Supplemental Remedial Investigation and Revised Feasibility Study

Vancouver Annex Terminal

5420 NW Fruit Valley Road

Vancouver, Washington

Prepared for:

NuStar Terminals Operations Partnership, L.P.

Prepared by:

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Project No. 0060-001-006
October 23, 2020

Cascadia
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Expires 02/24/2022

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1.0 INTRODUCTION

This Supplemental Remedial Investigation (SRI) and revised Feasibility Study (FS) was completed for the NuStar Terminals Operations Partnership L.P. (NuStar) Annex Terminal located at 5420 NW Fruit Valley Road, Vancouver, Washington (the Facility). A location map for the Facility is provided on Figure 1; a Facility plan is provided on Figure 2. The FS was conducted in accordance with the protocols in the Model Toxics Control Act (MTCA) as defined in Washington Administrative Code (WAC) 173-340 and pursuant to Agreed Order No. 09-TC-S DE5250 (Agreed Order) between the Washington State Department of Ecology (Ecology) and NuStar.

On July 12, 2012, NuStar submitted a draft FS to Ecology in accordance with the Agreed Order (Ash Creek, 2012). The technical basis of the FS was the Remedial Investigation (RI) and Risk Assessment (RA) documented in the Remedial Investigation and Risk Assessment Report (RI/RA Report) submitted to Ecology in December 2010 (Ash Creek, 2010) and approved by Ecology on June 23, 2011. The draft FS proposed monitored natural attenuation (MNA) to address residual hydrocarbon constituents (methyl tert butyl ether [MTBE] and benzene) in groundwater in the eastern portion of the Facility.

On October 16, 2013, Ecology provided NuStar with comments on the draft FS. In the months following receipt, NuStar held several meetings with Ecology to discuss Ecology's comments on the FS, as well as additional comments that were presented to NuStar in a February 4, 2014 meeting. The meetings culminated in a Final Project Coordinator's Decision (the "Decision") issued by Ecology on August 26, 2014, which established a series of steps for collecting additional data to support submittal of a revised FS. The additional data requested by Ecology included one year of quarterly groundwater monitoring of four wells, MW-1 through MW-4, located on the eastern portion of the property along with an additional soil and groundwater investigation in the western tank farm areas near historical borings SB-8 and SB-9.

The results of the additional investigations and groundwater monitoring were summarized in the following reports:

- *Groundwater Monitoring Results – December 2014* dated February 6, 2015 (Apex, 2015a);
- *Groundwater Results Report and Groundwater Investigation Work Plan* dated May 28, 2015 (Apex, 2015b);
- *September 2015 Groundwater Monitoring Results* dated November 5, 2015 (Apex, 2015c); and
- *Additional Investigation Summary Report and Pilot Test Work Plan* dated August 2, 2017 (Apex, 2017).

The 2017 Additional Investigation Summary Report detailed the investigation work conducted in the western tank farm areas from 2014 through 2016 including the installation of borings SB-8R and SB-9R which subsequently resulted in the installation of wells MW-5 and MW-6 immediately adjacent to these borings, depth-discrete groundwater investigation via the installation of 12 borings in the western tank farm areas, additional delineation outside the tank farm berm areas via the installation of two additional soil borings, and installation of one deep and four shallow compliance monitoring wells across the site as well as a summary of the groundwater monitoring program conducted in 2014 and 2015 on the eastern portion of the site.

The results of the various investigations conducted in the western tank farm areas indicated the presence of petroleum constituents (primarily total petroleum hydrocarbons [TPH] and benzene) in groundwater at concentrations above MTCA Method A (Unrestricted Land Use) Cleanup Levels in two localized areas in the vicinity of historical borings SB-8 and SB-9 (MW-5 and MW-6). Following discussions with Ecology, a pilot study was conducted in one of these areas to evaluate the efficacy of injecting chemical oxidants to address the petroleum hydrocarbons. The results of the pilot study were summarized in the Pilot Study Results report (Cascadia, 2019a) that was submitted to Ecology on January 17, 2019.

While evaluating the results from the pilot study, it became apparent that further delineation of petroleum constituents in soil and groundwater would be beneficial in the western portion of the site to aid in evaluation of applicable remedial alternatives for this FS. Additionally, through the course of various discussions and meetings with Ecology, it was agreed that soil investigation near the Truck Loading Rack area to better define the current presence and extent of petroleum constituents in soil would be helpful. The information and data collected from the additional investigations completed in 2018 and 2019 were reported in the Additional Investigation Results Report dated July 1, 2019 (Cascadia, 2019b), and identified a third small localized area of petroleum constituents in soil and groundwater in the western area of the site. The extent of petroleum hydrocarbons in this area was further defined in February 2020, and the results are presented in this FS report.

In addition to the above investigations, periodic groundwater monitoring has been conducted at the Facility since 2004 and the results are summarized herein.

1.1 PURPOSE

The purpose of this revised FS is to identify and evaluate remedial action alternatives for reducing and/or controlling contaminant concentrations at the Facility to levels that are considered protective of human health and the environment. The objective of the FS is to develop a range of remedial measures and to identify a preferred cleanup approach that is based on a reasoned evaluation of alternatives. The preferred alternative was selected based on a number of factors, including long-term effectiveness, permanence, implementability, cost, restoration time frame, and community concerns.

