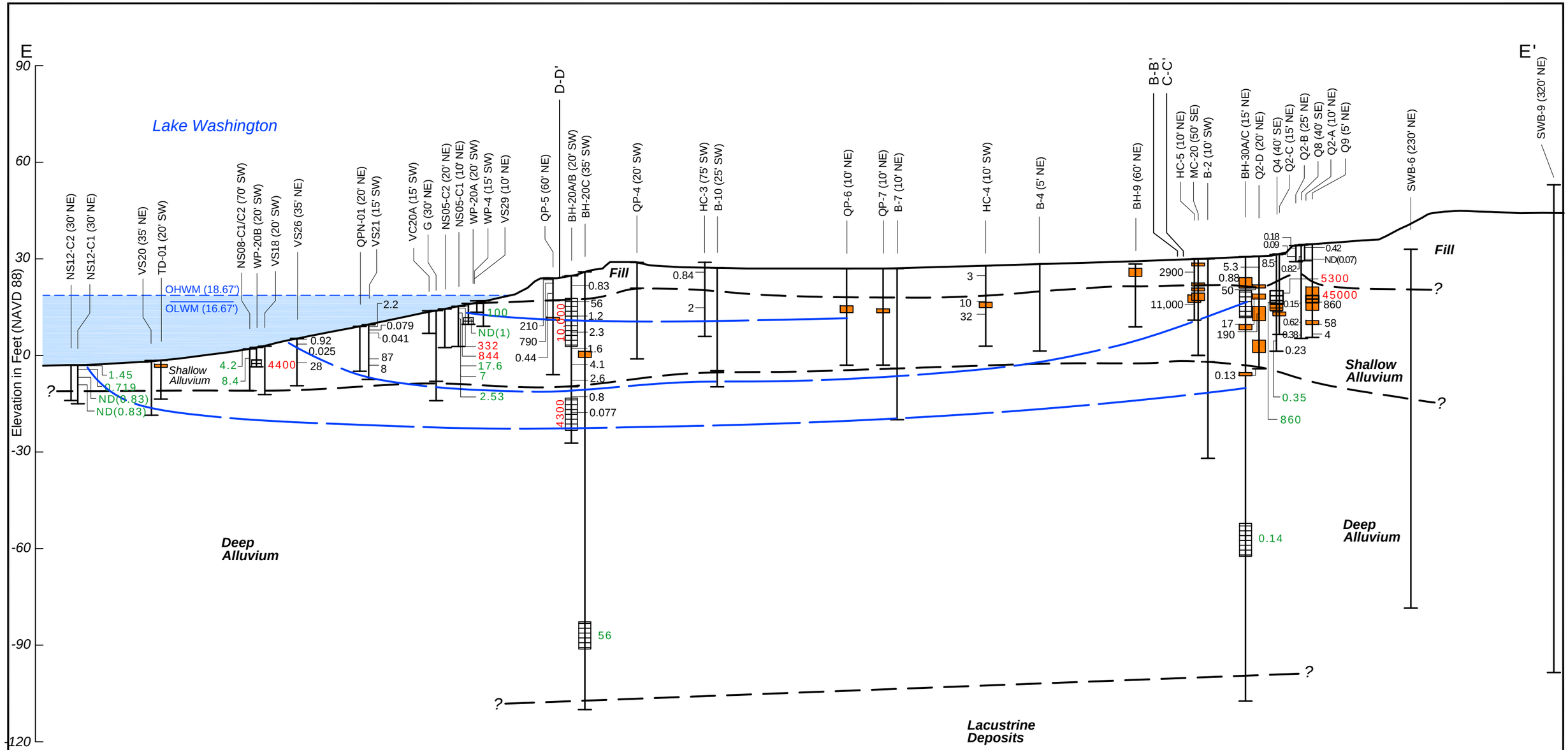
Aspect CONSULTING

Naphthalene Occurrences along Cross Section B-B'

Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP	
DRAWN BY: PMB	FIGURE NO. 5.2-11
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-5211.dwg Section BB (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:09pm || User: scudd



Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

DNAPL

Well Screen

25 — Naphthalene Concentration in Soil in mg/kg

<160 / >160 — Naphthalene Concentration in Groundwater/Porewater in µg/L

Model-Generated Groundwater Flowpaths

Note:
The groundwater flowpaths shown in this figure do not account for contaminant plume "spreading" due to diffusion and dispersion processes. The extent of contamination originating from a particular source may therefore be greater than that implied by the particle-tracking flowpaths.

Horizontal Scale
0 100 200
Feet

Vertical Scale
0 30 60
Feet

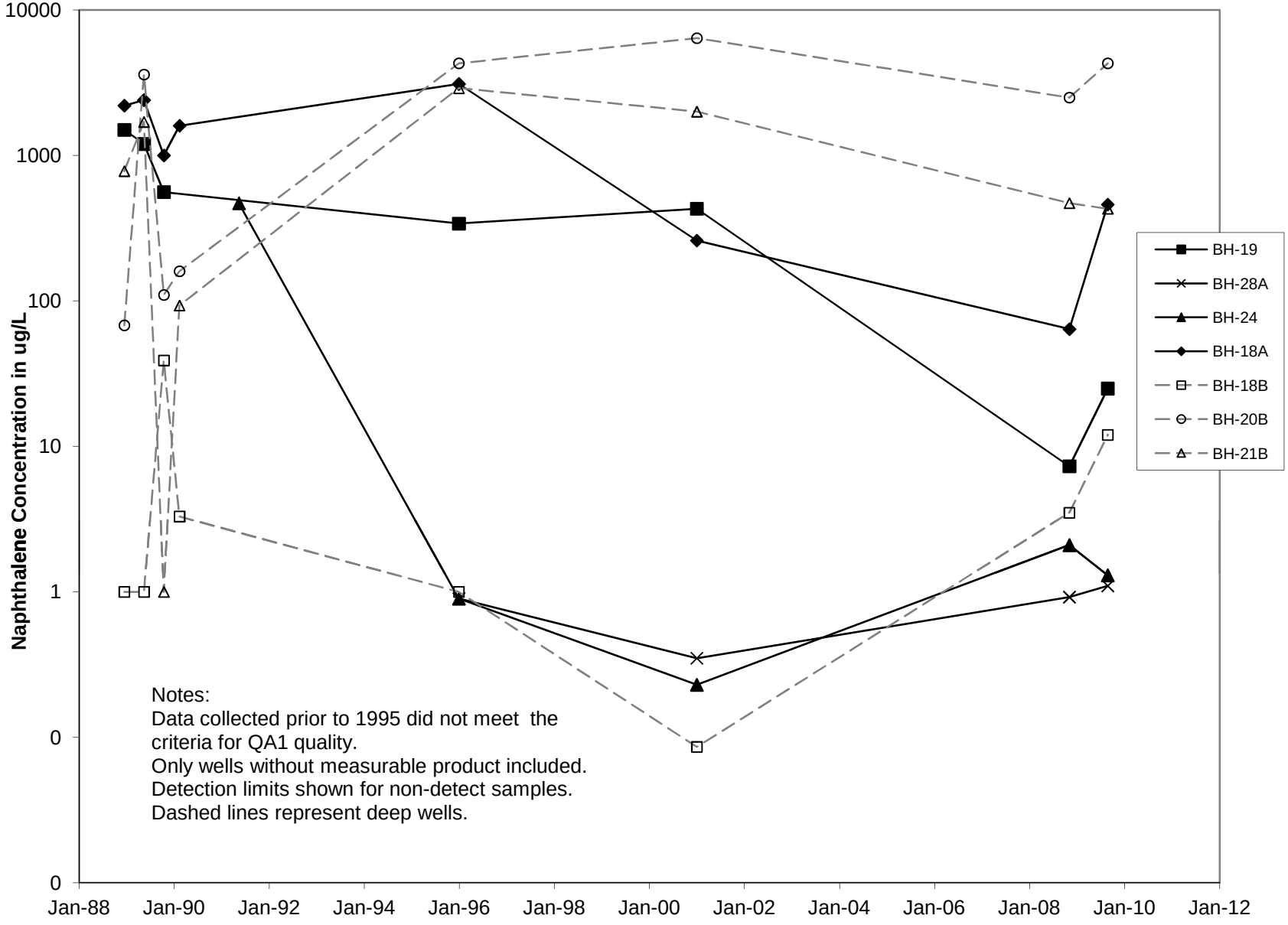
Vertical Exaggeration 6.66X

Aspect CONSULTING

Naphthalene Occurrences along Cross Section E-E'
Final Remedial Investigation, Quendall Terminals
Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH	
DRAWN BY: PMB/SCC	FIGURE NO. 5.2-12
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-5212.dwg Figure 5.2-12 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:14pm || User: scudd



Aspect Consulting
September 2012

Figure 5.2-13
Historical Naphthalene Concentrations at Shoreline Wells
Final Remedial Investigtion, Quendall Terminals

Legend

Non-Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

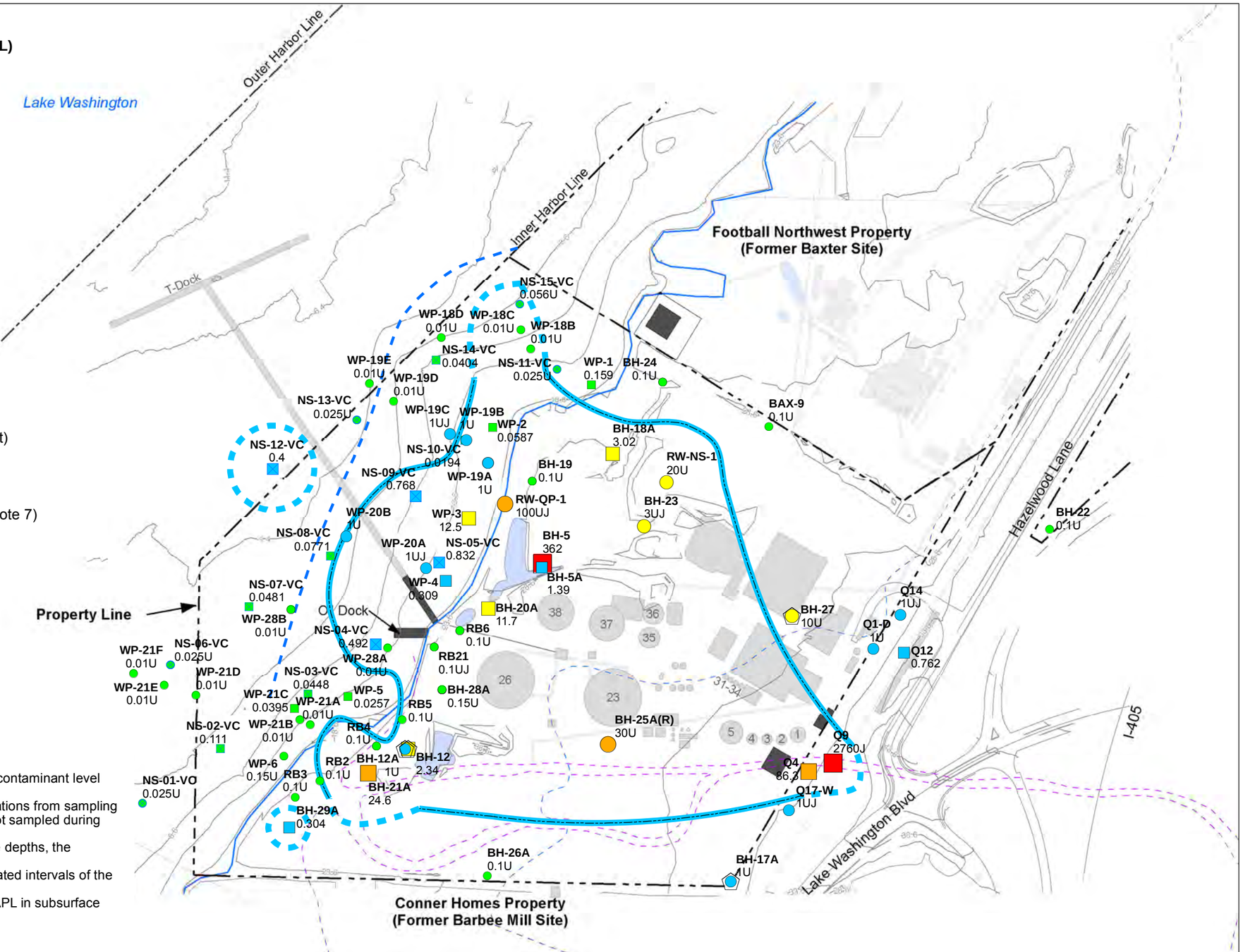
- <0.2
- ≥0.2 - 2
- ≥2 - 20
- ≥20 - 200
- ≥200

Basis of Screening Level Intervals
0.2 MCL
2 10x MCL
20 100x MCL
200 1000x MCL

Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

- <0.2
- ≥0.2 - 2
- ≥2 - 20
- ≥20 - 2,000
- ≥200
- QA0 Level Data
- Indicates Porewater Sample from Sediment Vibracore
- Approximate Extent of Detected cPAH (B[a]P Equivalent) Concentrations Exceeding MCL (0.2 µg/L)
- Inferred from Lines of Evidence other than Groundwater Chemistry
- Predicted Western Extent of Groundwater Discharge (Note 7)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond

Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4.The PRG screening level for cPAHs in groundwater is the maximum contaminant level (MCL) for benzo(a)pyrene of 0.2 microgram per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. At porewater sampling stations (e.g. NS-01-VC) with multiple sample depths, the maximum subsurface porewater concentration is shown.
7. Predicted western extent of groundwater discharging from contaminated intervals of the Site (see Section 6.4). Does not include dispersion.
8. Southern and northern boundaries adjusted to include extent of DNAPL in subsurface (see Figure 4.4-1).



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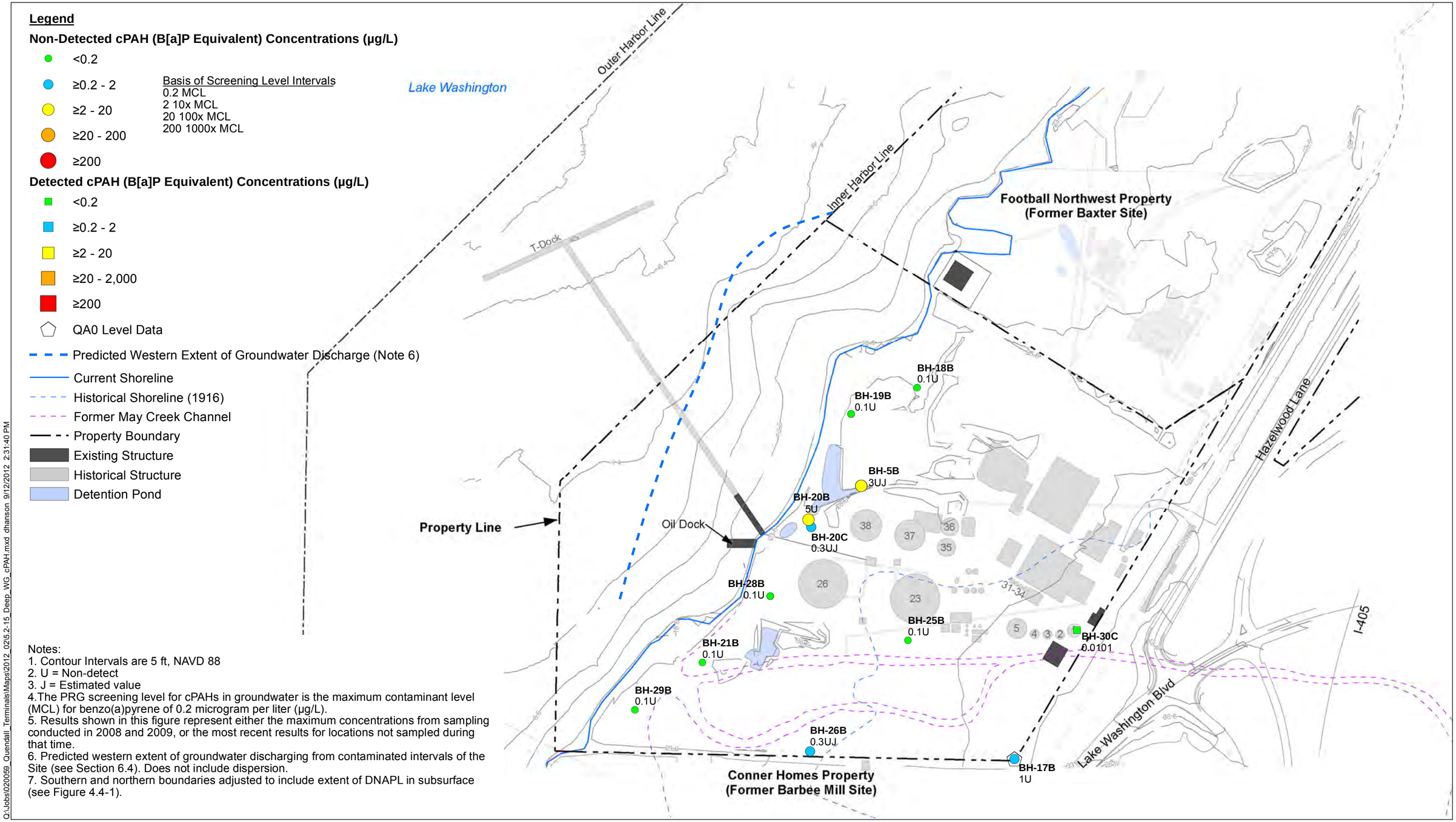
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-14
Shallow Groundwater cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals



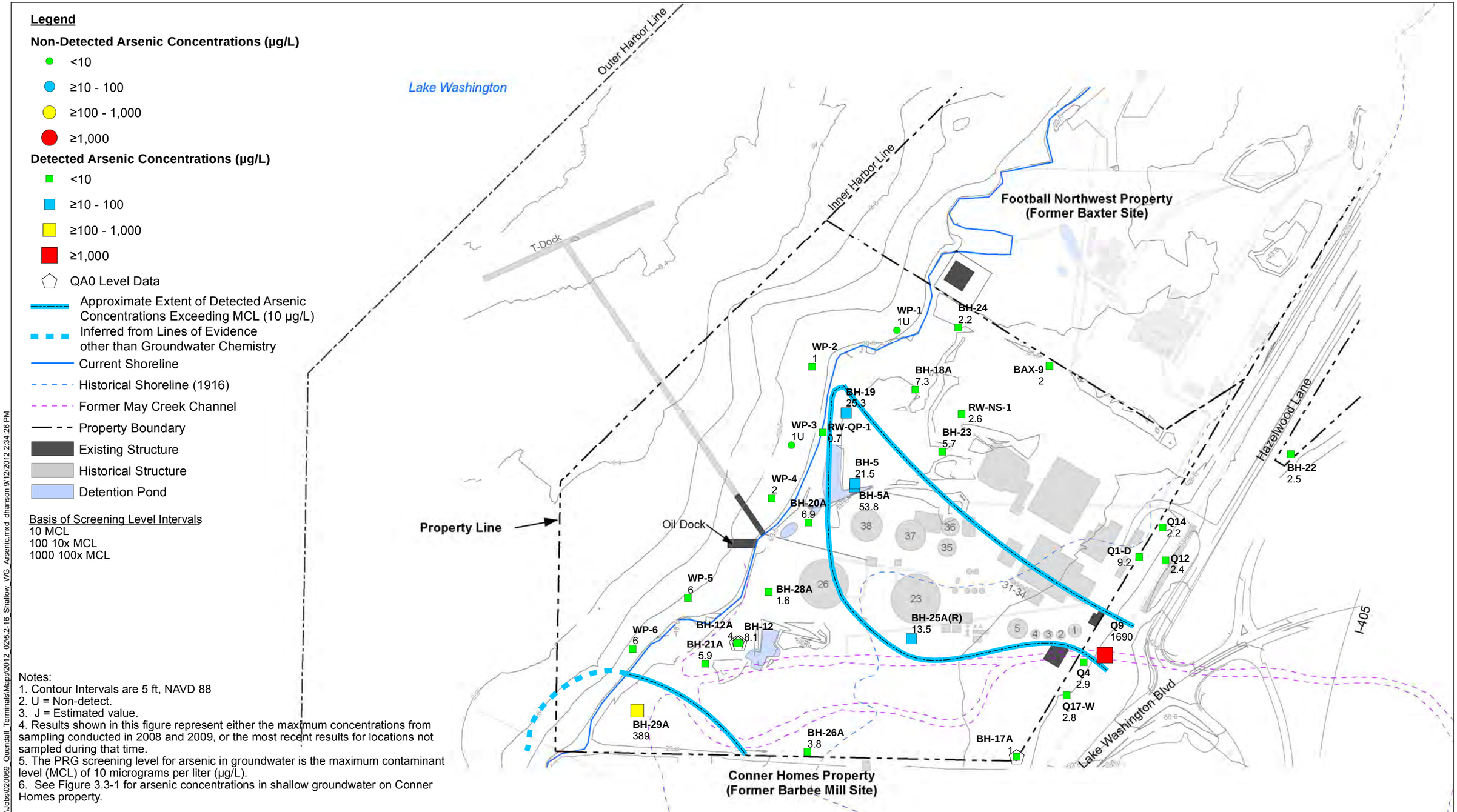
Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4.The PRG screening level for cPAHs in groundwater is the maximum contaminant level (MCL) for benzo(a)pyrene of 0.2 microgram per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Predicted western extent of groundwater discharging from contaminated intervals of the Site (see Section 6.4). Does not include dispersion.
7. Southern and northern boundaries adjusted to include extent of DNAPL in subsurface (see Figure 4.4-1).

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0205.2-15_Deep_WG_cPAH.mxd dhanson 9/12/2012 2:31:40 PM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-15
Deep Groundwater cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect.
3. J = Estimated value.
4. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
5. The PRG screening level for arsenic in groundwater is the maximum contaminant level (MCL) of 10 micrograms per liter (µg/L).
6. See Figure 3.3-1 for arsenic concentrations in shallow groundwater on Conner Homes property.

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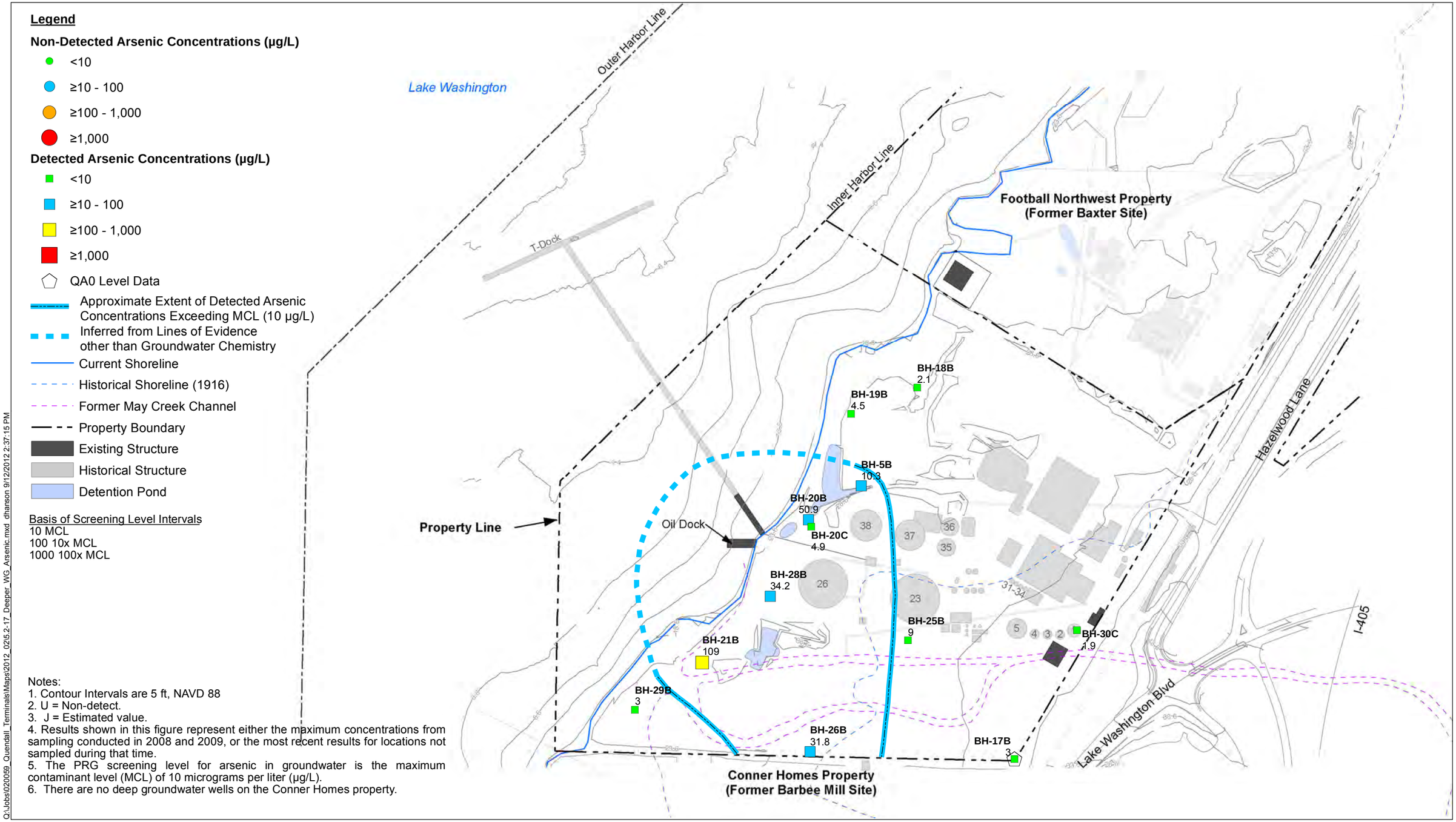
ANCHOR QEA

Feet
0 100 200 300 400

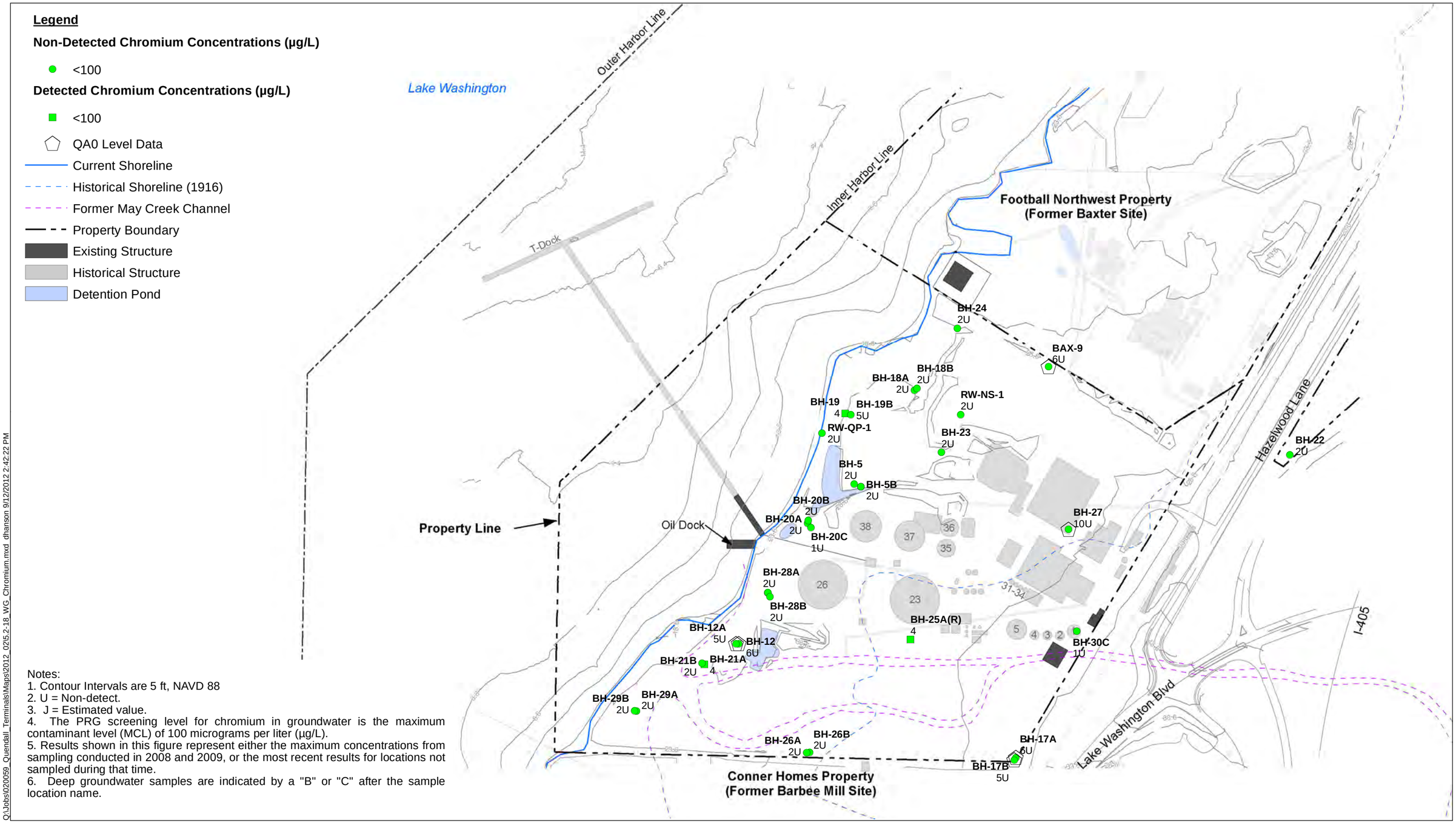
Figure 5.2-16
Shallow Groundwater Arsenic Concentrations
Final Remedial Investigation, Quendall Terminals



Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215.2-17_Deeper_WG_Arsenic.mxd dhanson 9/12/2012 2:37:15 PM

ANCHOR QEA

Figure 5.2-17
Deep Groundwater Arsenic Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for chromium in groundwater is the maximum contaminant level (MCL) of 100 micrograms per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Deep groundwater samples are indicated by a "B" or "C" after the sample location name.

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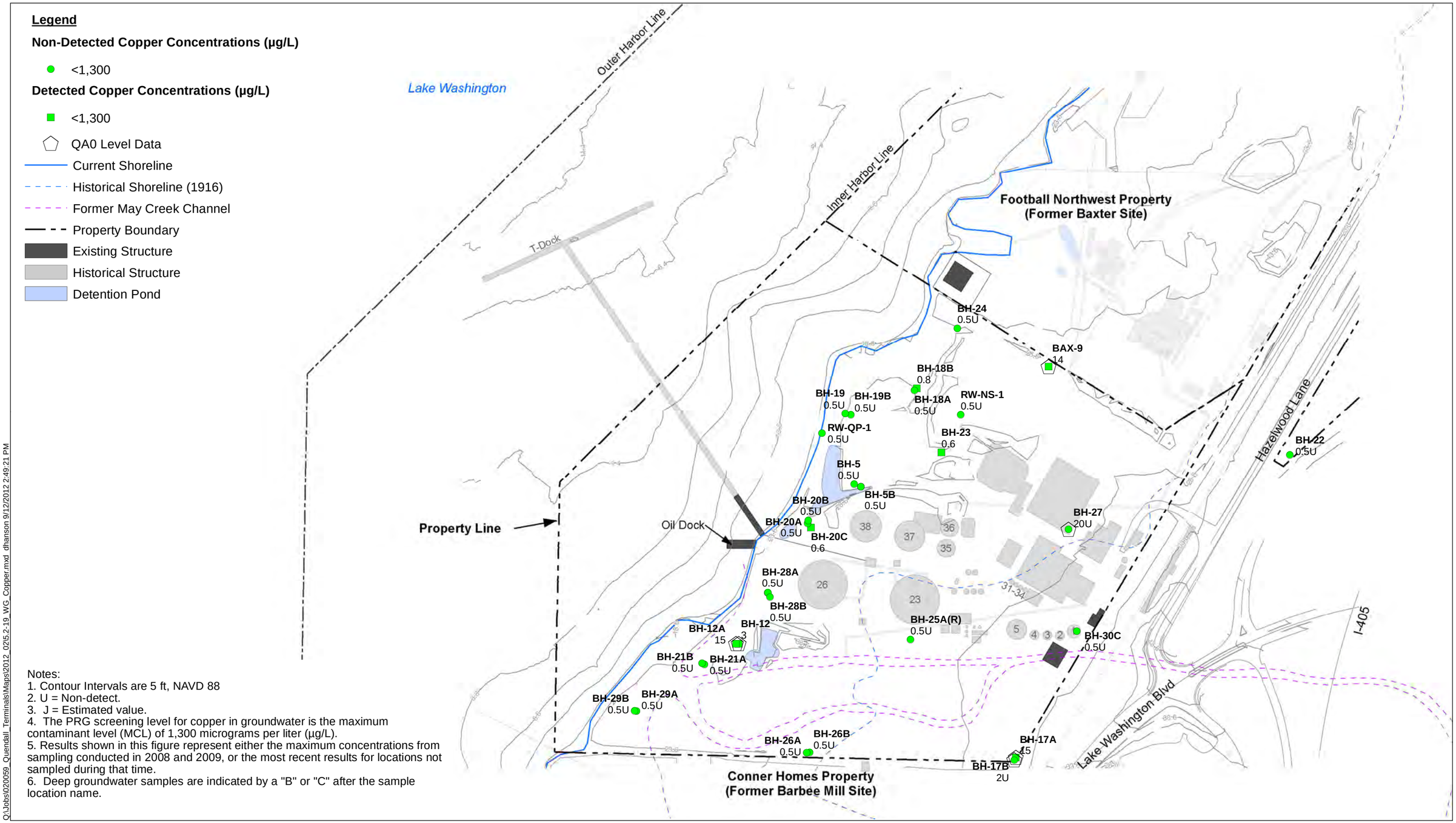
Figure 5.2-18
Groundwater Chromium Concentrations
Final Remedial Investigation, Quendall Terminals

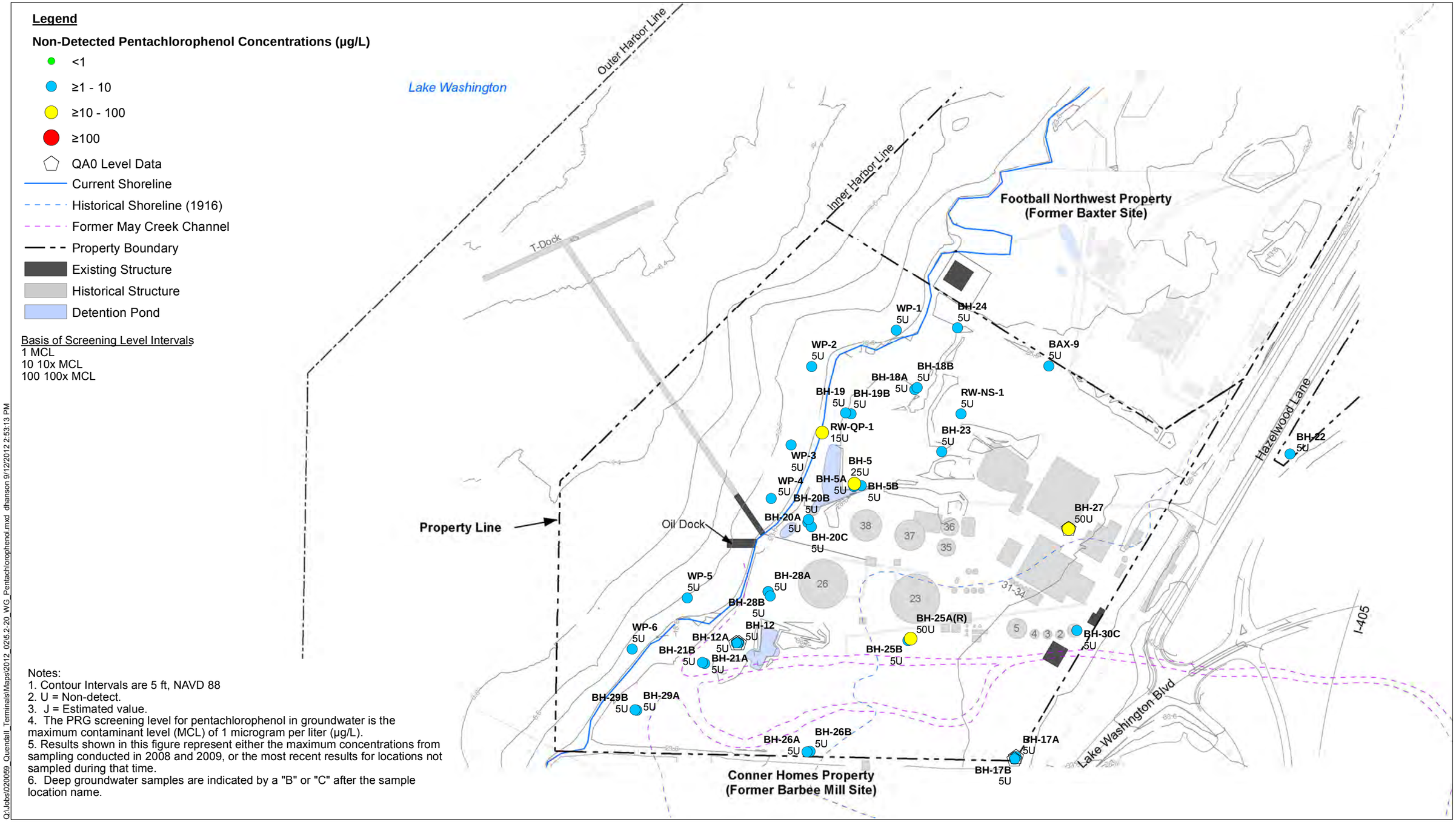


Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for copper in groundwater is the maximum contaminant level (MCL) of 1,300 micrograms per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Deep groundwater samples are indicated by a "B" or "C" after the sample location name.

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.2-19
Groundwater Copper Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for pentachlorophenol in groundwater is the maximum contaminant level (MCL) of 1 microgram per liter (µg/L).
5. Results shown in this figure represent either the maximum concentrations from sampling conducted in 2008 and 2009, or the most recent results for locations not sampled during that time.
6. Deep groundwater samples are indicated by a "B" or "C" after the sample location name.

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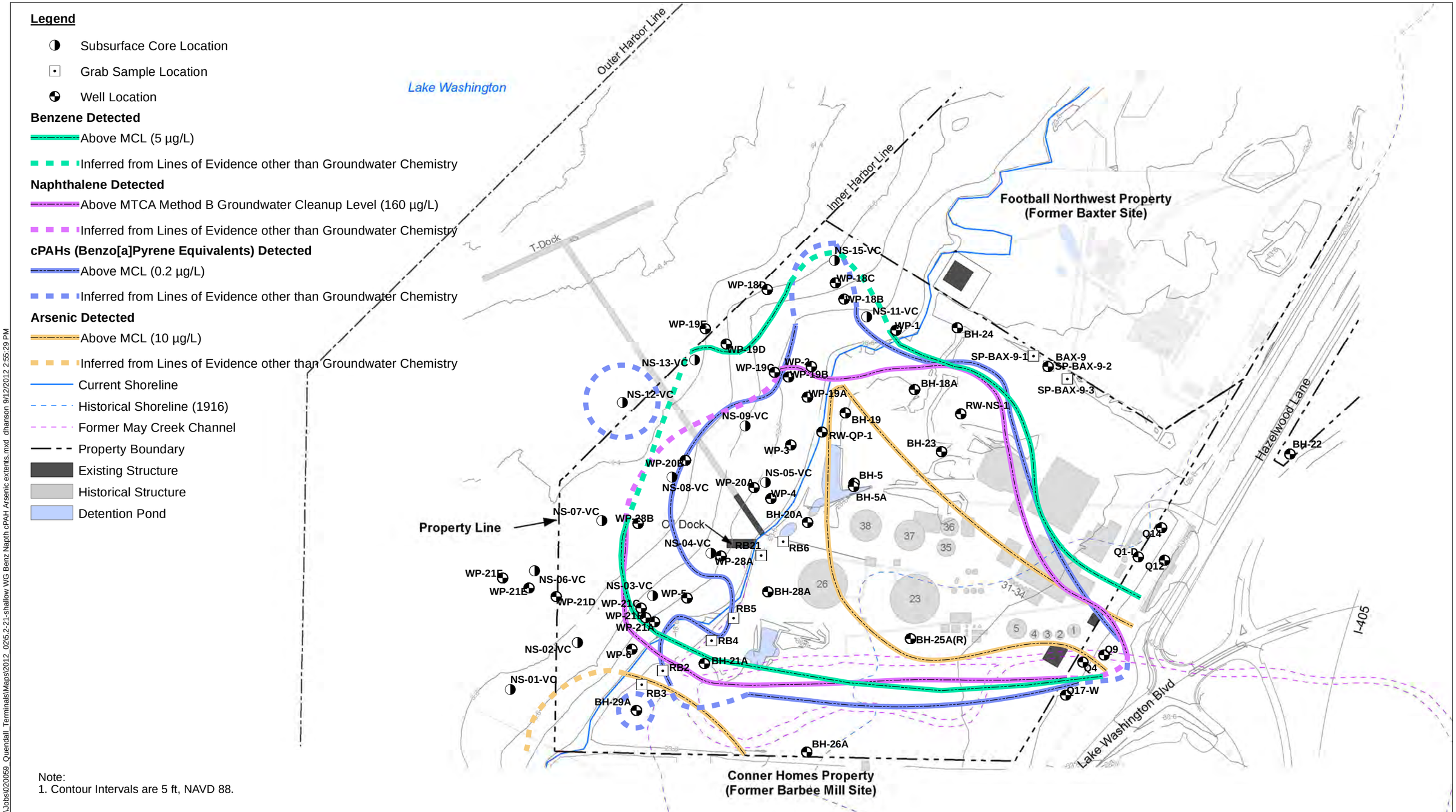
ANCHOR QEA

Figure 5.2-20
Groundwater Pentachlorophenol Concentrations
Final Remedial Investigation, Quendall Terminals

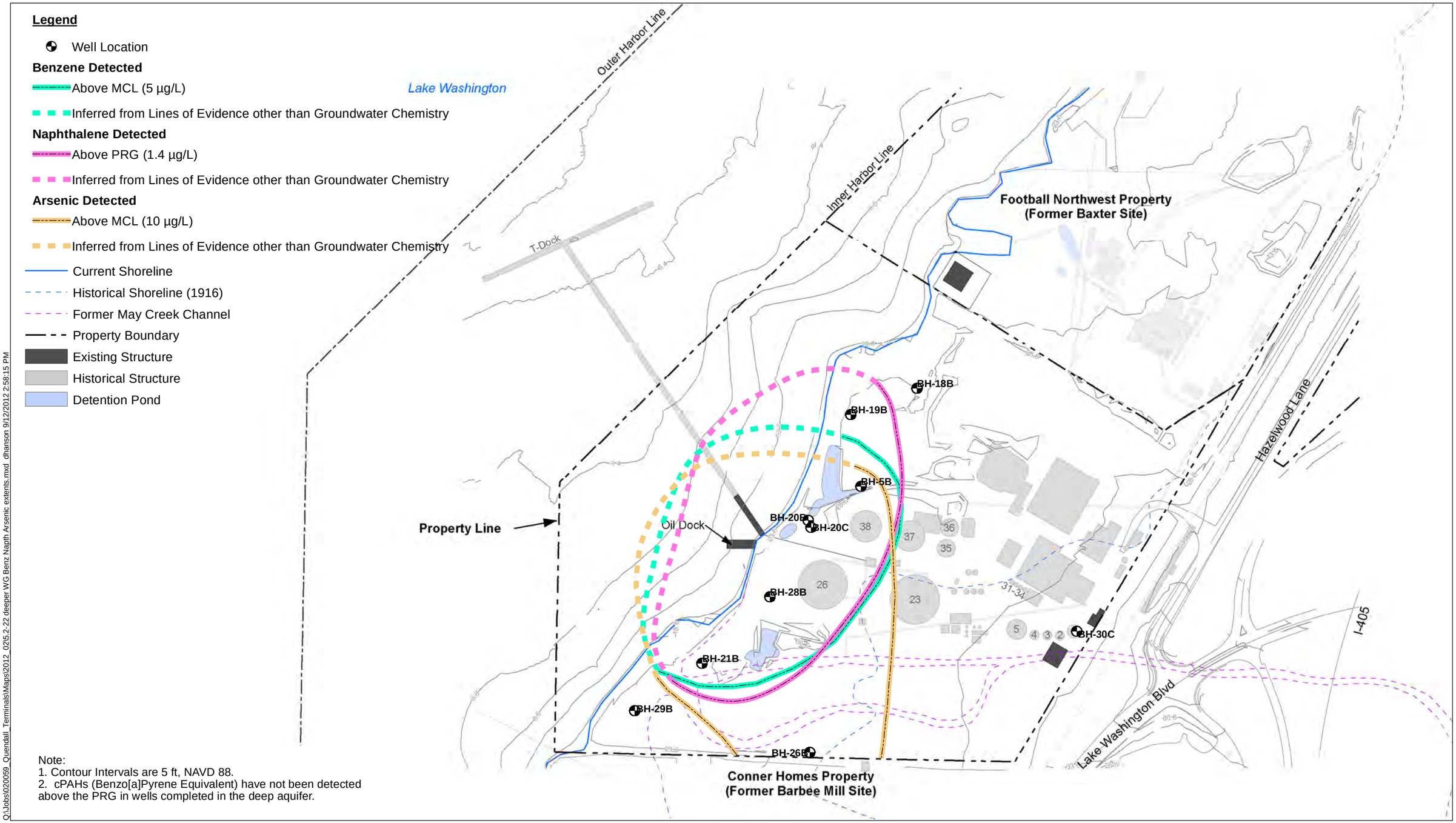


Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215_2-21-shallow WG Benz Napth cPAH Arsenic extents.mxd dhanson 9/12/2012 2:55:29 PM

Note:
1. Contour Intervals are 5 ft, NAVD 88.

ANCHOR QEA

Figure 5.2-21
Approximate Extents of Benzene, Napthalene, cPAHs, and Arsenic in Shallow Groundwater
Final Remedial Investigation, Quendall Terminals

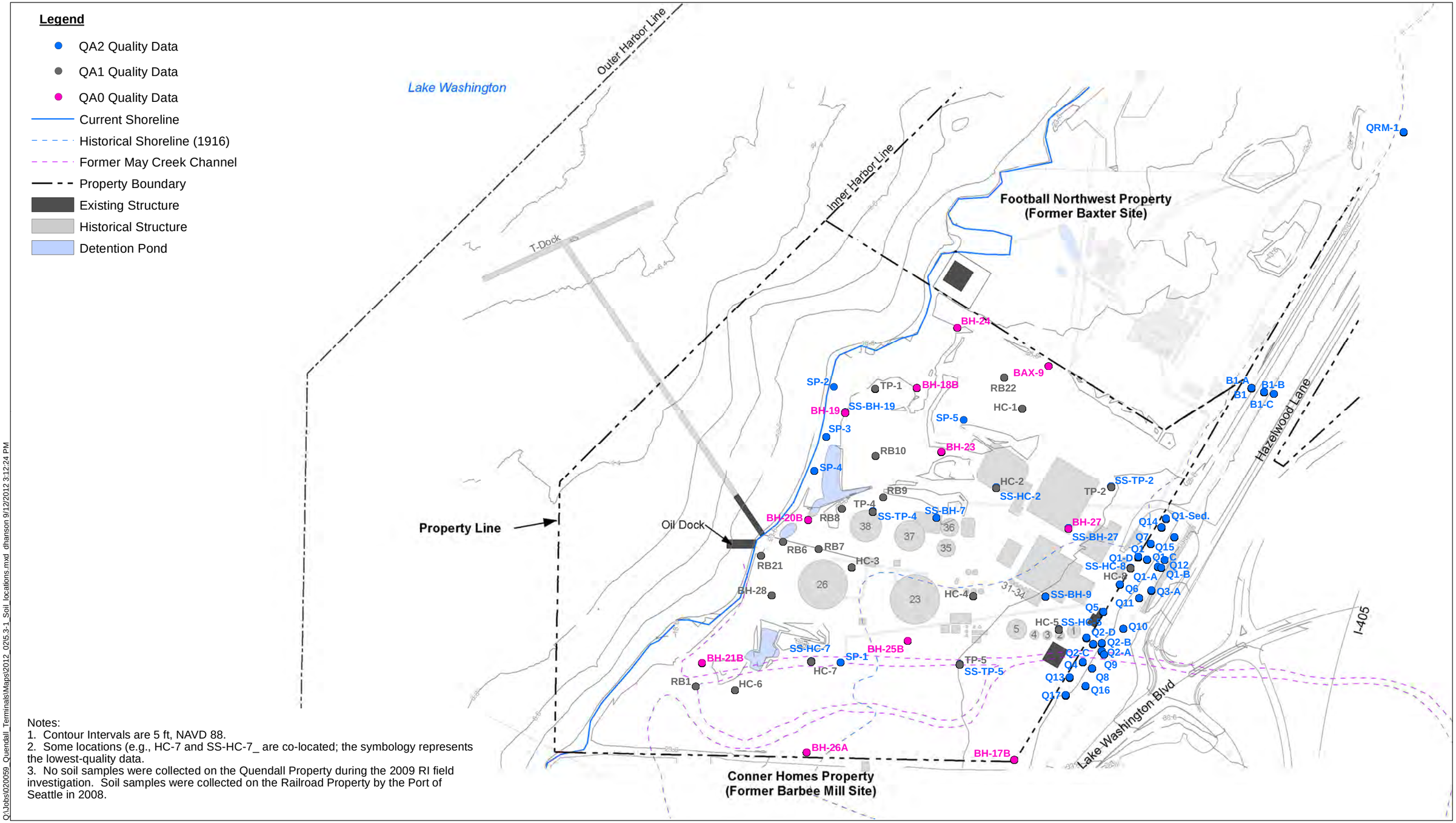


Note:
1. Contour Intervals are 5 ft, NAVD 88.
2. cPAHs (Benzo[a]Pyrene Equivalent) have not been detected above the PRG in wells completed in the deep aquifer.

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215.2-22 deeper WG Benz Napth Arsenic extents.mxd dhanson 9/12/2012 2:58:15 PM

ANCHOR QEA

Figure 5.2-22
Approximate Extents of Benzene, Napthalene, and Arsenic in Deep Groundwater
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. Some locations (e.g., HC-7 and SS-HC-7_ are co-located; the symbology represents the lowest-quality data.
3. No soil samples were collected on the Quendall Property during the 2009 RI field investigation. Soil samples were collected on the Railroad Property by the Port of Seattle in 2008.

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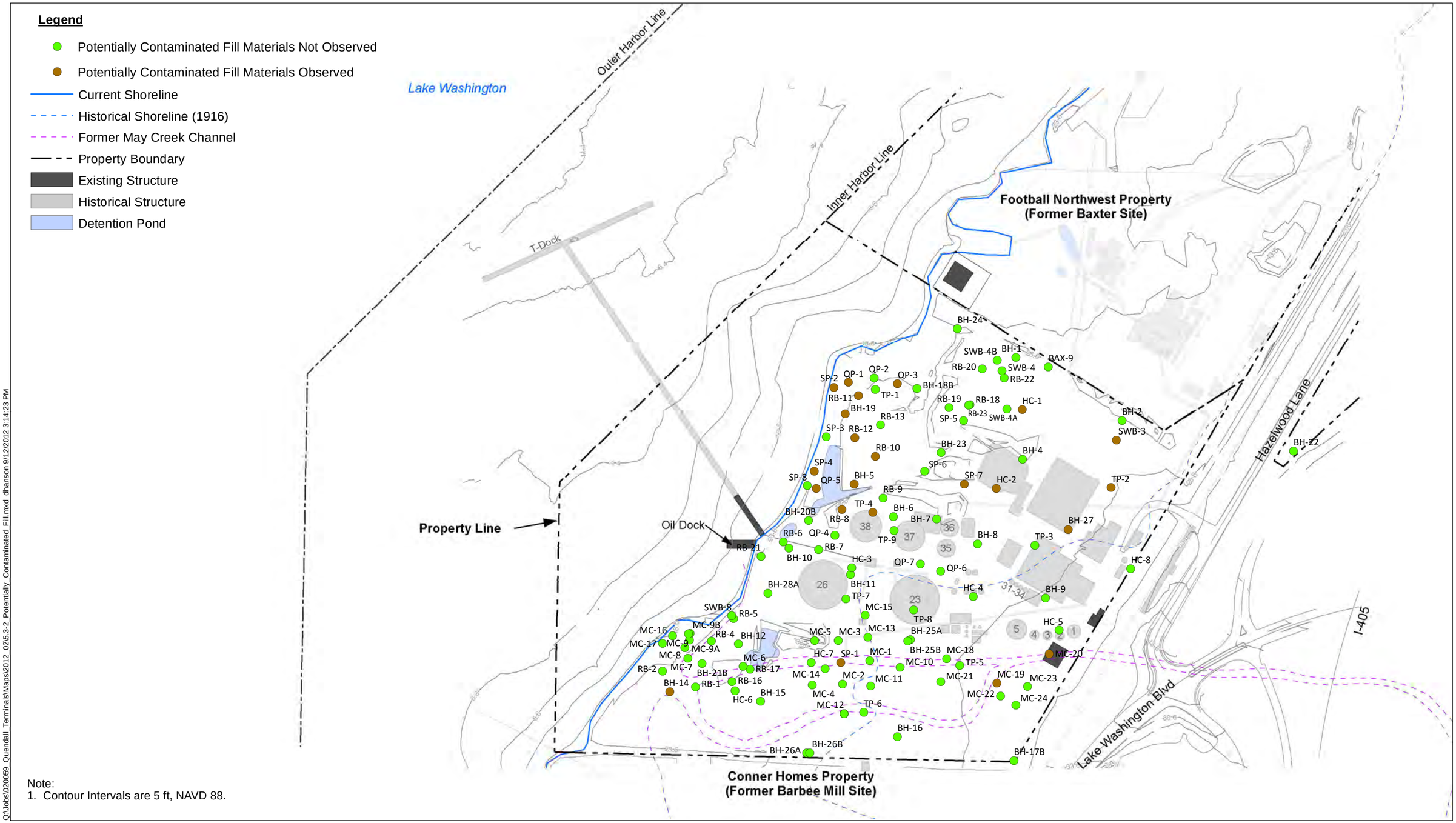
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-1
Locations of Soil Samples Used in the Remedial Investigation
Final Remedial Investigation, Quendall Terminals



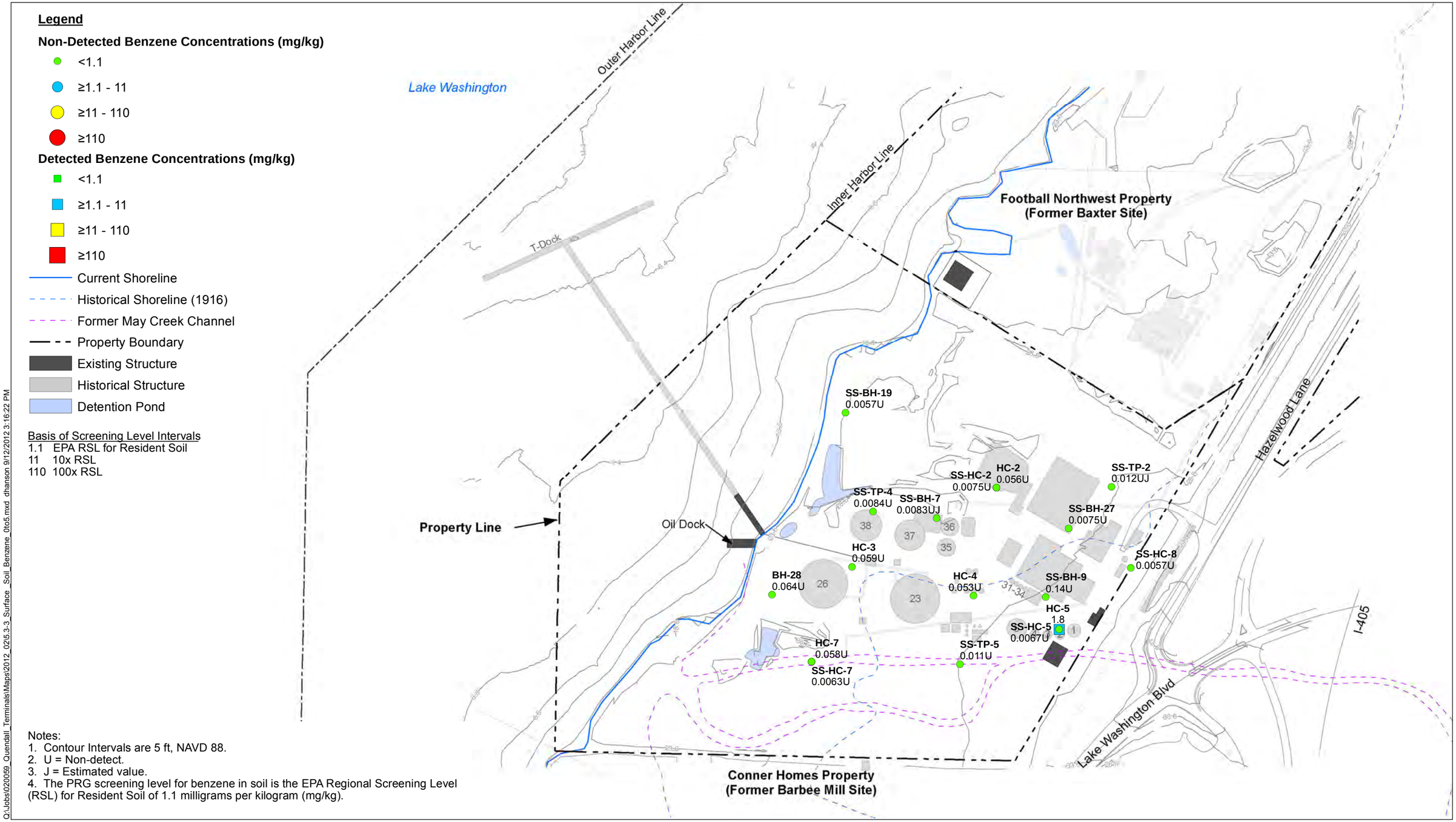
Note:
1. Contour Intervals are 5 ft, NAVD 88.

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_0215\3-2_Potentially_Contaminated_Fill.mxd dhanson 9/12/2012 3:14:23 PM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-2
Occurences of Potentially Contaminated Fill Materials
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for benzene in soil is the EPA Regional Screening Level (RSL) for Resident Soil of 1.1 milligrams per kilogram (mg/kg).

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ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-3
Surface Soil Benzene Concentrations - 0 to 5 Feet
Final Remedial Investigation, Quendall Terminals

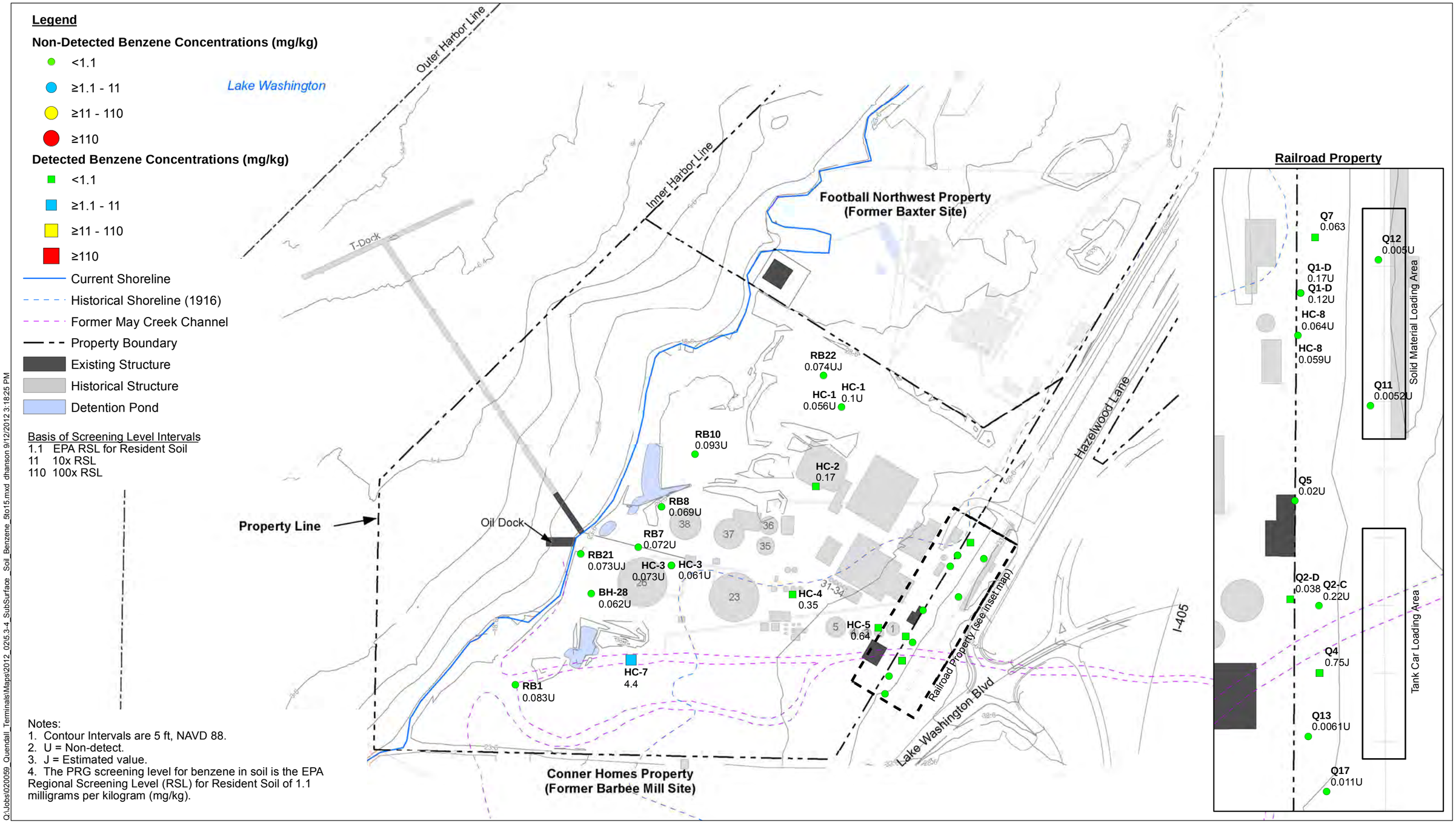
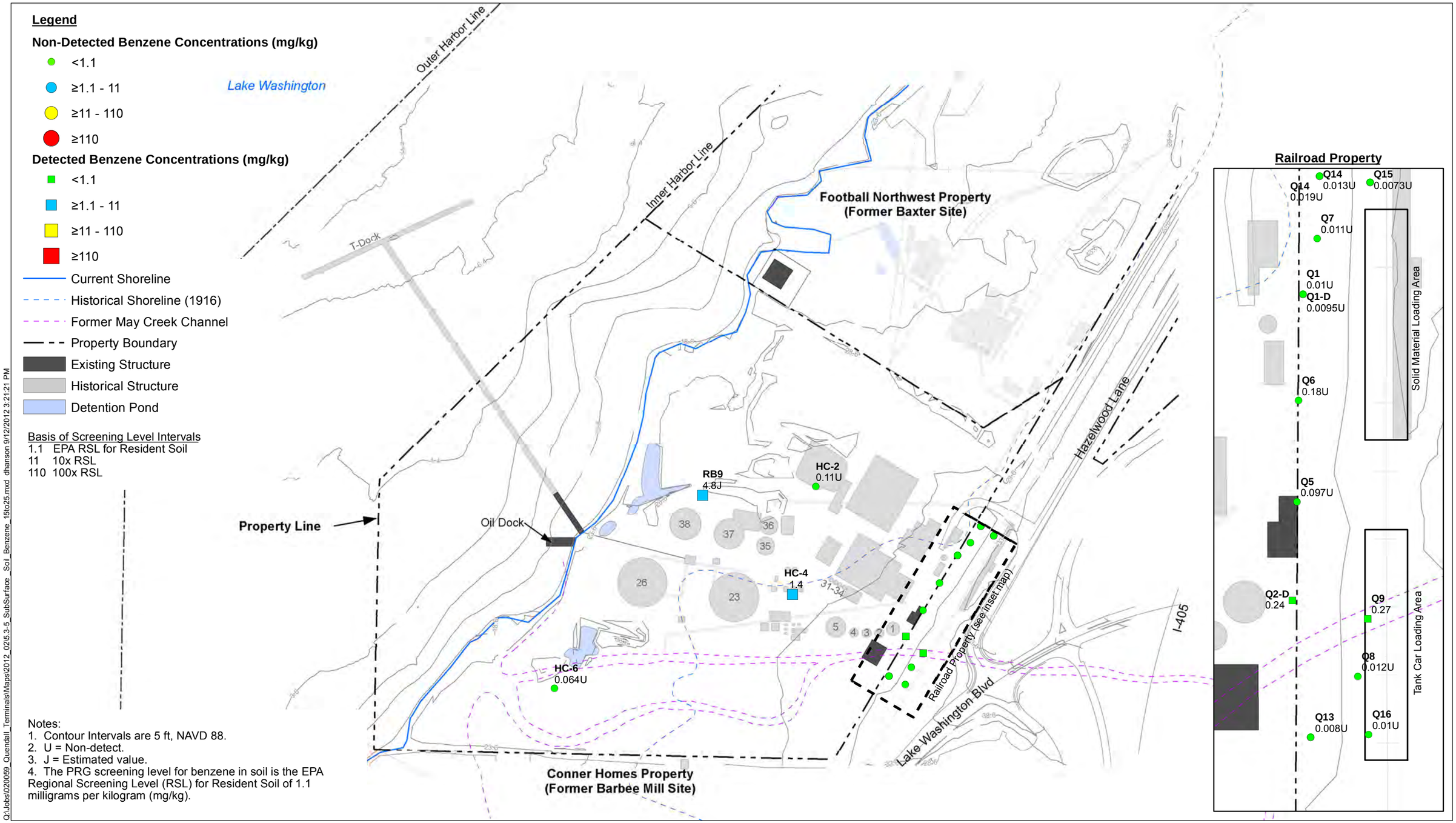


Figure 5.3-4
Subsurface Soil Benzene Concentrations - 5 to 15 Feet
Final Remedial Investigation, Quendall Terminals



ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-5
Subsurface Soil Benzene Concentrations - 15 to 25 Feet
Final Remedial Investigation, Quendall Terminals

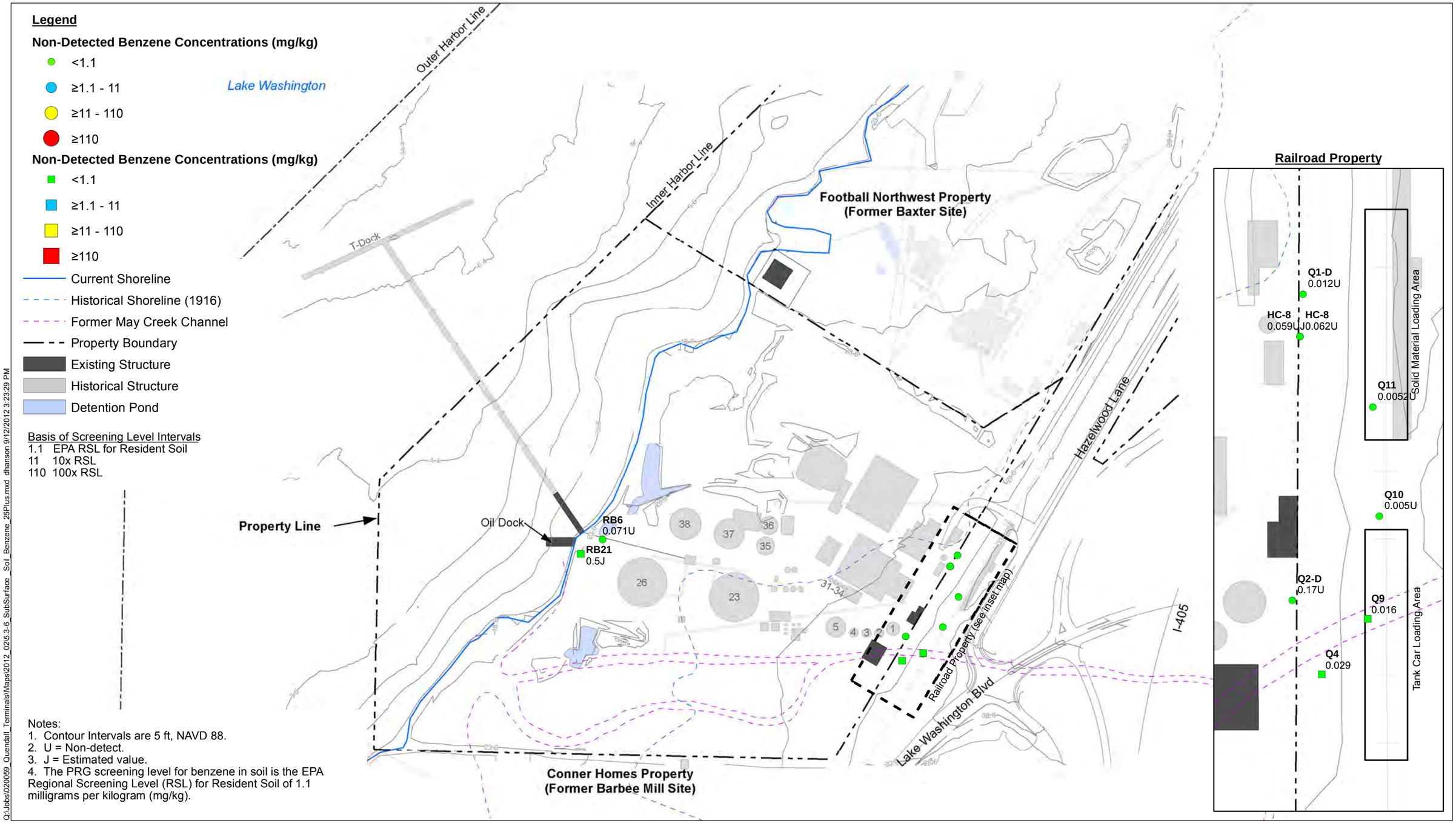
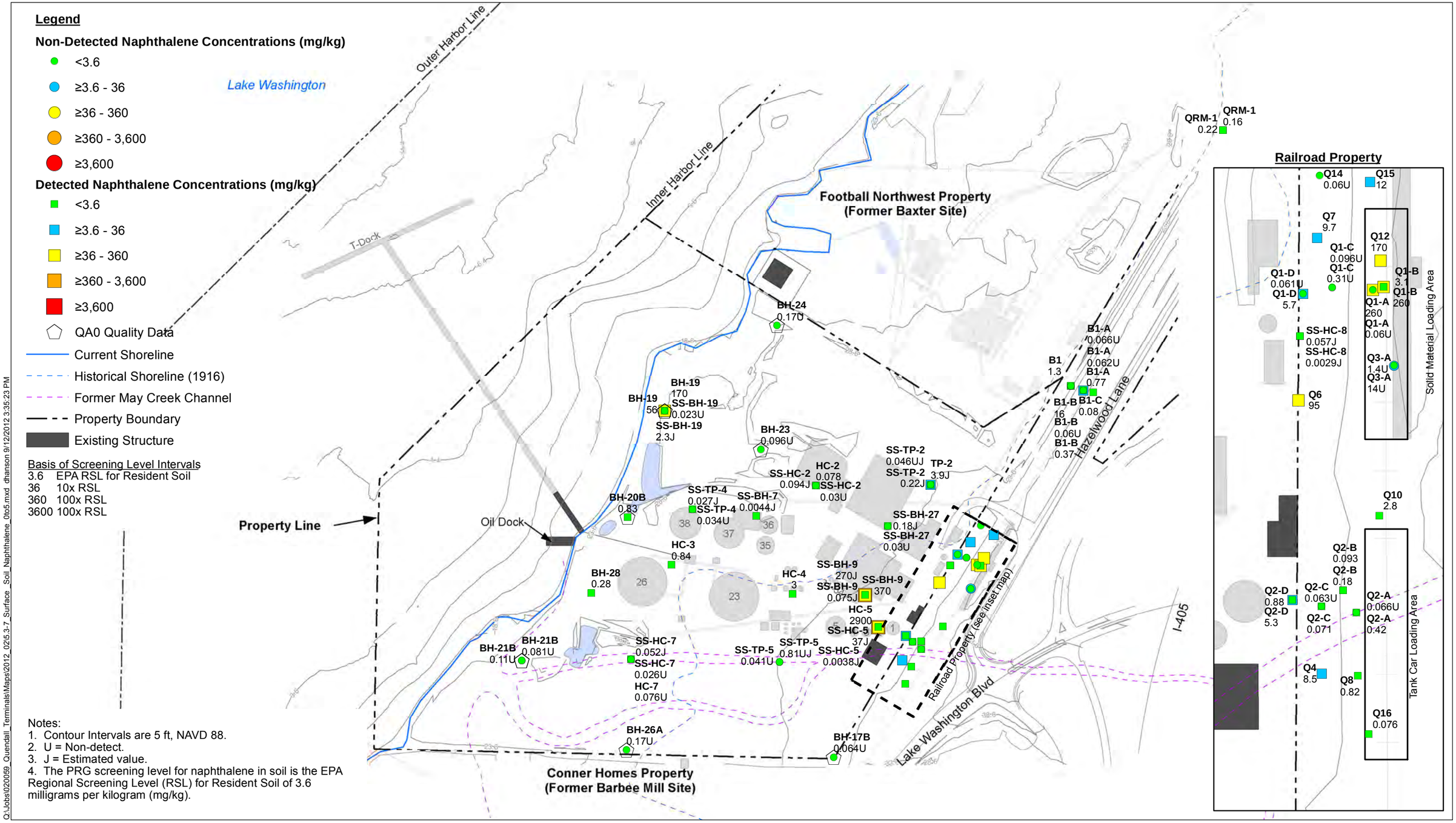


Figure 5.3-6
Subsurface Soil Benzene Concentrations - Depths Greater than 25 Feet
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for naphthalene in soil is the EPA Regional Screening Level (RSL) for Resident Soil of 3.6 milligrams per kilogram (mg/kg).

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Feet
0 100 200 300 400

Figure 5.3-7
Surface Soil Naphthalene Concentrations - 0 to 5 Feet
Final Remedial Investigation, Quendall Terminals

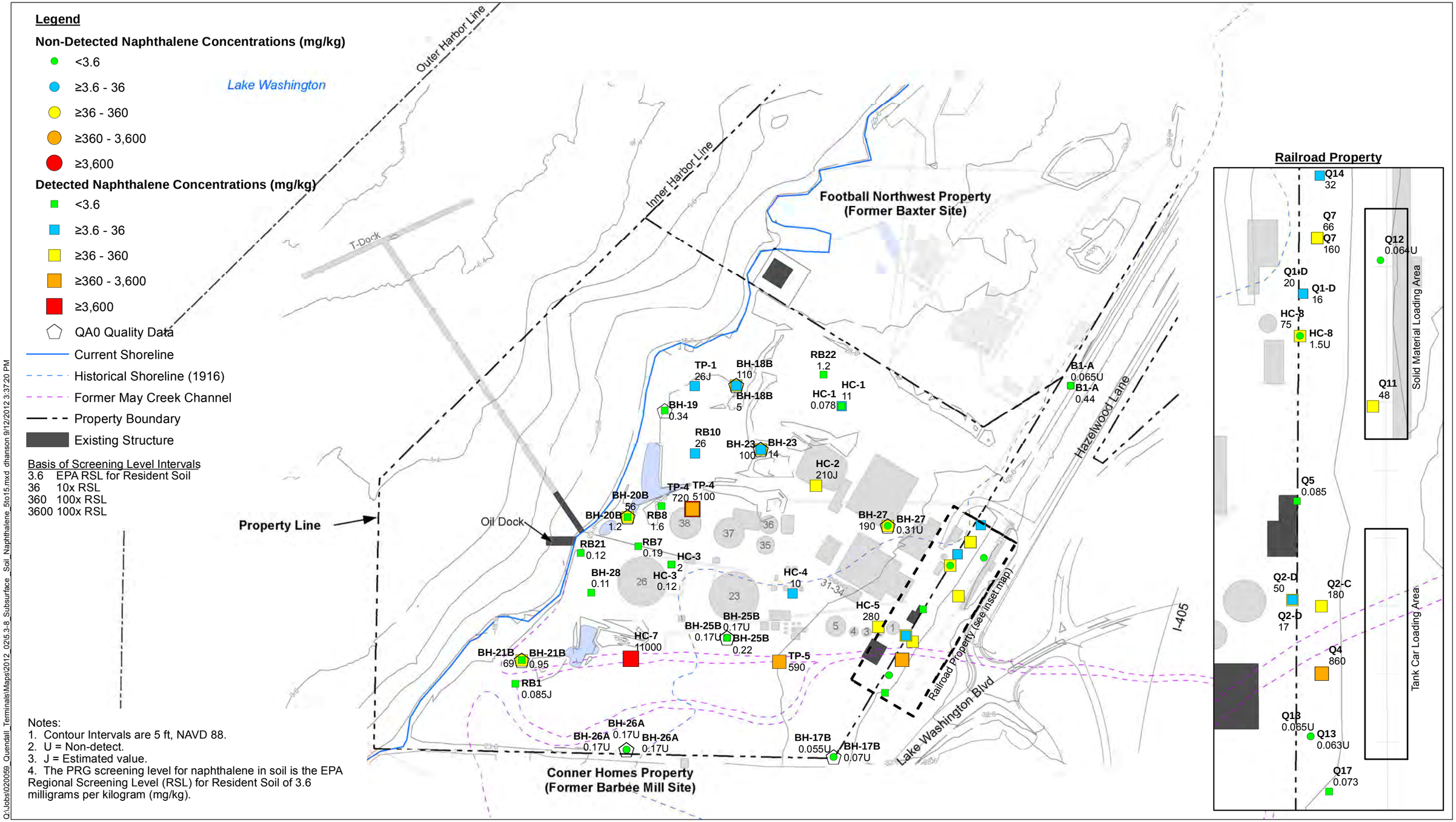

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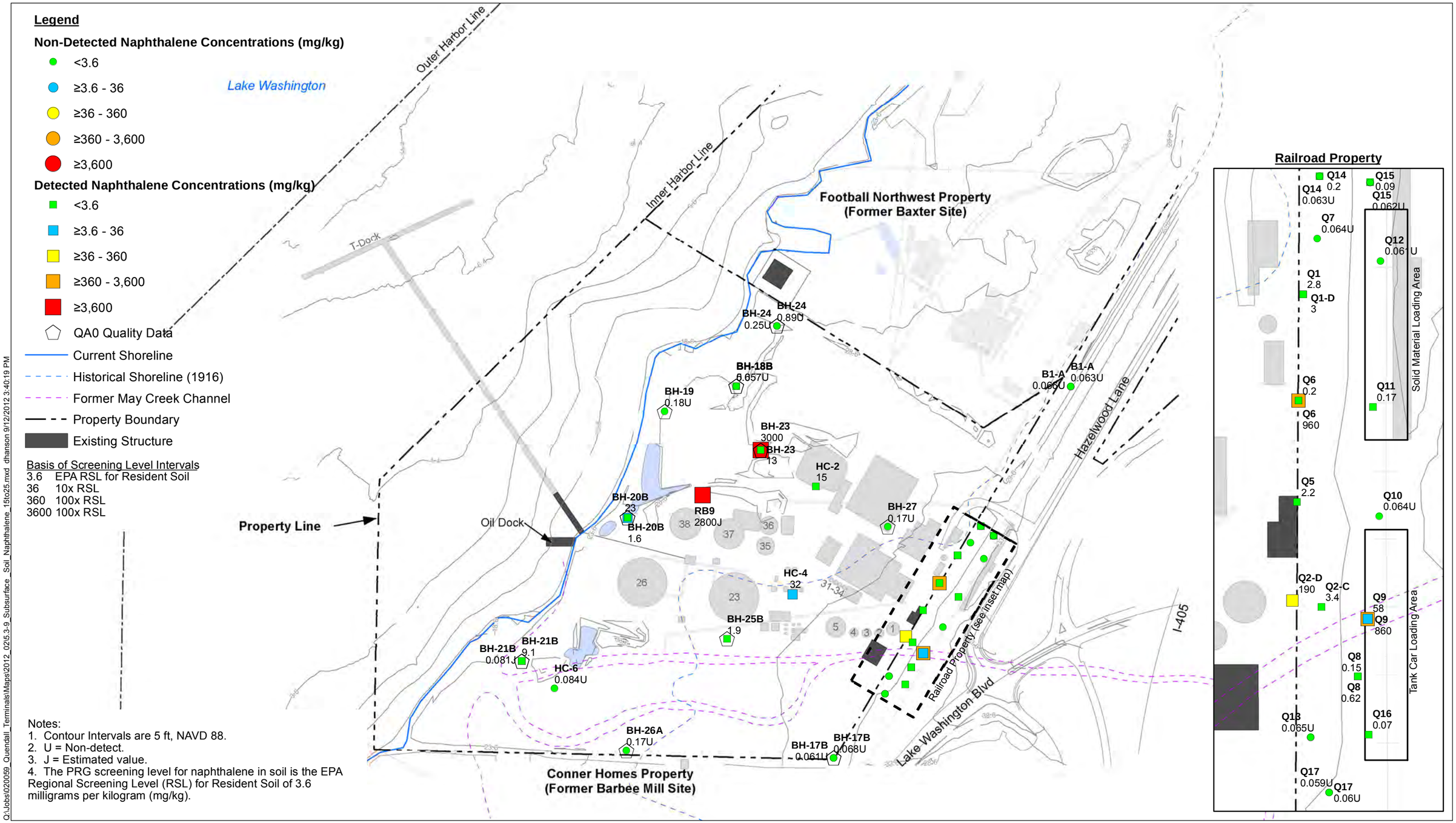
Figure 5.3-8
Subsurface Soil Naphthalene Concentrations - 5 to 15 Feet
Final Remedial Investigation, Quendall Terminals



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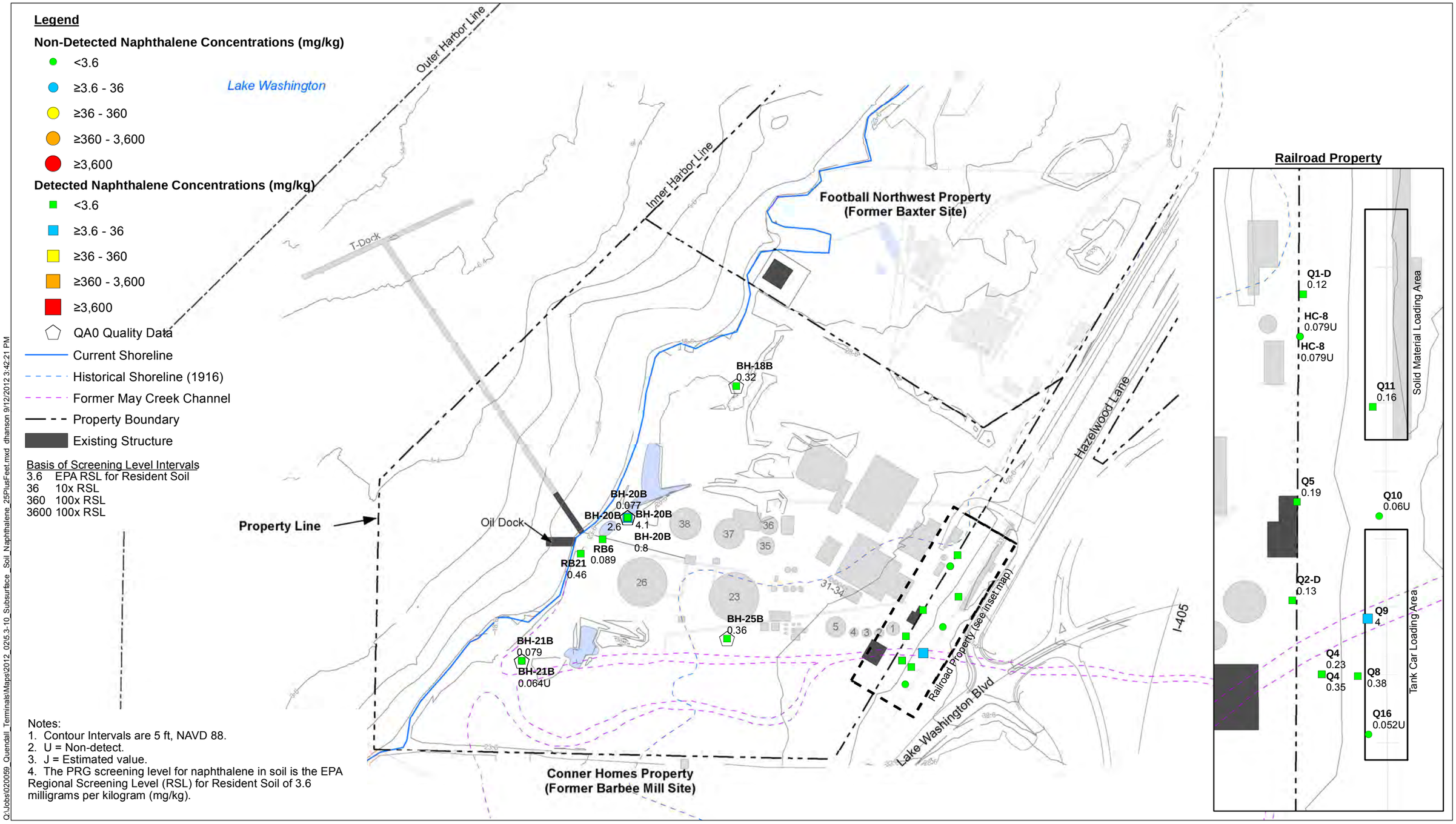
Feet
0 100 200 300 400

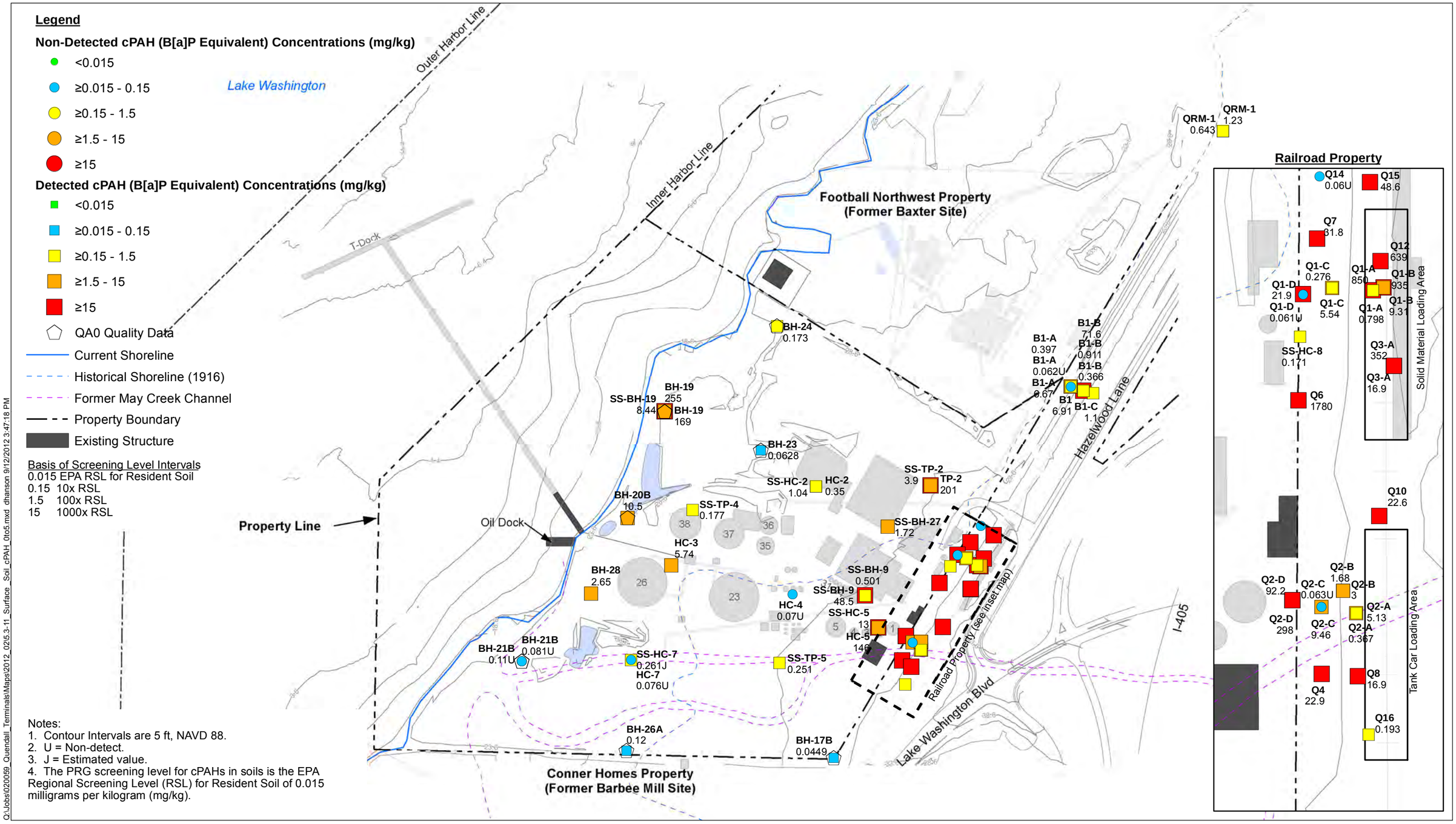
Figure 5.3-9
Subsurface Soil Naphthalene Concentrations - 15 to 25 Feet
Final Remedial Investigation, Quendall Terminals



ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-10
Subsurface Soil Naphthalene Concentrations - Depths Greater than 25 Feet
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for cPAHs in soils is the EPA Regional Screening Level (RSL) for Resident Soil of 0.015 milligrams per kilogram (mg/kg).

ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-11
Surface Soil cPAH (Benzo[a]Pyrene Equivalent) Concentrations - 0 to 5 Feet
Final Remedial Investigation, Quendall Terminals

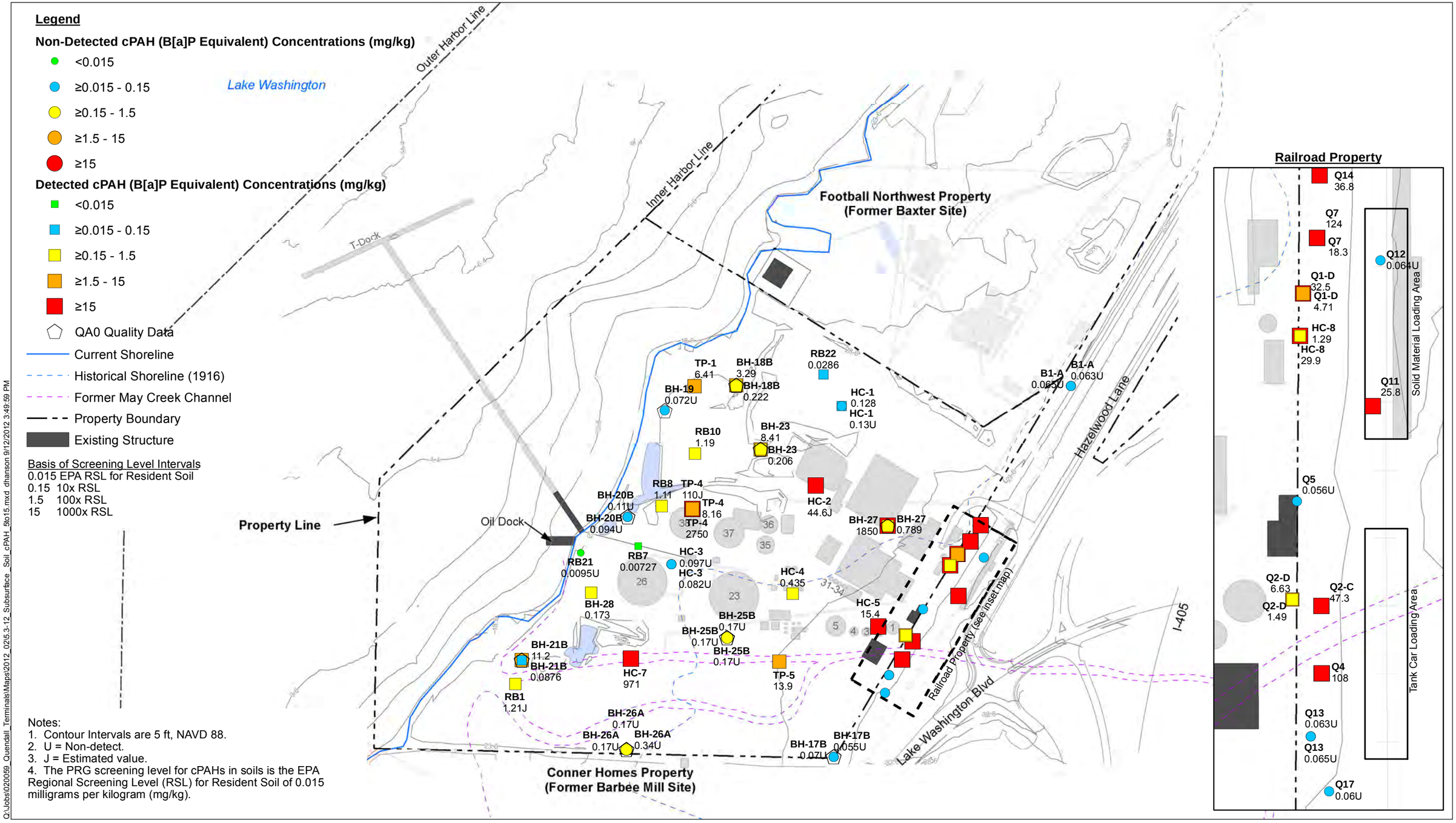


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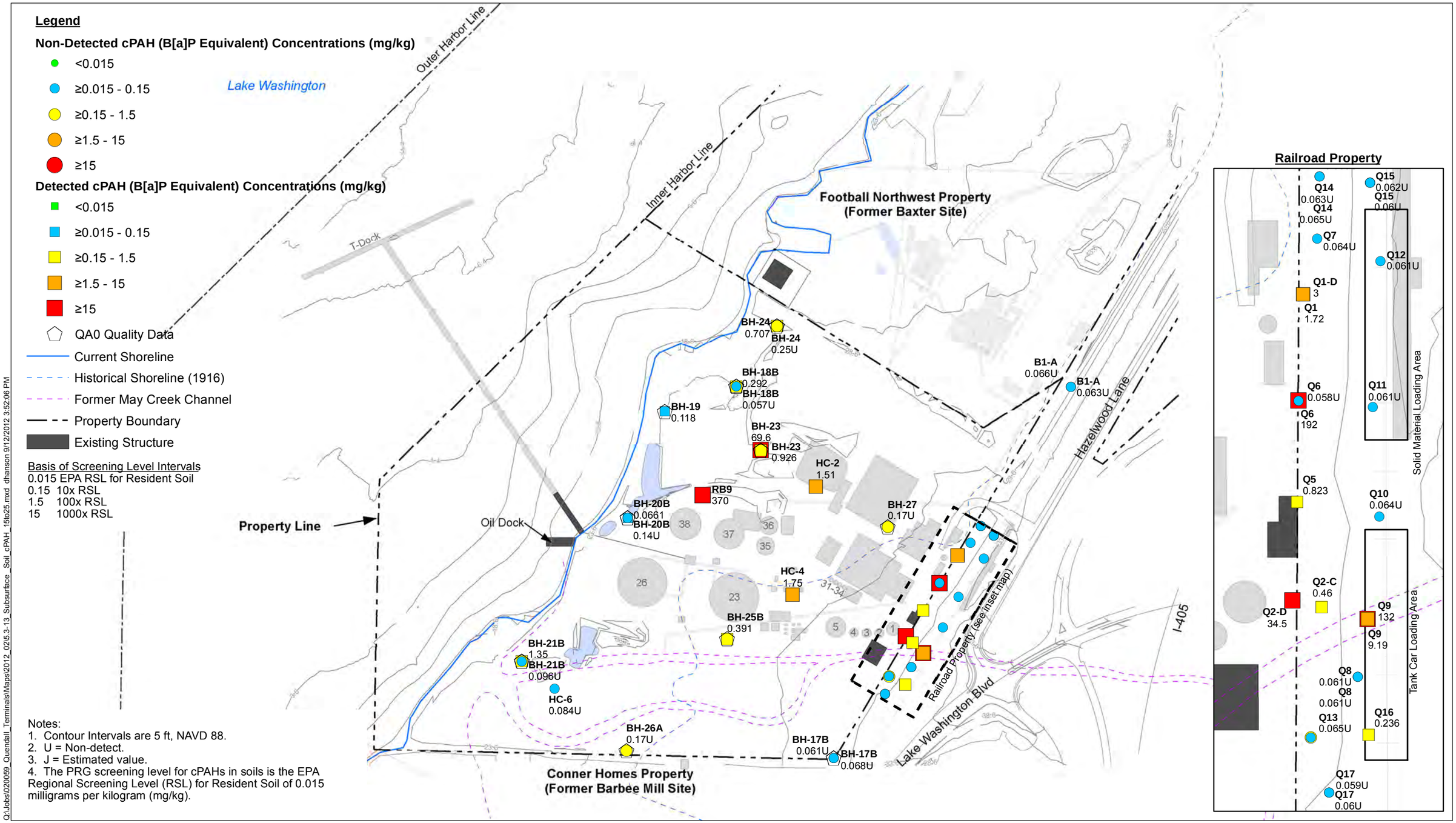
Figure 5.3-12
Subsurface Soil cPAH (Benzo[a]Pyrene Equivalent) Concentrations - 5 to 15 Feet
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-detect.
3. J = Estimated value.
4. The PRG screening level for cPAHs in soils is the EPA Regional Screening Level (RSL) for Resident Soil of 0.015 milligrams per kilogram (mg/kg).

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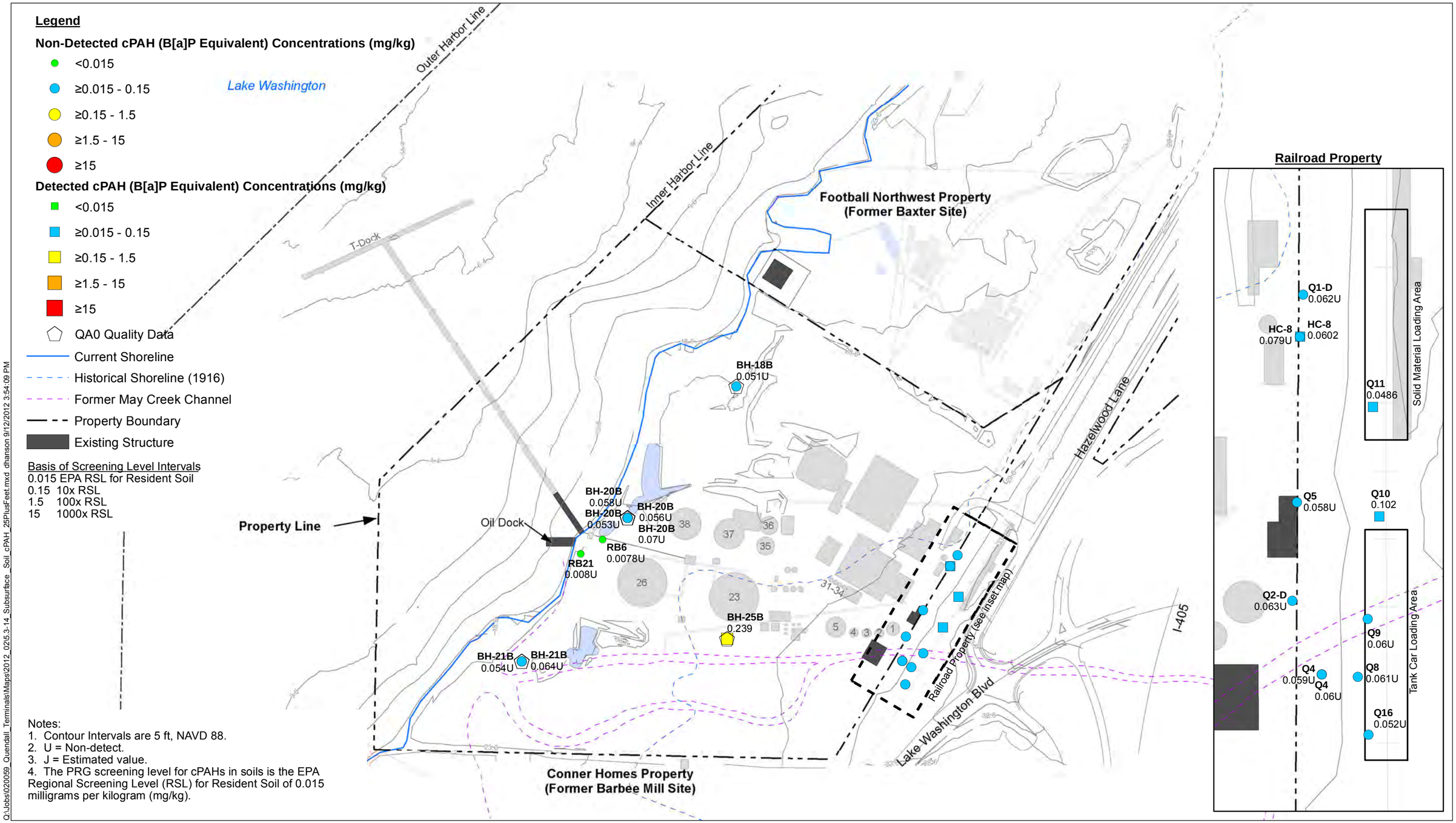
Feet
0 100 200 300 400

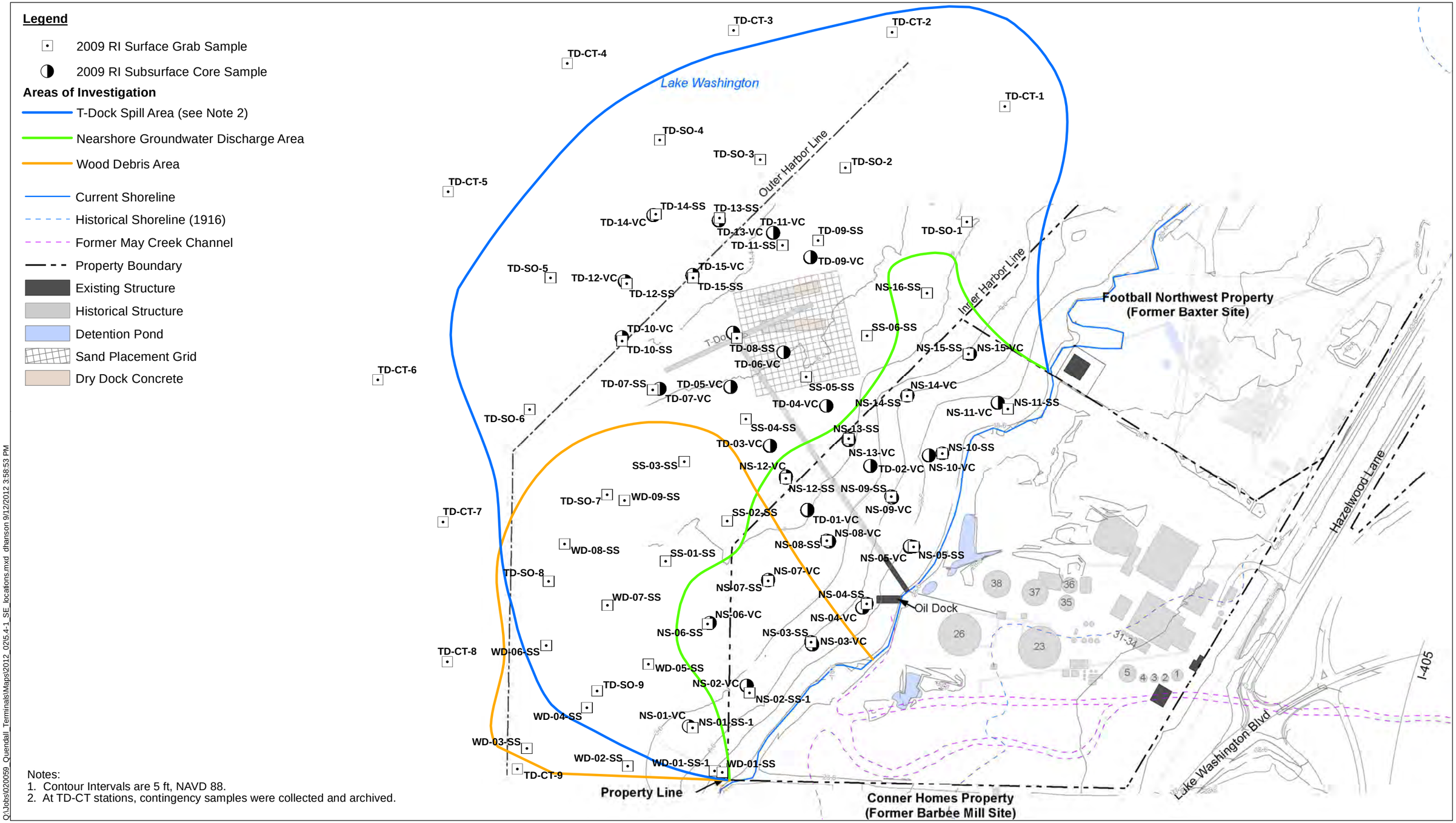
Figure 5.3-13
Subsurface Soil cPAH (Benzo[a]Pyrene Equivalent) Concentrations - 15 to 25 Feet
Final Remedial Investigation, Quendall Terminals



ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.3-14
Subsurface Soil cPAH (Benzo[a]Pyrene Equivalent) Concentrations - Depths Greater than 25 Feet
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. At TD-CT stations, contingency samples were collected and archived.

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Feet
0 200 400

Figure 5.4-1
Sediment Areas of Investigation
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Basis of Screening Level Intervals
0.176 EPA Region 3 BTAG Sediment Screening Value
0.529 Ecology 2003 Freshwater Sediment Guideline (LAET)
1.31 Ecology 2003 Freshwater Sediment Guideline (2LAET)

Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Historical Non-Detected Naphthalene Concentrations (mg/kg)

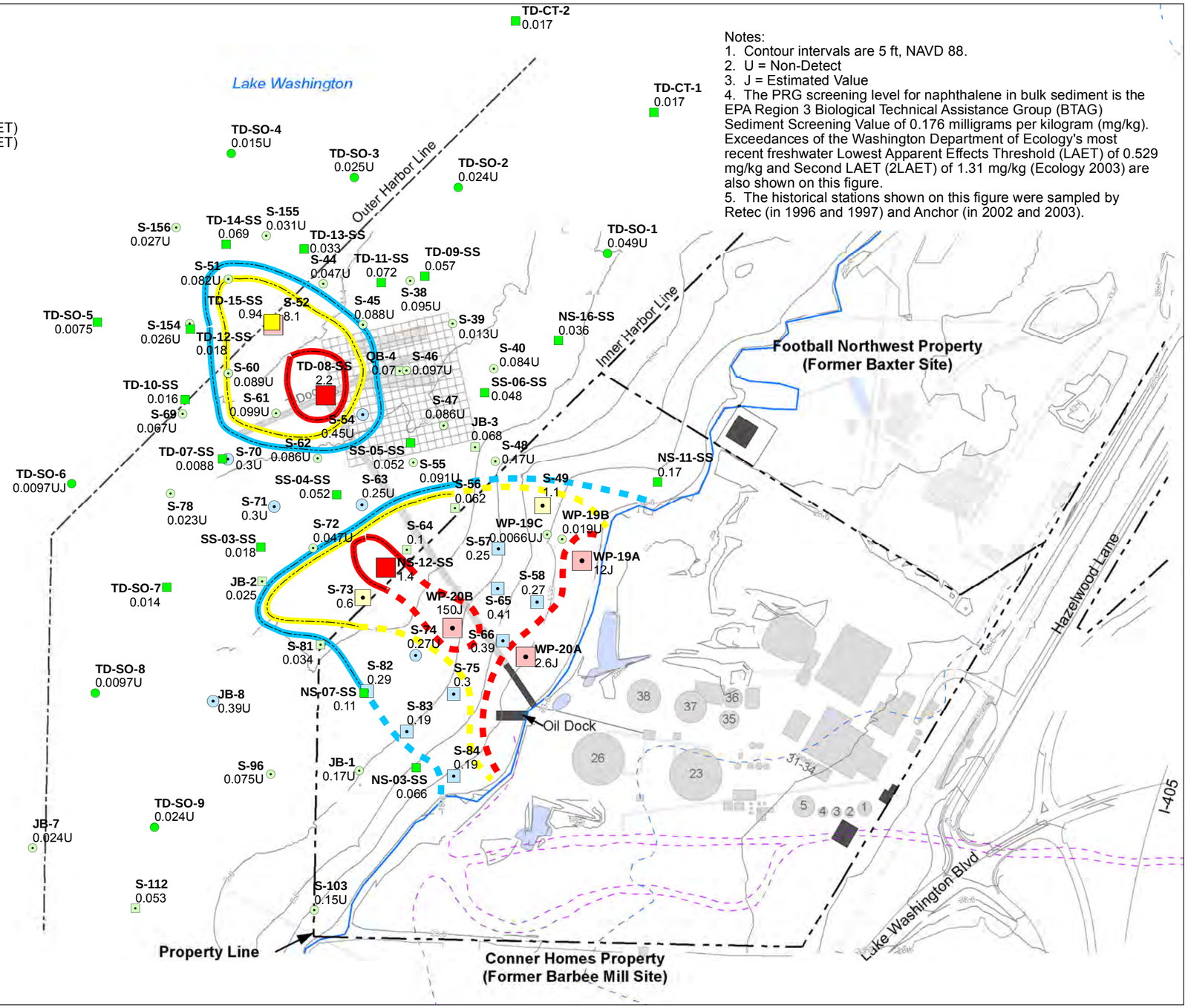
- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Historical Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

- Approximate Extent of Detected Naphthalene Concentrations Exceeding EPA Region 3 BTAG (0.176 mg/kg)
- Inferred from Historical Data
- Approximate Extent of Detected Naphthalene Concentrations Exceeding Ecology LAET (0.529 mg/kg)
- Inferred from Historical Data
- Approximate Extent of Detected Naphthalene Concentrations Exceeding Ecology 2LAET (1.31 mg/kg)
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The PRG screening level for naphthalene in bulk sediment is the EPA Region 3 Biological Technical Assistance Group (BTAG) Sediment Screening Value of 0.176 milligrams per kilogram (mg/kg). Exceedances of the Washington Department of Ecology's most recent freshwater Lowest Apparent Effects Threshold (LAET) of 0.529 mg/kg and Second LAET (2LAET) of 1.31 mg/kg (Ecology 2003) are also shown on this figure.
5. The historical stations shown on this figure were sampled by Retec (in 1996 and 1997) and Anchor (in 2002 and 2003).



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ANCHOR QEA

Feet
0 200 400

Figure 5.4-2
Surface Bulk Sediment Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Location Name — TD-08-VC
1 - 2 ft — **6.7**
4 - 5 ft — **1.9**
7 - 8 ft — **0.69**

Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Basis of Screening Level Intervals
0.176 EPA Region 3 BTAG Sediment Screening Value
0.529 Ecology 2003 Freshwater Sediment Guideline (LAET)
1.31 Ecology 2003 Freshwater Sediment Guideline (2LAET)

Historical Non-Detected Naphthalene Concentrations (mg/kg)

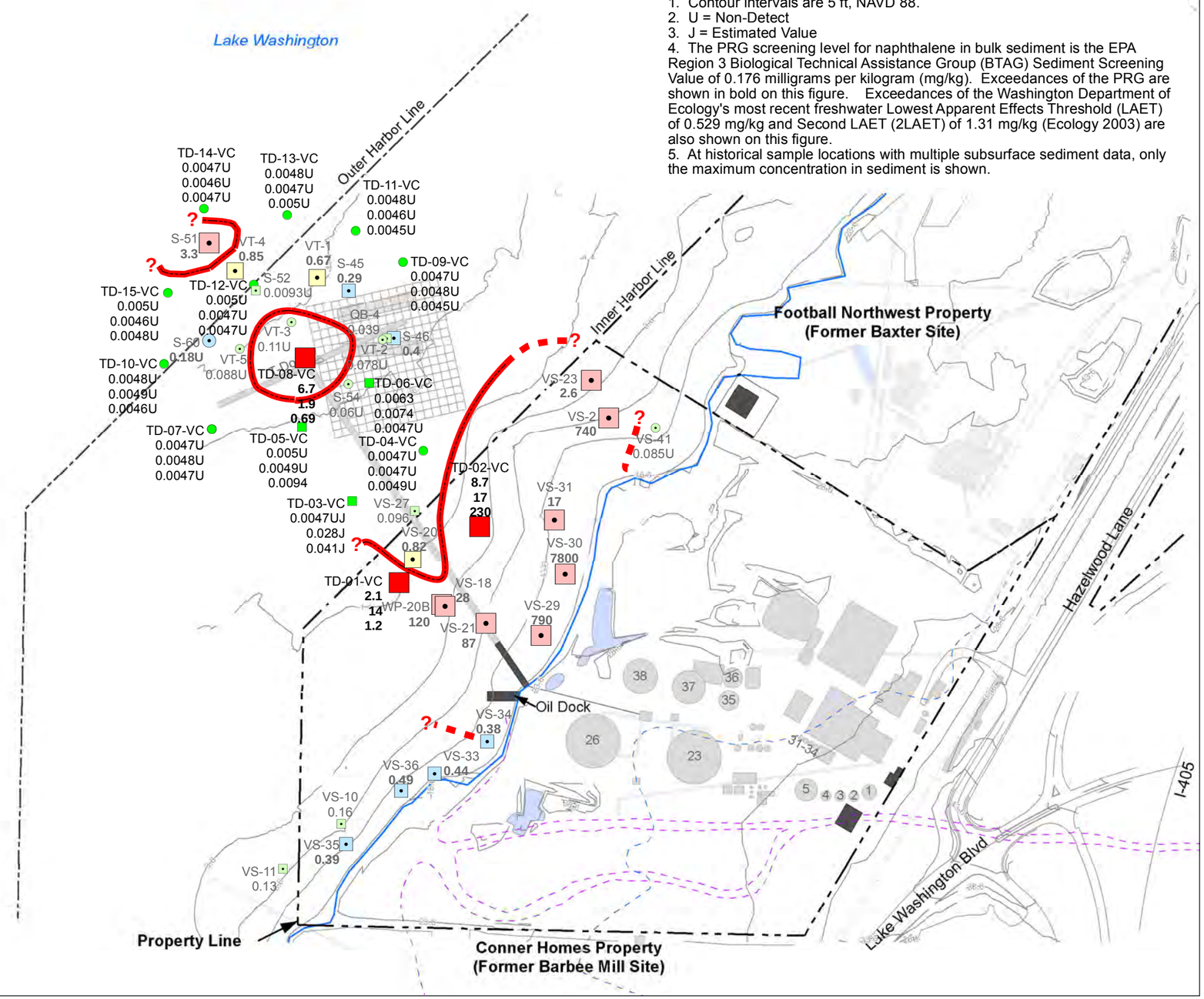
- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

Historical Detected Naphthalene Concentrations (mg/kg)

- <0.176
- ≥0.176 - 0.529
- ≥0.529 - 1.31
- ≥1.31

- Approximate Extent of Detected Naphthalene Concentrations Exceeding Ecology 2LAET (1.31 mg/kg)
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The PRG screening level for naphthalene in bulk sediment is the EPA Region 3 Biological Technical Assistance Group (BTAG) Sediment Screening Value of 0.176 milligrams per kilogram (mg/kg). Exceedances of the PRG are shown in bold on this figure. Exceedances of the Washington Department of Ecology's most recent freshwater Lowest Apparent Effects Threshold (LAET) of 0.529 mg/kg and Second LAET (2LAET) of 1.31 mg/kg (Ecology 2003) are also shown on this figure.
5. At historical sample locations with multiple subsurface sediment data, only the maximum concentration in sediment is shown.



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ANCHOR QEA

Feet
0 200 400

Figure 5.4-3
Subsurface Bulk Sediment Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

- <0.15
- ≥0.15 - 1.5
- ≥1.5 - 15
- ≥15 - 150
- ≥150

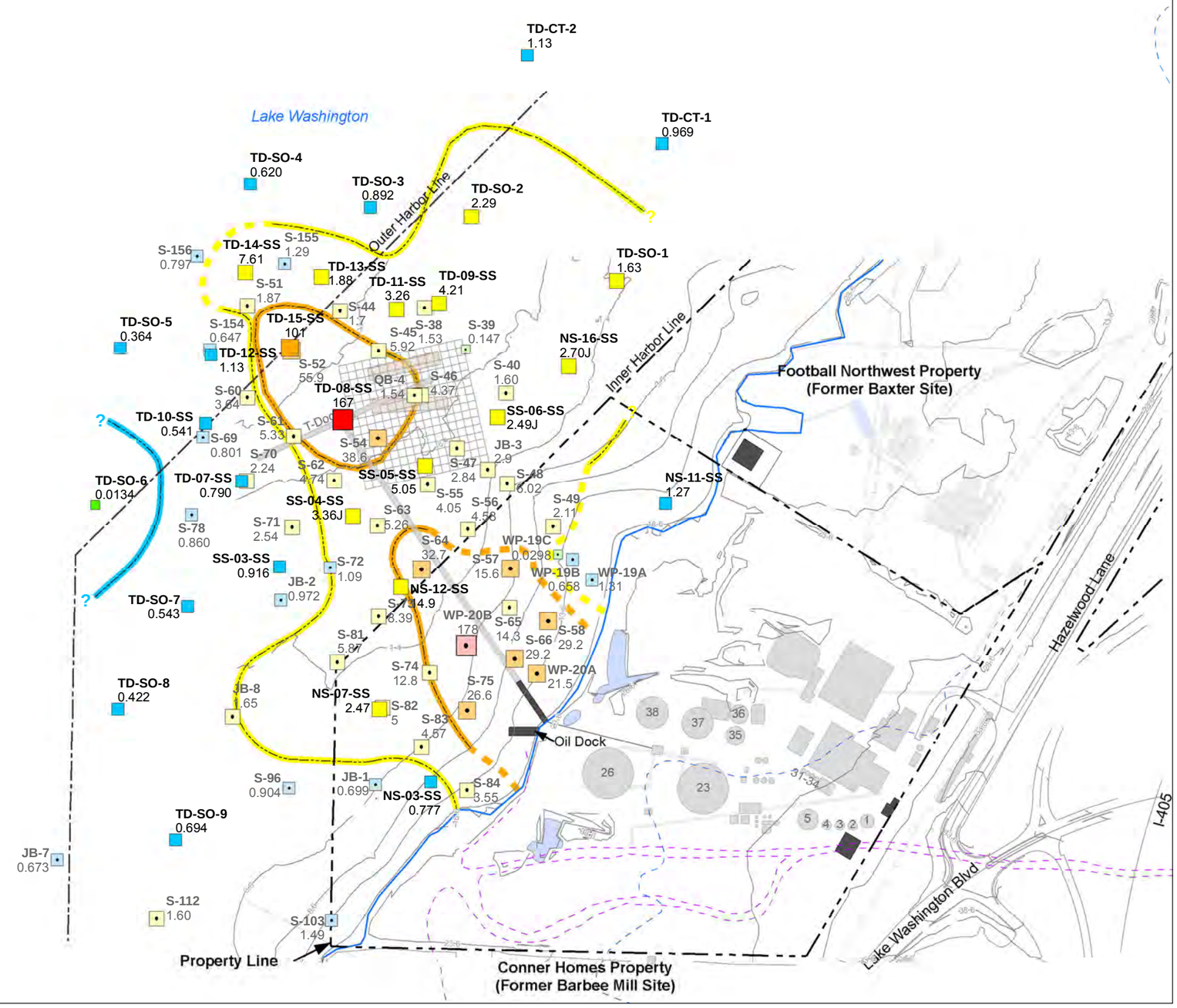
Basis of Screening Level Intervals
0.15 90% Upper Confidence Limit
1.5 10x Upper Confidence Limit
15 100x Upper Confidence Limit
150 1000x Upper Confidence

Historical Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

- <0.15
- ≥0.15 - 1.5
- ≥1.05 - 15
- ≥15 - 150
- ≥150

- Approximate Extent of Detected cPAH Concentrations Exceeding 1x 90% Upper Confidence Limit
- Approximate Extent of Detected cPAH Concentrations Exceeding 10x 90% Upper Confidence Limit
- Inferred from Historical Data
- Approximate Extent of Detected cPAH Concentrations Exceeding 100x 90% Upper Confidence Limit
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The dry weight PRG screening level for cPAHs in surface bulk sediment of 0.15 milligrams per kilogram (mg/kg) dry weight is the 90 percent upper confidence limit on the mean of site-specific background samples collected during the 2009 RI field investigation.
5. The historical stations shown on this figure were sampled by Retec (in 1996 and 1997) and Anchor (in 2002 and 2003).



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ANCHOR QEA

Feet
0 200 400

Figure 5.4-4
Surface Bulk Sediment Dry Weight cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Detected Organic Carbon Normalized cPAH (B[a]P Equivalent) Concentrations (mg/kg-OC)

- <6.2
- ≥6.2 - 62
- ≥62 - 620
- ≥620

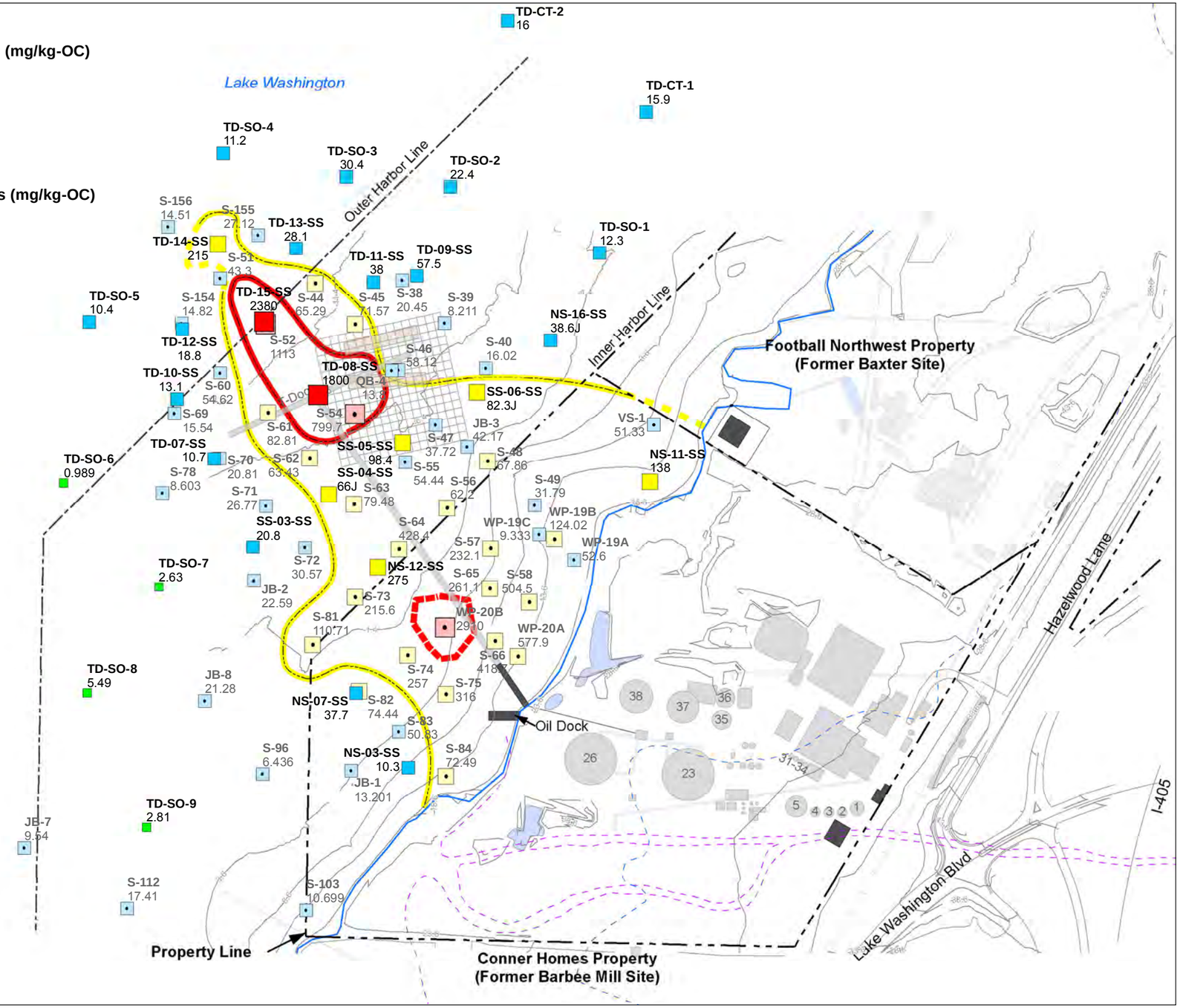
Historical Organic Carbon Normalized cPAH (B[a]P Equivalent) Concentrations (mg/kg-OC)

- <6.2
- ≥6.2 - 62
- ≥62 - 620
- ≥620

- Approximate Extent of Detected cPAH Concentrations Exceeding 10x 90% Upper Confidence Limit
- Inferred from Historical Data
- Approximate Extent of Detected cPAH Concentrations Exceeding 100x 90% Upper Confidence Limit
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals
6.2 90% Upper Confidence Limit
62 10x Upper Confidence Limit
620 100x Upper Confidence Limit

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The organic carbon normalized PRG screening level for cPAHs in surface bulk sediment of 6.2 milligrams per kilogram (mg/kg)-OC is the 90 percent upper confidence limit on the mean of site-specific background samples collected during the 2009 RI field investigation.
5. The historical stations shown on this figure were sampled by Retec (in 1996 and 1997) and Anchor (in 2002 and 2003).



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ANCHOR QEA

Feet
0 200 400

Figure 5.4-5
Surface Bulk Sediment Organic Carbon Normalized cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

- <0.15
- ≥0.15 - 1.5
- ≥1.5 - 15
- ≥15 - 150
- ≥150

Location Name – TD-08-VC
1 - 2 ft – **2.4**
4 - 5 ft – 0.0968
7 - 8 ft – **0.306**

Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

- <0.15
- ≥0.15 - 1.5
- ≥1.5 - 15
- ≥15 - 150
- ≥150

Historical Non-Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

- <0.15
- ≥0.15 - 1.5
- ≥1.05 - 15
- ≥15 - 150
- ≥150

Historical Detected Dry Weight cPAH (B[a]P Equivalent) Concentrations (mg/kg)

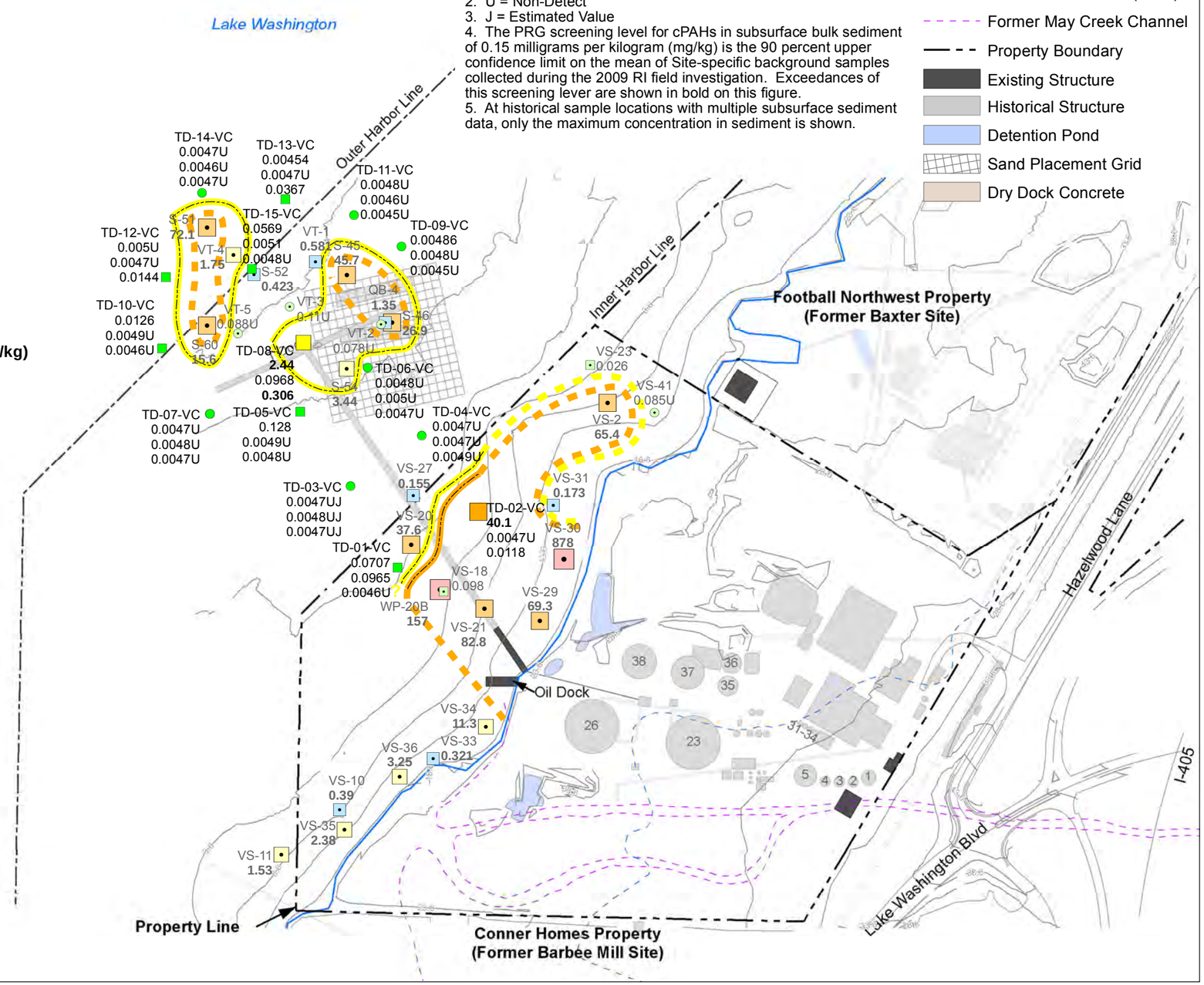
- <0.15
- ≥0.15 - 1.5
- ≥1.05 - 15
- ≥15 - 150
- ≥150

- Approximate Extent of Detected cPAH Concentrations Exceeding 10x 90% Upper Confidence Limit
- Inferred from Historical Data
- Approximate Extent of Detected cPAH Concentrations Exceeding 100x 90% Upper Confidence Limit
- Inferred from Historical Data

Basis of Screening Level Intervals
0.15 90% Upper Confidence Limit
1.5 10x Upper Confidence Limit
15 100x Upper Confidence Limit
150 1000x Upper Confidence Limit

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect
3. J = Estimated Value
4. The PRG screening level for cPAHs in subsurface bulk sediment of 0.15 milligrams per kilogram (mg/kg) is the 90 percent upper confidence limit on the mean of Site-specific background samples collected during the 2009 RI field investigation. Exceedances of this screening lever are shown in bold on this figure.
5. At historical sample locations with multiple subsurface sediment data, only the maximum concentration in sediment is shown.

- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete



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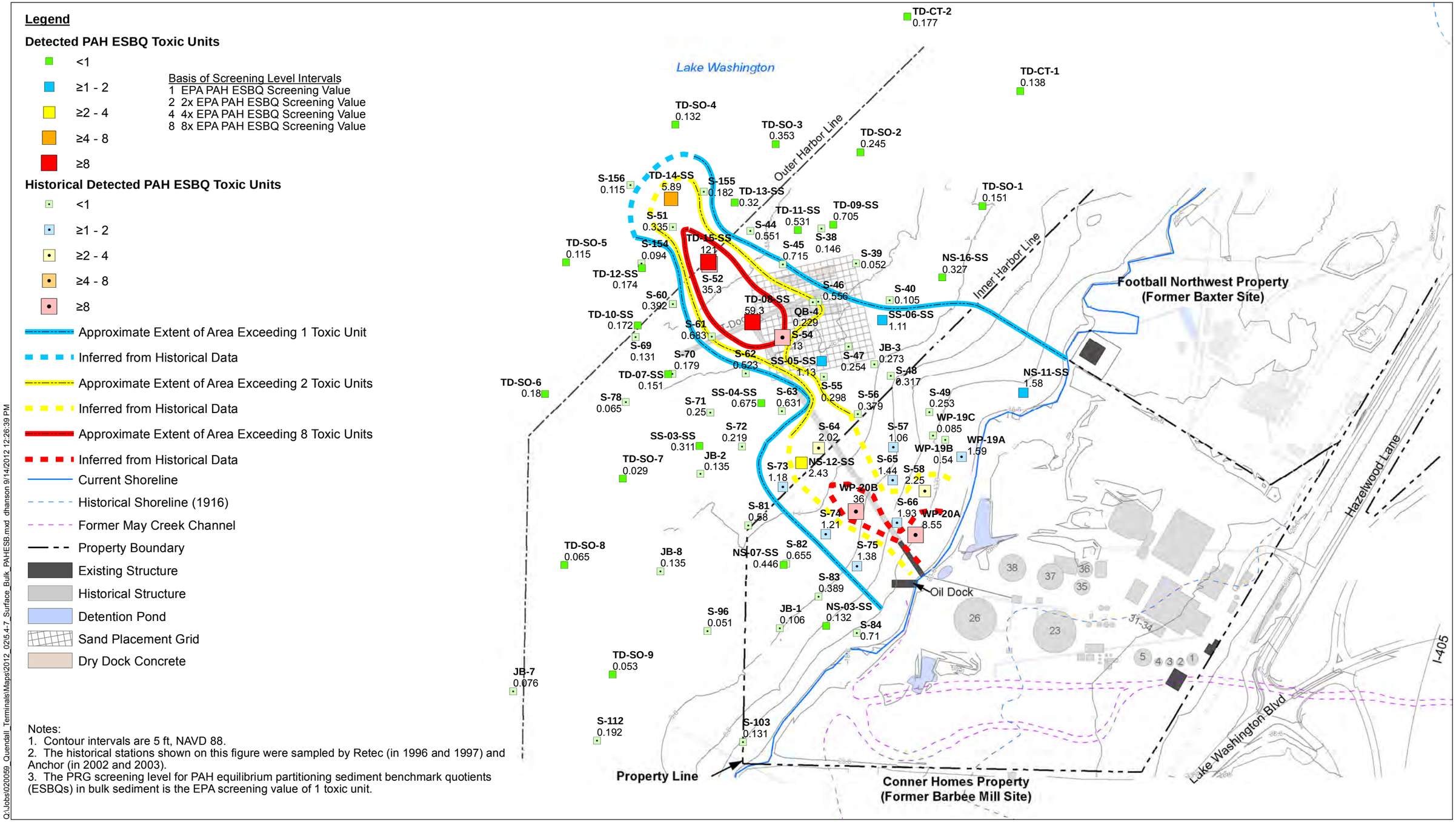
ANCHOR QEA

Feet
0 200 400

Figure 5.4-6
Subsurface Bulk Sediment Dry Weight cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. The historical stations shown on this figure were sampled by Retec (in 1996 and 1997) and Anchor (in 2002 and 2003).
3. The PRG screening level for PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in bulk sediment is the EPA screening value of 1 toxic unit.

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ANCHOR QEA

Feet
0 200 400

Figure 5.4-7
Surface Bulk Sediment PAH ESBQs
Final Remedial Investigation, Quendall Terminals

Legend

Detected PAH ESBQ Toxic Units

- <1
- ≥1 - 2
- ≥2 - 4
- ≥4 - 8
- ≥8

Location Name — TD-08-VC
1 - 2 ft — 5.524
4 - 5 ft — 0.333
7 - 8 ft — 2.835

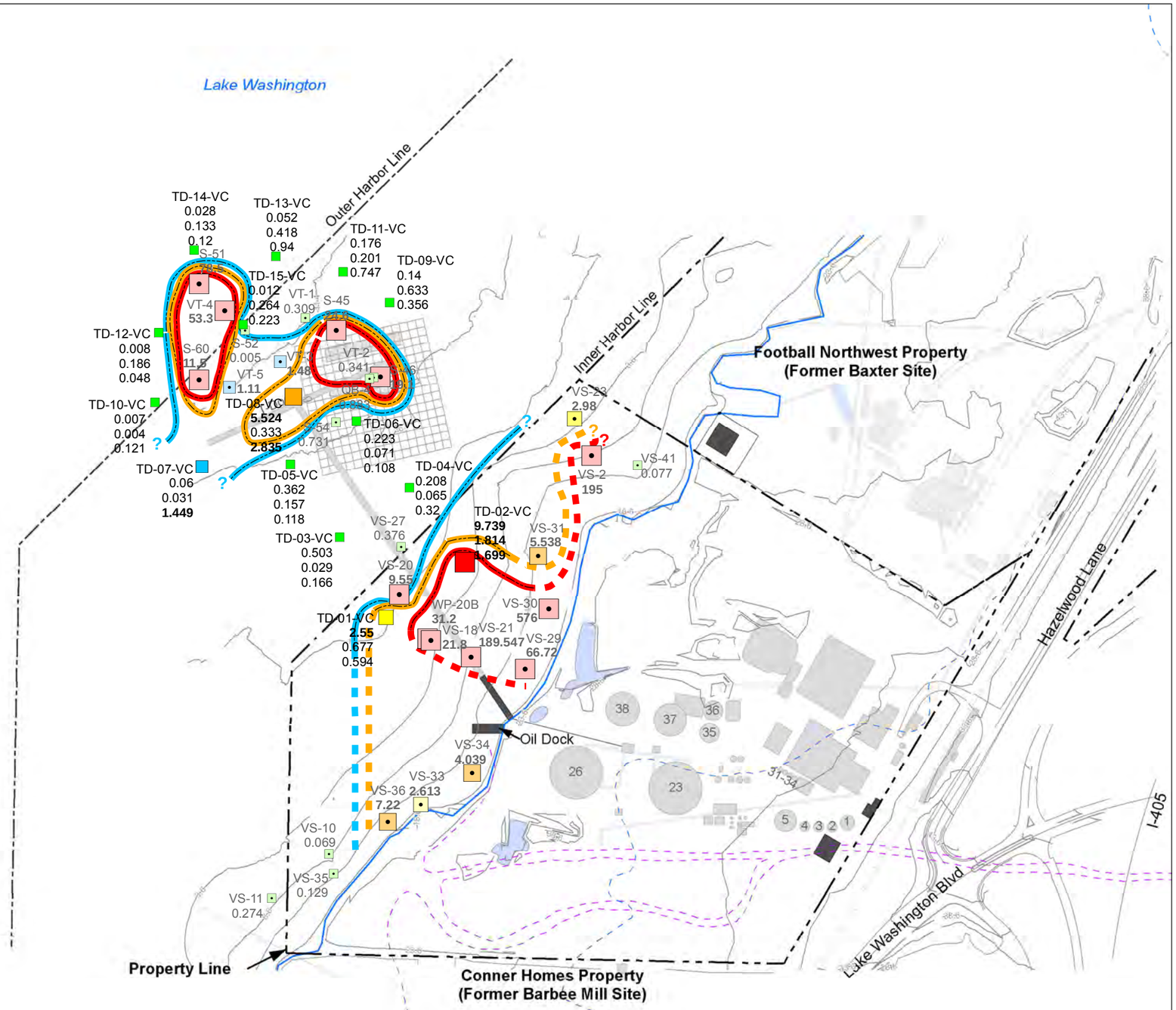
Historical Detected PAH ESBQ Toxic Units

- <1
- ≥1 - 2
- ≥2 - 4
- ≥4 - 8
- ≥8

Basis of Screening Level Intervals
1 EPA PAH ESBQ Screening Value
2 2x EPA PAH ESBQ Screening Value
4 4x EPA PAH ESBQ Screening Value
8 8x EPA PAH ESBQ Screening Value

- Approximate Extent of Area Exceeding 1 Toxic Unit
- Inferred from Historical Data
- Approximate Extent of Area Exceeding 4 Toxic Units
- Inferred from Historical Data
- Approximate Extent of Area Exceeding 8 Toxic Units
- Inferred from Historical Data
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. U = Non-Detect.
3. The PRG screening level for PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in bulk sediment is the EPA screening value of 1 toxic unit. Exceedances of this screening level are shown in bold on this figure.
4. At historical sample locations with multiple subsurface sediment data, only the maximum concentration in sediment is shown.



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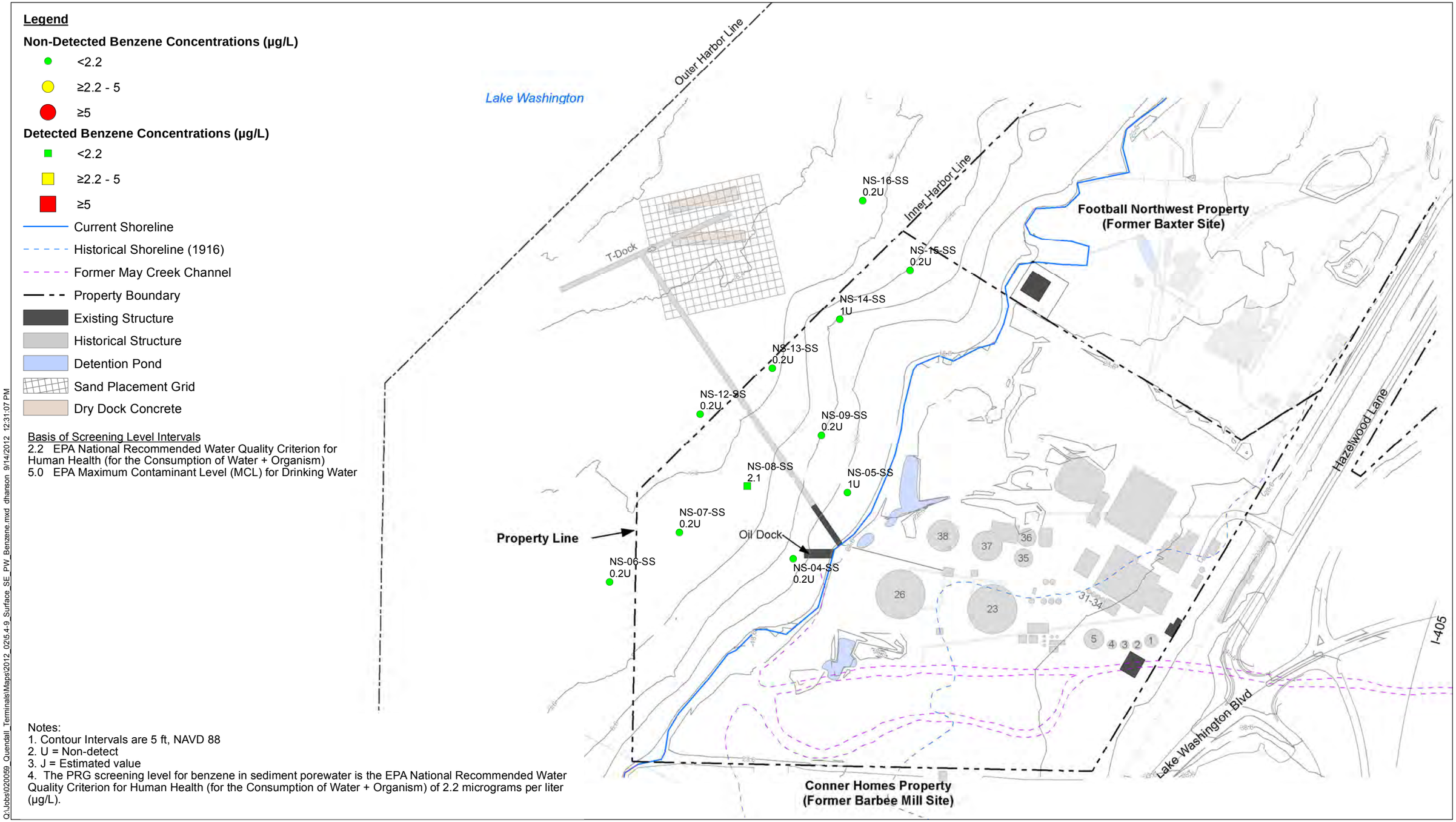
Feet
0 200 400

Figure 5.4-8
Subsurface Bulk Sediment PAH ESBQs
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for benzene in sediment porewater is the EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism) of 2.2 micrograms per liter (µg/L).

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Feet
0 100 200 300 400

Figure 5.4-9
Surface Sediment Porewater Benzene Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected Benzene Concentrations (µg/L)

- <2.2
- ≥2.2 - 5.0
- ≥5.0 - 50
- ≥50 - 500
- ≥500

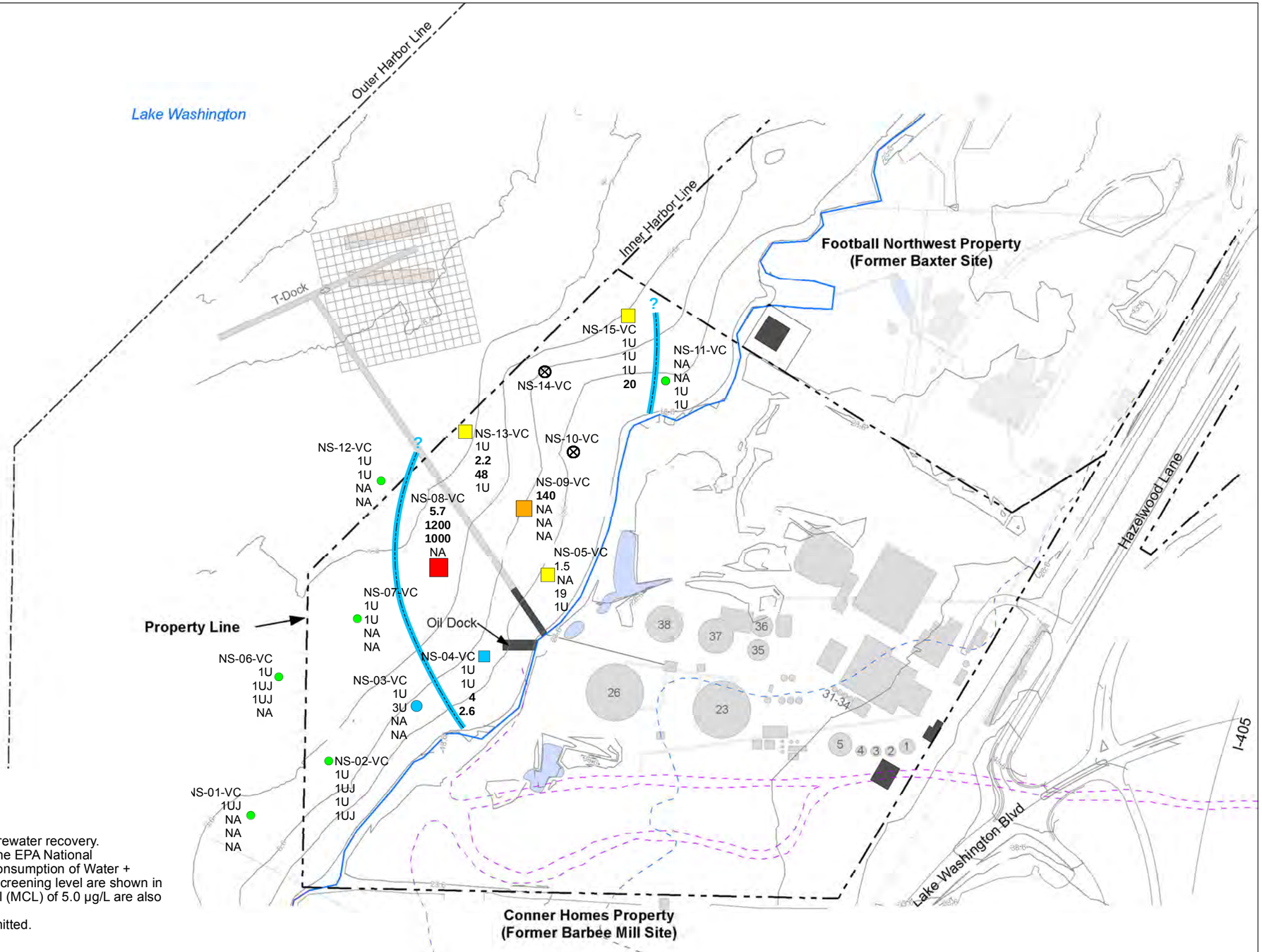
Location Name NS-08-VC
0 - 4 in — **5.7**
8- 12 in — **1200**
20 - 24 in — **1000**
36- 40 in — NA

Detected Benzene Concentrations (µg/L)

- <2.2
- ≥2.2 - 5.0
- ≥5.0 - 50
- ≥50 - 500
- ≥500
- No Sample Collected
- Approximate Extent of Area Exceeding PRG Screening Level (2.2 µg/L)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals
2.2 EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism)
5.0 EPA Maximum Contaminant Level (MCL) for Drinking Water
50 10x MCL
500 100x MCL

Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. NA = Not Applicable. Sample not collected due to insufficient porewater recovery.
5. The PRG screening level for benzene in sediment porewater is the EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism) of 2.2 micrograms per liter (µg/L). Exceedances of this screening level are shown in bold on this figure. Exceedances of the maximum contaminant level (MCL) of 5.0 µg/L are also shown on this figure.
6. Stations with no results due to insufficent recovery have been omitted.



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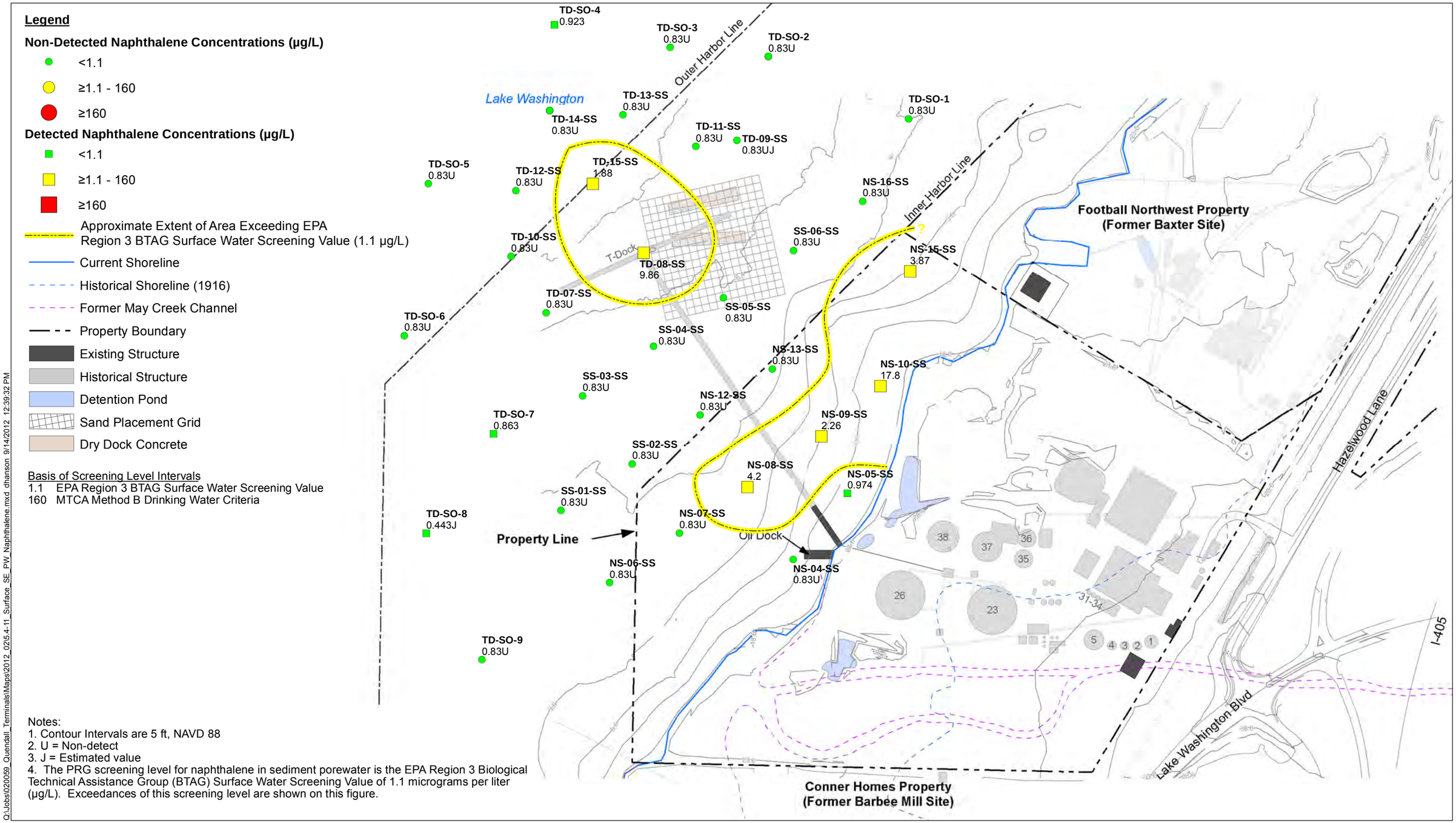
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-10
Subsurface Sediment Porewater Benzene Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for naphthalene in sediment porewater is the EPA Region 3 Biological Technical Assistance Group (BTAG) Surface Water Screening Value of 1.1 micrograms per liter (µg/L). Exceedances of this screening level are shown on this figure.

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ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-11
Surface Sediment Porewater Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected Naphthalene Concentrations (µg/L)

- <1.1
- ≥1.1 - 160
- ≥160

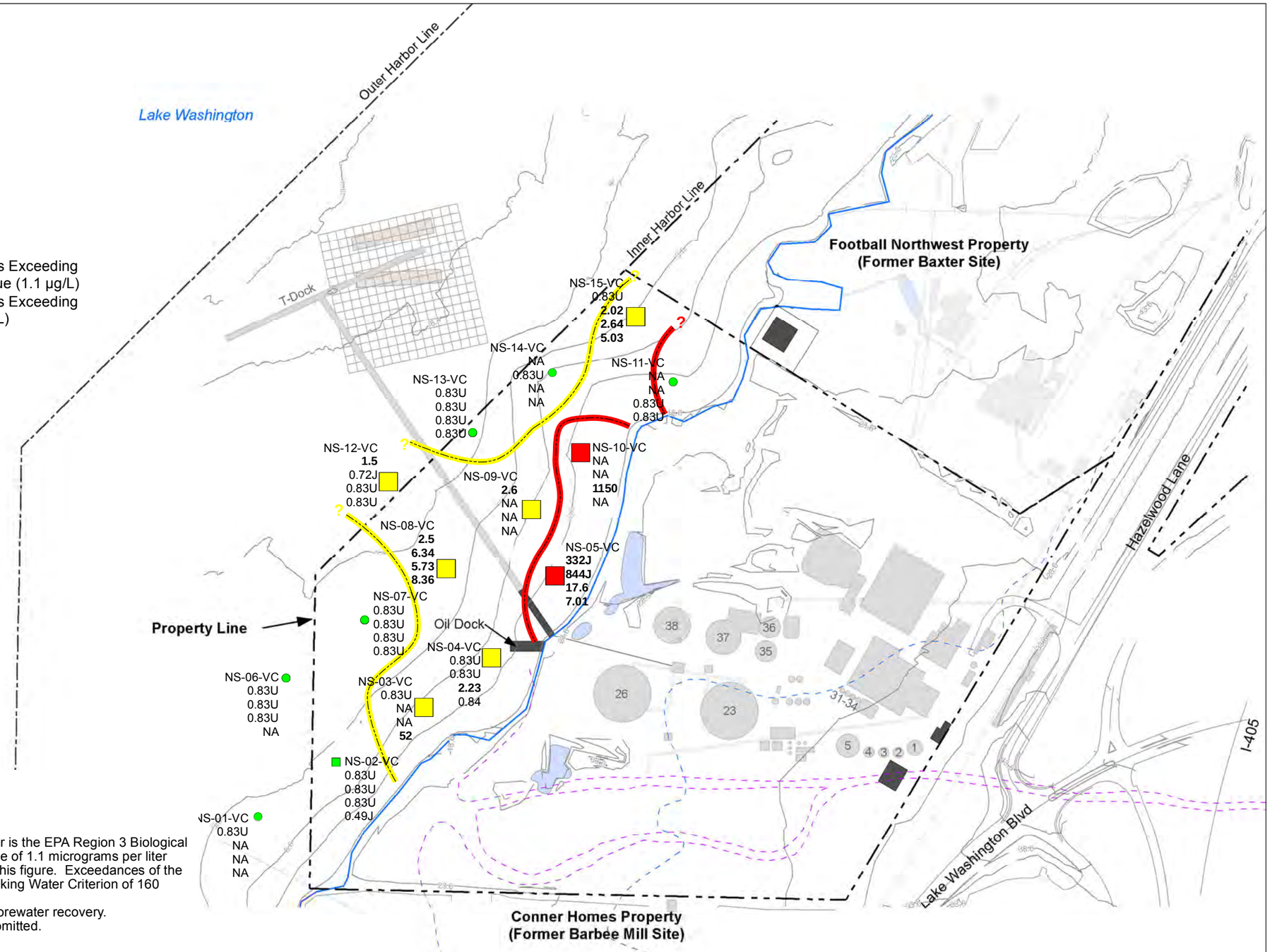
Location Name NS-012-VC
0 - 4 in — **1.5**
8- 12 in — **0.72J**
20 - 24 in — **0.83U**
36- 40 in — **0.83U**

Detected Naphthalene Concentrations (µg/L)

- <1.1
- ≥1.1 - 160
- ≥160

- Approximate Extent of Naphthalene Concentrations Exceeding EPA Region 3 BTAG Surface Water Screening Value (1.1 µg/L)
- Approximate Extent of Naphthalene Concentrations Exceeding MTCA Method B Drinking Water Criterion (160 µg/L)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals
1.1 EPA Region 3 BTAG Surface Water Screening Value
160 MTCA Method B Drinking Water Criteria



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for naphthalene in sediment porewater is the EPA Region 3 Biological Technical Assistance Group (BTAG) Surface Water Screening Value of 1.1 micrograms per liter (µg/L). Exceedances of this screening level are shown in bold on this figure. Exceedances of the Washington State Model Toxics Control Act (MTCA) Method B Drinking Water Criterion of 160 µg/L) are also shown on this figure.
5. NA = Not Applicable. Sample not collected due to insufficient porewater recovery.
6. Stations with no results due to insufficient recovery have been omitted.

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ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-12
Subsurface Sediment Porewater Naphthalene Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

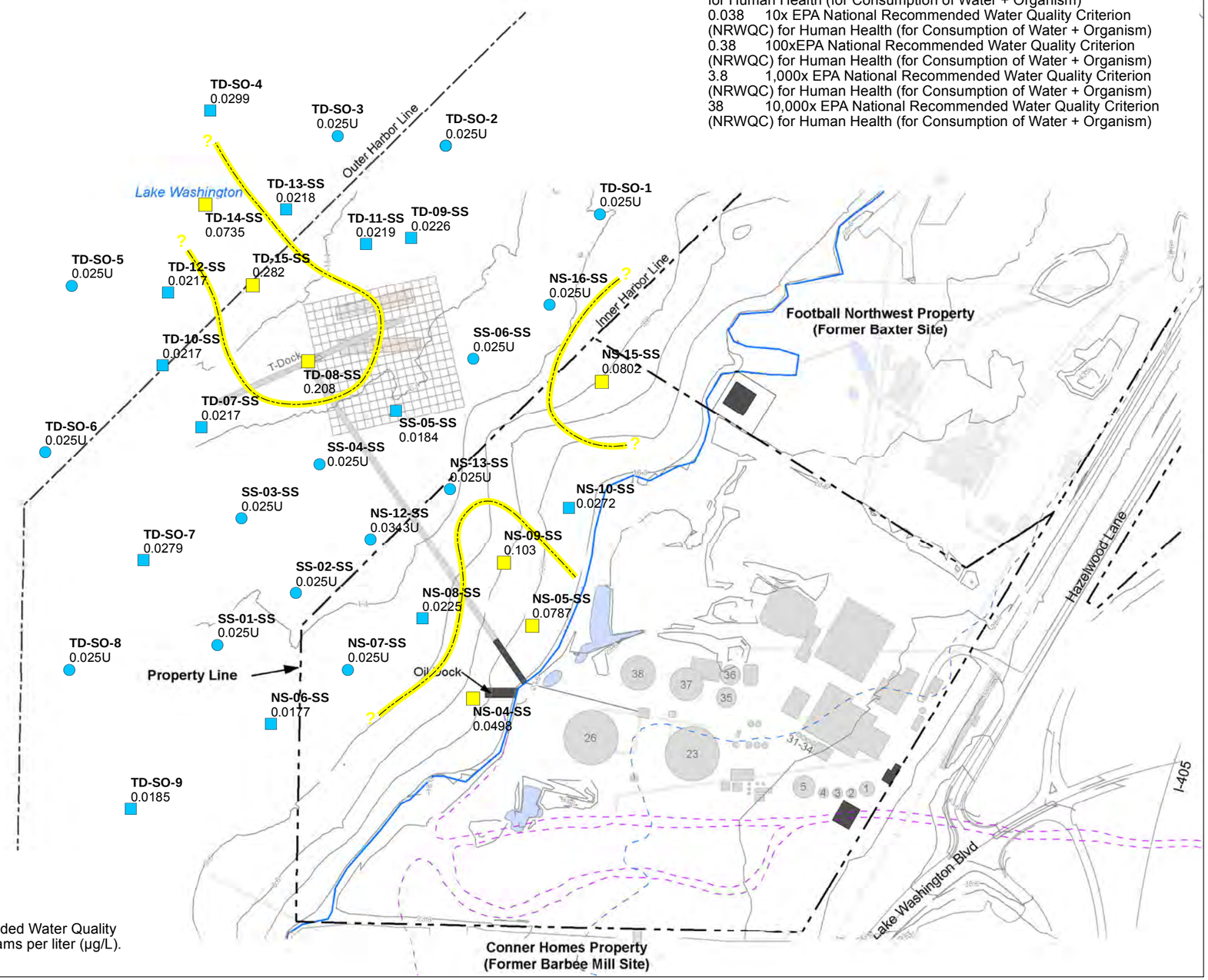
- <0.0038
- ≥0.0038 - 0.038
- ≥0.038 - 0.38
- ≥0.38 - 3.8
- ≥3.8 - 38
- ≥38

Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

- <0.0038
- ≥0.0038 - 0.038
- ≥0.038 - 0.38
- ≥0.38 - 3.8
- ≥3.8 - 38
- ≥38

- Approximate Extent of Area Exceeding 10x EPA National Recommended Water Quality Criterion for Human Health (for Consumption of Water + Organism) (0.038µg/L)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals
0.0038 EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)
0.038 10x EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)
0.38 100xEPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)
3.8 1,000x EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)
38 10,000x EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for cPAHs in sediment porewater is the EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (Consumption of Water + Organism) of 0.0038 micrograms per liter (µg/L).

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ANCHOR QEA

Feet
0 110 220 330 440

Figure 5.4-13
Surface Sediment Porewater cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals

Legend

Non-Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

- <0.0038
- ≥0.0038 - 0.038
- ≥0.038 - 0.2
- ≥0.2

Location Name NS-012-VC
0 - 4 in — **0.4**
8- 12 in — **0.019**
20 - 24 in — 0.025U
36- 40 in — 0.025U

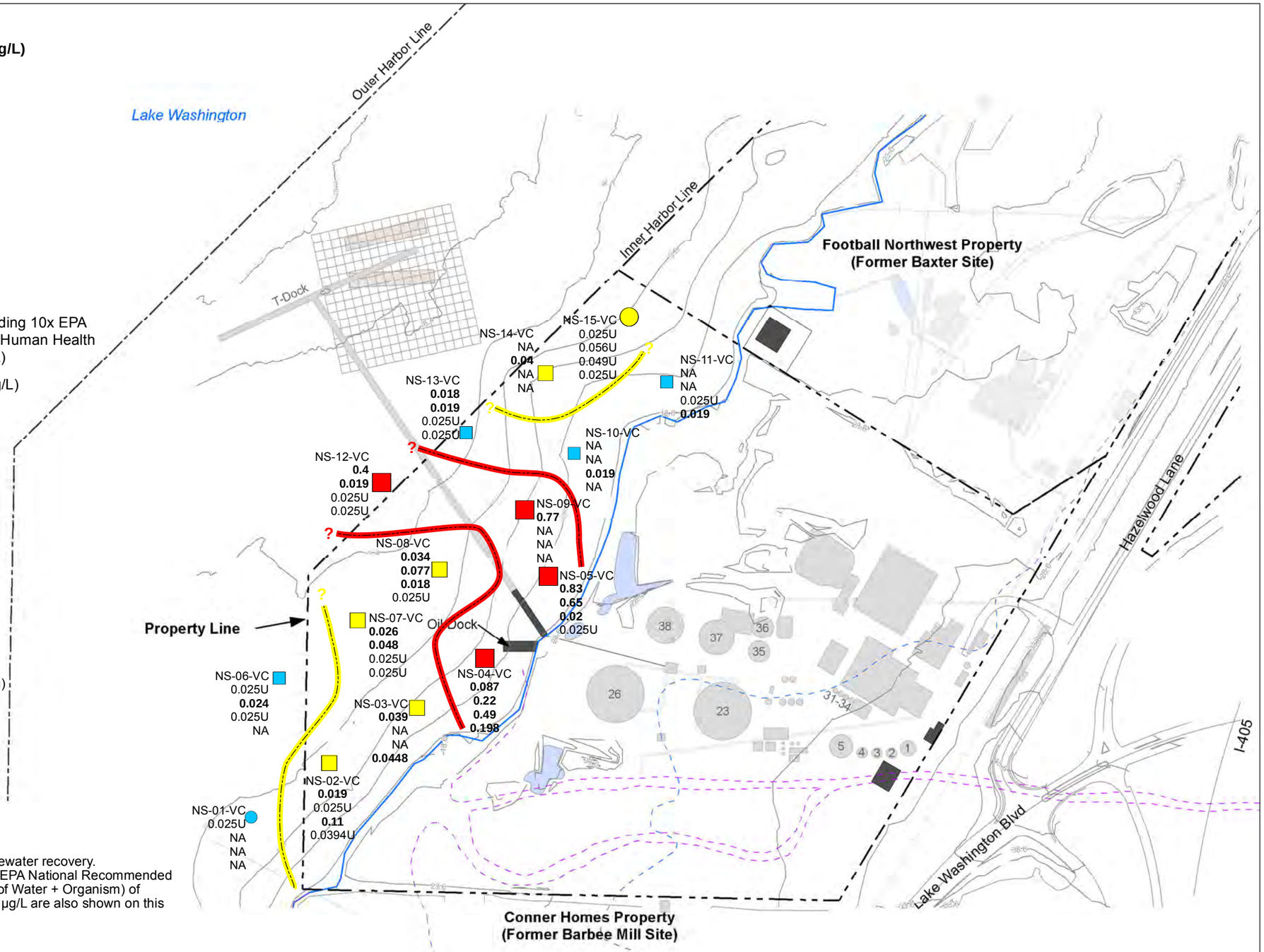
Detected cPAH (B[a]P Equivalent) Concentrations (µg/L)

- <0.0038
- ≥0.0038 - 0.038
- ≥0.038 - 0.2
- ≥0.2

- Approximate Extent of cPAH Concentrations Exceeding 10x EPA Recommended National Water Quality Criterion for Human Health (for Consumption of Water + Organism) (0.038 µg/L)
- Approximate Extent of Area Exceeding MCL (0.2 µg/L)
- Current Shoreline
- Historical Shoreline (1916)
- Former May Creek Channel
- Property Boundary
- Existing Structure
- Historical Structure
- Detention Pond
- Sand Placement Grid
- Dry Dock Concrete

Basis of Screening Level Intervals
0.0038 EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (for Consumption of Water + Organism)
0.038 10x NRWQC
0.2 MCL

Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. NA = Not Applicable. Sample not collected due to insufficient porewater recovery.
4. The PRG screening level for cPAHs in sediment porewater is the EPA National Recommended Water Quality Criterion (NRWQC) for Human Health (Consumption of Water + Organism) of 0.0038 micrograms per liter (µg/L). Exceedances of the MCL of 0.2 µg/L are also shown on this figure.
5. Exceedances of the NWRQC are shown in bold on this figure.



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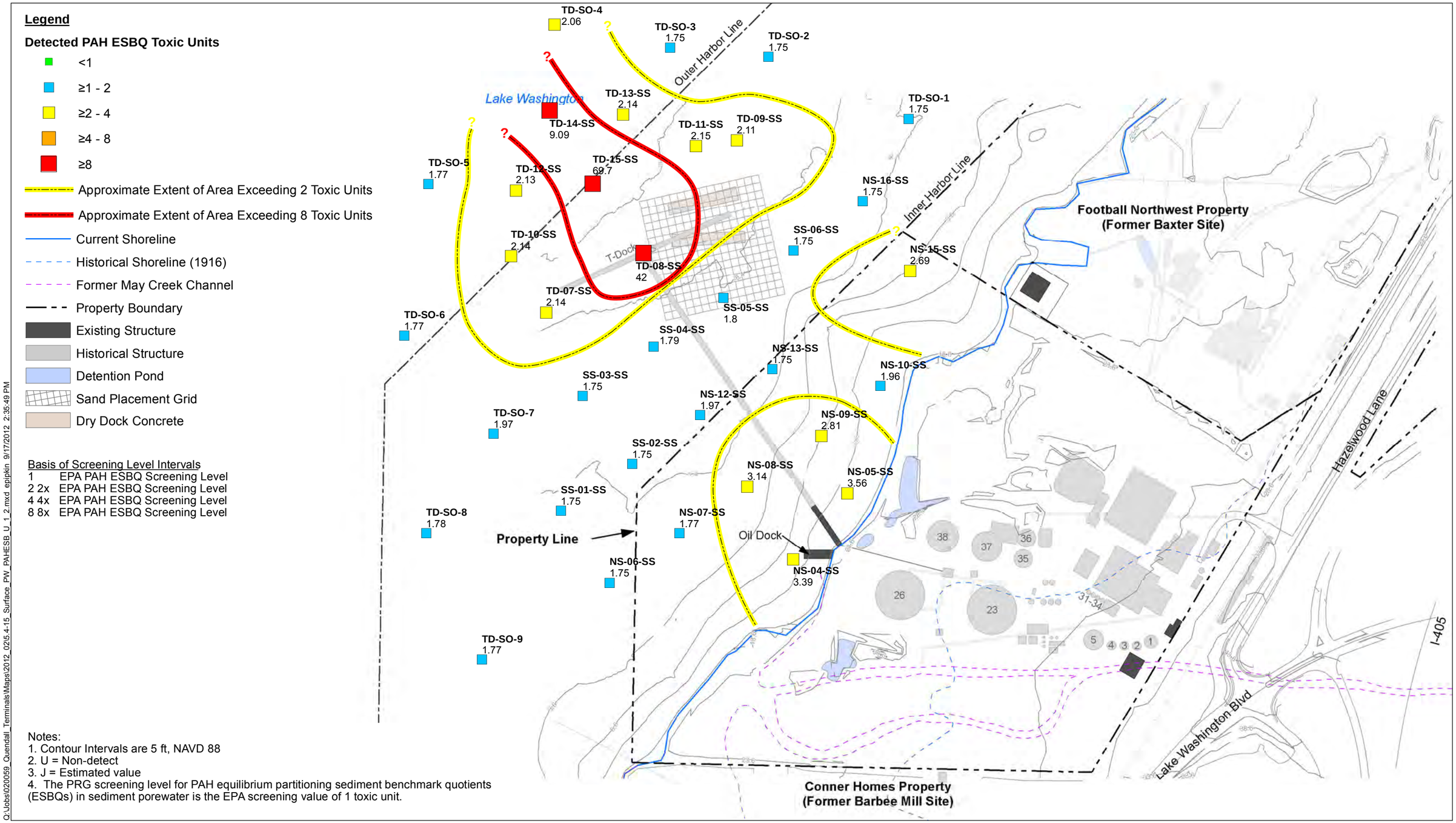
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-14
Subsurface Sediment Porewater cPAH (Benzo[a]Pyrene Equivalent) Concentrations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-detect
3. J = Estimated value
4. The PRG screening level for PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in sediment porewater is the EPA screening value of 1 toxic unit.

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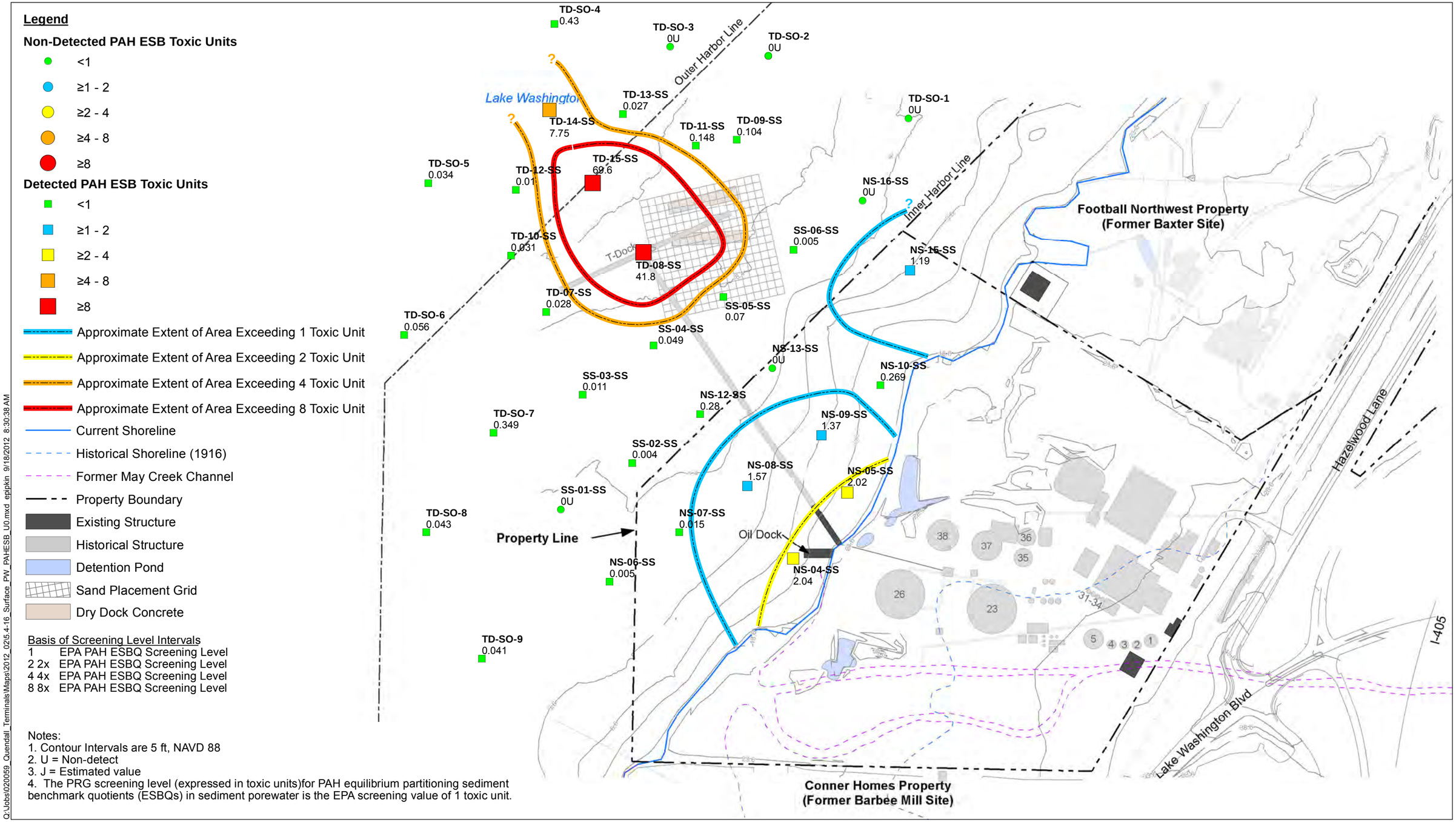
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-15
Surface Sediment Porewater PAH ESBQs (U=1/2)
Final Remedial Investigation, Quendall Terminals



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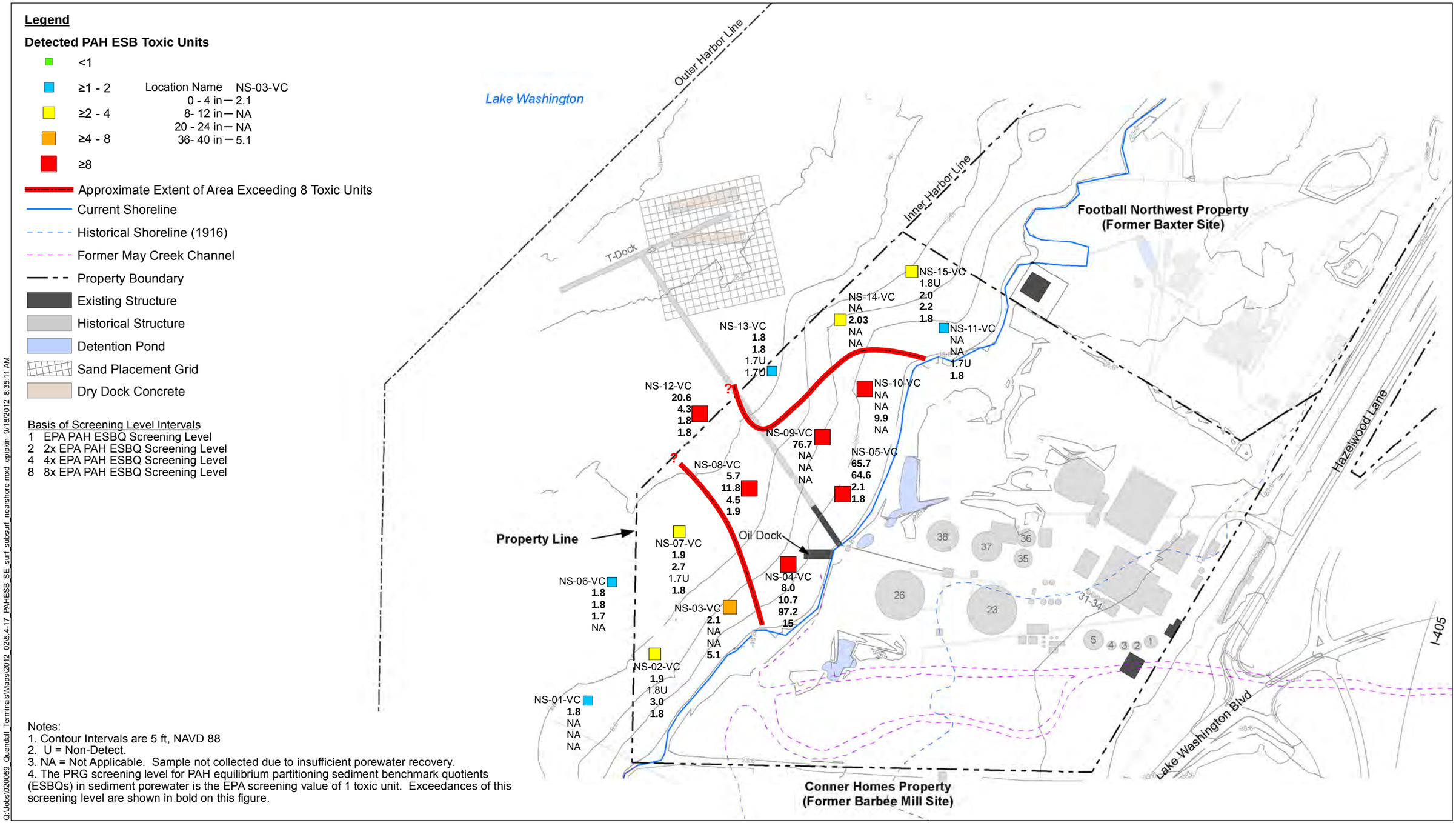
Feet
0 100 200 300 400

Figure 5.4-16
Surface Sediment Porewater PAH ESBQs (U=0)
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88
2. U = Non-Detect.
3. NA = Not Applicable. Sample not collected due to insufficient porewater recovery.
4. The PRG screening level for PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in sediment porewater is the EPA screening value of 1 toxic unit. Exceedances of this screening level are shown in bold on this figure.