1.2 REPORT ORGANIZATION

The SRI/Revised FS report is organized as follows:

- **Section 2** presents Facility background information and geologic/hydrogeologic conditions in the site vicinity.
- **Section 3** provides a summary of investigations and studies conducted from 2004 to 2010, which are the studies that comprised and supported the 2010 RI/RA Report and provided the basis for the 2012 FS. This section also includes a brief summary of the 2012 FS.
- **Section 4** presents the SRI, which is comprised of the additional investigations and studies conducted at the Facility from 2014 to 2020 following Ecology's Final Project Coordinator's Decision.
- **Section 5** updates the previously prepared risk assessment, including an updated summary of the extent, fate, and transport of petroleum hydrocarbons in site media. As summarized in Section 5, petroleum hydrocarbons have been identified in soil and groundwater in three localized areas of the Facility, referred to herein as the MW-5, MW-6, and Vapor Recovery Unit (VRU) Areas, and in soil in the Truck Loading Rack Area.
- **Section 6** summarizes federal, state, and local laws potentially applicable to Facility cleanup.
- **Section 7** describes the development of cleanup standards.
- **Sections 8 through 10** describe the basis for evaluating cleanup action alternatives for the MW-5, MW-6, and VRU Areas, initiating with a review of potentially applicable technologies in Section 8 and the development and evaluation of cleanup alternatives in Sections 9 and 10. Because the MW-5, MW-6, and VRU Areas involve petroleum hydrocarbons in saturated soil and groundwater, cleanup technologies for these areas are evaluated together. Supporting information is contained in the appendices.
- **Section 11** presents cleanup action technologies and alternatives for soil in the Truck Loading Rack Area. Petroleum hydrocarbons have not been detected in groundwater nor in soil below the water table in the Truck Loading Rack Area and do not have a leachable fraction; therefore, cleanup technologies were evaluated separately for this area.
- **Section 12** presents the recommended cleanup action for the Facility.

2.0 BACKGROUND

2.1 SITE LOCATION, DESCRIPTION, AND HISTORY

The "Site" is defined consistent with MTCA and the Agreed Order to include the area where a hazardous substance from a release at the Facility has "come to be located." The boundary of the Site as defined in the Agreed Order is shown on Figure 2.

Location. The Facility address is 5420 NW Fruit Valley Road, Vancouver, Washington 98660 (Latitude: 45.6617ºN, Longitude: 122.6932ºW) (Section 16, Range 1E, Township 2N), as shown on Figure 1. The Facility is located on Clark County Tax Lot No. 147360.

Physical Features. Figure 2 is a Facility Site Plan. The Facility is approximately 31 acres and is roughly rectangular, with dimensions of approximately 800 by 1,800 feet. The Facility is located in a mixed industrial-agricultural area and currently includes a tank farm consisting of seven large aboveground storage tanks (ASTs) contained in four containment areas; a covered truck loading rack; smaller ASTs containing fuel additives; a 42,000-gallon transmix AST; and several buildings used for equipment storage and offices. The large ASTs are used to store jet fuel and range in capacity size from 1,680,000 to 4,599,378 gallons. A former underground storage tank (UST) associated with a vapor recovery system was also located on the Facility and was removed in 2001. The current VRU and adjacent oil/water separator (OWS) are located within a pipeline area between the south and north tank farm containments. The Facility is connected to the municipal sanitary sewer and water supply systems. In accordance with a State Waste Discharge Permit, stormwater is monitored and generally discharged to ground for infiltration. Stormwater from one of the AST containment areas which is lined is directed to a lined Fire System Water Reservoir in the northwestern portion of the Facility. An unlined overflow Storm Pond is located immediately south of the Fire System Water Reservoir and is used for stormwater storage and infiltration during heavy rain events.

Property History. Support Terminals Operating Partnership, L.P. (STOP) purchased the Facility from Cenex Harvest States Cooperative (Cenex) in 2003. In March 2008, STOP changed its name to NuStar.

The property was developed in 1957 as a truck loading terminal. Records are unclear as to whether the Facility was developed by Cenex. Historically, chemicals and other products stored at the Facility included liquid fertilizers and refined petroleum products such as gasoline, diesel and kerosene, de-natured alcohol, and petroleum product additives. The transmix tank is located in the western portion of the Facility (Figure 2), and this is typically where waste (such as from tank-bottom cleanouts or the OWS) would be stored prior to off-site disposal or recycling. There is no indication that materials from tank-bottom cleanouts were buried at the Facility.

Prior to or during Cenex's ownership, American Cyanamid conducted agricultural research—including the testing of herbicides and pesticides—in the southeastern portion of the Facility (Figure 2).

2.2 GEOLOGY AND HYDROGEOLOGY

This section presents the understanding of the geology and hydrogeology as discussed in the RI/RA Report (Ash Creek, 2010) and updated based on investigation conducted during the past seven years.