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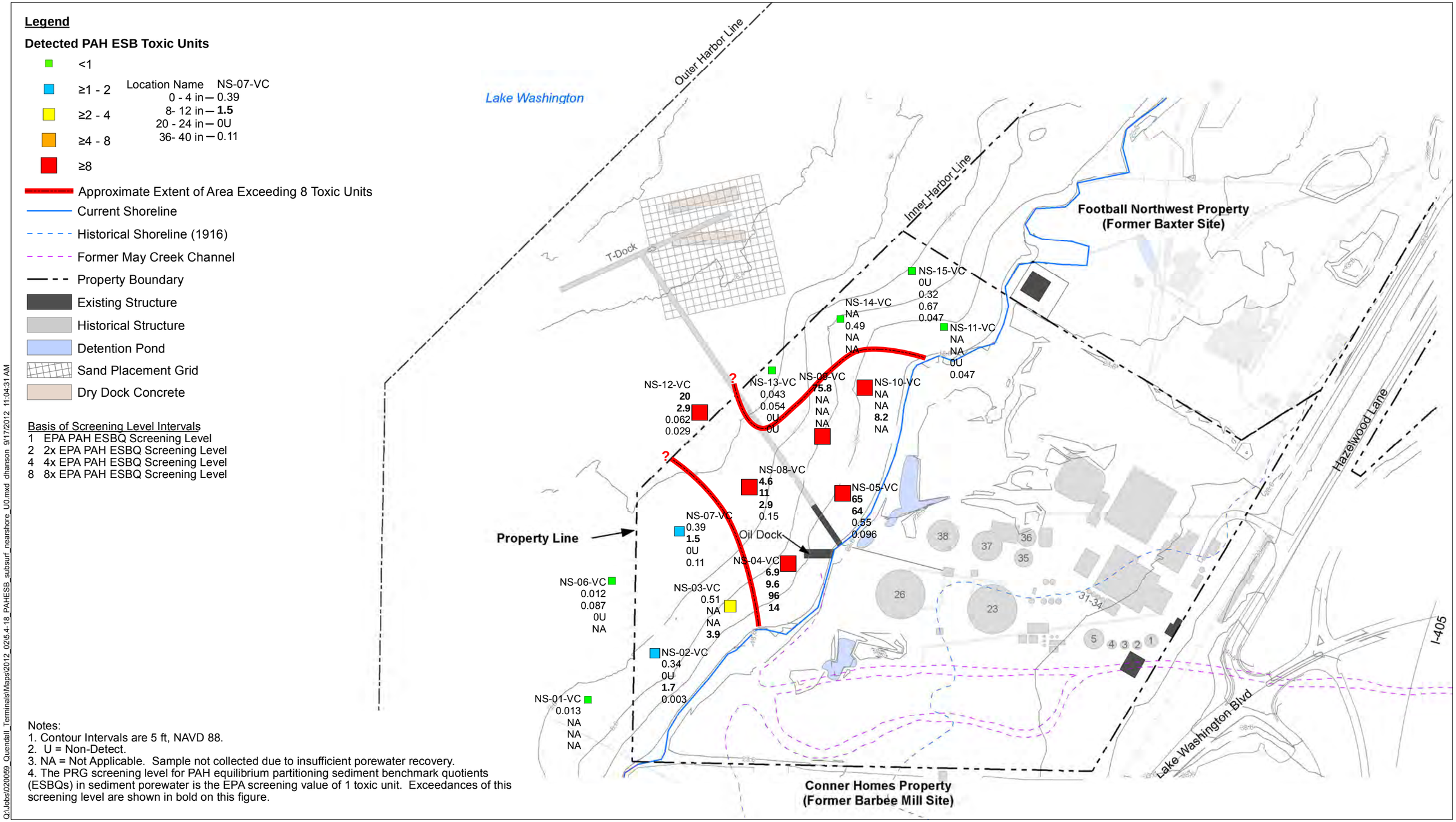
ANCHOR QEA

Feet
0 100 200 300 400

Figure 5.4-17
Subsurface Sediment Porewater PAH ESBQs (U=1/2)
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. U = Non-Detect.
3. NA = Not Applicable. Sample not collected due to insufficient porewater recovery.
4. The PRG screening level for PAH equilibrium partitioning sediment benchmark quotients (ESBQs) in sediment porewater is the EPA screening value of 1 toxic unit. Exceedances of this screening level are shown in bold on this figure.

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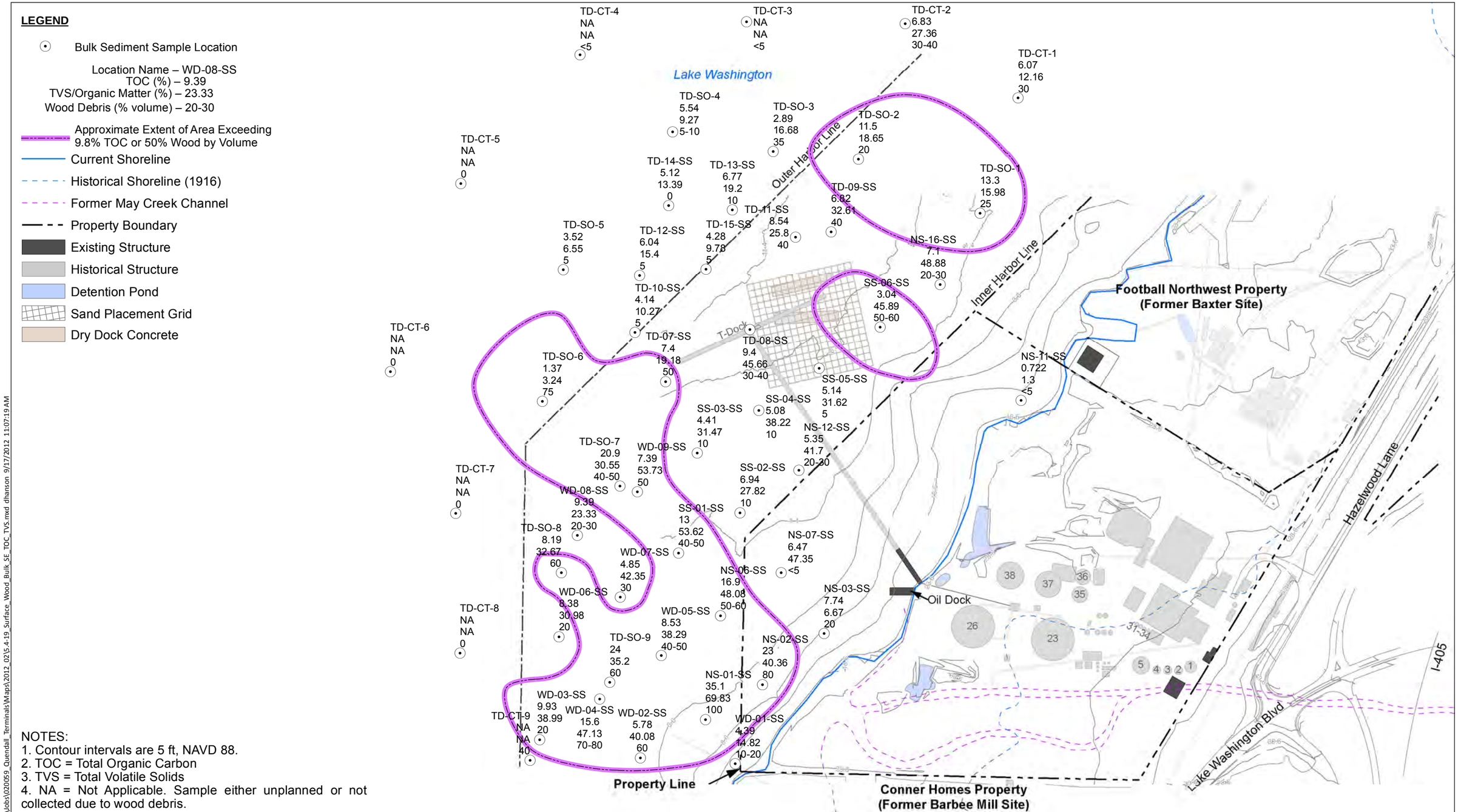
Feet
0 100 200 300 400

Figure 5.4-18
Subsurface Sediment Porewater PAH ESBQs (U = 0)
Final Remedial Investigation, Quendall Terminals



NOTES:
1. Contour intervals are 5 ft, NAVD 88.
2. TOC = Total Organic Carbon
3. TVS = Total Volatile Solids
4. NA = Not Applicable. Sample either unplanned or not collected due to wood debris.

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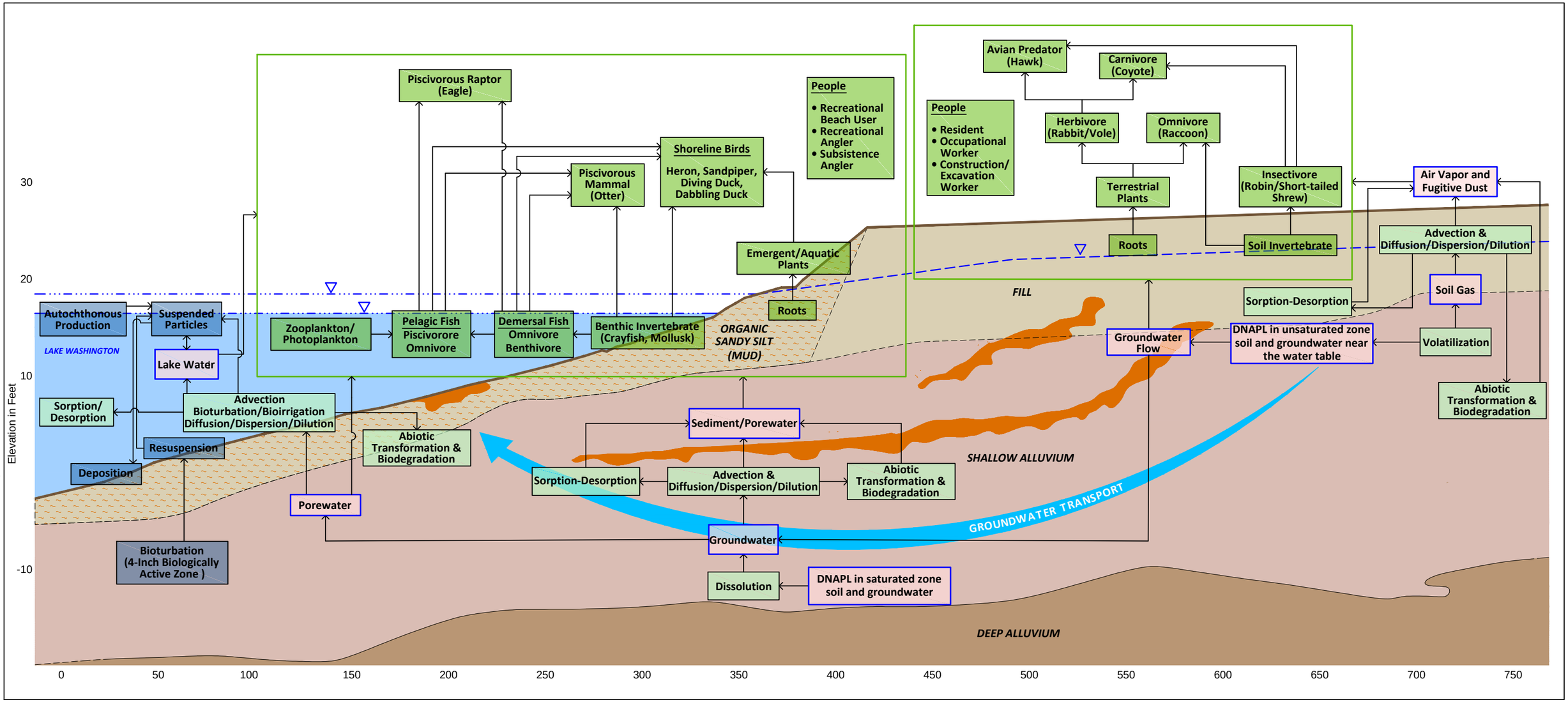
Feet
0 200 400

Figure 5.4-19
Wood Debris and Surface Bulk Sediment Indicator Parameters (TOC, TVS, and Percent Wood by Volume)
Final Remedial Investigation, Quendall Terminals



LEGEND:

Geology

- Ground Surface
- Inferred Geologic Contact
- Fill
- Organic Sandy Silt (Mud)
- Shallow Alluvium
- Deep Alluvium
- DNAPL

Conceptual Site Model

- Hydrodynamics and Sediment Dynamics
- Biological Fate and Transport (Predation/Bioaccumulation/Biomagnification)
- Chemical Fate and Transport Media
- Chemical Fate and Transport Process

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Sep 20, 2012 11:16am epipkin

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Figure 6.1-1
Graphic Illustration of the Contaminant Fate and Transport Conceptual Site Model
Final Remedial Investigation, Quendall Terminals

Aspect CONSULTING

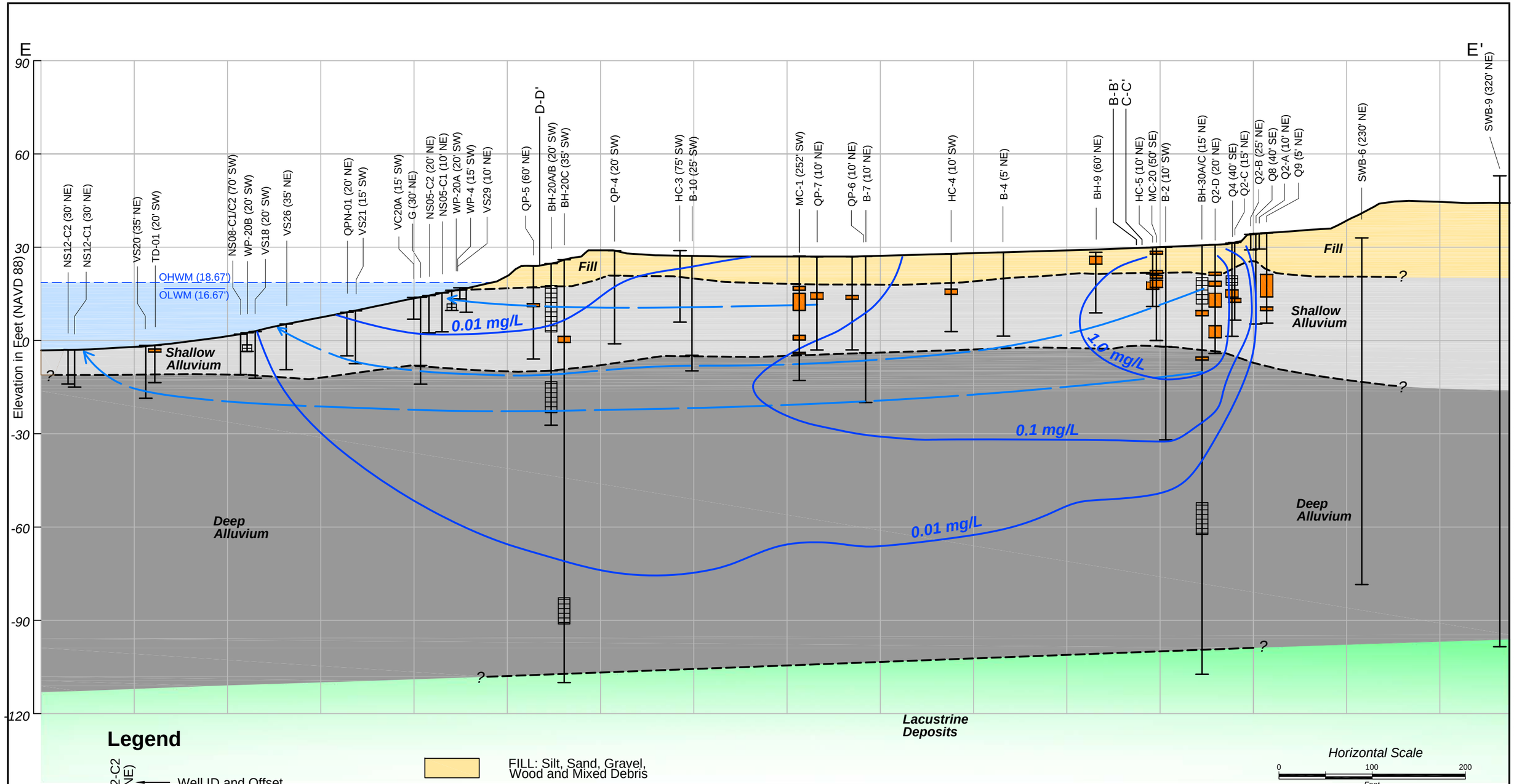
Advective Particle Tracking Discharge Locations

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: SM/JJP	
DRAWN BY: PMB/PMB	FIGURE NO. 6.4-1
REVISED BY: SCC	

Sep 11, 2012 4:26pm scudd Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report Keep Separate\020027-641.dwg Figure 6.4-1 (11 x 17)



Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

DNAPL

Well Screen

FILL: Silt, Sand, Gravel, Wood and Mixed Debris

Shallow Alluvium: Stratified Organic Silt, Peat, Sand

Deep Alluvium: Sand and Gravels

Lacustrine Deposits: Silt and Clay

Model-Generated Particle Flowpath

Model-Generated Pseudo-Steady-State Concentration Contours

Source constant concentration = 16 mg/L

Source vertical thickness = 33 feet

Horizontal Scale

0 100 200 Feet

Vertical Scale

0 30 60 Feet

Vertical Exaggeration 3.33X

Aspect CONSULTING

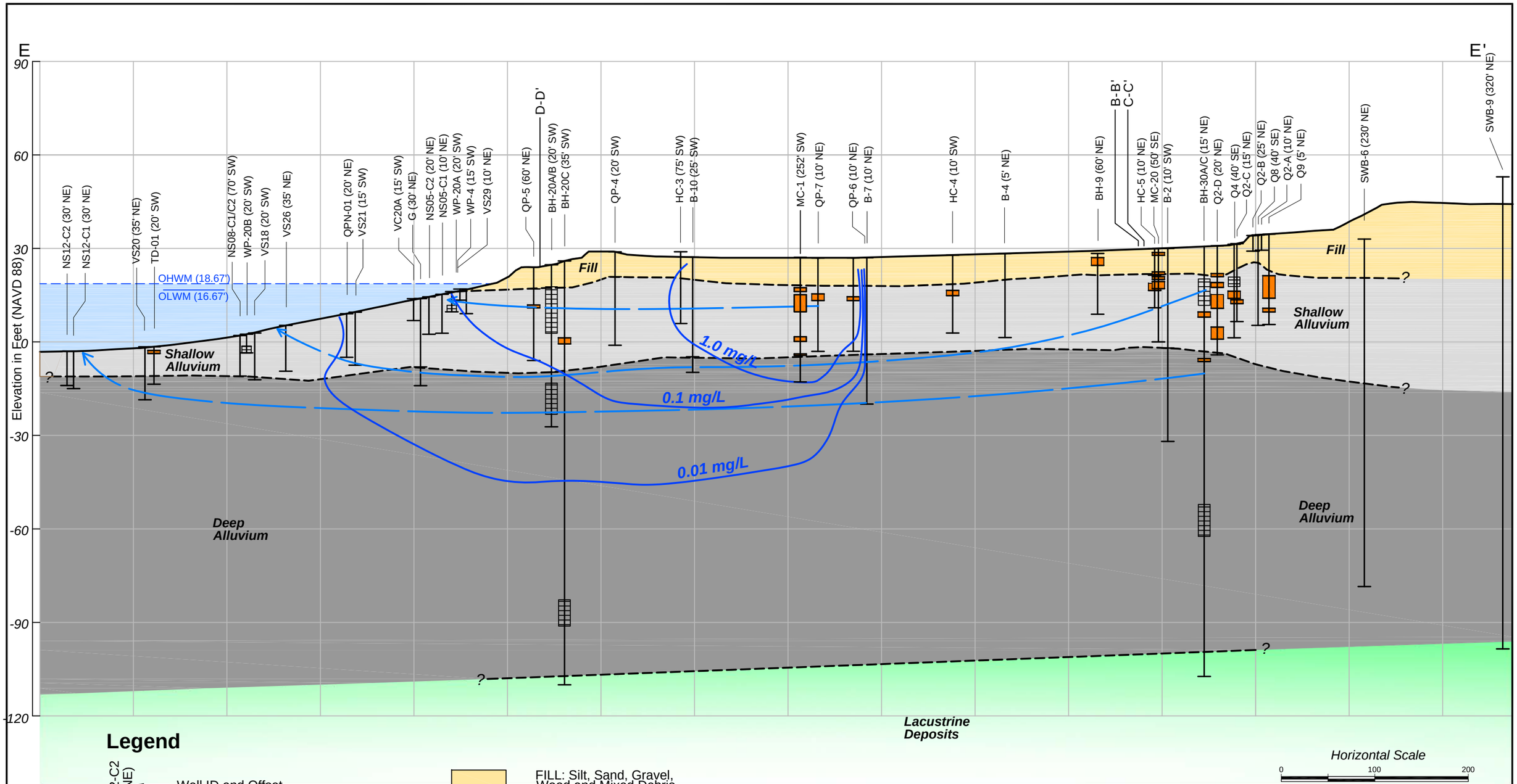
Particle Tracking Results and Simulated Naphthalene Concentrations from Representative Source at Boring BH-30C

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH	
DRAWN BY: PMB/SCC	FIGURE NO. 6.4-2
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-642.dwg Figure 6.4-2 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:41pm || User: scudd



Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

DNAPL

Well Screen

FILL: Silt, Sand, Gravel, Wood and Mixed Debris

Shallow Alluvium: Stratified Organic Silt, Peat, Sand

Deep Alluvium: Sand and Gravels

Lacustrine Deposits: Silt and Clay

Model-Generated Particle Flowpath

Model-Generated Pseudo-Steady-State Concentration Contours

Source constant concentration = 16 mg/L

Source vertical thickness = 28 feet

Horizontal Scale

0 100 200 Feet

Vertical Scale

0 30 60 Feet

Vertical Exaggeration 3.33X

Aspect CONSULTING

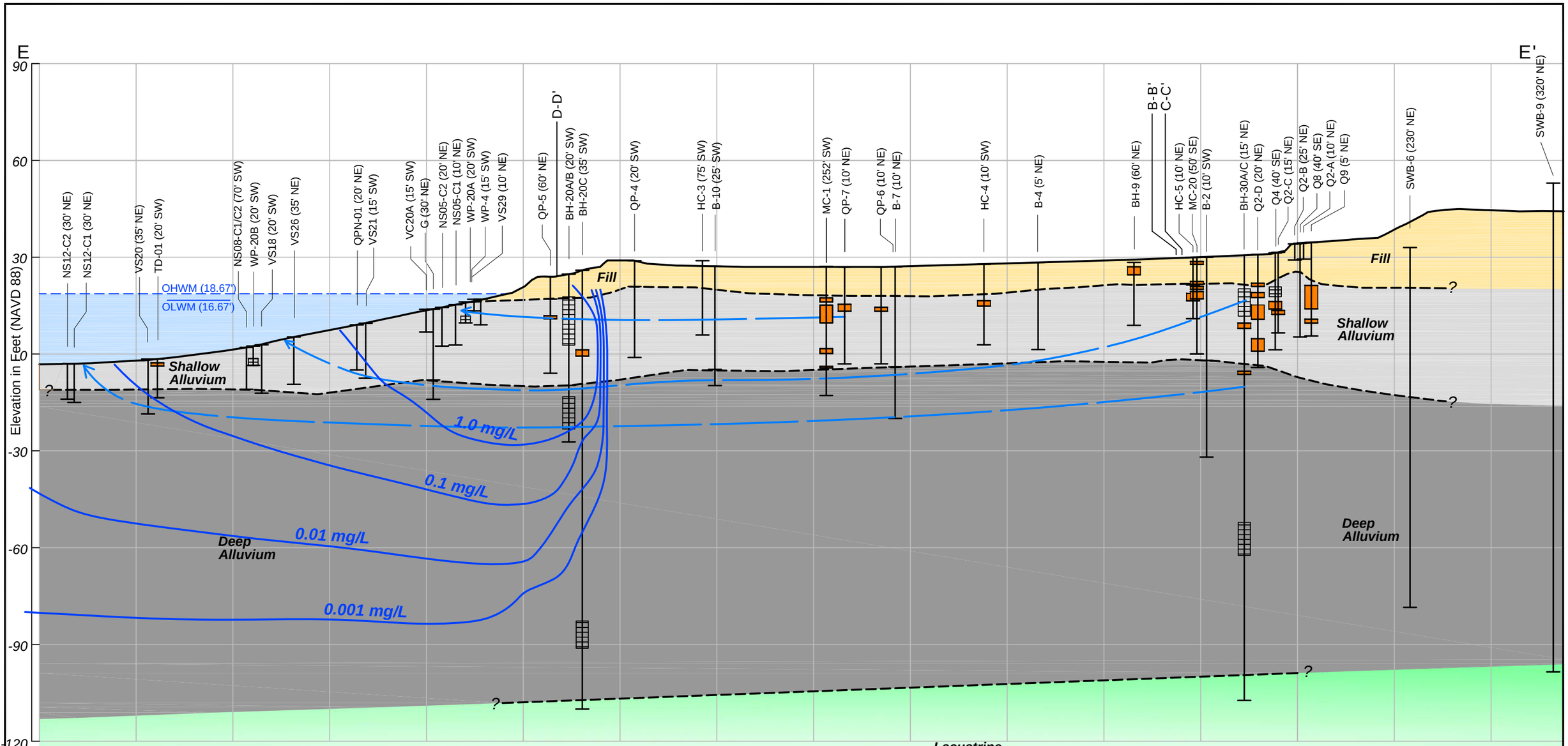
Particle Tracking Results and Simulated Naphthalene Concentrations from Representative Source at Boring MC-1

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH	
DRAWN BY: PMB/SCC	FIGURE NO. 6.4-3
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-643.dwg Figure 6.4-3 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:46pm || User: scudd



Legend

NS12-C2 (30' NE) — Well ID and Offset from Cross Section

DNAPL

Well Screen

FILL: Silt, Sand, Gravel, Wood and Mixed Debris

Shallow Alluvium: Stratified Organic Silt, Peat, Sand

Deep Alluvium: Sand and Gravels

Lacustrine Deposits: Silt and Clay

Model-Generated Particle Flowpath

Model-Generated Pseudo-Steady-State Concentration Contours

Source constant concentration = 8 mg/L

Source vertical thickness = 49 feet

Horizontal Scale

0 100 200

Feet

Vertical Scale

0 30 60

Feet

Vertical Exaggeration 3.33X

Aspect CONSULTING

Particle Tracking Results and Simulated Benzene Concentrations from Representative Source at Well Pair BH-20A/B

Final Remedial Investigation, Quendall Terminals

Renton, Washington

DATE: SEP 2012	PROJECT NO. 020027
DESIGNED BY: JJP/AJH	
DRAWN BY: PMB/SCC	FIGURE NO. 6.4-4
REVISED BY: SCC	

CAD Path: Q:\Quendall\020027 Quendall Terminals\2012-09 RI Final Report\020027-644.dwg Figure 6.4-4 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Sep 11, 2012 4:51pm || User: scudd

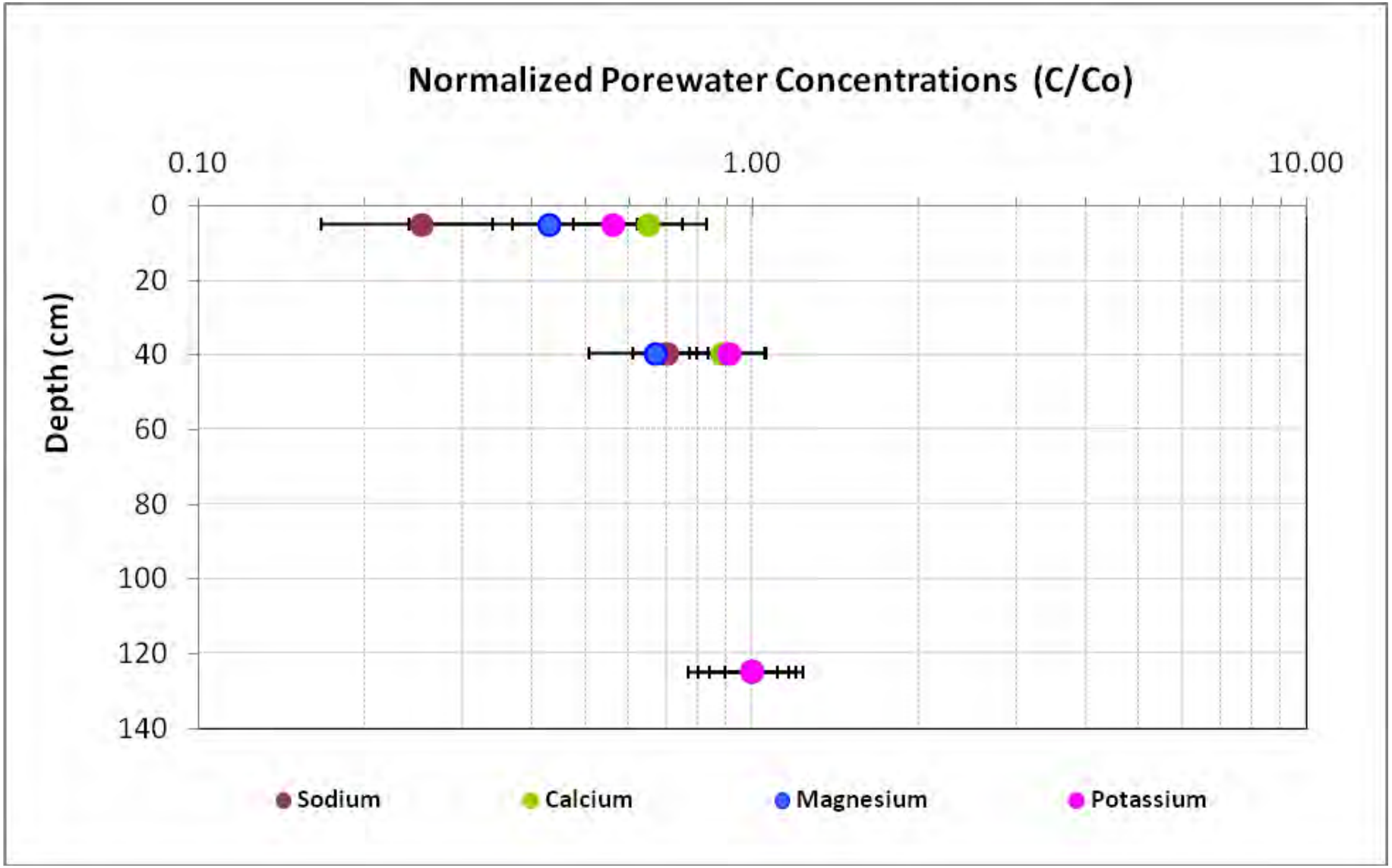


Figure 6.4-5
Cation Calibration Results
Final Remedial Investigation, Quendall Terminals

ANCHOR QEA

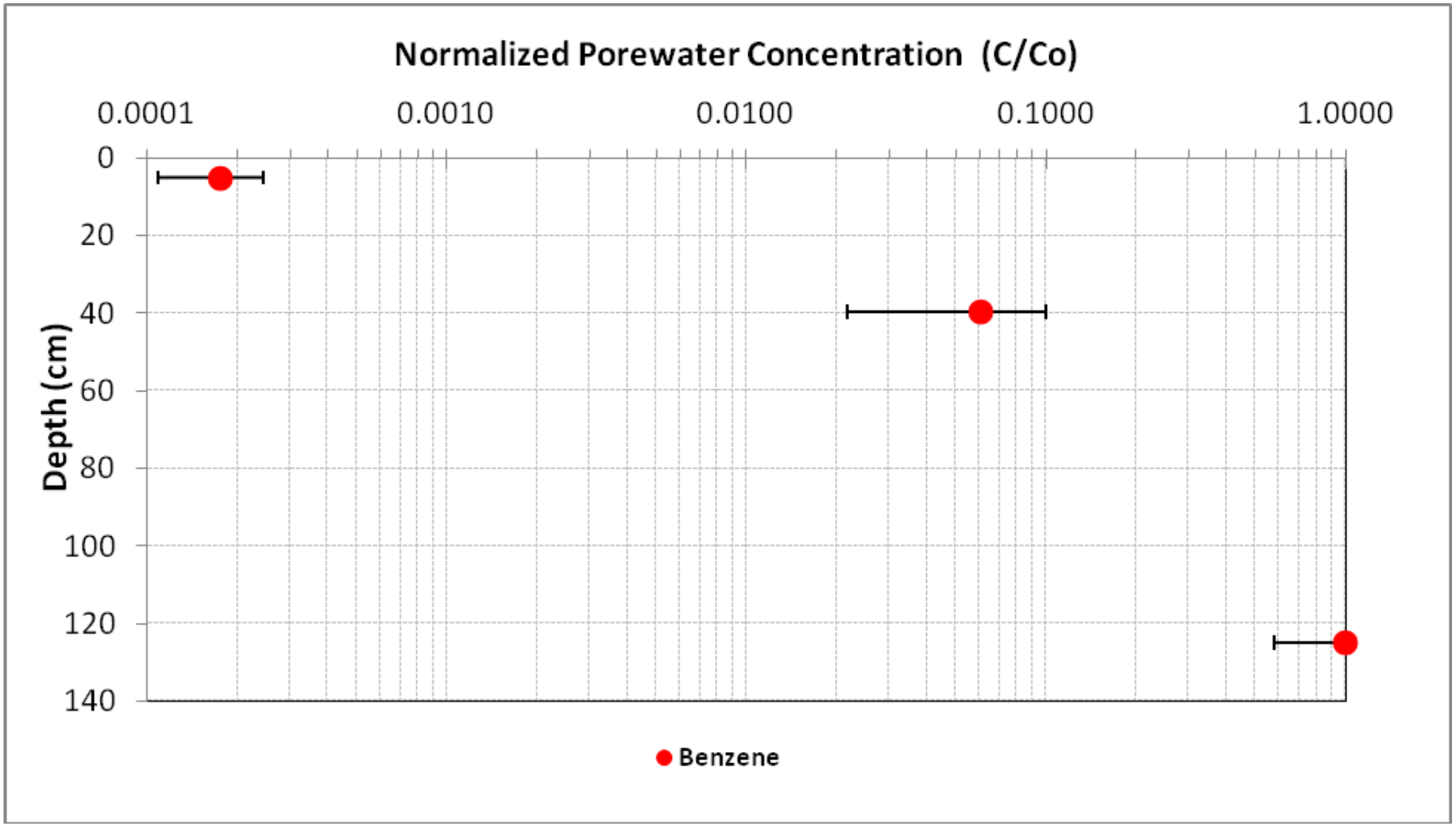


Figure 6.4-6
Benzene Calibration Results
Final Remedial Investigation, Quendall Terminals

ANCHOR QEA

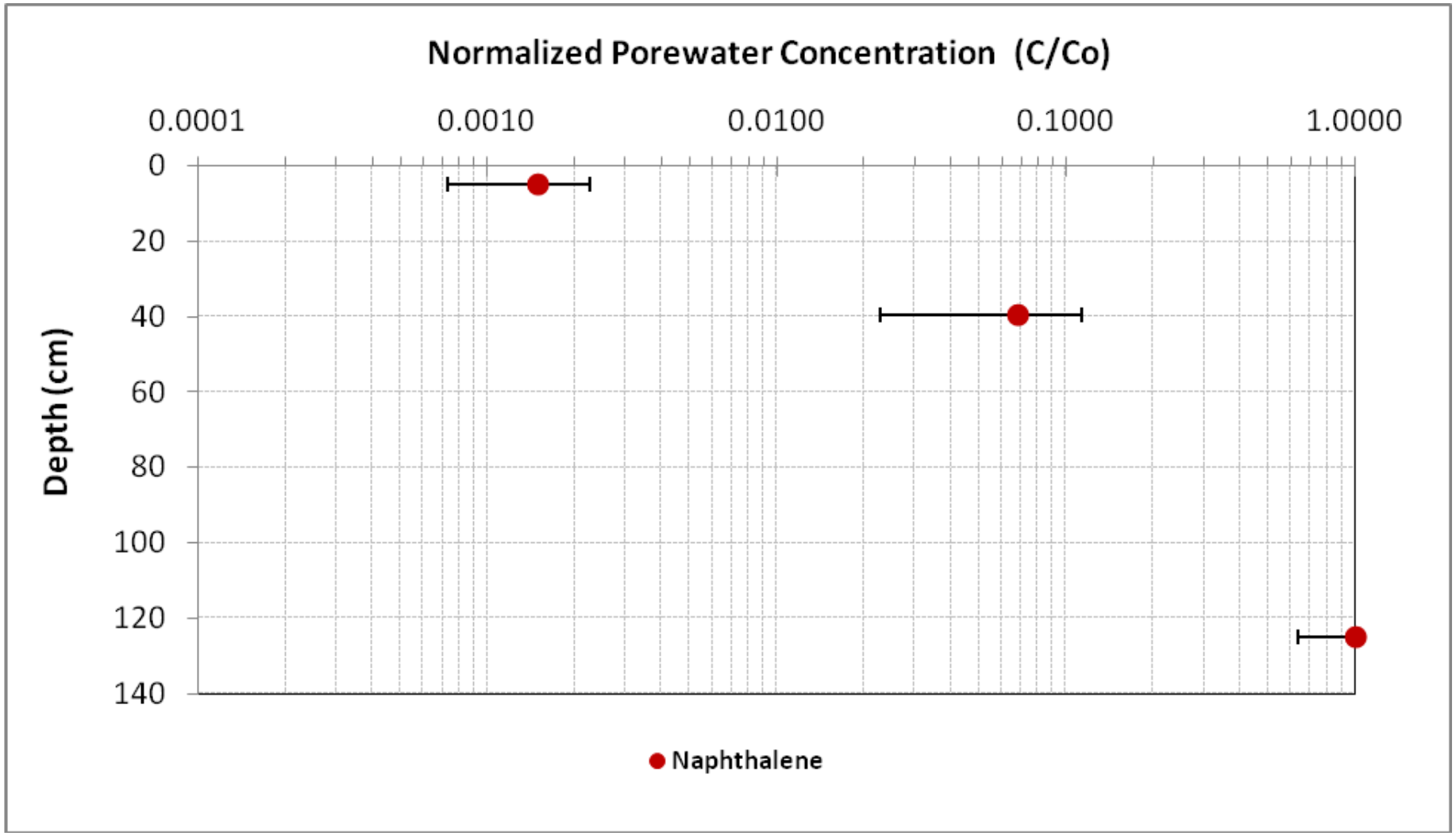
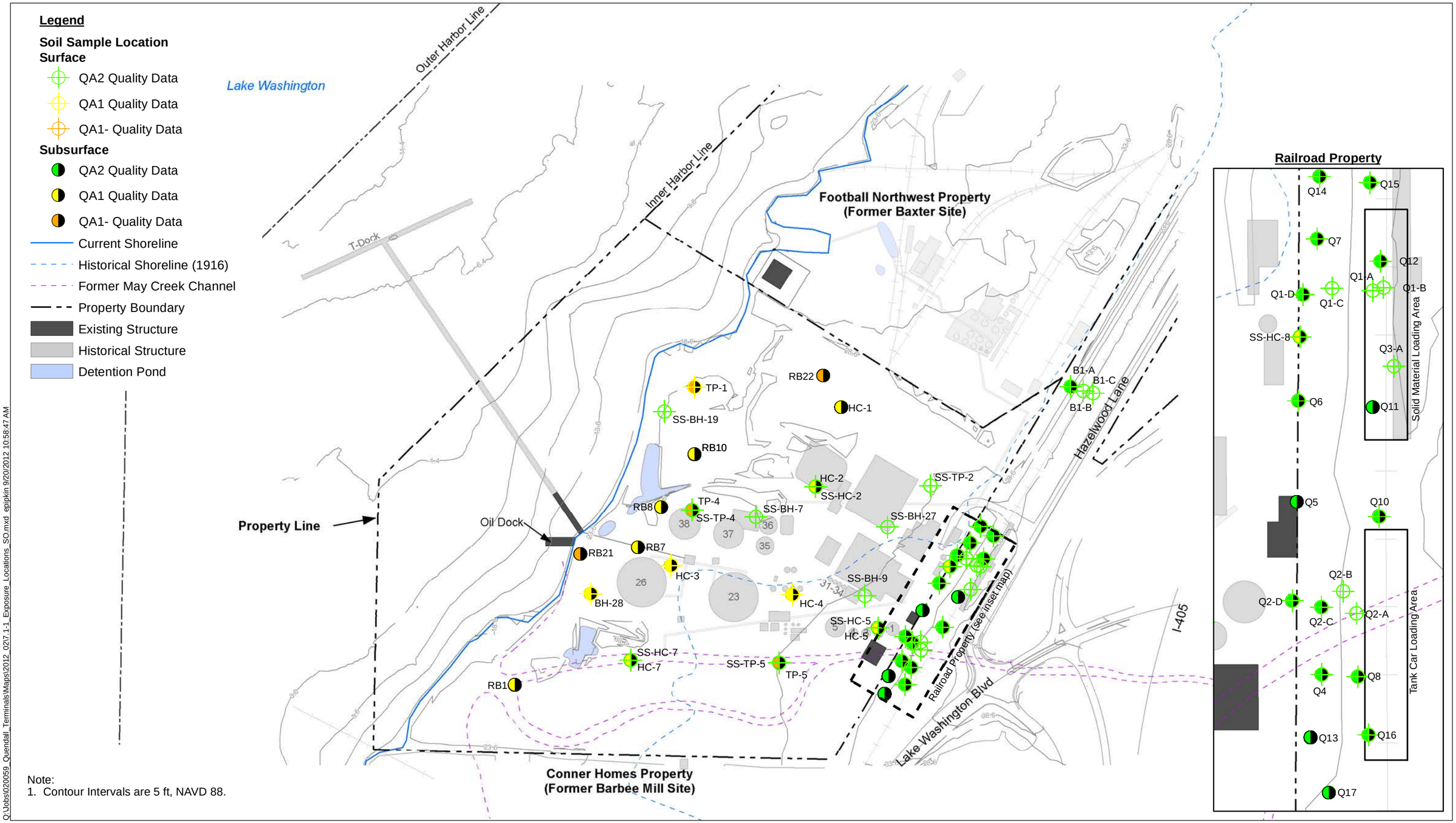


Figure 6.4-7
Naphthalene Calibration Results
Cityl·f Remedial Investigation, Quendall Terminals

ANCHOR QEA



Note:
1. Contour Intervals are 5 ft, NAVD 88.

ANCHOR QEA

Feet
0 100 200 300 400

Figure 7.1-1
Data Used in the Baseline Risk Assessment: Soil Sample Locations
Final Remedial Investigation, Quendall Terminals

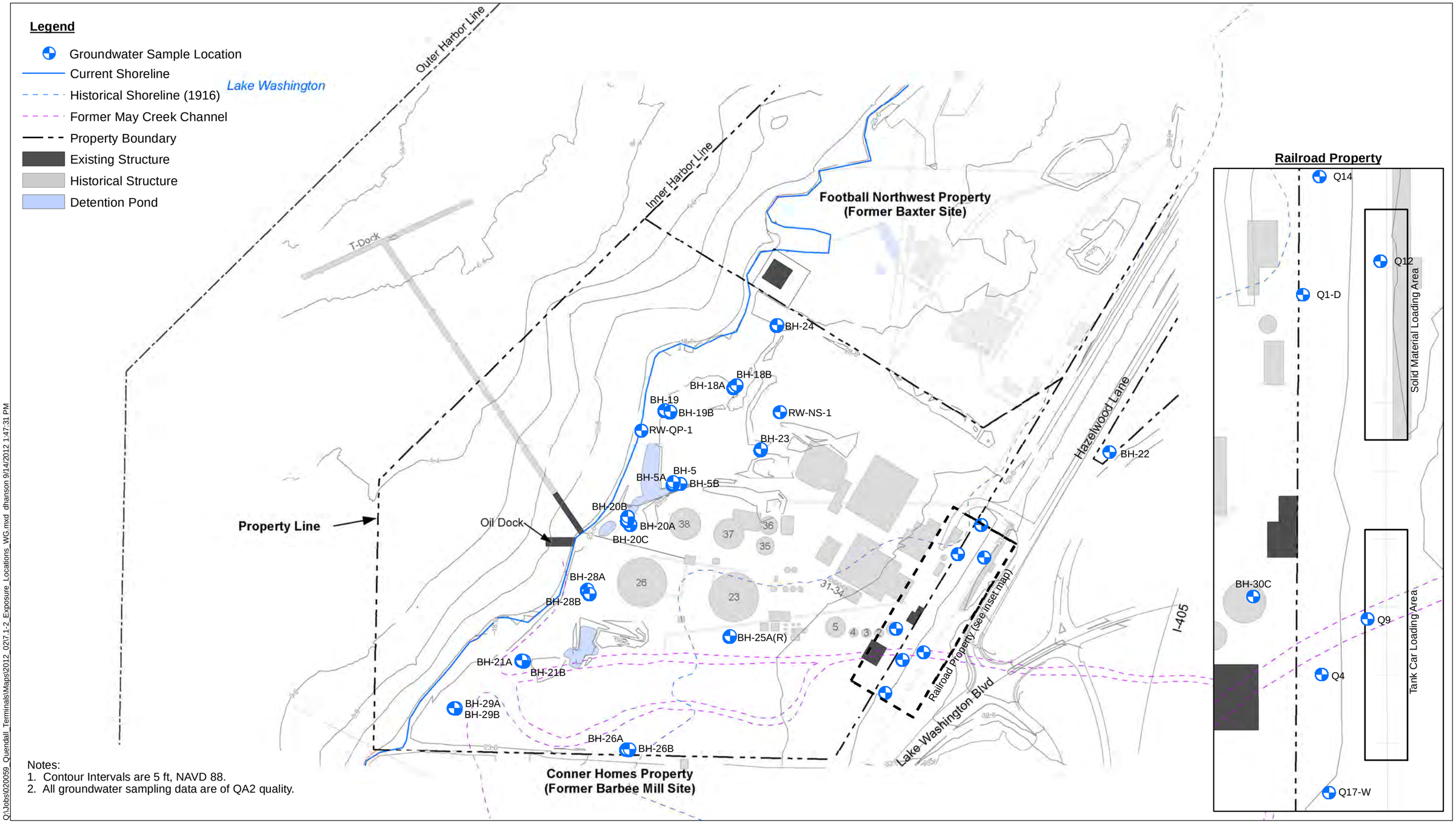
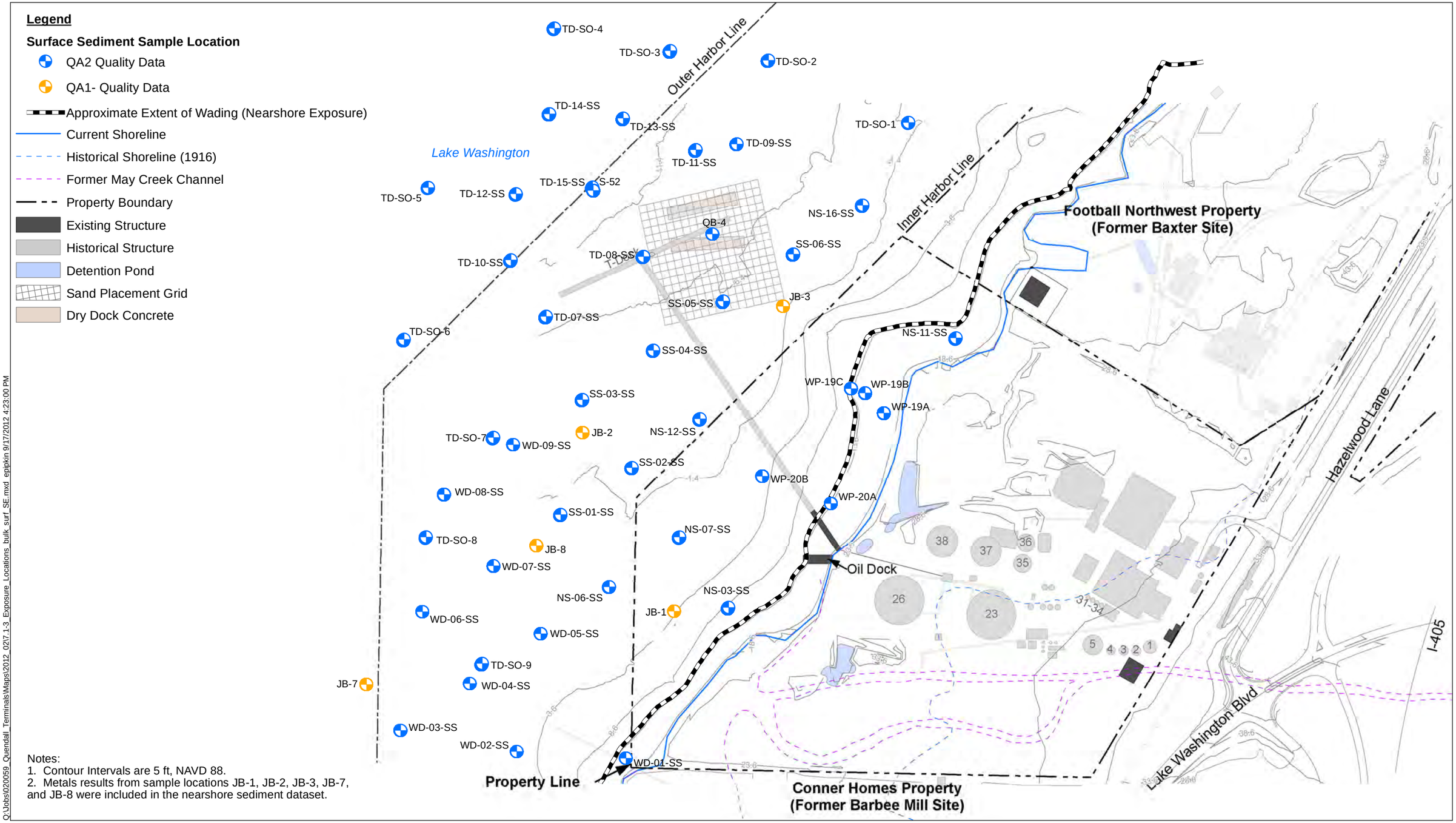


Figure 7.1-2
Data Used in the Baseline Risk Assessment: Groundwater Sample Locations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. Metals results from sample locations JB-1, JB-2, JB-3, JB-7, and JB-8 were included in the nearshore sediment dataset.

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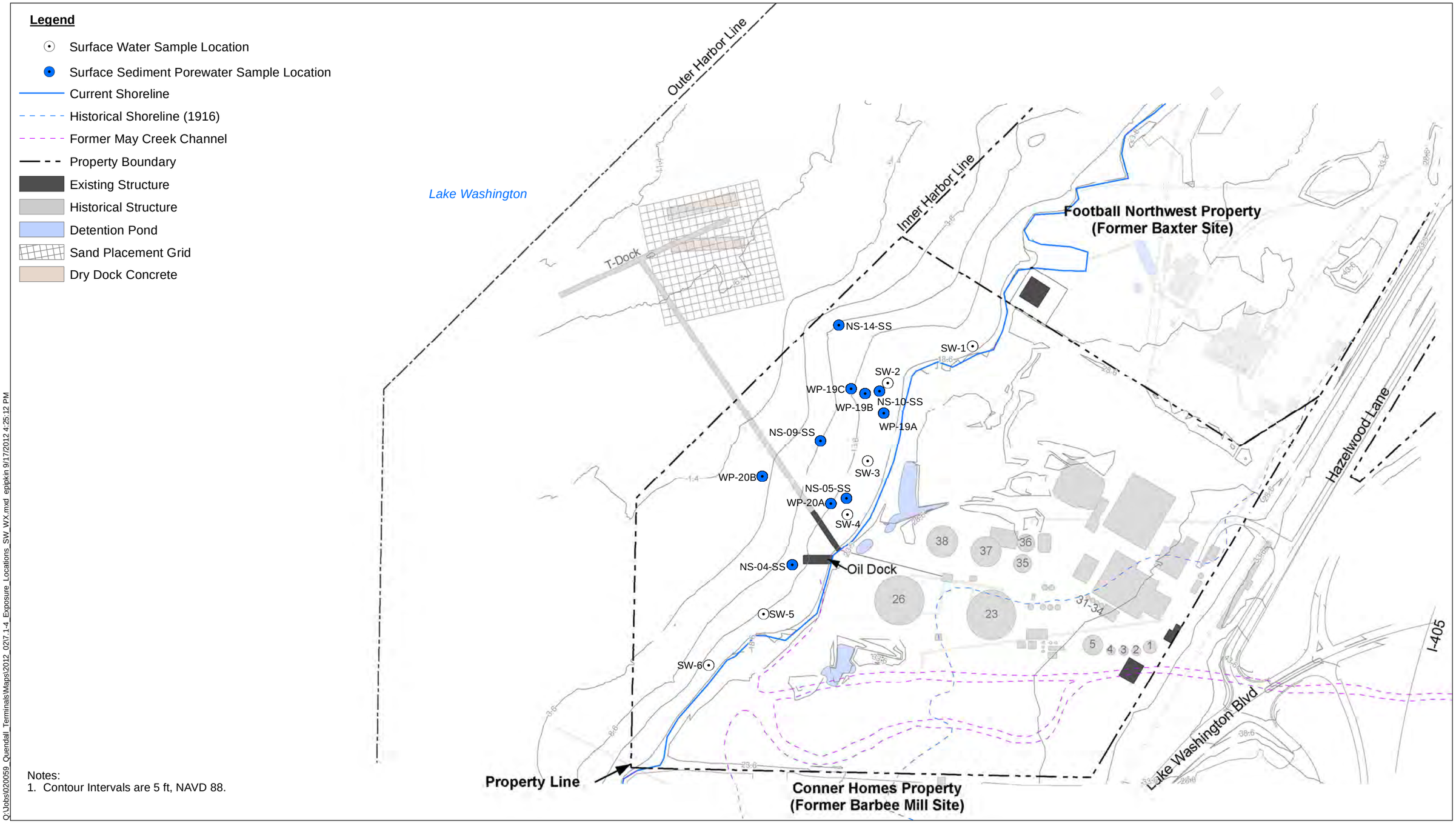
Feet
0 100 200 300 400

Figure 7.1-3
Data Used in the Baseline Risk Assessment: Surface Sediment Sample Locations
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.

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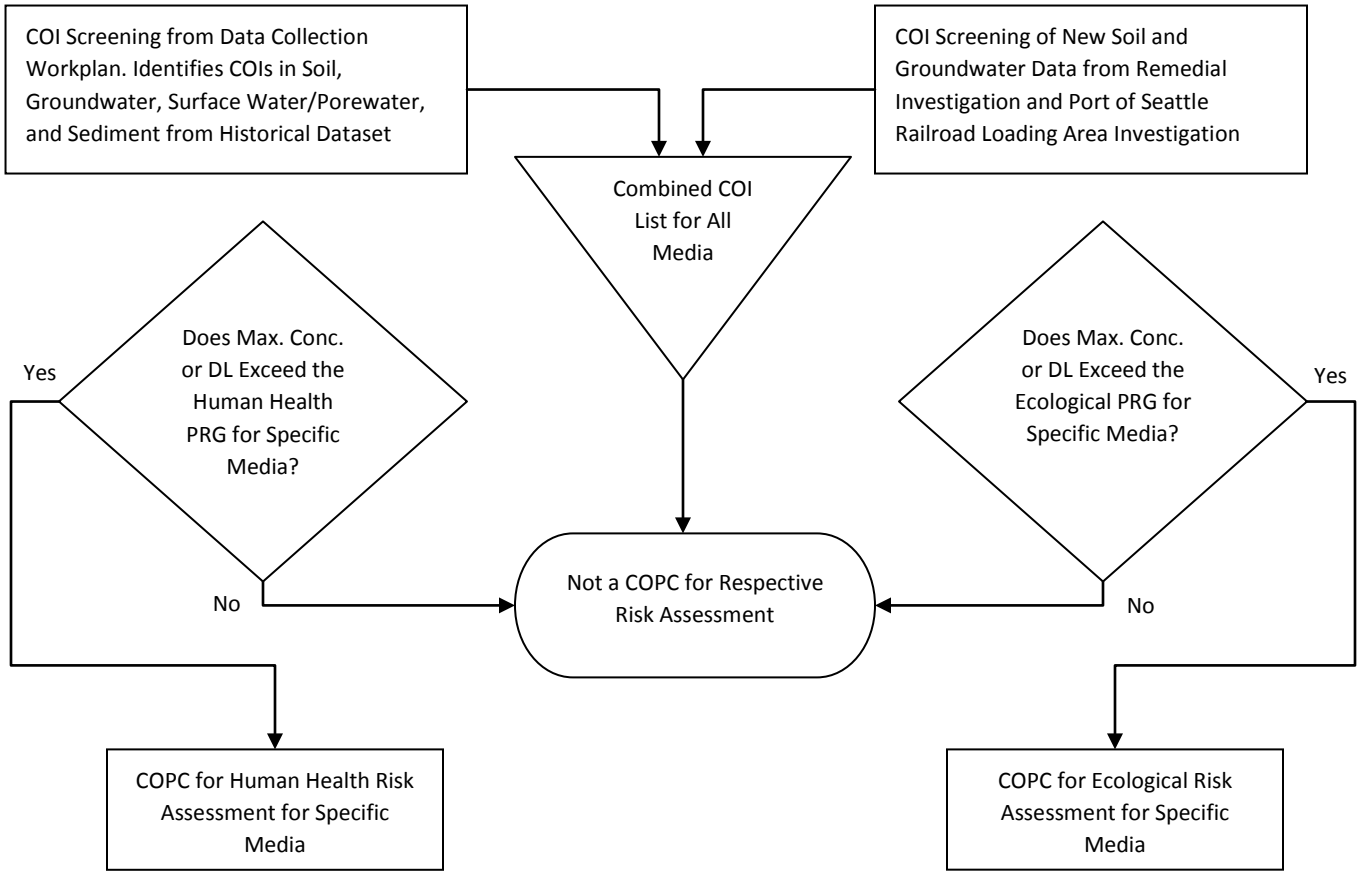
Figure 7.1-4
Data Used in the Baseline Risk Assessment: Surface Water and Surface Sediment Porewater Sample Locations
Final Remedial Investigation, Quendall Terminals

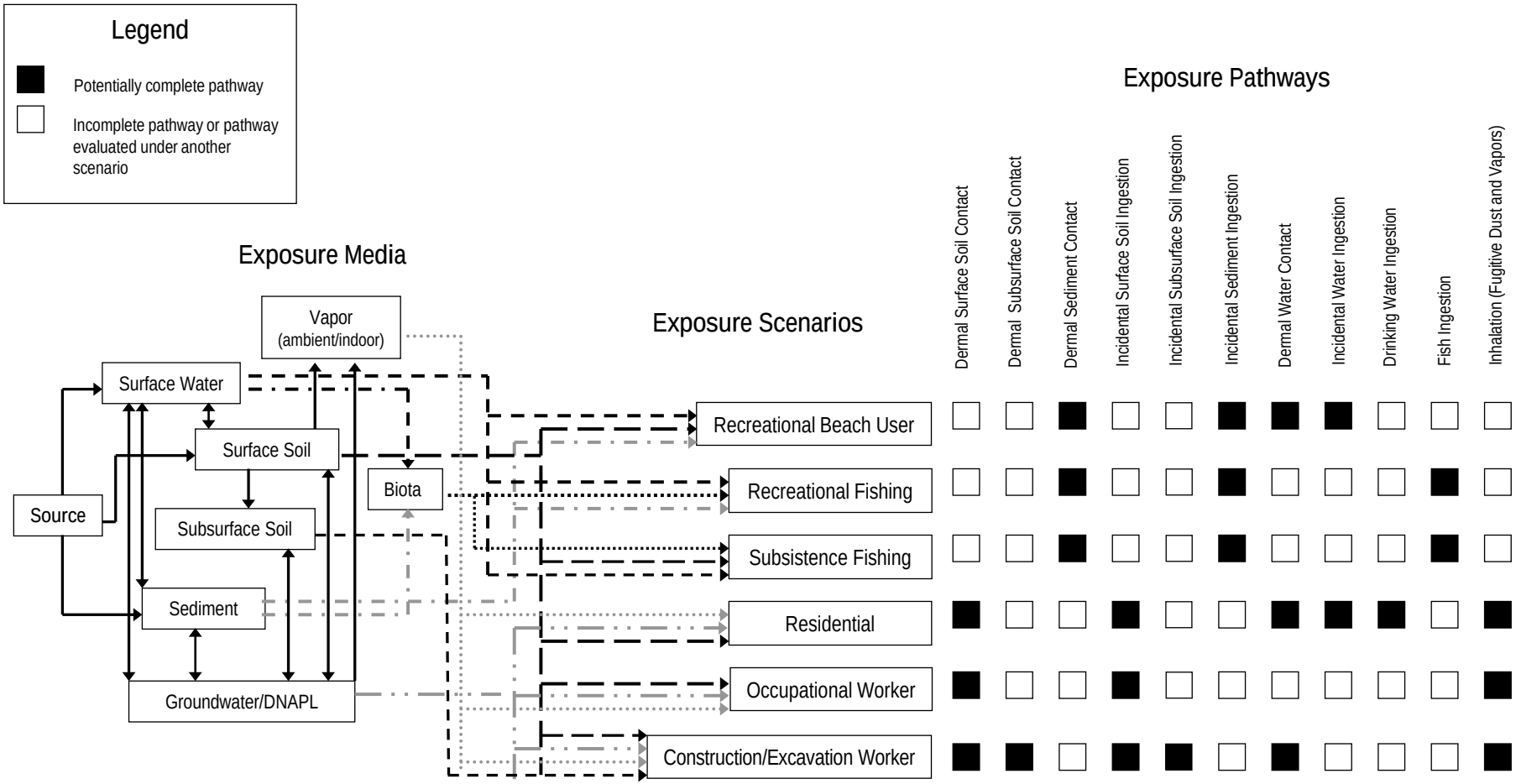


Notes:

DL Detection Limit
PRG Preliminary Remediation Goal
COI Contaminant of Interest
COPC Chemical of Potential Concern
PRG Preliminary Remediation Goal

Figure 7.1-5
Decision Matrix for Identifying Chemicals of Potential Concern
Final Remedial Investigation, Quendall Terminals

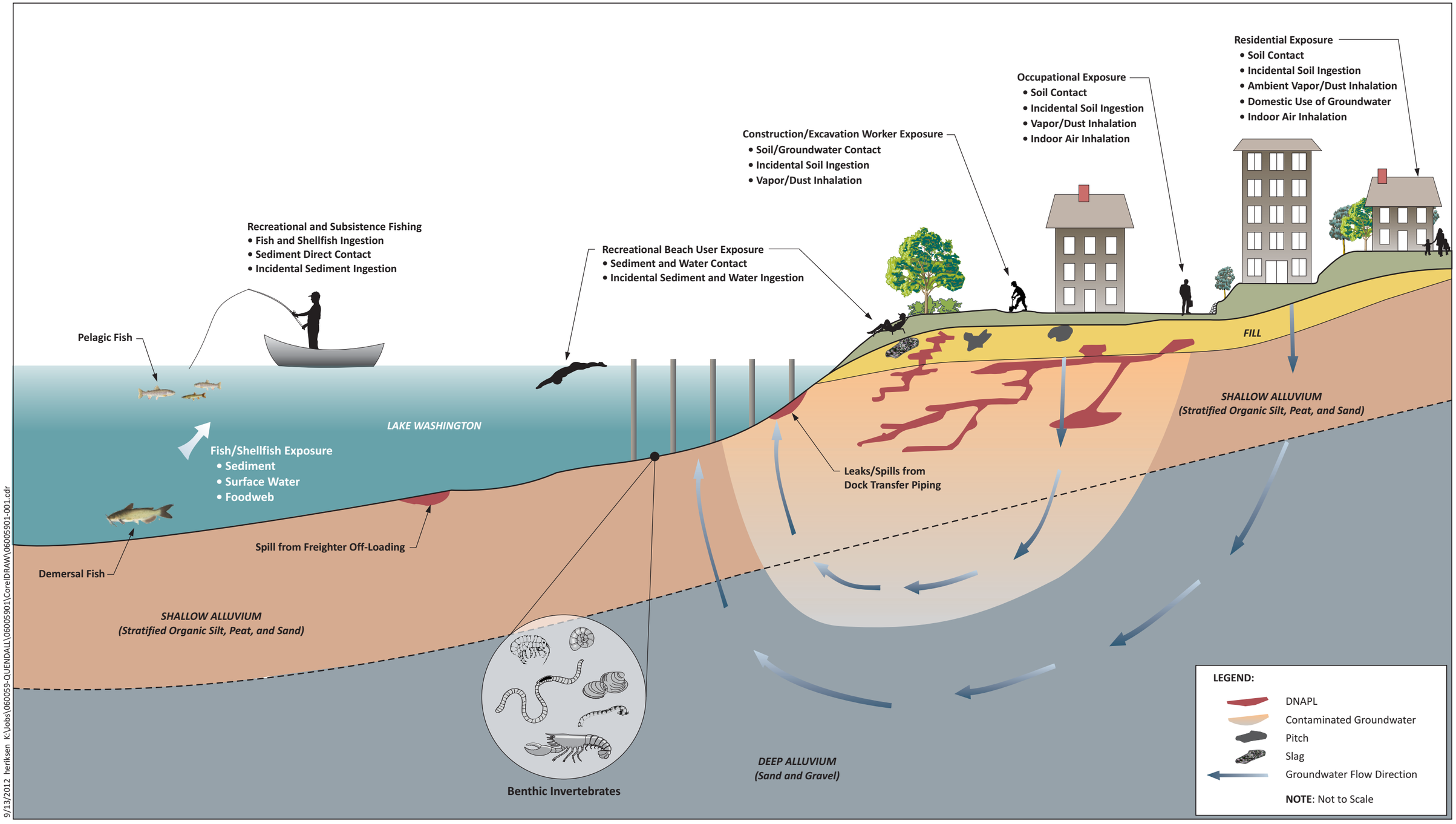
ANCHOR QEA



Note: Figure 2.2-1 presents the Quendall site-specific release mechanisms showing upland and aquatic primary sources in relation to exposure media.

Figure 7.1-6
Human Health Conceptual Site Exposure Model Schematic
Final Remedial Investigation, Quendall Terminals

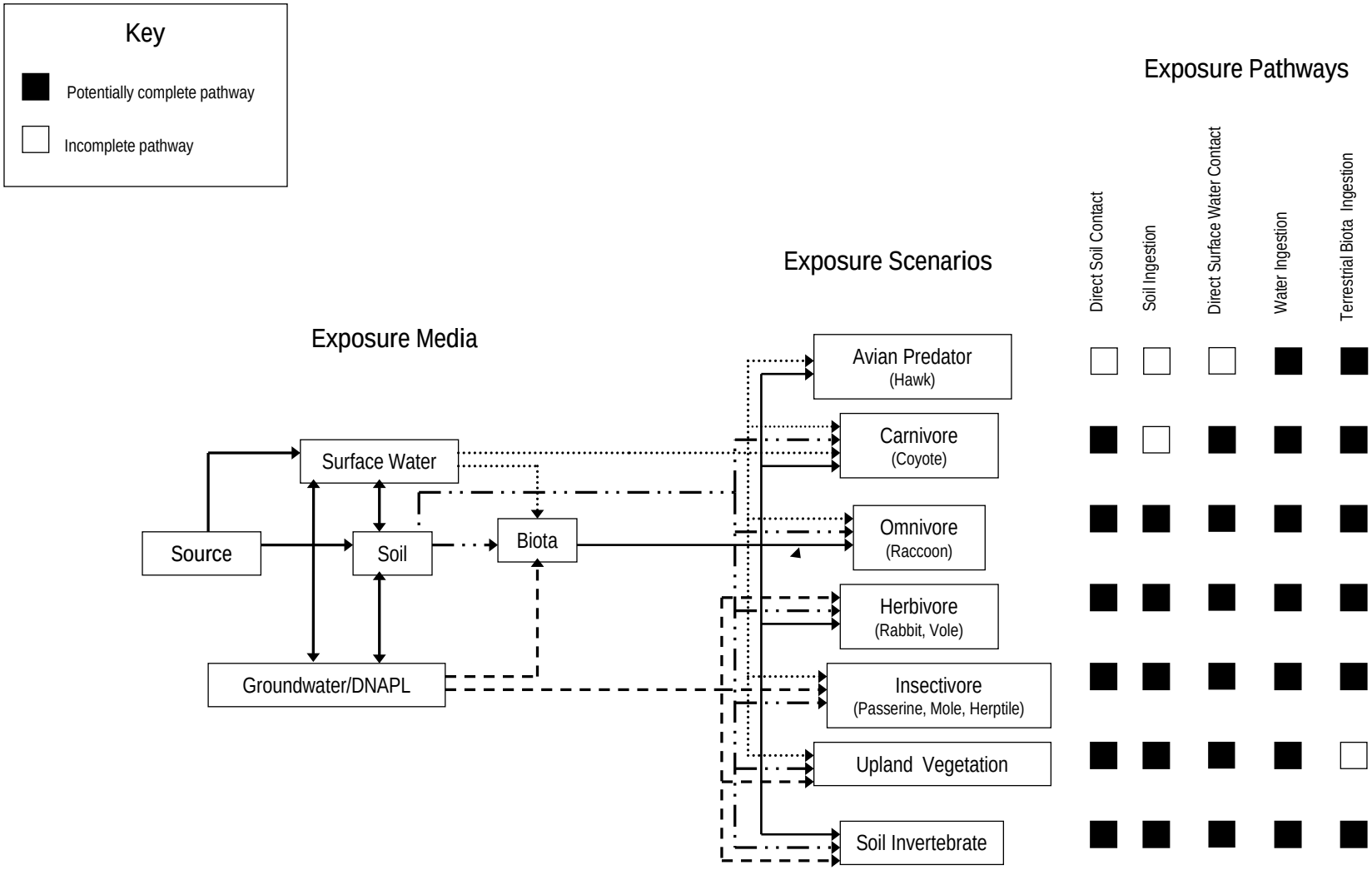
ANCHOR QEA



9/13/2012 heriksen K:\Jobs\060059-QUENDALL\06005901\CorelDRAW\06005901-001.cdr

ANCHOR QEA

Figure 7.1-7
Graphic Illustration of Human Health Conceptual Site Exposure Model
Final Remedial Investigation, Quendall Terminals



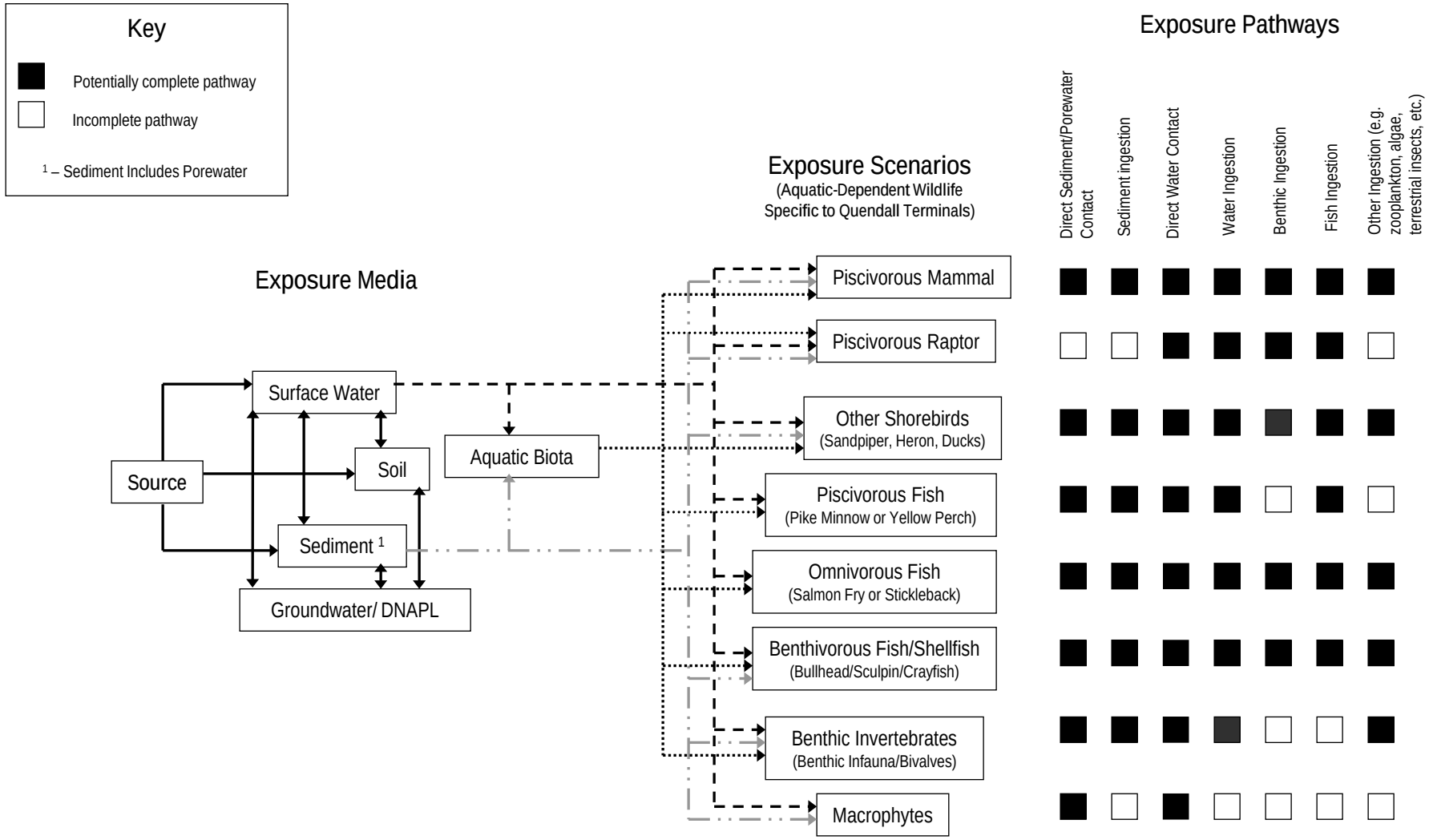
Note: Figure 2.2-1 presents the Quendall site-specific release mechanisms showing upland and aquatic primary sources in relation to exposure media. The exposure media presented above are those from Figure 2.2-1 as applicable to terrestrial wildlife exposure.

Figure 7.2-1

Conceptual Site Model for Terrestrial Receptors, Quendall Terminals Site

Final Remedial Investigation, Quendall Terminals

ANCHOR QEA



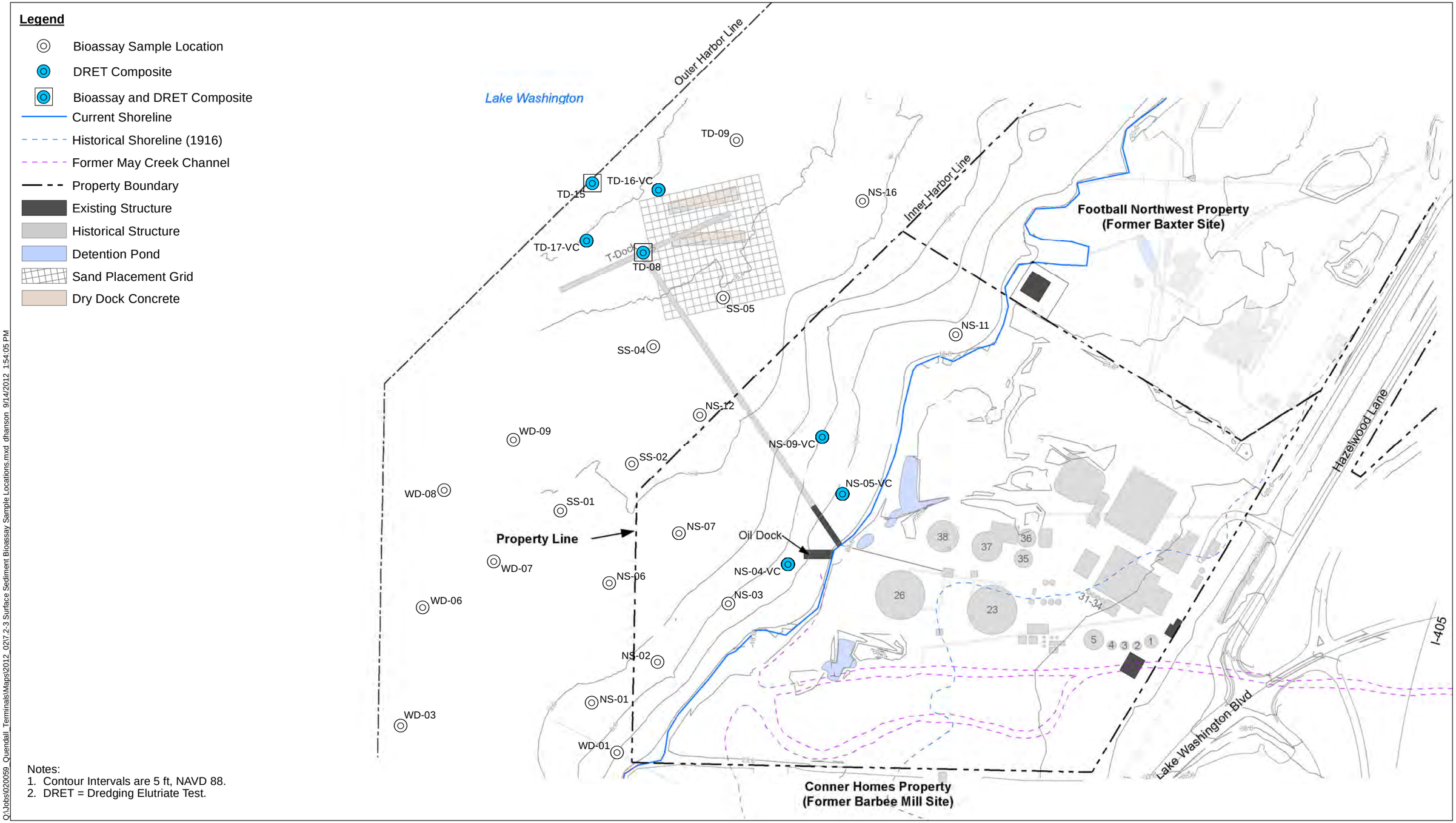
Note: Figure 2.2-1 presents the Quendall site-specific release mechanisms showing upland and aquatic primary sources in relation to exposure media. The exposure media presented above are those from Figure 2.2-1 as applicable to aquatic-dependent wildlife exposure.

Figure 7.2-2

Conceptual Site Model for Aquatic-Dependent Receptors, Quendall Terminals Site

Final Remedial Investigation, Quendall Terminals

ANCHOR QEA



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. DRET = Dredging Elutriate Test.

Q:\Jobs\020059_Quendall_Terminals\Maps\2012_02\7.2-3 Surface Sediment Bioassay Sample Locations.mxd dhanson 9/14/2012 1:54:05 PM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 7.2-3
Surface Sediment Bioassay Sample Locations
Final Remedial Investigation, Quendall Terminals

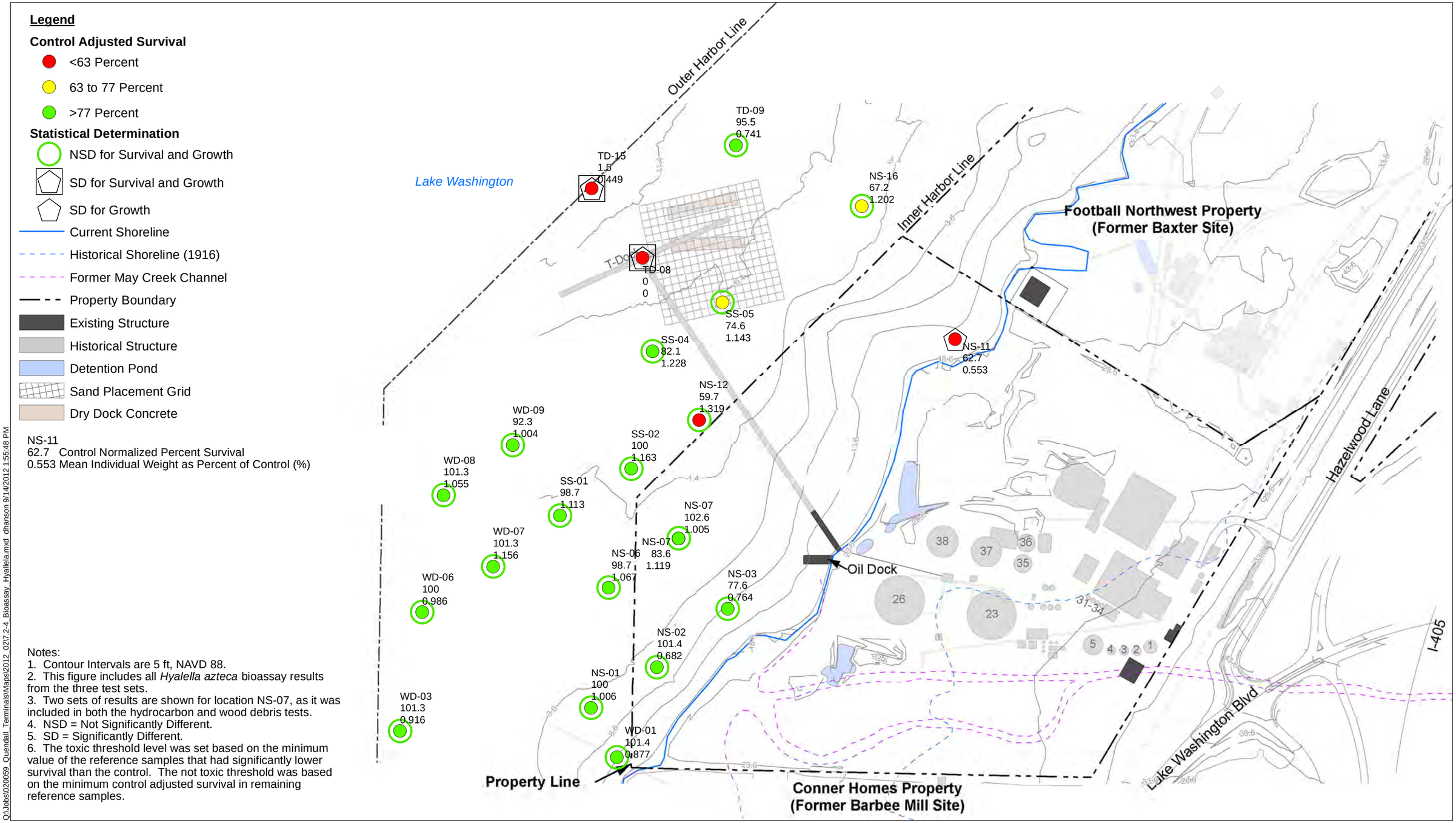


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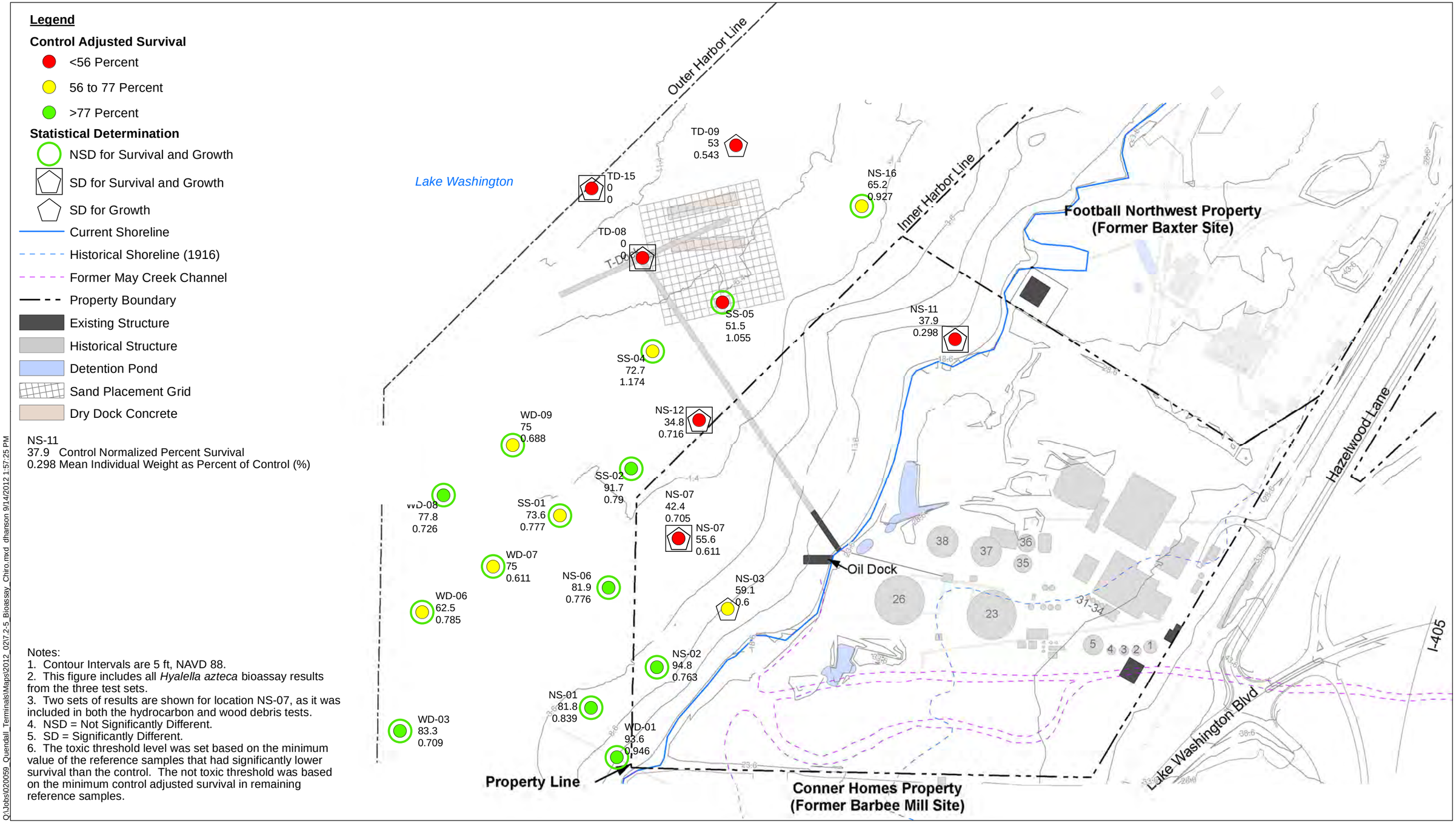
Figure 7.2-4
Mortality and Growth in 28-day *Hyalella azteca* Bioassay
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour Intervals are 5 ft, NAVD 88.
2. This figure includes all *Hyalella azteca* bioassay results from the three test sets.
3. Two sets of results are shown for location NS-07, as it was included in both the hydrocarbon and wood debris tests.
4. NSD = Not Significantly Different.
5. SD = Significantly Different.
6. The toxic threshold level was set based on the minimum value of the reference samples that had significantly lower survival than the control. The not toxic threshold was based on the minimum control adjusted survival in remaining reference samples.

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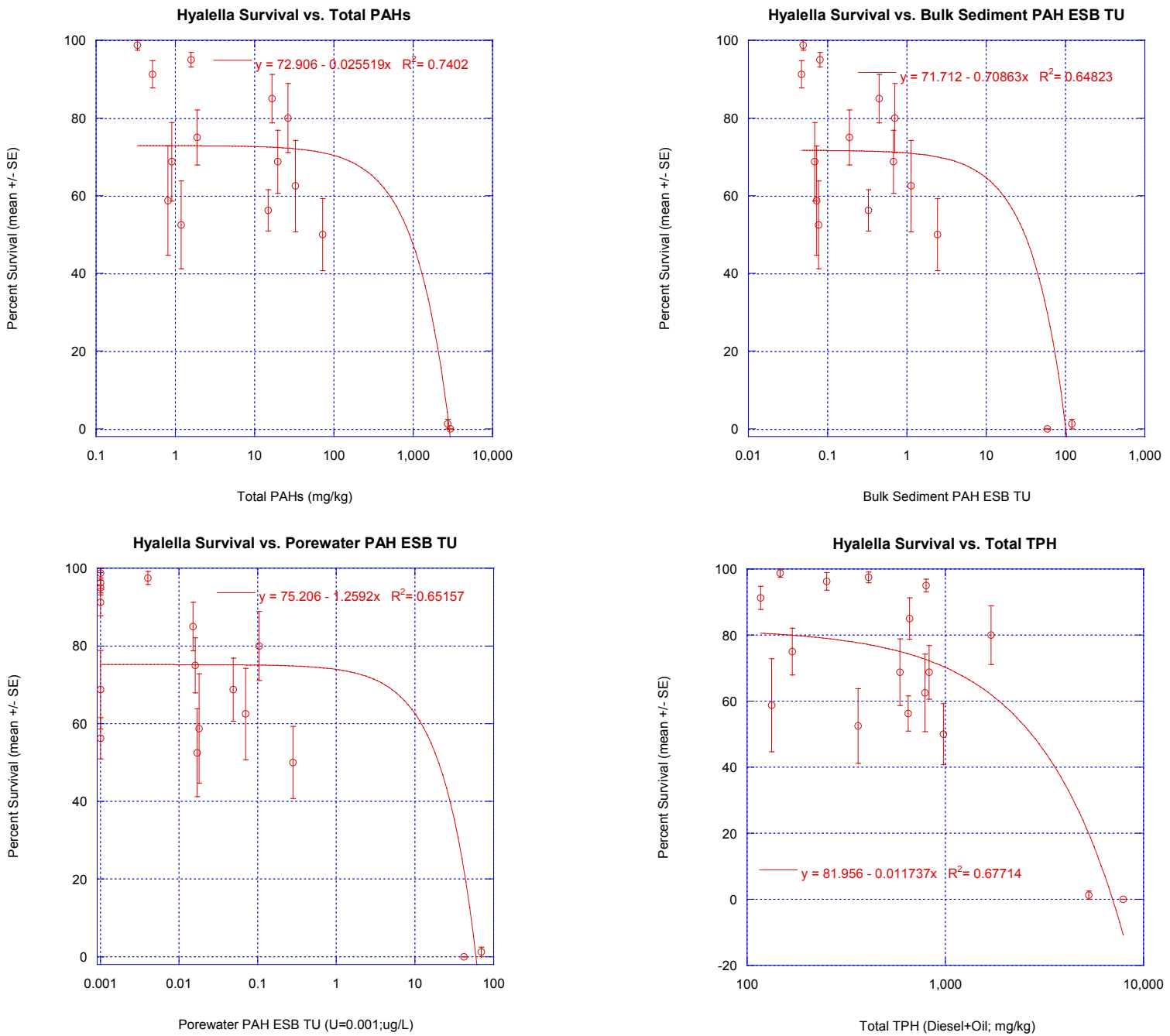
Figure 7.2-5
Mortality and Growth in 20-day *Chironomus dilutus* Bioassay
Final Remedial Investigation, Quendall Terminals



ANCHOR QEA

Figure 7.2-6a

Relationships between Bioassay Survival and Growth and Sediment Chemistry—28-day *Hyalella azteca* Test

Final Remedial Investigation, Quendall Terminals

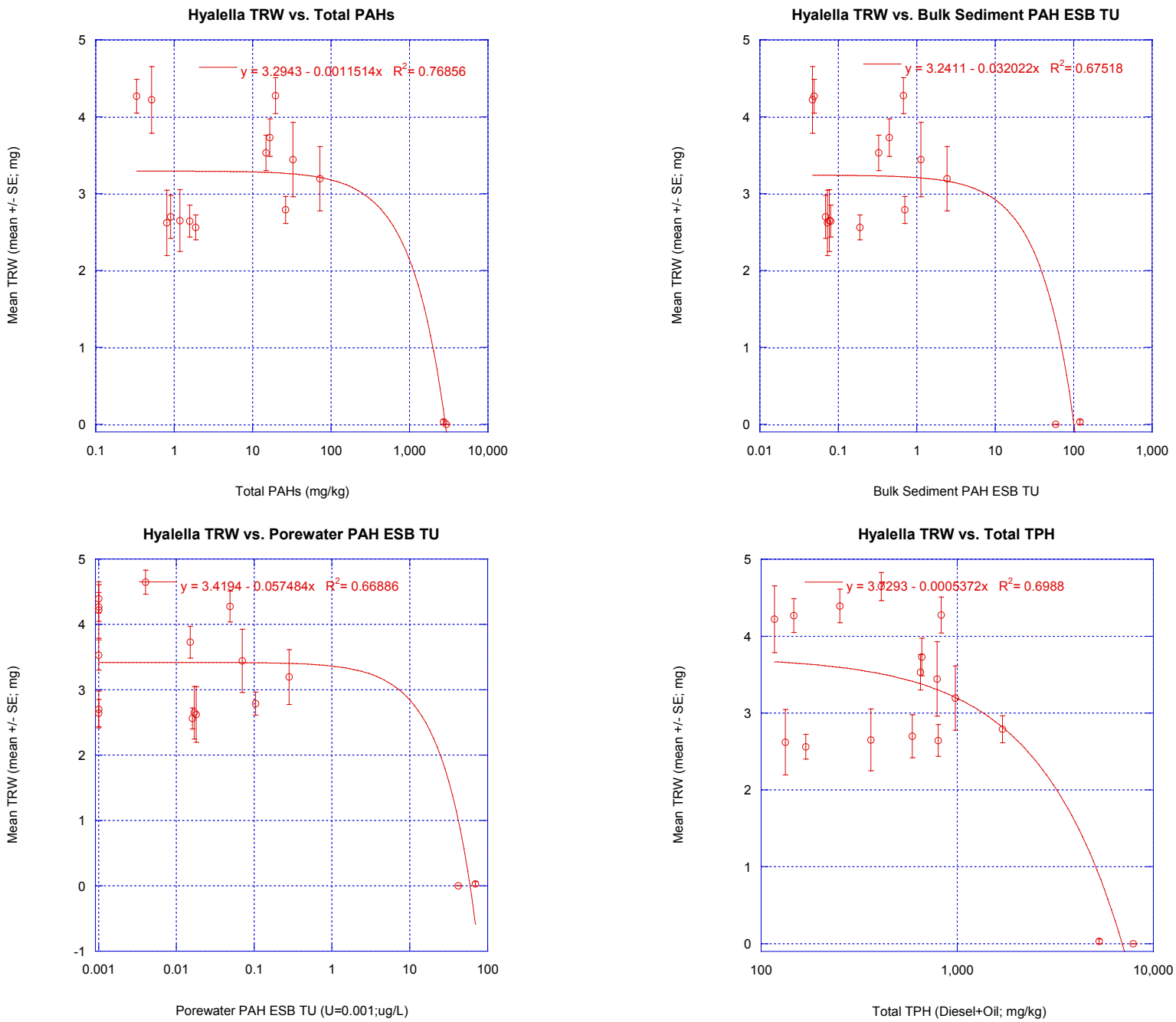


Figure 7.2-6b

Relationships between Bioassay Survival and Growth and Sediment Chemistry—28-day *Hyalella azteca* Test

Final Remedial Investigation, Quendall Terminals

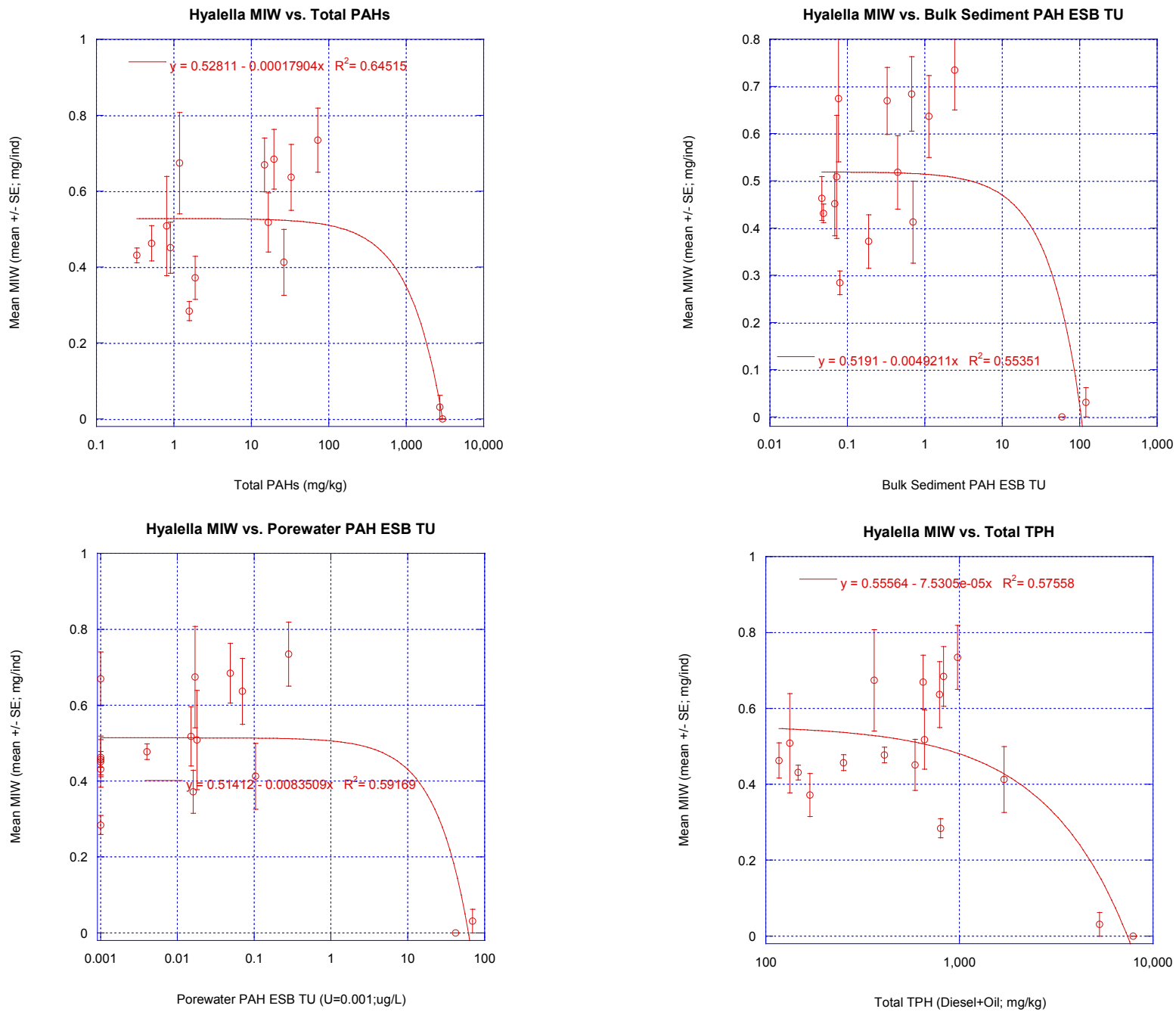


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Figure 7.2-6c

Relationships between Bioassay Survival and Growth and Sediment Chemistry—28-day *Hyalella azteca* Test

Final Remedial Investigation, Quendall Terminals

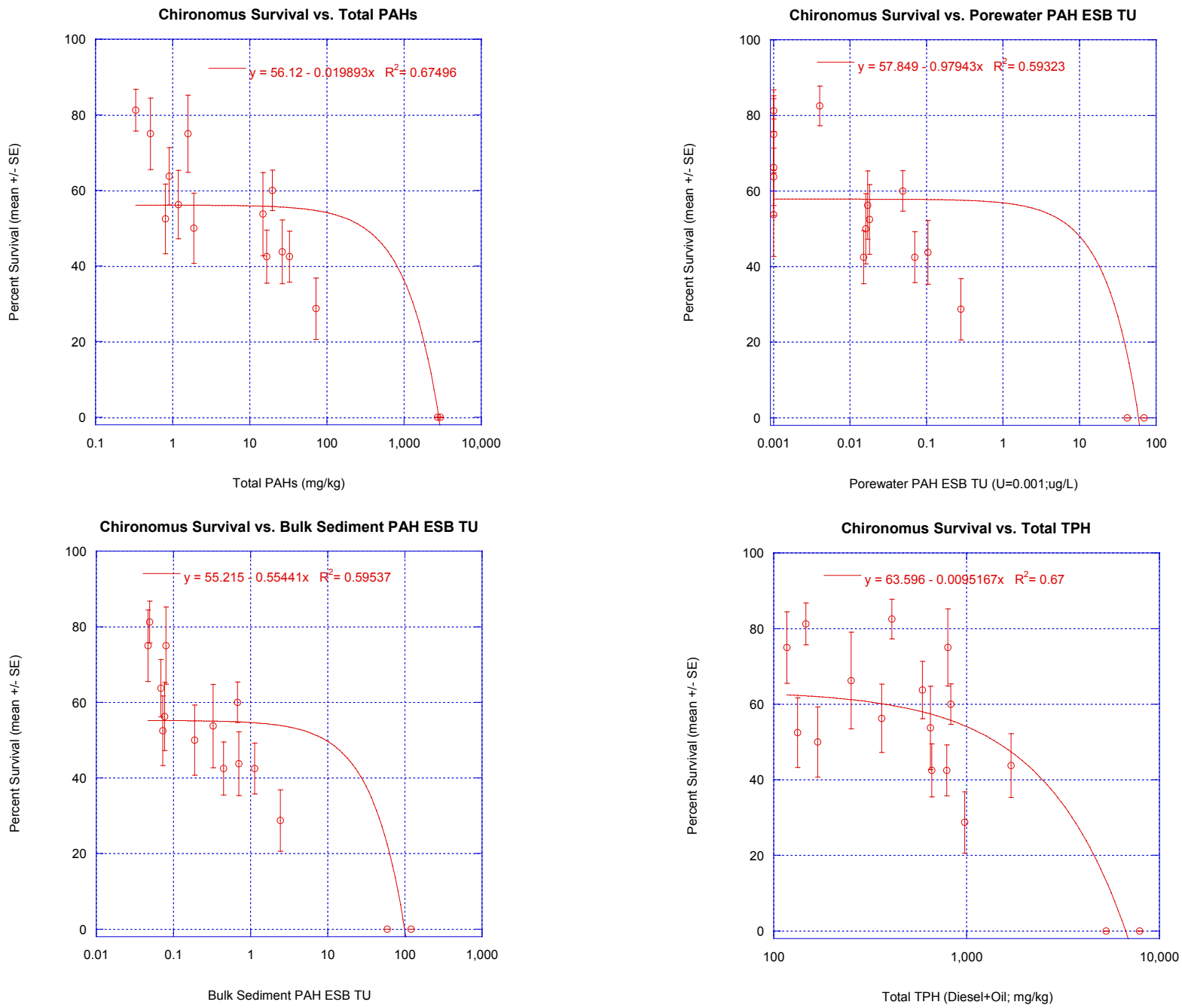

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Figure 7.2-7a

Relationships between Bioassay Survival and Growth and Sediment Chemistry—20-day *Chironomus dilutus* Test

Final Remedial Investigation, Quendall Terminals

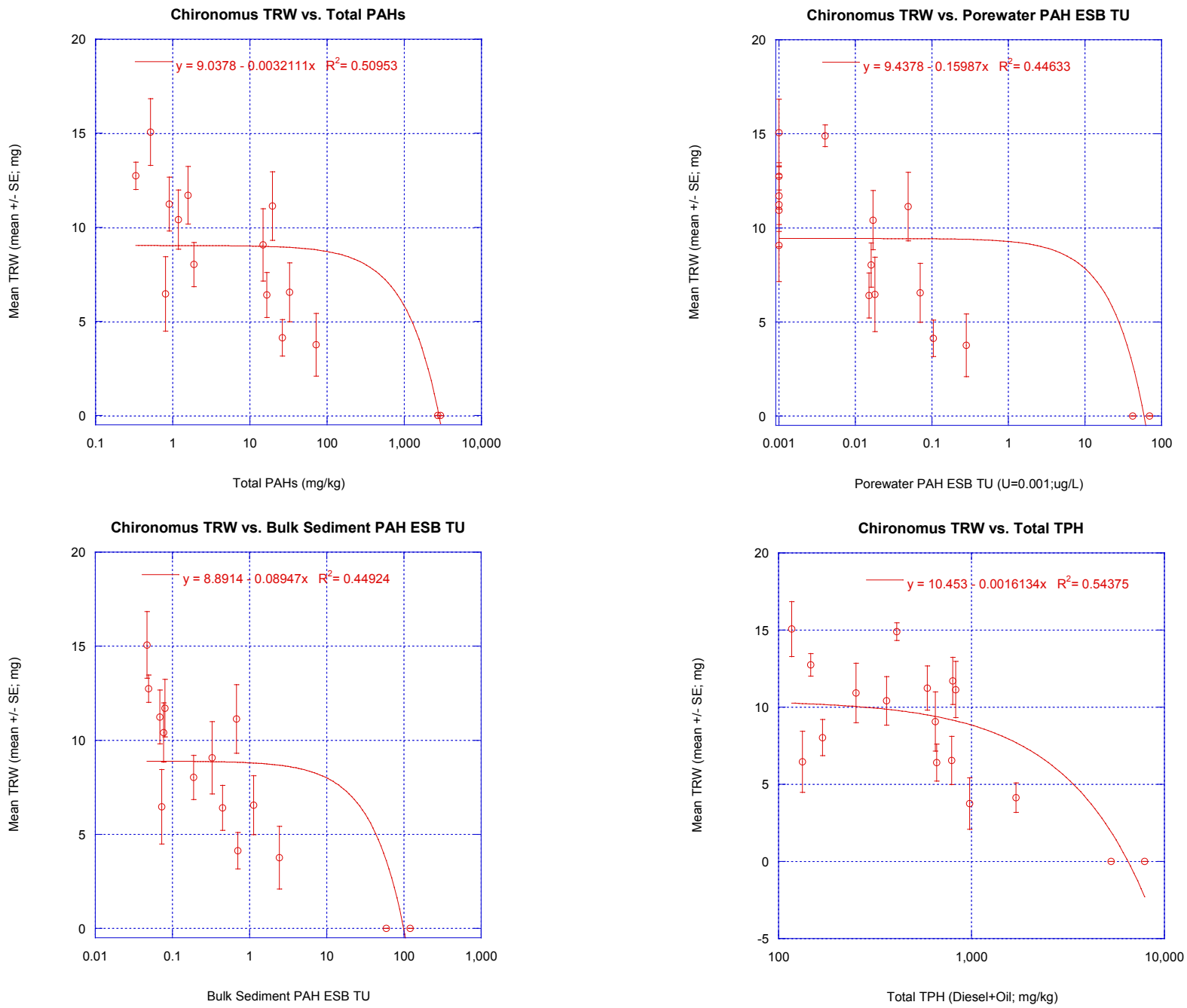

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Figure 7.2-7b

Relationships between Bioassay Survival and Growth and Sediment Chemistry—20-day *Chironomus dilutus* Test

Final Remedial Investigation, Quendall Terminals

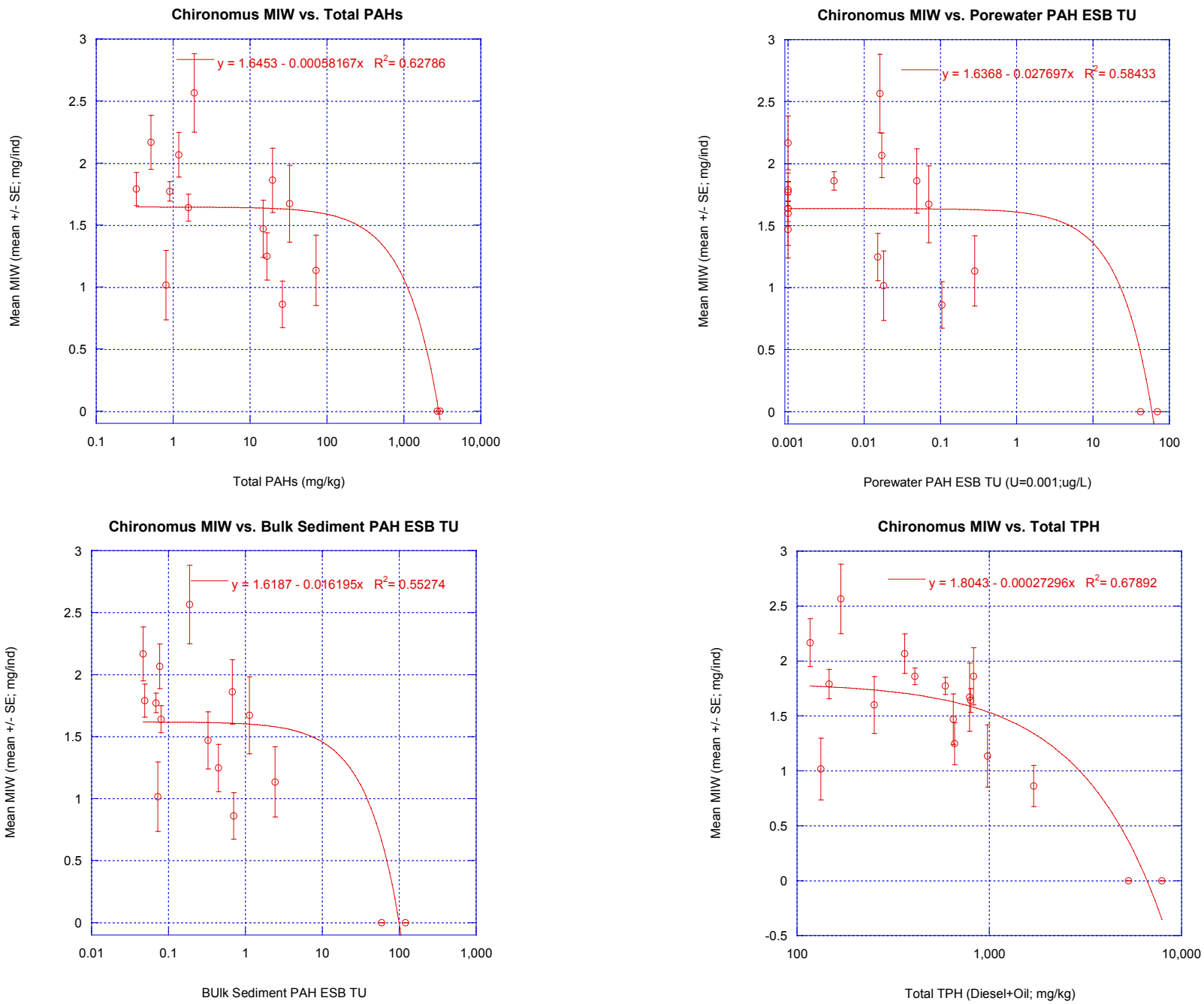
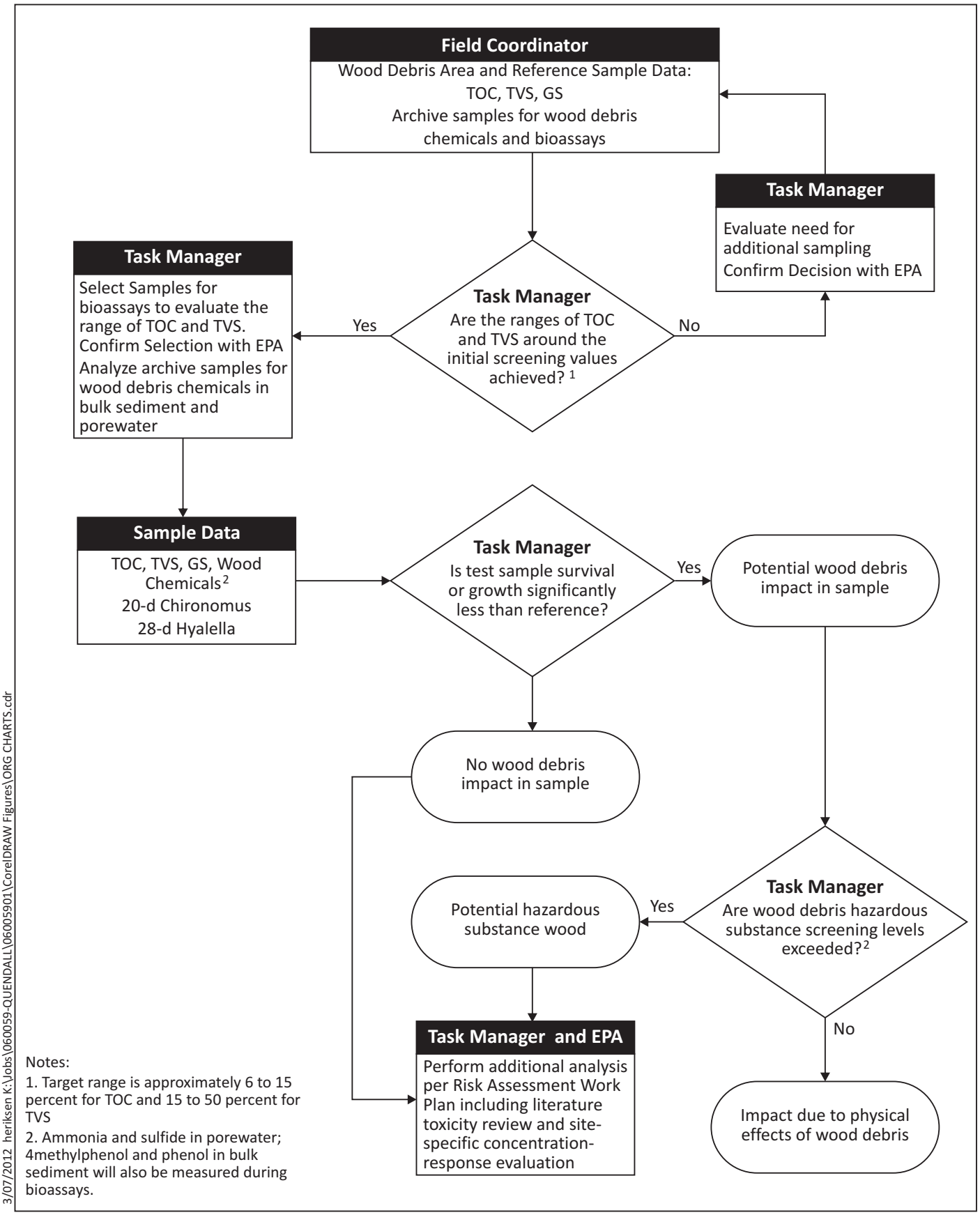


Figure 7.2-7c

Relationships between Bioassay Survival and Growth and Sediment Chemistry—20-day *Chironomus dilutus* Test

Final Remedial Investigation, Quendall Terminals



Notes:
1. Target range is approximately 6 to 15 percent for TOC and 15 to 50 percent for TVS
2. Ammonia and sulfide in porewater; 4methylphenol and phenol in bulk sediment will also be measured during bioassays.

3/07/2012 heriksen K:\Jobs\060059-QUENDALL\06005901\CorelDRAW Figures\ORG CHARTS.cdr

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Figure 7.2-8
Communication and Decision Matrix - Wood Debris Bioassay and Toxicity Evaluation
Final Remedial Investigation, Quendall Terminals

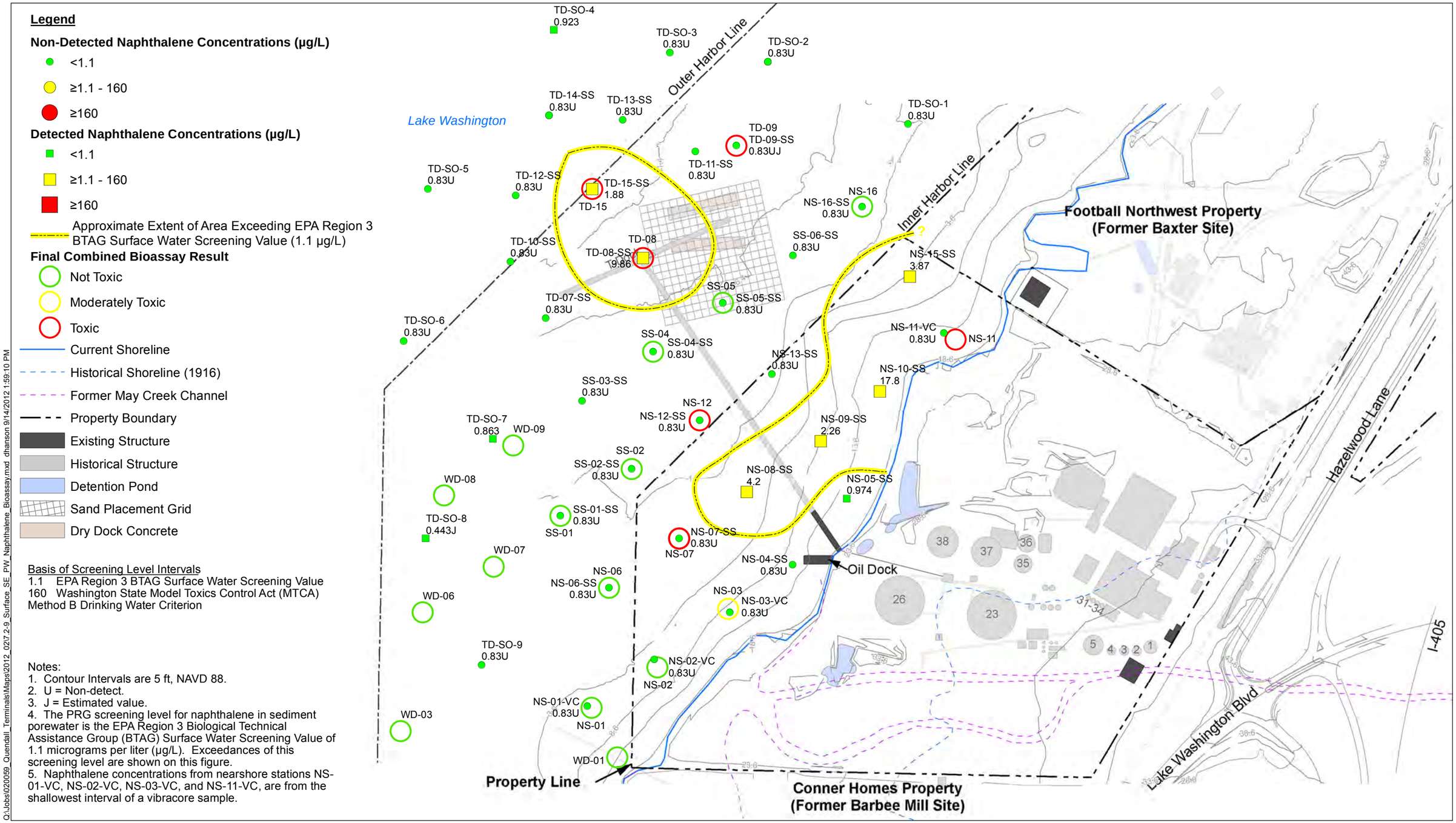

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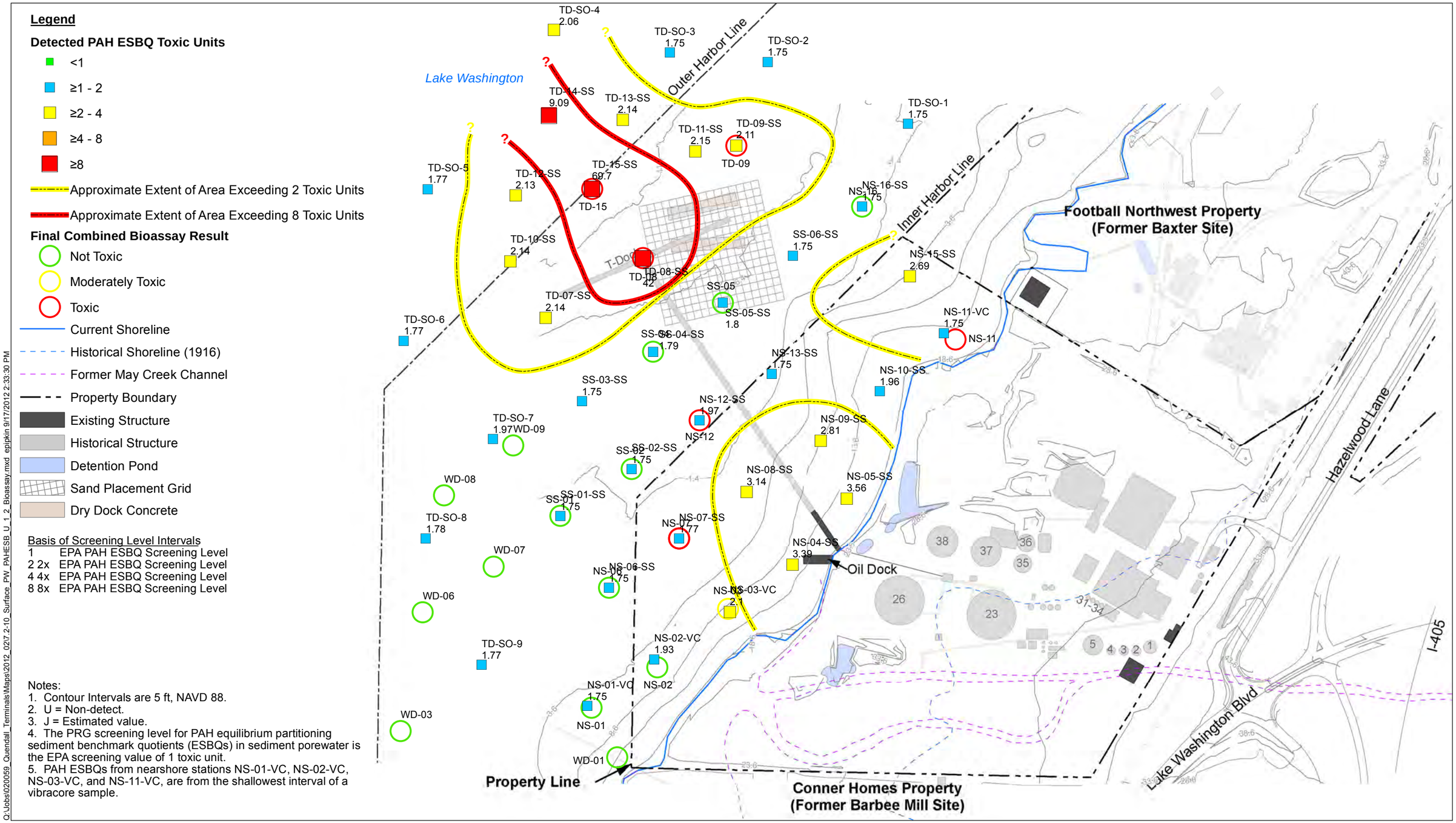
Figure 7.2-9
Surface Sediment Porewater Naphthalene Concentrations and Bioassay Results
Final Remedial Investigation, Quendall Terminals



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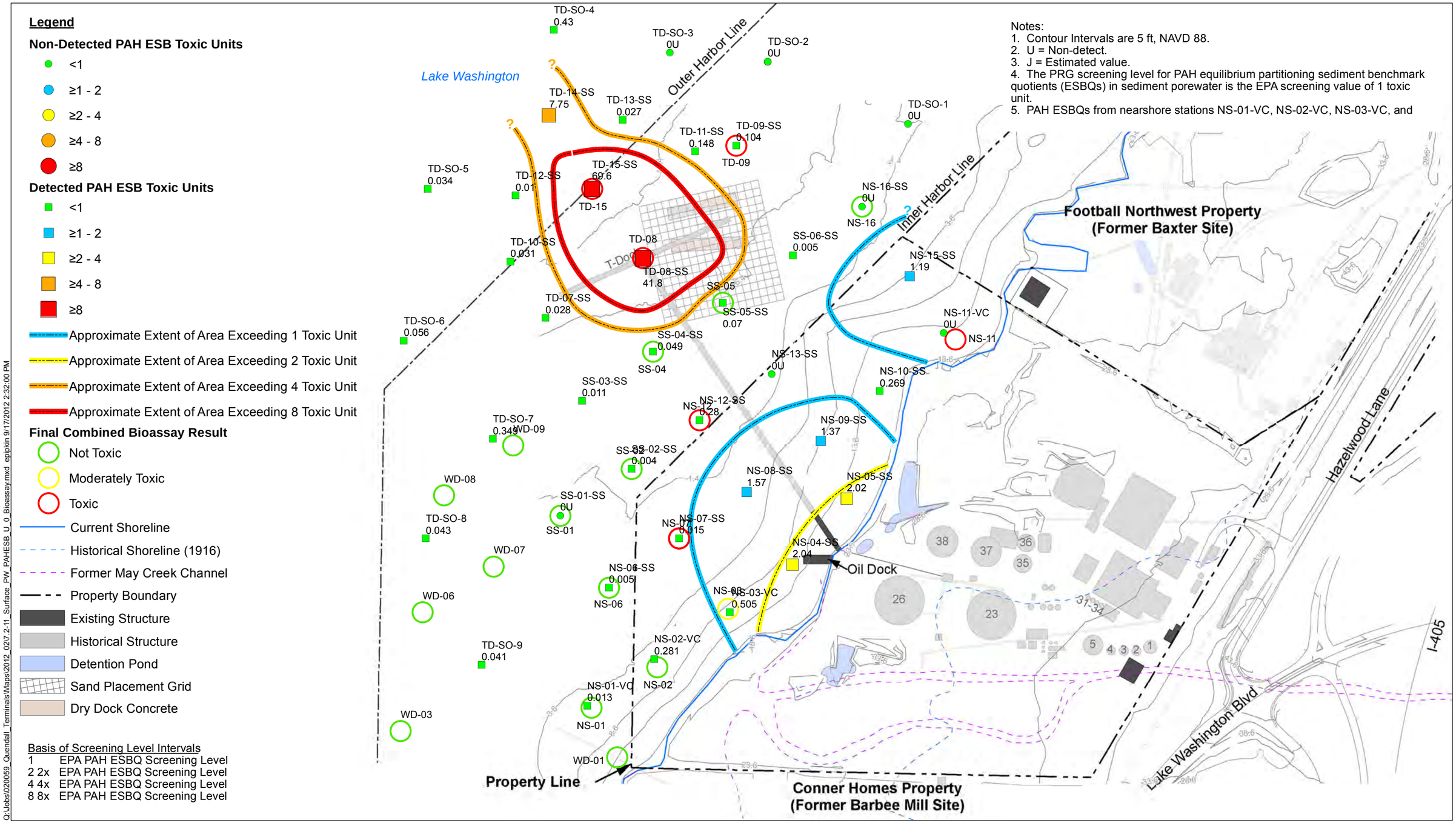
Feet
0 100 200 300 400

Figure 7.2-10
Surface Sediment Porewater PAH ESBQ (U = 1/2) and Bioassay Results
Final Remedial Investigation, Quendall Terminals



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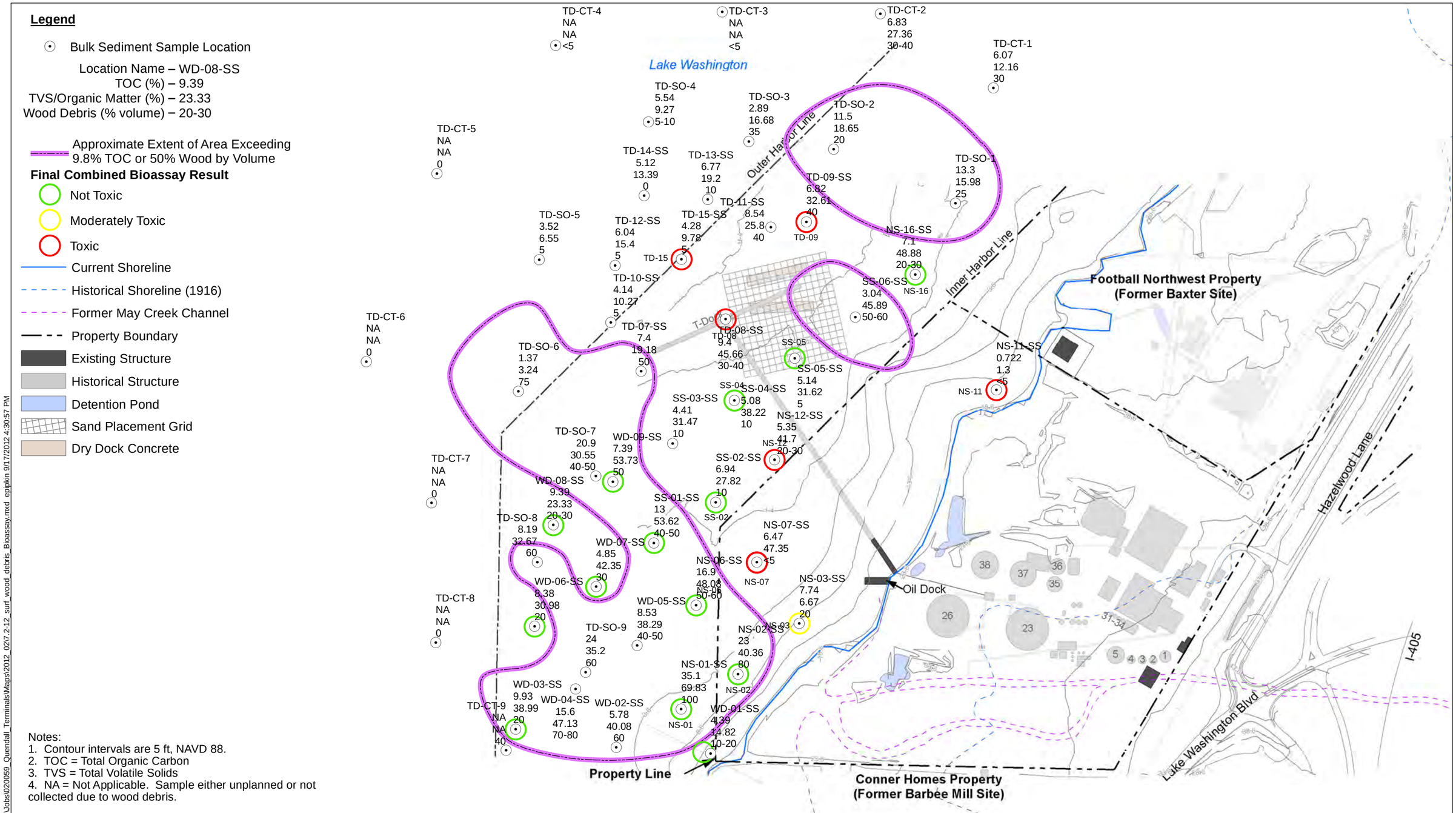
Feet
0 100 200 300 400

Figure 7.2-11
Surface Sediment Porewater PAH ESBQ (U = 0) and Bioassay Results
Final Remedial Investigation, Quendall Terminals



Notes:
1. Contour intervals are 5 ft, NAVD 88.
2. TOC = Total Organic Carbon
3. TVS = Total Volatile Solids
4. NA = Not Applicable. Sample either unplanned or not collected due to wood debris.

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Feet
0 110 220 330 440

Figure 7.2-12
Wood Debris and Surface Bulk Sediment Indicator Parameters (TOC, TVS, and Percent Wood by Volume) and Bioassay Results
Final Remedial Investigation, Quendall Terminals

FINAL REMEDIAL INVESTIGATION REPORT QUENDALL TERMINALS SITE, RENTON, WASHINGTON

Volume III:
Tables

Prepared for
U.S. Environmental Protection Agency, Region 10

On behalf of
Altino Properties, Inc. and
J.H. Baxter & Co.

Prepared by
Anchor QEA, LLC and
Aspect Consulting, LLC
Incorporates revisions provided by EPA Region 10

September 2012

Table 2.1-1
Primary Constituents of Creosote and Coal Tar

	Creosote		Coal Tar		Aqueous Solubility of Pure Compound (mg/L)
	% Commercial Creosote (EPA 1990)	% U.S. Creosote (USDA 1980)	% Coal Tar (GRI 1987)	% U.S. Coal Tar (USDA 1980)	
Volatile Aromatics					
Benzene			0.1%	0.12%	1,780
Toluene				0.02%	152
Ethylbenzene			0.2%	0.25%	515
Xylenes			1.0%	0.14%	200
Styrene				0.02%	300
Base/Neutrals					
Naphthalene	17.0%	3.0%	10.9%	8.8%	32
Methylnapthalenes	10.0%	2.1%	2.4%	1.9%	25
Dimethylnaphtalenes			3.3%		2
Biphenyl	1.9%	0.8%			7
Acenaphthene	7.8%	9.0%	1.3%	1.06%	3
Fluorene	6.0%	10.0%	1.6%	0.84%	2
Phenanthrene	19.4%	21.0%	4.0%	2.66%	1
Anthracene	2.5%	2.0%	1.1%	0.75%	0.07
Fluoranthene	11.8%	10.0%			0.3
Pyrene	8.4%	8.5%			0.1
Chrysene	4.2%	3.0%			0.002
Methylanthracene		4.0%			0.04
Acid Extractables					
Phenol			0.7%	0.61%	82,000
Cresols			1.1%	0.97%	24,000
Xylenols			0.2%	0.36%	5,000
N,S,O-Heterocyclics					
Carbazole	5.1%	2.0%	1.1%	0.60%	1
Pitch (See Note 1)			62%	63.5%	

Notes:

1. Pitch is a general term for the mixture of very-low-solubility, high-molecular-weight hydrocarbons.
2. Data as tabulated by Cohen and Mercer (1993). Original references as follows:

U.S. Environmental Protection Agency (EPA), 1990. Approaches for Remediation of Uncontrolled Wood Preserving Sites. EPA/625/7-90/011.

U.S. Department of Agriculture (USDA), 1980. The biologic and economic assessment of pentachlorophenol, inorganic arsenicals, creosote, Volume I: Wood preservatives. USDA Technical Bulletin 1658-I.

Gas Research Institute (GRI), 1987. Management of Manufactured Gas Plant Sites. RI-87/0260.

Table 2.3-1
Summary of Historical Quendall Site Investigations

Consultant/ Agency	Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals Analyzed For	Reference	Data Quality	Data Used in the Remedial Investigation?
Metro	1963	SO	7 borings	NA	NA	Metro 1963	QA0	No; data too old
Twelker & Associates	1971	SO, SE	15 upland and 15 offshore borings	8 soil, 11 sediment	Total aromatic hydrocarbons	Twelker 1973	QA0	No; data too old
CH2M HILL	1979	WS	3 in-lake stations	3 sampling events, 9 samples	Oil & grease, fecal coliforms, conventionals	CH2M HILL 1979	QA0	No; data too old
U.S. Environmental Protection Agency (EPA)	1983	SE	10 sediment cores	17 subsurface sediment samples	PAHs	EPA 1983	QA0	No; data too old
Woodward Clyde	1983	SO	4 trenches, 18 borings (12 completed as wells)	121 subsurface, 13 surface	PAH screening, VOC screening, VOCs, SVOCs, pesticides	Woodward Clyde 1983	QA0	No; data too old
Woodward Clyde	1983	WG	(Existing wells)	12 upland wells	pH, conventionals, VOCs, SVOCs	Woodward Clyde 1983	QA0	No; data too old
Woodward Clyde	1989	WG	(Existing wells)	3 quarters of sampling 11 upland wells	pH, conventionals, metals, VOCs, SVOCs	Woodward Clyde 1990	QA0	No; data too old
Woodward Clyde	1990	WG	(Existing wells)	10 upland wells	pH, conventionals, metals, SVOCs, VOCs	Woodward Clyde 1991a	QA0	No; data too old

Table 2.3-1
Summary of Historical Quendall Site Investigations

Consultant/ Agency	Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals Analyzed For	Reference	Data Quality	Data Used in the Remedial Investigation?
Washington Department of Ecology	1990/ 1991	SE	11 in-lake stations	22 surface samples, 11 per event	Conventionals, PAHs, SVOCs, bioassays	Ecology 1991 and 1992	QA0	No; data too old
Woodward Clyde	1990	SO	6 well borings	9 subsurface	SVOCs	Woodward Clyde 1991a	QA0	No; data too old
Woodward Clyde	1991	WG	(Existing wells)	6 upland wells	VOCs, SVOCs	Woodward Clyde 1991b	QA0	No; data too old
Hart Crowser	1995	SO	10 test pits/ 8 borings/ 1 well boring	42 subsurface	pH, TOC, TPH, metals, pesticides/PCBs, SVOCs, VOCs	Hart Crowser 1997	QA1, QA1-	Yes
Hart Crowser	1996	WG	1 upland groundwater well/ 6 in-lake temporary wellpoints	15 existing upland groundwater wells/ 6 in-lake temporary wellpoints	Metals, SVOCs, VOCs	Hart Crowser 1997	QA1, QA1-	Yes
Hart Crowser	1996	WS	6 in-lake stations	6 near lake bottom	Conventionals, metals, SVOCs, VOCs	Hart Crowser 1997	QA1, QA1-	Yes
Retec	1996	SE	53 grab samples	53 surface/ 7 subsurface	Conventionals, metals, SVOCs, VOCs	Retec 1997a	QA1-	Yes
Retec	1997	SE	23 vibracore samples/5 grab samples	11 surface/ 43 subsurface	Conventionals, metals, SVOCs, VOCs, bioassays	Retec 1997b	QA1-	Yes

Table 2.3-1
Summary of Historical Quendall Site Investigations

Consultant/ Agency	Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals Analyzed For	Reference	Data Quality	Data Used in the Remedial Investigation?
Shannon & Wilson	1997	SO	5 borings	NA	NA	Shannon & Wilson 1997	NA	Yes; boring logs only
Exponent	2000	SE	12 grab samples	12 surface	Conventionals, bioassays details)	Exponent 2001	QA2	Yes
Retec	2001	SO	23 geoprobe	9 subsurface	VOCs, SVOCs	Retec 2002	QA1, QA1-	Yes
Retec	2001	WG	19 in-lake permanent wellpoint	19 existing upland groundwater wells/19 in-lake permanent wellpoints/9 geoprobes	VOCs, SVOCs	Retec 2002	QA1, QA1-	Yes
Retec	2001	PW	5 vibracore	5 subsurface vibracore samples	VOCs, SVOCs	Retec 2002	QA1-	Yes
Anchor	2002	WG	(Existing wellpoints)	5 permanent wellpoints (subset of Retec 2001 wellpoints)	Conventionals, PAHs, VOCs	Anchor and Aspect 2004	QA2	Yes
Anchor	2002	SE	5 grab samples	5 surface	Conventionals, PAHs, VOCs	Anchor and Aspect 2004	QA2	Yes

Table 2.3-1
Summary of Historical Quendall Site Investigations

Consultant/ Agency	Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals Analyzed For	Reference	Data Quality	Data Used in the Remedial Investigation?
Anchor	2002	PW	5 grab samples	5 surface	Conventionals, PAHs, VOCs	Anchor and Aspect 2004	QA2	Yes
Anchor	2003	WG	(Existing wellpoints)	5 permanent wellpoints (subset of Retec 2001 wellpoints)	Conventionals, PAHs, VOCs	Anchor and Aspect 2004	QA2	Yes
Anchor	2003	PW	5 grab samples	5 surface	Conventionals, PAHs, VOCs	Anchor and Aspect 2004	QA2	Yes
Aspect	2003	WG	(Existing wells)	2 existing deep aquifer groundwater wells	Conventionals, metals, SVOCs, VOCs	Anchor and Aspect 2004	QA1, QA1-	Yes
Anchor	2003	WS	1 in-lake station	1 near lake bottom corresponding with wellpoint 19A	PAHs, VOCs	Anchor and Aspect 2004	NA	No
Anchor	2003	SE	3 grab samples	1 surface, 9 radiochemistry	Conventionals, PAHs, radiochemistry	Anchor and Aspect 2004	QA2, QA1	Yes
Anchor	2004	SE	6 grab samples	6 surface	Conventionals, bioassays	Anchor and Aspect 2004	QA1, QA1+	Yes

Table 2.3-1
Summary of Historical Quendall Site Investigations

Consultant/ Agency	Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals Analyzed For	Reference	Data Quality	Data Used in the Remedial Investigation?
Aspect	2004	SO	11 surface	11 surface	SVOCs and VOCs	Anchor and Aspect 2004	QA2	Yes

Matrix Definitions:
SO soil
SE sediment
WS surface water
WG groundwater
PW porewater

Chemicals:
PAHs polynuclear aromatic hydrocarbons
PCBs polychlorinated biphenyls
VOCs volatile organic compounds
SVOCs semivolatile organic compounds
TPH total petroleum hydrocarbons
TOC total organic carbon

Data Quality:
QA2 Assigned to data where full documentation was available and an independent third party performed a full validation.

QA1 Assigned to data where information such as method blanks, surrogates, or other quality control summary data were available and reviewed. QA1- or QA1+ are used to indicate that certain non-critical data quality indicators were either missing (QA1-) or available (QA1+).

QA0 Assigned to data that because of age, analytical method, or lack of complete laboratory report documentation, were determined to have too much uncertainty for use in determining boundaries of contamination or risk assessment exposure conditions.

NA Not available; not carried forward from Task 2—Summary of Existing Information and Data Quality Report (Anchor and Aspect 2007a).

Table 2.5-1
Site-Specific Contaminants of Interest and Indicator Chemicals

Chemical	Environmental Medium at the Quendall Site			
	Groundwater	Soil	Bulk Sediment	Sediment Porewater/ Surface Water
Metals				
Arsenic	X	X		
Cadmium				
Chromium (III)[1]	X	X		
Copper	X	X		
Lead				
Nickel				
Iron				
Zinc				
Polynuclear Aromatic Hydrocarbons (PAHs)				
Acenaphthene				
Acenaphthylene				
Anthracene				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(k)fluoranthene				
Chrysene				
Dibenz(a,h)anthracene				
Indeno(1,2,3-c,d)pyrene				
Fluoranthene				
Fluorene				
Naphthalene	X	X	X	X
Phenanthrene				
Pyrene				
2-Methylnaphthalene				
Total cPAH TEQ (minimum 7, CAEPA 2009)	X	X	X	X
Total 10 of 16 HPAHs		X	X	
Total 6 of 16 LPAHs		X	X	
Total PAH ESBQ			X	X
Semivolatiles, Miscellaneous				
Bis(2-Ethylhexyl)phthalate				
Dibenzofuran				
n-Nitroso-diphenylamine				
Semivolatiles, Phenolic				
Phenol			X	
2-Methylphenol				
4-Methylphenol			X	
2,4-Dimethylphenol				
Semivolatiles, Chlorinated				
Total Polychlorinated Biphenyls (PCBs)	X	X		
Pentachlorophenol (PCP)	X	X		

Table 2.5-1
Site-Specific Contaminants of Interest and Indicator Chemicals

Chemical	Environmental Medium at the Quendall Site			
	Groundwater	Soil	Bulk Sediment	Sediment Porewater/ Surface Water
Volatiles, Aromatic and Halogenated				
Benzene	X	X		X
Ethylbenzene				
Toluene				
Dichloromethane				
Carbon Disulfide				
Xylenes				
Styrene				
Methylene Chloride				
Chloroform				
Other				
Total Organic Carbon			X	

Notes:

Indicator chemicals are shaded.

The media associated with each indicator chemical are denoted with an "X".

[1] Soil conditions at the site are characterized by high organic content, supporting a reducing environment, and neutral pH. Because the oxidizing environment required to maintain chromium (VI) is not present at the site, chromium (VI) was not retained as a contaminant of interest.

CAEPA - California Environmental Protection Agency
cPAH - carcinogenic PAH(s) (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h] anthracene, and indeno [1,2,3-c,d]pyrene)

ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient
HPAHs - high-molecular-weight PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3,-c,d]pyrene, fluoranthene, and pyrene)

LPAHs - low-molecular-weight PAHs (acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene)
TEQ - toxicity equivalency quotient

Table 3.1-1
Summary of Groundwater Elevation Measurements

Well ID		BAX-9		BH-1		BH-2		BH-2A		BH-5		BH-5A		BH-5B		BH-6		BH-8	
Date of Installation		12/14/1988		5/17/1983		5/17/1983		5/17/1983		5/20/1983		5/20/1983		8/6/2009		5/20/1983		5/19/1983	
	Reference	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet
Top of Casing	--	--	27	--	27.02	--	29.07	--	28.66	--	29.24	--	27.88	--	27.96	--	25.45	--	28.72
Ground Level	--	--	25.5	--	27	--	24.4	--	24.4	--	26.9	--	26.9	--	25.29	--	23.6	--	27
Top of Sandpack	--	4	21.5	--	--	--	--	3	21.4	--	--	4	22.9	38	-12.71	--	--	--	--
Top of Screen	--	5	20.5	5	22	5	19.4	5	19.4	13	13.9	5	21.9	40	-14.71	8	15.6	13	14
Bottom of Screen	--	15	10.5	19.5	7.5	19.5	4.9	20	4.4	23	3.9	10	16.9	49.63	-24.34	18	5.6	23	4
Bottom of Well	--	18.5	7	19.5	7.5	19.5	4.9	20	4.4	23	3.9	10	16.9	49.63	-24.34	19.5	4.1	24.5	2.5
Measurement Date																			
6/8/1983	Woodward Clyde 1983	--	--	5.8	21.22	7.4	21.67	7.17	21.49	9.36	19.88	7.1	20.78	--	--	4.67	20.78	6.37	22.35
6/27/1983	Woodward Clyde 1983	--	--	6.11	20.91	7.53	21.54	7.16	21.5	9.51	19.73	7.81	20.07	--	--	4.84	20.61	6.4	22.32
1/12 - 1/16/89	Woodward Clyde 1990	6.45	20.55	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/7/1989	Woodward Clyde 1990	6.79	20.21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/12/1989	Woodward Clyde 1990	6.06	20.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/31 - 6/7/89	Woodward Clyde 1990	5.88	21.12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/14/1989	Woodward Clyde 1990	6.91	20.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11/21 - 11/28/89	Woodward Clyde 1990	6.7	20.3	--	--	--	--	--	--	5.37	23.87	9.71	18.17	--	--	--	--	--	--
1/16/1990	Woodward Clyde 1990	6.4	20.6	--	--	--	--	--	--	5.18	24.06	9.77	18.11	--	--	--	--	--	--
3/12 - 3/16/90	Woodward Clyde 1990	6.48	20.52	--	--	--	--	--	--	--	--	9.67	18.21	--	--	--	--	--	--
4/25/1991	Woodward Clyde 1991a	5.7	21.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/7/1991	Woodward Clyde 1991a	5.81	21.19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/10/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8/30/1995	Hart Crowser 1997	6.74	20.26	--	--	--	--	--	--	10.04	19.2	8.19	19.69	--	--	--	--	--	--
10/12/1995	Hart Crowser 1997	7.17	19.83	--	--	--	--	--	--	10.37	18.87	5.24	22.64	--	--	--	--	--	--
12/14/1995	Hart Crowser 1997	6.02	20.98	--	--	--	--	--	--	8.9	20.34	4.47	23.41	--	--	--	--	--	--
1/15/1996	Hart Crowser 1997	5.76	21.24	--	--	--	--	--	--	9.07	20.17	4.35	23.53	--	--	--	--	--	--
4/5/1996	Hart Crowser 1997	5.95	21.05	--	--	--	--	--	--	9.27	19.97	4.97	22.91	--	--	--	--	--	--
5/16/1996	Hart Crowser 1997	5.46	21.54	--	--	--	--	--	--	8.82	20.42	4.98	22.9	--	--	--	--	--	--
6/11/1996	Hart Crowser 1997	5.84	21.16	--	--	--	--	--	--	9.04	20.2	5.62	22.26	--	--	--	--	--	--
1/18/2001	Anchor and Aspect 2004	6.46	20.54		--	--	--	--	--	9.87	19.37	5.2	22.68	--	--	--	--	--	--
8/21/2003	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/9/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/16/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/24/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/8/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/13/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/3/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	10.51	18.73	--	--	--	--	--	--	--	--
9/22/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	10.46	18.78	--	--	--	--	--	--	--	--
10/14/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	10.38	18.86	--	--	--	--	--	--	--	--
11/11/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	10.36	18.88	--	--	--	--	--	--	--	--
12/20/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	9.81	19.43	--	--	--	--	--	--	--	--
1/5/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	10.19	19.05	--	--	--	--	--	--	--	--
1/21/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	9.31	19.93	--	--	--	--	--	--	--	--
2/8/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	9.92	19.32	--	--	--	--	--	--	--	--
2/25/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	10.07	19.17	--	--	--	--	--	--	--	--
3/10/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	10.2	19.04	--	--	--	--	--	--	--	--
5/17/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/11/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	9.68	19.56	--	--	--	--	--	--	--	--
6/7/2007	Aspect Field Forms	--	--	--	--	--	--	--	--	9.66	19.58	6.51	21.37	--	--	--	--	--	--
11/13 - 11/20/2008	Aspect Field Forms	--	--	--	--	--	--	--	--		29.24	5.85	22.03	--	--	--	--	--	--
9/9/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	10.75	18.49	8.77	19.11	8.77	19.19	--	--	--	--
10/28/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 3.1-1
Summary of Groundwater Elevation Measurements

Well ID		BH-8A		BH-10		BH-12		BH-12A		BH-15		BH-17A		BH-17B		BH-18A		BH-18B	
Date of Installation		5/19/1983		5/18/1983		5/17/1983				5/17/1983		12/22/1988		12/22/1988		12/14/1988		12/14/1988	
	Reference	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet
Top of Casing	--	--	27.24	--	26.1	--	27.99	--	25.01	--	25.3	--	32.81	--	32.76	--	22.72	--	23.04
Ground Level	--	--	27	--	25.1	--	25.5	--	25.5	--	25.5	--	31.3	--	31.3	--	23.72	--	21.5
Top of Sandpack	--	4.5	22.5	--	--	--	--	4.5	21	--	--	4	27.3	36	-4.7	3	20.72	40	-18.5
Top of Screen	--	5	22	5	20.1	13	12.5	5	20.5	5	20.5	6	25.3	38	-6.7	4	19.72	42	-20.5
Bottom of Screen	--	10	17	19.5	5.6	23	2.5	10	15.5	19.5	6	16	15.3	48	-16.7	14	9.72	52	-30.5
Bottom of Well	--	10	17	19.5	5.6	23	2.5	10	15.5	19.5	6	16	15.3	50	-18.7	14	9.72	54	-32.5
Measurement Date																			
6/8/1983	Woodward Clyde 1983	4.54	22.7	6.65	19.45	7.5	20.49	5.11	19.9	5.5	19.8	--	--	--	--	--	--	--	--
6/27/1983	Woodward Clyde 1983	4.72	22.52	6.59	19.51	7.56	20.43	5.11	19.9	5.55	19.75	--	--	--	--	--	--	--	--
1/12 - 1/16/89	Woodward Clyde 1990	--	--	--	--	5.35	22.64	--	--	--	--	9.72	23.09	11.31	21.45	2.22	20.5	3.06	19.98
2/7/1989	Woodward Clyde 1990	--	--	--	--	5.76	22.23	--	--	--	--	9.13	23.68	11.61	21.15	3.18	19.54	3.22	19.82
4/12/1989	Woodward Clyde 1990	--	--	--	--	5.47	22.52	--	--	--	--	8.02	24.79	10.37	22.39	2.94	19.78	1.98	21.06
5/31 - 6/7/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	9.17	23.64	10.21	22.55	2.91	19.81	1.74	21.3
9/14/1989	Woodward Clyde 1990	--	--	--	--	8.89	19.1	--	--	--	--	10.23	22.58	11.67	21.09	4.36	18.36	3.07	19.97
11/21 - 11/28/89	Woodward Clyde 1990	--	--	--	--	6.8	21.19	--	--	--	--	10.03	22.78	11.77	20.99	3.17	19.55	3.23	19.83
1/16/1990	Woodward Clyde 1990	--	--	--	--	4.85	23.14	--	--	--	--	8.75	24.06	11.38	21.38	3.12	19.6	3.03	20.01
3/12 - 3/16/90	Woodward Clyde 1990	--	--	--	--	4.96	23.03	--	--	--	--	8.54	24.27	11.04	21.72	2.67	20.05	2.56	20.48
4/25/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.5	18.22	--	--
5/7/1991	Woodward Clyde 1991a	--	--	--	--	6.43	21.56	--	--	--	--	8.71	24.1	--	--	2.69	20.03	--	--
6/10/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8/30/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	10.21	22.6	11.08	21.68	3.92	18.8	2.45	20.59
10/12/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	10.35	22.46	11.32	21.44	3.09	19.63	2.77	20.27
12/14/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	7.58	25.23	11.15	21.61	1.83	20.89	2.86	20.18
1/15/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	8.23	24.58	11.22	21.54	1.75	20.97	2.88	20.16
4/5/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	8.93	23.88	10.61	22.15	1.97	20.75	2.09	20.95
5/16/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	8.63	24.18	10.19	22.57	1.66	21.06	1.62	21.42
6/11/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	9.04	23.77	10.32	22.44	2.98	19.74	1.71	21.33
1/18/2001	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.92	19.8	3.25	19.79
8/21/2003	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/9/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/16/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/24/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/8/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/13/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/3/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/22/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10/14/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11/11/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12/20/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/5/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/21/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/8/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/25/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/10/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/17/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/11/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/7/2007	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.49	19.23	2.04	21
11/13 - 11/20/2008	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.07	19.65	3.1	19.94
9/9/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.25	17.47	3	20.04
10/28/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 3.1-1
Summary of Groundwater Elevation Measurements

Well ID		BH-19		BH-19B		BH-20A		BH-20B		BH-20C		BH-21A		BH-21B		BH-22		BH-23	
Date of Installation		12/19/1988		12/4/2000		12/20/1988		12/20/1988		12/20/1988		12/27/1988		12/27/1988		12/6/1988		12/28/1988	
	Reference	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet
Top of Casing	--	--	26.23	--	27.3	--	27	--	26.48	--	27.35	--	26.16	--	25.88	--	31.69	--	28.11
Ground Level	--	--	24.7	--	24.6	--	25.5	--	25	--	25.1	--	24.7	--	24.4	--	30.2	--	26.6
Top of Sandpack	--	3	21.7	38	-13.4	4	21.5	37	-12	111	-85.9	7	17.7	39	-14.6	13	17.2	4	22.6
Top of Screen	--	5	19.7	40	-15.4	7	18.5	39	-14	113	-87.9	9	15.7	41.5	-17.1	15	15.2	6	20.6
Bottom of Screen	--	15	9.7	50	-25.4	22	3.5	49	-24	120.35	-95.25	19	5.7	51.5	-27.1	25	5.2	21.5	5.1
Bottom of Well	--	17	7.7	50.5	-25.9	22.14	3.36	48.13	-23.13	120.35	-95.25	18.41	6.29	50.79	-26.39	24.8	5.4	21.5	5.1
Measurement Date																			
6/8/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/27/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/12 - 1/16/89	Woodward Clyde 1990	7.86	18.37	--	--	8.6	18.4	6.73	19.75	--	--	8.43	17.73	6.56	19.32	7.7	23.99	5.94	22.17
2/7/1989	Woodward Clyde 1990	8.37	17.86	--	--	8.72	18.28	6.9	19.58	--	--	--	--	6.72	19.16	--	--	7.08	21.03
4/12/1989	Woodward Clyde 1990	7.25	18.98	--	--	7.49	19.51	5.65	20.83	--	--	--	--	5.44	20.44	7.09	24.6	--	--
5/31 - 6/7/89	Woodward Clyde 1990	7	19.23	--	--	7.21	19.79	5.5	20.98	--	--	7	19.16	5.2	20.68	8.19	23.5	0	28.11
9/14/1989	Woodward Clyde 1990	8.35	17.88	--	--	8.43	18.57	6.7	19.78	--	--	10.44	15.72	6.45	19.43	9.79	21.9	8.1	20.01
11/21 - 11/28/89	Woodward Clyde 1990	8.08	18.15	--	--	8.61	18.39	6.84	19.64	--	--	8.48	17.68	6.66	19.22	8.99	22.7	7.39	20.72
1/16/1990	Woodward Clyde 1990	8.2	18.03	--	--	8.62	18.38	6.73	19.75	--	--	8.45	17.71	6.61	19.27	7.69	24	6.95	21.16
3/12 - 3/16/90	Woodward Clyde 1990	7.59	18.64	--	--	8.39	18.61	6.17	20.31	--	--	--	--	6	19.88	7.39	24.3	5.5	22.61
4/25/1991	Woodward Clyde 1991a	7.1	19.13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/7/1991	Woodward Clyde 1991a	6.98	19.25	--	--	7.23	19.77	--	--	--	--	--	--	--	--	--	--	6.3	21.81
6/10/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.2	23.49	--	--
8/30/1995	Hart Crowser 1997	7.69	18.54	--	--	7.89	19.11	6.09	20.39	--	--	7.57	18.59	5.88	20	--	--	8	20.11
10/12/1995	Hart Crowser 1997	7.95	18.28	--	--	8.33	18.67	6.43	20.05	--	--	7.92	18.24	6.18	19.7	--	--	8.38	19.73
12/14/1995	Hart Crowser 1997	7.43	18.8	--	--	8.13	18.87	6.56	19.92	--	--	8.05	18.11	6.4	19.48	--	--	5.61	22.5
1/15/1996	Hart Crowser 1997	7.5	18.73	--	--	8.32	18.68	6.58	19.9	--	--	7.98	18.18	6.4	19.48	--	--	5.79	22.32
4/5/1996	Hart Crowser 1997	7.3	18.93	--	--	7.66	19.34	5.75	20.73	--	--	7.29	18.87	5.54	20.34	--	--	6.52	21.59
5/16/1996	Hart Crowser 1997	6.85	19.38	--	--	7.13	19.87	5.27	21.21	--	--	6.81	19.35	5.05	20.83	--	--	6.05	22.06
6/11/1996	Hart Crowser 1997	6.97	19.26	--	--	7.24	19.76	5.39	21.09	--	--	6.88	19.28	5.15	20.73	--	--	6.56	21.55
1/18/2001	Anchor and Aspect 2004	8.22	18.01	7.92	19.38	8.72	18.28	6.94	19.54	--	--	8.49	17.67	6.71	19.17	--	--	6.24	21.87
8/21/2003	Anchor and Aspect 2004	--	--	5.75	21.55	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/9/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.73	18.43	--	--	--	--	--	--
3/16/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.64	18.52	--	--	--	--	--	--
3/24/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.54	18.62	--	--	--	--	--	--
4/8/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.3	18.86	--	--	--	--	--	--
4/13/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.13	19.03	--	--	--	--	--	--
9/3/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	8.01	18.15	--	--	--	--	--	--
9/22/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	7.88	18.28	--	--	--	--	--	--
10/14/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	8.08	18.08	--	--	--	--	--	--
11/11/2004	Aspect Field Forms	--	--	7.93	19.37	--	--	--	--	--	--	8.42	17.74	--	--	--	--	--	--
12/20/2004	Aspect Field Forms	7.9	18.33	8.04	19.26	--	--	--	--	--	--	8.46	17.7	--	--	--	--	--	--
1/5/2005	Aspect Field Forms	8.21	18.02	8.08	19.22	--	--	--	--	--	--	8.51	17.65	--	--	--	--	--	--
1/21/2005	Aspect Field Forms	7.18	19.05	7.9	19.4	--	--	--	--	--	--	8.35	17.81	--	--	--	--	--	--
2/8/2005	Aspect Field Forms	7.96	18.27	8.03	19.27	--	--	--	--	--	--	8.46	17.7	--	--	--	--	--	--
2/25/2005	Aspect Field Forms	8.16	18.07	7.83	19.47	--	--	--	--	--	--	8.39	17.77	--	--	--	--	--	--
3/10/2005	Aspect Field Forms	8.12	18.11	7.69	19.61	--	--	--	--	--	--	8.25	17.91	--	--	--	--	--	--
5/17/2005	Aspect Field Forms	6.68	19.55	6.27	21.03	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/11/2005	Aspect Field Forms	6.82	19.41	6.32	20.98	--	--	--	--	--	--	6.82	19.34	--	--	--	--	--	--
6/7/2007	Aspect Field Forms	7.14	19.09	6.69	20.61	7.62	19.38	5.76	20.72	--	--	7.17	18.99	5.49	20.39	8.63	23.06	7.43	20.68
11/13 - 11/20/2008	Aspect Field Forms	8.05	18.18	7.7	19.6	8.41	18.59	6.7	19.78	--	--	--	--	6.47	19.41	8.84	22.85	7.38	20.73
9/9/2009	Aspect Field Forms	8.29	17.94	7.62	19.68	8.26	18.74	6.68	19.8	7.45	19.9	8.11	18.05	6.43	19.45	9.14	22.55	8.99	19.12
10/28/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 3.1-1
Summary of Groundwater Elevation Measurements

Well ID		BH-24		BH-25A		BH-25B		BH-25AR		BH-26A		BH-26B		BH-27		BH-28A		BH-28B	
Date of Installation		7/31/1990		8/6/1990		8/3/1990		7/6/2009		8/9/1990		8/6/1990		8/1/1990		6/15/1995		12/4/2000	
	Reference	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet
Top of Casing	--	--	25.04	--	31.27	--	32.43	--	31.34	--	28.98	--	26.62	--	28.51	--	29.6	--	26.65
Ground Level	--	--	26	--	28	--	28	--	29.23	--	26.18	--	29.23	--	28.01	--	26.67	--	23.85
Top of Sandpack	--	7	19	7	21	23	5	6	23.23	5	21.18	23	6.23	13	15.01	3	23.67	38	-14.15
Top of Screen	--	9	17	9	19	25	3	8	21.23	7	19.18	25	4.23	15	13.01	5	21.67	40	-16.15
Bottom of Screen	--	19	7	19	9	45	-17	18	11.23	12	14.18	36	-6.77	25	3.01	15	11.67	50	-26.15
Bottom of Well	--	19	7	19	9	45	-17	18.8	10.43	12.8	13.38	36	-6.77	25	3.01	16.5	10.17	54	-30.15
Measurement Date																			
6/8/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/27/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/12 - 1/16/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/7/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/12/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/31 - 6/7/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/14/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11/21 - 11/28/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/16/1990	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/12 - 3/16/90	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/25/1991	Woodward Clyde 1991a	--	--	8.53	22.74	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/7/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/10/1991	Woodward Clyde 1991a	4.97	20.07	9.14	22.13	10.98	21.45	--	--	9.84	21.43	5.63	20.99	6.04	22.47	--	--	--	--
8/30/1995	Hart Crowser 1997	5.83	19.21	9.85	21.42	11.59	20.84	--	--	8.42	20.56	6.24	20.38	6.97	21.54	10	19.6	--	--
10/12/1995	Hart Crowser 1997	5.82	19.22	10.31	20.96	11.87	20.56	--	--	8.15	20.83	6.55	20.07	7.28	21.23	10.24	19.36	--	--
12/14/1995	Hart Crowser 1997	4.79	20.25	8.82	22.45	11.88	20.55	--	--	6.48	22.5	6.62	20	4.22	24.29	8.8	20.8	--	--
1/15/1996	Hart Crowser 1997	4.75	20.29	8.74	22.53	11.93	20.5	--	--	6.81	22.17	6.67	19.95	--	--	9.13	20.47	--	--
4/5/1996	Hart Crowser 1997	4.98	20.06	8.83	22.44	11.18	21.25	--	--	7.41	21.57	5.91	20.71	6.04	22.47	--	--	--	--
5/16/1996	Hart Crowser 1997	4.6	20.44	8.57	22.7	10.75	21.68	--	--	6.99	21.99	5.45	21.17	--	--	7.88	21.72	--	--
6/11/1996	Hart Crowser 1997	5.04	20	8.79	22.48	10.88	21.55	--	--	7.54	21.44	5.59	21.03	5.66	22.85	9.03	20.57	--	--
1/18/2001	Anchor and Aspect 2004	4.9	20.14	9.81	21.46	12.34	20.09	--	--	8.44	20.54	7.07	19.55	--	--	9.83	19.77	9.24	17.41
8/21/2003	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.14	18.51
3/9/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/16/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/24/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/8/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/13/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/3/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/22/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10/14/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11/11/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12/20/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/5/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/21/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/8/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/25/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/10/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/17/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/11/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/7/2007	Aspect Field Forms	5.28	19.76	--	--	--	--	--	--	8.19	20.79	5.94	20.68	--	--	9.57	20.03	8.03	18.62
11/13 - 11/20/2008	Aspect Field Forms	5.21	19.83	--	--	--	--	--	--	7.98	21	6.77	19.85	--	--	9.82	19.78	9.05	17.6
9/9/2009	Aspect Field Forms	6.14	18.9	--	--	--	--	10.47	20.87	9.29	19.69	6.88	19.74	--	--	10.92	18.68	8.96	17.69
10/28/2009	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 3.1-1
Summary of Groundwater Elevation Measurements

Well ID		BH-29A		BH-29B		BH-30A [1]		BH-30C		RW-QP-1		RW-NS-1		SG-1 (Quendall Pond)		SG-2 (Lake Wash.)		SG-3	
Date of Installation		7/8/2009		7/8/2009		10/23/2009		10/23/2009		11/13/2003		11/14/2003							
	Reference	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet	Depth in Feet	Elevation in Feet
Top of Casing	--	--	27.5	--	27.66	--	32.94	--	30.47	--	21.56	--	27.2	--	17.72	--	17.35	--	21.91
Ground Level	--	--	24.8	--	25.09	--	30.71	--	30.71	--	21.6	--	26	--	--	--	--	--	--
Top of Sandpack	--	6.5	18.3	38	-12.91	8	22.71	83	-52.29	4	17.6	4.5	21.5	--	--	--	--	--	--
Top of Screen	--	8.5	16.3	39	-13.91	10	20.71	85	-54.29	6.5	15.1	6.5	19.5	--	--	--	--	--	--
Bottom of Screen	--	18.5	6.3	49.6	-24.51	20	10.71	95	-64.29	16.5	5.1	16.5	9.5	--	--	--	--	--	--
Bottom of Well	--	18.55	6.25	49.43	-24.34	20.1	10.61	97.27	-66.56	16.5	5.1	16.5	9.5	--	--	--	--	--	--
Measurement Date																			
6/8/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/27/1983	Woodward Clyde 1983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/12 - 1/16/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2/7/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/12/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/31 - 6/7/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9/14/1989	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11/21 - 11/28/89	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/16/1990	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/12 - 3/16/90	Woodward Clyde 1990	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4/25/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5/7/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/10/1991	Woodward Clyde 1991a	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8/30/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	1.86	15.86	0.72	18.07	dry	
10/12/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	2.22	15.5	0.34	17.69	1.41	20.5
12/14/1995	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	5.16	12.56	-0.6	16.75	2.68	19.23
1/15/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	5.2	12.52	-0.35	17	2.58	19.33
4/5/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	3.84	13.88	0.9	18.25	3.3	18.61
5/16/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	4.2	13.52	1.41	18.76	2.4	19.51
6/11/1996	Hart Crowser 1997	--	--	--	--	--	--	--	--	--	--	--	--	3.9	13.82	1.41	18.76	2.09	19.82
1/18/2001	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8/21/2003	Anchor and Aspect 2004	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/9/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.43	18.13	--	--	--	--	--	--	--	--
3/16/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.33	18.23	5.44	21.76	--	--	--	--	--	--
3/24/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.06	18.5	--	--	--	--	--	--	--	--
4/8/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	2.9	18.66	--	--	--	--	--	--	--	--
4/13/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	2.62	18.94	5.95	21.25	--	--	--	--	--	--
9/3/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.49	18.07	8.02	19.18	--	--	--	--	--	--
9/22/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.42	18.14	--	--	--	--	--	--	--	--
10/14/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.53	18.03	--	--	--	--	--	--	--	--
11/11/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	3.93	17.63	--	--	--	--	--	--	--	--
12/20/2004	Aspect Field Forms	--	--	--	--	--	--	--	--	4.1	17.46	5.63	21.57	--	--	--	--	--	--
1/5/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	4.15	17.41	6.2	21	--	--	--	--	--	--
1/21/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	3.93	17.63	4.36	22.84	--	--	--	--	--	--
2/8/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	4.07	17.49	5.67	21.53	--	--	--	--	--	--
2/25/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	3.79	17.77	6.42	20.78	--	--	--	--	--	--
3/10/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	3.81	17.75	6.76	20.44	--	--	--	--	--	--
5/17/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6/11/2005	Aspect Field Forms	--	--	--	--	--	--	--	--	2.33	19.23	--	--	--	--	--	--	--	--
6/7/2007	Aspect Field Forms	--	--	--	--	--	--	--	--	2.67	18.89	6.87	20.64	--	--	--	--	--	--
11/13 - 11/20/2008	Aspect Field Forms	--	--	--	--	--	--	--	--	--	--	6.94	20.64	--	--	--	--	--	--
9/9/2009	Aspect Field Forms	9.65	17.85	8.59	19.07	--	--	--	--	3.67	17.89	8.09	20.64	--	--	--	--	--	--
10/28/2009	Aspect Field Forms	--	--	--	--	7.99	24.95	11.85	18.62	--	--	--	--	--	--	--	--	--	--

Table 3.1-2
Hydraulic Conductivity Estimates

Upland Soil and Subsurface Sediment Based on Aquifer Testing

Test Location	Hydraulic Conductivity in cm/sec	Type of Test	Depth of Screened Interval in Feet	Type of Soil in Screened Interval
BAX-9	0.011	Pumping test	5 to 15	Silty Sand with Silt and Clay Layer
BH-2A	0.00038	Pumping test	5 to 20	Silty Sand with Peat Interbeds
BH-6	0.0031	Pumping test	8 to 18	Silty Sand and Silty Clay with Peat
BH-8	0.00013	Pumping test	13 to 23	Silty Clay with Layer of Silty Sand
BH-10	0.0012	Pumping test	5 to 20	Silty Clay with Layer of Clayey Silt
BH-12	0.00076	Slug test	13 to 23	Sandy/Clayey Silt and Very Silty Sand
BH-15	0.0017	Pumping test	5 to 19.5	Silty Sand
BH-17A	0.00006	Slug test	6 to 16	Sand to V. Silty Sand with Layer of Silt
BH-18A	0.0002	Slug test	4 to 14	Silt
BH-18B	0.02	Slug test	42 to 52	Sandy Gravel
BH-19	0.006	Slug test	5 to 15	Sand with Layer of Silt
BH-19	0.0055	Pumping test	5 to 15	Sand with Layer of Silt
BH-20A	0.006	Slug test	7 to 22	Interbedded Sands and Silts
BH-21B	0.002	Slug test	41.5 to 51.5	Silty Sand
BH-23	0.00006	Slug test	7 to 21.5	Silt with a Small Sand layer
BH-25A	0.0024	Pumping test	9 to 19	Sand and Silty Sand with Layer of Silt
WP-1	0.0081	Slug test	2 to 3	Sand
WP-4	0.00017	Slug test	2 to 3	Silt
WP-5	0.0071	Slug test	2 to 3	Sand

Upland Soil Based on Grain Size Analyses

Sample Location	Hydraulic Conductivity in cm/sec	Grain Size D10 in mm	Sample Depth Interval in Feet	Type of Soil in Sample Interval
HC-2, S-5	0.023	0.1526	12.5 to 14	Sand
HC-3, S-8	0.019	0.1388	22 to 23.5	Slightly Silty Sand
HC-6, S-8	0.037	0.1914	16 to 17.5	Sand
HC-7, S-4	0.024	0.1542	10 to 11.5	Sand
TP-5A, BS-1	0.0085	0.0923	7 to 8	Slightly Silty Sand

Sediment

Sample Location	Vertical Permeability in cm/sec	Type of Test	Gradient Probe Depth in cm	Sediment Description
WP-19A, No. 1	0.0076	Piezo-seep meter	25	Silty Sand
WP-19A, No. 2	0.0026	Piezo-seep meter	25	Silty Sand
WP-19A, No. 3	0.011	Piezo-seep meter	25	Sand
WP-20A, No. 1	0.011	Piezo-seep meter	31	Silty Sand
WP-20A, No. 2	0.0023	Piezo-seep meter	31	Silty Sand
WP-20A, No. 3	0.028	Piezo-seep meter	31	Sand

Table 3.1-3
Summary of Lakebed Seepage

Investigation and Method	Location	Sediment Type - Surface to Depth of Seepage Meter Imbedment		Darcy Velocity in cm/day
		Based on Closest Exploration	Observed in Field	
Aspect 2003				
Field-measured permeability and gradient across upper 10 to 12 inches of surface sediment at each location.				
	WP-19A	No Adjacent Exploration	Silty Sand	4.88
		No Adjacent Exploration	Silty Sand	1.65
		No Adjacent Exploration	Sand	7.25
	WP-20A	Sandy Silt (VC-20A)	Silty Sand	2.44
		Sandy Silt (VC-20A)	Silty Sand	11.58
Aspect 2003				
Field-measured gradient across upper 4 to 6 feet of surface sediment at each location. Permeability of sand measured at other locations with similar sediment type (Aspect 2003). Permeability of silt based on calibrated groundwater model (Retec 1998).				
	WP-21A	Sand (VS-36)	Not Reported	5.49
	WP-21B	Sand (VS-36)	Not Reported	9.75
	WP-19C	Peaty Silt	Not Reported	0.21
	WP-19B	Sandy Silt	Not Reported	0.13
EPA 2009				
Bucket-and-bag seepage meters. Imbedment depth not reported. Assumed to be 1 foot or less for identifying sediment type. Data from June dive report (EPA, 2009b) assuming a bucket cross-sectional area of 559 cm^2.				
	A (near VS-28)	Sandy Silt	Not Reported	0.70
				2.22
				0.10
				0.05
	B (near VS-23)	Silty Sand	Not Reported	2.99
				0.08
				0.31
	C (near VS-30)	Sand	Not Reported	0.82
				0.80
				0.21
				1.06
	D (near VS-3)	Silty Peat	Not Reported	1.73
				0.05
Minimum				0.05
Maximum				11.58
Geometric Mean				0.83

Table 3.1-3
Summary of Lakebed Seepage

Investigation and Method	Location	Sediment Type - Surface to Depth of Seepage Meter Imbedment		Darcy Velocity in cm/day
		Based on Closest Exploration	Observed in Field	
Aspect 2009				
Calibrated Groundwater Model - Accounts for local variation in gradients and the thickness of the shallow alluvium. Does not account for local variation in material type.				
		Darcy Velocity along Transect		
	Distance from Shore in Feet	WP-21 (South of former T-Dock)	WP-20 (T-Dock)	WP-19 (North of former T-Dock)
	37.5	0.76	0.66	0.46
	62.5	0.61	0.53	0.40
	87.5	0.52	0.46	0.36
	112.5	0.47	0.41	0.32
	137.5	0.49	0.37	0.30
	162.5	0.52	0.35	0.29
	187.5	0.52	0.34	0.28
	212.5	0.53	0.34	0.28
	237.5	0.66	0.35	0.28
Minimum		0.47	0.34	0.28
Maximum		0.76	0.66	0.46
Average		0.56	0.42	0.33
Average - all three transects			0.44	
Standard Deviation - all three transects			0.13	

Notes:
Data Sources:
Aspect 2003: Draft Risk Assessment/Feasibility Study (Anchor and Aspect 2004), Appendix F - Groundwater Vertical Permeability and Vertical Head Study
Anchor 2009: sediment core logs for stations NS-01 through NS-15.
EPA 2009: Dive reports for dives in April 2009 (EPA 2009b) and May 2009 (EPA 2009c).

cm/day - centimeters per day

Table 3.1-4
Variability of Shallow Alluvium Composition

Variability of Shallow Alluvium Composition (Anchor 2009)		Percent of Core Thickness Composed Primarily of Silt	
		(Short cores less than 6 feet deep excluded)	
Location	Station	C1	C2 (Duplicate Location)
South of Former T-Dock			
	NS-01	3	27
	NS-02	42	
	NS-03	45	18
	NS-04	78	60
	NS-06	40	
	NS-07	54	24
	NS-08	55	67
	NS-12	29	39
		Average (C1 and C2): 42 percent	
North of Former T-Dock			
	NS-05	91	93
	NS-09	57	58
	NS-10	8	
	NS-11	69	
	NS-13	60	
	NS-14	10	
	NS-15	56	
		Average (C1 and C2): 56 percent	
		Average for Nearshore Area: 47 percent	
		Standard Deviation in Nearshore Area: ±25 percent	

Note:
Data Source: Anchor 2009, sediment core logs for stations NS-01 through NS-15.

Table 3.3-1
Well Construction Information for Area Groundwater Wells

Water Wells Within 0.5 Mile of Quendall Terminals Site

Well Owner	Reported Water Use	Location	Well Depth in Feet Below Ground Surface	Well Diameter in inches	Screen Interval in Feet Below Surface	Approximate Well Elevation in Feet	Depth to Water in Feet	Well Test Information	Completion Date
Duane Cederberg	Domestic, Irrigation	NW, NE, S32, T24N, R5E	89	6	No Screen	125	3	Pump - 24 gal/min with 27 ft drawdown after 3 hrs	8/3/1973
Graham Construction	Domestic	NW, NE, S32, T24N, R5E	144	6	139 to 144	125	95	Bailer - 20 gal/min with 0 ft drawdown after 2 hrs	11/17/1981
Hazelwood Gardens Nursery	Irrigation	NW, NE, S32, T24N, R5E	157	6	No Screen	300	--	Not tested	2/27/1992
Hazelwood Gardens Nursery	Irrigation (Well Deepened)	NW, NE, S32, T24N, R5E	325	6	No Screen	300	160	Air - 50 gal/min with stem set at 310 ft for 2.5 hrs	3/25/1993
A A Miller	--	S31, T24N, R5E	92	6	No Screen	--	--	--	2/10/1930
Kennydale Water Co.	--	S31, T24N, R5E	345	8	145 to 155 285 to 333	--	--	--	11/6/1936

Abandoned Water Wells Within 0.5 Mile of Quendall Terminals Site

Well Owner	Location	Well Depth in Feet Below Ground Surface	Well Diameter in Inches	Date Abandoned
Chaffey Corp.	SE, NE, S29, T24N, R5E	52	48	12/11/1991
Lorna (Walker) Ricks	SE, NE, 29, T24N, R5E	31	4	5/15/1983
George Sharrow	SE, NE, S29, T24N, R5E	42	36	12/3/2003
Woodside LLC	NW, NE, S32, T24N, R5E	22	40	7/5/2000
Woodside LLC	NW, NE, S32, T24N, R5E	6	2	7/5/2000
Water District 107	SW, NE, S32, T24N, R5E	388	18 to 30	2/23/1994

Notes:
-- Indicates information was not reported on well log or cannot be inferred from the information available.
Information based on data available on the Washington State Department of Ecology website (http://apps.ecy.wa.gov/welllog/index.asp).