2.2.1 Geology

Regional Geology. The regional geology is summarized below and is based on reports prepared by Pacific Groundwater Group (PGG, 2001) and AMEC (2002a). The Site and surrounding area is dominated by three primary geologic units: Recent Alluvial deposits, the Pleistocene Alluvial deposits, and the Troutdale Formation.

The Recent Alluvial deposits are the upper unit with deposits approximately 55 feet thick and consist of fine-grained silt and sand within the areas investigated near Vancouver Lake. The Pleistocene Alluvial deposits are approximately 95 to 115 feet thick and consist of coarse-grained sand and gravel. The Pleistocene Alluvial deposits originate from alluvial deposits from the Columbia River and deposits from the catastrophic Missoula Floods. The Troutdale Formation underlies the Pleistocene Alluvial deposits and can be in excess of 1,000 feet thick. It is made up of cemented sandy gravels and semi-consolidated sands, silts, and clays.

Site Geology. During site investigations, soil borings have been advanced to depths of up to 72 feet below ground surface (bgs) at the Facility. Boring logs from these investigations are contained in Appendix A for reference.

A geologic cross-section illustrating Site geology is presented on Figure 3; boring locations are shown on Figure 2. As illustrated on the cross-section and supported by the boring logs, the Recent Alluvial deposits underlying the western portion of the Facility consist of clayey silt, silt with some fine sand, and sandy silt to depths of approximately 28 to 35 feet bgs. In some areas, localized, thin laterally discontinuous sand layers are observed in the silt. Below 28 to 35 feet bgs, the Recent Alluvial deposits consist of layers of fine- to medium-grained sand to a depth of at least 65 feet bgs.

On the eastern portion of the Facility, the base of the silt layer is generally shallower, with fine- to medium-grained sand encountered at approximately 10 feet bgs near the VRU.

2.2.2 Hydrogeology

Regional Hydrogeology. The regional aquifers, Recent Alluvial Aquifer (RAA); Pleistocene Alluvial Aquifer (PAA); and the aquifers of the Troutdale Formation, follow the regional geology discussed above. The regional hydrogeology summarized below is based on reports prepared in support of

Clark Public Utilities (CPU) South Lake Wellfield (PGG, 2001; PGG, 2009), and by Ash Creek (2008a and 2008b).

The RAA is unconfined and receives recharge directly from the land surface and/or surface water features. The PAA directly underlies the RAA and is a productive aquifer with high well yields (several thousand gallons per minute [gpm] without significant drawdown). The groundwater flow system is highly influenced by local surface water bodies. The Columbia River, Vancouver Lake, Vancouver Lake Flushing Channel, and Lake River form natural hydrologic boundaries to the groundwater flow system. Tidal influences and seasonal variations in surface water runoff cause dynamic variation in the stage of the Columbia River, and resulting in adjustments in the stages of the other three connected surface water bodies. The groundwater flow system is also influenced by tidal and seasonal variations in the surface water bodies. Regionally, it is anticipated that groundwater within the RAA and PAA in the vicinity of the Facility would have a net gradient towards Vancouver Lake and the Columbia River.

The Troutdale Gravel Aquifer (TGA) has been observed at a depth of approximately 200 feet at the CPU wellfield located 500 feet north of the Facility. It is approximately 50 feet thick and is underlain by a 100-foot-thick clay confining layer. The Sand and Gravel Aquifer (SGA) of the Troutdale Formation is found beneath the confining layer.

Site Hydrogeology. First encountered groundwater is found in the sandy silt of the RAA. In the western portion of the Facility, depth to first encountered groundwater has ranged from approximately 8 to 22 feet bgs since 2014, and in the eastern portion of the Facility, near the former and current Truck Loading Rack, depth to groundwater has ranged from approximately 20 to 32 feet bgs since 2002. Depth to first groundwater varies seasonally, with the shallower depths generally encountered between December and June and the deeper depths encountered between July and November. Deeper groundwater of the PAA is encountered at depths of approximately 50 to 70 feet bgs beneath the Facility (Ash Creek, 2008a).

Shallow groundwater flow at the Facility has remained, under static conditions, relatively flat with a slight gradient (typically ranging between 0.0001 to 0.0005 foot per foot [ft/ft]) predominantly to the southeast (AMEC, 2002a; SECOR, 2003; Ash Creek, 2009) but at times to the east/northeast, or a divide is observed in the western portion of the Facility, with flow to the west on the western side of the divide and to the east/southeast on the eastern portion of the divide (Cascadia, 2020). Groundwater contour maps prepared for previous investigations are contained in Appendix B of this report for reference.

3.0 SUMMARY OF PREVIOUS INVESTIGATIONS

Several investigations were conducted at the Facility between 2001 and 2012. The initial investigation addressed evidence of a possible fuel release during UST decommissioning and resulted in further work to define the extent of potentially impacted soil and groundwater (AMEC, 2002a/2002b). In 2003, SECOR conducted a comprehensive Phase II Environmental Site Assessment (ESA) of the Facility as a part of due diligence activities for Cenex during the property transaction to NuStar (SECOR, 2003). Several investigations were conducted between 2006 and 2008 to characterize environmental conditions in support of a remedial investigation and risk assessment (Ash Creek, 2007, 2008a, and 2008b). Four monitoring wells (MW-1 through MW-4) were installed in 2004 and were monitored periodically and/or quarterly during the 2004 to 2012 period. The scope and results of each of these investigations and monitoring were detailed in the RI/RA Report (Ash Creek, 2010) and are summarized below. Figures summarizing data collected prior to 2010 were contained in the 2010 RI/RA (Ash Creek, 2010) and are contained in Appendix C for reference.