Table 4.2-1
Analytical Results for DNAPL and DNAPL-Containing Soil Samples

Location	Former May Creek Channel								Quendall Pond			North Sump
Well Number	BH-21A		MC-1 (10.5'-11.5')	MC-1 (26'-27')	MC-23 (9.5'-11')	BH-30 (11'-11.3')	T-7 TAR	T-7 UKM	BH-5	RW-QP-1	QP-1 (17'-18')	RW-NS-1
Sample Date	1/19/1996	12/18/2003	7/22/2009	7/22/2009	9/30/2009	9/30/2009	9/29/2009	9/29/2009	1/19/1996	12/18/2003	7/21/2009	12/18/2003
Medium	DNAPL		Soil	Soil	Soil	Soil	Tar	Tar	DNAPL	DNAPL	Soil	DNAPL
TPH (Concentrations in mg/kg)												
Analysis Method	*WTPH-HCID*	*NWTPH-Dx*							*WTPH-HCID*	*NWTPH-Dx*		
Gasoline Range Organics	59,000	--	--	--	--	--	--	--	510,000	--	--	--
Diesel Range Organics	640,000	860,000 Z	--	--	--	--	--	--	330,000	500,000 Z	--	610,000 Z
Residual Range Organics	200,000	260,000 Z	--	--	--	--	--	--	210,000	330,000 Z	--	240,000 Z
BTEX by EPA Method 8020, 8021B or 8260C (Concentrations in mg/kg)												
Benzene	50 U	5 U	6 U	84 U	24 U	24 U	81 U	12 U	9,900	2,100	460	550
Toluene	50 U	29	6 U	84 U	24 U	24 U	81 U	13	20,000	19,000	870	1,300
Ethylbenzene	850	470	6 U	92 U	24 U	26	81 U	12 U	6,500	6,000	910	1,000
m,p- Xylenes	1,100	670	6 U	120	24 U	29	81 U	15	20,000	21,000	1,400	2,000
o -Xylene	430	280	6 U	84 U	24 U	24 U	81 U	12 U	7,400	19,000	470	1,500
Total BTEX (U=1/2)	2,400	1,500	15	300	60	91	200	46	64,000	67,000	4,100	6,400
SVOCs by EPA Method 8270, 8270C or 8270D (Concentrations in mg/kg)												
Naphthalene	70,000	52,000	440	1,300	2,600	1,700	20,000	3,600	180,000	130,000	16,000	140,000
2-Methylnapthalene	32,000	27,000	260	590	700	740	2,900	1,400	48,000	32,000	4,300	39,000
Acenaphthylene	420	200	11 U	12 U	28	12 U	970	380 U	8,500	6,200	600	4,500
Acenaphthene	22,000	16,000	200	230	670	470	560	2,800	5,600	3,600	450	17,000
Dibenzofuran	9,100	7,400	87	82	280	150	1,600	380 U	4,000	3,000	320	6,600
Fluorene	14,000	13,000	150	160	470	310	2,600	690	6,300	4,400	530	11,000
Phenanthrene	61,000	48,000	760	500	1,900	1,300	9,000	3,400	18,000	9,700	1,600	34,000
Anthracene	10,000	7,100	130	71	290	160	8,000	1,200	4,100	2,500	320	7,800
Fluoranthene	28,000	17,000	330	180	1,000	640	4,900	10,000	9,000	7,200	660	16,000
Pyrene	27,000	14,000	300	140	950	590	4,400	14,000	9,700	10,000	690	16,000
Benzo[a]anthracene	8,100	6,900	91	39	310	150	1,800	13,000	5,400	6,300	360	4,900
Chrysene	6,300	5,300	100	38	210	100	2,200	24,000	8,600	7,200	550	5,200
Benzo[b]fluoranthene	5,600	5,200	55	16	220	80	1,100	11,000	7,100	11,000	410	6,200
Benzo[k]fluoranthene	5,600	4,000	55	16	220	80	1,100	11,000	7,600	6,900	410	3,900
Benzo[a]pyrene	6,600	5,100	78	21	300	120	1,800	18,000	8,900	11,000	650	6,800
Indeno[1,2,3-cd]pyrene	2,400	2,100	30	12 U	89	47	760	5,900	4,300	5,700	300	5,200
Dibenz[a,h]anthracene	970	720	15	12 U	42	19	320	3,200	1,600	1,800	130	1,300
Benzo[g,h,i]perylene	2,800	2,100	36	12 U	92	56	740	6,000	6,400	6,700	420	6,300
9H-Carbazole	3,200	2,200	--	--	--	--	--	--	2,000	1,100	--	3,600
Total cPAHs (U=1/2)	36,000	29,000	420	130	1,400	600	9,100	86,000	44,000	50,000	2,800	34,000
Total PAHs (U=1/2)	310,000	230,000	3,100	3,400	10,000	6,700	65,000	130,000	340,000	270,000	29,000	330,000
Total 6 of 16 LPAHs (U = 1/2)	180,000	140,000	1,700	2,300	790	3,900	41,000	12,000	220,000	160,000	3,500	210,000
Total 10 of 16 HPAHs (U = 1/2)	93,000	62,000	1,100	470	1,500	1,900	19,000	120,000	69,000	74,000	4,600	72,000
Flash Point by EPA Method 1020 (Temperature in Degrees Celsius)												
Flash Point	--	>200	--	--	--	--	--	--	--	112	--	>200
Specific Gravity by ASTM D-1298												
Specific Gravity	1.043	1.08	--	--	--	--	--	--	1.09	1.04	--	1.07
Kinematic Viscosity in Centistokes												
Analysis Temperature	@104° F	@122° F							@104° F	@122° F		@104° F
Viscosity (Measured)	10.2	7.4	--	--	--	--	--	--	3.41	4.22	--	4.51
Viscosity at 55° F (Calculated)	23.9	23.9	--	--	--	--	--	--	7.98	9.88	--	10.6

Notes:
Viscosity at 55° F calculated based on temperature-viscosity relationship of naphthalene.
-- Not measured/analyzed.
U Not detected at indicated detection limit.
Z Laboratory noted that the product fingerprint did not resemble a petroleum product.

Table 4.3-1
DNAPL Thickness Measurements at Site Monitoring Wells

	Product Thickness in Inches				
Date[1]	BH-20A	BH-21A	BH-5	RW-NS-1	RW-QP-1
Feb-1989	--	66	56	--	--
Apr-1989	--	70	55	--	--
Jun-1989	--	--	--	--	--
Sep-1989	--	48	<1	--	--
Jan-1990	--	42	12	--	--
Apr-1991	--	66	--	--	--
Aug-1991	0.8[2]	76	65	--	--
8/30/1995	8.4	69	62	--	--
10/12/1995	14	--	62	--	--
12/14/1995	0	63	51	--	--
1/15/1996	0	65	53	--	--
4/5/1996	TR	63	51	--	--
5/16/1996	0	67	55	--	--
6/11/1996	0	66	56	--	--
11/13/2003	--	--	--	--	0
11/14/2003	--	--	--	0	15
11/24/2003	--	66	--	--	44
11/26/2003	--	--	--	--	--
11/26/2003	--	66	--	18 [3]	44
11/29/2003	--	60	--	0	28
12/2/2003	--	64	--	0	37
12/5/2003	--	64	--	0	25
12/8/2003	--	62	--	0	34
12/10/2003	--	62	--	0	16
12/15/2003	--	64	--	0	29
12/18/2003	--	62	--	0	15
2/7/2004	--	63	--	0	58
2/11/2004	--	62	--	0	17
2/23/2004	--	66	--	0	30
3/1/2004	--	62	--	--	11
3/9/2004	--	61	--	--	13
3/16/2004	--	62	--	0	11
3/24/2004	--	65	--	--	13
4/1/2004	--	61	--	--	12
4/8/2004	--	62	--	--	13
4/13/2004	--	62	--	--	10
5/3/2004	--	65	--	--	23
8/5/2004	--	69	--	--	49
8/13/2004	--	67	61	--	9
9/3/2004	--	65	54	0	12
9/22/2004	--	63	45	--	12
10/14/2004	--	66	51	--	12
11/11/2004	--	68	39	--	16
12/20/2004	--	61	17	0	9
1/5/2005	--	63	21	--	12
1/21/2005	--	63	23	--	9

Table 4.3-1
DNAPL Thickness Measurements at Site Monitoring Wells

	Product Thickness in Inches				
Date[1]	BH-20A	BH-21A	BH-5	RW-NS-1	RW-QP-1
4/22/2005	--	--	28	--	--
5/17/2005	--	62	25	--	30
6/11/2005	--	62	24	--	11
9/16/2009	3	62	12	TR	83

Notes:

-- not measured

1. Thicknesses measured between February 1989 and June 11, 1996 originally reported in Final Remedial Investigation, Quendall Terminals Uplands, Renton, WA,
2. Product drawn into well during April/May 1991 aquifer testing.
3. Interface meter did not provide reproducible measurement at well RW-NS-1. Product thickness calculated from sump dimensions and volume product recovered.

TR = Trace product was detected.

Shaded value indicates that data were collected during periodic DNAPL pumping. and recovery tests.

Table 4.4-1
DNAPL Observations at Soil Borings

Boring ID	Depth of Boring in Feet	Site Area [1]	DNAPL Depth Intervals in Feet	DNAPL Thickness in Feet
BH-5	24	QP/NS	5 to 6	1
			16.5 to 17	0.5
			18.5 to 19	0.5
BH-5B	56	QP/NS	13.5 to 16	2.5
BH-20C	140	QP/NS	25.5 to 26.5	1
BH-30C	142	MC	7 to 9.5	2.5
			10.75 to 11	0.25
			33.25 to 33.75	0.5
HC-7	16.5	MC	8.5 to 15	6.5
MC-1	40	MC	9.75 to 11	1.25
			12 to 17.5	5.5
			25.5 to 27	1.5
			31 to 31.5	0.5
MC-2	25	MC	13.1 to 14.5	1.4
MC-7	25	MC	16 to 18	2
MC-8	30	MC	11 to 14	3
MC-13	35	MC	18 to 18.3	0.3
MC-16	25	MC	12.8 to 13	0.2
MC-18	30	MC	12.2 to 13	0.8
MC-20	30	MC	3 to 3.25	0.25
			8.75 to 9	0.25
			7.25 to 7.5	0.25
			10.5 to 12.25	1.75
MC-23	25	MC	9 to 11	2
			12.5 to 13	0.5
QP-1	30	QP/NS	16.5 to 18.5	2
QP-5	30	QP/NS	11 to 12	1
QP-6	25	QP/NS	11 to 12.25	1.25
QP-7	25	QP/NS	11.5 to 13.75	2.25
BH-8	24	QP/NS	8.5 to 12.5	4
BH-9	20	SH	1.5 to 3.5	2
BH-21A	20	MC	13.5 to 19	5.5
BH-23	24	QP/NS	8 to 10	2
			13.5 to 14.5	1
			18 to 19.5	1.5
			23 to 24	1
Q1-D	30	RR	8 to 9	1
			14 to 15	1
			15.5 to 17.5	2
			20 to 22	2
Q2-C	25	RR	17 to 18	1

Table 4.4-1
DNAPL Observations at Soil Borings

Boring ID	Depth of Boring in Feet	Site Area [1]	DNAPL Depth Intervals in Feet	DNAPL Thickness in Feet
Q2-D	35	RR	9 to 10	1
			12.5 to 14	1.5
			15.5 to 20	4.5
			26 to 30	4
Q4	31	RR	14 to 16.5	2.5
Q7	24	RR	18.5 to 19	0.5
Q9	29	RR	13.5 to 15.5	2
			15.5 to 17.5	2
			18 to 21	3
			23.5 to 25	1.5
RB9	21	QP/NS	15 to 20.2	5.2
RB11	18	QP/NS	16 to 18	2
RB12	18	QP/NS	17.6 to 18	0.4
RB14	22	QP/NS	19 to 21	2
RB19	15	QP/NS	11 to 12.6	1.6
RB23	12	QP/NS	8 to 12	4
SP-1	26	MC	9.2 to 9.8	0.6
SP-2	22	QP/NS	21.8 to 22	0.2
SP-3	26	QP/NS	14 to 16	2
SP-4	22	QP/NS	6.8 to 7	0.2
			8.3 to 9	0.7
			11.5 to 12.5	1
SP-5	22	QP/NS	10 to 16	6
SP-6	18	QP/NS	9.5 to 13	3.5
SP-7	22	QP/NS	10 to 13	3
			17.6 to 17.8	0.2
SP-8	18	QP/NS	9.2 to 10	0.8
			16.6 to 18	1.4
SWB-4A	14	QP/NS	10 to 11	1

Notes:
See the tables in Appendix G for boring coordinates, elevations, and DNAPL interpretation notes.

[1] MC = Former May Creek Channel Area
SH = Still House Area
QP/NS = Quendall Pond/North Sump Area
RR = Railroad Loading Area

Table 4.4-2
DNAPL Observations at Sediment Borings

Boring ID	Depth of Boring in Feet	Site Area [1]	DNAPL Depth Intervals in Feet			DNAPL Thickness in Feet
NS-15-C1	14	QP/NS	9.2	to	9.3	0.1
QPN-02	15	QP/NS	3.1	to	4	0.9
			4.7	to	5.2	0.5
			6.7	to	6.8	0.1
			7.2	to	7.4	0.2
QPN-07	15	QP/NS	8.5	to	8.7	0.2
TD-01	14	TD	0.7	to	0.8	0.1
TD-08	14	TD	0.3	to	0.4	0.1
EPA-1	5	TD	0	to	0.5	0.5
EPA-8	3	TD	0	to	1	1
VS-2	17	QP/NS	16	to	16.3	0.3
VS-27	17	TD	2.5	to	2.7	0.2
VS-30	9	QP/NS	4	to	9	5
VT-1	11	TD	0	to	1	1
VT-4	16	TD	0	to	3.8	3.8

Notes:
See the tables in Appendix G for boring coordinates, elevations, and DNAPL interpretation notes.
[1] QP/NS = Quendall Pond/North Sump Area
TD = T-Dock Area

Table 4.4-3
Cumulative DNAPL Thickness Observed at Soil and Sediment Borings

Boring	Site Area	DNAPL Thickness in Feet	Maximum Depth of DNAPL in Feet
BH-5	Quendall Pond/North Sump Area	2	19
BH-23	Quendall Pond/North Sump Area	5.5	24
HC-2	Quendall Pond/North Sump Area	3.9	15.1
RB9	Quendall Pond/North Sump Area	5.2	20.2
RB11	Quendall Pond/North Sump Area	2	18
RB12	Quendall Pond/North Sump Area	0.4	18
RB14	Quendall Pond/North Sump Area	2	21
RB19	Quendall Pond/North Sump Area	1.6	12.6
RB-23	Quendall Pond/North Sump Area	4	12
SP-2	Quendall Pond/North Sump Area	0.2	22
SP-3	Quendall Pond/North Sump Area	2	16
SP-4	Quendall Pond/North Sump Area	1.9	12.5
SP-5	Quendall Pond/North Sump Area	6	16
SP-6	Quendall Pond/North Sump Area	3.5	13
SP-7	Quendall Pond/North Sump Area	3.2	17.8
SP-8	Quendall Pond/North Sump Area	2.2	18
SWB-4	Quendall Pond/North Sump Area	1.5	14
SWB-4A	Quendall Pond/North Sump Area	1	11
VS30	Quendall Pond/North Sump Area	5	9
QP-1	Quendall Pond/North Sump Area	2	18.5
BH-5B	Quendall Pond/North Sump Area	2.5	16
BH-20C	Quendall Pond/North Sump Area	1	26.5
QP-5	Quendall Pond/North Sump Area	1	12
QPN-02	Quendall Pond/North Sump Area	1.7	7.4
QPN-07	Quendall Pond/North Sump Area	0.2	8.7
NS15-C1	Quendall Pond/North Sump Area	0.1	9.3
VS2	Quendall Pond/North Sump Area	0.3	16.3
EPA-8	Quendall Pond/North Sump Area	1	1
TD-01	T-Dock Area	0.1	0.8
VT-1	T-Dock Area	1	1
VT-4	T-Dock Area	3.8	3.8
EPA-1	T-Dock Area	0.5	0.5
VS-27	T-Dock Area	0.2	2.7
TD-08	T-Dock Area	0.1	0.4
BH-21A	Former May Creek Channel Area	5.5	19
HC-7	Former May Creek Channel Area	6.5	15
SP-1	Former May Creek Channel Area	0.6	9.8
MC-1	Former May Creek Channel Area	8.75	31.5
MC-2	Former May Creek Channel Area	1.4	14.5
MC-7	Former May Creek Channel Area	2	18
MC-8	Former May Creek Channel Area	3	14
MC-13	Former May Creek Channel Area	0.3	18.3
MC-16	Former May Creek Channel Area	0.2	13

Table 4.4-3
Cumulative DNAPL Thickness Observed at Soil and Sediment Borings

Boring	Site Area	DNAPL Thickness in Feet	Maximum Depth of DNAPL in Feet
MC-18	Former May Creek Channel Area	0.8	13
MC-20	Former May Creek Channel Area	2.5	12.25
MC-23	Former May Creek Channel Area	2.5	13
BH-30C	Former May Creek Channel Area	3.25	33.75
Q4	Former May Creek Channel Area/Railroad Loading Area [1]	2.5	16.5
Q9	Former May Creek Channel Area/Railroad Loading Area [1]	8.5	25
HC-5	Still House Area	2.5	13
Q2-D	Still House Area/Railroad Loading Area [1]	11	30
BH-8	Still House Area	4	12.5
QP-6	Still House Area	1.25	12.25
QP-7	Still House Area	2.25	13.75
BH-9	Still House Area	2	3.5
HC-4	Still House Area	1	10
Q1-D	Still House Area/Railroad Loading Area [1]	6	22
Q2-C	Railroad Loading Area	1	18
Q7	Railroad Loading Area	0.5	19

Notes:

See Tables 4.4-1 and 4.4-2 for DNAPL depth intervals at each boring

1 = Includes area in both the Still House or the Former May Creek Channel Area (on Quendall property) and the Railroad Loading Area (on Railroad property).

Table 4.4-4
Estimated DNAPL Volumes in the Subsurface at the Quendall Site

Source Area	Approximate Area in Acres	Volume of DNAPL-Contaminated Soil and/or Sediment in Cubic Yards	Volume of Soil and/or Sediment to Bottom of DNAPL in Cubic Yards	DNAPL Volume in Gallons	Percentage of Soil and/or Sediment Containing DNAPL[1]
Quendall Pond/North Sump Area (soil and sediment)	4.1	16,000	110,000	200,000	15%
Former May Creek Channel Area (soil only)	1.5	7,100	40,000	88,000	18%
Still House Area (soil only)	2.2	8,100	38,000	100,000	21%
Railroad Loading Area (soil only)	0.2	1,700	7,800	21,000	22%
TOTAL UPLANDS AND OFFSHORE FROM QUENDALL POND	**8.0**	**33,000**	**196,000**	**409,000**	**17%**
T-Dock Area (sediment only)	1.7	2,900	4,400	36,000	66%
TOTAL	**9.7**	**36,000**	**200,000**	**445,000**	**18%**

Notes:
Values are totals based on calculations presented in Appendix G, Table G-5, rounded to two significant figures.
[1]Volume of soil/sediment containing DNAPL divided by the volume of soil/sediment to the bottom of DNAPL.

Table 5.1-1
Summary of Site Media Indicator Chemicals and PRG Screening Levels

Site Medium/ Indicator Chemical	Units	PRG Screening Level for Nature and Extent Evaluation	Background (a)	Source (b)
Groundwater				
Benzene	µg/L	5.0	--	MCL
Naphthalene	µg/L	160	--	MTCA Method B Groundwater Cleanup Level
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2) (c)	µg/L	0.2	--	MCL
Arsenic	µg/L	10	5.0	MCL; background is MTCA Method A Groundwater Cleanup Level based on Washington State Background Level
Chromium	µg/L	100	--	MCL
Copper	µg/L	1,300	--	MCL
Total PCBs (U=1/2) (d)	µg/L	0.5	--	MCL
Pentachlorophenol	µg/L	1.0	--	MCL
Soil				
Benzene	mg/kg	1.1	--	EPA RSL Summary Table May 2011, Resident Soil
Naphthalene	mg/kg	3.6	--	EPA RSL Summary Table May 2011, Resident Soil
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2) (c)	mg/kg	0.015	--	EPA RSL Summary Table May 2011, Resident Soil
Total 10 of 16 HPAHs (U = 1/2) (e)	mg/kg	1.1	--	EPA Ecological Soil Screening Level - Mammalian
Total 6 of 16 LPAHs (U = 1/2) (f)	mg/kg	29	--	EPA Ecological Soil Screening Level - Soil Invertebrate
Arsenic	mg/kg	0.39	7.3	EPA RSL Summary Table May 2011, Resident Soil
Chromium	mg/kg	26	48.2	EPA Ecological Soil Screening Level - Avian (Chromium III)
Copper	mg/kg	28	36.4	EPA Ecological Soil Screening Level - Avian
Total PCBs (U=1/2) (d)	mg/kg	0.22	--	EPA RSL Summary Table May 2011, Resident Soil
Pentachlorophenol	mg/kg	0.89	--	EPA RSL Summary Table May 2011, Resident Soil
Bulk Sediment				
Naphthalene	mg/kg	0.176	--	EPA Region 3 BTAG Sediment Screening Value
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2) (c)	mg/kg	--	0.15 mg/kg	The site-specific background concentration was developed based on the 90 percent upper confidence limit on site-specific background samples collected during the RI field investigation in 2009.
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2) (c)	mg/kg-OC	--	6.2 mg/kg-OC	The site-specific background concentration was developed based on the 90 percent upper confidence limit on site-specific OCN background samples collected during the RI field investigation in 2009.
Total 10 of 16 HPAHs (U = 1/2) (e)	mg/kg	0.19	--	EPA Region 3 BTAG Sediment Screening Value
Total 6 of 16 LPAHs (U = 1/2) (f)	mg/kg	0.076	--	EPA Region 3 BTAG Sediment Screening Value
Total PAH ESBQ (U=1/2 and U=0) (g)	TU	1.0	--	EPA PAH ESBQ Screening Value
4-Methylphenol	mg/kg	0.67	--	EPA Region 3 BTAG Sediment Screening Value
Phenol	mg/kg	0.42	--	EPA Region 3 BTAG Sediment Screening Value
Total Organic Carbon	%	9.82	--	Ecology 2003 Freshwater Sediment Screening Value (LAET)
Sediment Porewater/Surface Water				
Benzene	µg/L	2.2	--	EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism)
Naphthalene	µg/L	1.1	--	EPA Region 3 BTAG Surface Water Screening Value
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2) (c)	µg/L	0.0038	--	EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism)
Total PAH SPME ESBQ (U=1/2 and U=0) (h)	TU	1.0	--	EPA PAH ESBQ Screening Value

Notes:
µg/L - microgram(s) per liter; mg/kg - milligram(s) per kilogram; mg/kg-OC - mg/kg-organic carbon (normalized).
BTAG - Biological Technical Assistance Group
CAEPA - California Environmental Protection Agency
cPAH - carcinogenic PAH(s) (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h] anthracene, and indeno [1,2,3-c,d]pyrene)
ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient

Table 5.1-1
Summary of Site Media Indicator Chemicals and PRG Screening Levels

HPAHs - high-molecular-weight PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3,-c,d]pyrene, fluoranthene, and pyrene)
LAET - lowest apparent effects threshhold
LPAHs - low-molecular-weight PAHs (acenaphthylene, acenaphthene, anthracene, fluorene, naphthalene, and phenanthrene)
MCL - maximum contaminant level
MTCA - Washington State Model Toxics Control Act
OC - organic carbon (normalized)
PAH - polynuclear aromatic hydrocarbon(s)
PCB - polychlorinated biphenyl
PRG - preliminary remediation goal
RSL - Regional Screening Level
SPME - solid-phase micro-extraction
TEF - toxicity equivalency factor; TEQ - toxicity equivalency quotient
TU - toxic unit(s)

(a) Background values for soil are based on MTCA Method B - Puget Sound Background-Regional (Ecology 1994). Note that the background value for arsenic in groundwater (PTI, 1989) is below the MCL.

(b) PRG screening levels are based on the following sources:

EPA National Primary Drinking Water Regulations (40 CFR 141)	http://water.epa.gov/drink/contaminants/upload/mcl-2.pdf
MTCA Method A for Groundwater (WAC 173-340-720 [Table 720-1])	http://www.ecy.wa.gov/pubs/wac173340.pdf
MTCA Method B for Groundwater (WAC 173-340-720[4])	http://www.ecy.wa.gov/pubs/wac173340.pdf
EPA Ecological Screening Levels	http://www.epa.gov/ecotox/ecossl/
EPA Regional Screening Levels	http://www.epa.gov/region9/superfund/prg/
EPA National Recommended Water Quality Criteria	http://water.epa.gov/scitech/swguidance/standards/current/upload/nrwqc-2009.pdf
EPA Region 3 BTAG Screening Values	http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm
Ecology 2003 Freshwater Sediment Screening Value (LAET)	http://www.ecy.wa.gov/pubs/0309088.pdf
EPA PAH ESB Screening Values	http://www.epa.gov/nheerl/publications/files/PAHESB.pdf

(c) Total cPAH TEQ (7 minimum, CAEPA 2005) (U = 1/2): Screening level for cPAHs. Total cPAH TEQ based on benzo(a)pyrene equivalent concentrations calculated by multiplying concentrations of seven carcinogenic PAHs by TEFs per 2009 California EPA guidance and summing the results. When calculating and comparing sample-specific results to this screening level, 1/2 the detection limit was used for non-detects (U-flagged results); the maximum detection limit was used for comparison in cases where all cPAHs were non-detects.

(d) Total PCBs (U=1/2): Screening level for PCBs. When calculating and comparing sample-specific results to this screening level, 1/2 the detection limit was used for non-detects (U-flagged results); the maximum detection limit was used for comparison in cases where all PCBs were non-detects.

(e) Total 10 of 16 HPAHs (U = 1/2): Screening level for HPAHs. When calculating and comparing sample-specific results to this screening level, 1/2 the detection limit was used for non-detects (U-flagged results); the maximum detection limit was used for comparison in cases where all HPAHs were non-detects. Total 10 of 16 HPAHs based on summing the concentrations of the 10 HPAHs.

(f) Total 6 of 16 LPAHs (U = 1/2): Screening level for LPAHs. When calculating and comparing sample-specific results to this screening level, 1/2 the detection limit was used for non-detects (U-flagged results); the maximum detection limit was used for comparison cases where all LPAHs were non-detects. Total 6 of 16 LPAHs based on summing the concentrations of the 6 LPAHs.

(g) Total PAH ESBQ (U=1/2 and U=0): Benthic organisms should be acceptably protected from the narcotic effects of PAH mixtures in freshwater and saltwater sediments if the final chronic ESBQ is less than or equal to 1.0 TU. If the final chronic ESBQ is greater than 1.0 TU, sensitive benthic organisms may be adversely affected. Total PAH ESBQs were calculated using both 1/2 the detection limit for non-detects and also using a value of zero for non-detects, as non-detected results contribute significantly to the ESBQs. More details on how PAH ESBQ results are interpreted are provided in Section 7.2, Baseline Ecological Risk Assessment.

(h) PAH SPME ESBQ (U=1/2 and U=0): Same as above, except that porewater samples were analyzed using SPME.

Table 5.2-1a
Statistical Summary of Indicator Chemicals in Groundwater - Quendall Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	µg/L	91	119	76%	0.0043	180	0.012	390	BH-25A	63	--	--	--	--	--	--	--
Acenaphthylene	µg/L	46	119	39%	0.01	1100	0.03	710	BH-25A	35	--	--	--	--	--	--	--
Anthracene	µg/L	44	119	37%	0.01	100	0.0071	160	BH-5A	6.6	--	--	--	--	--	--	--
Arsenic (dissolved)	**µg/L**	**43**	**43**	**100%**	**--**	**--**	**0.7**	**389**	**BH-29A**	**24**	**MCL**	**10**	**14**	**--**	**5**	**20**	**--**
Arsenic	**µg/L**	**19**	**21**	**90%**	**1**	**1**	**1**	**150**	**BH-5**	**21**	**MCL**	**10**	**5**	**--**	**5**	**13**	**--**
Benzene	**µg/L**	**77**	**131**	**59%**	**0.2**	**60**	**0.2**	**31000**	**BH-5A**	**1179**	**MCL**	**5**	**63**	**2**	**--**	**--**	**--**
Benzo(a)anthracene	µg/L	19	119	16%	0.01	100	0.014	170	BH-5A	3.9	cPAH	--	--	--	--	--	--
Benzo(a)pyrene	µg/L	20	119	17%	0.01	100	0.016	290	BH-5A	5.1	cPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	µg/L	20	119	17%	0.01	100	0.01	210	BH-5A	4.4	cPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	µg/L	11	119	9%	0.01	100	0.0056	120	BH-5A	3.7	--	--	--	--	--	--	--
Benzo(k)fluoranthene	µg/L	19	119	16%	0.01	100	0.0097	210	BH-5A	4.3	cPAH	--	--	--	--	--	--
Chromium (dissolved)	µg/L	3	26	12%	1	5	4	4	BH-21A	2.3	MCL	100	--	--	--	--	--
Chrysene	µg/L	14	119	12%	0.01	100	0.025	270	BH-5A	5.0	cPAH	--	--	--	--	--	--
Copper (dissolved)	µg/L	3	26	12%	0.5	0.5	0.6	0.8	BH-18B	0.52	MCL	1300	--	--	--	--	--
Dibenz(a,h)anthracene	µg/L	10	119	8%	0.01	100	0.0079	2	WP-3	3.2	cPAH	--	--	--	--	--	--
Fluoranthene	µg/L	46	119	39%	0.01	100	0.0051	250	BH-5A	8.0	--	--	--	--	--	--	--
Fluorene	µg/L	78	119	66%	0.01	100	0.041	290	BH-5A	20	--	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	µg/L	12	119	10%	0.01	100	0.006	4.8	BH-23	3.5	cPAH	--	--	--	--	--	--
Naphthalene	**µg/L**	**113**	**133**	**85%**	**0.039**	**1.8**	**0.051**	**19000**	**WP-19B**	**1906**	**MTCA B**	**160**	**56**	**--**	**--**	**--**	**--**
Pentachlorophenol	µg/L	0	47	0%	5	100	--	--	ND	11	MCL	1	--	47	--	--	--
Phenanthrene	µg/L	72	119	61%	0.01	100	0.0043	590	BH-5A	23	--	--	--	--	--	--	--
Pyrene	µg/L	39	119	33%	0.01	100	0.0038	330	BH-25A	9.5	--	--	--	--	--	--	--
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**µg/L**	**22**	**119**	**18%**	**0.0100**	**100**	**0.0101**	**362**	**BH-5A**	**5.8**	**MCL**	**0.2**	**13**	**26**	**--**	**--**	**--**

Notes:
µg/L - microgram(s) per liter. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, via PRG screening levels identified for that chemical group.
MCL - maximum contaminant level
MTCA B - Washington State Model Toxics Control Act Method B cleanup level

Table 5.2-1b
Statistical Summary of Indicator Chemicals in Groundwater - Quendall Property, QA0 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	µg/L	28	48	58%	1	10	2	1900	BH-23	122	--	--	--	--	--	--	--
Acenaphthylene	µg/L	14	48	29%	1	10	0.5	2300	BH-23	68	--	--	--	--	--	--	--
Anthracene	µg/L	20	48	42%	1	10	0.4	1200	BH-23	45	--	--	--	--	--	--	--
Arsenic	**µg/L**	**25**	**30**	**83%**	**1**	**1**	**1**	**38**	**BH-20B**	**9.9**	**MCL**	**10**	**9**	**--**	**5**	**13**	**--**
Benzene	**µg/L**	**23**	**46**	**50%**	**0.4**	**1**	**12**	**14000**	**BH-20A**	**1024**	**MCL**	**5**	**23**	**--**	**--**	**--**	**--**
Benzo(a)anthracene	µg/L	14	48	29%	1	10	0.5	1100	BH-23	44	cPAH	--	--	--	--	--	--
Benzo(a)pyrene	µg/L	14	48	29%	1	10	0.5	1700	BH-23	53	cPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	µg/L	3	21	14%	1	10	18	50	BH-21A	7.3	cPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	µg/L	8	48	17%	1	20	2	1000	BH-23	30	--	--	--	--	--	--	--
Benzo(k)fluoranthene	µg/L	2	20	10%	1	20	14	17	BH-21A	5.7	cPAH	--	--	--	--	--	--
Chromium	µg/L	1	30	3%	5	10	8	8	BH-20B	5.8	MCL	100	--	--	--	--	--
Chrysene	µg/L	15	49	31%	1	10	0.5	1700	BH-23	52	cPAH	--	--	--	--	--	--
Copper	µg/L	10	40	25%	2	20	2	15	BH-17A	4.7	MCL	1300	--	--	--	--	--
Dibenz(a,h)anthracene	µg/L	6	48	13%	1	20	3.1	420	BH-23	14	cPAH	--	--	--	--	--	--
Fluoranthene	µg/L	21	48	44%	1	10	0.3	2800	BH-21A	111	--	--	--	--	--	--	--
Fluorene	µg/L	27	48	56%	1	10	0.5	2200	BH-23	98	--	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	µg/L	7	48	15%	1	20	2	830	BH-23	27	cPAH	--	--	--	--	--	--
Naphthalene	**µg/L**	**35**	**48**	**73%**	**1**	**10**	**0.8**	**43000**	**BH-23**	**2177**	**MTCA B**	**160**	**20**	**--**	**--**	**--**	**--**
Pentachlorophenol	µg/L	0	47	0%	5	630	--	--	ND	28	MCL	1	--	47	--	--	--
Phenanthrene	µg/L	25	48	52%	1	10	0.7	6200	BH-21A	255	--	--	--	--	--	--	--
Pyrene	µg/L	21	49	43%	1	10	0.4	2400	BH-23	106	--	--	--	--	--	--	--
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**µg/L**	**15**	**49**	**31%**	**1**	**10**	**0.655**	**1952**	**BH-23**	**60**	**MCL**	**0.2**	**15**	**34**	**--**	**--**	**--**

Notes:
µg/L - microgram(s) per liter. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, via PRG screening levels identified for that chemical group.
MCL - maximum contaminant level
MTCA B - Washington State Model Toxics Control Act Method B cleanup level

Table 5.2-2
Statistical Summary of Indicator Chemicals in Groundwater - Railroad Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels			
											Source	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	µg/L	4	6	67%	1	1	1.5	10000	Q9	1771	--	--	--	--
Acenaphthylene	µg/L	1	6	17%	1	20	1000	1000	Q9	171	--	--	--	--
Anthracene	µg/L	2	6	33%	1	1	94	3600	Q9	616	--	--	--	--
Arsenic (dissolved)	**µg/L**	**6**	**6**	**100%**	**--**	**--**	**2.2**	**1690**	**Q9**	**284**	**MCL**	**10**	**1**	**--**
Benzene	**µg/L**	**2**	**6**	**33%**	**0.25**	**0.25**	**92**	**1600**	**Q9**	**282**	**MCL**	**5**	**2**	**--**
Benzo(a)anthracene	µg/L	2	7	29%	1	1	94	3100	Q9	457	cPAH	--	--	--
Benzo(a)pyrene	µg/L	2	7	29%	1	1	65	2000	Q9	296	cPAH	--	--	--
Benzo(b)fluoranthene	µg/L	2	7	29%	1	1	60	1900	Q9	281	cPAH	--	--	--
Benzo(g,h,i)perylene	µg/L	2	6	33%	1	1	28	800	Q9	139	--	--	--	--
Benzo(k)fluoranthene	µg/L	2	7	29%	1	1	36	1400	Q9	206	cPAH	--	--	--
Chrysene	µg/L	3	7	43%	1	1	1.2	2200	Q9	324	cPAH	--	--	--
Dibenz(a,h)anthracene	µg/L	1	7	14%	1	20	200	200	Q9	32	cPAH	--	--	--
Fluoranthene	µg/L	4	6	67%	1	1	1.1	10000	Q9	1717	--	--	--	--
Fluorene	µg/L	3	6	50%	1	1	1.1	7300	Q9	1272	--	--	--	--
Indeno(1,2,3-c,d)pyrene	µg/L	2	7	29%	1	1	7	760	Q9	110	cPAH	--	--	--
Naphthalene	**µg/L**	**6**	**6**	**100%**	**--**	**--**	**1.1**	**45000**	**Q9**	**8387**	**MTCA B**	**160**	**2**	**--**
Phenanthrene	µg/L	5	6	83%	1	1	1.3	23000	Q9	3974	--	--	--	--
Pyrene	µg/L	4	6	67%	1	1	1.4	11000	Q9	1879	--	--	--	--
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**µg/L**	**3**	**7**	**43%**	**1**	**1**	**0.762**	**2758**	**Q9**	**407**	**MCL**	**0.2**	**3**	**4**

Notes:
µg/L - microgram(s) per liter. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, via PRG screening levels identified for that chemical group.
MCL - maximum contaminant level
MTCA B - Washington State Model Toxics Control Act Method B cleanup level

Table 5.3-1a
Statistical Summary of Indicator Chemicals in Surface Soil - Quendall Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	14	18	78%	0.072	0.81	0.02	470	HC-5	30	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	8	18	44%	0.07	0.81	0.034	44	HC-5	2.9	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	17	18	94%	0.076	0.076	0.052	1100	HC-5	70	LPAH	--	--	--	--	--	--
Arsenic	**mg/kg**	**8**	**8**	**100%**	**--**	**--**	**0.8**	**31**	**HC-5**	**8.8**	**EPA RSL**	**0.39**	**8**	**--**	**7.3**	**4**	**--**
Benzene	**mg/kg**	**1**	**17**	**6%**	**0.0057**	**0.14**	**1.8**	**1.8**	**HC-5**	**0.14**	**EPA RSL**	**1.1**	**1**	**--**	**--**	**--**	**--**
Benzo(a)anthracene	mg/kg	15	18	83%	0.07	150	0.092	37	SS-BH-9	14	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	16	18	89%	0.07	0.076	0.13	160	TP-2	19	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	16	18	89%	0.07	0.076	0.1	140	TP-2	16	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	16	18	89%	0.07	0.076	0.098	200	TP-2	17	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	16	18	89%	0.07	0.076	0.094	98	HC-5	13	cPAH/HPAH	--	--	--	--	--	--
Chromium	**mg/kg**	**4**	**4**	**100%**	**--**	**--**	**29.3**	**65.3**	**BH-28**	**50**	**Eco SSL Avian**	**26**	**4**	**--**	**48.2**	**2**	**--**
Chrysene	mg/kg	16	18	89%	0.07	0.076	0.14	200	HC-5	21	cPAH/HPAH	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg	12	18	67%	0.032	0.44	0.041	29	TP-2	3.5	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	17	18	94%	0.076	0.076	0.12	390	HC-5	30	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	15	18	83%	0.072	0.81	0.021	47	SS-BH-9	4.9	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	15	18	83%	0.07	4.5	0.092	120	TP-2	12	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**20**	**29**	**69%**	**0.023**	**0.81**	**0.0029**	**2900**	**HC-5**	**124**	**EPA RSL**	**3.6**	**5**	**--**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	17	0%	0.15	30	--	--	ND	2.1	EPA RSL	0.89	--	2	--	--	--
Phenanthrene	mg/kg	17	18	94%	0.076	0.076	0.14	1000	HC-5	66	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	17	18	94%	0.076	0.076	0.11	540	HC-5	40	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**17**	**18**	**94%**	**0.0760**	**0.0760**	**0.520**	**1631**	**HC-5**	**185**	**Eco SSL Mammal**	**1.1**	**16**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**17**	**18**	**94%**	**0.0760**	**0.0760**	**0.495**	**5530**	**HC-5**	**353**	**Eco SSL Invert**	**29**	**4**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**16**	**18**	**89%**	**0.0700**	**0.0760**	**0.171**	**201**	**TP-2**	**24**	**EPA RSL**	**0.015**	**16**	**2**	**--**	**--**	**--**
Total PCB Aroclors (U=1/2)	mg/kg	0	4	0%	0.037	0.042	--	--	ND	0.039	EPA RSL	0.22	--	--	--	--	--

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL - Regional Screening Level for Resident Soil
Eco SSL Avian - Ecological Soil Screening Level - Avian
Eco SSL Mammal - Ecological Soil Screening Level - Mammalian
Eco SSL Invert - Ecological Soil Screening Level - Soil Invertebrate

Table 5.3-1b
Statistical Summary of Indicator Chemicals in Surface Soil - Quendall Property, QA0 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	3	10	30%	0.064	0.17	1.1	64	BH-19	9.7	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	3	10	30%	0.064	0.17	1	5	BH-19	0.85	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	3	10	30%	0.064	0.17	3.7	79	BH-19	13	LPAH	--	--	--	--	--	--
Benzo(a)anthracene	mg/kg	5	10	50%	0.064	0.17	0.043	280	BH-19	42	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	5	10	50%	0.081	0.17	0.035	200	BH-19	35	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	2	3	67%	0.17	0.17	0.069	0.15	BH-24	0.13	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	3	10	30%	0.064	0.17	5.7	170	BH-19	29	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	1	3	33%	0.17	0.17	0.062	0.062	BH-26A	0.13	cPAH/HPAH	--	--	--	--	--	--
Chromium	**mg/kg**	**3**	**3**	**100%**	**--**	**--**	**24**	**29**	**BH-25B**	**27**	**Eco SSL Avian**	**26**	**2**	**--**	**48.2**	**--**	**--**
Chrysene	mg/kg	6	10	60%	0.064	0.17	0.038	270	BH-19	42	cPAH/HPAH	--	--	--	--	--	--
Copper	**mg/kg**	**3**	**3**	**100%**	**--**	**--**	**13**	**30**	**BH-26A**	**21**	**Eco SSL Avian**	**28**	**1**	**--**	**36.4**	**--**	**--**
Dibenz(a,h)anthracene	mg/kg	3	10	30%	0.064	0.17	3.1	85	BH-19	12	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	6	10	60%	0.081	0.17	0.043	390	BH-19	60	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	3	10	30%	0.064	0.17	0.98	55	BH-19	8.1	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	3	10	30%	0.064	0.17	6.8	160	BH-19	28	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**3**	**10**	**30%**	**0.064**	**0.17**	**0.83**	**170**	**BH-19**	**23**	**EPA RSL**	**3.6**	**2**	**--**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	10	0%	0.32	12	--	--	ND	2.5	EPA RSL	0.89	--	2	--	--	--
Phenanthrene	mg/kg	7	10	70%	0.081	0.17	0.05	500	BH-19	73	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	7	10	70%	0.081	0.17	0.054	520	BH-19	80	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**7**	**10**	**70%**	**0.0810**	**0.170**	**0.342**	**2075**	**BH-19**	**328**	**Eco SSL**	**1.1**	**4**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**7**	**10**	**70%**	**0.0810**	**0.170**	**0.228**	**873**	**BH-19**	**127**	**Eco SSL Invert**	**29**	**2**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**7**	**10**	**70%**	**0.0810**	**0.170**	**0.045**	**255**	**BH-19**	**44**	**EPA RSL**	**0.015**	**7**	**3**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL - Regional Screening Level for Resident Soil
Eco SSL Avian - Ecological Soil Screening Level - Avian
Eco SSL Invert - Ecological Soil Screening Level - Soil Invertebrate

Table 5.3-2
Statistical Summary of Indicator Chemicals in Surface Soil - Railroad Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	24	44	55%	0.054	1.4	0.083	600	Q6	27	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	9	44	20%	0.054	17	0.068	8.3	Q2-D	1.7	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	30	44	68%	0.054	14	0.066	590	Q6	34	LPAH	--	--	--	--	--	--
Arsenic	**mg/kg**	**21**	**44**	**48%**	**5**	**10**	**5**	**110**	**Q1-A**	**12**	**EPA RSL**	**0.39**	**21**	**23**	**7.3**	**15**	**2**
Benzo(a)anthracene	mg/kg	35	44	80%	0.054	0.063	0.1	1100	Q6	78	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	36	44	82%	0.054	0.063	0.083	1400	Q6	94	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	36	44	82%	0.054	0.063	0.11	960	Q6	68	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	34	44	77%	0.054	0.096	0.095	1100	Q6	48	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	36	44	82%	0.054	0.063	0.079	660	Q6	50	cPAH/HPAH	--	--	--	--	--	--
Chromium	**mg/kg**	**4**	**4**	**100%**	**--**	**--**	**19.8**	**30.1**	**Q1-D**	**25**	**Eco SSL Avian**	**26**	**1**	**--**	**48.2**	**--**	**--**
Chrysene	mg/kg	36	44	82%	0.054	0.063	0.099	1500	Q6	104	cPAH/HPAH	--	--	--	--	--	--
Copper	**mg/kg**	**5**	**5**	**100%**	**--**	**--**	**10**	**52**	**Q2**	**29**	**Eco SSL Avian**	**28**	**2**	**--**	**36.4**	**1**	**--**
Dibenz(a,h)anthracene	mg/kg	27	44	61%	0.054	1.4	0.068	190	Q6	12	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	36	44	82%	0.054	1400	0.07	2200	Q6	143	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	23	44	52%	0.054	1.4	0.068	350	Q6	18	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	34	44	77%	0.054	0.096	0.086	730	Q6	36	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**25**	**44**	**57%**	**0.054**	**14**	**0.071**	**260**	**Q1-B**	**20**	**EPA RSL**	**3.6**	**10**	**1**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	25	0%	0.3	71	--	--	ND	6.9	EPA RSL	0.89	--	12	--	--	--
Phenanthrene	mg/kg	37	44	84%	0.054	0.062	0.092	2800	Q6	151	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	38	44	86%	0.054	0.062	0.084	3200	Q6	197	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**38**	**44**	**86%**	**0.0540**	**0.0620**	**0.374**	**13040**	**Q6**	**813**	**Eco SSL Mammal**	**1.1**	**35**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**37**	**44**	**84%**	**0.0540**	**0.0620**	**0.242**	**4440**	**Q6**	**251**	**Eco SSL Invert**	**29**	**13**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**36**	**44**	**82%**	**0.0540**	**0.0630**	**0.112**	**1779**	**Q6**	**119**	**EPA RSL**	**0.015**	**36**	**8**	**--**	**--**	**--**
Total PCB Aroclors (U=1/2)	mg/kg	0	4	0%	0.029	0.032	--	--	ND	0.031	EPA RSL	0.22	--	--	--	--	--

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as either cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL - Regional Screening Level for Resident Soil
Eco SSL Avian - Ecological Soil Screening Level - Avian
Eco SSL Mammal - Ecological Soil Screening Level - Mammalian
Eco SSL Invert - Ecological Soil Screening Level - Soil Invertebrate

Table 5.3-3a
Statistical Summary of Indicator Chemicals in Subsurface Soil - Quendall Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	24	30	80%	0.075	0.097	0.023	3200	HC-7	153	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	6	30	20%	0.0078	150	0.042	200	RB9	13	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	21	30	70%	0.0078	0.13	0.092	1300	HC-7	77	LPAH	--	--	--	--	--	--
Arsenic	**mg/kg**	**15**	**15**	**100%**	**--**	**--**	**1.5**	**7**	**HC-4**	**4.2**	**EPA RSL**	**0.39**	**15**	**--**	**7.3**	**--**	**--**
Benzene	**mg/kg**	**7**	**25**	**28%**	**0.056**	**0.11**	**0.17**	**4.8**	**RB9**	**0.54**	**EPA RSL**	**1.1**	**3**	**--**	**--**	**--**	**--**
Benzo(a)anthracene	mg/kg	20	30	67%	0.0078	1000	0.012	1500	TP-4	94	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	19	30	63%	0.0078	1.5	0.02	2100	TP-4	110	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	19	30	63%	0.0078	1.5	0.018	1700	TP-4	92	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	18	30	60%	0.0078	1.5	0.015	1500	TP-4	76	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	18	30	60%	0.0078	1.5	0.019	1400	TP-4	72	cPAH/HPAH	--	--	--	--	--	--
Chromium	mg/kg	1	1	100%	--	--	18.3	18.3	HC-2	18	Eco SSL Avian	26	--	--	48.2	--	--
Chrysene	mg/kg	22	30	73%	0.0078	0.13	0.019	2500	TP-4	131	cPAH/HPAH	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg	10	30	33%	0.0078	310	0.17	180	HC-7	19	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	22	30	73%	0.0078	0.13	0.027	4400	TP-4	259	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	22	30	73%	0.0078	0.13	0.016	2500	HC-7	115	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	16	30	53%	0.0078	1.5	0.014	1500	TP-4	72	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**26**	**30**	**87%**	**0.079**	**1.5**	**0.078**	**11000**	**HC-7**	**697**	**EPA RSL**	**3.6**	**15**	**--**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	15	0%	0.38	41	--	--	ND	5.8	EPA RSL	0.89	--	6	--	--	--
Phenanthrene	mg/kg	25	30	83%	0.079	0.13	0.0094	7800	HC-7	413	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	22	30	73%	0.0078	0.13	0.042	5200	TP-4	345	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**22**	**30**	**73%**	**0.00780**	**0.130**	**0.125**	**21955**	**TP-4**	**1248**	**Eco SSL Mammal**	**1.1**	**18**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**28**	**30**	**93%**	**0.0790**	**0.0840**	**0.148**	**25820**	**HC-7**	**1466**	**Eco SSL Invert**	**29**	**14**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**22**	**30**	**73%**	**0.00780**	**0.130**	**0.00727**	**2751**	**TP-4**	**144**	**EPA RSL**	**0.015**	**21**	**5**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL - Regional Screening Level for Resident Soil
Eco SSL Avian - Ecological Soil Screening Level - Avian
Eco SSL Mammal - Ecological Soil Screening Level - Mammalian
Eco SSL Invert - Ecological Soil Screening Level - Soil Invertebrate

Table 5.3-3b
Statistical Summary of Indicator Chemicals in Subsurface Soil - Quendall Property, QA0 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	17	42	40%	0.051	0.89	0.026	220	BH-27	8.6	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	5	42	12%	0.051	8.5	0.32	82	BH-23	2.5	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	13	42	31%	0.051	0.89	0.092	300	BH-27	9.2	LPAH	--	--	--	--	--	--
Benzo(a)anthracene	mg/kg	13	42	31%	0.051	0.89	0.037	1900	BH-27	47	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	16	42	38%	0.051	0.25	0.055	1300	BH-27	33	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	3	14	21%	0.17	0.89	0.2	760	BH-27	55	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	10	42	24%	0.051	0.89	0.031	250	BH-27	7.3	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	2	14	14%	0.17	0.89	1.9	2200	BH-27	158	cPAH/HPAH	--	--	--	--	--	--
Chromium	**mg/kg**	**5**	**5**	**100%**	**--**	**--**	**17**	**28**	**BH-27**	**22**	**Eco SSL Avian**	**26**	**1**	**--**	**48.2**	**--**	**--**
Chrysene	mg/kg	14	42	33%	0.051	0.89	0.038	1700	BH-27	43	cPAH/HPAH	--	--	--	--	--	--
Copper	mg/kg	5	5	100%	--	--	9	22	BH-27	13	Eco SSL Avian	28	--	--	36.4	--	--
Dibenz(a,h)anthracene	mg/kg	9	42	21%	0.051	0.89	0.06	140	BH-27	3.8	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	16	42	38%	0.051	0.89	0.032	1200	BH-27	32	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	13	42	31%	0.051	0.89	0.15	180	BH-27	7.8	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	9	42	21%	0.051	0.89	0.22	280	BH-27	8.1	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**26**	**42**	**62%**	**0.055**	**0.89**	**0.077**	**3000**	**BH-23**	**86**	**EPA RSL**	**3.6**	**13**	**--**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	42	0%	0.25	42	--	--	ND	1.9	EPA RSL	0.89	--	10	--	--	--
Phenanthrene	mg/kg	18	42	43%	0.051	0.89	0.076	1100	BH-27	33	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	17	42	40%	0.051	0.89	0.031	1800	BH-27	46	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**20**	**42**	**48%**	**0.0510**	**0.340**	**0.322**	**11530**	**BH-27**	**290**	**Eco SSL**	**1.1**	**15**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**28**	**42**	**67%**	**0.0550**	**0.890**	**0.210**	**3398**	**BH-23**	**146**	**Eco SSL Invert**	**29**	**7**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**17**	**42**	**40%**	**0.0510**	**0.340**	**0.0661**	**1845**	**BH-27**	**46**	**EPA RSL**	**0.015**	**17**	**25**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL - EPA Regional Screening Level for Resident Soil
Eco SSL Avian - Ecological Soil Screening Level - Avian
Eco SSL Mammal - Ecological Soil Screening Level - Mammalian
Eco SSL Invert - Ecological Soil Screening Level - Soil Invertebrate

Table 5.3-4
Statistical Summary of Indicator Chemicals in Subsurface Soil - Railroad Property, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	24	51	47%	0.052	0.33	0.082	860	Q6	48	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	4	51	8%	0.052	46	0.73	3.5	Q2-C	2.1	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	17	51	33%	0.052	0.066	0.56	150	Q6	13	LPAH	--	--	--	--	--	--
Arsenic	**mg/kg**	**3**	**48**	**6%**	**5**	**9**	**7**	**10**	**Q1-D**	**6.4**	**EPA RSL**	**0.39**	**3**	**45**	**7.3**	**2**	**3**
Benzene	mg/kg	7	29	24%	0.005	0.22	0.016	0.75	Q4	0.087	EPA RSL	1.1	--	--	--	--	--
Benzo(a)anthracene	mg/kg	18	51	35%	0.052	0.066	0.071	310	Q6	17	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	18	51	35%	0.052	19	0.078	130	Q6	11	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	17	51	33%	0.052	19	0.068	150	Q6	9.9	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	14	51	27%	0.052	46	0.19	38	Q9	4.2	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	16	51	31%	0.052	19	0.32	95	Q6	8.0	cPAH/HPAH	--	--	--	--	--	--
Chrysene	mg/kg	19	51	37%	0.052	0.066	0.064	190	Q6	15	cPAH/HPAH	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg	9	51	18%	0.052	46	0.067	9.1	Q7	2.4	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	22	51	43%	0.052	0.066	0.07	1300	Q6	64	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	19	51	37%	0.052	0.066	0.18	660	Q6	35	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	15	51	29%	0.052	46	0.066	34	Q9	3.9	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**35**	**51**	**69%**	**0.052**	**0.066**	**0.07**	**960**	**Q6**	**69**	**EPA RSL**	**3.6**	**15**	**--**	**--**	**--**	**--**
Pentachlorophenol	mg/kg	0	14	0%	0.3	3.1	--	--	ND	0.67	EPA RSL	0.89	--	3	--	--	--
Phenanthrene	mg/kg	30	51	59%	0.052	0.066	0.058	2200	Q6	119	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	20	51	39%	0.052	0.066	0.081	900	Q6	52	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**23**	**51**	**45%**	**0.0520**	**0.0660**	**0.346**	**3144**	**Q6**	**185**	**Eco SSL**	**1.1**	**17**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**39**	**51**	**76%**	**0.0520**	**0.330**	**0.223**	**4853**	**Q6**	**286**	**Eco SSL Invert**	**29**	**15**	**--**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**mg/kg**	**20**	**51**	**39%**	**0.0520**	**0.0660**	**0.04864**	**192**	**Q6**	**15**	**EPA RSL**	**0.015**	**20**	**31**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA RSL = EPA Regional Screening Level for Resident Soil
Eco SSL = Ecological Soil Screening Level
Eco SSL Invert = Ecological Soil Screening Level - Soil Invertebrate

Table 5.4-1
Statistical Summary of Indicator Chemicals in Surface Bulk Sediment, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
4-Methylphenol (p-Cresol)	**mg/kg**	**18**	**31**	**58%**	**0.02**	**0.39**	**0.017**	**0.75**	**BG-03**	**0.076**	**EPA R3 BTAG**	**0.67**	**1**	**--**	**--**	**--**	**--**
Acenaphthene	mg/kg	66	103	64%	0.0047	0.39	0.0054	190	TD-15-SS	4.9	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	55	103	53%	0.0047	0.39	0.0067	3	WP-20B	0.15	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	95	103	92%	0.0047	0.39	0.0055	240	TD-08-SS	4.3	LPAH	--	--	--	--	--	--
Benzo(a)anthracene	mg/kg	101	103	98%	0.24	0.39	0.017	260	TD-08-SS	7.6	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	101	103	98%	0.0097	0.24	0.021	140	WP-20B	7.4	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	102	103	99%	0.24	0.24	0.024	130	WP-20B	7.7	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	102	103	99%	0.24	0.24	0.0093	33	TD-08-SS	2.9	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	102	103	99%	0.24	0.24	0.018	130	WP-20B	5.9	cPAH/HPAH	--	--	--	--	--	--
Chrysene	mg/kg	102	103	99%	0.24	0.24	0.028	340	TD-08-SS	9.3	cPAH/HPAH	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg	96	103	93%	0.0066	0.39	0.006	17	TD-08-SS	1.1	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	101	103	98%	0.24	0.39	0.024	670	TD-15-SS	19	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	71	103	69%	0.0047	0.39	0.0052	160	TD-15-SS	4.1	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	102	103	99%	0.24	0.24	0.0093	34	TD-08-SS	2.9	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**58**	**103**	**56%**	**0.0047**	**0.45**	**0.0049**	**150**	**WP-20B**	**1.8**	**EPA R3 BTAG**	**0.176**	**20**	**7**	**--**	**--**	**--**
PAH Total ESBQ (U=1/2)	**TU**	**103**	**103**	**100%**	**--**	**--**	**0.0130**	**121**	**TD-15-SS**	**3.3**	**ESB**	**1**	**24**	**--**	**--**	**--**	**--**
Phenanthrene	mg/kg	101	103	98%	0.24	0.39	0.008	720	TD-15-SS	18	LPAH	--	--	--	--	--	--
Phenol	mg/kg	11	31	35%	0.02	0.39	0.024	0.31	JB-3	0.058	EPA R3 BTAG	0.42	--	--	--	--	--
Pyrene	mg/kg	102	103	99%	0.39	0.39	0.02	440	TD-15-SS	14	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**103**	**103**	**100%**	**--**	**--**	**0.188**	**2004**	**TD-08-SS**	**78**	**EPA R3 BTAG**	**0.19**	**102**	**--**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**101**	**103**	**98%**	**0.24**	**0.39**	**0.0245**	**1134**	**TD-15-SS**	**33**	**EPA R3 BTAG**	**0.076**	**94**	**2**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	mg/kg	102	103	99%	0.24	0.24	0.0134	178	WP-20B	10.0	NA	--	--	--	0.15	91	1
Total cPAH TEQ/OCN	mg/kg	102	103	99%	4	4	0.951	2914	WP-20B	180	NA	--	--	--	6.2	86	--
Total Organic Carbon	**PCT**	**150**	**150**	**100%**	**--**	**--**	**0.32**	**31.3**	**NS-06-VC**	**7.0**	**Ecol 2003 LAET**	**9.82**	**27**	**--**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram; TU - toxic unit(s). Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA R3 BTAG - EPA Region 3 Biological Technical Assistance Group
ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient
Ecol 2003 LAET - Ecology 2003 lowest apparent effects threshhold
NA - not available

Table 5.4-2
Statistical Summary of Indicator Chemicals in Subsurface Bulk Sediment, QA1 and QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels				Background		
											Source	Value	Number of Detections > Value	Number of Nondetects > Value	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	mg/kg	55	108	51%	0.0037	0.26	0.0067	170	VS-30	6.3	LPAH	--	--	--	--	--	--
Acenaphthylene	mg/kg	22	108	20%	0.0037	21	0.0051	320	VS-30	3.8	LPAH	--	--	--	--	--	--
Anthracene	mg/kg	44	108	41%	0.0037	21	0.0093	120	VS-30	3.9	LPAH	--	--	--	--	--	--
Benzo(a)anthracene	mg/kg	52	108	48%	0.0037	0.21	0.0052	300	VS-30	8.4	cPAH/HPAH	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg	53	108	49%	0.0037	0.21	0.0089	680	VS-30	14	cPAH/HPAH	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg	57	108	53%	0.0037	0.21	0.0054	660	VS-30	14	cPAH/HPAH	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg	52	108	48%	0.0037	0.21	0.0051	380	VS-30	7.8	HPAH	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg	56	108	52%	0.0037	0.21	0.0052	440	VS-30	10	cPAH/HPAH	--	--	--	--	--	--
Chrysene	mg/kg	54	108	50%	0.0037	0.21	0.0053	460	VS-30	11	cPAH/HPAH	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg	38	108	35%	0.0037	21	0.0068	96	VS-30	2.2	cPAH/HPAH	--	--	--	--	--	--
Fluoranthene	mg/kg	56	108	52%	0.0037	0.21	0.005	400	S-51	14	HPAH	--	--	--	--	--	--
Fluorene	mg/kg	48	108	44%	0.0037	0.21	0.0087	220	VS-30	5.5	LPAH	--	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	51	108	47%	0.0037	0.21	0.0067	440	VS-30	8.4	cPAH/HPAH	--	--	--	--	--	--
Naphthalene	**mg/kg**	**59**	**108**	**55%**	**0.0037**	**0.18**	**0.0063**	**7800**	**VS-30**	**102**	**EPA R3 BTAG**	**0.176**	**44**	**1**	**--**	**--**	**--**
PAH Total ESBQ (U=1/2)	**TU**	**108**	**108**	**100%**	**--**	**--**	**0.00100**	**576**	**VS-30**	**16**	**ESB**	**1**	**38**	**--**	**--**	**--**	**--**
Phenanthrene	mg/kg	57	108	53%	0.0037	0.21	0.005	540	VS-30	18	LPAH	--	--	--	--	--	--
Pyrene	mg/kg	55	108	51%	0.0037	0.21	0.0074	600	VS-30	17	HPAH	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	**mg/kg**	**60**	**108**	**56%**	**0.00370**	**0.210**	**0.0266**	**4326**	**VS-30**	**107**	**EPA R3 BTAG**	**0.19**	**48**	**1**	**--**	**--**	**--**
Total 6 of 16 LPAHs (U=1/2)	**mg/kg**	**74**	**108**	**69%**	**0.00370**	**0.0880**	**0.0173**	**9170**	**VS-30**	**139**	**EPA R3 BTAG**	**0.076**	**60**	**3**	**--**	**--**	**--**
Total cPAH TEQ (7 minimum, CAEPA 2009) (U = 1/2)	mg/kg	57	108	53%	0.00370	0.210	0.00454	878	VS-30	18	NA	--	--	--	0.15	40	1
Total cPAH TEQ/OCN	mg/kg	57	108	53%	0.0106	29.6	0.0323	28538	VS-21	740	NA	--	--	--	6.2	40	4
Total Organic Carbon	**PCT**	**160**	**160**	**100%**	**--**	**--**	**0.178**	**46.2**	**TD-10-VC**	**4.5**	**Ecol 2003 LAET**	**9.82**	**18**	**--**	**--**	**--**	**--**

Notes:
mg/kg - milligram(s) per kilogram; TU - toxic unit(s). Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH, HPAH, and/or LPAH in this column indicates that these individual PAHs are evaluated as cPAH TEQs, HPAHs, and/or LPAHs, via PRG screening levels identified for those chemical groups.
EPA R3 BTAG - EPA Region 3 Biological Technical Assistance Group
ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient
Ecol 2003 LAET - Ecology 2003 lowest apparent effects threshhold
NA - not available

Table 5.4-3
Statistical Summary of Indicator Chemicals in Surface Sediment Porewater, QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels			
											Source	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	µg/L	36	72	50%	0.21	4.2	0.136	266	TD-15-SS	19	ESBQ	--	--	--
Acenaphthylene	µg/L	16	72	22%	0.21	5	0.109	6.24	TD-15-SS	0.71	ESBQ	--	--	--
Anthracene	µg/L	30	72	42%	0.12	4.2	0.0646	25	TD-08-SS	1.7	ESBQ	--	--	--
Benzene	**µg/L**	**8**	**34**	**24%**	**0.2**	**20**	**1.5**	**770**	**WP-19A**	**40**	**NRWQC**	**2.2**	**6**	**1**
Benzo(a)anthracene	µg/L	20	72	28%	0.0042	4.2	0.0307	22	WP-20B	0.68	cPAH/ESBQ	--	--	--
Benzo(a)pyrene	µg/L	22	72	31%	0.025	4.2	0.0146	30	WP-20B	0.76	cPAH/ESBQ	--	--	--
Benzo(b)fluoranthene	µg/L	24	72	33%	0.025	4.2	0.0146	32	WP-20B	0.80	cPAH/ESBQ	--	--	--
Benzo(g,h,i)perylene	µg/L	9	72	13%	0.025	4.2	0.0136	20	WP-20B	0.52	ESBQ	--	--	--
Benzo(k)fluoranthene	µg/L	25	72	35%	0.025	4.2	0.0122	29	WP-20B	0.73	cPAH/ESBQ	--	--	--
Chrysene	µg/L	31	72	43%	0.00455	4.2	0.00255	16	WP-20B	0.54	cPAH/ESBQ	--	--	--
Dibenz(a,h)anthracene	µg/L	4	72	6%	0.025	5	0.0161	0.0297	NS-05-VC	0.27	cPAH/ESBQ	--	--	--
Fluoranthene	µg/L	36	72	50%	0.0212	4.2	0.0261	54	TD-15-SS	2.8	ESBQ	--	--	--
Fluorene	µg/L	33	72	46%	0.12	4.2	0.0744	170	TD-15-SS	8.4	ESBQ	--	--	--
Indeno(1,2,3-c,d)pyrene	µg/L	9	72	13%	0.025	4.2	0.0143	14	WP-20B	0.42	cPAH/ESBQ	--	--	--
Naphthalene	**µg/L**	**20**	**72**	**28%**	**0.83**	**1**	**0.443**	**5500**	**WP-20B**	**117**	**EPA R3 BTAG**	**1.1**	**16**	**--**
PAH SPME ESBQ (U=0)	**TU**	**46**	**61**	**75%**	**0**	**0**	**0**	**75.8**	**NS-09-VC**	**5.4**	**ESB**	**1**	**15**	**--**
Phenanthrene	µg/L	37	72	51%	0.104	4.2	0.0628	138	TD-15-SS	8.9	ESBQ	--	--	--
Pyrene	µg/L	39	72	54%	0.022	4.2	0.0234	50	WP-20B	2.4	ESBQ	--	--	--
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**µg/L**	**39**	**72**	**54%**	**0.0250**	**4.20**	**0.0177**	**40.1**	**WP-20B**	**0.98**	**NRWQC**	**0.004**	**39**	**33**

Notes:
µg/L - microgram(s) per liter. Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH and/or ESBQ in this column indicates that these individual PAHs are evaluated as cPAHs and/or EQBQs, via PRG screening levels identified for those chemical groups.
EPA R3 BTAG - EPA Region 3 Biological Technical Assistance Group
ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient
NRWQC - EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism)

Table 5.4-4
Statistical Summary of Indicator Chemicals in Subsurface Sediment Porewater, QA2 Data

Chemical Name	Units	Number of Detections	Number of Samples	Frequency of Detection	Minimum Nondetect Value	Maximum Nondetect Value	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detection	Arithmetic Mean	PRG Screening Levels			
											Source	Value	Number of Detections > Value	Number of Nondetects > Value
Acenaphthene	µg/L	23	40	58%	0.026	0.946	0.067	223	NS-04-VC	18	ESBQ	--	--	--
Acenaphthylene	µg/L	9	40	23%	0.01	0.21	0.118	5.29	NS-04-VC	0.47	ESBQ	--	--	--
Anthracene	µg/L	19	40	48%	0.062	0.224	0.004	20.5	NS-04-VC	1.1	ESBQ	--	--	--
Benzene	**µg/L**	**12**	**32**	**38%**	**1**	**3**	**0.6**	**1200**	**NS-08-VC**	**74**	**NRWQC**	**2.2**	**9**	**1**
Benzo(a)anthracene	µg/L	12	40	30%	0.00328	0.067	0.015	0.821	NS-05-VC	0.071	cPAH/ESBQ	--	--	--
Benzo(a)pyrene	µg/L	14	40	35%	0.01	0.067	0.0128	0.463	NS-05-VC	0.057	cPAH/ESBQ	--	--	--
Benzo(b)fluoranthene	µg/L	17	40	43%	0.01	0.067	0.0124	0.447	NS-05-VC	0.054	cPAH/ESBQ	--	--	--
Benzo(g,h,i)perylene	µg/L	10	40	25%	0.01	0.067	0.01	0.0937	NS-05-VC	0.030	ESBQ	--	--	--
Benzo(k)fluoranthene	µg/L	16	40	40%	0.01	0.067	0.0153	0.445	NS-05-VC	0.054	cPAH/ESBQ	--	--	--
Chrysene	µg/L	13	40	33%	0.0042	0.252	0.00784	0.741	NS-05-VC	0.076	cPAH/ESBQ	--	--	--
Dibenz(a,h)anthracene	µg/L	4	40	10%	0.01	0.067	0.0079	0.0242	NS-14-VC	0.025	cPAH/ESBQ	--	--	--
Fluoranthene	µg/L	18	40	45%	0.0318	0.431	0.0052	14.9	NS-04-VC	0.86	ESBQ	--	--	--
Fluorene	µg/L	20	40	50%	0.062	0.189	0.0079	97.2	NS-04-VC	5.5	ESBQ	--	--	--
Indeno(1,2,3-c,d)pyrene	µg/L	10	40	25%	0.01	0.067	0.0072	0.0794	NS-05-VC	0.029	cPAH/ESBQ	--	--	--
Naphthalene	**µg/L**	**20**	**40**	**50%**	**0.045**	**0.83**	**0.49**	**1150**	**NS-10-VC**	**57**	**EPA R3 BTAG**	**1.1**	**16**	**--**
PAH SPME ESBQs (U=0)	**TU**	**28**	**35**	**80%**	**0**	**0**	**0**	**96.3**	**NS-04-VC**	**6.2**	**ESB**	**1**	**28**	**--**
PAH SPME ESBQs (U=1/2)	**TU**	**28**	**35**	**80%**	**1.75**	**1.76**	**1.75**	**97.2**	**NS-04-VC**	**7.8**	**ESB**	**1**	**28**	**7**
Phenanthrene	µg/L	18	40	45%	0.062	1.34	0.0086	106	NS-04-VC	5.7	ESBQ	--	--	--
Pyrene	µg/L	19	40	48%	0.01	0.34	0.0211	10	NS-04-VC	0.69	ESBQ	--	--	--
Total cPAH TEQ (7 minimum, CAEPA 2009) (U=1/2)	**µg/L**	**20**	**40**	**50%**	**0.010**	**0.0670**	**0.0181**	**0.651**	**NS-05-VC**	**0.072**	**NRWQC**	**0.004**	**20**	**20**

Notes:
µg/L - microgram(s) per liter; TU - toxic unit(s). Other abbreviations and acronyms for chemical names are provided in the notes on Table 5.1-1.
Bold indicates chemicals that exceed PRG screening levels.
U=1/2 denotes that when results were summed, non-detects were valued at one-half the detection limit.

PRG Screening Level Sources:
cPAH and/or ESBQ in this column indicates that these individual PAHs are evaluated as cPAHs and/or EQBQs, via PRG screening levels identified for those chemical groups.
EPA R3 BTAG - EPA Region 3 Biological Technical Assistance Group
ESBQ - equilibrium partitioning sediment benchmark (ESB) quotient
NRWQC - EPA National Recommended Water Quality Criterion for Human Health (for the Consumption of Water + Organism)

Table 6.2-1
Fate and Transport Properties of Site Contaminants of Interest

Analyte	CASRN	Solubility (mg/L) (20-25°C)	Henry's Law Constant (atm-m^3/mol)	Log Octanol-Water Partitioning Coefficient (Log K_{ow})	Soil-Soil Water Partitioning Coefficient (K_d in L/kg)	Source(s)
Coal Tar and Creosote Products						
Non-halogenated VOCs						
Benzene	71-43-2	1,790	0.0055	2.13	--	
Carbon disulfide	75-15-0	2,300 - 2,940	0.0122	1.84 - 2.16	--	2
Ethylbenzene	100-41-4	152 - 208	0.0066 - 0.0087	3.13 - 4.34	--	2
Styrene	100-42-5	300	0.00261	2.95	--	2
Toluene	108-88-3	534.8	0.00594	2.72	--	2
Xylenes (total)	1330-20-7	106	No data	No data	--	2
m-Xylene	108-38-3	161	0.00718	3.2	--	2
o-Xylene	95-47-6	178	0.00518	2.12	--	2
p-Xylene	106-42-3	162	0.0069	3.15	--	2
Non-halogenated SVOCs						
Polynuclear Aromatic Hydrocarbons						
2-Methylnaphthlene	91-57-6	24.6	0.000499	3.86	--	2
Acenaphthene	83-29-9	1.93	0.0000791	3.98	--	2
Acenaphthylene	208-96-8	3.93	0.00145	4.07	--	2
Anthracene	120-12-7	4.45	0.0000177	4.45	--	2
Benzo(a)anthracene	56-55-3	0.01	0.000001	5.61	--	2
Benzo(a)pyrene	50-32-8	0.0023	0.00000049	6.06	--	2
Benzo(b)fluoranthene	205-99-2	0.0012	0.0000122	6.04	--	2
Benzo(k)fluoranthene	207-08-9	0.00076	0.0000387	6.06	--	2
Chrysene	218-01-9	0.0028	0.00000105	5.16	--	2
Dibenz(a,h)anthracene	53-70-3	0.0005	0.000000073	6.84	--	2
Fluoranthene	206-44-0	0.20 - 0.26	0.0000065	4.9	--	2
Fluorene	86-73-7	1.68 - 1.98	0.0001	4.18	--	2
Indeno(1,2,3-cd)pyrene	193-39-5	0.062	6.95E-08	6.58	--	2
Naphthalene	91-20-3	31.7	0.00046	3.29	--	2
Phenanthrene	85-01-8	1.2	0.0000256	4.45	--	2
Pyrene	129-00-00	0.077	0.0000114	4.88	--	2
Semivolatiles, Miscellaneous						
Bis(2-	117-81-7	0.041	0.0000171	7.5	--	2
Dibenzofuran	132-64-9	3.1	0.000213	4.12	--	3
n-Nitroso-diphenylamine	86-30-6	40	0.00066	2.57 - 3.13	--	2
Semivolatiles, Phenolic						
2,4-Dimethylphenol	105-67-9	7,870	0.000017	2.3	--	3
2-Methylphenol	95-48-7	25,900	0.0000012	1.95	--	3
4-Methylphenol	106-44-5	21,400	0.000001	1.94	--	3
Phenol	108-95-2	82,800	0.000000333	1.46	--	2

Table 6.2-1
Fate and Transport Properties of Site Contaminants of Interest

Analyte	CASRN	Solubility (mg/L) (20-25°C)	Henry's Law Constant (atm-m^3/mol)	Log Octanol-Water Partitioning Coefficient (Log K_{ow})	Soil-Soil Water Partitioning Coefficient (K_d in L/kg)	Source(s)
Other Sources						
Metals						
Arsenic	7440-38-2	Insoluble*	0.77	--	25-31	4, 6
Cadmium	7440-43-9	Insoluble*	0.031	--	15-4,300	5, 6
Chromium (III)[1]	7440-47-3	Insoluble*		--	1,200-430,000	5
Copper	7440-50-8	Insoluble*	0.025	--	22-132,000	5, 6
Iron	7439-89-6	Soluble*	0.025	--	--	6
Lead	7439-92-1	Insoluble*	0.025	--	900-280,000	5, 6
Nickel	7440-02-0	1.13 at 37 °C	0.025	--	16-1,900	5, 6
Zinc	7440-66-6	Insoluble*	0.025	--	16-530	5, 6
Halogenated VOCs						
1,3-Dichloropropane	142-28-9	2750	0.000976	2	--	3
Chloroform	67-66-3	7,220 - 9,300	0.003 - 0.00406	1.97	--	2
Dichloromethane	75-09-2	13,000	0.00325	1.25	--	3
Halogenated SVOCs						
Pentachlorophenol	87-86-5	14	0.000034	5.01	--	2
Total PCBs	--	--	--	--	--	--

Notes:

Indicator chemicals are shaded.

* Metal solubility is a function of valence state, redox conditions, and pH.

1. Soil conditions at the Site are characterized by high organic content, supporting a reducing environment, and neutral pH. Because the oxidizing environment required to maintain chromium (VI) is not present at the Site, chromium (VI) was not retained as a contaminant of interest. The screening was based on total chromium.
2. Agency for Toxic Substances and Disease Registry (ATSDR) Toxocological Profile Information Sheet: http://www.atsdr.cdc.gov/toxpro2.html
3. National Institute of Health National Library of Medicine Toxicology Data Network: http://toxnet.nlm.nih.gov/
4. Cornett et al., 1992, "Arsenic transport between water and sediments", Hydrobiologia 235/236, pp. 533-544.
5. Allison and Allison, 2005, Partition Coefficients For Metals in Surface Water, Soil, and Waste, EPA/600/R-05/074. http://www.epa.gov/athens/publications/reports/Ambrose600R05074PartitionCoefficients.pdf
6. U.S. Environmental Protection Agency Superfund Chemical Data Matrix (SCDM): http://www.epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm

CASRN - Chemical Abstracts Service Registry Number
atm-m^3/mol - atmosphere cubic meter per mole
mg/L - milligram(s) per liter
L/kg - liters per kilogram

Table 6.4-1
Estimated Contaminant Travel Times

Source Area	Pathway[1]	Groundwater Particle Travel Time in Years[2]	Retardation Factor[3]			Contaminant Travel Time in Years[5]		
			Benzene	Naphthalene	Benzo(a)Pyrene[4]	Benzene	Naphthalene	Benzo(a)Pyrene
Near MC-1, 15' bgs	Shallow Groundwater	3	2.2	13.2	18,000	7	40	54,000
Near BH-30, 33' bgs	Deep Groundwater	5	1.4	4.7	5,500	8	28	28,000

Notes:

[1]See Section 6.4.2 for discussion of pathways.

[2]Travel times were estimated using the groundwater flow model and are illustrated in the particle tracking output displayed in Figures D-16 through D-18 in Appendix D.

[3]Retardation factor =1+(bulk density/effective porosity)*(organic carbon fraction*$10^{\log Koc}$). See Table D-5 in Appendix D for the calculation of retardation factors for benzene and naphthalene.

[4]The retardation factor for benzo(a)pyrene was calculated using a log K_{oc} equal to 5.95, the most conservative value found in the Groundwater Chemicals Desk Reference (Montgomery, 1996).

[5]Contaminant travel time is the product of the contaminant's retardation factor and groundwater travel time.

bgs - below ground surface

Table 6.4-2
Summary of Cation Concentrations in Sediment Porewater for Contaminant Attenuation Evaluation

Depth (cm)	Potassium (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
Original Data				
Surface Water	0.90+/-0.00	4.2+/-0.060	9.0+/-0.09	3.4+/-0.04
0-10	2.2+/-0.45	8.2+/-1.4	22+/-3.4	8.2+/-2.1
40	3.1+/-0.33	15+/-1.5	26+/-3.4	11+/-1.8
125	3.3+/-0.38	20+/-1.7	28+/-4.6	15+/-2.2
Normalized Data (unitless)				
0-10	0.56+/-0.19	0.25+/-0.09	0.65+/-0.17	0.43+/-0.19
40	0.91+/-0.14	0.70+/-0.09	0.88+/-0.18	0.67+/-0.16
125	1.00+/-0.16	1.0+/-0.11	1.0+/-0.24	1.0+/-0.20

Notes:

All porewater concentrations are average values +/- standard error.

cm - centimeter(s)

mg/L - milligram(s) per liter

Table 6.4-3
Summary of Benzene and Naphthalene Concentrations in Sediment Porewater for Contaminant Attenuation Evaluation

Depth (cm)	Benzene (µg/L)	Naphthalene (µg/L)
Original Data		
0-10	0.39+/-0.15	2.2+/-1.1
40	134+/-86	102+/-68
125	2215+/-928	1487+/-550
Normalized Data (unitless)		
0-10	0.00018+/-0.00007	0.0015+/-0.00076
40	0.061+/-0.039	0.068+/-0.046
125	1.0+/-0.42	1.0+/-0.37

Notes:
All porewater concentrations are average values +/- standard error.
cm - centimeter(s)
µg/L - microgram(s) per liter

Table 7.1-1
Summary of Data Used for the Baseline Human Health Risk Assessment

Year	Matrix	Number of New Exploration Locations and General Type	Number of Samples and General Type	Chemicals	Reference	QA Level
1995	Soil	3 test pits, 8 borings	20 samples	pH, TOC, TPH, metals, pesticides/PCBs, SVOCs, and VOCs	Hart Crowser (1997)	QA1
1996	Surface Water	6 in-lake stations	6 samples near lake bottom	Conventional parameters, metals, SVOCs, and VOCs	Hart Crowser (1997)	QA1, QA1-
1997	Sediment	5 offshore locations	5 surface samples	Metals	Retec (1997b)	QA1, QA1-
2001	Soil	6 borings	6 subsurface samples	SVOCs and VOCs	Retec (2002)	QA1
2002	Sediment	4 neashore stations and 1 offshore station	5 surface samples	Conventional parameters, PAHs, and VOCs	Anchor and Aspect (2004)	QA2
2003	Sediment	3 offshore stations	3 surface samples	Conventional parameters, PAHs, and radiochemistry	Anchor and Aspect (2004)	QA2
2004	Soil	3 test pits, 8 borings	22 samples	SVOCs and VOCs	Anchor and Aspect (2004)	QA2
2008 and 2009	Groundwater	19 existing wells and 5 new wells	37 samples	SVOCs, VOCs, and metals	RI Sampling	QA2
2009	Sediment	41 offshore site locations, 10 background locations	44 site samples, 10 background samples	Conventional parameters, BTEX, and PAHs	RI Sampling	QA2
2009	Groundwater	6 well points	7 samples	SVOCs, BTEX, TPH, and metals	Pinnacle GeoSciences (2009)	QA2_TBD
2009	Soil	25 borings	50 samples	SVOCs, BTEX, TPH, and metals	Pinnacle GeoSciences (2009)	QA2_TBD

Notes:

BTEX - benzene, toluene, ethylbenzene, and xylenes
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls
RI = Remedial Investigation
SVOCs - semivolatile organic compounds
TOC - total organic carbon
TPH - total petroleum hydrocarbons
VOCs = volatile organic compounds

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing
Quendall Site													
Soil	TP-1	13-Jun-95	14_TP-1-6/13/95-6.5-7S	N	6.5	7	ft	X	X	X	--	--	--
Soil	TP-4	13-Jun-95	14_TP-4(1)-6/13/95-8-8.5S	N	8	8.5	ft	X	X	X	--	--	--
Soil	TP-4	13-Jun-95	14_TP-4-6/13/95-8-8.5S	N	8	8.5	ft	X	X	X	--	--	--
Soil	TP-4	13-Jun-95	14_TP-4-6/13/95-9.5-10S	N	9.5	10	ft	X	X	X	--	--	--
Soil	TP-5	13-Jun-95	14_TP-5-6/13/95-7-8S	N	7	8	ft	X	X	X	--	--	--
Soil	HC-1	14-Jun-95	14_HC-1-06/14/95-10-11.5S	N	10	11.5	ft	X	X	X	--	--	--
Soil	HC-2	14-Jun-95	14_HC-2-06/14/95-10-11.5S	N	10	11.5	ft	X	X	X	--	--	--
Soil	HC-2	14-Jun-95	14_HC-2-06/14/95-7.5-9S	N	7.5	9	ft	X	X	X	--	--	--
Soil	HC-3	14-Jun-95	14_HC-3-06/14/95-13-14.5S	N	13	14.5	ft	X	X	X	--	--	--
Soil	HC-3	14-Jun-95	14_HC-3-06/14/95-2.5-4S	N	2.5	4	ft	X	X	X	--	--	--
Soil	HC-3	14-Jun-95	14_HC-3-06/14/95-7.5-9S	N	7.5	9	ft	X	X	X	--	--	--
Soil	HC-4	14-Jun-95	14_HC-4-06/14/95-10-11.5S	N	10	11.5	ft	X	X	X	--	--	--
Soil	BH-28	15-Jun-95	14_BH-28-06/15/95-10-11.5S	N	10	11.5	ft	X	X	X	--	--	--
Soil	BH-28	15-Jun-95	14_BH-28-06/15/95-2.5-4S	N	2.5	4	ft	X	X	X	--	--	--
Soil	BH-28	15-Jun-95	14_BH-28-06/15/95-7.5-9S	N	7.5	9	ft	X	X	X	--	--	--
Soil	HC-5	15-Jun-95	14_HC-5-06/15/95-12.5-14S	N	12.5	14	ft	X	X	X	--	--	--
Soil	HC-7	15-Jun-95	14_HC-7-06/15/95-12.5-14S	N	12.5	14	ft	X	X	X	--	--	--
Soil	HC-8	15-Jun-95	14_HC-8-06/15/95-10-11.5S	N	10	11.5	ft	X	X	X	--	--	--
Soil	TP-1	19-Jun-95	14_TP-1-06/19/95-1-3S	N	1	3	ft	X	X	X	--	--	--
Soil	TP-4	19-Jun-95	14_TP-4-06/19/95-1-3S	N	1	3	ft	X	X	X	--	--	--
Soil	RB1	09-Apr-01	14_RB-1-0401	N	15	15	ft	X	X	X	--	--	--
Soil	RB7	10-Apr-01	14_RB-7-0401	N	10	10	ft	X	X	X	--	--	--
Soil	RB8	10-Apr-01	14_RB-8-0401	N	14	14	ft	X	X	X	--	--	--
Soil	RB10	11-Apr-01	14_RB-10-0401	N	11	11	ft	X	X	X	--	--	--
Soil	RB21	13-Apr-01	14_RB-21-0401-S-12-14	N	12	14	ft	X	X	X	--	--	--
Soil	RB22	13-Apr-01	14_RB-22-0401-S	N	13	13	ft	X	X	X	--	--	--
Soil	SS-BH-27	27-Feb-04	SS-BH27-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-BH-27	27-Feb-04	SS-BH27-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-BH-7	27-Feb-04	SS-BH7-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-BH-9	27-Feb-04	SS-BH7-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-BH-9	27-Feb-04	SS-BH9-0/2	N	0	2	ft	X	X	X	--	--	--
Soil	SS-BH-9	27-Feb-04	SS-BH9-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-HC-2	27-Feb-04	SS-HC2-0/2.3	N	0	2.3	ft	X	X	X	--	--	--
Soil	SS-HC-2	27-Feb-04	SS-HC2-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-HC-5	27-Feb-04	SS-HC5-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-HC-5	27-Feb-04	SS-HC5-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-HC-8	27-Feb-04	SS-HC8-0/2.1	N	0	2.1	ft	X	X	X	--	--	--
Soil	SS-HC-8	27-Feb-04	SS-HC8-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-TP-2	27-Feb-04	SS-TP2-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-TP-2	27-Feb-04	SS-TP2-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-BH-19	01-Mar-04	SS-BH19-0.3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-BH-19	01-Mar-04	SS-BH19-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-HC-7	01-Mar-04	SS-HC7-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-HC-7	01-Mar-04	SS-HC7-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-TP-4	01-Mar-04	SS-TP4-0/3	N	0	3	ft	X	X	X	--	--	--

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing
Soil	SS-TP-4	01-Mar-04	SS-TP4-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Soil	SS-TP-5	01-Mar-04	SS-TP5-0/3	N	0	3	ft	X	X	X	--	--	--
Soil	SS-TP-5	01-Mar-04	SS-TP5-1.5	N	1.5	1.5	ft	X	X	X	--	--	--
Railroad Property													
Soil	B1-A	27-Aug-08	B1-A-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	B1-A	27-Aug-08	B1-A-10.0	N	9.5	10	ft	X	X	X	--	--	--
Soil	B1-A	27-Aug-08	B1-A-15.0	N	14.5	15	ft	X	X	X	--	--	--
Soil	B1-A	27-Aug-08	B1-A-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	B1-A	27-Aug-08	B1-A-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	B1-B	27-Aug-08	B1-B-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	B1-B	27-Aug-08	B1-B-3.0	N	2.5	3	ft	X	X	X	--	--	--
Soil	B1-B	27-Aug-08	B1-B-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	B1-C	27-Aug-08	B1-C-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q1-A	27-Aug-08	Q1-A-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	Q1-A	27-Aug-08	Q1-A-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q1-B	27-Aug-08	Q1-B-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	Q1-B	27-Aug-08	Q1-B-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q1-C	27-Aug-08	Q1-C-2.5	N	2	2.5	ft	X	X	X	--	--	--
Soil	Q1-C	27-Aug-08	Q1-C-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q1-D	27-Aug-08	Q1-D-15.0	N	14.5	15	ft	X	X	X	--	--	--
Soil	Q1-D	27-Aug-08	Q1-D-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	Q1-D	27-Aug-08	Q1-D-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q1-D	27-Aug-08	Q1-D-9.0	N	8.5	9	ft	X	X	X	--	--	--
Soil	Q2-A	27-Aug-08	Q2-A-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	Q2-A	27-Aug-08	Q2-A-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q2-B	27-Aug-08	Q2-B-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	Q2-B	27-Aug-08	Q2-B-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q2-C	27-Aug-08	Q2-C-13.0	N	12.5	13	ft	X	X	X	--	--	--
Soil	Q2-C	27-Aug-08	Q2-C-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	Q2-C	27-Aug-08	Q2-C-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q2-D	27-Aug-08	Q2-D-10.0	N	9.5	10	ft	X	X	X	--	--	--
Soil	Q2-D	27-Aug-08	Q2-D-13.0	N	12.5	13	ft	X	X	X	--	--	--
Soil	Q2-D	27-Aug-08	Q2-D-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	Q2-D	27-Aug-08	Q2-D-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q3-A	27-Aug-08	Q3-A-1.0	N	0.5	1	ft	X	X	X	--	--	--
Soil	Q3-A	27-Aug-08	Q3-A-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q13	28-Oct-08	Q13-10.0	N	9.5	10	ft	X	X	X	--	--	--
Soil	Q13	28-Oct-08	Q13-15.0	N	14.5	15	ft	X	X	X	--	--	--
Soil	Q17	28-Oct-08	Q17-11.0	N	10.5	11	ft	X	X	X	--	--	--
Soil	Q4	28-Oct-08	Q4-15.0	N	14.5	15	ft	X	X	X	--	--	--
Soil	Q4	28-Oct-08	Q4-2.5	N	2	2.5	ft	X	X	X	--	--	--
Soil	Q5	28-Oct-08	Q5-14.0	N	13.5	14	ft	X	X	X	--	--	--
Soil	Q6	28-Oct-08	Q6-4.0	N	3.5	4	ft	X	X	X	--	--	--
Soil	Q10	29-Oct-08	Q10-5.0	N	4.5	5	ft	X	X	X	--	--	--
Soil	Q14	29-Oct-08	Q14-2.5	N	2	2.5	ft	X	X	X	--	--	--
Soil	Q14	29-Oct-08	Q14-6.5	N	6	6.5	ft	X	X	X	--	--	--

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing
Soil	Q16	29-Oct-08	Q16-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	Q7	29-Oct-08	Q7-4.0	N	3.5	4	ft	X	X	X	--	--	--
Soil	Q7	29-Oct-08	Q7-9.0	N	8.5	9	ft	X	X	X	--	--	--
Soil	Q8	29-Oct-08	Q8-3.5	N	3	3.5	ft	X	X	X	--	--	--
Soil	Q11	30-Oct-08	Q11-11.5	N	11	11.5	ft	X	X	X	--	--	--
Soil	Q12	30-Oct-08	Q12-15.0	N	14.5	15	ft	X	X	X	--	--	--
Soil	Q12	30-Oct-08	Q12-4.5	N	4	4.5	ft	X	X	X	--	--	--
Soil	Q15	30-Oct-08	Q15-4.0	N	3.5	4	ft	X	X	X	--	--	--
Quendall Site													
Groundwater	BH-18B	19-Nov-08	BH-18B-11192008-WG	N	42	52	ft	X	--	X	--	--	--
Groundwater	BH-19B	19-Nov-08	BH-19B-11192008-WG	N	40	50	ft	X	--	X	--	--	--
Groundwater	BH-24	19-Nov-08	BH-24-11192008-WG	N	9	19	ft	X	--	X	--	--	--
Groundwater	BH-28A	19-Nov-08	BH-28A-11192008-WG	N	5	15	ft	X	--	X	--	--	--
Groundwater	BH-28B	19-Nov-08	BH-28B-11192008-WG	N	40	50	ft	X	--	X	--	--	--
Groundwater [b]	BH-5A	19-Nov-08	BH-5A-11192008-WG	N	5	10	ft	X	--	X	--	--	--
Groundwater	BH-18A	20-Nov-08	BH-18A-11202008-WG	N	4	14	ft	X	--	X	--	--	--
Groundwater	BH-19	20-Nov-08	BH-19-11202008-WG	N	5	15	ft	X	--	X	--	--	--
Groundwater	BH-20A	20-Nov-08	BH-20A-11202008-WG	N	7	22	ft	X	--	X	--	--	--
Groundwater	BH-20B	20-Nov-08	BH-20B-11202008-WG	N	39	49	ft	X	--	X	--	--	--
Groundwater	BH-21B	20-Nov-08	BH-21B-11202008-WG	N	41.5	51.5	ft	X	--	X	--	--	--
Groundwater [b]	BH-5	11-Sep-09	BH-509112009	N	13	23	ft	X	--	X	--	--	--
Groundwater	BH-5B	11-Sep-09	BH-5B09112009	N	40	49.63	ft	X	--	X	--	--	--
Groundwater	BH-5B	11-Sep-09	FD-2-09112009	FD	40	49.63	ft	X	--	X	--	--	--
Groundwater	BH-18A	11-Sep-09	BH-18A09112009	N	4	14	ft	X	--	X	--	--	--
Groundwater	BH-18B	11-Sep-09	BH-18B09112009	N	42	52	ft	X	--	X	--	--	--
Groundwater	BH-19	10-Sep-09	BH-1909102009	N	5	15	ft	X	--	X	--	--	--
Groundwater	BH-19B	10-Sep-09	BH-19B09102009	N	40	50	ft	X	--	X	--	--	--
Groundwater	BH-20A	10-Sep-09	BH-20A09102009	N	7	22	ft	X	--	X	--	--	--
Groundwater	BH-20B	10-Sep-09	BH-20B09102009	N	39	49	ft	X	--	X	--	--	--
Groundwater	BH-20C	10-Sep-09	BH-20C09102009	N	113	120.35	ft	X	--	X	--	--	--
Groundwater	BH-21A	10-Sep-09	BH-21A09102009	N	9	19	ft	X	--	X	--	--	--
Groundwater	BH-21B	10-Sep-09	BH-21B09102009	N	41.5	51.5	ft	X	--	X	--	--	--
Groundwater	BH-22	10-Sep-09	BH-2209102009	N	15	25	ft	X	--	X	--	--	--
Groundwater	BH-23	11-Sep-09	BH-2309112009	N	6	21.5	ft	X	--	X	--	--	--
Groundwater	BH-24	10-Sep-09	BH-2409102009	N	9	19	ft	X	--	X	--	--	--
Groundwater	BH-25A(R)	09-Sep-09	BH-25AR09092009	N	8	18	ft	X	--	X	--	--	--
Groundwater	BH-26A	09-Sep-09	BH-26A09092009	N	7	12	ft	X	--	X	--	--	--
Groundwater	BH-26B	09-Sep-09	BH-26B09092009	N	25	36	ft	X	--	X	--	--	--
Groundwater	BH-28A	10-Sep-09	BH-28A09102009	N	5	15	ft	X	--	X	--	--	--
Groundwater	BH-28A	10-Sep-09	FD-1-09102009	FD	5	15	ft	X	--	X	--	--	--
Groundwater	BH-28B	10-Sep-09	BH-28B09102009	N	40	50	ft	X	--	X	--	--	--
Groundwater	BH-29A	09-Sep-09	BH-29A09092009	N	8.5	18.5	ft	X	--	X	--	--	--
Groundwater	BH-29B	09-Sep-09	BH-29B09092009	N	39	49.6	ft	X	--	X	--	--	--
Groundwater	BH-30C	28-Oct-09	BH-30C-10282009-W6	N	85	95	ft	X	--	X	--	--	--
Groundwater	RW-NS-1	11-Sep-09	RW-NS-109112009	N	6.5	16.5	ft	X	--	X	--	--	--
Groundwater	RW-QP-1	11-Sep-09	RW-QP-109112009	N	6.5	16.5	ft	X	--	X	--	--	--

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing
Railroad Property													
Groundwater	Q1-D	27-Aug-08	Q1-D-W	N	15	20	ft	X	--	X	--	--	--
Groundwater	Q12	03-Nov-08	Q12-W	N	14.9	19.9	ft	X	--	X	--	--	--
Groundwater	Q12	03-Nov-08	WD-2 (Q12-W)	FD	14.9	19.9	ft	X	--	X	--	--	--
Groundwater	Q14	03-Nov-08	Q14-W	N	10.3	15.3	ft	X	--	X	--	--	--
Groundwater	Q17-W	03-Nov-08	Q17-W	N	12.4	17.4	ft	X	--	X	--	--	--
Groundwater	Q4	03-Nov-08	Q4-W	N	12.4	17.9	ft	X	--	X	--	--	--
Groundwater	Q9	03-Nov-08	Q9-W	N	15.8	20.8	ft	X	--	X	--	--	--
Sediment (Nearshore)	WP-19A	24-Sep-02	WP-19A-SED	N	0	10	cm	--	--	--	X	X	X
Sediment (Nearshore)	WP-19B	24-Sep-02	WP-19B-SED	N	0	10	cm	--	--	--	X	X	X
Sediment (Nearshore)	WP-19C	24-Sep-02	WP-19C-SED	N	0	10	cm	--	--	--	X	X	X
Sediment (Nearshore)	WP-20A	25-Sep-02	WP-20A-SED	N	0	10	cm	--	--	--	X	X	X
Sediment (Nearshore)	NS-03-SS	16-Jun-09	NS-03-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Nearshore)	NS-11-SS	16-Jun-09	NS-11-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Offshore)[a]	JB-1	07-Feb-97	14_JB-1-02/07/97-0-10SD	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)[a]	JB-2	07-Feb-97	14_JB-2-02/07/97-0-10SD	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)[a]	JB-3	07-Feb-97	14_JB-3-02/07/97-0-10SD	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)[a]	JB-7	14-Feb-97	14_JB-7-02/14/97-0-10SD	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)[a]	JB-8	14-Feb-97	14_JB-8-02/14/97-0-10SD	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)	WP-20B	25-Sep-02	WP-20B-SED	N	0	10	cm	--	--	--	X	X	X
Sediment (Offshore)	S-52	18-Sep-03	AQT-S052-CA	N	0	10	cm	--	--	--	--	X	X
Sediment (Offshore)	QB-4	19-Sep-03	AQT-QB4-CA	N	0	10	cm	--	--	--	--	X	X
Sediment (Offshore)	WP-20B	19-Sep-03	AQT-WP20B-CA	N	0	10	cm	--	--	--	--	X	X
Sediment (Offshore)	TD-07-SS	29-May-09	TD-07-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-09-SS	29-May-09	TD-09-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-10-SS	29-May-09	TD-10-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-11-SS	29-May-09	TD-11-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-12-SS	29-May-09	TD-12-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-13-SS	29-May-09	TD-13-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-14-SS	29-May-09	TD-14-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-14-SS	29-May-09	TD-64-BS	FD	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	NS-12-SS	15-Jun-09	NS-12-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	NS-16-SS	15-Jun-09	NS-16-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-03-SS	15-Jun-09	SS-03-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-04-SS	15-Jun-09	SS-04-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-05-SS	15-Jun-09	SS-05-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-06-SS	15-Jun-09	SS-06-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-08-SS	15-Jun-09	TD-08-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-15-SS	15-Jun-09	TD-15-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	NS-07-SS	16-Jun-09	NS-07-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-01-SS	16-Jun-09	SS-01-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	SS-02-SS	16-Jun-09	SS-02-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	NS-06-SS	17-Jun-09	NS-06-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-04-SS	17-Jun-09	WD-04-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-05-SS	17-Jun-09	WD-05-BS	N	0	4	in	--	--	--	--	X	X

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing
Sediment (Offshore)	WD-01-SS	18-Jun-09	WD-01-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-02-SS	18-Jun-09	WD-02-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-03-SS	18-Jun-09	WD-03-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-06-SS	18-Jun-09	WD-06-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-07-SS	18-Jun-09	WD-07-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-08-SS	18-Jun-09	WD-08-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-08-SS	18-Jun-09	WD-58-BS	FD	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	WD-09-SS	18-Jun-09	WD-09-BS	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-CT-1	30-Sep-09	TD-CT-01-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-CT-2	30-Sep-09	TD-CT-02-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-1	30-Sep-09	TD-SO-01-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-2	30-Sep-09	TD-SO-02-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-2	30-Sep-09	TD-SO-52-SS-090930	FD	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-3	30-Sep-09	TD-SO-03-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-4	30-Sep-09	TD-SO-04-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-5	30-Sep-09	TD-SO-05-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-6	30-Sep-09	TD-SO-06-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-7	30-Sep-09	TD-SO-07-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-8	30-Sep-09	TD-SO-08-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Offshore)	TD-SO-9	30-Sep-09	TD-SO-09-SS-090930	N	0	4	in	--	--	--	--	X	X
Sediment (Background)	BG-12	27-May-09	BG-12-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-13	27-May-09	BG-13-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-15	27-May-09	BG-15-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-17	27-May-09	BG-17-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-19	27-May-09	BG-19-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-02	28-May-09	BG-02-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-03	28-May-09	BG-03-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-04	28-May-09	BG-04-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-06	28-May-09	BG-06-BS	N	0	4	in	--	--	--	X	X	X
Sediment (Background)	BG-09	28-May-09	BG-09-BS	N	0	4	in	--	--	--	X	X	X
Surface Water	SW-1	19-Jan-96	SW-01	N	--	--	--	--	--	--	X	--	--
Surface Water	SW-2	19-Jan-96	SW-02	N	--	--	--	--	--	--	X	--	--
Surface Water	SW-3	19-Jan-96	SW-03	N	--	--	--	--	--	--	X	--	--
Surface Water	SW-4	18-Jan-96	SW-04	N	--	--	--	--	--	--	X	--	--
Surface Water	SW-5	18-Jan-96	SW-05	N	--	--	--	--	--	--	X	--	--
Surface Water	SW-6	19-Jan-96	SW-06	N	--	--	--	--	--	--	X	--	--

Notes:

[a] Metals results from these samples were also used to represent nearshore sediment.

[b] Wells BH-5 and BH-5A are part of a well cluster and are located within 10 feet of each other. The maximum concentration for these two wells was applied as the BH-5/BH-5A maximum exposure concentration for the risk assessment.

The data presented in this table were collected during the Quendall Site investigations listed in Table 7.1-1.

cm - centimeter(s)
FD - field duplicate
ft - foot/feet
in - inch(es)

Table 7.1-2
Samples Used in the Baseline Human Health Risk Assessment

Exposure Medium	Sample Location	Sample Date	Sample ID	Sample Type	Start Depth	End Depth	Depth Units	Human Exposure Scenarios					
								Residential	Occupational Worker	Construction/ Excavation Worker	Recreational Beach User	Recreational Fishing	Subsistence Fishing

N - normal

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Soil	2-Methylnaphthalene	mg/kg	83	54	65%	0.025	5,200	175.5	3.3	533.1	533.1	97.5% KM (Chebyshev) UCL
Soil	Arsenic	mg/kg	61	33	54%	1.5	110	13.45	7.5	12.26	12.26	95% KM (t) UCL
Soil	Benzene	mg/kg	39	7	18%	0.038	4.4	0.916	0.35	0.4	0.4	95% KM (t) UCL
Soil	Benzo(a)anthracene	mg/kg	83	67	81%	0.012	1,500	81.08	4.9	220.3	220.3	97.5% KM (Chebyshev) UCL
Soil	Benzo(a)pyrene	mg/kg	83	65	78%	0.02	2,100	113.6	5.2	299.6	299.6	97.5% KM (Chebyshev) UCL
Soil	Benzo(b)fluoranthene	mg/kg	83	65	78%	0.018	1,700	87.53	4.9	229.7	229.7	97.5% KM (Chebyshev) UCL
Soil	Benzo(g,h,i)perylene	mg/kg	83	64	77%	0.015	1,500	66.97	2.3	196.8	196.8	97.5% KM (Chebyshev) UCL
Soil	Benzo(k)fluoranthene	mg/kg	83	65	78%	0.019	1,400	66.42	3.8	178.3	178.3	97.5% KM (Chebyshev) UCL
Soil	Chromium	mg/kg	8	8	100%	18.3	65.3	37.58	29.7	49.66	49.66	95% Student's-t UCL
Soil	Chrysene	mg/kg	83	68	82%	0.019	2,500	125.4	7	343	343	97.5% KM (Chebyshev) UCL
Soil	Dibenz(a,h)anthracene	mg/kg	83	44	53%	0.041	190	17.41	1.35	32.16	32.16	97.5% KM (Chebyshev) UCL
Soil	Dibenzofuran	mg/kg	82	46	56%	0.011	1,200	40.64	1.95	115.3	115.3	97.5% KM (Chebyshev) UCL
Soil	Ethylbenzene	mg/kg	39	12	31%	0.11	92	10.36	1.7	18.49	18.49	97.5% KM (Chebyshev) UCL
Soil	Fluoranthene	mg/kg	83	68	82%	0.027	4,400	201.5	7.75	588	588	97.5% KM (Chebyshev) UCL
Soil	Fluorene	mg/kg	83	59	71%	0.016	2,500	81.3	2.7	251.4	251.4	97.5% KM (Chebyshev) UCL
Soil	Indeno(1,2,3-c,d)pyrene	mg/kg	83	61	73%	0.014	1,500	59.83	2.5	173.5	173.5	97.5% KM (Chebyshev) UCL
Soil	Lead	mg/kg	52	38	73%	3	1,120	129.8	18.5	327.1	327.1	97.5% KM (Chebyshev) UCL
Soil	Naphthalene	mg/kg	98	73	74%	0.0029	11,000	285.2	2	984.5	984.5	97.5% KM (Chebyshev) UCL
Soil	Phenanthrene	mg/kg	83	73	88%	0.012	7,800	289	6.1	930.7	930.7	97.5% KM (Chebyshev) UCL
Soil	Pyrene	mg/kg	83	70	84%	0.042	5,200	284	12.5	818.4	818.4	97.5% KM (Chebyshev) UCL
Groundwater	2,4-Dimethylphenol	ug/L	30	5	17%	3.4	9,500	--	--	--	SS	--
Groundwater	2-Methylnaphthalene*	ug/L	30	27	90%	0.054	17,000	--	--	--	SS	--
Groundwater	2-Methylphenol (o-Cresol)	ug/L	30	3	10%	7.9	2,000	--	--	--	SS	--
Groundwater	4-Methylphenol (p-Cresol)	ug/L	30	5	17%	1.2	7,800	--	--	--	SS	--
Groundwater	Acenaphthene*	ug/L	30	23	77%	0.19	10,000	--	--	--	SS	--
Groundwater	Anthracene*	ug/L	30	11	37%	0.041	3,600	--	--	--	SS	--
Groundwater	Arsenic	ug/L	30	24	80%	0.7	389	--	--	--	SS	--
Groundwater	Benzene*	ug/L	30	16	53%	0.4	31,000	--	--	--	SS	--
Groundwater	Benzo(a)anthracene	ug/L	30	7	23%	0.018	3,100	--	--	--	SS	--
Groundwater	Benzo(a)pyrene	ug/L	30	5	17%	0.24	2,000	--	--	--	SS	--
Groundwater	Benzo(b)fluoranthene	ug/L	30	6	20%	0.01	1,900	--	--	--	SS	--
Groundwater	Benzo(k)fluoranthene	ug/L	30	6	20%	0.01	1,400	--	--	--	SS	--
Groundwater	Bis(2-ethylhexyl) phthalate	ug/L	30	7	23%	1	8	--	--	--	SS	--
Groundwater	Chloroform*	ug/L	30	1	3%	0.3	0.3	--	--	--	SS	--
Groundwater	Chrysene	ug/L	30	8	27%	0.025	2,200	--	--	--	SS	--
Groundwater	Dibenz(a,h)anthracene	ug/L	30	4	13%	0.13	200	--	--	--	SS	--
Groundwater	Dibenzofuran*	ug/L	30	17	57%	0.2	3,800	--	--	--	SS	--
Groundwater	Ethylbenzene*	ug/L	30	16	53%	14	2,900	--	--	--	SS	--
Groundwater	Fluoranthene	ug/L	30	13	43%	0.077	10,000	--	--	--	SS	--
Groundwater	Fluorene*	ug/L	30	20	67%	0.15	7,300	--	--	--	SS	--
Groundwater	Indeno(1,2,3-c,d)pyrene	ug/L	30	5	17%	0.45	760	--	--	--	SS	--
Groundwater	Naphthalene*	ug/L	30	29	97%	0.14	45,000	--	--	--	SS	--
Groundwater	Phenanthrene	ug/L	30	20	67%	0.15	23,000	--	--	--	SS	--
Groundwater	Pyrene*	ug/L	30	14	47%	0.065	11,000	--	--	--	SS	--
Groundwater	Styrene*	ug/L	30	3	10%	1.6	4,400	--	--	--	SS	--
Groundwater	Toluene*	ug/L	30	15	50%	0.6	19,000	--	--	--	SS	--
Groundwater	Total Xylenes*	ug/L	30	16	53%	8.5	10,600	--	--	--	SS	--
Sediment (Nearshore)	2-Methylnaphthalene	mg/kg	4	3	75%	0.0071	1.5	0.709	0.62	N/A	1.5	Max. Detect
Sediment (Nearshore)	Acenaphthene	mg/kg	6	4	67%	0.038	2.8	0.754	0.0895	1.447	1.447	95% KM (BCA) UCL
Sediment (Nearshore)	Acenaphthylene	mg/kg	6	5	83%	0.01	0.51	0.116	0.016	0.935	0.51	Max. Detect

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Sediment (Nearshore)	Anthracene	mg/kg	6	5	83%	0.012	3.9	0.912	0.17	3.569	3.569	95% KM (Chebyshev) UCL
Sediment (Nearshore)	Benzo(a)anthracene	mg/kg	6	6	100%	0.022	8.2	1.524	0.245	14.82	8.2	Max. Detect
Sediment (Nearshore)	Benzo(a)pyrene	mg/kg	6	6	100%	0.021	16	3.19	0.8	38.1	16	Max. Detect
Sediment (Nearshore)	Benzo(g,h,i)perylene	mg/kg	6	6	100%	0.0093	6.7	1.527	0.62	7.69	6.7	Max. Detect
Sediment (Nearshore)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	44	Max. Detect
Sediment (Nearshore)	Chrysene	mg/kg	6	6	100%	0.028	19	3.651	0.625	47.9	19	Max. Detect
Sediment (Nearshore)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Nearshore)	Dibenz(a,h)anthracene	mg/kg	6	5	83%	0.12	2.5	0.672	0.25	3.034	2.5	Max. Detect
Sediment (Nearshore)	Fluoranthene	mg/kg	6	6	100%	0.024	38	6.583	0.29	129.6	38	Max. Detect
Sediment (Nearshore)	Fluorene	mg/kg	6	4	67%	0.038	3.4	0.902	0.084	6.459	3.4	Max. Detect
Sediment (Nearshore)	Indeno(1,2,3-c,d)pyrene	mg/kg	6	6	100%	0.0093	6.2	1.332	0.445	14.09	6.2	Max. Detect
Sediment (Nearshore)	Naphthalene	mg/kg	6	4	67%	0.066	12	3.709	1.385	6.068	6.068	95% KM (Percentile Bootstrap) UCL
Sediment (Nearshore)	Phenanthrene	mg/kg	6	6	100%	0.008	47	7.974	0.2	85.64	47	Max. Detect
Sediment (Nearshore)	Pyrene	mg/kg	6	6	100%	0.02	38	6.559	0.31	69.13	38	Max. Detect
Sediment (Nearshore)	Total 10 of 16 HPAH (U = 1/2)	mg/kg	6	6	100%	0.188	170.6	31.8	5.445	447.7	170.6	Max. Detect
Sediment (Nearshore)	Total 16 PAH (U = 1/2)	mg/kg	6	6	100%	0.212	231	44	6.526	628.3	230.8	Max. Detect
Sediment (Nearshore)	Total 6 of 16 LPAH (U = 1/2)	mg/kg	6	6	100%	0.0245	60	12	0.906	223	60	Max. Detect
Sediment (Site-Wide)	2-Methylnaphthalene	mg/kg	13	7	54%	0.0071	150	21.9	0.62	130.7	130.7	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	4-Methylphenol (p-Cresol)	mg/kg	19	8	42%	0.017	0.068	0.0319	0.028	0.0298	0.0298	95% KM (t) UCL
Sediment (Site-Wide)	Acenaphthene	mg/kg	42	31	74%	0.0067	190	12.09	0.066	61.96	61.96	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Acenaphthylene	mg/kg	42	34	81%	0.0093	3	0.217	0.0345	0.55	0.55	95% KM (Chebyshev) UCL
Sediment (Site-Wide)	Anthracene	mg/kg	42	38	90%	0.012	240	9.198	0.22	66.93	66.93	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(a)anthracene	mg/kg	42	41	98%	0.022	260	13.06	0.58	57.7	57.7	97.5% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(a)pyrene	mg/kg	42	41	98%	0.021	140	9.911	1	37.14	37.14	97.5% KM (Chebyshev) UCL
Sediment (Site-Wide)	Benzo(g,h,i)perylene	mg/kg	42	42	100%	0.0093	33	2.875	0.64	7.14	7.14	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	44	Max. Detect
Sediment (Site-Wide)	Chrysene	mg/kg	42	42	100%	0.028	340	15.4	1.05	53.8	53.8	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Site-Wide)	Dibenz(a,h)anthracene	mg/kg	42	38	90%	0.024	17	1.299	0.24	3.315	3.315	95% KM (Chebyshev) UCL
Sediment (Site-Wide)	Dibenzofuran	mg/kg	8	3	38%	0.035	0.43	0.168	0.038	0.43	0.43	95% KM (BCA) UCL
Sediment (Site-Wide)	Fluoranthene	mg/kg	42	41	98%	0.024	670	36.07	0.61	245.5	245.5	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Fluorene	mg/kg	42	32	76%	0.0077	160	10.1	0.066	54.05	54.05	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Indeno(1,2,3-c,d)pyrene	mg/kg	42	42	100%	0.0093	34	2.747	0.59	7.107	7.107	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Naphthalene	mg/kg	42	30	71%	0.0075	150	5.706	0.0545	39.79	39.79	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Phenanthrene	mg/kg	42	41	98%	0.008	720	34.55	0.26	237.3	237.3	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Pyrene	mg/kg	42	41	98%	0.02	440	25.06	0.64	162.8	162.8	99% KM (Chebyshev) UCL
Sediment (Site-Wide)	Total 10 of 16 HPAHs (U = 1/2)	mg/kg	42	42	100%	0.188	2,004	122.9	6.365	395.6	395.6	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Total 16 PAHs (U = 1/2)	mg/kg	42	42	100%	0.212	2,948	185.9	7.916	611.8	611.8	95% Chebyshev (Mean, Sd) UCL
Sediment (Site-Wide)	Total 6 of 16 LPAHs (U = 1/2)	mg/kg	42	41	98%	0.0245	1,134	64.46	0.693	417.8	417.8	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	2-Methylnaphthalene	mg/kg	13	7	54%	0.179	2459	362.4	10.28	574.9	574.9	95% KM (BCA) UCL
OC-Normalized Site Sediment	Acenaphthene	mg/kg	42	31	74%	0.067	4,439	221.2	1.299	1,265	1,265	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Acenaphthylene	mg/kg	42	34	81%	0.067	49.18	3.588	0.662	8.668	8.668	95% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Anthracene	mg/kg	42	38	90%	0.306	2,553	128.7	3.264	810	810	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(a)anthracene	mg/kg	42	41	98%	1.292	3,505	208.3	10.53	873.9	873.9	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(a)pyrene	mg/kg	42	41	98%	1.866	2,295	168.2	16.88	601.5	601.5	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Benzo(g,h,i)perylene	mg/kg	42	42	100%	0.917	420.6	51.79	10.96	116.7	116.7	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Chrysene	mg/kg	42	42	100%	2.057	3617	230.8	17.6	708.8	708.8	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Dibenz(a,h)anthracene	mg/kg	42	38	90%	0.246	200.9	22.62	4.833	65.49	65.49	97.5% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Dibenzofuran	mg/kg	8	3	38%	0.339	4.019	1.624	0.515	2.015	2.015	95% KM (t) UCL
OC-Normalized Site Sediment	Fluoranthene	mg/kg	42	41	98%	1.531	15,654	639.9	11.11	4,593	4,593	99% KM (Chebyshev) UCL

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
OC-Normalized Site Sediment	Fluorene	mg/kg	42	32	76%	0.0622	3,738	181.9	1.293	1,072	1,072	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg	42	42	100%	0.876	443.9	48.07	10.22	113.9	113.9	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	Naphthalene	mg/kg	42	30	71%	0.067	2,459	104.3	0.848	667.3	667.3	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Phenanthrene	mg/kg	42	41	98%	0.718	16,822	639	5.283	4,773	4,773	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	Pyrene	mg/kg	42	41	98%	1.483	10,280	447.8	11.2	3,054	3,054	99% KM (Chebyshev) UCL
OC-Normalized Site Sediment	OC Total 10 of 16 HPAHs (U = 1/2	mg/kg	42	42	100%	15.18	37,397	2,096	126.2	6,674	6,674	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	OC Total 16 PAHs (U = 1/2)	mg/kg	42	42	100%	16.46	63,881	3,217	137	10,736	10,736	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Site Sediment	OC Total 6 of 16 LPAHs (U = 1/2)	mg/kg	42	41	98%	1.287	26,484	1,147	11.1	7,904	7,904	99% KM (Chebyshev) UCL
Sediment (Background)	Acenaphthene	mg/kg	10	5	50%	0.0054	0.0061	0.00582	0.0059	0.00579	0.00579	95% KM (t) UCL
Sediment (Background)	Acenaphthylene	mg/kg	10	1	10%	0.0067	0.0067	0.0067	0.0067	NA	0.0067	Max. Detect
Sediment (Background)	Anthracene	mg/kg	10	9	90%	0.0055	0.025	0.0142	0.013	0.0168	0.0168	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Arsenic	mg/kg	5	3	60%	9	20	13	10	16.44	20	Max. Detect
Sediment (Background)	Benzo(a)anthracene	mg/kg	10	10	100%	0.017	0.13	0.0672	0.056	0.0909	0.0909	95% Student's-t UCL
Sediment (Background)	Benzo(a)pyrene	mg/kg	10	10	100%	0.026	0.18	0.0891	0.075	0.118	0.118	95% Student's-t UCL
Sediment (Background)	Benzo(g,h,i)perylene	mg/kg	10	10	100%	0.025	0.12	0.0578	0.0585	0.0748	0.0748	95% Student's-t UCL
Sediment (Background)	Chromium	mg/kg	5	5	100%	21	48	39	44	49.77	48	Max. Detect
Sediment (Background)	Chrysene	mg/kg	10	10	100%	0.033	0.23	0.113	0.0985	0.152	0.152	95% Student's-t UCL
Sediment (Background)	Copper	mg/kg	5	5	100%	12	52.6	28.74	25.5	44.65	52.6	Max. Detect
Sediment (Background)	Dibenz(a,h)anthracene	mg/kg	10	10	100%	0.006	0.041	0.0182	0.0175	0.0244	0.0244	95% Student's-t UCL
Sediment (Background)	Fluoranthene	mg/kg	10	10	100%	0.051	0.34	0.121	0.095	0.178	0.178	95% Approximate Gamma UCL
Sediment (Background)	Fluorene	mg/kg	10	6	60%	0.0052	0.0084	0.00685	0.0066	0.00696	0.00696	95% KM (t) UCL
Sediment (Background)	Indeno(1,2,3-c,d)pyrene	mg/kg	10	10	100%	0.024	0.11	0.053	0.0495	0.0691	0.0691	95% Student's-t UCL
Sediment (Background)	Naphthalene	mg/kg	10	7	70%	0.0049	0.012	0.00723	0.0056	0.00796	0.00796	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Phenanthrene	mg/kg	10	10	100%	0.019	0.12	0.0509	0.0485	0.0706	0.0706	95% Approximate Gamma UCL
Sediment (Background)	Pyrene	mg/kg	10	10	100%	0.047	0.32	0.117	0.093	0.171	0.171	95% Approximate Gamma UCL
Sediment (Background)	Total 10 of 16 HPAHs (U = 1/2)	mg/kg	10	10	100%	0.301	1.718	0.84	0.694	1.103	1.103	95% Student's-t UCL
Sediment (Background)	Total 16 PAHs (U = 1/2)	mg/kg	10	10	100%	0.332	1.875	0.922	0.774	1.204	1.204	95% Student's-t UCL
Sediment (Background)	Total 6 of 16 LPAHs (U = 1/2)	mg/kg	10	10	100%	0.0308	0.157	0.0817	0.0793	0.103	0.103	95% Student's-t UCL
OC-Normalized Background Sediment	Acenaphthene	mg/kg	10	5	50%	0.149	0.324	0.22	0.219	0.221	0.221	95% KM (t) UCL
OC-Normalized Background Sediment	Acenaphthylene	mg/kg	10	1	10%	0.17	0.17	0.17	0.17	NA	0.17	Max. Detect
OC-Normalized Background Sediment	Anthracene	mg/kg	10	9	90%	0.206	1.02	0.519	0.456	0.645	0.645	95% KM (Percentile Bootstrap) UCL
OC-Normalized Background Sediment	Benzo(a)anthracene	mg/kg	10	10	100%	0.769	7.027	2.45	1.794	3.725	3.725	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Benzo(a)pyrene	mg/kg	10	10	100%	1.176	9.73	3.328	2.755	4.955	4.955	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Benzo(g,h,i)perylene	mg/kg	10	10	100%	0.906	4.324	2.11	2.037	2.759	2.759	95% Student's-t UCL
OC-Normalized Background Sediment	Chrysene	mg/kg	10	10	100%	1.493	11.35	4.114	3.275	6.123	6.123	95% Approximate Gamma UCL
OC-Normalized Background Sediment	Dibenz(a,h)anthracene	mg/kg	10	10	100%	0.217	1.405	0.658	0.643	0.887	0.887	95% Student's-t UCL
OC-Normalized Background Sediment	Fluoranthene	mg/kg	10	10	100%	1.91	18.38	4.737	3.374	11.48	11.48	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	Fluorene	mg/kg	10	6	60%	0.135	0.449	0.245	0.228	0.267	0.267	95% KM (t) UCL
OC-Normalized Background Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg	10	10	100%	0.906	4.432	1.945	1.815	2.597	2.597	95% Student's-t UCL
OC-Normalized Background Sediment	Naphthalene	mg/kg	10	7	70%	0.173	0.304	0.231	0.216	0.246	0.246	95% KM (t) UCL
OC-Normalized Background Sediment	Phenanthrene	mg/kg	10	10	100%	0.86	6.486	1.954	1.629	4.213	4.213	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	Pyrene	mg/kg	10	10	100%	1.873	17.3	4.556	3.027	10.84	10.84	95% Chebyshev (Mean, Sd) UCL
OC-Normalized Background Sediment	OC Total 10 of 16 HPAHs (U = 1/2	mg/kg	10	10	100%	13.63	92.86	31.35	26.31	45.56	45.56	95% Approximate Gamma UCL
OC-Normalized Background Sediment	OC Total 16 PAHs (U = 1/2)	mg/kg	10	10	100%	15.02	101.4	34.41	29.19	49.82	49.82	95% Approximate Gamma UCL
OC-Normalized Background Sediment	OC Total 6 of 16 LPAHs (U = 1/2)	mg/kg	10	10	100%	1.391	8.492	3.062	2.741	4.311	4.311	95% Approximate Gamma UCL
Surface Water	Arsenic	ug/L	6	2	33%	1	1	1	1	NA	1	Max. Detect
Surface Water	Benzene	ug/L	6	3	50%	16	68	33.33	16	44.19	68	Max. Detect
Surface Water	Benzo(a)anthracene	ug/L	6	1	17%	0.064	0.064	0.064	0.064	NA	0.064	Max. Detect
Surface Water	Benzo(a)pyrene	ug/L	6	4	67%	0.016	0.17	0.057	0.021	0.21	0.17	Max. Detect
Surface Water	Benzo(b)fluoranthene	ug/L	6	4	67%	0.02	0.25	0.0803	0.0255	0.31	0.25	Max. Detect

Table 7.1-3
Summary Statistics and Exposure Point Concentrations for COPCs Included in the Baseline Human Health Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Surface Water	Benzo(k)fluoranthene	ug/L	6	3	50%	0.011	0.089	0.0373	0.012	0.089	0.089	Max. Detect
Surface Water	Chrysene	ug/L	6	1	17%	0.12	0.12	0.12	0.12	NA	0.12	Max. Detect
Surface Water	Dibenz(a,h)anthracene	ug/L	6	1	17%	0.092	0.092	0.092	0.092	NA	0.092	Max. Detect
Surface Water	Indeno(1,2,3-c,d)pyrene	ug/L	6	3	50%	0.026	0.15	0.0703	0.035	0.108	0.15	Max. Detect
Surface Water	Total Xylenes	ug/L	6	3	50%	3	12.9	9.233	11.8	10.57	12.9	Max. Detect
Surface Water	Naphthalene	ug/L	6	1	17%	2.2	2.2	2.2	2.2	NA	2.2	Max. Detect

Notes:

* - indicates the analyte is a volatile organic compound.

BSAF - biota-sediment accumulation factor
COPC - chemical of potential concern
EPC - exposure point concentration
HPAHs - high-molecular-weight polynuclear aromatic hydrocarbons
KM (BCA) - UCL based on Kaplan-Meier estimates using bias-corrected accelerated bootstrap method
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
KM (percentile bootstrap) - UCL based on Kaplan-Meier estimates using the percentile bootstrap method
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
LPAHs - low-molecular-weight polynuclear aromatic hydrocarbons
Max. Detect - UCL based on the maximum detected value
mg/kg - milligram(s) per kilogram
NA - not available
OC - organic carbon
PAHs - polynuclear aromatic hydrocarbons
sd - standard deviation
SS - sample-specific; groundwater statistics are based on maximum detected values from 30 wells sampled during the RI field investigation (2008 and 2009) and the Port of Seattle sampling at the Railroad Property.
UCL - upper confidence limit
ug/L - microgram(s) per liter

Table 7.1-4
Estimated Exposure Point Concentrations for Fish and Shellfish Tissue

	Literature-Based BSAFs			Sitewide Sediment Exposure Area					Background Sediment Exposure Area				
Chemical	Mollusk BSAF[a]	Freshwater Crustacean BSAF[a]	Bottom-feeding Fish BSAF[a]	Sediment EPC (mg/kg)	Mollusk Tissue EPC (mg/kg)	Freshwater Crustacean Tissue EPC (mg/kg)	Bottom-feeding Fish Tissue EPC (mg/kg)	Final Fish/Shellfish Tissue EPC (mg/kg)	Sediment EPC (mg/kg)	Mollusk Tissue EPC (mg/kg)	Freshwater Crustacean Tissue EPC (mg/kg)	Bottom-feeding Fish Tissue EPC (mg/kg)	Final Fish/Shellfish Tissue EPC (mg/kg)
2-Methylnaphthalene	5.52E-01	NV	9.58E-02	5.75E+02	4.31E+00	NV	2.11E+00	3.21E+00			NV	NV	NV
Acenaphthene	1.52E-01	4.42E-02	3.82E-02	1.27E+03	2.61E+00	2.77E+00	1.86E+00	2.41E+00	2.21E-01	4.56E-04	4.84E-04	3.24E-04	4.22E-04
Acenaphthylene	2.33E-01	3.75E-02	1.92E-02	8.67E+00	2.74E-02	1.61E-02	6.39E-03	1.66E-02	1.70E-01	5.38E-04	3.16E-04	1.25E-04	3.26E-04
Anthracene	2.09E-01	3.87E-02	1.05E-02	8.10E+02	2.30E+00	1.55E+00	3.27E-01	1.39E+00	6.45E-01	1.83E-03	1.24E-03	2.60E-04	1.11E-03
Arsenic	NV	NV	NV		NV	NV	NV	NV		NV	NV	NV	NV
Benzo(a)anthracene	1.92E-01	1.15E-02	2.24E-03	8.74E+02	2.28E+00	4.97E-01	7.52E-02	9.50E-01	3.73E+00	9.71E-03	2.12E-03	3.20E-04	4.05E-03
Benzo(a)pyrene	4.12E-02	8.44E-03	2.56E-03	6.02E+02	3.37E-01	2.52E-01	5.91E-02	2.16E-01	4.96E+00	2.77E-03	2.07E-03	4.87E-04	1.78E-03
Benzo(g,h,i)perylene	5.80E-02	1.55E-02	4.04E-03	1.17E+02	9.19E-02	8.99E-02	1.81E-02	6.66E-02	2.76E+00	2.17E-03	2.12E-03	4.28E-04	1.58E-03
Chrysene	2.09E-01	7.13E-03	2.57E-03	7.09E+02	2.01E+00	2.50E-01	7.00E-02	7.77E-01	6.12E+00	1.74E-02	2.16E-03	6.04E-04	6.72E-03
Copper	NV	NV	NV		NV	NV	NV	NV		NV	NV	NV	NV
Dibenz(a,h)anthracene	1.68E-01	NV	3.84E-03	6.55E+01	1.49E-01	NV	9.66E-03	7.95E-02	8.87E-01	2.02E-03	NV	1.31E-04	1.08E-03
Dibenzofuran	NV	NV	3.59E-02	2.02E+00	NV	NV	2.78E-03	2.78E-03		NV	NV	NV	NV
Fluoranthene	4.53E-01	8.88E-02	3.48E-03	4.59E+03	2.83E+01	2.02E+01	6.14E-01	1.64E+01	1.15E+01	7.06E-02	5.05E-02	1.53E-03	4.09E-02
Fluorene	3.57E-01	5.47E-02	2.61E-02	1.07E+03	5.20E+00	2.91E+00	1.07E+00	3.06E+00	2.67E-01	1.29E-03	7.24E-04	2.68E-04	7.62E-04
Indeno(1,2,3-c,d)pyrene	7.43E-02	NV	2.71E-03	1.14E+02	1.15E-01	NV	1.19E-02	6.34E-02	2.60E+00	2.62E-03	NV	2.70E-04	1.45E-03
Naphthalene	4.67E-01	5.19E-02	1.11E-01	6.67E+02	4.23E+00	1.72E+00	2.84E+00	2.93E+00	2.46E-01	1.56E-03	6.33E-04	1.05E-03	1.08E-03
Phenanthrene	2.29E-01	2.39E-02	8.50E-03	4.77E+03	1.48E+01	5.66E+00	1.56E+00	7.35E+00	4.21E+00	1.31E-02	4.99E-03	1.38E-03	6.49E-03
Pyrene	2.03E-01	8.88E-03	2.29E-03	3.05E+03	8.42E+00	1.34E+00	2.69E-01	3.34E+00	1.08E+01	2.99E-02	4.77E-03	9.53E-04	1.19E-02

Notes:

[a] Details on the identification of appropriate BSAFs are provided in Appendix J-5.

Lipid values used for tissue EPC calculations are listed below and summarized in Appendix J-5.

Species Guild	Lipid	Lipid Fraction
Freshwater Mollusk	1.358	0.01358
Freshwater Crustacean	4.956	0.04956
Bottom-Feeding Fish	3.84	0.0384

Lipid data are taken from:
http://el.erdc.usace.army.mil/bsafnew/LipidOrgMean.dbw

BSAF - biota-sediment accumulation factor
EPC - exposure point concentration
mg/kg - milligrams per kilogram
NV - No BSAF or sediment chemistry value

Table 7.1-5
Reasonable Maximum Exposure Assumptions

Exposure Parameter	Units	Occupational Worker	Source	Construction/ Excavation Worker	Source	Resident	Source	Beach User	Source	Fish Consumer	Source
Exposure Concentration (soil/sediment)	mg/kg-dry	95% UCL of mean	calc.	95% UCL of mean	calc.	95% UCL of mean	calc.	95% UCL of mean	calc.	--	--
Exposure Concentration (groundwater/surface water)	ug/L	--	--	Sitewide maximum	a	Well-specific	b	Sitewide maximum	c	--	--
Exposure Concentration (indoor air/trench air)	ug/m^3	--	--	Sitewide maximum	calc.	Well-specific	calc.	--	--	--	--
Exposure Concentration (fish tissue)	mg/kg-wet	--	--	--	--	--	--	--	--	95% UCL of mean	d
Adult Body Weight	kg	70	e	70	e	70	e	70	e	70	e
Child Body Weight	kg	--	--	--	--	15	e	15	e	--	--
Exposure Frequency	days/yr	250	e	250	e	350	e	94	f	350/39/65	g
Adult Exposure Duration	yrs	25	e	1	h	24	e	24	e	30	e
Subsistence Fish Consumption Exposure Duration	yrs	--	--	--	--	--	--	--	--	70	k
Child Exposure Duration	yrs	--	--	--	--	6	e	6	e	--	--
Inhalation Exposure Time Fraction	unitless	0.33	i	0.33	i	1.0	i	--	--	--	--
Carcinogenic Averaging Time	yrs	70	e	70	e	70	e	70	e	70	e
Noncarcinogenic Averaging Time	yrs	25	e	1	h	30	e	30	e	30	e
Adult Incidental Soil/Sediment Ingestion Rate	mg/day	100	e	330	j	100	e	100	e	100	e
Child Incidental Soil/Sediment Ingestion Rate	mg/day	--	--	--	--	200	e	200	e	--	--
Adult Water Ingestion Rate	L/day	--	--	--	--	2	e	0.05	k	--	--
Child Water Ingestion Rate	L/day	--	--	--	--	1	k	0.05	k	--	--
Recreator Fish Consumption Rate	g/day-wet	--	--	--	--	--	--	--	--	17.37	l
Subsistence Fish Consumption Rate	g/day-wet	--	--	--	--	--	--	--	--	143.4	l
Adult Skin Surface Area (soil)	cm^2	3,300	m	3,300	m	5,700	m	5,700	m	1,980	n
Child Skin Surface Area (soil)	cm^2	--	--	--	--	2,800	m	2,800	m	--	--
Adult Skin Surface Area (water)	cm^2	--	--	3,300	m	18,000	m	18,000	m	--	--
Child Skin Surface Area (water)	cm^2	--	--	--	--	6,600	m	6,600	m	--	--
Dermal Absorption Fraction (from soil/sediment)	unitless	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m,n
Dermal Permeability Coefficient (water)	cm/hr	--	--	Chemical-specific	m	Chemical-specific	m	Chemical-specific	m	--	--
Adult Event Duration (water)	hr/event	--	--	1.0	o	0.58	m	1.0	o	--	--
Child Event Duration (water)	hr/event	--	--	--	--	1.0	m	1.0	o	--	--
Adult Soil-to-Skin Adherence Factor	mg/cm^2	0.2	m	0.3	m	0.07	m	0.3	m,p	0.3	m,p
Child Soil-to-Skin Adherence Factor	mg/cm^2	--	--	--	--	0.2	m	3.3	m,p	--	--
Particulate Emission Factor	m^3/kg	1.32E+09	q	1.32E+09	q	1.32E+09	q	--	--	--	--
Volatilization Factor	m^3/kg	Chemical-specific	q	Chemical-specific	q	Chemical-specific	q	--	--	--	--

Notes:

BSAF - biota-sediment accumulation factor
cm^2 - square centimeters
days/yr - days per year
kg - kilograms
m^3/kg - cubic meters per kilogram
mg/cm^2 - milligrams per square centimeter
mg/day - milligrams per day
mg/kg - milligrams per kilogram
mg/L- milligrams per liter
yrs - years
calc. - calculated value; EPC - exposure point concentration; UCL - upper confidence limit

a. Based on Site-wide maximum groundwater concentration from RI (2008-2009).
b. Based on Site-wide highest well-specific groundwater concentration from RI (2008-2009).
c. Based on Site-wide maximum surface water concentration.
d. Based on average (sediment 95%UCL x BSAF x Lipid fraction) of three fish groups.

Table 7.1-5
Reasonable Maximum Exposure Assumptions

Notes (continued):

e. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors (EPA 1991).

f. Professional judgment. Assumes recreational use occurs for an average of about 3 months per year.

g. Exposure frequencies listed for fish consumption/recreational angler sediment contact/subsistence angler sediment contact. Assumes 3 and 5 days per week over the entire year for in-water recreational and subsistence fishing, respectively. Assumes fishing near the site occurs 25 percent of total fishing days.

h. Professional judgment. Assumes that construction work occurs over a one-year period.

i. Fraction of exposure time applied to calculation of inhalation risk (worker equates to 8 hr/day, recreational user equates to 4 hr/day).

j. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA 2002e).

k. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final (EPA 1989).

l. Based on the 90th percentile for recreational fishing and the 99th percentile for subsistence fishing from Estimated Per Capita Fish Consumption in the United States (EPA 2002b).

m. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final (EPA 2004).

n. Average surface area for hands and forearms of men (EPA 1997a).

o. Professional judgment. Assumes a one-hour swimming or contact event per day.

p. From Exhibit 3-3 in EPA 2004. Value for residential adults as gardeners and value for children playing in wet soil.

q. Soil Screening Guidance: Users Guide (EPA 1996).

Table 7.1-6
Toxicity Values Used for the Baseline Human Health Risk Assessment

Analyte	CASRN	Mutagen (Y/N)	Water Permeability Constant (Kp) (cm/hr)	Volatilization Factor (m^3/kg)	Dermal Absorption Fraction	GI Absorption Fraction	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Source	Inhalation Unit Risk (ug/m^3)	Source	Oral Reference Dose (mg/kg-day)	Source	Inhalation Reference Concentration (RfC) (mg/m^3)	Source
2,4-Dimethylphenol	105-67-9	N	1.1E-02	--	0.1	1	--	--	--	--	2.0E-02	I	--	--
2-Methylnaphthalene	91-57-6	N	9.2E-02	6.34E+04	0.1	1	--	--	--	--	4.0E-03	I	--	--
2-Methylphenol (o-Cresol)	95-48-7	N	7.7E-03	--	0.1	1	--	--	--	--	5.0E-02	I	--	--
4-Methylphenol	106-44-5	N	7.5E-03	--	0.1	1	--	--	--	--	5.0E-03	H	--	--
Acenaphthene	83-32-9	N	8.6E-02	1.52E+05	0.13	1	--	--	--	--	6.0E-02	I	--	--
Anthracene	120-12-7	N	1.4E-01	5.64E+05	0.13	1	--	--	--	--	3.0E-01	I	--	--
Arsenic	7440-38-2	N	1.6E-03	--	0.03	1	1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C
Benzene	71-43-2	N	1.5E-02	3.80E+03	0.1	1	5.5E-02	I	7.8E-06	I	4.0E-03	I	3.0E-02	I
Benzo(a)anthracene	56-55-3	Y	5.0E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Benzo(a)pyrene	50-32-8	Y	7.1E-01	--	0.13	1	7.3E+00	C	1.1E-03	C	--	--	--	--
Benzo(b)fluoranthene	205-99-2	Y	4.2E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Benzo(k)fluoranthene	207-08-9	Y	6.9E-01	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
bis(2-Ethylhexyl)phthalate	117-81-7	N	1.1E+00	--	0.1	1	1.4E-02	I	2.4E-06	C	2.0E-02	I	--	--
Cadmium (soil)	7440-43-9	N	--	--	0.001	0.025	--	--	1.8E-03	I	1.0E-03	I	2.0E-05	C
Cadmium (water)	7440-43-9	N	--	--	0.001	0.05	--	--	1.8E-03	I	5.0E-04	I	2.0E-05	C
Carbon disulfide	75-15-0	N	--	1.24E+03	0.1	1	--	--	--	--	1.0E-01	I	7.0E-01	I
Chloroform	67-66-3	N	6.83E-03	2.85E+03	0.1	1	3.1E-02	C	2.3E-05	I	1.0E-02	I	9.8E-02	A
Chromium III	7440-47-3	N	--	--	--	0.013	--	--	--	--	1.5E+00	I	--	--
Chrysene	16065-83-1	Y	6.0E-01	--	0.13	1	7.3E-02	C	1.1E-05	C	--	--	--	--
Copper	7440-50-8	N	--	--	--	1	--	--	--	--	4.0E-02	H	--	--
Dibenz(a,h)anthracene	53-70-3	Y	2.2E+00	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Dibenzofuran	132-64-9	N	9.8E-02	2.13E+05	0.1	1	--	--	--	--	1.0E-03	X	--	--
Ethylbenzene	100-41-4	N	4.9E-02	6.18E+03	0.1	1	1.1E-02	C	2.5E-06	C	1.0E-01	I	1.0E+00	I
Fluoranthene	206-44-0	N	3.1E-01	--	0.13	1	--	--	--	--	4.0E-02	I	--	--
Fluorene	86-73-7	N	1.1E-01	3.06E+05	0.13	1	--	--	--	--	4.0E-02	I	--	--
Indeno(1,2,3-c,d)pyrene	193-39-5	Y	1.2E+00	--	0.13	1	7.3E-01	C	1.1E-04	C	--	--	--	--
Iron	7439-89-6	N	--	--	--	1	--	--	--	--	7.0E-01	P	--	--
Methylene chloride	75-09-2	N	--	2.40E+03	0.1	1	7.5E-03	I	4.7E-07	I	6.0E-02	I	1.0E+00	A
Naphthalene	91-20-3	N	4.7E-02	5.04E+04	0.15	1	--	--	3.4E-05	C	2.0E-02	I	3.0E-03	I
Nickel	7440-02-0	N	--	--	--	0.04	--	--	2.6E-04	C	2.0E-02	I	9.0E-05	A
N-Nitrosodiphenylamine	86-30-6	N	--	--	0.1	1	4.9E-03	I	2.6E-06	C	--	--	--	--
Pentachlorophenol	87-86-5	N	--	--	0.25	1	4.0E-01	I	5.1E-06	C	5.0E-03	I	--	--
Phenol	108-95-2	N	--	--	0.1	1	--	--	--	--	3.0E-01	I	2.0E-01	C
Pyrene	129-00-0	N	2.0E-01	2.56E+06	0.13	1	--	--	--	--	3.0E-02	I	--	--
Styrene	100-42-5	N	3.7E-02	1.02E+04	0.1	1	--	--	--	--	2.0E-01	I	1.0E+00	I
Toluene	108-88-3	N	3.1E-02	4.65E+03	0.1	1	--	--	--	--	8.0E-02	I	5.0E+00	I
Xylenes, Total	1330-20-7	N	--	6.33E+03	0.1	1	--	--	--	--	2.0E-01	I	1.0E-01	I
Zinc	7440-66-6	N	--	--	--	1	--	--	--	--	3.00E-01	I	--	--

Notes:
CASRN = Chemical Abstract System Registry Number

Sources:
A - Agency for Toxic Substances and Disease Registry (ATSDR)
C - California Environmental Protection Agency (CAEPA)
E - Environmental Criteria and Assessment Office (ECAO)
H - Health Effects Assessment Summary Tables (HEAST)
I - Integrated Risk Information System (IRIS)
P - Provisional Peer-Reviewed Toxicity Values (PPRTV)
X - PPRTV Appendix

Kp values from the EPA Estimation Program Interface (EPI) Suite database.
EPA May 2011 regional screening levels (RSLs) and volatilization factors (VFs).
Cancer slope factors and inhalation unit risks (IURs) for carcinogenic polynuclear aromatic hydrocarbons (PAHs) were weighted according to their respective benzo(a)pyrene toxicity equivalency factors (TEFs) using the scheme of CAEPA (2009).

m^3/kg = cubic meters per kilogram; mg/kg = milligrams per kilogram; ug/m^3 = micrograms per cubic meter; mg/m^3 = milligrams per cubic meter

Table 7.1-7
Summary of Risk and Hazard Estimates for the Residential Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	1	2E-02	Naphthalene (HQ=7, 80%)	Benzo(a)pyrene (ELCR=2E-02, 77%)
Dermal	0.5	7E-03	2-Methylnaphthalene (HQ=0.6, 8%)	Benzo(b)fluoranthene (ELCR=2E-03, 6%)
Inhalation	6	3E-04		Benzo(a)anthracene (ELCR=1E-03, 6%)
Total Soil Routes	**8**	**3E-02**		Benzo(k)fluoranthene (ELCR=1E-03, 5%)
				Indeno(1,2,3-c,d)pyrene (ELCR=1E-03, 4%)
				Naphthalene (ELCR=3E-04, 1%)
				Chrysene (ELCR=2E-04, 0.9%)
				Dibenz(a,h)anthracene (ELCR=2E-04, 0.8%)
				Arsenic (ELCR=3E-05, 0.1%)
				Ethylbenzene (ELCR=3E-06, 0.01%)
Groundwater Use - Based on Maximum Well Risk (Q9)				
Ingestion	602	8E-01	Naphthalene (HQ=7,291, 91%)	Benzo(a)pyrene (ELCR=5E-01, 47%)
Dermal	175	5E-04	2-Methylnaphthalene (HQ=225, 3%)	Naphthalene (ELCR=3E-01, 26%)
Inhalation	7,218	3E-01	Dibenzofuran (HQ=206, 3%)	Benzo(a)anthracene (ELCR=1E-01, 9%)
Total Groundwater Routes	**7,995**	**>8E-01[b]**	Arsenic (HQ=197, 2%)	Benzo(b)fluoranthene (ELCR=6E-02, 6%)
			Benzene (HQ=41, 0.5%)	Benzo(k)fluoranthene (ELCR=5E-02, 4%)
			Pyrene (HQ=13, 0.2%)	Arsenic (ELCR=4E-02, 4%)
			Fluoranthene (HQ=9, 0.1%)	Indeno(1,2,3-c,d)pyrene (ELCR=3E-02, 2%)
			Total Xylenes (HQ=7, 0.09%)	Chrysene (ELCR=7E-03, 1%)
			Fluorene (HQ=6, 0.08%)	Dibenz(a,h)anthracene (ELCR=7E-03, 0.6%)
			Acenaphthene (HQ=6, 0.07%)	Benzene (ELCR=4E-03, 0.4%)
				Ethylbenzene (ELCR=6E-04, 0.1%)
Indoor Air - Based on Maximum Well Risk (BH-5A)				
Inhalation Route	**280**	**2E-02**	Benzene (HQ=180, 64%)	Benzene (ELCR=2E-02, 81%)
			Naphthalene (HQ=81, 29%)	Naphthalene (ELCR=4E-03, 16%)
			Total Xylenes (HQ=17, 6%)	Ethylbenzene (ELCR=7E-04, 3%)

Notes:

[a]Primary contributors to the total risk are listed when ELCR > 10^{-6} or HI > 1.
[b]Due to the very high concentrations found in this well and the inherent limitations quantifying risk at these levels, the ELCR is reported as a greater than estimate.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Q9	7,995	>8E-01[b]	Naphthalene (HQ=7,291, 91%) 2-Methylnaphthalene (HQ=225, 3%) Dibenzofuran (HQ=206, 3%) Arsenic (HQ=197, 2%) Benzene (HQ=41, 0.5%) Pyrene (HQ=13, 0.2%) Fluoranthene (HQ=9, 0.1%) Total Xylenes (HQ=7, 0.09%) Fluorene (HQ=6, 0.08%) Acenaphthene (HQ=6, 0.07%)	Benzo(a)pyrene (ELCR=5E-01, 47%) Naphthalene (ELCR=3E-01, 26%) Benzo(a)anthracene (ELCR=1E-01, 9%) Benzo(b)fluoranthene (ELCR=6E-02, 6%) Benzo(k)fluoranthene (ELCR=5E-02, 4%) Arsenic (ELCR=4E-02, 4%) Indeno(1,2,3-cd)pyrene (ELCR=3E-02, 2%) Chrysene (ELCR=7E-03, 1%) dibenz(a,h)anthracene (ELCR=7E-03, 0.6%) Benzene (ELCR=4E-03, 0.4%) Ethylbenzene (ELCR=6E-04, 0.1%)
BH-5/5A	3,516	3E-01	Naphthalene (HQ=2,592, 74%) Benzene (HQ=787, 22%) 4-Methylphenol (HQ=56, 2%) Total Xylenes (HQ=36, 1%) 2-Methylnaphthalene (HQ=29, 0.8%) 2,4-Dimethylphenol (HQ=18, 0.5%) Toluene (HQ=11, 0.3%) Dibenzofuran (HQ=10, 0.3%) Arsenic (HQ=6, 0.2%) Ethylbenzene (HQ=2, 0.1%) Styrene (HQ=2, 0.1%)	Naphthalene (ELCR=1E-01, 35%) Benzo(a)pyrene (ELCR=9E-02, 31%) Benzene (ELCR=8E-02, 25%) Benzo(b)fluoranthene (ELCR=7E-03, 2%) Benzo(k)fluoranthene (ELCR=7E-03, 2%) Benzo(a)anthracene (ELCR=6E-03, 2%) Ethylbenzene (ELCR=2E-03, 0.6%) Arsenic (ELCR=1E-03, 0.4%) Chrysene (ELCR=9E-04, 0.3%) Indeno(1,2,3-cd)pyrene (ELCR=2E-05, 0.005%) dibenz(a,h)anthracene (ELCR=4E-06, 0.001%)
RW-QP-1	2,007	1E-01	Naphthalene (HQ=1,782, 89%) Benzene (HQ=196, 10%) Total Xylenes (HQ=53, 3%) Toluene (HQ=12, 0.6%) 2-Methylnaphthalene (HQ=10, 0.5%) Styrene (HQ=3, 0.2%) Ethylbenzene (HQ=3, 0.1%) Dibenzofuran (HQ=2, 0.09%)	Naphthalene (ELCR=7E-02, 78%) Benzene (ELCR=2E-02, 20%) Ethylbenzene (ELCR=2E-03, 2%) Arsenic (ELCR=2E-05, 0.02%)
BH-20A	1,832	9E-02	Naphthalene (HQ=1,620, 88%) Benzene (HQ=201, 11%) Total xylenes (HQ=12, 0.6%) 2-Methylnaphthalene (HQ=7, 0.4%) Ethylbenzene (HQ=2, 0.1%)	Naphthalene (ELCR=7E-02, 73%) Benzene (ELCR=2E-02, 21%) Benzo(a)pyrene (ELCR=3E-03, 3%) Ethylbenzene (ELCR=2E-03, 2%) Benzo(b)fluoranthene (ELCR=3E-04, 0.3%) Benzo(k)fluoranthene (ELCR=2E-04, 0.2%) Arsenic (ELCR=2E-04, 0.2%) Indeno(1,2,3-cd)pyrene (ELCR=1E-04, 0.2%) Benzo(a)anthracene (ELCR=1E-04, 0.1%) dibenz(a,h)anthracene (ELCR=6E-05, 0.1%) Chrysene (ELCR=1E-05, 0.01%)
BH-5B	2,120	9E-02	Naphthalene (HQ=2,106, 99%) 2-Methylnaphthalene (HQ=9, 0.4%) Total Xylenes (HQ=4, 0.2%) Benzene (HQ=2, 0.1%)	Naphthalene (ELCR=9E-02, 99%) Ethylbenzene (ELCR=5E-04, 0.5%) Arsenic (ELCR=2E-04, 0.3%) Benzene (ELCR=2E-04, 0.2%)
BH-25A(R)	1,823	8E-02	Naphthalene (HQ=1,782, 98%) 2-Methylnaphthalene (HQ=13, 0.7%) Benzene (HQ=13, 0.7%) 4-Methylphenol (HQ=6, 0.3%) Dibenzofuran (HQ=6, 0.3%) Total Xylenes (HQ=4, 0.2%) Arsenic (HQ=2, 0.1%)	Naphthalene (ELCR=7E-02, 98%) Benzene (ELCR=1E-03, 2%) Arsenic (ELCR=3E-04, 0.4%) Ethylbenzene (ELCR=3E-04, 0.4%)

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Q4	892	7E-02	Naphthalene (HQ=859, 96%) 2-Methylnaphthalene (HQ=15, 2%) Dibenzofuran (HQ=14, 2%) Total Xylenes (HQ=3, 0.3%) Benzene (HQ=2, 0.3%)	Naphthalene (ELCR=4E-02, 55%) Benzo(a)pyrene (ELCR=2E-02, 33%) Benzo(a)anthracene (ELCR=3E-03, 5%) Benzo(b)fluoranthene (ELCR=2E-03, 3%) Benzo(k)fluoranthene (ELCR=1E-03, 2%) Ethylbenzene (ELCR=3E-04, 0.4%) Indeno(1,2,3-c,d)pyrene (ELCR=2E-04, 0.04%) Benzene (ELCR=2E-04, 0.3%) Chrysene (ELCR=2E-04, 0.3%) Arsenic (ELCR=7E-05, 0.1%)
BH-20B	757	4E-02	Naphthalene (HQ=697, 92%) Benzene (HQ=48, 6%) Arsenic (HQ=6, 0.8%) 2-Methylnaphthalene (HQ=4, 0.5%) Total Xylenes (HQ=4, 0.5%)	Naphthalene (ELCR=3E-02, 82%) Benzene (ELCR=5E-03, 13%) Arsenic (ELCR=1E-03, 3%) Ethylbenzene (ELCR=6E-04, 2%)
BH-21A	357	2E-02	Naphthalene (HQ=340, 95%) 2-Methylnaphthalene (HQ=9, 3%) Dibenzofuran (HQ=6, 2%)	Naphthalene (ELCR=1E-02, 92%) Benzo(a)anthracene (ELCR=1E-03, 7%) Arsenic (ELCR=1E-04, 0.8%) Ethylbenzene (ELCR=3E-05, 0.2%) Benzene (ELCR=9E-06, 0.1%)
BH-29A	48	9E-03	Arsenic (HQ=45, 94%) Naphthalene (HQ=3, 6%)	Arsenic (ELCR=9E-03, 97%) Naphthalene (ELCR=1E-04, 1%) Benzo(a)pyrene (ELCR=8E-05, 0.9%) Benzo(a)anthracene (ELCR=5E-06, 05%) Benzo(k)anthracene (ELCR=5E-06, 05%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.02%)
BH-28B	122	6E-03	Naphthalene (HQ=113, 93%) Arsenic (HQ=4, 3%) 2-Methylnaphthalene (HQ=2, 2%) Benzene (HQ=2, 2%)	Naphthalene (ELCR=5E-03, 83%) Arsenic (ELCR=8E-04, 13%) Benzene (ELCR=2E-04, 3%) Ethylbenzene (ELCR=3E-05, 0.4%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.03%)
BH-21B	91	6E-03	Naphthalene (HQ=76, 84%) Arsenic (HQ=13, 14%) Dibenzofuran (HQ=2, 2%)	Naphthalene (ELCR=3E-03, 57%) Arsenic (ELCR=2E-03, 42%) Benzene (ELCR=4E-05, 0.7%) Ethylbenzene (ELCR=1E-05, 0.2%)
RW-NS-1	132	6E-03	Naphthalene (HQ=123, 93%) Dibenzofuran (HQ=4, 3%) 2-Methylnaphthalene (HQ=3, 2%)	Naphthalene (ELCR=5E-03, 95%) Benzene (ELCR=1E-04, 3%) Ethylbenzene (ELCR=8E-05, 1%) Arsenic (ELCR=6E-05, 1%)
BH-18A	88	4E-03	Naphthalene (HQ=75, 85%) Benzene (HQ=9, 10%) 2-Methylnaphthalene (HQ=2, 2%) Dibenzofuran (HQ=2, 2%)	Naphthalene (ELCR=3E-03, 72%) Benzene (ELCR=9E-04, 20%) Arsenic (ELCR=2E-04, 4%) Indeno(1,2,3-c,d)pyrene (ELCR=9E-05, 2%) Ethylbenzene (ELCR=7E-05, 2%) Dibenz(a,h)anthracene (ELCR=3E-05, 0.7%) Chrysene (ECLR=2E-06, 0.04%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.04%)
BH-19B	84	4E-03	Naphthalene (HQ=83, 99%)	Naphthalene (ELCR=4E-03, 97%) Arsenic (ELCR=1E-04, 3%) Ethylbenzene (ELCR=2E-05, 0.5%) bis(2-Ethylhexyl)phthalate (ELCR=2E-06, 0.04%)

Table 7.1-8
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well Location	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-23	62	3E-03	Naphthalene (HQ=49, 79%) Benzene (HQ=9, 14%) 2-Methylnaphthalene (HQ=2, 4%)	Naphthalene (ELCR=2E-03, 65%) Benzene (ELCR=9E-04, 27%) Ethylbenzene (ELCR=1E-04, 4%) Arsenic (ELCR=1E-04, 4%) bis(2-Ethylhexyl)phthalate (ELCR=3E-06, 0.1%)
BH-19	10	9E-04	Naphthalene (HQ=4, 40%) Arsenic (HQ=3, 29%)	Arsenic (ELCR=6E-04, 61%) Naphthalene (ELCR=2E-04, 19%) Benzene (ELCR=1E-04, 16%) Ethylbenzene (ELCR=5E-05, 5%)
BH-26B	6	8E-04	Arsenic (HQ=4, 59%) Naphthalene (HQ=3, 41%)	Arsenic (ELCR=7E-04, 86%) Naphthalene (ELCR=1E-04, 14%)
BH-20C	10	5E-04	Naphthalene (HQ=9, 93%)	Naphthalene (ELCR=4E-04, 77%) Arsenic (ELCR=1E-04, 22%) bis(2-Ethylhexyl)phthalate (ELCR=7E-06, 1%) Chloroform (ELCR=2E-06, 0.3%)
Q1-D	1	2E-04	none identified	Arsenic (ELCR=2E-04, 100%)
Q12	2	1E-04	Naphthalene (HQ=2, 86%)	Naphthalene (ELCR=8E-05, 59%) Arsenic (ELCR=5E-05, 38%) Chrysene (ECLR=4E-06, 3%)
BH-18B	2	1E-04	Naphthalene (HQ=2, 88%)	Naphthalene (ELCR=8E-05, 64%) Arsenic (ELCR=5E-05, 36%)
BH-29B	1	1E-04	none identified	Arsenic (ELCR=7E-05, 60%) Naphthalene (ELCR=4E-05, 40%)
BH-26A	0.8	1E-04	none identified	Arsenic (ELCR=9E-05, 84%) Naphthalene (ELCR=2E-05, 16%)
BH-28A	1	7E-05	none identified	Arsenic (ELCR=4E-05, 51%) Naphthalene (ELCR=4E-05, 49%)
Q17-W	0.5	7E-05	none identified	Arsenic (ELCR=6E-05, 89%) Naphthalene (ELCR=8E-06, 11%)
Q14	0.7	7E-05	none identified	Arsenic (ELCR=5E-05, 72%) Naphthalene (ELCR=2E-05, 28%)
BH-22	0.5	7E-05	none identified	Arsenic (ELCR=6E-05, 84%) Naphthalene (ELCR=1E-05, 16%)
BH-24	0.7	7E-05	none identified	Arsenic (ELCR=5E-05, 76%) Naphthalene (ELCR=1E-05, 23%)
BH-30C	0.2	5E-05	none identified	Benzo(a)anthracene (ELCR=4E-05, 95%)

Notes:

[a]Primary contributors to the total risk are listed when ELCR > 10^{-6} or HI > 1.

[b]Due to the very high concentrations found in this well and the inherent limitations quantifying risk at these levels, the ELCR is reported as a greater than estimate.

ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient
ND - no chemicals were detected

Table 7.1-9
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-5/5A	280	2E-02	Benzene (HQ=180, 64%) Naphthalene (HQ=81, 29%) Total Xylenes (HQ=17, 6%)	Benzene (ELCR=2E-02, 81%) Naphthalene (ELCR=4E-03, 16%) Ethylbenzene (ELCR=7E-04, 3%)
Q9	240	1E-02	Naphthalene (HQ=227, 95%) Benzene (HQ=9, 4%) Total Xylenes (HQ=4, 1%)	Naphthalene (ELCR=1E-02, 90%) Benzene (ELCR=9E-04, 8%) Ethylbenzene (ELCR=2E-04, 2%)
RW-QP-1	128	8E-03	Naphthalene (HQ=56, 44%) Benzene (HQ=45, 35%) Total Xylenes (HQ=25, 20%)	Benzene (ELCR=5E-03, 58%) Naphthalene (ELCR=2E-03, 32%) Ethylbenzene (ELCR=8E-04, 10%)
BH-20A	103	7E-03	Naphthalene (HQ=51, 49%) Benzene (HQ=46, 45%) Total Xylenes (HQ=6, 5%)	Benzene (ELCR=5E-03, 62%) Naphthalene (ELCR=2E-03, 30%) Ethylbenzene (ELCR=7E-04, 9%)
BH-5B	68	3E-03	Naphthalene (HQ=66, 97%) Total Xylenes (HQ=2, 3%)	Naphthalene (ELCR=3E-03, 93%) Ethylbenzene (ELCR=2E-04, 6%) Benzene (ELCR=4E-05, 1%)
BH-25A(R)	61	3E-03	Naphthalene (HQ=56, 92%) Benzene (HQ=3, 5%) Total Xylenes (HQ=2, 3%)	Naphthalene (ELCR=2E-03, 86%) Benzene (ELCR=3E-04, 10%) Ethylbenzene (ELCR=1E-04, 4%)
BH-20B	35	2E-03	Naphthalene (HQ=22, 62%) Benzene (HQ=11, 32%) Total Xylenes (HQ=2, 5%)	Benzene (ELCR=1E-03, 48%) Naphthalene (ELCR=9E-04, 42%) Ethylbenzene (ELCR=2E-04, 10%)
Q4	29	1E-03	Naphthalene (HQ=27, 93%)	Naphthalene (ELCR=1E-03, 88%) Ethylbenzene (ELCR=1E-04, 8%) Benzene (ELCR=5E-05, 4%)
BH-21A	11	5E-04	Naphthalene (HQ=11, 98%)	Naphthalene (ELCR=5E-04, 97%) Ethylbenzene (ELCR=1E-05, 2%) Benzene (ELCR=2E-06, 0.4%)
BH-18A	4	3E-04	Naphthalene (HQ=2, 53%) Benzene (HQ=2, 46%)	Benzene (ELCR=2E-04, 62%) Naphthalene (ELCR=1E-04, 31%) Ethylbenzene (ELCR=3E-05, 8%)
BH-23	4	3E-04	Benzene (HQ=2, 52%) Naphthalene (HQ=2, 39%)	Benzene (ELCR=2E-04, 64%) Naphthalene (ELCR=7E-05, 21%) Ethylbenzene (ELCR=5E-05, 16%)
RW-NS-1	5	2E-04	Naphthalene (HQ=4, 82%)	Naphthalene (ELCR=2E-04, 73%) Benzene (ELCR=3E-05, 15%) Ethylbenzene (ELCR=3E-05, 13%)
BH-28B	4	2E-04	Naphthalene (HQ=4, 87%)	Naphthalene (ELCR=2E-04, 73%) Benzene (ELCR=5E-05, 22%) Ethylbenzene (ELCR=1E-05, 5%)
BH-19B	3	1E-04	Naphthalene (HQ=3, 95%)	Naphthalene (ELCR=1E-04, 94%) Ethylbenzene (ELCR=7E-06, 6%)
BH-21B	3	1E-04	Naphthalene (HQ=2, 94%)	Naphthalene (ELCR=1E-04, 89%) Benzene (ELCR=9E-06, 8%) Ethylbenzene (ELCR=4E-06, 3%)
BH-19	0.5	6E-05	none identified	Benzene (ELCR=3E-05, 60%) Ethylbenzene (ELCR=2E-05, 30%) Naphthalene (ELCR=6E-06, 10%)
BH-20C	0.3	1E-05	none identified	Naphthalene (ELCR=1E-05, 97%)
BH-29A	0.09	4E-06	none identified	Naphthalene (ELCR=4E-06, 100%)
BH-26B	0.08	4E-06	none identified	Naphthalene (ELCR=4E-06, 100%)

Table 7.1-9
Summary of Location-Specific Risk and Hazard Estimates for Residential Indoor Air Exposure
(Sorted from Higher to Lower Risk)

Well	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
BH-18B	0.06	3E-06	none identified	Naphthalene (ELCR=3E-06, 100%)
Q12	0.06	3E-06	none identified	Naphthalene ELCR=3E-06, 100%
BH-29B	0.03	1E-06	none identified	none identified
BH-28A	0.03	1E-06	none identified	none identified
BH-24	0.01	7E-07	none identified	none identified
Q14	0.01	6E-07	none identified	none identified
BH-26A	0.01	5E-07	none identified	none identified
BH-22	0.008	3E-07	none identified	none identified
Q17-W	0.006	2E-07	none identified	none identified
BH-30C	0.0007	3E-08	none identified	none identified
Q1-D	ND	ND	none identified	none identified

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient
ND - no chemicals were detected

Table 7.1-10
Summary of Risk and Hazard Estimates for the Occupational Worker Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	0.4	1E-03	Naphthalene (HQ=2, 74%)	Benzo(a)pyrene (ELCR=1E-03, 75%)
Dermal	0.3	8E-04	2-Methylnaphthalene (HQ=0.2, 10%)	Benzo(b)fluoranthene (ELCR=1E-04, 6%)
Inhalation	1	5E-05		Benzo(a)anthracene (ELCR=1E-04, 6%)
Total Soil Routes	**2**	**2E-03**		Benzo(k)fluoranthene (ELCR=8E-05, 4%)
				Indeno(1,2,3-c,d)pyrene (ELCR=8E-05, 4%)
				Naphthalene (ELCR=5E-05, 3%)
				Chrysene (ELCR=2E-05, 1%)
				Dibenz(a,h)anthracene (ELCR=2E-05, 1%)
				Arsenic (ELCR=8E-06, 0.4%)

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-11
Summary of Risk and Hazard Estimates for the Construction/Excavation Worker Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Soil - 0 to 15 feet bgs				
Ingestion	1	1E-04	Naphthalene (HQ=2, 55%)	Benzo(a)pyrene (ELCR=1E-04, 76%)
Dermal	0.4	5E-05	2-Methylnaphthalene (HQ=0.6, 18%)	Benzo(b)fluoranthene (ELCR=1E-05, 6%)
Inhalation	1	2E-06		Benzo(a)anthracene (ELCR=1E-05, 6%)
Total Soil Routes	**3**	**2E-04**		Benzo(k)fluoranthene (ELCR=8E-06, 5%)
				Indeno(1,2,3-c,d)pyrene (ELCR=8E-06, 4%)
				Naphthalene (ELCR=2E-06, 1%)
				Chrysene (ELCR=2E-06, 1%)
				Dibenz(a,h)anthracene (ECLR=2E-06, 1%)
Contact with Trench Groundwater - Based on Maximum Detections from all Well Points				
Dermal	**33**	**1E-05**	2-Methylnaphthalene (HQ=13, 38%)	Benzene (ELCR=1E-05, 81%)
			Dibenzofuran (HQ=12, 36%)	Arsenic (ELCR=2E-06, 13%)
			Benzene (HQ=4, 11%)	
			Naphthalene (HQ=3, 10%)	
Trench Vapor - Based on Maximum Detections from all Well Points				
Inhalation	**486**	**8E-04**	Naphthalene (HQ=451, 93%)	Naphthalene (ELCR=7E-04, 86%)
			Benzene (HQ=31, 6%)	Benzene (ELCR=1E-04, 14%)
			Total Xylenes (HQ=3, 0.7%)	Ethylbenzene (ELCR=3E-06, 0.4%)

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

bgs - below ground surface
ELCR - excess lifetime cancer risk
HI - hazard index
HQ - hazard quotient

Table 7.1-12
Summary of Risk and Hazard Estimates for the Recreational Beach User Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Exposure to Site Nearshore Sediment				
Ingestion	0.004	2E-04	none identified	Benzo(a)pyrene (ELCR=3E-04, 89%)
Dermal	0.01	9E-05		Benzo(a)anthracene (ELCR=1E-05, 5%)
Total Sediment Routes	**0.02**	**3E-04**		Indeno(1,2,3-c,d)pyrene (ELCR=1E-05, 3%)
				Dibenz(a,h)anthracene (ELCR=5E-06, 1%)
				Chrysene (ELCR=3E-06, 1%)
Exposure to Site Surface Water				
Ingestion	0.007	2E-06	none identified	Benzene (ELCR=2E-06, 67%)
Dermal	0.02	2E-06		
Total Surface Water Routes	**0.03**	**3E-06**		
Exposure to Background Sediment				
Ingestion	0.001	2E-06	none identified	Benzo(a)pyrene (ELCR=2E-06, 86%)
Dermal	0.00005	7E-07		
Total Sediment Routes	**0.001**	**3E-06**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-13
Summary of Risk and Hazard Estimates for the Recreational Fishing Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Fish/Shellfish Consumption (Based on Site-Wide Sediment)				
Ingestion	**0.4**	**2E-04**	none identified	Benzo(a)pyrene (ELCR=2E-04, 65%) Benzo(a)anthracene (ELCR=7E-05, 29%) Dibenz(a,h)anthracene (ELCR=6E-06, 2%) Chrysene (ELCR=6E-06, 2%) Indeno(1,2,3-c,d)pyrene (ELCR=5E-06, 2%)
Exposure to Site-Wide Sediment				
Ingestion	0.008	2E-05	none identified	Benzo(a)pyrene (ELCR=3E-05, 83%) Benzo(a)anthracene (ELCR=5E-06, 13%)
Dermal	0.005	2E-05		
Total Sediment Routes	**0.01**	**4E-05**		
Fish/Shellfish Consumption (Based on Background Sediment)				
Ingestion	**0.0004**	**2E-06**	none identified	Benzo(a)pyrene (ELCR=1E-06, 71%)
Exposure to Background Sediment				
Ingestion	0.0002	7E-08	none identified	none identified
Dermal	0.000001	5E-08		
Total Sediment Routes	**0.0002**	**1E-07**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-14
Summary of Risk and Hazard Estimates for the Subsistence Fishing Exposure Scenario

Exposure Route	Noncancer Hazard Index	Excess Lifetime Cancer Risk	Primary Contributors to HI[a]	Primary Contributors to ELCR[a]
Fish/Shellfish Consumption (Based on Site-Wide Sediment)				
Ingestion	**3**	**5E-03**	2-Methylnaphthalene (HQ=2, 50%)	Benzo(a)pyrene (ELCR=3E-03, 65%) Benzo(a)anthracene (ELCR=1E-03, 29%) Dibenz(a,h)anthracene (ELCR=1E-04, 2%) Chrysene (ELCR=1E-04, 2%) Indeno(1,2,3-c,d)pyrene (ELCR=9E-05, 2%)
Exposure to Site-Wide Sediment				
Ingestion	0.01	4E-05	none identified	Benzo(a)pyrene (ELCR=5E-05, 83%) Benzo(a)anthracene (ELCR=8E-06, 13%)
Dermal	0.008	3E-05		
Total Sediment Routes	**0.02**	**6E-05**		
Fish/Shellfish Consumption (Based on Background Sediment)				
Ingestion	**0.003**	**4E-05**	none identified	Benzo(a)pyrene (ELCR=3E-05, 71%) Benzo(a)anthracene (ELCR=6E-06, 16%) Indeno(1,2,3-c,d)pyrene (ELCR=2E-06, 6%) Dibenz(a,h)anthracene (ELCR=2E-06, 6%)
Exposure to Background Sediment				
Ingestion	0.0003	1E-07	none identified	none identified
Dermal	0.000002	8E-08		
Total Sediment Routes	**0.0003**	**2E-07**		

Notes:

[a] Primary contributors to the total risk are listed when ELCR > 10-6 or HI > 1.

ELCR - excess lifetime cancer risk
HI - hazard index

Table 7.1-15
Summary of Risk and Hazard Estimates for Human Exposure Scenarios

Exposure Medium	Exposure Route	Human Exposure Scenarios											
		Residential		Occupational Worker		Construction/ Excavation Worker		Recreational Beach User		Recreational Fishing		Subsistence Fishing	
		HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR
Soil (0 to 15 feet bgs)	Ingestion	**1**	**2E-02**	0.4	**1E-03**	**1**	**1E-04**	--	--	--	--	--	--
	Dermal	0.5	**7E-03**	0.3	**8E-04**	0.4	**5E-05**	--	--	--	--	--	--
	Inhalation	**6**	**3E-04**	**1**	**5E-05**	**1**	**2E-06**	--	--	--	--	--	--
	Total	**8**	**3E-02**	**2**	**2E-03**	**3**	**2E-04**	--	--	--	--	--	--
Groundwater	Ingestion	**602**	**8E-01**	--	--	--	--	--	--	--	--	--	--
	Dermal	**175**	**5E-04**	--	--	0.00001	**1E-05**	--	--	--	--	--	--
	Inhalation	**7,218**	**3E-01**	--	--	--	--	--	--	--	--	--	--
	Total	**7,995**	**>8E-01**[a]	--	--	0.00001	**1E-05**	--	--	--	--	--	--
Indoor Air	Inhalation	**280**	**2E-02**	--	--	--	--	--	--	--	--	--	--
Trench Vapor	Inhalation	--	--	--	--	486	**8E-04**	--	--	--	--	--	--
Nearshore Sediment	Ingestion	--	--	--	--	--	--	0.004	**2E-04**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.01	**9E-05**	--	--	--	--
	Total	--	--	--	--	--	--	0.02	**3E-04**	--	--	--	--
Site-Wide Sediment	Ingestion	--	--	--	--	--	--	--	--	0.008	**2E-05**	0.01	**4E-05**
	Dermal	--	--	--	--	--	--	--	--	0.005	**2E-05**	0.01	**3E-05**
	Total	--	--	--	--	--	--	--	--	0.01	**4E-05**	0.02	**6E-05**
Site Surface Water	Ingestion	--	--	--	--	--	--	0.007	**2E-06**	--	--	--	--
	Dermal	--	--	--	--	--	--	0.02	**2E-06**	--	--	--	--
	Total	--	--	--	--	--	--	0.03	**3E-06**	--	--	--	--
Site Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.4	**2E-04**	**3**	**5E-03**
Background Sediment	Ingestion	--	--	--	--	--	--	0.001	**2E-06**	0.0002	7E-08	0.0003	1E-07
	Dermal	--	--	--	--	--	--	0.00005	7E-07	0.000001	5E-08	0.000002	8E-08
	Total	--	--	--	--	--	--	0.001	**3E-06**	0.0002	1E-07	0.0003	2E-07
Background Fish/Shellfish	Ingestion	--	--	--	--	--	--	--	--	0.0004	**2E-06**	0.003	**4E-05**

Notes:

[a]Due to the very high concentrations found in well Q9 and the inherent limitations quantifying risk at these levels, the ELCR is reported as a "greater than" estimate.

Risks to future residents from exposure to groundwater and indoor air were estimated from the maximum single-well risk.

Risks to construction/excavation workers from exposure to groundwater and trench vapor were estimated from maximum detected concentrations from all wellpoints.

bgs - below ground surface

ELCR - excess lifetime cancer risk

HI - hazard index; HQ - hazard quotient

Boldface without highlighting - HQ greater than 1 or ELCR greater than 1E-06

Boldface with highlighting - HQ greater than 10 or ELCR greater than 1E-04

Table 7.2-1
Summary of Site Data Used to Characterize Ecological Exposures

Exposure Scenario		Direct Surface Soil Contact	Incidental Surface Soil Ingestion	Direct Sediment Contact	Incidental Sediment Ingestion	Direct Water Contact	Drinking Water Ingestion	Food/Prey Ingestion
Soil Invertebrates and Terrestrial Plants	**Exposure Assumptions**	All upland surface soil considered one exposure unit.	All upland surface soil considered one exposure unit.	NA	NA	NA	NA	NA
	Exposure Sample Data	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	NA	NA	NA	NA	NA
Terrestrial Birds (robin, hawk)	**Exposure Assumptions**	All upland surface soil considered one exposure unit.	All upland surface soil considered one exposure unit.	NA	NA	Exposure to upland and shoreline surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Exposure to upland and shoreline surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Soil invertebrates and plants foraged from the Site are a potentially complete exposure pathway for bioaccumulative COPCs.
	Exposure Sample Data	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	NA	NA	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Potential bioaccumulation exposure estimated using BAF approach consistent with EPA Eco-SSLs. Surface soil concentrations (Appendix J-3) and BAFs used to estimate plant and soil invertebrate tissue burdens.
Terrestrial Mammals and Herptiles (raccoon, rabbit, vole, shrew, coyote)	**Exposure Assumptions**	All upland surface soil considered one exposure unit.	All upland surface soil considered one exposure unit.	NA	NA	Exposure to upland and shoreline surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Exposure to upland and shoreline surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Soil invertebrates and plants foraged from the Site are a potentially complete exposure pathway for bioaccumulative COPCs.
	Exposure Sample Data	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	Surface soil samples (0 - 5 feet bgs); Appendix J-3.	NA	NA	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Potential bioaccumulation exposure estimated using BAF approach consistent with EPA Eco-SSLs. Surface soil concentrations (Appendix J-3) and BAFs used to estimate plant and soil invertebrate tissue burdens.
Aquatic-Dependent Birds (sandpiper, mallard, scaup, heron, eagle)	**Exposure Assumptions**	NA	NA	Potential exposure to sediment during foraging for fish, invertebrates, or plants throughout the Site. Surface sediment samples within this area represent exposure point.	Potential exposure to sediment during foraging for fish, invertebrates, or plants throughout the Site. Surface sediment samples within this area represent exposure point.	Exposure surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Exposure surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Fish and shellfish foraged from the Site are a potentially complete exposure pathway for bioaccumulative COPCs.
	Exposure Sample Data	NA	NA	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3.	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Potential bioaccumulation exposure estimated using BSAF approach. Site-wide surface sediment concentrations (Appendix J-3) and BSAFs (Appendix J-5) used to estimate fish/shellfish tissue burdens.