Analytical data from the investigations for soil, grab groundwater, and monitoring well sampling are summarized in Tables 2, 3, and 4, respectively.

3.1 ENVIRONMENTAL SITE ASSESSMENT – APRIL 2002

In April 2002, petroleum-impacted soils were encountered during the decommissioning of an underground gasoline-vapor recovery tank. Cenex excavated several test pits to delineate the extent of the impacted soils, and approximately 60 to 100 cubic yards of soil were then excavated. Cenex retained AMEC to conduct further investigations to assess soil and groundwater conditions at and near the former UST. A brief summary of those activities and results is presented below:

- Twelve borings (GP-1 through GP-12) were completed to depths ranging from 20 to 32 feet bgs around the VRU and the former UST pit (Figure 2). Seven soil samples (one each from borings GP-2, GP-3, GP-5, GP-7, GP-8, GP-9, and GP-12) were analyzed for the presence of petroleum hydrocarbons using Northwest Method NWTPH-HCID. Petroleum hydrocarbons were not identified in the soil samples. Results were summarized on Figures 3 and 4 of the 2010 RI/RA (Ash Creek, 2010) which are contained in Appendix C for reference.
- AMEC coordinated the removal of the soil excavated from the former UST area by Cenex and backfilling of the former tank excavation. Confirmation soil sampling conducted at the final limits of the UST excavation did not identify petroleum hydrocarbons or fuel constituents in the residual soil (AMEC, 2002b).
- Groundwater samples were collected from locations GP-3 and GP-7 through GP-12; see Figure 2 for locations. The groundwater samples were analyzed for the presence of TPH as gasoline (TPHg) and diesel (TPHd) using NWTPH-Gx and NWTPH-Dx, respectively; polycyclic aromatic hydrocarbons (PAHs) by EPA Method 8270-SIM; and/or volatile organic

compounds (VOCs) by U.S. Environmental Protection Agency (EPA) Method 8260B. TPHg; TPHd; benzene, toluene, ethylbenzene, and xylenes (BTEX); and several PAH constituents were detected in the grab groundwater samples. Based on the results of the groundwater analyses, AMEC concluded that additional investigation was needed to better assess the subsurface extent of the fuel constituents (AMEC, 2002a).

3.2 SUBSURFACE INVESTIGATION – DECEMBER 2002

In December 2002, further subsurface investigation was conducted to evaluate the extent of petroleum hydrocarbons in soil and groundwater in the vicinities of the former UST, the existing VRU, and the existing and former truck loading racks. The investigation included:

- Twenty-five direct-push borings (GP-13 through GP-37) were completed to depths ranging from 24 to 50 feet bgs. Soil samples selected from borings advanced within the Former Truck Loading Rack (GP-14 and GP-31 through GP-35) and from beneath the existing VRU (GP-26) were submitted for chemical analysis. Locations of the borings are shown on Figure 2.
- Grab depth-discrete groundwater samples were collected from borings GP-21 through GP-25 and GP-28 through GP-30. Fuel constituents were noted to be primarily detected near/southeast of the VRU and decreased rapidly with distance from the unit (Ash Creek, 2010).
- Installation and sampling of four monitoring wells (MW-1 through MW-4). Locations of wells MW-1 through MW-4 are shown on Figure 2.

The subsurface investigation successfully delineated the extent of fuel-related constituents in soil and groundwater near the former UST, VRU, and truck loading racks. Lead concentrations in groundwater were non-detect, supporting that the fuel constituents in the subsurface are not a source of lead to groundwater.

3.3 PHASE II ENVIRONMENTAL SITE ASSESSMENT – 2003

SECOR performed a comprehensive Phase II ESA during April 2003 in support of due diligence efforts during the property transfer from Cenex to NuStar. SECOR conducted research on the historical uses of the Facility to assist in developing the scope of the investigation. SECOR's research of historical operations indicated the following uses or potential areas of concern: fuel storage in ASTs; stormwater pond used to collect non-contact stormwater; slop tank used to store oily wastes prior to recycling or disposal; current and former truck loading racks used to transfer fuel; VRU and OWS; former UST; and former pesticide/herbicide handling and storage areas associated with American Cyanamid's site usage.