Table 7.2-1
Summary of Site Data Used to Characterize Ecological Exposures

Exposure Scenario		Direct Surface Soil Contact	Incidental Surface Soil Ingestion	Direct Sediment Contact	Incidental Sediment Ingestion	Direct Water Contact	Drinking Water Ingestion	Food/Prey Ingestion
Piscivorous Mammals (otter)	**Exposure Assumptions**	NA	NA	Potential exposure to sediment during foraging. Nearshore area bounded by OHW line, and OHW - 6 feet represents foraging depth. Surface sediment samples within this area represent exposure point.	Potential exposure to sediment during foraging. Nearshore area bounded by OHW line, and OHW - 6 feet represents foraging depth. Surface sediment samples within this area represent exposure point.	Exposure surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Exposure surface water during foraging. Available shoreline surface water and porewater samples provide a conservative exposure estimate. Porewater dilution model appropriate to estimate exposure.	Fish and shellfish foraged from the Site are a potentially complete exposure pathway for bioaccumulative COPCs.
	Exposure Sample Data	NA	NA	Nearshore surface sediment samples (0 to 4 inches); Appendix J-3.	Nearshore surface sediment samples (0 to 4 inches); Appendix J-3.	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	Potential bioaccumulation exposure estimated using BSAF approach. Site-wide sediment concentrations (Appendix J-3) and BSAFs (Appendix J-5) used to estimate fish/shellfish tissue burdens.
Fish/ Shellfish	**Exposure Assumptions**	NA	NA	Fish and shellfish at the Site may be exposed to COPCs in sediment through direct contact. Site-wide surface sediment represents potential exposure point.	Fish and shellfish at the Site may be exposed to COPCs in sediment through incidental ingestion while foraging. Site-wide surface sediment represents potential exposure point	Fish and shellfish at the Site may be exposed to surface water and porewater through direct contact. Porewater exposure as a surface water surrogate measure is conservative. Porewater dilution model appropriate to estimate exposure.	NA	Invertebrates and shellfish foraged from the Site are a potentially complete exposure pathway of bioaccumulative COPCs
	Exposure Sample Data	NA	NA	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3.	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	NA	Potential bioaccumulation exposure estimated using BSAF approach. Site-wide surface sediment concentrations (Appendix J-3) and BSAFs (Appendix J-5) used to estimate fish/shellfish tissue burdens.
Benthic Invertebrates	**Exposure Assumptions**	NA	NA	Benthos at the Site may be exposed to COPCs in sediment through direct contact and porewater. Site-wide surface sediment represents potential exposure point.	NA	Benthos at the Site may be exposed to surface water and porewater through direct contact.	NA	NA
	Exposure Sample Data	NA	NA	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3 (chemistry and bioassay results).	NA	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	NA	NA
Aquatic Macrophytes	**Exposure Assumptions**	NA	NA	Plants at the Site may be exposed to COPCs in sediment through direct contact. Site-wide surface sediment represents potential exposure point.	NA	Plants at the Site may be exposed to surface water and porewater through direct contact.	NA	NA
	Exposure Sample Data	NA	NA	Site-wide surface sediment samples (0 to 4 inches); Appendix J-3.	NA	Site-wide surface sediment porewater (0 to 4 inches) and surface water samples; Appendix J-3.	NA	NA

Notes:

BAF - bioaccumulation factor
bgs - below ground surface
BSAF - biota-sediment accumulation factor
COPC - chemical of potential concern
Eco-SSL - ecological soil screening level
EPA - U.S. Environmental Protection Agency
NA - not applicable
OHW - ordinary high water

Table 7.2-2
Chemicals of Potential Concern for Ecological Receptors

COI	Soil		Surface Water		Sediment		
	COPC?	Rationale	COPC?	Rationale	COPC?	Rationale	Bio-accumulative?
2,4-Dimethylphenol	Y	Max. detect > SL	NA	Not a SW COI	NA	Not a sed. COI	
2-Methylnaphthalene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	
4-Methylphenol (p-Cresol)	NA	Not a soil COI	NA	Not a SW COI	N	Max. detect < SL	
Acenaphthene	N	Max. detect < SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Acenaphthylene	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	Y
Anthracene	N	Max. detect < SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Arsenic	Y	Max. detect > SL	Y	Max. detect GW > SL	Y	QA1- DL > SL; Indicator	Y
Benzene	N	All ND; DL < SL	Y	Max. detect > SL	NA	Not a sed. COI	
Benzo(a)anthracene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Benzo(a)pyrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Benzo(b)fluoranthene	Y	Max. detect > SL	Y	No SL	NA	Not a sed. COI	Y
Benzo(g,h,i)perylene	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Benzo(k)fluoranthene	Y	Max. detect > SL	Y	No SL	NA	Not a sed. COI	Y
Cadmium	N	QA1- Max. < BKGD	NA	Not a SW COI	N	QA1-	Y
Carbon disulfide	NA	Not a soil COI	NA	Not a SW COI	N	QA1-	
Chromium	Y	QA1- max. > SL; Indicator	NA	Not a SW COI	Y	QA1- max. > SL; Indicator	
Chrysene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Copper	NA	Not a soil COI	NA	Not a SW COI	Y	QA1- max. > SL; Indicator	Y
Dibenz(a,h)anthracene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Dibenzofuran	Y	No SL	NA	Not a SW COI	Y	Max. detect > SL	
Ethylbenzene	N	Max. detect < SL	Y	Max. detect > SL	N	QA1- max. < BKGD	
Fluoranthene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Fluorene	Y	Max. detect > SL	Y	Max detect > SL	Y	Max. detect > SL	Y
Indeno(1,2,3-c,d)pyrene	Y	Max. detect > SL	Y	No SL	Y	Max. detect > SL	Y
Lead	Y	Max. detect > SL	NA	Not a SW COI	N	QA1-	Y
m,p-Xylene	N	Max. det. total xylenes < SL	Y	Max. detect > SL	NA	Not a sed. COI	
Mercury	NA	Not a soil COI	NA	Not a SW COI	N	Not a sed. COI	Y
Naphthalene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	
Nickel	N	QA1-	NA	Not a SW COI	N	QA1-	Y
o-Xylene	N	Max. det. total xylenes < SL	NA	Not a SW COI	NA	Not a sed. COI	
Pentachlorophenol	Y	All ND; DL > SL	NA	Not a SW COI	NA	Not a sed. COI	Y
Phenanthrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y

Table 7.2-2
Chemicals of Potential Concern for Ecological Receptors

COI	Soil		Surface Water		Sediment		
	COPC?	Rationale	COPC?	Rationale	COPC?	Rationale	Bio-accumulative?
Phenol	NA	Not a soil COI	NA	Not a SW COI	N	Max. detect < SL	Y
Pyrene	Y	Max. detect > SL	Y	Max. detect > SL	Y	Max. detect > SL	Y
Sulfide	NA	Not a soil COI	NA	Not a SW COI	N	QA1-	
Toluene	N	Max. detect < SL	Y	Max. detect > SL	NA	Not a sed COI	
Total 10 of 16 HPAHs (U=1/2)	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Total 16 PAHs (U=1/2)	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	Y
Total 6 of 16 LPAHs (U=1/2)	Y	Max. detect > SL	NA	Not a SW COI	Y	Max. detect > SL	Y
Total PCB Aroclors (U=1/2)	Y	QA1- max. > SL; Indicator	NA	Not a SW COI	NA	Not eco COI	Y
Total cPAH TEQs (7 minimum) (U=1/2)	NA	Not eco COI	NA	Not eco COI	NA	Not eco COI	Y
Total Organic Carbon	NA	Not a soil COI	NA	Not a SW COI	Y	Max. detect > SL	
Total PAH ESBQs (U=1/2)	NA	Not a soil COI	Y	Max. detect > SL	Y	Max. detect > SL	
Total Xylenes (U=1/2)	N	Max. detect < SL	Y	Max. detect > SL	NA	Not a sed COI	
Zinc	N	QA1-	NA	Not a SW COI	N	QA1-	Y

Notes:

All ND; DL > SL - All non-detects; detection limit exceeds screening level.

Max. detect > SL - Max.imum detected concentration exceeds screening level.

QA1- max. > SL; Indicator - Maximum value of QA1- quality exceeds screening level; indicator chemical.

QA1- DL > SL; Indicator - Analyte not detected, detection limit exceeds screening level; indicator chemical.

Max. detect total xylenes < SL - Total xylenes (used as surrogate for individual isomers) do not exceed screening level.

Details supporting the COPC screening for the ecological risk assessment are provided in Appendix J-8.

The samples included:

Soil - all surface soil samples (0-5 feet) in risk dataset.

Surface Water - groundwater, porewater (undiluted), and surface water samples in risk dataset.

Sediment - all surface sediment samples (0-4 inches) in risk dataset.

COI - contaminant of interest

COPC - chemical of potential concern

cPAH TEQs - carcinogenic PAH toxicity equivalency quotients

ESBQs - equilibrium partitioning sediment benchmark quotients

HPAH - high-molecular-weight PAHs

LPAH - low-molecular-weight PAHs

PAHs - polynuclear aromatic hydrocarbons

Table 7.2-3
Rationale for the Selection or Exclusion of Quantitative Ecological Exposure Pathways

Receptor Group	Exposure Point	Exposure Medium	Exposure Route	Type of Analysis	Rationale for Type of Analysis
Soil Invertebrates and Terrestrial Plants	Site uplands	Surface soil	Direct contact and ingestion	Numeric	Surface soil ingestion is the primary route of exposure.
		Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to soil exposure.
Terrestrial Birds	Site uplands and adjacent areas within home range	Surface soil	Direct contact and ingestion	Numeric	Surface soil ingestion is a primary route of exposure.
		Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to soil exposure.
		Soil biota	Ingestion	Numeric	Prey ingestion is a primary route of exposure.
Terrestrial Mammals and Herptiles	Site uplands and adjacent areas within home range	Surface soil	Direct contact and ingestion	Numeric	Surface soil ingestion is a primary route of exposure.
		Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to soil exposure.
		Soil biota	Ingestion	Numeric	Prey ingestion is a primary route of exposure.
Aquatic-Dependent Birds	Site and adjacent shorelines and Lake water within home range	Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to sediment and prey tissue exposure.
		Sediment	Direct contact and ingestion	Numeric	Sediment ingestion is likely during foraging.
		Fish/shellfish	Ingestion	Numeric	Fish and shellfish prey ingestion are the primary routes of exposure.
Piscivorous Mammals	Site and adjacent shorelines and Lake water within home range	Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to sediment and prey tissue exposure.
		Sediment	Direct contact and ingestion	Numeric	Sediment ingestion is likely during foraging.
		Fish/shellfish	Ingestion	Numeric	Fish and shellfish prey ingestion are the primary routes of exposure.
Fish/Shellfish	Site and adjacent shorelines and Lake water within home range	Surface water	Direct contact and ingestion	Numeric	Surface water exposure is a primary route of exposure.
		Sediment	Direct contact and ingestion	Numeric	Sediment exposure is a primary route of exposure.
		Fish/invertebrates	Ingestion	Numeric	Fish and benthic invertebrate prey ingestion are primary routes of exposure.
Benthic Invertebrates and Aquatic Macrophytes	Lake Washington adjacent to Site	Surface water	Direct contact and ingestion	Qualitative	Surface water exposure is insignificant relative to sediment exposure.
		Sediment	Direct contact and ingestion	Numeric	Sediment exposure is the primary route of exposure.

Table 7.2-4
Summary of Ecological Assessment and Measurement Endpoints

Exposure Scenario/Receptors	Assessment Endpoint	Measurement Endpoint	Exposure Point Concentration	Receptor Exposure Parameters	Toxicity Data
Soil Invertebrates	Probability of reduced survival, growth, and reproduction of plants	Soil: Bulk soil concentrations compared to ecological soil screening guidelines.	See Table 7.2-5.	EPA EcoSSLs and relevant sources (e.g., ORNL, literature)	EPA soil screening guidelines (e.g., EcoSSLs, Region 5),
Terrestrial Plants	Probability of reduced survival, growth, and reproduction of soil invertebrate communities	Soil: Bulk soil concentrations compared to ecological soil screening guidelines.	See Table 7.2-5.	EPA EcoSSLs and relevant sources (e.g., ORNL, literature)	EPA soil screening guidelines (e.g., EcoSSL, Region 5)
Terrestrial Birds (avian predator/hawk, avian insectivore/passerines)	Probability of reduced survival, growth, and reproduction of terrestrial bird populations	Soil: Bulk soil concentrations compared to ecological soil quality screening guidelines. Dietary Total Daily Intake: Estimated based on modeled plant and soil invertebrate tissue data and incidental soil and surface water uptake.	See Table 7.2-8.	Wildlife Exposure Factors Handbook (EPA 1993b) and relevant sources (e.g., ORNL, literature)	EPA soil screening guidelines (e.g., EcoSSL, Region 5), Literature TRVs
Terrestrial Mammals (carnivore/coyote; omnivore/raccoon; herbivore/rabbit and vole; and insectivore/shrew)	Probability of reduced survival, growth, and reproduction of terrestrial mammal populations	Soil: Bulk soil concentrations compared to ecological soil screening guidelines. Dietary Total Daily Intake: Estimated based on modeled plant, soil invertebrate and small mammal data and incidental soil and surface water uptake.	See Table 7.2-8.	Wildlife Exposure Factors Handbook (EPA 1993b) and relevant sources (e.g., ORNL, literature)	EPA soil screening guidelines (e.g., EcoSSL, Region 5), literature TRVs
Aquatic Macrophytes	Probability of reduced survival, growth, and reproduction of aquatic plants	Porewater: Porewater and modeled surface water concentrations compared directly to AWQC or TRVs.	See Table 7.2-28.	None - direct comparison to AWQC or TRVs	Ambient water quality criteria, TRVs
Benthic Invertebrates	Probability of reduced survival, growth, and reproduction of benthic invertebrate communities	Porewater: Porewater and modeled surface water concentrations compared directly to PAH ESB model FCVs and AWQC or other TRVs. Bulk sediment: Bulk sediment concentrations compared to benchmarks. Bioassays: Results of Site co-located COPC concentrations and bioassay results compared with background and controls. Wood debris: Results of wood debris analysis correlated with chemistry	See Table 7.2-28.	None - direct comparison to AWQC, TRVs or Site-specific reference data	Ambient water quality criteria, TRVs
Fish/Shellfish (all species)	Probability of reduced survival, growth, and reproduction of fish or shellfish populations	Porewater: Porewater and modeled surface water concentrations compared directly to PAH model FCVs and AWQC or other TRVs. Tissue Residue: Fish tissue estimated based on BSAF-modeled concentrations compared to tissue-based TRVs. Dietary Intake: Fish tissue estimated based on BSAF-modeled concentrations compared to dietary TRVs.	See Tables 7.2-30 and 7.2-31	Literature life history information to inform diet inputs	Ambient water quality criteria, literature TRVs
Aquatic-Dependent Birds (piscivorous raptor/osprey and bald eagle; piscivorous wading bird/heron; sediment probing bird/sandpiper; omnivorous waterfowl/scaup and mallard)	Probability of reduced survival, growth, and reproduction of aquatic-dependent bird populations	Dietary Total Daily Intake: Estimated based on BSAF-modeled fish and shellfish tissue data and, depending on species, incidental surface water and sediment.	See Tables 7.2-30 and 7.2-31	Wildlife Exposure Factors Handbook (EPA 1993b) and relevant sources (e.g., ORNL, literature)	Literature TRVs

Table 7.2-4
Summary of Ecological Assessment and Measurement Endpoints

Exposure Scenario/Receptors	Assessment Endpoint	Measurement Endpoint	Exposure Point Concentration	Receptor Exposure Parameters	Toxicity Data
Aquatic-Dependent Mammals (piscivorous otter)	Probability of reduced survival, growth, and reproduction of piscivorous mammal populations	Dietary Total Daily Intake: Estimated based on BSAF-modeled fish and shellfish tissue data and, depending on species, incidental surface water and sediment.	See Tables 7.2-30 and 7.2-31	Wildlife Exposure Factors Handbook (EPA 1993b) and relevant sources (e.g., ORNL, literature)	Literature TRVs

Notes:
AWQC - ambient water quality criteria
BSAF - biota-sediment accumulation factor
COPC - chemical of potential concern
EPA EcoSSLs - U.S. Environmental Protection Agency Ecological Soil Screening Levels
FCV - final chronic value
ORNL - Oak Ridge National Laboratory
PAH ESB - polynuclear aromatic hydrocarbon equilibrium partitioning sediment benchmark
TRV - toxicity reference value

Table 7.2-5
Bulk Soil Screening: Soil Invertebrates and Terrestrial Plants

COPC	Unit	EPA Eco-SSL Plant	EPA Eco-SSL Invertebrates	Number of Samples	Number of Detections	Number of Non-detects	Frequency of Detection (%)	Minimum Value	Maximum Value	Mean Value	Minimum Detected Value	Maximum Detected Value	Mean Detected Value	Exposure Point Concentration 95 UCL	EPC Basis	95 UCL Exceedance Factor Plant SSL (HQ)	95 UCL Exceedance Factor Invert. SSL (HQ)
2,4-Dimethylphenol	mg/kg	--	--	38	3	35	8%	0.06	14	1.09	0.13	1.3	0.74	0.264	95% KM (t) UCL	--	--
2-Methylnaphthalene	mg/kg	--	--	47	28	19	60%	0.06	14	16.6	0.025	180	27.1	83.63	99% KM (Chebyshev) UCL	--	--
Arsenic	mg/kg	18	--	37	21	16	57%	5	10	12.7	4.9	110	17.88	17.4	95% KM (t) UCL	1.0	--
Benzo(a)anthracene	mg/kg	--	--	47	43	4	91%	0.06	0.063	73.9	0.092	1,100	80.76	373.1	99% KM (Chebyshev) UCL	--	--
Benzo(a)pyrene	mg/kg	--	--	47	43	4	91%	0.06	0.063	89.1	0.13	1,400	97.39	460.5	99% KM (Chebyshev) UCL	--	--
Benzo(b)fluoranthene	mg/kg	--	--	47	43	4	91%	0.06	0.063	65.1	0.1	960	71.19	320.1	99% KM (Chebyshev) UCL	--	--
Benzo(g,h,i)perylene	mg/kg	--	--	47	42	5	89%	0.06	0.096	45.5	0.095	1,100	50.93	290	99% KM (Chebyshev) UCL	--	--
Benzo(k)fluoranthene	mg/kg	--	--	47	43	4	91%	0.06	0.063	48	0.094	660	52.46	232.8	99% KM (Chebyshev) UCL	--	--
Chromium(III)[a]	mg/kg	--	--	7	7	0	100%			40.3	25	65.3	40.33	56.86	Use 95% Approximate Gamma UCL	--	--
Chrysene	mg/kg	--	--	47	43	4	91%	0.06	0.063	99	0.14	1,500	108.2	497.3	99% KM (Chebyshev) UCL	--	--
Dibenz(a,h)anthracene	mg/kg	--	--	47	33	14	70%	0.032	1.4	11.7	0.041	190	16.64	62.25	99% KM (Chebyshev) UCL	--	--
Dibenzofuran	mg/kg	--	--	47	24	23	51%	0.06	1.4	3.44	0.02	34	6.5	15.59	99% KM (Chebyshev) UCL	--	--
Fluoranthene	mg/kg	--	--	47	43	4	91%	0.061	1400	136	0.07	2,200	116.2	625	99% KM (Chebyshev) UCL	--	--
Fluorene	mg/kg	--	--	47	34	13	72%	0.06	1.4	18.5	0.021	350	25.49	103.6	99% KM (Chebyshev) UCL	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	--	--	47	41	6	87%	0.06	4.5	34.4	0.086	730	39.31	200.8	99% KM (Chebyshev) UCL	--	--
Lead	mg/kg	120	1,700	37	35	2	95%	2	2	133	3	1,120	140.1	638.7	99% KM (Chebyshev) UCL	**5**	0.4
Naphthalene	mg/kg	--	--	58	38	20	66%	0.023	14	26.7	0.0029	370	40.34	128.5	99% KM (Chebyshev) UCL	--	--
Pentachlorophenol	mg/kg	--	--	38	0	38	0%	0.15	71	4.68	ND	ND	ND	71	Max. non-detect	--	--
Phenanthrene	mg/kg	--	--	47	45	2	96%	0.061	0.062	145	0.092	2,800	151.8	838.9	99% KM (Chebyshev) UCL	--	--
Pyrene	mg/kg	--	--	47	45	2	96%	0.061	0.062	188	0.09	3,200	196.2	1012	99% KM (Chebyshev) UCL	--	--
Total 10 of 16 HPAHs (U=1/2)	mg/kg	--	18	47	45	2	96%	0.061	0.062	778	0.374	13,040	812.4	4,061	99% KM (Chebyshev) UCL	--	**226**
Total 6 of 16 LPAHs (U=1/2)	mg/kg	--	29	47	45	2	96%	0.061	0.062	252	0.242	4,440	262.7	1,373	99% KM (Chebyshev) UCL	--	**47**
Total PCB Aroclors (U=1/2)[a]	mg/kg	--	--	7	0	7	0%	0.029	0.042	0.035	ND	ND	ND	0.042	Max. non-detect	--	--

Notes:
[a] Based on QA1 data.
-- - No screening value
COPC - chemical of potential concern
Eco-SSL - ecological soil screening level
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
HPAHs - high-molecular-weight PAHs
HQ - hazard quotient
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
Student's (t) - UCL based on Student's t-distribution
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
LPAHs - low-molecular-weight PAHs
Max. non-detect - UCL based on the maximum non-detected value
mg/kg - milligram(s) per kilogram
ND - not detected
PAH - polynuclear aromatic hydrocarbon
PCB - polychlorinated biphenyl
UCL - upper confidence limit

Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

Table 7.2-6
Wildlife Exposure Parameters

Receptor Group	Receptor	Body Weight (BW) kg ww		Food Ingestion Rate (FIR) kg ww/d		Water Ingestion Rate (WIR) L/d		Sediment % dw diet		Soil % dw diet		Home Range		Site Use Factor (SUF)	
Terrestrial Wildlife															
Insectivorous Birds	American Robin	0.081	a	0.023	m	0.011	d	0	e	10	h	0.25 ha	a	1	e
Avian Predators	Red-tailed Hawk	1.134	a	1.119	a	0.064	d	0	e	10	e	672 ha	a	0.5	e
Herbivorous Mammals	Eastern Cottontail	1.22	a	0.226	q	0.118	g	0	e	6.3	h	3.02 ha	r	1	e
Herbivorous Mammals	Meadow Vole	0.0373	a	0.013	s	0.005	g	0	e	2.4	h	0.027 ha	a	1	e
Insectivorous Mammals	Short-tailed Shrew	0.0168	a	0.007	s	0.003	g	0	e	10	t	0.39 ha	a	1	e
Omnivorous Mammals	Raccoon	6.5	a	0.656	f	0.534	g	0	e	10	h	156 ha	k	1	e
Carnivorous Mammals	Coyote	10	v	0.950	f	0.786	g	0	e	3	u	9240 ha	w	0.5	e
Aquatic-Dependent Wildlife															
Piscivorous Raptors	Bald Eagle	3.75	a	0.450	c	0.143	d	2	e	0	e	3.5 km	j	1	e
Piscivorous Mammals	River Otter	8.55	b	0.830	f	0.683	g	2	e	0	e	28 km	b	1	e
Sediment-probing Birds	Spotted Sandpiper	0.0425	a	0.027	l	0.007	d	18	i	0	e	0.25 ha	a	1	e
Dabbling Ducks	Mallard	1.161	a	0.267	l	0.065	d	3.3	h	0	e	435 ha	a	0.5	e
Diving Ducks	Lesser Scaup	0.815	o	0.332	n	0.051	d	2	e	0	e	89 ha	a	0.75	e
Shorebirds	Great Blue Heron	2.336	a	0.745	n	0.104	d	2	e	0	e	4.5 ha	p	1	e

Notes:

a Average for adults (both sexes) (cited in EPA 1993b).
b Average for adults (both sexes) in Idaho (cited in EPA 1993b).
c Average for free-flying adults (both sexes) in Washington (cited in EPA 1993b).
d Equation 3-15 in EPA 1993b.
e Professional judgment.
f Calculated using allometric equation for carnivorous mammals as cited in Nagy 2001.
g Equation 3-17 in EPA 1993b.
h Beyer et al. 1994.
i Beyer et al. 1994, average of 4 sandpiper values.
j Average of pair in Washington (cited in EPA 1993b).

Table 7.2-6
Wildlife Exposure Parameters

Receptor Group	Receptor	Body Weight (BW) kg ww	Food Ingestion Rate (FIR) kg ww/d	Water Ingestion Rate (WIR) L/d	Sediment % dw diet	Soil % dw diet	Home Range	Site Use Factor (SUF)

k Average for adults (both sexes) in Michigan (cited in EPA 1993b).
l Calculated using allometric equation for all birds as cited in Nagy 2001.
m Calculated using allometric equation for insectivorous birds as cited in Nagy 2001.
n Calculated using allometric equation for shorebirds as cited in Nagy 2001.
o Average for male and female (non-molting study; cited in EPA 1993b).
p Average feeding territory for adults in Oregon (both sexes; cited in EPA 1993b).
q Calculated using allometric equation for herbivorous mammals as cited in Nagy 2001.
r Average for adults (both sexes) in Wisconsin woodlot (cited in EPA 1993b).
s Calculated using allometric equation for rodents as cited in Nagy 2001.
t Assumption based on a range of values presented in Beyer et al. 1994 as cited in EPA 1999b.
u Value for Red Fox as cited in Beyer et al. 1994 used as surrogate.
v Based on average weight of coyotes in the western United States (Houben and Mason 2004).
w Overall home range in south-central Washington (Springer 1982).

ha - hectare(s)
kg ww - kilograms wet weight
kg ww/d - kilograms wet weight per day
km - kilometer(s)
L/d - liters per day
% dw diet - percent dry weight diet

Table 7.2-7
Summary of Dietary Fractions for Wildlife Exposure Assessment

Receptor Group	Receptor	Source	Fraction of Items in Diet (by weight)									
			Terrestrial-Based				Aquatic-Based					
			Invert. Earthworm PDF_{ie}	Other Soil Invert. PDF_{si}	Small Mammal PDF_{sm}	Terrest. Plants PDF_{plant}	Fish Demersal PDF_{df}	Fish Pelagic PDF_{pf}	Invert. Crustacean PDF_{c}	Invert. Worm PDF_{w}	Invert. Mollusc PDF_{m}	Aquatic Plants PDF_{ap}
Terrestrial Wildlife												
Insectivorous Birds	American Robin	a	0	1	0	0	0	0	0	0	0	0
Avian Predators	Red-tailed Hawk	a	0	0	1	0	0	0	0	0	0	0
Herbivorous Mammals	Eastern Cottontail	a	0	0	0	1	0	0	0	0	0	0
Herbivorous Mammals	Meadow Vole	a	0	0	0	1	0	0	0	0	0	0
Insectivorous Mammals	Short-tailed Shrew	a	0.8	0.2	0	0	0	0	0	0	0	0
Omnivorous Mammals	Raccoon	a	0.15	0.8	0	0.05	0	0	0	0	0	0
Carnivorous Mammals	Coyote	a	0	0	1	0	0	0	0	0	0	0
Aquatic-Dependent Wildlife												
Piscivorous Raptors	Bald Eagle	a	0	0	0	0	0.25	0.75	0	0	0	0
Piscivorous Mammals	River Otter	a	0	0	0	0	0.6	0.25	0.1	0	0.05	0
Sediment-probing Birds	Spotted Sandpiper	a	0	0	0	0	0	0	0.8	0 [b]	0.2	0
Dabbling Ducks	Mallard	a	0	0	0	0 [c]	0	0	0.1	0	0	0.9
Diving Ducks	Lesser Scaup	a	0	0	0	0	0.05	0	0.75	0	0.1	0.1
Shorebirds	Great Blue Heron	a	0	0	0	0	0.75	0.2	0.05	0	0	0

Notes:

a Professional judgment based on available fish species at the Site and dietary composition data cited in EPA 1993b.

b Inadequate data available to estimate aquatic worm BSAF. Therefore, to evaluate exposure, the dietary fraction of molluscs increased from 0.1 to 0.2.

c Terrestrial plant consumption by the mallard was not quantitatively assessed in the baseline ecological risk assessment. The dietary fraction of aquatic plants was increased from 0.8 to 0.9 to address this change.

Table 7.2-8
Bulk Soil Screening: Terrestrial Wildlife

COPC	Unit	EPA Eco-SSL Avian	EPA Eco-SSL Mammalian	Number of Samples	Number of Detections	Number of Non-detects	Frequency of Detection (%)	Minimum Value	Maximum Value	Mean Value	Minimum Detected Value	Maximum Detected Value	Mean Detected Value	Exposure Point Concentration 95 UCL	EPC Basis	95 UCL Exceedance Factor Avian SSL (HQ)	95 UCL Exceedance Factor Mammalian SSL (HQ)
2,4-Dimethylphenol	mg/kg	--	--	38	3	35	8%	0.06	14	1.09	0.13	1.3	0.74	0.264	95% KM (t) UCL	--	--
2-Methylnaphthalene	mg/kg	--	--	47	28	19	60%	0.06	14	16.6	0.025	180	27.1	83.63	99% KM (Chebyshev) UCL	--	--
Arsenic	mg/kg	43	46	37	21	16	57%	5	10	12.7	4.9	110	17.88	17.4	95% KM (t) UCL	0.40	0.38
Benzo(a)anthracene	mg/kg	--	--	47	43	4	91%	0.06	0.063	73.9	0.092	1,100	80.76	373.1	99% KM (Chebyshev) UCL	--	--
Benzo(a)pyrene	mg/kg	--	--	47	43	4	91%	0.06	0.063	89.1	0.13	1,400	97.39	460.5	99% KM (Chebyshev) UCL	--	--
Benzo(b)fluoranthene	mg/kg	--	--	47	43	4	91%	0.06	0.063	65.1	0.1	960	71.19	320.1	99% KM (Chebyshev) UCL	--	--
Benzo(g,h,i)perylene	mg/kg	--	--	47	42	5	89%	0.06	0.096	45.5	0.095	1,100	50.93	290	99% KM (Chebyshev) UCL	--	--
Benzo(k)fluoranthene	mg/kg	--	--	47	43	4	91%	0.06	0.063	48	0.094	660	52.46	232.8	99% KM (Chebyshev) UCL	--	--
Chromium (III)[a]	mg/kg	26	34	7	7	0	100%			40.3	25	65.3	40.33	56.86	Use 95% Approximate Gamma UCL	**2.2**	**1.7**
Chrysene	mg/kg	--	--	47	43	4	91%	0.06	0.063	99	0.14	1,500	108.2	497.3	99% KM (Chebyshev) UCL	--	--
Dibenz(a,h)anthracene	mg/kg	--	--	47	33	14	70%	0.032	1.4	11.7	0.041	190	16.64	62.25	99% KM (Chebyshev) UCL	--	--
Dibenzofuran	mg/kg	--	--	47	24	23	51%	0.06	1.4	3.44	0.02	34	6.5	15.59	99% KM (Chebyshev) UCL	--	--
Fluoranthene	mg/kg	--	--	47	43	4	91%	0.061	1400	136	0.07	2,200	116.2	625	99% KM (Chebyshev) UCL	--	--
Fluorene	mg/kg	--	--	47	34	13	72%	0.06	1.4	18.5	0.021	350	25.49	103.6	99% KM (Chebyshev) UCL	--	--
Indeno(1,2,3-c,d)pyrene	mg/kg	--	--	47	41	6	87%	0.06	4.5	34.4	0.086	730	39.31	200.8	99% KM (Chebyshev) UCL	--	--
Lead	mg/kg	11	56	37	35	2	95%	2	2	133	3	1,120	140.1	638.7	99% KM (Chebyshev) UCL	**58**	**11.4**
Naphthalene	mg/kg	--	--	58	38	20	66%	0.023	14	26.7	0.0029	370	40.34	128.5	99% KM (Chebyshev) UCL	--	--
Pentachlorophenol	mg/kg	2.1	2.8	38	0	38	0%	0.15	71	4.68	ND	ND	ND	71	Max Non-detect	**34**	**25.4**
Phenanthrene	mg/kg	--	--	47	45	2	96%	0.061	0.062	145	0.092	2,800	151.8	838.9	99% KM (Chebyshev) UCL	--	--
Pyrene	mg/kg	--	--	47	45	2	96%	0.061	0.062	188	0.09	3,200	196.2	1012	99% KM (Chebyshev) UCL	--	--
Total 10 of 16 HPAHs (U=1/2)	mg/kg	--	1.1	47	45	2	96%	0.061	0.062	778	0.374	13,040	812.4	4,061	99% KM (Chebyshev) UCL	--	**3692**
Total 6 of 16 LPAHs (U=1/2)	mg/kg	--	100	47	45	2	96%	0.061	0.062	252	0.242	4,440	262.7	1,373	99% KM (Chebyshev) UCL	--	**14**
Total PCB Aroclors (U=1/2)[a]	mg/kg	--	--	7	0	7	0%	0.029	0.042	0.035	ND	ND	ND	0.042	Max Non-detect	--	--

Notes:
[a] Based on QA1 data.
-- - No screening value
COPC - chemical of potential concern
EPC - exposure point concentration
HPAHs - high-molecular-weight PAHs
HQ - hazard quotient
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
Student's (t) - UCL based on Student's t-distribution
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
LPAH - low-molecular-weight PAHs
Max. Detect - UCL based on the maximum non-detected value
mg/kg - milligram(s) per kilogram
ND - not detected
PAH - polynuclear aromatic hydrocarbon
PCB = polychlorinated biphenyl
UCL - upper confidence limit
Eco-SSL - ecological soil screening level
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

Table 7.2-9
Food Web Risk Calculations for American Robin - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Earthworm*			Other Soil Invertebrate			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie} (mg/kg BW/Day	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si} (mg/kg BW/day	EPC UCL (mg/L)	DI_{water} (mg/kg BW/day	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Other Soil Invertebrates	Soil	Water	Total
Fraction Moisture (FM)	0.2			0.84			0.65									
COPC																
2,4-Dimethylphenol	0.264	0.006	Cie = Cs	0.042	0.0	Cio=Cie*1/3	0.031	0.009	NA	NA	0.015	0.96	<1	<1	NA	<1
Arsenic	17.4	0.395	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.291	0.0	Cio=Cie*1/3	0.212	0.060	0.001	0.0001	0.455	2.24	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.017	0.002	0.002	NTRV	NA	NA	NTRV	NA
Benzo(a)pyrene	460.5	10.443	Cie = 1.33 * Cs	97.994	0.0	Cio=Cie*1/3	71.454	20.256	0.0007	0.00010	30.699	0.28	**72**	**37**	<1	**110**
Chromium	56.86	1.289	Cie = 0.306 * Cs	2.784	0.0	Cio=Cie*1/3	2.030	0.575	NA	NA	1.865	2.66	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	4.05	NA	NA	NA	NA
Dibenzofuran	15.59	0.354	Cie = Cs	2.494	0.0	Cio=Cie*1/3	1.819	0.516	NA	NA	0.869	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.005	0.001	0.001	NTRV	NA	NA	NTRV	NA
Lead	638.7	14.484	ln(Cie) = 0.807 * ln(Cs) - 0.218	23.622	0.0	Cio=Cie*1/3	17.224	4.883	NA	NA	19.367	1.63	**3.0**	**8.9**	NA	**11.9**
Pentachlorophenol	71	1.610	ln(Cie) = 0.3308 * ln(Cs)+5.5463	167.975	0.0	Cio=Cie*1/3	122.482	34.720	NA	NA	36.331	40.7	<1	<1	NA	ND
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.003	0.000	0.000	NTRV	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	4,061	92.095	Cie = 2.6 * Cs	1689.376	0.0	Cio=Cie*1/3	1231.837	349.195	NA	NA	441.291	8	**44**	**12**	NA	**55**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	8	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373	31.137	Cie = 3.04 * Cs	667.827	0.0	Cio=Cie*1/3	486.957	138.040	NA	NA	169.177	8	**17**	**3.9**	NA	**21**
Total PCBs (U=1/2)	0.042	0.001	Cie = 1.13 * Cs * 6.25	0.047	0.0	Cio=Cie*1/3	0.035	0.010	NA	NA	0.011	0.29	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.001	0.001	1.746	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity Reference Value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

*Earthworm BAF equations and estimated concentrations are included here because the they are the basis for the "Other Soil Invertebrate" BAFs.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.023	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	1.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.011	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.081	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-10
Food Web Risk Calculations for American Robin - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Earthworm*			Other Soil Invertebrate			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie} (mg/kg BW/Day	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si} (mg/kg BW/day	EPC UCL (mg/L)	DI_{water} (mg/kg BW/day	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Other Soil Invertebrates	Soil	Water	Total
Fraction Moisture	**0.2**			**0.84**			**0.65**									
COPC																
2,4-Dimethylphenol	1.09	0.025	Cie = Cs	0.174	0.0	Cio=Cie*1/3	0.127	0.036	NA	NA	0.061	4.8	<1	<1	NA	<1
Arsenic	12.7	0.288	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.233	0.0	Cio=Cie*1/3	0.170	0.048	0.001	0.0001	0.336	4.5	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.026	0.004	0.004	NTRV	NA	NA	NTRV	NA
Benzo(a)pyrene	89.1	2.021	Cie = 1.33 * Cs	18.960	0.0	Cio=Cie*1/3	13.825	3.919	0.0003	0.00003	5.940	1.4	**2.8**	**1.4**	<1	**4.2**
Chromium	40.3	0.914	Cie = 0.306 * Cs	1.973	0.0	Cio=Cie*1/3	1.439	0.408	NA	NA	1.322	15.6	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	12.1	NA	NA	NA	NA
Dibenzofuran	3.44	0.078	Cie = Cs	0.550	0.0	Cio=Cie*1/3	0.401	0.114	NA	NA	0.192	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.009	0.0012	0.0012	NTRV	NA	NA	NTRV	NA
Lead	133	3.016	ln(Cie) = 0.807 * ln(Cs) - 0.218	6.659	0.0	Cio=Cie*1/3	4.855	1.376	NA	NA	4.393	3.26	<1	<1	NA	**1.3**
Pentachlorophenol	4.68	0.106	ln(Cie) = 0.3308 * ln(Cs)+5.5463	68.323	0.0	Cio=Cie*1/3	49.819	14.122	NA	NA	14.228	52	<1	<1	NA	<1
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.0008	0.0008	NTRV	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	778	17.644	Cie = 2.6 * Cs	323.648	0.0	Cio=Cie*1/3	235.993	66.898	NA	NA	84.542	40	**1.7**	<1	NA	**2.1**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	40	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	5.715	Cie = 3.04 * Cs	122.573	0.0	Cio=Cie*1/3	89.376	25.336	NA	NA	31.051	40	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.001	Cie = 1.13 * Cs * 6.25	0.040	0.0	Cio=Cie*1/3	0.029	0.008	NA	NA	0.009	0.58	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.0008	0.0008	17.46	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

*Earthworm BAF equations and estimated concentrations are included here because the they are the basis for the "Other Soil Invertebrate" BAFs.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.023	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	1.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.011	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.081	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-11
Food Web Risk Calculations for Red-Tailed Hawk - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Small Mammal			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	**EPC 95UCL (mg/kg) - Site-wide**	**DI_{soil}**	**BAF Equation (mg/kg dw)**	**Estimated Concentration (mg/kg ww)**	**DI_{sm}**	**EPC UCL (mg/L)**	**DI_{water}**	**Total Dietary Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**Small Mammal**	**Soil**	**Water**	**Total**
Fraction Moisture (FM)	**0.2**			**0.68**									
COPC													
2,4-Dimethylphenol	0.264	0.010	Csm = 0.00452 * Cd + 0.198	0.064	0.031	NA	NA	0.042	0.96	<1	<1	NA	<1
Arsenic	17.40	0.687	ln(Csm) = 0.8188 * ln(Cs) - 4.8471	0.026	0.013	0.001	0.00003	0.700	2.24	<1	<1	<1	<1
Benzene	NA	NA	Csm=0	NA	NA	0.017	0.000	0.000	NTRV	NA	NA	NTRV	NA
Benzo(a)pyrene	460.5	18.181	Csm=0	0	0.0	0.0007	0.00002	18.181	0.28	<1	**65**	<1	**65**
Chromium	56.9	2.245	ln(Csm) = 0.7338 * ln(Cs) - 1.4599	1.441	0.711	NA	NA	2.956	2.66	<1	<1	NA	**1.11**
Dibenzofuran	15.59	0.615	Csm=Cs	15.590	7.694	NA	NA	8.309	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Csm=0	NA	NA	0.005	0.0001	0.0001	NTRV	NA	NA	NTRV	NA
Lead	638.7	25.216	ln(Csm) = 0.4422 * ln(Cs) + 0.0761	6.008	2.965	NA	NA	28.181	1.63	**1.8**	**15.5**	NA	**17**
Pentachlorophenol	71	2.803	Csm = 0.00452 * Cs + 0.198	0.166	0.1	NA	NA	2.885	40.7	<1	<1	NA	<1
Toluene	NA	NA	Csm=0	NA	NA	0.003	0.0001	0.0001	NTRV	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	4,061	160.328	Csm=0	0	0.0	NA	NA	160.328	8	<1	**20**	NA	**20**
Total 16 PAHs (U=1/2)	NA	NA	Csm=0	NA	NA	NA	NA	NA	8	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373	54.206	Csm=0	0	0.0	NA	NA	54.206	8	<1	**6.8**	NA	**6.8**
Total PCBs (U=1/2)	0.042	0.002	Csm=0.0000742*Cs*3.125	0.000	0.0	NA	NA	0.002	0.29	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Csm=0	NA	NA	0.006	0.0002	0.0002	1.746	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Csm - Concentration in small mammals
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site use factor
FIR =	1.119	= Food ingestion rate (kg/day, wet weight)
Fc_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	1.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.064	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.134	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake

Table 7.2-12
Food Web Risk Calculations for Red-Tailed Hawk - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Small Mammal			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{sm}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Small Mammal	Soil	Water	Total
Fraction Moisture	**0.2**			**0.68**									
COPC													
2,4-Dimethylphenol	1.09	0.043	Csm = 0.00452 * Cd + 0.198	0.0649	0.032	NA	NA	0.075	4.8	<1	<1	NA	<1
Arsenic	12.7	0.501	ln(Csm) = 0.8188 * ln(Cs) - 4.8471	0.020	0.0099	0.001	0.00003	0.511	4.5	<1	<1	<1	<1
Benzene	NA	NA	Csm=0	NA	NA	0.026	0.0007	0.0007	NTRV	NA	NA	NTRV	NA
Benzo(a)pyrene	89.1	3.518	Csm=0	0.0	0	0.0003	0.000007	3.518	1.4	<1	**2.5**	<1	**2.5**
Chromium	40.3	1.591	ln(Csm) = 0.7338 * ln(Cs) - 1.4599	1.120	0.55	NA	NA	2.144	15.6	<1	<1	NA	<1
Copper	NA	NA	ln(Csm) = 0.1444 * ln(Cs) + 2.042	NA	NA	NA	NA	NA	12.1	NA	NA	NA	NA
Dibenzofuran	3.44	0.136	Csm=Cs	3.440	1.7	NA	NA	1.833	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Csm=0	NA	NA	0.009	0.0002	0.0002	NTRV	NA	NA	NTRV	NA
Lead	133	5.251	ln(Csm) = 0.4422 * ln(Cs) + 0.0761	3.002	1.5	NA	NA	6.732	3.26	<1	**1.6**	NA	**2.1**
Pentachlorophenol	4.68	0.185	Csm = 0.00452 * Cs + 0.198	0.0701	0.035	NA	NA	0.219	52	<1	<1	NA	<1
Toluene	NA	NA	Csm=0	NA	NA	0.006	0.00018	0.00018	NTRV	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	778	30.715	Csm=0	0.0	0	NA	NA	30.715	40	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	NA	NA	Csm=0	NA	NA	NA	NA	NA	40	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	9.949	Csm=0	0.0	0	NA	NA	9.949	40	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.001	Csm=0.0000742*Cs*3.125	0.000003	1.28E-06	NA	NA	0.001	0.58	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Csm=0	NA	NA	0.006	0.0002	0.0002	17.46	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Csm - Concentration in small mammals
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site use factor
FIR =	1.119	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS	0.1	= Proportion of diet composed of soil in addition to diet dry weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	1.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.064	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.134	= Body weight (kg wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-13
Food Web Risk Calculations for Eastern Cottontail Rabbit - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{plant}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Terrestrial Plants	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.7**									
COPC													
2,4-Dimethylphenol	0.264	0.002	Cp = Cs	0.079	0.015	NA	NA	0.017	3.66	<1	<1	NA	<1
Arsenic	17.40	0.162	Cp=0.0375*Cs	0.196	0.036	0.001	0.0001	0.199	1.76	<1	<1	<1	<1
Benzene	NA	NA	Cp = Cs	NA	NA	0.017	0.002	0.002	20.88	NA	NA	<1	<1
Benzo(a)pyrene	460.5	4.300	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	15.082	2.795	0.0007	0.00007	7.095	0.79	**3.5**	**5.4**	<1	**9.0**
Chromium	56.9	0.531	Cp=0.041*Cs	0.699	0.130	NA	NA	0.661	5.49	<1	<1	NA	<1
Dibenzofuran	15.59	0.146	Cp = Cs	4.677	0.867	NA	NA	1.012	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cp = Cs	NA	NA	0.005	0.0005	0.0005	7.11	NA	NA	<1	<1
Lead	638.7	5.965	ln(Cp)=0.561*ln(Cs)-1.328	2.980	0.552	NA	NA	6.517	5.85	<1	**1.02**	NA	**1.11**
Pentachlorophenol	71	0.663	Cp = 5.93 * Cs	126.309	23.404	NA	NA	24.067	5.29	**4.4**	<1	NA	**4.5**
Toluene	NA	NA	Cp = Cs	NA	NA	0.003	0.0003	0.0003	20.59	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	4,061	37.924	ln(Cp)=0.9469 *ln(Cs) - 1.7026	142.793	26.458	NA	NA	64.382	0.24	**109**	**156**	NA	**264**
Total 16 PAHs (U=1/2)	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	0.24	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373	12.822	Cp=2.09*Cs	860.871	159.510	NA	NA	172.331	48.01	**3.3**	<1	NA	**3.6**
Total PCBs (U=1/2)	0.042	0.000	Cp=0.01*Cs	0.0001	0.00002	NA	NA	0.0004	0.04	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cp = Cs	NA	NA	0.006	0.0006	0.0006	0.83	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.226	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.063	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	1.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.118	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.220	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake

Table 7.2-14
Food Web Risk Calculations for Eastern Cottontail Rabbit - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{plant}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Terrestrial Plants	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.7**									
COPC													
2,4-Dimethylphenol	1.09	0.010	Cp = Cs	0.327	0.061	NA	NA	0.071	10.98	<1	<1	NA	<1
Arsenic	12.7	0.119	Cp=0.0375*Cs	0.143	0.026	0.001	0.0001	0.145	2.81	<1	<1	<1	<1
Benzene	NA	NA	Cp = Cs	NA	NA	0.026	0.003	0.003	104.38	NA	NA	<1	<1
Benzo(a)pyrene	89.1	0.832	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	3.041	0.563	0.0003	0.00002	1.395	3.96	<1	<1	<1	<1
Chromium	40.3	0.376	Cp=0.041*Cs	0.496	0.092	NA	NA	0.468	27.46	<1	<1	NA	<1
Copper	NA	NA	ln(Cp)=0.394*ln(Cs)+0.668	NA	NA	NA	NA	NA	14.65	NA	NA	NA	NA
Dibenzofuran	3.44	0.032	Cp = Cs	1.032	0.191	NA	NA	0.223	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cp = Cs	NA	NA	0.009	0.0008	0.0008	21.30	NA	NA	<1	<1
Lead	133	1.242	ln(Cp)=0.561*ln(Cs)-1.328	1.236	0.229	NA	NA	1.471	58.55	<1	<1	NA	<1
Pentachlorophenol	4.68	0.044	Cp = 5.93 * Cs	8.326	1.543	NA	NA	1.586	26.45	<1	<1	NA	<1
Toluene	NA	NA	Cp = Cs	NA	NA	0.006	0.0006	0.0006	102.96	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	778	7.265	ln(Cp)=0.9469 *ln(Cs) - 1.7026	29.865	5.534	NA	NA	12.799	1.22	**4.6**	**6.0**	NA	**10.5**
Total 16 PAHs (U=1/2)	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	1.22	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	2.353	Cp=2.09*Cs	158.004	29.276	NA	NA	31.630	240.05	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.0003	Cp=0.01*Cs	0.0001	0.00002	NA	NA	0.0003	0.09	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cp = Cs	NA	NA	0.006	0.0006	0.0006	1.03	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.226	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.063	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	1.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.118	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.220	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-15
Food Web Risk Calculations for Meadow Vole - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{plant}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Terrestrial Plants	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.7**									
COPC													
2,4-Dimethylphenol	0.264	0.002	Cp = Cs	0.079	0.028	NA	NA	0.030	8.751	<1	<1	NA	<1
Arsenic	17.40	0.120	Cp=0.0375*Cs	0.196	0.070	0.001	0.0001	0.191	4.208	<1	<1	<1	<1
Benzene	NA	NA	Cp = Cs	NA	NA	0.017	0.002	0.002	49.926	NA	NA	<1	<1
Benzo(a)pyrene	460.50	3.178	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	15.082	5.421	0.0007	0.00010	8.599	1.894	**2.9**	**1.7**	<1	**4.5**
Chromium	56.9	0.392	Cp=0.041*Cs	0.699	0.251	NA	NA	0.644	13.135	<1	<1	NA	<1
Dibenzofuran	15.590	0.108	Cp = Cs	4.677	1.681	NA	NA	1.789	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cp = Cs	NA	NA	0.005	0.0007	0.0007	16.995	NA	NA	<1	<1
Lead	638.700	4.408	ln(Cp)=0.561*ln(Cs)-1.328	2.980	1.071	NA	NA	5.479	14.002	<1	<1	NA	<1
Pentachlorophenol	71.000	0.490	Cp = 5.93 * Cs	126.309	45.400	NA	NA	45.890	12.649	**3.6**	<1	NA	**3.6**
Toluene	NA	NA	Cp = Cs	NA	NA	0.003	0.0004	0.0004	49.244	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	4,061.0	28.026	ln(Cp)=0.9469 *ln(Cs) - 1.7026	142.793	51.325	NA	NA	79.351	0.582	**88**	**48**	NA	**136**
Total 16 PAHs (U=1/2)	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	0.582	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373.0	9.475	Cp=2.09*Cs	860.871	309.430	NA	NA	318.906	114.814	**2.7**	<1	NA	**2.8**
Total PCBs (U=1/2)	0.042	0.000	Cp=0.01*Cs	0.0001	0.000	NA	NA	0.000	0.104	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cp = Cs	NA	NA	0.006	0.0008	0.0008	1.989	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as $((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW$
DI_{plant} - Dietary intake from terrestrial plants calculated as $((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW$
DI_{si} - Dietary intake from soil invertebrates calculated as $((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW$
DI_{sm} - Dietary intake from small mammal calculated as $((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW$
DI_{soil} - Dietary intake from soil calculated as $((EPC_{soil}*(1-FM))*FIR*PDS)/BW$
DI_{water} - Dietary intake from water calculated as $(EPC_{water}*WIR)/BW$
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.013	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.024	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	1.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.005	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.037	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-16
Food Web Risk Calculations for Meadow Vole - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	**EPC Mean (mg/kg) - Site-wide**	**DI_{soil}**	**BAF Equation (mg/kg dw)**	**Estimated Concentration (mg/kg ww)**	**DI_{plant}**	**EPC Mean (mg/L)**	**DI_{water}**	**Total Dietary Intake (mg/kg BW/day)**	**LOAEL TRV (mg/kg BW/day)**	**Terrestrial Plants**	**Soil**	**Water**	**Total**
Fraction Moisture (FM)	**0.2**			**0.7**									
COPC													
2,4-Dimethylphenol	1.09	0.008	Cp = Cs	0.327	0.118	NA	NA	0.125	26.25	<1	<1	NA	<1
Arsenic	12.7	0.088	Cp=0.0375*Cs	0.143	0.051	0.001	0.0001	0.139	6.72	<1	<1	<1	<1
Benzene	NA	NA	Cp = Cs	NA	NA	0.026	0.004	0.004	249.63	NA	NA	<1	<1
Benzo(a)pyrene	89.1	0.615	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	3.041	1.093	0.0003	0.00003	1.708	9.47	<1	<1	<1	<1
Chromium	40.3	0.278	Cp=0.041*Cs	0.496	0.178	NA	NA	0.456	65.67	<1	<1	NA	<1
Copper	NA	NA	ln(Cp)=0.394*ln(Cs)+0.668	NA	NA	NA	NA	NA	35.04	NA	NA	NA	NA
Dibenzofuran	3.44	0.024	Cp = Cs	1.032	0.371	NA	NA	0.395	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cp = Cs	NA	NA	0.009	0.0012	0.0012	50.93	NA	NA	<1	<1
Lead	133	0.918	ln(Cp)=0.561*ln(Cs)-1.328	1.236	0.444	NA	NA	1.362	140.02	<1	<1	NA	<1
Pentachlorophenol	4.68	0.032	Cp = 5.93 * Cs	8.326	2.993	NA	NA	3.025	63.25	<1	<1	NA	<1
Toluene	NA	NA	Cp = Cs	NA	NA	0.006	0.0009	0.0009	246.22	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	778	5.369	ln(Cp)=0.9469 *ln(Cs) - 1.7026	29.865	10.735	NA	NA	16.104	2.91	**3.7**	**1.8**	NA	**5.5**
Total 16 PAHs (U=1/2)	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	2.91	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	1.739	Cp=2.09*Cs	158.004	56.793	NA	NA	58.532	574.07	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.000	Cp=0.01*Cs	0.0001	0.000	NA	NA	0.000	0.21	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cp = Cs	NA	NA	0.006	0.0008	0.0008	2.46	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.013	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.024	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	1.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.005	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.037	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-17
Food Web Risk Calculations for Short-tailed Shrew - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Earthworm			Other Soil Invertebrate			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Earthworm	Other Soil Invertebrates	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.84**			**0.65**										
COPC																	
2,4-Dimethylphenol	0.264	0.008	Cie = Cs	0.042	0.014	Cio=Cie*1/3	0.031	0.002	NA	NA	0.024	10.68	<1	<1	<1	NA	<1
Arsenic	17.40	0.558	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.291	0.093	Cio=Cie*1/3	0.212	0.017	0.001	0.0001	0.668	5.14	<1	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.017	0.002	0.002	60.94	NA	NA	NA	<1	<1
Benzo(a)pyrene	460.5	14.759	Cie = 1.33 * Cs	97.994	31.407	Cio=Cie*1/3	71.454	5.7252	0.0007	0.00011	51.891	2.31	**14**	**2.5**	**6.4**	<1	**22**
Chromium	56.9	1.822	Cie = 0.306 * Cs	2.784	0.892	Cio=Cie*1/3	2.030	0.163	NA	NA	2.877	16.03	<1	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	32.50	NA	NA	NA	NA	NA
Dibenzofuran	15.59	0.500	Cie = Cs	2.494	0.799	Cio=Cie*1/3	1.819	0.146	NA	NA	1.445	NTRV	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.005	0.0007	0.0007	20.74	NA	NA	NA	<1	<1
Lead	638.7	20.470	ln(Cie) = 0.807 * ln(Cs) - 0.218	23.622	7.571	Cio=Cie*1/3	17.224	1.380	NA	NA	29.421	17.09	<1	<1	**1.20**	NA	**1.72**
Pentachlorophenol	71	2.276	ln(Cie) = 0.3308 * ln(Cs)+5.5463	167.975	53.836	Cio=Cie*1/3	122.482	9.814	NA	NA	65.925	15.44	**3.5**	<1	<1	NA	**4.3**
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.003	0.0005	0.0005	60.11	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	4,061	130.154	Cie = 2.6 * Cs	1,689.376	541.442	Cio=Cie*1/3	1,231.837	98.700	NA	NA	770.296	0.71	**762**	**139**	**183**	NA	**1084**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	0.71	NA	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373	44.004	Cie = 3.04 * Cs	667.827	214.037	Cio=Cie*1/3	486.957	39.017	NA	NA	297.059	140.15	**1.5**	<1	<1	NA	**2.1**
Total PCBs (U=1/2)	0.042	0.001	Cie = 1.13 * Cs * 6.25	0.047	0.015	Cio=Cie*1/3	0.035	0.003	NA	NA	0.019	0.13	<1	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.0009	0.0009	2.43	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.007	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.800	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.200	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.003	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.017	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake

Table 7.2-18
Food Web Risk Calculations for Short-tailed Shrew - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Earthworm			Other Soil Invertebrate			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Earthworm	Other Soil Invertebrates	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.84**			**0.65**										
COPC																	
2,4-Dimethylphenol	1.09	0.035	Cie = Cs	0.174	0.056	Cio=Cie*1/3	0.127	0.010	NA	NA	0.101	32.05	<1	<1	<1	NA	<1
Arsenic	12.7	0.407	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.233	0.075	Cio=Cie*1/3	0.170	0.014	0.001	0.0001	0.495	8.20	<1	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.026	0.004	0.004	304.72	NA	NA	NA	<1	<1
Benzo(a)pyrene	89.1	2.856	Cie = 1.33 * Cs	18.960	6.077	Cio=Cie*1/3	13.825	1.1077	0.0003	0.00004	10.040	11.56	<1	<1	<1	<1	<1
Chromium	40.3	1.292	Cie = 0.306 * Cs	1.973	0.632	Cio=Cie*1/3	1.439	0.115	NA	NA	2.039	80.17	<1	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	42.78	NA	NA	NA	NA	NA
Dibenzofuran	3.44	0.110	Cie = Cs	0.550	0.176	Cio=Cie*1/3	0.401	0.032	NA	NA	0.319	NTRV	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.009	0.0013	0.0013	62.17	NA	NA	NA	<1	<1
Lead	133	4.263	ln(Cie) = 0.807 * ln(Cs) - 0.218	6.659	2.134	Cio=Cie*1/3	4.855	0.389	NA	NA	6.786	170.91	<1	<1	<1	NA	<1
Pentachlorophenol	4.68	0.150	ln(Cie) = 0.3308 * ln(Cs)+5.5463	68.323	21.897	Cio=Cie*1/3	49.819	3.992	NA	NA	26.039	77.20	<1	<1	<1	NA	<1
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.0009	0.0009	300.56	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	778	24.935	Cie = 2.6 * Cs	323.648	103.729	Cio=Cie*1/3	235.993	18.909	NA	NA	147.572	3.55	**29**	**5.3**	**7.0**	NA	**42**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	NA	NA	NA	3.55	NA	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	8.077	Cie = 3.04 * Cs	122.573	39.284	Cio=Cie*1/3	89.376	7.161	NA	NA	54.522	700.75	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.001	Cie = 1.13 * Cs * 6.25	0.040	0.013	Cio=Cie*1/3	0.029	0.002	NA	NA	0.016	0.25	<1	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	0.006	0.0009	0.0009	3.01	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.007	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.800	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.200	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.003	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.017	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-19
Food Web Risk Calculations for Raccoon - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Earthworm			Other Soil Invertebrate			Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)					
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{plant}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Earthworm	Other Soil Invertebrates	Terrestrial Plants	Soil	Water	Total
Fraction Moisture (FM)	0.2			0.84			0.65			0.7											
COPC																					
2,4-Dimethylphenol	0.264	0.002	Cie = Cs	0.042	0.001	Cio=Cie*1/3	0.031	0.002	Cp = Cs	0.079	0.0004	NA	NA	0.006	2.16	<1	<1	<1	<1	NA	<1
Arsenic	17.40	0.140	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.291	0.004	Cio=Cie*1/3	0.212	0.017	Cp=0.0375*Cs	0.196	0.001	0.001	0.0001	0.163	1.04	<1	<1	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.017	0.001	0.001	12.34	NA	NA	NA	NA	<1	<1
Benzo(a)pyrene	460.50	3.718	Cie = 1.33 * Cs	97.994	1.483	Cio=Cie*1/3	71.454	5.7687	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	15.082	0.076	0.0007	0.00006	11.046	0.47	**3.2**	**12**	<1	**7.9**	<1	**24**
Chromium	56.9	0.459	Cie = 0.306 * Cs	2.784	0.042	Cio=Cie*1/3	2.030	0.164	Cp=0.041*Cs	0.699	0.004	NA	NA	0.669	3.25	<1	<1	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	ln(Cp)=0.394*ln(Cs)+0.668	NA	NA	NA	NA	NA	6.58	NA	NA	NA	NA	NA	NA
Dibenzofuran	15.590	0.126	Cie = Cs	2.494	0.038	Cio=Cie*1/3	1.819	0.147	Cp = Cs	4.677	0.024	NA	NA	0.334	NTRV	NTRV	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.005	0.0004	0.0004	4.20	NA	NA	NA	NA	<1	<1
Lead	638.700	5.156	ln(Cie) = 0.807 * ln(Cs) - 0.218	23.622	0.358	Cio=Cie*1/3	17.224	1.391	ln(Cp)=0.561*ln(Cs)-1.328	2.980	0.015	NA	NA	6.920	3.46	<1	<1	<1	**1.49**	NA	**2.0**
Pentachlorophenol	71.000	0.573	ln(Cie) = 0.3308 * ln(Cs)+5.5463	167.975	2.543	Cio=Cie*1/3	122.482	9.888	Cp = 5.93 * Cs	126.309	0.637	NA	NA	13.641	3.13	<1	**3.2**	<1	<1	NA	**4.4**
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.003	0.0003	0.0003	12.17	NA	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	4,061.0	32.785	Cie = 2.6 * Cs	1,689.376	25.573	Cio=Cie*1/3	1,231.837	99.449	ln(Cp)=0.9469 *ln(Cs) - 1.7026	142.793	0.721	NA	NA	158.528	0.14	**178**	**691**	**5.0**	**228**	NA	**1101**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	0.14	NA	NA	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373.0	11.085	Cie = 3.04 * Cs	667.827	10.109	Cio=Cie*1/3	486.957	39.313	Cp=2.09*Cs	860.871	4.344	NA	NA	64.851	28.37	<1	**1.4**	<1	<1	NA	**2.3**
Total PCBs (U=1/2)	0.042	0.000	Cie = 1.13 * Cs * 6.25	0.047	0.001	Cio=Cie*1/3	0.035	0.003	Cp=0.01*Cs	0.0001	0.000001	NA	NA	0.004	0.03	<1	<1	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.006	0.0005	0.0005	0.49	NA	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.656	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.150	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.800	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.050	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.534	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	6.500	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake

Table 7.2-20
Food Web Risk Calculations for Raccoon - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Earthworm			Other Soil Invertebrate			Terrestrial Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)					
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{ie}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{si}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{plant}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Earthworm	Other Soil Invertebrates	Terrestrial Plants	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.84**			**0.65**			**0.7**											
COPC																					
2,4-Dimethylphenol	1.09	0.009	Cie = Cs	0.174	0.003	Cio=Cie*1/3	0.127	0.010	Cp = Cs	0.327	0.002	NA	NA	0.023	7.23	<1	<1	<1	<1	NA	<1
Arsenic	12.7	0.103	ln(Cie) = 0.706 * ln(Cs) - 1.42	0.233	0.004	Cio=Cie*1/3	0.170	0.014	Cp=0.0375*Cs	0.143	0.001	0.001	0.0001	0.121	1.85	<1	<1	<1	<1	<1	<1
Benzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.026	0.002	0.002	68.71	NA	NA	NA	NA	<1	<1
Benzo(a)pyrene	89.1	0.719	Cie = 1.33 * Cs	18.960	0.287	Cio=Cie*1/3	13.825	1.1162	ln(Cp)= 0.9750 * ln(Cs) - 2.0615	3.041	0.015	0.0003	0.00002	2.138	2.61	<1	<1	<1	<1	<1	<1
Chromium	40.3	0.325	Cie = 0.306 * Cs	1.973	0.030	Cio=Cie*1/3	1.439	0.116	Cp=0.041*Cs	0.496	0.003	NA	NA	0.474	18.08	<1	<1	<1	<1	NA	<1
Copper	NA	NA	Cie = 0.515 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	ln(Cp)=0.394*ln(Cs)+0.668	NA	NA	NA	NA	NA	9.64	NA	NA	NA	NA	NA	NA
Dibenzofuran	3.44	0.028	Cie = Cs	0.550	0.008	Cio=Cie*1/3	0.401	0.032	Cp = Cs	1.032	0.005	NA	NA	0.074	NTRV	NTRV	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.009	0.0007	0.0007	14.02	NA	NA	NA	NA	<1	<1
Lead	133	1.074	ln(Cie) = 0.807 * ln(Cs) - 0.218	6.659	0.101	Cio=Cie*1/3	4.855	0.392	ln(Cp)=0.561*ln(Cs)-1.328	1.236	0.006	NA	NA	1.573	38.54	<1	<1	<1	<1	NA	<1
Pentachlorophenol	4.68	0.038	ln(Cie) = 0.3308 * ln(Cs)+5.5463	68.323	1.034	Cio=Cie*1/3	49.819	4.022	Cp = 5.93 * Cs	8.326	0.042	NA	NA	5.136	17.41	<1	<1	<1	<1	NA	<1
Toluene	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.006	0.0005	0.0005	67.77	NA	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	778	6.281	Cie = 2.6 * Cs	323.648	4.899	Cio=Cie*1/3	235.993	19.052	ln(Cp)=0.9469 *ln(Cs) - 1.7026	29.865	0.151	NA	NA	30.383	0.80	**6.1**	**24**	<1	**7.8**	NA	**38**
Total 16 PAHs (U=1/2)	NA	NA	Cie = 3.04 * Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp=2.09*Cs	NA	NA	NA	NA	NA	0.80	NA	NA	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	2.034	Cie = 3.04 * Cs	122.573	1.855	Cio=Cie*1/3	89.376	7.216	Cp=2.09*Cs	158.004	0.797	NA	NA	11.903	158.00	<1	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.0003	Cie = 1.13 * Cs * 6.25	0.040	0.001	Cio=Cie*1/3	0.029	0.002	Cp=0.01*Cs	0.0001	0.000001	NA	NA	0.003	0.06	<1	<1	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Cie = Cs	NA	NA	Cio=Cie*1/3	NA	NA	Cp = Cs	NA	NA	0.006	0.0005	0.0005	0.68	NA	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Cie - Concentration in invertebrate earthworm
Cio - Concentration in other soil invertebrates
Cp - Concentration in terrestrial plants
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC Mean - Exposure point concentration based on the mean
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site use factor
FIR =	0.656	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.1	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.150	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.800	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	0.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.050	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =		= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.534	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	6.500	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level

Table 7.2-21
Food Web Risk Calculations for Coyote - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Soil		Small Mammal			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC 95UCL (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Estimated Concentration (mg/kg ww)	DI_{sm}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Small Mammal	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.68**									
COPC													
2,4-Dimethylphenol	0.264	0.0003	Csm = 0.00452 * Cd + 0.198	0.0637	0.003	NA	NA	0.003	2.163	<1	<1	NA	<1
Arsenic	17.40	0.020	ln(Csm) = 0.8188 * ln(Cs) - 4.8471	0.026	0.001	0.001	0.00004	0.021	1.040	<1	<1	<1	<1
Benzene	NA	NA	Csm=0	NA	NA	0.017	0.001	0.001	12.338	NA	NA	<1	<1
Benzo(a)pyrene	460.50	0.525	Csm=0	0.0	0.0	0.0007	0.00003	0.525	0.468	<1	**1.12**	<1	**1.12**
Chromium	56.9	0.065	ln(Csm) = 0.7338 * ln(Cs) - 1.4599	1.441	0.068	NA	NA	0.133	3.246	<1	<1	NA	<1
Copper	NA	NA	ln(Csm) = 0.1444 * ln(Cs) + 2.042	NA	NA	NA	NA	NA	1.514	NA	NA	NA	NA
Dibenzofuran	15.590	0.018	Csm=Cs	15.590	0.740	NA	NA	0.758	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Csm=0	NA	NA	0.005	0.0002	0.0002	4.200	NA	NA	<1	<1
Lead	638.700	0.728	ln(Csm) = 0.4422 * ln(Cs) + 0.0761	6.008	0.285	NA	NA	1.013	3.460	<1	<1	NA	<1
Pentachlorophenol	71.000	0.081	Csm = 0.00452 * Cs + 0.198	0.1661	0.008	NA	NA	0.089	3.126	<1	<1	NA	<1
Toluene	NA	NA	Csm=0	NA	NA	0.003	0.0001	0.0001	12.170	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	4,061.0	4.628	Csm=0	0.0	0.0	NA	NA	4.628	0.144	<1	**32**	NA	**32**
Total 16 PAHs (U=1/2)	NA	NA	Csm=0	NA	NA	NA	NA	NA	12.170	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	1,373.0	1.565	Csm=0	0.0	0.0	NA	NA	1.565	28.374	<1	<1	NA	<1
Total PCBs (U=1/2)	0.042	0.00005	Csm=0.0000742*Cs*3.125	0.000003	0.0000001	NA	NA	0.00005	0.026	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Csm=0	NA	NA	0.006	0.0002	0.0002	0.491	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Csm - Concentration in small mammals
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site use factor
FIR =	0.950	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.03	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	1.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.786	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	10.000	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake

Table 7.2-22
Food Web Risk Calculations for Coyote - Mean Exposure Concentrations and LOAEL Toxicity Values

	Soil		Small Mammal			Surface Water		TDI	TRV	HQ (TDI/TRV)			
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{soil}	BAF Equation (mg/kg dw)	Concentration (mg/kg ww)	DI_{sm}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Small Mammal	Soil	Water	Total
Fraction Moisture (FM)	**0.2**			**0.68**									
COPC													
2,4-Dimethylphenol	1.09	0.001	Csm = 0.00452 * Cd + 0.198	0.0649	0.003083	NA	NA	0.004	6.49	<1	<1	NA	<1
Arsenic	12.7	0.014	ln(Csm) = 0.8188 * ln(Cs) - 4.8471	0.020	0.000956	0.001	0.00004	0.015	1.66	<1	<1	<1	<1
Benzene	NA	NA	Csm=0	NA	NA	0.026	0.0010	0.0010	61.69	NA	NA	<1	<1
Benzo(a)pyrene	89.1	0.102	Csm=0	0.0	0.0	0.0003	0.00001	0.102	2.34	<1	<1	<1	<1
Chromium	40.3	0.046	ln(Csm) = 0.7338 * ln(Cs) - 1.4599	1.120	0.053167	NA	NA	0.099	16.23	<1	<1	NA	<1
Copper	NA	NA	ln(Csm) = 0.1444 * ln(Cs) + 2.042	NA	NA	NA	NA	NA	8.66	NA	NA	NA	NA
Dibenzofuran	3.44	0.004	Csm=Cs	3.440	0.163346	NA	NA	0.167	NTRV	NTRV	NTRV	NA	NTRV
Ethylbenzene	NA	NA	Csm=0	NA	NA	0.009	0.0003	0.0003	12.59	NA	NA	<1	<1
Lead	133	0.152	ln(Csm) = 0.4422 * ln(Cs) + 0.0761	3.002	0.142533	NA	NA	0.294	34.60	<1	<1	NA	<1
Pentachlorophenol	4.68	0.0053	Csm = 0.00452 * Cs + 0.198	0.0701	0.00333	NA	NA	0.009	15.63	<1	<1	NA	<1
Toluene	NA	NA	Csm=0	NA	NA	0.006	0.0002	0.0002	60.85	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	778	0.887	Csm=0	0.0	0.0	NA	NA	0.887	0.72	<1	**1.2**	NA	**1.2**
Total 16 PAHs (U=1/2)	NA	NA	Csm=0	NA	NA	NA	NA	NA	0.72	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	252	0.287	Csm=0	0.0	0.0	NA	NA	0.287	141.87	<1	<1	NA	<1
Total PCBs (U=1/2)	0.035	0.00004	Csm=0.0000742*Cs*3.125	0.000003	1.23E-07	NA	NA	0.00004	0.05	<1	<1	NA	<1
Total Xylenes (U=1/2)	NA	NA	Csm=0	NA	NA	0.006	0.0002	0.0002	0.61	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BAF - Bioaccumulation factor
Csm - Concentration in small mammals
Cs - Concentration in soil
DI_{ie} - Dietary intake from invert earthworms calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{ie})/BW
DI_{plant} - Dietary intake from terrestrial plants calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{plant})/BW
DI_{si} - Dietary intake from soil invertebrates calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{si})/BW
DI_{sm} - Dietary intake from small mammal calculated as ((EPC_{soil}* BAF*(1-FM))*FIR*PDF_{sm})/BW
DI_{soil} - Dietary intake from soil calculated as ((EPC_{soil}*(1-FM))*FIR*PDS)/BW
DI_{water} - Dietary intake from water calculated as (EPC_{water}*WIR)/BW
EPC 95UCL - Exposure point concentration 95% upper confidence limit on the mean as determined by ProUCL
NA - Not a COPC for this medium
NTRV - Toxicity data for COPC not available
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
TRV - Toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site use factor
FIR =	0.950	= Food ingestion rate (kg/day, wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.03	= Proportion of diet composed of soil (wet weight basis)
PDF_{ie} =	0.000	= Proportion of diet composed of invert earthworms (wet weight basis)
PDF_{si} =	0.000	= Proportion of diet composed of other soil invertebrates (wet weight basis)
PDF_{sm} =	1.000	= Proportion of diet composed of small mammals (wet weight basis)
PDF_{plant} =	0.000	= Proportion of diet composed of terrestrial plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in soil (mg/kg, wet weight)
WIR =	0.786	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	10.000	= Body weight (kg, wet weight)

PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-23
Control and Reference Bioassay Performance Standards

Test and Endpoint	Method	Number of Replicates	Control Survival and Growth		Reference Survival and Growth	
			Control Survival[1]	Control Growth[1]	Reference Survival[1]	Reference Growth[1]
Amphipod *(Hyalella azteca)* 28-day Survival and Growth.	Modification of EPA Method 100.4	8 per treatment	Mean control survival of ≥80 percent on Day 28.	Average weight ≥0.15 mg/individual.	Mean reference survival of ≥70 percent on Day 28.	Average weight ≥0.15 mg/individual
Midge *(Chironomus dilutus)* 20-day Survival and Growth.	Modification of EPA Method 100.5	8 per treatment	Mean control survival of ≥68 percent on Day 20.	Average weight ≥0.48 mg/individual as AFDW[2].	Mean reference survival of ≥65 percent on Day 20.	Average weight is Reference/Control ≥0.8 AFDW[2].

Notes:
1. Criteria are as published in Sediment Evaluation Framework for the Pacific Northwest (U.S. Army Corps of Engineers and other federal and state agencies May 2009).
2. AFDW - ash-free dry weight

Table 7.2-24
Bioassay Results Summary - Hydrocarbon Tests

Amphipod *(Hyalella azteca)* 28-day Sediment Toxicity Test

Sample		Mean Mortality (%)	Standard Error (%)	Statistically Different from Reference? Initial[1,3]	Statistically Different from Reference? Final[2]	Survival as Percent of Control (%)	Total Replicate Weight: Mean Total Weight (mg)	Total Replicate Weight: Standard Error Total Weight (mg)	Total Replicate Weight: Statistically Different from Reference? Initial	Total Replicate Weight: Statistically Different from Reference? Final[2,4]	Mean Individual Weight: Mean Individual Weight (mg)	Mean Individual Weight: Standard Error Mean Individual Weight (mg)	Mean Individual Weight: Statistically Different from Reference? Initial[1,3]	Mean Individual Weight: Statistically Different from Reference? Final[2,4]	Mean Individual Weight: Mean Individual Weight as Percent of Control (%)
Reference and Control Samples	Control	16.25	6.80	--	--		4.30	0.33	NA	--	0.557	0.08	--	--	
	BG-04	47.50	11.30	--	--	62.69	2.65	0.40	NA	--	0.674	0.13	--	--	121
	BG-06	41.25	14.07	--	--	70.15	2.62	0.42	NA	--	0.508	0.13	--	--	91.3
	BG-19	31.25	10.08	--	--	82.09	2.70	0.28	NA	--	0.451	0.07	--	--	81.1
Test Samples	NS-03[3b]	35.00	7.79	--	--	77.61	2.53	0.14	NA	--	0.426	0.05	--	--	76.4
	NS-07[3a]	30.00	10.18	--	--	83.58	3.33	0.41	NA	--	0.623	0.15	--	--	112
	NS-11[3b]	47.50	15.56	--	--	62.69	1.77	0.43	NA	Yes	0.308	0.09	--	--	55.3
	NS-12[3a]	50.00	9.26	--	--	59.70	3.19	0.42	NA	--	0.735	0.08	--	--	132
	NS-16[3a]	43.75	5.32	--	--	67.16	3.53	0.23	NA	--	0.669	0.07	--	--	120
	SS-04[3a]	31.25	8.11	--	--	82.09	4.27	0.24	NA	--	0.684	0.08	--	--	123
	SS-05[3a]	37.50	11.76	--	--	74.63	3.44	0.48	NA	--	0.637	0.09	--	--	114
	TD-08[3a]	100.00	0.00	Yes	Yes	0.00	0.00	0.00	NA	Yes	0.000	0.00	Yes	Yes	0.0
	TD-09[3a]	20.00	8.86	--	--	95.52	2.79	0.17	NA	--	0.413	0.09	Yes	--	74.1
	TD-15[3a]	98.75	1.25	Yes	Yes	1.49	0.03	0.03	NA	Yes	0.250	0.03	Yes	Yes	44.9

Midge *(Chironomus dilutus)* 20-day Sediment Toxicity Test

Sample		Mean Mortality (%)	Standard Error (%)	Statistically Different from Reference? Initial[1,3]	Statistically Different from Reference? Final[2,4]	Survival as Percent of Control (%)	Total Replicate Weight: Mean Total Weight (mg)	Total Replicate Weight: Standard Error Total Weight (mg)	Total Replicate Weight: Statistically Different from Reference? Initial	Total Replicate Weight: Statistically Different from Reference? Final[2,4]	Mean Individual Weight: Mean Individual Weight (mg)	Mean Individual Weight: Standard Error Mean Individual Weight (mg)	Mean Individual Weight: Statistically Different from Reference? Initial[1,3]	Mean Individual Weight: Statistically Different from Reference? Final[2,4]	Mean Individual Weight: Mean Individual Weight as Percent of Contol (%)
Reference and Control Samples	Control	17.5	2.50	--	--		12.35	1.61	NA	--	1.59	0.18	--	--	
	BG-04	43.75	9.05	--	--	68.18	10.41	1.58	NA	--	2.07	0.18	--	--	130
	BG-06	47.5	9.21	--	--	63.64	6.46	1.98	NA	--	1.02	0.28	--	--	64.1
	BG-19	36.25	7.54	--	--	77.27	11.24	1.43	NA	--	1.77	0.08	--	--	112
Test Samples	NS-03[3b]	51.25	9.90	--	--	59.09	5.87	1.87	NA	Yes	0.95	0.21	--	Yes	60.0
	NS-07[3a]	65	8.45	--	Yes	42.42	5.10	1.71	NA	Yes	1.12	0.31	Yes	Yes	70.5
	NS-11[3b]	68.75	13.68	--	Yes	37.88	3.13	1.88	NA	Yes	0.47	0.22	--	Yes	29.8
	NS-12[3a]	71.25	8.11	Yes	Yes	34.85	3.75	1.66	NA	Yes	1.13	0.28	Yes	Yes	71.6
	NS-16[3a]	46.25	11.01	--	--	65.15	9.07	1.92	NA	--	1.47	0.23	Yes	--	92.7
	SS-04[3a]	40	5.35	--	--	72.73	11.14	1.82	NA	--	1.86	0.26	--	--	117
	SS-05[3a]	57.5	6.75	--	--	51.52	6.55	1.57	NA	--	1.67	0.31	--	--	105
	TD-08[3a]	100	0.00	Yes	Yes	0.00	0.00	0.00	NA	Yes	0.00	0.00	Yes	Yes	0.0
	TD-09[3a]	56.25	8.44	--	--	53.03	4.13	0.96	NA	Yes	0.86	0.19	Yes	Yes	54.3
	TD-15[3a]	100	0.00	Yes	Yes	0.00	0.00	0.00	NA	Yes	0.00	0.00	Yes	Yes	0.0

Notes:
1. Initial - Initial evaluation performed by Northwestern Aquatic Sciences using grain-size-paired matches to appropriate reference stations. The statistical approach was pair-wise means testing.
2. Final - Final evaluation using conservative reference stations. The statistical approach was an analysis of variance (ANOVA) followed by a multiple comparisons means test.
3. Reference samples used in Initial evaluation were used based on closest matching grain size.
3a. Reference sample used in Initial evaluation - BG-04
3b. Reference sample used in initial evaluation - BG-06
4. BG-19 was the only reference sample used in the Final evaluation because of the high percent mortalities observed for the other two reference samples.
NA = not applicable; statistical test was not run
-- - Not statistically different
Reference samples removed for final evaluations.

Table 7.2-25
Bioassay Results Summary - Wood Debris Test 1

Amphipod *(Hyalella azteca)* 28-day Sediment Toxicity Test															
							Total Replicate Weight				Mean Individual Weight				
		Mean Mortality	Standard Error	Statistically Different from Reference[1]?		Survival as Percent of Control	Mean Total Weight	Standard Error Total Weight	Statistically Different from Reference[1]?		Mean Individual Weight	Standard Error Mean Individual Weight	Statistically Different from Reference[1]?		Mean Individual Weight as Percent of Control
Sample		(%)	(%)	Initial[2]	Final[3]	(%)	(mg)	(mg)	Initial	Final[3]	(mg)	(mg)	Initial[2]	Final[3]	(%)
Reference and Control Samples	Control	2.5	1.64	--	--		3.99	0.14	NA	--	0.41	0.02	--	--	
	BG-02	1.25	1.25	--	--	101	4.27	0.22	NA	--	0.43	0.02	--	--	105
	BG-03	25	7.07	--	--	76.9	2.56	0.16	NA	--	0.37	0.06	--	--	90.5
	BG-13	5	1.89	--	--	97.4	2.64	0.21	NA	--	0.28	0.03	--	--	69.2
Test Samples	NS-06 [1a]	3.75	2.63	--	--	98.7	4.23	0.25	NA	--	0.44	0.02	--	--	107
	NS-07 [1c]	0	0.00	--	--	103	4.13	0.21	NA	--	0.41	0.02	--	--	100
	SS-01 [1b]	3.75	2.63	--	--	98.7	4.39	0.22	NA	--	0.46	0.02	--	--	111
	SS-02 [1a]	2.5	1.64	--	--	100	4.64	0.18	NA	--	0.48	0.02	--	--	116
	WD-03 [1b]	1.25	1.25	--	--	101	3.71	0.15	NA	--	0.38	0.02	--	--	91.6
	WD-06 [1b]	2.5	1.64	--	--	100	3.94	0.08	NA	--	0.41	0.01	--	--	98.6
	WD-07 [1b]	1.25	1.25	--	--	101	4.66	0.31	NA	--	0.47	0.02	--	--	116
	WD-08 [1a]	1.25	1.25	--	--	101	4.22	0.20	NA	--	0.43	0.02	--	--	106
	WD-09 [1a]	10	3.78	--	-- [4]	92.3	3.69	0.20	NA	--	0.41	0.02	--	--	100

Midge *(Chironomus dilutus)* 20-day Sediment Toxicity Test															
							Total Replicate Weight				Mean Individual Weight				
		Mean Mortality	Standard Error	Statistically Different from Reference[1]?		Survival as Percent of Control	Mean Total Weight	Standard Error Total Weight	Statistically Different from Reference[1]?		Mean Individual Weight	Standard Error Mean Individual Weight	Statistically Different from Reference[1]?		Mean Individual Weight as Percent of Control
Sample		(%)	(%)	Initial[2]	Final[3]	(%)	(mg)	(mg)	Initial	Final[3]	(mg)	(mg)	Initial[2]	Final[3]	(%)
Reference and Control Samples	Control	10	3.78	--	--		15.00	1.67	NA	--	2.36	0.36	--	--	
	BG-02	18.75	5.49	--	--	90.3	12.74	0.73	NA	--	1.79	0.13	--	--	76.0
	BG-03	50	9.26	--	--	55.6	8.03	1.18	NA	--	2.56	0.32	--	--	109
	BG-13	25	10.18	--	--	83.3	11.71	1.53	NA	--	1.64	0.11	--	--	69.6
Test Samples	NS-06 [1a]	26.25	8.65	--	--	81.9	12.40	0.88	NA	--	1.83	0.17	--	--	77.6
	NS-07 [1c]	50	11.02	Yes	Yes	55.6	7.71	1.65	NA	Yes	1.44	0.24	--	--	61.1
	SS-01 [1a]	33.75	12.81	--	--	73.6	10.93	1.93	NA	--	1.83	0.26	Yes, See note [5]	--	77.7
	SS-02 [1a]	17.5	5.26	--	--	91.7	14.90	0.58	NA	--	1.86	0.07	--	--	79.0
	WD-03 [1a]	25	5.67	--	--	83.3	12.11	0.81	NA	--	1.67	0.15	Yes, See note [5]	--	70.9
	WD-06 [1a]	43.75	11.17	--	--	62.5	10.04	1.79	NA	--	1.85	0.25	Yes, See note [5]	--	78.5
	WD-07 [1a]	32.5	9.96	--	--	75.0	10.34	1.70	NA	--	1.44	0.19	Yes, See note [5]	--	61.1
	WD-08 [1a]	30	12.82	--	--	77.8	12.08	2.28	NA	--	1.71	0.22	--	--	72.6
	WD-09 [1a]	32.5	10.48	--	--	75.0	10.61	1.65	NA	--	1.62	0.21	--	--	68.8

Notes:
1. Reference samples were based on closest matching grain size.
1a. Reference sample used in evaluation - BG-02
1b. Reference sample used in evaluation - BG-03
1c. Reference sample used in evaluation - BG-13
2. Initial - Initial evaluation performed by Northwestern Aquatic Sciences using grain-size-paired matches to appropriate reference stations. The statistical approach was pair-wise means testing.
3. Final - Final evaluation using conservative reference stations. The statistical approach was an analysis of variance (ANOVA) followed by a multiple comparisons means test.
4. This sample was significantly different but did not exceed mean control performance critiera, so the difference is not biologically significant.
5. The Initial evaluation used reference BG-03, which had high mortality that resulted in high individual weight. When re-analyzed using reference BG-02, no statistical difference existed.
NA - not applicable; statistical test was not run.
-- - Not statistically different
Reference samples removed for final evaluations.

Table 7.2-26
Bioassay Results Summary - Wood Debris Test 2

Amphipod *(Hyalella azteca)* 28-day Sediment Toxicity Test												
						Total Replicate Weight			Mean Individual Weight			
Sample		Mean Mortality (%)	Standard Error (%)	Survival as Percent of Control (%)	Statistically Different from Reference[1]? Final[2]	Mean Total Weight (mg)	Standard Error Total Weight (mg)	Statistically Different from Reference[1]? Final[2]	Mean Individual Weight (mg/ind)	Standard Error Mean Individual Weight (mg)	Statistically Different from Reference[1]? Final[2]	Mean Individual Weight as Percent of Control (%)
Reference and Control Samples	Control	3.8	1.84		--	6.00	0.12	--	0.63	0.01	--	
	Silica Sand	5	2.69		--	3.55	0.19	--	0.37	0.02	--	
	BG-12	8.8	3.50	94.8	--	4.22	0.43	--	0.46	0.05	--	74.1
	BG-13	10	4.24	93.6	--	3.92	0.18	--	0.45	0.04	--	71.7
Test Samples	NS-01 [1a]	3.8	2.62	100	--	6.03	0.20	--	0.63	0.02	--	100.6
	NS-02 [1a]	2.5	1.63	101	--	4.14	0.25	--	0.43	0.01	--	68.2
	WD-01 [1a]	2.5	1.63	101	--	5.33	0.31	--	0.55	0.04	--	87.7

Midge *(Chironomus dilutus)* 20-day Sediment Toxicity Test												
						Total Replicate Weight			Mean Individual Weight			
Sample		Mean Mortality (%)	Standard Error (%)	Survival as Percent of Control (%)	Statistically Different from Reference[1]? Final[2]	Mean Total Weight (mg)	Standard Error Total Weight (mg)	Statistically Different from Reference[1]? Final[2]	Mean Individual Weight (mg)	Standard Error Mean Individual Weight (mg)	Statistically Different from Reference[1]? Final[2]	Mean Individual Weight as Percent of Control (%)
Reference and Control Samples	Control	3.8	1.84		--	28.50	8.49	--	1.86	0.07	--	
	Silica Sand	67.5	4.53		--	7.35	0.77	--	2.17	0.22	--	
	BG-12	25	9.44	78.0	--	15.07	1.78	--	1.62	0.18	--	87.1
	BG-13	23.8	11.49	79.2	--	16.88	1.42	--	1.64	0.10	--	88.2
Test Samples	NS-01 [1a]	21.3	11.70	81.8	--	16.23	0.70	--	1.56	0.11	--	83.9
	NS-02 [1a]	8.8	3.50	94.8	--	16.03	0.55	--	1.42	0.05	--	76.3
	WD-01 [1a]	10	4.63	93.6	--	19.05	1.05	--	1.76	0.13	--	94.6

Notes:
1. Reference samples were based on closest matching grain size.
1a. Reference sample used in evaluation - BG-12.
2. Final - Final evaluation using conservative reference stations. The statistical approach was an analysis of variance (ANOVA) followed by a multiple comparisons means test.
-- - Not statistically different

Table 7.2-27
Summary of Bioassay Concentration-Response Regression Coefficients

	Survival	TRW (mg)	MIW (mg/ind)
Amphipod *(Hyalella azteca)* Regression Coefficient (R^2)			
Sediment Porewater PAH ESBQ TUs (U=0)	0.652	0.669	0.592
Bulk Sediment PAH ESBQ TUs	0.648	0.675	0.554
Bulk Sediment Total PAHs	0.740	0.769	0.645
Bulk Sediment Total TPH	0.677	0.699	0.576
Midge *(Chironomus dilutus)* Regression Coefficient (R^2)			
Sediment Porewater PAH ESBQ TUs (U=0)	0.593	0.446	0.584
Bulk Sediment PAH ESBQ TUs	0.595	0.449	0.553
Bulk Sediment Total PAHs	0.675	0.510	0.628
Bulk Sediment Total TPH	0.670	0.544	0.544

Notes:
ESBQ - equilibrium sediment benchmark quotient
mg - milligram(s)
mg/ind - milligram(s) per individual
MIW - mean individual weight
PAH(s) - polynuclear aromatic hydrocarbon(s)
TPH - total petroleum hydrocarbons
TRW - total replicate weight
TUs - toxic units
U=0 - Undetected results treated as zero

Table 7.2-28
Surface Water Toxicity Screening: Aquatic Plants and Fish

COPC	EPA Aquatic Plant Screening Criterion	EPA Aquatic Plant Screening Value	EPA Fish Screening Criterion	EPA Fish Screening Value	Criterion Units	Number of Samples	Number of Detections	Number of Non-detects	Frequency of Detection (%)	Minimum Value	Maximum Value	Mean Value	Maximum Detected Value	95 UCL Surface Water	EPC Basis	Aquatic Plant HQ	Fish HQ
2-Methylnaphthalene	R3 BTAG SW	4.7	R5 ESL SW	330	µg/L	40	12	28	30	0.042	89	9.581	89	6.8	99% KM (Chebyshev) UCL	**1**	0.02
Acenaphthene	R3 BTAG SW	5.8	R5 ESL SW	38	µg/L	46	26	20	57	0.0136	26.6	2.70	26.6	9.24	99% KM (Chebyshev) UCL	**1.6**	0.24
Anthracene	R3 BTAG SW	0.012	R5 ESL SW	0.035	µg/L	46	17	29	37	0.00664	2.5	0.40	2.5	0.505	97.5% KM (Chebyshev) UCL	**42**	**14**
Arsenic[a,b]	R3 BTAG SW	5	R5 ESL SW	148	µg/L	6	2	4	33	1	1	1.00	1	1	Max. Detect	0.2	0.01
Benzene	R3 BTAG SW	370	R5 ESL SW	114	µg/L	22	7	15	32	0.21	77	26.30	77	16.8	95% KM (Percentile Bootstrap) UCL	0.0	0.15
Benzo(a)anthracene	R3 BTAG SW	0.018	R5 ESL SW	0.025	µg/L	46	12	34	26	0.00307	2.2	0.23	2.2	0.277	95% KM (t) UCL	**15**	**11**
Benzo(a)pyrene	R3 BTAG SW	0.015	R5 ESL SW	0.014	µg/L	46	14	32	30	0.00209	3	0.25	3	0.744	95% KM (t) UCL	**50**	**53**
Benzo(b)fluoranthene	--	--	R5 ESL SW	9.07	µg/L	46	16	30	35	0.00146	3.2	0.24	3.2	0.793	95% KM (t) UCL	--	0.09
Benzo(k)fluoranthene	--	--	--	--	µg/L	46	14	32	30	0.00187	2.9	0.23	2.9	0.355	95% KM (t) UCL	--	--
Chrysene	--	--	--	--	µg/L	46	20	26	43	0.000255	1.6	0.10	1.6	0.399	95% KM (t) UCL	--	--
Dibenz(a,h)anthracene	--	--	--	--	µg/L	52	3	49	6	0.00287	0.092	0.06	0.092	0.0386	99% KM (Chebyshev) UCL	--	--
Ethylbenzene	R3 BTAG SW	90	R3 BTAG SW	90	µg/L	22	7	15	32	0.07	22	8.57	22	5.00	95% KM (Percentile Bootstrap) UCL	0.1	0.06
Fluoranthene	R3 BTAG SW	0.04	R5 ESL SW	1.9	µg/L	46	22	24	48	0.00261	5.4	0.66	5.4	1.951	95% KM (t) UCL	**49**	**1.0**
Fluorene	R3 BTAG SW	3	R5 ESL SW	19	µg/L	46	21	25	46	0.00744	17	1.66	17	5.243	99% KM (Chebyshev) UCL	**1.7**	0.28
Indeno(1,2,3-c,d)pyrene	NV	NV	R5 ESL SW	4.31	µg/L	52	10	42	19	0.00143	1.4	0.19	1.4	0.0866	95% KM (t) UCL	--	0.02
Naphthalene	R3 BTAG SW	1.1	R5 ESL SW	13	µg/L	46	14	32	30	0.0443	550	43.52	550	135.5	95% KM (t) UCL	**123**	**10**
Phenanthrene	R3 BTAG SW	0.4	R5 ESL SW	3.6	µg/L	46	21	25	46	0.00873	13.8	1.78	13.8	5.16	99% KM (Chebyshev) UCL	**13**	**1.4**
Pyrene	R3 BTAG SW	0.025	R5 ESL SW	0.3	µg/L	46	24	22	52	0.00234	5	0.46	5	1.55	99% KM (Chebyshev) UCL	**62**	**5.2**
Toluene	R3 BTAG SW	2	R5 ESL SW	253	µg/L	22	5	17	23	0.11	16	6.21	16	3.16	95% KM (Percentile Bootstrap) UCL	**1.6**	0.01
Total Xylenes (U=1/2)	R3 BTAG SW	13	R5 ESL SW	27	µg/L	11	6	5	55	0.31	12.9	5.79	12.9	6.02	95% KM (Percentile Bootstrap) UCL	0.5	0.22
PAH ESBQ (U=0)	--	--	ESBQ Guidance	1	TU	35	29	6	83	0.004	69.59	4.46	69.59	15.01	Use 95% Chebyshev (Mean, Sd) UCL	--	**15**
PAH ESBQ (U=1/2)	--	--	ESBQ Guidance	1	TU	35	35	0	100	1.745	69.72	5.34	69.72	26.45	99% KM (Chebyshev) UCL	--	**26**

Notes:

[a] COPCs identified based on groundwater detections to be protective of the groundwater transport to ecological receptors, not detections in surface water or porewater.