SECOR implemented a Facility-wide investigation to assess the potential impacts of each of these Facility uses/areas of potential concern. A brief summary of those activities and results is provided below, and the location of referenced borings and wells are shown on Figure 2:

- Thirteen direct-push borings, three temporary monitoring wells, and 14 hand-auger borings were advanced across the Facility.
- Soil samples were selected for laboratory analysis from locations SB-4, SB-8, SB-9, SB-11, HA-3, HA-5, and PMW-5.
- Groundwater samples were collected from locations SB-1-GW, SB-3-GW, SB-4-GW, SB-8-GW through SB-11-GW, SB-18-GW, PMW-5W, and PMW-7. In addition, the four on-site monitoring wells (MW-1 through MW-4) were re-sampled.
- Significant areas of concern associated with fuel-related constituents in soil or groundwater were not identified outside of the former UST/VRU Area. TPH and BTEX concentrations detected in soil are shown on Figures 3 and 4 of the 2010 RI/RA; TPH and BTEX concentrations detected in groundwater samples collected from the direct-push boring locations are shown on Figures 5 and 6 of the 2010 RI/RA (Ash Creek, 2010). Copies of these figures are contained in Appendix C for reference.
- Soil and groundwater samples were collected for pesticide, herbicides, triazines, and nitrogen analyses in areas where American Cyanamid historically operated. Triazines, pesticides, and herbicides were not detected in soil or groundwater (Ash Creek, 2010). Nitrates were not detected at concentrations that would be indicative of a source.
- Lead concentrations in groundwater appeared slightly elevated and were inconsistent with previous analyses performed by AMEC for lead in groundwater at the Facility. As described below, additional lead analyses were performed on samples collected from Facility monitoring wells and the results were non-detect.

3.4 SITE INVESTIGATIONS – 2006 TO 2008

Ash Creek performed several investigations between 2006 and 2008 to assess the conditions at the Facility. The investigations included sampling of off-site wells, direct-push groundwater assessment of deeper groundwater at the Facility, and a year-long quarterly groundwater monitoring program. Below is a brief summary of the investigations.

- On September 26, 2006, two samples (IRIG-Firestone and House-Firestone) were collected off-site to evaluate the migration potential of groundwater constituents to the north of the Facility. Samples collected from the irrigation wells at the Firestone Property were analyzed for TPHg using NWTPH-Gx, TPHd using NWTPH-Dx, VOCs using EPA Method 8260B, and PAHs using EPA Method 8270 SIM. None of the analyzed constituents were detected in the groundwater samples above method reporting limits (MRLs).
- On June 11, 2007, two direct-push borings (GP-1 and GP-2) were advanced into the PAA unit using a heavy duty Geoprobe Systems® unit to assess deeper groundwater conditions beneath the Facility; the locations of these borings are shown on Figure 2. The direct-push

borings were advanced to depths of between 65 and 72 feet, respectively. Grab groundwater samples collected from the deeper groundwater zone were analyzed for TPHg, TPHd, and VOCs (including BTEX). Except for MTBE, detected at a concentration of 13.7 micrograms per liter (µg/L) at location GP-1, no other VOCs, TPH, or PAHs were detected in the direct-push explorations.

- A one-year quarterly groundwater monitoring program was initiated in the second quarter of 2007. Groundwater samples were analyzed for TPHg by NWTPH-Gx; TPHd and TPHo by method NWTPH-Dx with silica gel cleanup; and BTEX and fuel oxygenates by EPA Method 8260B. Concentrations decreased significantly—in some cases up to three orders of magnitude—since the initial investigations in 2002/2003 (Table 4). With the exception of TPHg in well MW-3, the results demonstrated constituent concentrations below MTCA Method A Cleanup Levels. The significant and expeditious decreases in groundwater concentrations support the conclusion that the residual concentrations of fuel-related constituents in Facility soil in the eastern portion of the Site are not sufficient to present an ongoing source of degradation to shallow groundwater.
- Groundwater samples were analyzed for lead during one quarterly event; lead concentrations were non-detect in all four wells.

3.5 PERIODIC GROUNDWATER MONITORING AND DRAFT FS

Groundwater monitoring of wells MW-1 through MW-4 was conducted periodically between 2004 and preparation of the RI/RA report in 2010. The results indicated steadily decreasing BTEX and MTBE concentrations (Table 4).

A draft FS was conducted in 2012 and evaluated potential cleanup options for groundwater at the Facility. Three alternatives were evaluated: no action, groundwater recirculation, and MNA. The draft FS included a comparative analysis of the options and concluded that MNA was the preferred alternative. An analysis of benzene and MTBE concentration trends in groundwater was conducted as part of the draft FS and indicated that benzene and MTBE concentrations would be below MTCA Level A criteria in wells MW-1 through MW-4 in 5 to 10 years. As detailed in Section 4, results of continued groundwater monitoring demonstrated that wells MW-1 through MW-4 achieved the MTCA Level A criteria by 2014, confirming the predicted timeframe of the draft 2012 FS and that natural attenuation is actively occurring at the Site.

4.0 SUPPLEMENTAL REMEDIAL INVESTIGATION

Since Ecology's 2014 issuance of the Final Project Coordinator's Decision establishing a series of steps for collecting additional data to support revision and resubmittal of the FS, seven additional soil and groundwater investigations have been conducted, nine monitoring wells have been installed, a remedial action pilot study was completed, and a quarterly groundwater monitoring program was initiated. The results of these additional investigations and studies are summarized below.

Figures summarizing results from investigations conducted from 2014 to 2019 were presented in the *Additional Investigation Summary Report and Pilot Test Work Plan* (Apex, 2017) and/or the May 2019 *Additional Soil and Groundwater Investigation Results Report* (Cascadia, 2019b) and are contained in Appendix D for reference. An additional investigation was conducted in February 2020 in support of this Revised FS; the results are presented in this section, and Appendix E contains the analytical data sheets from the 2020 investigation.

Analytical results from the SRI assessments as well as the historical investigations are summarized in Tables 2, 3, and 4 for soil, grab groundwater, and monitoring well sampling, respectively.

4.1 SUMMARY OF INVESTIGATION – 2014 THROUGH 2016

As presented in Section 1.0, Ecology provided NuStar with comments on the draft FS on October 16, 2013. In the months following receipt, NuStar held several meetings with Ecology to discuss Ecology's comments on the FS, as well as additional comments that were presented to NuStar in a February 4, 2014 meeting. The additional comments included a request for additional groundwater investigation near historical borings SB-8 and SB-9 in the western tank farm areas; the locations of these borings are shown on Figure 2. The preliminary investigation results indicated that petroleum hydrocarbon constituents were present in groundwater near historical borings SB-8 and SB-9 at concentrations above MTCA Method A Cleanup Levels. As a result, additional site investigation, well installation, and groundwater monitoring were conducted to evaluate the magnitude and extent of petroleum hydrocarbon constituents in groundwater in the western portion of the Facility. The results of these investigations are detailed in Apex 2015a, 2015b, 2015c, and 2017, and Cascadia 2019. The soil results are included in Table 2, and the grab groundwater results are summarized in Table 3. Boring and monitoring well locations are shown on Figure 2.

In summary, these investigations included:

- Installing two monitoring wells, MW-5 and MW-6, at the locations of historical borings SB-8 and SB-9, respectively;
- Conducting one year of quarterly groundwater monitoring of existing wells MW-1 through MW-4 and the new wells, MW-5 and MW-6;

- Conducting additional groundwater investigation to define the extent of petroleum hydrocarbons and related constituents in the areas of wells MW-5 and MW-6, including the installation of 12 direct-push borings (B-1 through B-12) and the collection of two to three grab groundwater samples from each boring using temporary well points;
- Conducting a groundwater investigation to delineate the extent of petroleum hydrocarbons in groundwater to the west of wells MW-5 and MW-6, including the installation of two borings, B-13 and B-14, outside and to the west of the tank farm berms of the Facility;
- Installing four shallow compliance wells, MW-7 through MW-10, to monitor the potential for offsite migration to the north, west, and south; and
- Installing two deeper monitoring wells, MW-5D and MW-8D, adjacent to wells MW-5 and MW-8, respectively, to evaluate potential vertical gradients in groundwater.

As shown in Table 3, benzene and toluene were not detected in groundwater in the MW-5 Area and ethylbenzene and xylenes concentrations were low. Although benzene was detected in groundwater in the MW-6 Area, concentrations were low and limited in extent. The results indicated that the impacts consisted predominantly of TPH in the gasoline and diesel hydrocarbon ranges (TPHg and TPHd, respectively). MTBE was not detected.

Detected concentrations of TPH and BTEX in grab groundwater samples obtained from borings B-13 and B-14, and wells MW-7 through MW-10 and MW-8D were below MRLs. The results were presented to Ecology in a meeting on September 22, 2016. During the meeting, Ecology supported the conclusion that the compliance well network was acceptable for monitoring purposes.

4.2 PILOT STUDY – 2017

In the September 2016 meeting, Ecology stated that the FS would need to evaluate active remediation to address the petroleum hydrocarbons in groundwater near wells MW-5 and MW-6 based on the additional groundwater investigations conducted from 2014 to 2016. As such, NuStar indicated that initial evaluations of potential remedial alternatives identified injection of oxygen releasing compound (ORC) and/or *in-situ* chemical oxidation (ISCO) as possible options. However, due to the presence of the heavier hydrocarbons in the saturated soil and shallow groundwater, it was determined that a pilot study would be needed to better evaluate the viability of this option. A pilot study work plan was submitted to Ecology in August 2017 (Apex, 2017) and implemented in October and November 2017. After the injections were completed, one year of groundwater monitoring was conducted to assess the effectiveness of the ORC and ISCO injections. The results of the pilot study were submitted to Ecology in the *Pilot Study Results Report* (Cascadia, 2019ab). The groundwater monitoring conducted following the pilot study did not indicate significant decreases in petroleum constituent concentrations. While the remedial technology was not ruled out as a potential future cleanup option for the Facility, the tight soils in the tank farm area limited the effective distribution of the ISCO/ORC products into the subsurface. The pilot study was beneficial for identifying physical issues that would have to be overcome for *in situ* injection technologies to be successful at the Facility.

4.3 ADDITIONAL INVESTIGATION – 2019

In 2018, additional investigation in both the western and eastern areas of the Facility were proposed to assist in completing the FS. The additional investigation was conducted in 2019 and consisted of:

- Conducting an additional groundwater investigation in the western tank farm area to better assess the vertical extent of petroleum constituents in groundwater;
- Collecting soil samples from two locations in the overflow storm pond;
- Soil sampling adjacent to the Truck Loading Rack to assess current petroleum hydrocarbon constituent concentrations in soil; and
- Advancing a soil boring followed by a new groundwater monitoring well (MW-11) between existing wells MW-1 and MW-3 to assess whether petroleum hydrocarbons in groundwater in this area are below MTCA Method A Cleanup Levels.