[b] Includes dilution factor of 10 for porewater data, except for PAH ESBQ values, which are not diluted.

-- - no screening value
COPC - chemical of potential concern
EPC - exposure point concentration
HQ - hazard quotient
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
KM (Percentile Bootstrap) - UCL based on Kaplan-Meier estimates using the percentile bootstrap method
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
Max. Detect - UCL based on the maximum detected value
NV - no screening value
PAH ESBQ - polynuclear aromatic hydrocarbon equilibrium-partitioning sediment benchmark quotient
R3 BTAG SW - U.S. Environmental Protection Agency (EPA) Region 3 Biological Technical Assessment Group Surface Water Criterion
R5 ESL SW - EPA Region 5 Ecological Screening Level for Surface Water
sd - standard deviation
Student's (t) - UCL based on Student's t-distribution
TU - toxic unit(s)
UCL - upper confidence limit
µg/L - microgram(s) per liter
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

Table 7.2-29
Fish Tissue and Dietary Toxicity Reference Values

	Diet						Tissue					
	NOAEL				LOAEL		NOAEL				LOAEL	
Chemical	**Source**	**Endpoint**	**Test Species**	**NOAEL (mg/kg dw)**	**Source**	**LOAEL (mg/kg dw)**	**Source**	**Endpoint**	**Test Species**	**NOAEL (ug/kg ww)**	**Source**	**LOAEL (ug/kg ww)**
2,4-Dimethylphenol	--	--	--	--	--	--	Based on phenol: McKin and Schmeider (1990) as cited by Windward (2007)	Survival	Rainbow Trout	1470	Same as NOAEL	73400
Arsenic	Oladimeji et al 1984 as cited by Windward 2007	Growth	Rainbow Trout	20	Same as NOAEL	30	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	Hart and Heddle 1991, as cited by Windward (2007)	Growth	Rainbow Trout	100	Rice et al. (2000) as cited by Windward (2007); English sole - growth	116	--	--	--	--	--	--
Chromium	Walsh et al 1994, as cited by Windward 2007	Growth	Grey Mullet	9.42	NOAEL * 5	47.1	--	--	--	--	--	44100
Copper	Kang et al 2005, as cited by Windward (2007)	Growth	Rainbow Trout	50	Same as NOAEL	100	--	--	--	2800	--	3100
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--
Lead	Goett et al 1976, as cited by Windward (2007)	Growth	Rainbow Trout	7040	NOAEL * 5	35200	--	--	--	--	--	--
Pentachlorophenol	--	--	--	--	--	--	Based on phenol: McKin and Schmeider (1990) as cited by Windward (2007)	Survival	Rainbow Trout	1470	Same as NOAEL	73400
Toluene	--	--	--	--	--	--	--	--	--	--	--	--
Total 10 of 16 HPAHs (U=1/2)	Benzo(a)pyrene	--	--	100	Same as NOAEL	116	--	--	--	--	--	--
Total 16 PAHs (U=1/2)	Meador et al 2006, as cited by Windward (2007) for PAH mixture	Growth	Chinook Salmon	324	Same as NOAEL	951	--	--	--	--	--	--
Total 6 of 16 LPAHs (U=1/2)	Total PAHs	--	--	324	Same as NOAEL	951	--	--	--	--	--	--
Total PCBs (U=1/2)	--	--	--	--	--	--	Lowest of range provided by Windward (2007) from Hugla and Thome (1999)	Reproduction	Common Barbel	104	Same as NOAEL	520
Total Xylenes	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
Rationale for TRV selection summarized in Appendix J-9.
NA = not applicable; PAHs to be assessed via benzo(a)pyrene and PAH totals
NOAEL (No Observed Adverse Effects Level):
1 Eco-SSL recommended
2 Sample et al. 1996
3 Other literature
LOAEL (Lowest Observed Adverse Effects Level):
1a If Eco-SSL single study, and LOAEL value exists for same study, use that.
1b If Eco-SSL is based on geomean, use geomean of same dataset.
1c If dataset for LOAELs <= 3, use professional judgment whether to use geomean or use single value from Eco-SSL or from other literature sources (e.g., Sample et al. 1996)
2 Same study as literature-based NOAEL.
3 Adjustment using selected NOAEL.

-- - no data available
Eco-SSL - U.S. Environmental Protection Agency (EPA) Ecological Soil Screening Level.
mg/kg dw - milligram per kilogram dry weight
ug/kg ww - microgram per kilogram wet weight
HPAHs - high-molecular-weight PAHs
LPAHs - low-molecular-weight PAHs
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls

Table 7.2-30
Sediment Exposure Point Concentrations for COPCs Included in the Ecological Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
Sediment (Nearshore)	2-Methylnaphthalene	mg/kg	4	3	75%	0.0071	1.5	0.709	0.62	NA	1.5	Max. Detect
Sediment (Nearshore)	4-Methylphenol (p-Cresol)	mg/kg	6	1	17%	0.037	0.037	0.037	0.037	NA	0.037	Max. Detect
Sediment (Nearshore)	Acenaphthene	mg/kg	6	4	67%	0.038	2.8	0.754	0.0895	1.447	1.447	95% KM (BCA) UCL
Sediment (Nearshore)	Acenaphthylene	mg/kg	6	5	83%	0.01	0.51	0.116	0.016	0.935	0.51	Max. Detect
Sediment (Nearshore)	Anthracene	mg/kg	6	5	83%	0.012	3.9	0.912	0.17	3.569	3.569	95% KM (Chebyshev) UCL
Sediment (Nearshore)	Benzo(a)anthracene	mg/kg	6	6	100%	0.022	8.2	1.524	0.245	14.82	8.2	Max. Detect
Sediment (Nearshore)	Benzo(a)pyrene	mg/kg	6	6	100%	0.021	16	3.19	0.8	38.1	16	Max. Detect
Sediment (Nearshore)	Benzo(g,h,i)perylene	mg/kg	6	6	100%	0.0093	6.7	1.527	0.62	7.69	6.7	Max. Detect
Sediment (Nearshore)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	43.27	Use 95% Student's-t UCL
Sediment (Nearshore)	Chrysene	mg/kg	6	6	100%	0.028	19	3.651	0.625	47.9	19	Max. Detect
Sediment (Nearshore)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Nearshore)	Dibenz(a,h)anthracene	mg/kg	6	5	83%	0.12	2.5	0.672	0.25	3.034	2.5	Max. Detect
Sediment (Nearshore)	Dibenzofuran	mg/kg	5	1	20%	0.035	0.035	0.035	0.035	NA	0.035	Max. Detect
Sediment (Nearshore)	Fluoranthene	mg/kg	6	6	100%	0.024	38	6.583	0.29	129.6	38	Max. Detect
Sediment (Nearshore)	Fluorene	mg/kg	6	4	67%	0.038	3.4	0.902	0.084	6.459	3.4	Max. Detect
Sediment (Nearshore)	Indeno(1,2,3-c,d)pyrene	mg/kg	6	6	100%	0.0093	6.2	1.332	0.445	14.09	6.2	Max. Detect
Sediment (Nearshore)	Naphthalene	mg/kg	6	4	67%	0.066	12	3.709	1.385	6.068	6.068	95% KM (Percentile Bootstrap) UCL
Sediment (Nearshore)	Phenanthrene	mg/kg	6	6	100%	0.008	47	7.974	0.2	85.64	47	Max. Detect
Sediment (Nearshore)	Pyrene	mg/kg	6	6	100%	0.02	38	6.559	0.31	69.13	38	Max. Detect
Sediment (Nearshore)	Total 10 of 16 HPAHs (U=1/2)	mg/kg	6	6	100%	0.188	170.6	31.8	5.445	447.7	171	Max. Detect
Sediment (Nearshore)	Total 16 PAHs (U=1/2)	mg/kg	6	6	100%	0.212	230.8	44.21	6.526	628.3	230.8	Max. Detect
Sediment (Nearshore)	Total 6 of 16 LPAHs (U=1/2)	mg/kg	6	6	100%	0.0245	60.21	12.41	0.906	223.1	60.21	Max. Detect
Sediment (Sitewide)	2-Methylnaphthalene	mg/kg	13	7	54%	0.0071	150	21.9	0.62	130.7	130.7	99% KM (Chebyshev) UCL
Sediment (Sitewide)	4-Methylphenol (p-Cresol)	mg/kg	19	8	42%	0.017	0.068	0.0319	0.028	0.0298	0.0298	95% KM (t) UCL
Sediment (Sitewide)	Acenaphthene	mg/kg	42	31	74%	0.0067	190	12.09	0.066	61.96	61.96	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Acenaphthylene	mg/kg	42	34	81%	0.0093	3	0.217	0.0345	0.55	0.55	95% KM (Chebyshev) UCL
Sediment (Sitewide)	Anthracene	mg/kg	42	38	90%	0.012	240	9.198	0.22	66.93	66.93	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Benzo(a)anthracene	mg/kg	42	41	98%	0.022	260	13.06	0.58	57.7	57.7	97.5% KM (Chebyshev) UCL
Sediment (Sitewide)	Benzo(a)pyrene	mg/kg	42	41	98%	0.021	140	9.911	1	37.14	37.14	97.5% KM (Chebyshev) UCL
Sediment (Sitewide)	Benzo(g,h,i)perylene	mg/kg	42	42	100%	0.0093	33	2.875	0.64	7.14	7.14	95% Chebyshev (Mean, sd) UCL
Sediment (Sitewide)	Chromium	mg/kg	5	5	100%	39	44	41.2	40	43.27	44	Max. Detect
Sediment (Sitewide)	Chrysene	mg/kg	42	42	100%	0.028	340	15.4	1.05	53.8	53.8	95% Chebyshev (Mean, sd) UCL
Sediment (Sitewide)	Copper	mg/kg	5	5	100%	24.2	46.4	39.66	42	48.27	46.4	Max. Detect
Sediment (Sitewide)	Dibenz(a,h)anthracene	mg/kg	42	38	90%	0.024	17	1.299	0.24	3.315	3.315	95% KM (Chebyshev) UCL
Sediment (Sitewide)	Dibenzofuran	mg/kg	8	3	38%	0.035	0.43	0.168	0.038	0.43	0.43	95% KM (BCA) UCL
Sediment (Sitewide)	Fluoranthene	mg/kg	42	41	98%	0.024	670	36.07	0.61	245.5	245.5	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Fluorene	mg/kg	42	32	76%	0.0077	160	10.1	0.066	54.05	54.05	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Indeno(1,2,3-c,d)pyrene	mg/kg	42	42	100%	0.0093	34	2.747	0.59	7.107	7.107	95% Chebyshev (Mean, sd) UCL
Sediment (Sitewide)	Naphthalene	mg/kg	42	30	71%	0.0075	150	5.706	0.0545	39.79	39.79	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Phenanthrene	mg/kg	42	41	98%	0.008	720	34.55	0.26	237.3	237.3	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Pyrene	mg/kg	42	41	98%	0.02	440	25.06	0.64	162.8	162.8	99% KM (Chebyshev) UCL
Sediment (Sitewide)	Total 10 of 16 HPAHs (U=1/2)	mg/kg	42	42	100%	0.188	2,004	122.9	6.365	395.6	395.6	Use 95% Chebyshev (Mean, sd) UCL
Sediment (Sitewide)	Total 16 PAHs (U=1/2)	mg/kg	42	42	100%	0.212	2,948	185.9	7.916	611.8	611.8	Use 95% Chebyshev (Mean, sd) UCL
Sediment (Sitewide)	Total 6 of 16 LPAHs (U=1/2)	mg/kg	42	41	98%	0.0245	1,134	64.46	0.693	417.8	417.8	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	2-Methylnaphthalene	mg/kg OC	13	7	54%	0.179	2459	362.4	10.28	574.9	574.9	95% KM (BCA) UCL
OC Normalized Site Sediment	Acenaphthene	mg/kg OC	42	31	74%	0.067	4,439	221.2	1.299	1,265	1,265	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Acenaphthylene	mg/kg OC	42	34	81%	0.067	49.18	3.588	0.662	8.668	8.668	95% KM (Chebyshev) UCL
OC Normalized Site Sediment	Anthracene	mg/kg OC	42	38	90%	0.306	2,553	128.7	3.264	810	810	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Benzo(a)anthracene	mg/kg OC	42	41	98%	1.292	3,505	208.3	10.53	873.9	873.9	97.5% KM (Chebyshev) UCL
OC Normalized Site Sediment	Benzo(a)pyrene	mg/kg OC	42	41	98%	1.866	2,295	168.2	16.88	601.5	601.5	97.5% KM (Chebyshev) UCL
OC Normalized Site Sediment	Benzo(g,h,i)perylene	mg/kg OC	42	42	100%	0.917	420.6	51.79	10.96	116.7	116.7	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Site Sediment	Chrysene	mg/kg OC	42	42	100%	2.057	3617	230.8	17.6	708.8	708.8	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Site Sediment	Dibenz(a,h)anthracene	mg/kg OC	42	38	90%	0.246	200.9	22.62	4.833	65.49	65.49	97.5% KM (Chebyshev) UCL
OC Normalized Site Sediment	Dibenzofuran	mg/kg OC	8	3	38%	0.339	4.019	1.624	0.515	2.015	2.015	95% KM (t) UCL
OC Normalized Site Sediment	Fluoranthene	mg/kg OC	42	41	98%	1.531	15,654	639.9	11.11	4,593	4,593	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Fluorene	mg/kg OC	42	32	76%	0.0622	3,738	181.9	1.293	1,072	1,072	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg OC	42	42	100%	0.876	443.9	48.07	10.22	113.9	113.9	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Site Sediment	Naphthalene	mg/kg OC	42	30	71%	0.067	2,459	104.3	0.848	667.3	667.3	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Phenanthrene	mg/kg OC	42	41	98%	0.718	16,822	639	5.283	4,773	4,773	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	Pyrene	mg/kg OC	42	41	98%	1.483	10,280	447.8	11.2	3,054	3,054	99% KM (Chebyshev) UCL
OC Normalized Site Sediment	OC Total 10 of 16 HPAHs (U=1/2)	mg/kg OC	42	42	100%	15.18	37,397	2,096	126.2	6,674	6,674	Use 95% Chebyshev (Mean, sd) UCL

Table 7.2-30
Sediment Exposure Point Concentrations for COPCs Included in the Ecological Risk Assessment

Media	COPC	Units	Number of Samples	Number of Detects	Percent Detected	Minimum Value	Maximum Value	Mean	Median	95% UCL	EPC	EPC Basis
OC Normalized Site Sediment	OC Total 16 PAHs (U=1/2)	mg/kg OC	42	42	100%	16.46	63,881	3,217	137	10,736	10,736	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Site Sediment	OC Total 6 of 16 LPAHs (U=1/2)	mg/kg OC	42	41	98%	1.287	26,484	1,147	11.1	7,904	7,904	99% KM (Chebyshev) UCL
Sediment (Background)	Acenaphthene	mg/kg	10	5	50%	0.0054	0.0061	0.00582	0.0059	0.00579	0.00579	95% KM (t) UCL
Sediment (Background)	Acenaphthylene	mg/kg	10	1	10%	0.0067	0.0067	0.0067	0.0067	NA	0.0067	Max. Detect
Sediment (Background)	Anthracene	mg/kg	10	9	90%	0.0055	0.025	0.0142	0.013	0.0168	0.0168	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Arsenic	mg/kg	5	3	60%	9	20	13	10	16.44	20	Max. Detect
Sediment (Background)	Benzo(a)anthracene	mg/kg	10	10	100%	0.017	0.13	0.0672	0.056	0.0909	0.0909	95% Student's-t UCL
Sediment (Background)	Benzo(a)pyrene	mg/kg	10	10	100%	0.026	0.18	0.0891	0.075	0.118	0.118	95% Student's-t UCL
Sediment (Background)	Benzo(g,h,i)perylene	mg/kg	10	10	100%	0.025	0.12	0.0578	0.0585	0.0748	0.0748	95% Student's-t UCL
Sediment (Background)	Chromium	mg/kg	5	5	100%	21	48	39	44	49.77	48	Max. Detect
Sediment (Background)	Chrysene	mg/kg	10	10	100%	0.033	0.23	0.113	0.0985	0.152	0.152	95% Student's-t UCL
Sediment (Background)	Copper	mg/kg	5	5	100%	12	52.6	28.74	25.5	44.65	52.6	Max. Detect
Sediment (Background)	Dibenz(a,h)anthracene	mg/kg	10	10	100%	0.006	0.041	0.0182	0.0175	0.0244	0.0244	95% Student's-t UCL
Sediment (Background)	Fluoranthene	mg/kg	10	10	100%	0.051	0.34	0.121	0.095	0.178	0.178	95% Approximate Gamma UCL
Sediment (Background)	Fluorene	mg/kg	10	6	60%	0.0052	0.0084	0.00685	0.0066	0.00696	0.00696	95% KM (t) UCL
Sediment (Background)	Indeno(1,2,3-c,d)pyrene	mg/kg	10	10	100%	0.024	0.11	0.053	0.0495	0.0691	0.0691	95% Student's-t UCL
Sediment (Background)	Naphthalene	mg/kg	10	7	70%	0.0049	0.012	0.00723	0.0056	0.00796	0.00796	95% KM (Percentile Bootstrap) UCL
Sediment (Background)	Phenanthrene	mg/kg	10	10	100%	0.019	0.12	0.0509	0.0485	0.0706	0.0706	95% Approximate Gamma UCL
Sediment (Background)	Pyrene	mg/kg	10	10	100%	0.047	0.32	0.117	0.093	0.171	0.171	95% Approximate Gamma UCL
Sediment (Background)	Total 10 of 16 HPAHs (U=1/2)	mg/kg	10	10	100%	0.301	1.718	0.84	0.694	1.103	1.103	Use 95% Student's-t UCL
Sediment (Background)	Total 16 PAHs (U=1/2)	mg/kg	10	10	100%	0.332	1.875	0.922	0.774	1.204	1.204	Use 95% Student's-t UCL
Sediment (Background)	Total 6 of 16 LPAHs (U=1/2)	mg/kg	10	10	100%	0.0308	0.157	0.0817	0.0793	0.103	0.103	Use 95% Student's-t UCL
OC Normalized Background Sediment	Acenaphthene	mg/kg OC	10	5	50%	0.149	0.324	0.22	0.219	0.221	0.221	95% KM (t) UCL
OC Normalized Background Sediment	Acenaphthylene	mg/kg OC	10	1	10%	0.17	0.17	0.17	0.17	NA	0.17	Max. Detect
OC Normalized Background Sediment	Anthracene	mg/kg OC	10	9	90%	0.206	1.02	0.519	0.456	0.645	0.645	95% KM (Percentile Bootstrap) UCL
OC Normalized Background Sediment	Benzo(a)anthracene	mg/kg OC	10	10	100%	0.769	7.027	2.45	1.794	3.725	3.725	Use 95% Approximate Gamma UCL
OC Normalized Background Sediment	Benzo(a)pyrene	mg/kg OC	10	10	100%	1.176	9.73	3.328	2.755	4.955	4.955	Use 95% Approximate Gamma UCL
OC Normalized Background Sediment	Benzo(g,h,i)perylene	mg/kg OC	10	10	100%	0.906	4.324	2.11	2.037	2.759	2.759	Use 95% Student's-t UCL
OC Normalized Background Sediment	Chrysene	mg/kg OC	10	10	100%	1.493	11.35	4.114	3.275	6.123	6.123	Use 95% Approximate Gamma UCL
OC Normalized Background Sediment	Dibenz(a,h)anthracene	mg/kg OC	10	10	100%	0.217	1.405	0.658	0.643	0.887	0.887	Use 95% Student's-t UCL
OC Normalized Background Sediment	Fluoranthene	mg/kg OC	10	10	100%	1.91	18.38	4.737	3.374	11.48	11.48	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Background Sediment	Fluorene	mg/kg OC	10	6	60%	0.135	0.449	0.245	0.228	0.267	0.267	95% KM (t) UCL
OC Normalized Background Sediment	Indeno(1,2,3-c,d)pyrene	mg/kg OC	10	10	100%	0.906	4.432	1.945	1.815	2.597	2.597	Use 95% Student's-t UCL
OC Normalized Background Sediment	Naphthalene	mg/kg OC	10	7	70%	0.173	0.304	0.231	0.216	0.246	0.246	95% KM (t) UCL
OC Normalized Background Sediment	Phenanthrene	mg/kg OC	10	10	100%	0.86	6.486	1.954	1.629	4.213	4.213	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Background Sediment	Pyrene	mg/kg OC	10	10	100%	1.873	17.3	4.556	3.027	10.84	10.84	Use 95% Chebyshev (Mean, sd) UCL
OC Normalized Background Sediment	OC Total 10 of 16 HPAHs (U=1/2)	mg/kg OC	10	10	100%	13.63	92.86	31.35	26.31	45.56	45.56	Use 95% Approximate Gamma UCL
OC Normalized Background Sediment	OC Total 16 PAHs (U=1/2)	mg/kg OC	10	10	100%	15.02	101.4	34.41	29.19	49.82	49.82	Use 95% Approximate Gamma UCL
OC Normalized Background Sediment	OC Total 6 of 16 LPAHs (U=1/2)	mg/kg OC	10	10	100%	1.391	8.492	3.062	2.741	4.311	4.311	Use 95% Approximate Gamma UCL

Notes:
COPC - chemical of potential concern
EPC - exposure point concentration
HPAHs - high-molecular-weight PAHs
KM (BCA) - UCL based on Kaplan-Meier estimates using bias-corrected accelerated bootstrap method
KM (Chebyshev) - UCL based on Kaplan-Meier estimates using the Chebychev inequality
KM (Percentile Bootstrap) - UCL based on Kaplan-Meier estimates using the percentile bootstrap method
KM (t) - UCL based on Kaplan-Meier estimates using the Student's t-distribution cutoff value
LPAHs - low-molecular-weight PAHs
Max. Detect - UCL based on the maximum detected value
mg/kg - milligram(s) per kilogram
NA - not available
OC - organic carbon (normalized)
PAHs - polynuclear aromatic hydrocarbons
sd - standard deviation
UCL - upper confidence limit

Table 7.2-31
Estimated Exposure Point Concentrations for Fish and Shellfish

Chemical	Literature-Based Biota-Sediment Accumulation Factors (BSAF)[a]				Sitewide Sediment Exposure Area				
	Mollusc BSAF	Freshwater Crustacean BSAF	Mid-water-feeding Fish BSAF	Bottom-feeding Fish BSAF	Sediment EPC (mg/kg OC)	Mollusc EPC (mg/kg)	Freshwater Crustacean EPC (mg/kg)	Mid-water-feeding Fish Tissue EPC (mg/kg)	Bottom-feeding Fish EPC (mg/kg)
Arsenic	NV	NV	NV	NV	NC	NV	NV	NV	NV
Benzo(a)pyrene	0.0412	0.00844	0.00021	0.00256	602	0.34	0.25	0.0084	0.059
Chromium	NV	NV	NV	NV	NC	NV	NV	NV	NV
Copper	NV	NV	NV	NV	NC	NV	NV	NV	NV
Dibenzofuran	NV	NV	0.031	0.036	2.0	NV	NV	0.0042	0.003
Total 10 of 16 HPAHs (U=1/2)	0.453	0.0888	0.0117	0.00348	6,674	41.06	29.36	5.2196	0.892
Total 16 PAHs (U=1/2)	0.453	0.0888	0.0117	0.00348	10,736	66.05	47.23	8.3965	1.435
Total 6 of 16 LPAHs (U=1/2)	0.229	0.0239	0.0289	0.0085	7,904	24.58	9.37	15.2554	2.580

Notes:

[a] Details on the identification of appropriate BSAFs are provided in Appendix J-5.

BSAF - biota-sediment accumulation factor

EPC - exposure point concentration

HPAHs - high-molecular-weight PAHs

LPAHs - low-molecular-weight PAHs

mg/kg - milligram(s) per kilogram

mg/kg OC - milligrams per kilogram organic carbon (normalized)

NC - not calculated--no BSAF available

NV - no BSAF or sediment chemistry value

PAHs - polynuclear aromatic hydrocarbons

Lipid values used for tissue EPC calculations are listed below and summarized in Appendix J-5.

Species Guild	Lipid Percent	Lipid Fraction
Freshwater Mollusc	1.358	0.01358
Freshwater Crustacean	4.956	0.04956
Mid-water-feeding Fish	6.676	0.06676
Bottom-feeding Fish	3.84	0.0384

Lipid data are taken from:
http://el.erdc.usace.army.mil/bsafnew/LipidOrgMean.dbw

Table 7.2-32
Dietary Fish Hazard Quotients

			Piscivorous Fish			Omnivorous Fish						Benthivore				
fraction of diet			**1**			**0.01**	**0.05**	**0.47**	**0.47**			**0.05**	**0.6**	**0.35**		
COPC	**Diet TRV - NOAEL mg/kg dw**	**Diet TRV - LOAEL mg/kg dw**	**C pelagic fish mg/kg dw; 60% water**	**NOAEL HQ**	**LOAEL HQ**	**C sed mg/kg dw Site-wide**	**C demersal fish mg/kg dw; 60% water**	**C crustacean mg/kg dw; 70% water**	**C mollusc mg/kg dw; 80% water**	**NOAEL HQ**	**LOAEL HQ**	**C sed mg/kg dw Site-wide**	**C crustacean mg/kg dw; 70% water**	**C mollusc mg/kg dw; 80% water**	**NOAEL HQ**	**LOAEL HQ**
Arsenic	20	30	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF
Benzo(a)pyrene	100	116	0.02	0.0002	0.0002	37.14	0.15	0.84	1.68	0.016	0.013	37.14	0.75	0.21	0.024	0.021
Chromium	9.42	47.1	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
Copper	50	100	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF	NBSAF
Dibenzofuran	--	--	0.011	NB	NB	0.4	NB	NB	NB	NB	NB	0.4	NB	NB	NB	NB
Total 10 of 16 HPAHs (U=1/2)	100	116	13.0	0.13	0.11	395.6	2.2	97.9	205.3	**1.5**	**1.3**	395.6	97.9	205.3	**1.5**	**1.3**
Total 16 PAHs (U=1/2)	324	951	21.0	0.06	0.02	611.8	3.6	157.4	330.2	0.73	0.25	611.8	157.4	330.2	0.74	0.25
Total 6 of 16 LPAHs (U=1/2)	324	951	38.1	0.12	0.04	417.8	6.4	31.2	122.9	0.24	0.081	417.8	31.2	122.9	0.26	0.087

Notes:
-- - No tissue TRV available.
C pelagic fish, C sed, C demersal fish, C crustacean, and C mollusc - concentrations of these tissues or sediment
COPC - chemical of potential concern
HPAH - high-molecular-weight PAHs
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
LPAH - low-molecular-weight PAHs
mg/kg dw - milligram(s) per kilogram dry weight
NB - not sediment-bioaccumulative
NBSAF - no biota-sediment accumulation factor for sediment bioaccumulative COPC
NOAEL - no observed adverse effects level
PAHs - polynuclear aromatic hydrocarbons; PAHs summarized via benzo(a)pyrene and PAH totals.
TRV - toxicity reference value
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
Moisture content based on EPA 1993 and professional judgment.

Table 7.2-33
Avian Toxicity Reference Values

Chemical	NOAEL						LOAEL			
	Source	Endpoint	Test Species	LD50 to NOAEL	LOAEL to NOAEL	NOAEL (mg/kg-day)	Source	LD50 to LOAEL	NOAEL to LOAEL	LOAEL (mg/kg-day)
2,4-Dimethylphenol	4-methylphenol	--	--	--	--	0.96	--	--	--	4.8
Arsenic	Eco-SSL (EPA 2005d); lowest NOAEL	Reproduction, growth, and survival	Chicken	--	--	2.24	Geomean of reported LOAELs (n=3) in Eco-SSL (EPA 2005b)	--	--	4.5
Benzene	--	--	--	--	--	NTRV	--	--	--	NTRV
Benzo(a)pyrene	LOAEL / 5	--	--	--	5	0.28	Hough et al. (1993); pigeon - reproduction	--	--	1.4
Chromium	Eco-SSL (EPA 2008c); geomean (n=12)	Reproduction and growth	Multiple	--	--	2.66	Geomean of reported reproduction and growth LOAELs (n=3) in Eco-SSL (EPA 2008c)	--	--	15.6
Copper	Eco-SSL (EPA 2007d); single value lower than lowest LOAEL	Reproduction, growth, and survival	Chicken	--	--	4.05	LOAEL from NOAEL study	--	--	12.1
Dibenzofuran	--	--	--	--	--	NTRV	--	--	--	NTRV
Ethylbenzene	--	--	--	--	--	NTRV	--	--	--	NTRV
Lead	Eco-SSL (EPA 2005e); single value lower than lowest LOAEL	Reproduction, growth, and survival	Chicken	--	--	1.63	LOAEL from NOAEL study	--	--	3.26
Pentachlorophenol	geomean of NOAELs (n=4); Eco-SSLs (EPA 2007e)	Growth and Survival (no repro. data avail.)	NA	--	--	40.7	Geomean of LOAELs in NOAEL dataset	--	--	52
Toluene	--	--	--	--	--	NTRV	--	--	--	NTRV
Total 10 of 16 HPAHs	Patton and Dieter (1980); Petroleum Hydrocarbon Mixtures	Growth	Mallard Duck	--	--	8	--	--	5	40
Total 6 of 16 LPAHs	Patton and Dieter (1980); Petroleum Hydrocarbon Mixtures	Growth	Mallard Duck	--	--	8	--	--	5	40
Total 16 PAHs	Patton and Dieter (1980); Petroleum Hydrocarbon Mixtures	Growth	Mallard Duck	--	--	8	--	--	5	40
Total PCBs	Britton and Huston (1973); Aroclor 1242	Reproduction	Chicken	--	--	0.29	--	--	--	0.58
Total Xylenes	Hill and Camardese (1986)	--	Japanese Quail	100	--	1.746	--	10	--	17.46

Notes:

HPAHs - high-molecular-weight PAHs
LD50 - lethal dose that causes death in 50 percent of a group of test animals
LOAEL - lowest observed adverse effects level
LPAHs - low-molecular-weight PAHs
mg/kg-day - milligram(s) per kilogram per day
n - number of samples
NOAEL - no observed adverse effects level
NTRV - no TRV available based on literature search
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls
SSL - soil screening level
TRV - toxicity reference value
-- No data available.

Endpoints evaluated including reproduction, growth, and survival unless otherwise noted in source.
PAHs to be assessed via benzo(a)pyrene and PAH totals.
Rationale for TRV selection summarized in Appendix J-9.
TRV selection was performed through review of EPA Ecological Soil Screening Level (Eco-SSL) reports, selected TRVs for regional risk assessments including the Lower Duwamish and Lower Willamette Rivers, and literature.

Table 7.2-34
Mammalian Toxicity Reference Values

Chemical	Source	Endpoint	Test Species	Test Species Body Weight (kg)	Subchronic to Chronic	LOAEL to NOAEL	NOAEL (mg/kg-day)	NOAEL to LOAEL	LOAEL (mg/kg-day)	Body Weight Adjusted TRVs											
										River Otter		Raccoon		Eastern Cottontail		Meadow Vole		Short-tailed Shrew		Coyote	
										8.55		6.5		1.22		0.0373		0.0168		10	
										NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
2,4-Dimethylphenol	2-methylphenol	--	--	0.35	--	--	5	--	15.0	2.25	6.75	2.41	7.23	3.66	11.0	8.75	26.3	10.7	32.0	2.16	6.49
Arsenic	Eco-SSL (EPA 2005b); highest bounded NOAEL lower than lowest bounded LOAEL	growth	dog	10	--	--	1.04	--	1.66	1.08	1.73	1.16	1.85	1.76	2.81	4.21	6.72	5.14	8.20	1.04	1.66
Benzene	Sample et al. 1996	reproduction	mouse	0.03	--	5	52.72	--	264	12.8	64.2	13.7	68.7	20.9	104	49.9	250	60.9	305	12.3	61.7
Benzo(a)pyrene	MacKenzie and Angevine 1981	reproduction	mouse	0.03	--	5	2	--	10	0.49	2.43	0.52	2.61	0.79	3.96	1.89	9.47	2.31	11.6	0.47	2.34
Chromium	Eco-SSL (EPA 2008c); geomean (n=9)	growth	rat, mouse, pig	33.46	--	--	2.4	5	12.0	3.38	16.9	3.62	18.1	5.49	27.5	13.1	65.7	16.0	80.2	3.2	16.2
Copper	Sample et al. 1996	--	mink	1	--	--	11.7	--	15.4	6.84	9.01	7.33	9.64	11.1	14.7	26.6	35.0	32.5	42.8	6.58	8.66
Dibenzofuran		--	--	--	--	--	NTRV	--	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV
Ethylbenzene	IRIS (EPA 2011c)	growth and survival	rat	0.35	--	--	9.71	--	29.1	4.37	13.1	4.68	14.0	7.11	21.3	17.0	50.9	20.7	62.2	4.20	12.6
Lead	Sample et al. 1996	--	rat	0.35	--	--	8	--	80.0	3.60	36.0	3.85	38.5	5.85	58.5	14.0	140	17.1	171	3.46	34.6
Pentachlorophenol	Eco-SSL (EPA 2007e); geomean	reproduction and growth	mouse and rat	0.19	--	--	8.42	5	42.1	3.25	16.3	3.48	17.4	5.29	26.4	12.6	63.2	15.4	77.2	3.13	15.6
Toluene	Sample et al. 1996	reproduction	mouse	0.03	--	5	52	--	260.00	12.7	63.3	13.6	67.8	20.6	103	49.2	246	60.1	301	12.2	60.8
Total 10 of 16 HPAHs	Eco-SSL (EPA 2007a); highest bounded NOAEL lower than lowest bounded LOAEL	survival	mouse	0.03	--	--	0.615	--	3.07	0.150	0.747	0.160	0.800	0.244	1.22	0.582	2.91	0.711	3.55	0.144	0.718
Total 16 PAHs	Total HPAHs	--	--	0.03	--	--	0.615	--	3.07	0.15	0.75	0.16	0.80	0.24	1.22	0.58	2.91	0.71	3.55	0.14	0.72
Total 6 of 16 LPAHs	Eco-SSL (EPA 2007a); highest bounded NOAEL lower than lowest bounded LOAEL	growth	rat	0.35	--	--	65.6	--	328	29.5	148	31.6	158	48.0	240	115	574	140	701	28.4	142
Total PCBs	Brunstrom et al. 2001	reproduction	mink	1.12	--	2	0.0445	--	0.09	0.03	0.05	0.03	0.06	0.04	0.09	0.10	0.21	0.13	0.25	0.03	0.05
Total Xylenes	Sample et al. 1996	reproduction	mouse	0.03	--	--	2.1	--	2.60	0.511	0.633	0.547	0.678	0.832	1.03	1.99	2.46	2.43	3.01	0.491	0.608
Zinc	Sample et al. 1996	--	rat	0.35	--	--	160	--	320	72	144	77	154	117	234	280	560	342	684	69.2	138

Table 7.2-34
Mammalian Toxicity Reference Values

Chemical	Source	Endpoint	Test Species	Test Species Body Weight (kg)	Subchronic to Chronic	LOAEL to NOAEL	NOAEL (mg/kg-day)	NOAEL to LOAEL	LOAEL (mg/kg-day)	Body Weight Adjusted TRVs											
										River Otter		Raccoon		Eastern Cottontail		Meadow Vole		Short-tailed Shrew		Coyote	
										8.55		6.5		1.22		0.0373		0.0168		10	
										NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL

Notes:

HPAHs - high-molecular-weight PAHs
LD50 - lethal dose that causes death in 50 percent of a group of test animals
LOAEL - lowest observed adverse effects level
LPAH - low-molecular-weight PAHs
mg/kg-day - milligram(s) per kilogram per day
n - number of samples
NOAEL - no observed adverse effects level
NTRV - no TRV available based on literature search
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls
TRV - toxicity reference value
-- - No data available.

Endpoints evaluated including reproduction, growth, and survival unless otherwise noted in source.
PAHs to be assessed via benzo(a)pyrene and PAH totals.
Rationale for TRV selection summarized in Appendix J-9.
TRV selection was performed through review of EPA Ecological Soil Screening Level (Eco-SSL) reports, selected TRVs for regional risk assessments including the Lower Duwamish and Lower Willamette Rovers, and literature.
A conversion based on body size (i.e., weight) was used to extrapolate between species for all mammalian TRVs. The body-weight-adjusted TRVs were calculated using the allometric equation described in Sample et al. (1996):

$TRV_{adj} = TRV_t (BW_t/BW_r)^{0.25}$

Where:
TRV_{adj} = Adjusted NOAEL-equivalent TRV (mg/kg body weight-day)
TRV_t = NOAEL-equivalent TRV for test organism (mg/kg body weight-day)
BW_t = Body weight for test organism (kg), and
BW_r = Body weight for receptor species (kg).

-- - No TRV available based on literature search.
Test species body weight reported from source study. If not reported in study, then body weights from Sample et al. (1996) or from summary source were used.

Table 7.2-35
Terrestrial Wildlife Total Dietary Intake Hazard Quotients

Ecological COPC	Soil COPC	Water COPC	Insectivorous Birds American Robin		Avian Predators Red-Tailed Hawk		Herbivorous Mammals Eastern Cottontail		Herbivorous Mammals Meadow Vole		Insectivorous Mammals Short-tailed Shrew		Omnivorous Mammals Raccoon		Carnivorous Mammals Coyote	
			NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
2,4-Dimethylphenol	Y	N	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	Y	Y	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzene	N	Y	NA	NA	NA	NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene	Y	Y	**110**	**4.2**	**65**	**2.5**	**9.0**	<1	**4.5**	<1	**22**	<1	**24**	<1	**1.12**	<1
Chromium	Y	N	<1	<1	**1.11**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper	N	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	Y	N	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV
Ethylbenzene	N	Y	NA	NA	NA	NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lead	Y	N	**11.9**	**1.3**	**17**	**2.1**	**1.11**	<1	<1	<1	**1.72**	<1	**2.0**	<1	<1	<1
Pentachlorophenol	Y	N	ND	<1	<1	<1	**4.5**	<1	**3.6**	<1	**4.3**	<1	**4.4**	<1	<1	<1
Toluene	N	Y	NA	NA	NA	NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total 10 of 16 HPAHs (U=1/2)	Y	N	**55**	**2.1**	**20**	<1	**264**	**10.5**	**136**	**5.5**	**1084**	**42**	**1101**	**38**	**32**	**1.2**
Total 16 PAHs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total 6 of 16 LPAHs (U=1/2)	Y	N	**21**	<1	**6.8**	<1	**3.6**	<1	**2.8**	<1	**2.1**	<1	**2.3**	<1	<1	<1
Total PCBs (U=1/2)	Y	N	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes (U=1/2)	N	Y	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total HQ with B[a]P for PAHs			**122**	**6.1**	**84**	**4.9**	**15**	<1	**8.7**	<1	**29**	**1.4**	**30**	**1.3**	**1.5**	<1
Total HQ with HPAHs for PAHs			**68**	**3.9**	**39**	**3.1**	**270**	**10.7**	**140**	**5.6**	**1090**	**42**	**1108**	**38**	**33**	**1.3**

Notes:
COPC - chemical of potential concern
NA - not a COPC for the media evaluated for this receptor.
No Data - Water COPCs were identified using groundwater, surface water and porewater. No data in exposure point dataset (surface water and porewater only).
NTRV - Toxicity data for COPC not available.
Xylenes summarized via total xylenes.
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

HPAHs - high-molecular-weight PAHs
LOAEL - lowest observed adverse effects level
LPAH - low-molecular-weight PAHs
NOAEL - no observed adverse effects level
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls

Table 7.2-36
Food Web Risk Calculations for Bald Eagle - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC 95% UCL (mg/kg) - Site-wide	DI_{sed}	EPC 95% UCL (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	EPC 95% UCL (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																	
Fraction Lipid (F_l)					**0.0384**			**0.067**										
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	NA	NA	NA	NA	NA
Arsenic	20.0	0.034	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.00004	0.034	2.24	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.017	0.001	0.001	NTRV	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	37.14	0.062	601.5	0.00256	0.059	0.002	0.0002	0.008	0.0008	0.00074	0.00003	0.065	0.28	<1	<1	<1	<1	<1
Chromium	44.0	0.074	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.074	2.66	NB	NB	<1	NA	<1
Copper	46.4	0.078	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.078	4.05	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005	0.0002	0.0002	NTRV	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.63	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.7	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.003	0.0001	0.0001	NTRV	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	396	0.665	6,674	0.00348	0.892	0.027	0.0117	5.238	0.471	NA	NA	1.163	8	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	612	1.028	10,736	0.00348	1.435	0.043	0.0117	8.427	0.758	NA	NA	1.829	8	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	418	0.702	7,904	0.0085	2.580	0.077	0.0289	15.310	1.378	NA	NA	2.157	8	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.29	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0002	0.0002	1.746	NA	NA	NA	<1	<1

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.450	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.250	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.750	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.000	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.000	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.143	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	3.750	= Body weight (kg wet weight)

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95% UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-37
Food Web Risk Calculations for Bald Eagle- Mean Exposure Concentration and LOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	EPC Mean (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Sediment	Water	Total
Fraction Moisture (FM)	0.3																	
Fraction Lipid (F_l)					0.0384			0.067										
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.8	NA	NA	NA	NA	NA
Arsenic	13.0	0.022	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.00004	0.022	4.5	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.026	0.0010	0.00100	NTRV	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	9.9	0.017	168.2	0.00256	0.017	0.0005	0.0002	0.002	0.0002	0.0003	0.00001	0.017	1.4	<1	<1	<1	<1	<1
Chromium	41.2	0.069	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.069	15.6	NB	NB	<1	NA	<1
Copper	39.7	0.067	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.067	12.1	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.009	0.0003	0.0003	NTRV	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.26	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0002	0.0002	NTRV	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	122.9	0.206	2,096	0.00348	0.280	0.008	0.0117	1.645	0.148	NA	NA	0.363	40	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	185.9	0.312	3,217	0.00348	0.430	0.013	0.0117	2.525	0.227	NA	NA	0.552	40	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	64.5	0.108	1,147	0.0085	0.374	0.011	0.0289	2.222	0.200	NA	NA	0.319	40	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.58	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0002	0.0002	17.46	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC Mean - Exposure Point Concentration based on the Mean
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.450	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.250	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.750	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.000	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.000	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.143	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	3.750	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-38
Food Web Risk Calculations for Otter - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Crustacean			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)						
Constituent	EPC 95% UCL (mg/kg) - Site-wide	DI_{sed}	EPC 95% UCL (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	BSAF (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_m	EPC 95% UCL (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Crustacean	Mollusc	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																									
Fraction Lipid (F_l)					**0.0384**			**0.067**			**0.04956**			**0.01358**												
COPC																										
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.25	NA	NA	NA	NA	NA	NA	NA
Arsenic	20.0	0.027	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.0001	0.027	1.08	NAF	NAF	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.017	0.001	0.001	12.83	NA	NA	NA	NA	NA	<1	<1
Benzo(a)pyrene	16.00	0.022	601.5	0.00256	0.059	0.003	0.0002	0.008	0.0002	0.008	0.252	0.002	0.041	0.337	0.002	0.0007	0.00006	0.030	0.49	<1	<1	<1	<1	<1	<1	<1
Chromium	43.3	0.059	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.059	3.38	NB	NB	NB	NB	<1	NA	<1
Copper	46.4	0.063	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.063	6.84	NAF	NAF	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005	0.000	0.000	4.37	NA	NA	NA	NA	NA	<1	<1
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.60	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.25	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.003	0.0003	0.0003	12.66	NA	NA	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	171	0.232	6,674	0.00348	0.892	0.052	0.0117	5.238	0.127	0.089	29.363	0.285	0.453	41.057	0.199	NA	NA	0.895	0.15	<1	<1	**1.9**	**1.3**	**1.5**	NA	**6**
Total 16 PAHs (U=1/2)	231	0.314	10,736	0.00348	1.435	0.084	0.0117	8.427	0.205	0.089	47.234	0.459	0.453	66.045	0.321	NA	NA	1.381	0.15	<1	**1.4**	**3.1**	**2.1**	**2.1**	NA	**9**
Total 6 of 16 LPAHs (U=1/2)	60	0.082	7,904	0.0085	2.580	0.150	0.0289	15.310	0.372	0.024	9.366	0.091	0.229	24.580	0.119	NA	NA	0.814	29.51	<1	<1	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	NA	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0005	0.0005	0.51	NA	NA	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.830	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis) = Concentration of chemical in sediment (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.600	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.250	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.100	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.050	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.683	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	8.550	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-39
Food Web Risk Calculations for Otter - Mean Exposure Concentrations and LOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Crustacean			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)						
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	BSAF (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_m	EPC Mean (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Crustacean	Mollusc	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																									
Fraction Lipid (F_l)					**0.0384**			**0.067**			**0.04956**			**0.01358**												
COPC																										
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.75	NA	NA	NA	NA	NA	NA	NA
Arsenic	13.0	0.018	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.000	0.0178	1.73	NAF	NAF	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.026	0.002	0.002	64.16	NA	NA	NA	NA	NA	<1	<1
Benzo(a)pyrene	3.2	0.004	168.2	0.00256	0.017	0.001	0.0002	0.002	0.0001	0.008	0.070	0.001	0.041	0.094	0.0005	0.0003	0.00002	0.007	2.43	<1	<1	<1	<1	<1	<1	<1
Chromium	41.2	0.056	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.056	16.88	NB	NB	NB	NB	<1	NA	<1
Copper	39.7	0.054	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.054	9.01	NAF	NAF	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.009	0.0007	0.0007	13.09	NA	NA	NA	NA	NA	<1	<1
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	35.98	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	16.25	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0005	0.0005	63.28	NA	NA	NA	NA	NA	<1	<1
Total 10 of 16 HPAHs (U=1/2)	31.8	0.043	2,096	0.00348	0.280	0.016	0.0117	1.645	0.040	0.089	9.222	0.090	0.453	12.894	0.063	NA	NA	0.252	0.75	<1	<1	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	44.2	0.060	3,217	0.00348	0.430	0.025	0.0117	2.525	0.061	0.089	14.153	0.137	0.453	19.790	0.096	NA	NA	0.380	0.75	<1	<1	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	12.4	0.017	1,147	0.0085	0.374	0.022	0.0289	2.222	0.054	0.024	1.359	0.013	0.229	3.567	0.017	NA	NA	0.123	147.54	<1	<1	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.05	NA	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0005	0.0005	0.63	NA	NA	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration based on the Mean
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.830	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.600	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.250	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.100	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.050	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.683	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	8.550	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-40
Food Web Risk Calculations for Spotted Sandpiper - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Crustacean			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	**EPC 95% UCL (mg/kg) - Site-wide**	**DI_{sed}**	**EPC 95% UCL (mg/kg OC) - Site-wide**	**BSAF (kg OC dw/ kg lipid ww)**	**Concentration (mg/kg ww)**	**DI_c**	**BSAF (kg OC dw/ kg lipid ww)**	**Estimated Concentration (mg/kg ww)**	**DI_m**	**EPC 95% UCL (mg/L)**	**DI_{sw}**	**Total Dietary Intake (mg/kg BW/day)**	**NOAEL TRV (mg/kg BW/day)**	**Crustacean**	**Mollusc**	**Sediment**	**Water**	**Total**
Fraction Moisture (FM)	**0.3**																	
Fraction Lipid (F_l)					**0.04956**			**0.01358**										
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	NA	NA	NA	NA	NA
Arsenic	20.0	1.62	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.0002	1.622	2.24	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.017	0.003	0.003	NTRV	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	37.14	3.01	601.5	0.008	0.252	0.130	0.041	0.337	0.043	0.0007	0.00012	3.184	0.28	<1	<1	**10.75**	<1	**11.37**
Chromium	44.0	3.57	NB	NB	NB	NB	NB	NB	NB	NA	NA	3.567	2.66	NB	NB	**1.34**	NA	**1.34**
Copper	46.4	3.76	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	3.762	4.05	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005	0.001	0.001	NTRV	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.63	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.7	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.003	0.0005	0.0005	NTRV	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	396	32.1	6,674	0.089	29.363	15.114	0.453	41.057	5.283	NA	NA	52.469	8	**1.89**	<1	**4.01**	NA	**6.56**
Total 16 PAHs (U=1/2)	612	49.6	10,736	0.089	47.234	24.313	0.453	66.045	8.499	NA	NA	82.410	8	**3.04**	**1.06**	**6.20**	NA	**10.30**
Total 6 of 16 LPAHs (U=1/2)	418	33.9	7,904	0.024	9.366	4.821	0.229	24.580	3.163	NA	NA	41.855	8	<1	<1	**4.23**	NA	**5.23**
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.29	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.001	0.0010	1.746	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.027	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.18	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.000	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.800	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.200	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.007	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.043	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-41
Food Web Risk Calculations for Spotted Sandpiper - Mean Exposure Concentrations and LOAEL Toxicity Values

	Sediment			Crustacean			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_m	EPC Mean (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Crustacean	Mollusc	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																	
Fraction Lipid (F_l)					**0.04956**			**0.01358**										
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.8	NA	NA	NA	NA	NA
Arsenic	13.0	1.1	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.0002	1.054	4.5	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.026	0.004	0.004	NTRV	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	9.9	0.8	168.2	0.008	0.070	0.036	0.041	0.094	0.012	0.0003	0.00004	0.852	1.4	<1	<1	<1	<1	<1
Chromium	41.2	3.3	NB	NB	NB	NB	NB	NB	NB	NA	NA	3.340	15.6	NB	NB	<1	NA	<1
Copper	39.7	3.2	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	3.215	12.1	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.009	0.001	0.001	NTRV	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.26	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0010	0.0010	NTRV	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	122.9	10.0	2,096	0.089	9.222	4.747	0.453	12.894	1.659	NA	NA	16.369	40	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	185.9	15.1	3,217	0.089	14.153	7.285	0.453	19.790	2.547	NA	NA	24.903	40	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	64.5	5.2	1,147	0.024	1.359	0.700	0.229	3.567	0.459	NA	NA	6.384	40	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.58	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0010	0.0010	17.46	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM)/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_w - Dietary intake from worms as (SUF(EPC_{sed}* BSAF)*FIR*PDF_w)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC Mean - Exposure Point Concentration based on the Mean
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.027	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.18	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.000	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.800	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.200	= Proportion of diet composed of mollusks (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.007	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.043	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-42
Food Web Risk Calculations for Mallard - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Crustacean			Aquatic Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC 95% UCL (mg/kg) - Site-wide	DI_{sed}	EPC UCL (mg/kg OC) - Site-wide	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	Aq Plant Water AF (kg/ kg ww)	Estimated Concentration (mg/kg ww)	DI_{ap}	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Crustacean	Aquatic Plant	Sediment	Water	Total
Fraction Moisture (FM)	0.3																	
Fraction Lipid (F_l)					0.04956													
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	NA	NA	NA	NA	NA
Arsenic	20.0	0.053	NAF	NAF	NAF	NAF	5.0	0.005	0.0005	0.001	0.00003	0.054	2.24	NAF	<1	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.017	0.0005	0.000	NTRV	NA	NAF	NA	NTRV	NA
Benzo(a)pyrene	37.14	0.099	601.5	0.008	0.252	0.003	5,258	3.912	0.405	0.0007	0.00002	0.506	0.28	<1	**1.45**	<1	<1	**1.81**
Chromium	44.0	0.117	NB	NB	NB	NB	NA	NA	NA	NA	NA	0.117	2.66	NB	NA	<1	NA	<1
Copper	46.4	0.123	NAF	NAF	NAF	NAF	NA	NA	NA	NA	NA	0.123	4.05	NAF	NA	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NA	NA	NA	NA	NA	--	NTRV	NB	NA	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.005	0.0001	0.0001	NTRV	NA	NAF	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.63	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.7	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.003	0.0001	0.0001	NTRV	NA	NAF	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	396	1.051	6,674	0.089	29.363	0.338	NA	NA	NA	NA	NA	1.389	8	<1	NA	<1	NA	<1
Total 16 PAHs (U=1/2)	612	1.625	10,736	0.089	47.234	0.543	NA	NA	NA	NA	NA	2.169	8	<1	NA	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	418	1.110	7,904	0.024	9.366	0.108	NA	NA	NA	NA	NA	1.218	8	<1	NA	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.29	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.006	0.0002	0.0002	1.746	NA	NAF	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM)/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site Use Factor
FIR =	0.267	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.033	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.000	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.100	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.900	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.065	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.161	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-43
Food Web Risk Calculations for Mallard - Mean Exposure Concentrations and LOAEL Toxicity Values

	Sediment			Crustacean			Aquatic Plant			Surface Water		TDI	TRV	HQ (TDI/TRV)				
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	Aq Plant Water AF (kg/ kg ww)	Estimated Concentration (mg/kg ww)	DI_{ap}	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Crustacean	Aquatic Plant	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																	
Fraction Lipid (F_l)					**0.04956**													
COPC																		
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.8	NA	NA	NA	NA	NA
Arsenic	13.0	0.035	NAF	NAF	NAF	NAF	5.0	0.005	0.0005	0.001	0.00003	0.035	4.5	NAF	<1	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.026	0.0007	0.0007	NTRV	NA	NAF	NA	NTRV	NA
Benzo(a)pyrene	9.9	0.026	168.2	0.008	0.070	0.001	5,258	1.315	0.136	0.0003	0.000007	0.163	1.4	<1	<1	<1	<1	<1
Chromium	41.2	0.109	NB	NB	NB	NB	NA	NA	NA	NA	NA	0.109	15.6	NB	NA	<1	NA	<1
Copper	39.7	0.105	NAF	NAF	NAF	NAF	NA	NA	NA	NA	NA	0.105	12.1	NAF	NA	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NA	NA	NA	NA	NA	--	NTRV	NB	NA	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.009	0.00024	0.0002	NTRV	NA	NAF	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.26	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.006	0.00017	0.00017	NTRV	NA	NAF	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	122.9	0.327	2,096	0.089	9.222	0.106	NA	NA	NA	NA	NA	0.433	40	<1	NA	<1	NA	<1
Total 16 PAHs (U=1/2)	185.9	0.494	3,217	0.089	14.153	0.163	NA	NA	NA	NA	NA	0.657	40	<1	NA	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	64.5	0.171	1,147	0.024	1.359	0.016	NA	NA	NA	NA	NA	0.187	40	<1	NA	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.58	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	0.006	0.0002	0.0002	17.46	NA	NAF	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.500	= Site Use Factor
FIR =	0.267	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.033	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.000	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.100	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.000	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.900	= Proportion of diet composed of aquatic plant (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.065	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	1.161	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-44
Food Web Risk Calculations for Lesser Scaup - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Demersal Fish			Crustacean			Aquatic Plant			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)						
Constituent	EPC 95% UCL (mg/kg) - Site-wide	DI_{sed}	EPC UCL (mg/kg OC) - Site-wide	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	Aq Plant Water AF (kg/ kg ww)	Estimated Concentration (mg/kg ww)	DI_{ap}	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_m	EPC UCL (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Demersal Fish	Crustacean	Aquatic Plant	Mollusc	Sediment	Water	Total
Fraction Moisture (FM)	0.3																									
Fraction Lipid (F_l)					0.0384			0.04956						0.01358												
COPC																										
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	NA	NA	NA	NA	NA	NA	NA
Arsenic	20.0	0.085	NAF	NAF	NAF	NAF	NAF	NAF	NAF	5.0	0.005	0.0002	NAF	NAF	NAF	0.001	0.00005	0.085	2.24	NAF	NAF	<1	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.017	0.001	0.001	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Benzo(a)pyrene	37.14	0.159	601.5	0.003	0.059	0.0009	0.008	0.008	0.008	5,258	3.912	0.119	0.041	0.337	0.010	0.0007	0.00004	0.178	0.28	<1	<1	<1	<1	<1	<1	**1.06**
Chromium	44.0	0.188	NB	NB	NB	NB	NB	NB	NB	NA	NA	NA	NB	NB	NB	NA	NA	0.188	2.66	NB	NB	NA	NB	<1	NA	<1
Copper	46.4	0.198	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	NA	NAF	NAF	NAF	NA	NA	0.198	4.05	NAF	NAF	NA	NAF	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NB	NB	NB	NA	NA	NA	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NA	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.005	0.0002	0.0002	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.63	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.7	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.003	0.0001	0.0001	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	396	1.690	6,674	0.003	0.892	0.014	0.089	0.089	0.089	NA	NA	NA	0.453	41.1	1.253	NA	NA	3.045	8	<1	<1	NA	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	612	2.614	10,736	0.003	1.435	0.022	0.089	0.089	0.089	NA	NA	NA	0.453	66.0	2.015	NA	NA	4.740	8	<1	<1	NA	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	418	1.785	7,904	0.009	2.580	0.039	0.024	0.024	0.024	NA	NA	NA	0.229	24.6	0.750	NA	NA	2.598	8	<1	<1	NA	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.29	NA	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.006	0.0003	0.0003	1.746	NA	NA	NAF	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.750	= Site Use Factor
FIR =	0.332	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.050	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.750	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.100	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.100	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.051	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.815	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-45
Food Web Risk Calculations for Lesser Scaup - Mean Exposure Concentrations and LOAEL Toxicity Value

	Sediment			Demersal Fish			Crustacean			Aquatic Plant			Mollusc			Surface Water		TDI	TRV	HQ (TDI/TRV)						
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	Aq Plant Water AF (kg/ kg ww)	Estimated Concentration (mg/kg ww)	DI_{ap}	BSAF 95 UCL (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_m	EPC Mean (mg/L)	DI_{water}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Demersal Fish	Crustacean	Aquatic Plant	Mollusc	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																									
Fraction Lipid (F_l)					**0.0384**			**0.04956**						**0.01358**												
COPC																										
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.8	NA	NA	NA	NA	NA	NA	NA
Arsenic	13.0	0.06	NAF	NAF	NAF	NAF	NAF	NAF	NAF	5.0	0.005	0.0002	NAF	NAF	NAF	0.001	0.00005	0.056	4.5	NAF	NAF	<1	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.026	0.001	0.001	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Benzo(a)pyrene	9.9	0.04	168.2	0.003	0.017	0.0003	0.008	0.070	0.016	5,258	1.315	0.040	0.041	0.094	0.003	0.0003	0.00001	0.062	1.4	<1	<1	<1	<1	<1	<1	<1
Chromium	41.2	0.18	NB	NB	NB	NB	NB	NB	NB	NA	NA	NA	NB	NB	NB	NA	NA	0.176	15.6	NB	NB	NA	NB	<1	NA	<1
Copper	39.7	0.17	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	NA	NAF	NAF	NAF	NA	NA	0.169	12.1	NAF	NAF	NA	NAF	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NB	NB	NB	NA	NA	NA	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NA	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.009	0.0004	0.0004	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.3	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52.0	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.006	0.0003	0.0003	NTRV	NA	NA	NAF	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	122.9	0.53	2,096	0.003	0.280	0.00427364	0.089	9.222	2.111	NA	NA	NA	0.453	12.894	0.393	NA	NA	3.033	40.0	<1	<1	NA	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	185.9	0.79	3,217	0.003	0.430	0.0065593	0.089	14.153	3.239	NA	NA	NA	0.453	19.790	0.604	NA	NA	4.644	40.0	<1	<1	NA	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	64.5	0.28	1,147	0.009	0.374	0.00571228	0.024	1.359	0.311	NA	NA	NA	0.229	3.567	0.109	NA	NA	0.701	40.0	<1	<1	NA	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.6	NA	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NAF	NAF	NAF	NA	NA	NA	0.006	0.0003	0.0003	17.5	NA	NA	NAF	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	0.750	= Site Use Factor
FIR =	0.332	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.050	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.000	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.750	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.100	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.100	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.051	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	0.815	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-46
Food Web Risk Calculations for Great Blue Heron - 95 UCL Exposure Concentrations and NOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Crustacean			Surface Water		TDI	TRV	HQ (TDI/TRV)					
Constituent	EPC 95% UCL (mg/kg) - Site-wide	DI_{sed}	EPC 95% UCL (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	BSAF (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	EPC 95% UCL (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	NOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Crustacean	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																					
Fraction Lipid (F_l)					**0.0384**			**0.067**			**0.04956**											
COPC																						
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	NA	NA	NA	NA	NA	NA
Arsenic	20.0	0.089	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.001	0.00004	0.089	2.24	NAF	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.017	0.001	0.001	NTRV	NA	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	37.14	0.166	601.5	0.003	0.059	0.014	0.0002	0.008	0.0005	0.008	0.252	0.004	0.0007	0.00003	0.185	0.28	<1	<1	<1	<1	<1	<1
Chromium	44.0	0.197	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.197	2.66	NB	NB	NB	<1	NA	<1
Copper	46.4	0.207	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.207	4.05	NAF	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	2.015	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005	0.0002	0.0002	NTRV	NA	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.63	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40.7	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.003	0.0001	0.0001	NTRV	NA	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	396	1.767	6,674	0.003	0.892	0.213	0.012	5.238	0.334	0.089	29.363	0.468	NA	NA	2.783	8	<1	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	612	2.733	10,736	0.003	1.435	0.343	0.012	8.427	0.538	0.089	47.234	0.753	NA	NA	4.367	8	<1	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	418	1.866	7,904	0.009	2.580	0.617	0.029	15.310	0.977	0.024	9.366	0.149	NA	NA	3.610	8	<1	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.29	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.0003	0.0003	1.746	NA	NA	NA	NA	<1	<1

Notes:

-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.745	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.750	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.200	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.050	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.000	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.104	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	2.336	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
NOAEL - no observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-47
Food Web Risk Calculations for Great Blue Heron - Mean Exposure Concentrations and LOAEL Toxicity Values

	Sediment			Demersal Fish			Pelagic Fish			Crustacean			Surface Water		TDI	TRV	HQ (TDI/TRV)					
Constituent	EPC Mean (mg/kg) - Site-wide	DI_{sed}	EPC Mean (mg/kg OC) - Site-wide	BSAF (kg OC dw/ kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{df}	BSAF (kg OC dw / kg lipid ww)	Estimated Concentration (mg/kg ww)	DI_{pf}	BSAF (kg OC dw/ kg lipid ww)	Concentration (mg/kg ww)	DI_c	EPC Mean (mg/L)	DI_{sw}	Total Dietary Intake (mg/kg BW/day)	LOAEL TRV (mg/kg BW/day)	Demersal Fish	Pelagic Fish	Crustacean	Sediment	Water	Total
Fraction Moisture (FM)	**0.3**																					
Fraction Lipid (F_l)					**0.0384**			**0.067**			**0.04956**											
COPC																						
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.8	NA	NA	NA	NA	NA	NA
Arsenic	13.0	0.058	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	0.0010	0.00004	0.058	4.5	NAF	NAF	NAF	<1	<1	<1
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.026	0.0012	0.0012	NTRV	NA	NA	NA	NA	NTRV	NA
Benzo(a)pyrene	9.9	0.044	168.2	0.003	0.017	0.004	0.0002	0.002	0.0002	0.008	0.070	0.001	0.0003	0.000011	0.050	1.4	<1	<1	<1	<1	<1	<1
Chromium	41.2	0.184	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	0.184	15.6	NB	NB	NB	<1	NA	<1
Copper	39.7	0.177	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NAF	NA	NA	0.177	12.1	NAF	NAF	NAF	<1	NA	<1
Dibenzofuran	--	--	1.624	NB	NB	NB	NB	NB	NB	NB	NB	NB	NA	NA	--	NTRV	NB	NB	NB	--	NA	--
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.009	0.0004	0.0004	NTRV	NA	NA	NA	NA	NTRV	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.26	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.00028	0.00028	NTRV	NA	NA	NA	NA	NTRV	NA
Total 10 of 16 HPAHs (U=1/2)	122.9	0.549	2,096	0.003	0.280	0.067	0.012	1.645	0.105	0.089	9.222	0.147	NA	NA	0.868	40	<1	<1	<1	<1	NA	<1
Total 16 PAHs (U=1/2)	185.9	0.830	3,217	0.003	0.430	0.103	0.012	2.525	0.161	0.089	14.153	0.226	NA	NA	1.320	40	<1	<1	<1	<1	NA	<1
Total 6 of 16 LPAHs (U=1/2)	64.5	0.288	1,147	0.009	0.374	0.090	0.029	2.222	0.142	0.024	1.359	0.022	NA	NA	0.541	40	<1	<1	<1	<1	NA	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.58	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.006	0.00026	0.00026	17.46	NA	NA	NA	NA	<1	<1

Notes:
-- - No COPC data in exposure dataset
BSAF - Biota-Sediment Accumulation Factor (Sediment mg/kg OC dw divided by Tissue mg/kg lipid ww)
DI_{sed} - Dietary intake from sediment calculated as((SUF*(EPC_{sed}*FIR*PDS))*(1-FM))/BW
DI_{df} - Dietary intake from demersal fish as (SUF*(EPC_{sed}* BSAF)*FIR*PDF_{df})/BW
DI_{pf} - Dietary intake from pelagic fish as (SUF(EPC_{sed}* BSAF)*FIR*PDF_{pf})/BW
DI_c - Dietary intake from crustaceans as (SUF(EPC_{sed}* BSAF)*FIR*PDF_c)/BW
DI_m - Dietary intake from molluscs as (SUF(EPC_{sed}* BSAF)*FIR*PDF_m)/BW
DI_{ap} - Dietary intake from aquatic plants as (SUF(EPC_{sed}* BsAF)*FIR*PDF_{ap})/BW
DI_{water} - Dietary intake from water calculated as (SUF*(EPCwater*WIR))/BW
EPC 95UCL - Exposure Point Concentration 95% Upper Confidence Limit on the Mean as determined by ProUCL
NA - Not COPC in medium
NAF - No BSAF for sediment bioaccumulative COPC or water accumulation factor for aquatic plants
NB - Not a sediment bioaccumulative
NTRV - Toxicity data for COPC not available
OC - Organic Carbon
PAHs - Polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - Polychlorinated biphenyls
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10
mg/kg ww - milligram per kilogram wet weight
mg/kg BW/day - milligram per kilogram of body weight per day
mg/kg dw - milligram per kilogram dry weight
U=1/2 - Non-detects included at 1/2 the method detection limit.

$$TDI_x = \frac{SUF * \left[\left[\sum_i (FIR)(FC_{xi})(PDF_i)\right] + (WIR)(WC_x) + (FIR)(SC_x)(PDS)\right]}{BW}$$

TDI_x =	Chemical-specific	= Dietary intake for chemical (mg chemical/kg body weight/day)
SUF =	1.000	= Site Use Factor
FIR =	0.745	= Food ingestion rate (kg/day wet weight)
FC_{xi} =	Chemical-specific	= Concentration of chemical in food item (wet weight basis)
PDS =	0.02	= Proportion of diet composed of sediment, in addition to diet dry weight basis)
PDF_{df} =	0.750	= Proportion of diet composed of demersal fish (wet weight basis)
PDF_{pf} =	0.200	= Proportion of diet composed of pelagic fish (wet weight basis)
PDF_c =	0.050	= Proportion of diet composed of crustaceans (wet weight basis)
PDF_m =	0.000	= Proportion of diet composed of molluscs (wet weight basis)
PDF_{ap} =	0.000	= Proportion of diet composed of aquatic plants (wet weight basis)
SC_x =	Chemical-specific	= Concentration of chemical in sediment (wet weight basis)
WIR =	0.104	= Water ingestion rate (L/day)
WC_x =	Chemical-specific	= Concentration of chemical in water (mg/L)
BW =	2.336	= Body weight (kg wet weight)

Fraction lipid from BSAF source.
PAHs summarized via benzo(a)pyrene and PAH totals.
COPC - chemical of potential concern
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
TDI - total dietary intake
TRV - toxicity reference value

Table 7.2-48
Aquatic-Dependent Wildlife Total Dietary Intake Hazard Quotients

Ecological COPC	Piscivorous Raptors Bald Eagle		Piscivorous Mammals River Otter		Sediment-probing Birds Spotted Sandpiper		Dabbling Ducks Mallard		Diving Ducks Lesser Scaup		Shore Birds Great Blue Heron	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzene	NA	NA	<1	<1	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	<1	<1	<1	<1	**11**	<1	**1.8**	<1	**1.1**	<1	<1	<1
Chromium	<1	<1	<1	<1	**1.3**	<1	<1	<1	<1	<1	<1	<1
Copper	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	NA	NA	<1	<1	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	<1	<1	NA	NA	NA	NA	NA	NA	NA	NA
Total 10 of 16 HPAHs (U=1/2)	<1	<1	**6**	<1	**7**	<1	<1	<1	<1	<1	<1	<1
Total 16 PAHs (U=1/2)	<1	<1	**9**	<1	**10**	<1	<1	<1	<1	<1	<1	<1
Total 6 of 16 LPAHs (U=1/2)	<1	<1	<1	<1	**5.2**	<1	<1	<1	<1	<1	<1	<1
Total PCBs (U=1/2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Xylenes (U=1/2)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total HQ with B[a]P for PAHs	<1	<1	<1	<1	**14**	**1.3**	**1.9**	<1	**1.2**	<1	<1	<1
Total HQ with HPAHs for PAHs	<1	<1	**6**	<1	**10**	**1.1**	<1	<1	<1	<1	<1	<1

Notes:

NA - Not a COPC for exposure media evaluated for receptor.
PAHs summarized via benzo(a)pyrene and PAH totals.
Xylenes summarized via total xylenes.
-- - No COPC data in exposure dataset.
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

COPC - chemical of potential concern
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
PAHs - polynuclear aromatic hydrocarbons; HPAHs/LPAHs - high-/low-molecular-weight PAHs
PCBs - polychlorinated biphenyls

U=1/2 - Non-detects included at 1/2 the method detection limit.

Table 7.2-49
Summary of Hazard Estimates for Ecological Receptors

	Terrestrial Receptors						Aquatic-Dependent Receptors				
	Bulk Soil Screening HQs				TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)		Surface Water Screening HQs		Fish Diet LOAEL HQs	TDI Assessment NOAEL HQs (Maximum HQs for Birds and Mammals)	
Ecological COPC	**Plant**	**Invert.**	**Avian**	**Mammal**	**Robin**	**Racoon**	**Aq. Plant**	**Fish**	**Benthivore**	**Sandpiper**	**Otter**
2,4-Dimethylphenol	NTRV	NTRV	NTRV	NTRV	<1	<1	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
2-Methylnaphthalene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**1**	<1	PAHs	PAHs	PAHs
Acenaphthene	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	**1.6**	<1	PAHs	PAHs	PAHs
Acenaphthylene	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	PAHs	PAHs	PAHs
Anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**42**	**14**	PAHs	PAHs	PAHs
Arsenic	<1	NTRV	<1	<1	<1	<1	<1	<1	NBSAF	<1	<1
Benzene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	<1	<1	NCOPC	NCOPC	<1
Benzo(a)anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**15**	**11.1**	PAHs	PAHs	PAHs
Benzo(a)pyrene	NTRV	NTRV	NTRV	NTRV	**110**	**24**	**50**	**53**	<1	**11**	<1
Benzo(b)fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	<1	NCOPC	PAHs	PAHs
Benzo(g,h,i)perylene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NCOPC	NCOPC	PAHs	PAHs	PAHs
Benzo(k)fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	NCOPC	PAHs	PAHs
Chromium	NTRV	NTRV	**2.2**	**1.7**	<1	<1	NCOPC	NCOPC	NB	**1.3**	--
Chrysene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	PAHs	PAHs	PAHs
Copper	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NBSAF	<1	--
Dibenz(a,h)anthracene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	NTRV	PAHs	PAHs	PAHs
Dibenzofuran	NTRV	NTRV	NTRV	NTRV	NTRV	NTRV	NCOPC	NCOPC	NB	--	--
Ethylbenzene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	<1	<1	NCOPC	NCOPC	<1
Fluoranthene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**49**	**1.03**	PAHs	PAHs	PAHs
Fluorene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**1.7**	<1	PAHs	PAHs	PAHs
Indeno(1,2,3-c,d)pyrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	NTRV	<1	PAHs	PAHs	PAHs
Lead	**5.3**	<1	**58**	**11.4**	**11.9**	**2.00**	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
m,p-Xylene	NCOPC	NCOPC	NCOPC	NCOPC	Xylenes	Xylenes	Xylenes	Xylenes	NCOPC	Xylenes	Xylenes
Naphthalene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**123**	**10.4**	PAHs	PAHs	PAHs
Pentachlorophenol	--	--	**34**	**25**	ND	**4.4**	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
Phenanthrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**13**	**1.4**	PAHs	PAHs	PAHs
Pyrene	PAHs	PAHs	PAHs	PAHs	PAHs	PAHs	**62**	**5.2**	PAHs	PAHs	PAHs
Toluene	NCOPC	NCOPC	NCOPC	NCOPC	NTRV	<1	**1.6**	<1	NCOPC	NCOPC	<1
Total 10 of 16 HPAHs (U=1/2)	NTRV	**226**	NTRV	**3,692**	**55**	**1101**	NCOPC	NCOPC	**1.3**	**7**	**6**
Total 16 PAHs(U=1/2)	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	<1	**10**	**9**
Total 6 of 16 LPAHs (U=1/2)	NTRV	**47**	NTRV	**14**	**21**	**2.3**	NCOPC	NCOPC	<1	**5.2**	<1
Total PCBs (U=1/2)	NTRV	NTRV	NTRV	NTRV	<1	<1	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC
Total Xylenes (U=1/2)	NCOPC	NCOPC	NCOPC	NCOPC	<1	<1	<1	<1	NCOPC	<1	<1
PAH ESBQ TUs	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	NCOPC	**26.5**	NCOPC	NCOPC	NCOPC

Notes:

-- - No COPC data in exposure dataset.
COPC - chemical of potential concern
ESBQ TUs - equilibrium partitioning sediment benchmark quotient toxic units
HPAHs - high-molecular-weight PAHs
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
LPAHs - low-molecular-weight PAHs
NB - Not sediment-bioaccumulative; NBSAF - no BSAF available.
Boldface without highlighting = HQ greater than 1
Boldface with highlighting = HQ greater than 10

NCOPC - Not a COPC for exposure media evaluated for receptor.
NOAEL - no observed adverse effects level
NTRV - No tissue TRV available.
PAHs - polynuclear aromatic hydrocarbons
PAHs summarized via benzo(a)pyrene and PAH totals.
PCBs - polychlorinated biphenyls
TDI - total dietary intake
TRV - toxicity reference value
Xylenes summarized via total xylenes.
U=1/2 - Non-detects included at 1/2 the method detection limit.

Table 7.2-50
Summary of Lines of Evidence, Baseline Ecological Risk Assessment

Ecological Receptor Group	Line(s) of Evidence	Weight	Risk Characterization Summary	Uncertainty
Soil Invertebrates and Terrestrial Plants	Comparison of Site data with soil screening values for single chemicals or chemical groups	Primary	Lead exceeds the plant Eco-SSL; HPAHsand LPAHs exceed the invertebrate Eco-SSL.	High uncertainty because of lack of Site-specificity. Future remediation will require a soil cap; therefore, uncertainty is acceptable and estimates are conservative.
Terrestrial Birds and Mammals	Multi-media exposure model calculations and comparisons with single-chemical toxicity data	Primary	LOAEL HQs >1 for at least one chemical or chemical group for each receptor. Highest HQs for HPAHs for the short-tailed shrew and the raccoon.	Moderate conservative uncertainty in models. More Site-specificity than Eco-SSLs.
	Comparison of Site data with soil screening values for single chemicals or chemical groups	Secondary	Chromium, lead, and pentachlorophenol exceeded the avian Eco-SSLs. Chromium, lead, pentachlorophenol, HPAHs, and LPAHs exceeded the mammal Eco-SSLs. HPAHs had the highest HQ, consistent with the primary line of evidence.	Higher uncertainty than multi-media model because of lack of Site-specificity. Results from this line of evidence support the primary line of evidence.
Aquatic Macrophytes	Comparison of Site data with surface water screening values for single chemicals or chemical groups	Primary	Individual PAHs HQs (including naphthalene) and PAH ESBQ TU >1.	Moderate uncertainty due to generic nature of screening levels; however, the overall risk to aquatic macrophytes was reasonably addressed with the PAH ESB approach.
Benthic Invertebrates	Site-specific sediment bioassays using amphipods and midges with Site and statistical comparisons with reference sediment tests	Primary	Midge and amphipod bioassay results indicate toxicity in samples associated with elevated hydrocarbons.	Because bioassays are a direct measure of toxicity, this line of evidence is primary.
	Comparison of Site data with porewater screening values or benchmarks for single chemicals or chemical groups	Secondary	Sediment porewater PAH ESBQ TU values were elevated in areas associated with hydrocarbon releases. Toxicity was observed where porewater TU values were greatest, corroborating the primary line of evidence.	Because sediment porewater is a direct measure of exposure to benthos, this line of evidence is secondary. Results from this line of evidence support the primary line of evidence.
	Comparison of Site data with bulk sediment screening values or benchmarks for single chemicals or chemical groups	Tertiary	Bulk sediment PAH ESBQ TU values were elevated in areas associated with hydrocarbon releases. Toxicity was observed where bulk sediment TU values were greatest, corroborating the primary line of evidence.	Because bulk sediment is an indirect measure of exposure to benthos, this line of evidence is tertiary. Results from this line of evidence support the primary line of evidence.
Fish and Shellfish	Comparison of Site data with surface water and sediment porewater screening values or benchmarks for single chemicals or chemical groups	Primary	Individual PAHs HQs (including naphthalene) and PAH ESBQ TU >1.	Because surface water and porewater are direct measures of exposure to fish and shellfish, this line of evidence is primary.
	Dietary exposure model calculations and comparisons with single-chemical toxicity data	Secondary	Only one LOAEL (HPAH) HQ>1.	Dietary exposure models for PAHs and fish are highly uncertain given the lack of Site-specific data.
	Modeled tissue residue values for single chemicals or chemical groups	Tertiary	Risk was not characterized for this line of evidence.	Because PAHs are metabolized and there are a paucity of effects data, this line of evidence could not be evaluated.
Aquatic-dependent Birds and Mammals	Multi-media exposure model calculations and single-chemical toxicity data	Primary	LOAEL HQs >1 only for spotted sandpiper. Highest NOAEL HQs were for PAHs for the river otter and spotted sandpiper. Bald Eagle and great blue heron NOAEL HQs <1.	Moderately conservative uncertainty in models. This is the sole line of evidence for these receptors.

Notes:

Eco-SSL - Ecological Soil Screening Level
ESBQ TUs - equilibrium partitioning sediment benchmark quotient toxic units
HPAHs - high-molecular-weight PAHs
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
LPAHs - low-molecular-weight PAHs
NOAEL - no observed adverse effects level
PAHs - polynuclear aromatic hydrocarbons

Table 7.2-51
Uncertainty Analysis for the Ecological Risk Assessment

Parameter	Level of Uncertainty[a]	Effect on Risk Estimate	Alternative Parameter Basis to Reduce Uncertainty	Effect of Alternative Parameter on Risk Estimate[b]	Quantified?	Comment
Dataset and COPC Screening						
Inclusion of COPCs based on non-detect data.	Low	May overestimate exposure to and risk from chemicals that are not actually at the Site.	Achieve lower detection limits.	Low	N	No comment.
Inclusion of Indicator chemicals based on QA1 quality data in some exposure point datasets for selected chemicals in surface soil and surface sediment.	High	May overestimate or underestimate actual risk from COPCs with QA1 quality data. Likely has no impact on overall risk decisions for the Site.	Add QA2 quality data for COPCs with only QA1 quality data.	Medium	N	Data of QA2 quality are available for chemicals associated with coal tar and creosote, which are associated with the highest risk estimates; therefore, the inclusion of QA1 data provides additional conservatism.
Exposure and Effects Assessments						
All Receptors						
Use of UCL for NOAEL EPC.	Low - Medium	May overestimate actual EPCs.	Unknown.	Medium	N	UCLs are an estimate of the upper bound of the arithmetic mean of a population. With the inclusion of target "hot spot" areas in the risk dataset, the EPC is likely overestimated using a UCL. The LOAEL evaluation provides the bound for likely estimates of population means.
Application of safety factor to derive NOAEL or LOAEL TRV.	Medium	May overestimate or underestimate actual risk.	Unknown.	na	N	NOAEL/LOAEL safety factors were used for certain PAHs, PCP, benzene, toluene, and PCBs. Because PAHs, PCP and benzene are indicator chemicals and NOAEL risks were identified, risks were not likely underestimated.
Assumption that field bioavailability equals test bioavailability for use of TRVs.	Medium	May overestimate actual risks of COPCs that are not as bioavailable at the Site.	Perform Site-specific bioavailability tests.	Low	N	It is unlikely that collection of Site-specific bioavailability data would lead to different risk decisions.
Lack of effects screening values for some COPCs in some pathways.	High	Exclusion of some chemicals from quantitative evaluation may result in some underestimation of risk at the Site.	Unknown.	Low	N	Most of the site contamination was derived from coal tar and creosote sources associated with historical facility operations. Toxicity values for many of the key chemicals associated with these sources are readily available.
Terrestrial Receptors						
Assumption of SUF of 1 for most receptors.	Medium	May overestimate actual risks for receptors that do not spend 100% of their time at the Site.	Reduce SUF for certain receptors unlikely to spend 100% of their time at the Site.	Medium	N	Though individual risks for certain receptors would decrease through a reduction in SUF, risk decisions will be driven by other receptors and human health risks.
Dietary fractions were based on professional judgment and EPA 1993 (Wildlife Exposure Factors Handbook).	Medium	May overestimate or underestimate risk for receptors with a lower or greater fraction of a particular prey item than assumed.	Modify dietary fractions using additional Site information.	Medium	N	Dietary fractions developed to be a conservative representation of a particular feeding guild.

Table 7.2-51
Uncertainty Analysis for the Ecological Risk Assessment

Parameter	Level of Uncertainty[a]	Effect on Risk Estimate	Alternative Parameter Basis to Reduce Uncertainty	Effect of Alternative Parameter on Risk Estimate[b]	Quantified?	Comment
Aquatic-Dependent Receptors - Benthic Macroinvertebrates						
Effect of non-detects on PAH ESBQ estimates.	High	May overestimate risk especially in samples with low frequency of detection (such as background samples or those collected further from the former T-Dock).	Use regression-on-order (ROS) statistics to evaluate the impact of detection limits (and inclusion of non-detected data) on PAH ESBQ estimates.	Low	Y	Use of ROS-estimated detection limits did not change the interpretation of sediment porewater relative to the U=0 calculation.
Sediment toxicity test.	Low	May overestimate or underestimate risk for receptors due to manipulation of sediment in laboratory.	Unknown.	Low	Y	The area of potential benthic impacts is corroborated by both toxicity tests and PAH ESBQ toxic units calculated from bulk sediment and porewater measurements.
Aquatic-Dependent Receptors - Fish						
Dilution factor of 10 used to model surface water from porewater.	High	May overestimate risk from COPCs in surface water based on porewater data.	Develop a Site-specific dilution model based on the range of groundwater flow velocities, interface exchange coefficients, and lake dispersion factors measured at the Site and in other areas of Lake Washington.	Low	N	Because surface water exposure is small in comparison to other ecological pathways, this uncertainty has little effect on the overall baseline risk estimates.
No tissue-residue HQs quantified due to lack of PAH TRVs.	Low	PAHs are the only sediment COPCs identified as bioaccumulatives with BSAFs.	Unknown.	Low	N	Because fish readily metabolize PAHs and tissue-residue TRVs were therefore not derived, no adverse risk to fish from tissue residue is expected.
Dietary fractions were based on professional judgment and EPA 1993 (Wildlife Exposure Factors Handbook).	Medium	May overestimate or underestimate risk for receptors with a lower or greater fraction of a particular prey item than assumed.	Modify dietary fractions using additional Site information.	Low	N	Dietary fractions developed to be a conservative representation of a particular feeding guild. No significant risks were identified using the conservative SUF of 1.
Assumption of SUF of 1 for most receptors.	Medium	May overestimate risks for fish that do not spend 100% of their time exposed to Site sediment.	Reduce SUF for certain receptors unlikely to spend 100% of their time at the site.	Low	N	No significant risks were identified using the conservative SUF of 1.
Fish and shellfish BSAFs for PAHs.	Medium	May overestimate or underestimate actual concentrations of Site tissue.	Collect Site-specific data.	Low	N	It is unlikely that collection of Site tissue data would lead to different risk decisions.
Lack of BSAFs for bioaccumulative COPCs (arsenic and copper).	High	May underestimate Site risks to sediment bioaccumulative COPCs.	Derive BSAFs using other literature source(s) or collect Site-specific tissue data.	Low	N	It is unlikely that collection of Site tissue data would lead to different risk decisions.
Aquatic-Dependent Receptors - Wildlife						
Assumption of SUF of 1 for most receptors.	Medium	May overestimate actual risks for receptors that do not spend 100% of their time at the Site.	Reduce SUF for certain receptors unlikely to spend 100% of their time at the Site.	Medium	N	Though individual risks for certain receptors would decrease through a reduction in SUF, risk decisions will be driven by other receptors and human health risks.

Table 7.2-51
Uncertainty Analysis for the Ecological Risk Assessment

Parameter	Level of Uncertainty[a]	Effect on Risk Estimate	Alternative Parameter Basis to Reduce Uncertainty	Effect of Alternative Parameter on Risk Estimate[b]	Quantified?	Comment
Dietary fractions were based on professional judgment and EPA 1993 (Wildlife Exposure Factors Handbook).	Medium	May overestimate or underestimate risk for receptors with a lower or greater fraction of a particular prey item than assumed.	Modify dietary fractions using additional Site information.	Medium	N	Dietary fractions developed to be a conservative representation of a particular feeding guild.
Use of EPA 1999 aquatic plant bioconcentration factors (BCFs) for dissolved fractions.	Medium	May overestimate actual risks to receptors consuming aquatic plants by overpredicting concentrations in aquatic plant tissue. BCFs in EPA 1999 reported in dissolved fraction, most Site data reported in total fraction.	Unknown.	Low	N	Risks from surface water exposure insignificant.
Assumption of moisture content of Site sediments for calculation of sediment ingestion risks.	High	Conservative assumptions based on EPA's WEFH (EPA 1993b) and professional judgment. Assumption appears to overestimate exposures to COPCs for sediment (assumed 30% moisture) when compared to Site total solids content data.	Use Site-specific estimate. The average moisture content (as calculated as 100% – % total solids) for Site sediment samples of QA2 quality is 65% moisture.	Medium	Y	For the river otter, sediment ingestion HQs were recalculated based on a moisture content of 65% and the HQs were reduced by approximately one-half, although some COPCs still exceed 1 for NOAEL estimates.
Fish and shellfish BSAFs for PAHs.	Medium	May overestimate or underestimate actual concentrations of Site tissue because of the extrapolation from laboratory data or from other Site investigation data.	Collect Site-specific data.	Low	N	It is unlikely that collection of Site tissue data would lead to different risk decisions.
Lack of BSAFs for bioaccumulative COPCs (arsenic and copper).	High	May underestimate Site risks to sediment bioaccumulative COPCs.	Derive BSAFs using other literature source or collect Site-specific tissue data.	Low	N	It is unlikely that collection of Site tissue data would lead to different risk decisions.

Notes:

[a]Level of uncertainty based on the dataset size, quality, representativeness, or Site-specificity.

[b]Effect of alternative parameter on risk estimates based on the likelihood to affect threshold exceedances, pathway identification, and/or risk management decisions.

BCF - bioconcentration factor
BSAF - biota-sediment accumulation factor
COI - chemical of interest
COPC - chemical of potential concern
EPC - exposure point concentration
ESBQ - equilibrium partitioning sediment benchmark quotient
HQ - hazard quotient
LOAEL - lowest observed apparent effects level
NOAEL - no observed apparent effects level
PAH(s) - polynuclear aromatic hydrocarbon(s)
PCBs - polychlorinated biphenyls
PCP - pentachlorophenol
ROS - regression on order statistics
SUF - site use factor
TRV - toxicity reference value
UCL - upper confidence limit
WEFH - Wildlife Exposure Factors Handbook