Vertical Definition in the Western Tank Farm Area. Seven additional borings (B-15 through B-21) were installed to define the vertical extent of petroleum hydrocarbons in groundwater around wells MW-5 and MW-6. Results defined the vertical extent in the MW-5 Area as predominantly limited to shallow groundwater above 40 feet below grade. Just one boring had TPH detections to 55 feet below grade. The vertical extent in the MW-6 Area did not extend below 40 feet below grade. During the 2019 investigation in the western tank farm area, an additional apparently localized area of petroleum hydrocarbons in soil was identified in boring B-18 located just to the east of well MW-6.

Soil Sampling in Overflow Storm Pond. Two borings, B-15 and B-16, were installed in the locations where two historical borings, HA-5 and HA-6, were installed for soil sample collection in 2003; TPH and BTEX had been identified at location HA-5 at depths between 3 and 6 feet below grade. Soil results from borings B-15 and B-16 indicated significantly lower TPH concentrations and no BTEX. Results are summarized in Table 2.

Soil in Truck Loading Rack Area. Historical sampling conducted in 2002 and 2003 in the Former Truck Loading Rack, located just east of the current truck loading rack, indicated the presence of petroleum hydrocarbon constituents in soil, generally at the 8- to 10-foot depth interval. Historical grab groundwater sampling conducted in this area did not indicate the presence of petroleum hydrocarbons or related constituents above MTCA Method A Cleanup Levels, and hydrocarbon constituents have not been detected in groundwater samples collected from monitoring well MW-4 located adjacent to this area since the well was installed in 2002 (Table 4).

To assess current soil conditions and to better support remedial alternative evaluations for soil containing residual hydrocarbons in the Truck Loading Rack Area, six soil borings were installed at the locations shown on Figure 2. Borings B-23, B-24, B-25, and B-27 were advanced at or near the locations of historical borings GP-34, GP-14, GP-33, and GP-32, respectively, to assess current hydrocarbon concentrations at these locations. Two additional borings (B-26 and B-28) were advanced in the grassy area to the east of these borings to verify the low to non-detect results reported in the 2002/2003 investigation in this area. As detailed in Section 4, the results of the recent soil sampling and analysis in this area showed that residual hydrocarbons have attenuated significantly since the 2002/2003 investigation and are limited both vertically and laterally in extent.

Groundwater in VRU Area. In reviewing the historical grab groundwater data collected in the Former Truck Loading Rack Area, an area of higher petroleum hydrocarbon concentrations was identified between wells MW-1 and MW-3, near the VRU, specifically at historical boring location GP-8. Historical figures summarizing these data are contained in Appendix D. Monitoring wells MW-1, MW-2, and MW-3 surround the VRU Area, and no longer contain petroleum hydrocarbon constituents at concentrations above MTCA Method A Cleanup Levels. In 2019, boring B-22 was advanced adjacent to historical boring GP-8, in the approximate center of wells MW-1, MW-2, and MW-3. Detected concentrations of gasoline range hydrocarbons as well as benzene, ethylbenzene, and xylenes above MTCA Method A Cleanup Levels were identified in the B-22 grab groundwater sample indicating a highly localized area of residual contamination. Monitoring well MW-11 was installed adjacent to boring B-22 to allow continued monitoring of groundwater in this area.

4.4 ADDITIONAL INVESTIGATION – FEBRUARY 2020

In February 2020, petroleum hydrocarbons in soil and groundwater were further delineated in the western portion of the Facility prior to initiating an updated FS. Specifically, additional borings were completed within the overflow Storm Pond and an area around boring B-18.

Boring B-18 Area. As identified above, an additional localized area of soil and groundwater containing petroleum hydrocarbons was identified in boring B-18, the location of which is shown on Figure 2. The vertical extent of petroleum hydrocarbons in groundwater in this area was defined during the 2019 investigation; however, the lateral extent of petroleum hydrocarbons in soil and shallow groundwater around boring B-18 was not. Nine additional borings (B-29 through B-34 and B-37 through B-39) were advanced around boring location B-18 in February 2020 to better assess the lateral extent of soil and shallow groundwater containing petroleum hydrocarbons in this area. Up to three soil samples and one grab groundwater sample were collected from each location. Samples were analyzed for TPH, BTEX, and naphthalene. Table 2 includes the analytical results of soil samples collected during the 2020 investigation; Table 3 includes the analytical results of the grab groundwater samples. Figure 4 illustrates the extent of TPH in soil around B-18. Figures 5 and 6 illustrate the extent of TPH and BTEX, respectively, in groundwater around boring B-18.

Overflow Storm Pond. As presented above, investigations of the current conditions of soil beneath the overflow Storm Pond were conducted in 2019. The 2019 investigation was conducted via hand-auger because access by a drill rig was not possible at that time and groundwater samples could not be obtained. A ramp was constructed into the Storm Pond in 2020 and a drill rig was able to access the area. Two borings, B-35 and B-36 were installed in the overflow Storm Pond during the 2020 investigation to assess soil and groundwater conditions beneath the pond. Soil samples from three depth intervals were collected from borings B-35 and B-36. TPHg, TPHd, BTEX, and naphthalene were not detected in any of these samples above MRLs. Analytical results in soil are summarized in Table 2.

Groundwater was encountered at an approximate depth of 6.5 feet bgs beneath the overflow Storm Pond at the time of the investigation, and groundwater samples were collected from a depth interval extending from 6 to 10 feet bgs in borings B-35 and B-36. In addition, a deeper groundwater sample was collected from boring B-36 from a depth of 16 to 20 feet bgs to be comparable to groundwater depths previously sampled in the well MW-6 Area. Analytical results for the groundwater samples are summarized in Table 3; TPHg, TPHd, BTEX, and naphthalene concentrations were below MRLs in the three groundwater samples.

4.5 GROUNDWATER MONITORING – 2014 TO 2020

Comprehensive groundwater monitoring events have been conducted periodically since submittal of the draft FS and Ecology's Project Coordinator Decision. As identified above, the monitoring well network was expanded from the four monitoring wells MW-1 through MW-4 located in the eastern area of the Facility in 2007 to a total network of 11 shallow wells and two deeper wells across the Site. In summary:

- Shallow wells MW-5 and MW-6, screened from 10 to 25 feet bgs, were installed in 2014 to monitor groundwater conditions at former boring locations SB-8R and SB-9R, respectively.
- Shallow wells MW-7 through MW-10, screened from 10 to 25 feet bgs, were installed in 2016 to provide compliance monitoring wells around the lateral extent of the two localized petroleum hydrocarbon areas identified at wells MW-5 and MW-6.
- Deeper wells MW-5D and MW-8D, screened from 35 to 45 feet bgs, were installed in 2016 to monitor deeper groundwater adjacent to wells MW-5 and MW-8.
- Shallow well MW-11, screened from 10 to 25 feet bgs, was installed in 2019 to monitor groundwater conditions in the VRU Area.

Twelve comprehensive monitoring events have been conducted at the Facility in the period from 2014 to 2020. Monitoring included gauging depth to groundwater and collecting groundwater samples from each well. Groundwater samples were analyzed for TPHg, TPHd, TPHo, BTEX, and MTBE. Naphthalene was added to the analytical program in 2019. Depth to groundwater and groundwater elevation data collected during these routine groundwater monitoring events are tabulated in Table 1; chemical analytical results are summarized in Table 4. Results from the continued groundwater monitoring have confirmed that the TPH and related constituents are confined to two localized areas in the western tank farm—one area around MW-5 and the second around MW-6—and a small area around well MW-11 in the VRU Area.

5.0 SUMMARY AND UPDATE OF 2010 RISK ASSESSMENT

The 2010 RI/RA Report was submitted to Ecology in December 2010. Ecology approved the RI/RA Report in a letter to NuStar dated June 23, 2011. Since that time, additional investigations have been performed to better define the extent of petroleum hydrocarbons and related constituents at the Site, as detailed in Section 3.0. In this section, the Conceptual Site Model (CSM) and RA presented in the 2010 RI/RA report are summarized and updated as appropriate based on new information and data obtained since 2010.

5.1 LAND AND BENEFICIAL WATER USE

Land Use. The Site is an industrial property as defined by WAC 173-340-200. This conclusion is based on the following.

- The Site is located within the City of Vancouver, which has conducted land use planning under the State Growth Management Act (Vancouver Municipal Code [VMC] 20.110.010.A).
- The City of Vancouver zoning map defines the Facility and surrounding area as IL: Light Industrial. The nearest non-industrial zoning is a greenway area located adjacent to and west/northwest of the Facility.
- The Facility is a light refined petroleum products storage and distribution facility that currently handles jet fuel and methanol.

Groundwater Use. Shallow groundwater at the Facility is not currently used for any purpose. CPU installed a domestic water supply wellfield, referred to as the Carol Curtis Wellfield, on vacant land approximately 500 feet north of the Facility in 2010; the location of the wellfield is shown on Figure 1. Currently, the wellfield consists of three production wells screened from 500 to 600 feet bgs in the SGA. The wellfield extracts groundwater at rates between 1,000 to 3,000 gpm. CPU has indicated that it plans to bring additional wells into service that will draw from the PAA. Specifically, it has stated that a PAA production well will be brought into service with a pumping rate of 5,000 gpm by the end of 2021.

Irrigation wells are present near the Facility and include irrigation wells at the Firestone Property located directly north of the Facility. No constituents were detected in water samples collected from wells at the Firestone Property in 2003 and 2006.

Surface Water. There are no surface waters at the Facility. The nearest surface water feature is Vancouver Lake, which is located approximately 2,600 feet west of the Facility. The Columbia River is located approximately 1.75 miles south of the Facility.

5.2 CHEMICALS OF POTENTIAL CONCERN

Previous investigations and activities conducted at the Site have included chemical analysis of more than 150 soil samples, 100 grab groundwater samples, and 16 rounds of groundwater sampling and analysis for TPH, VOCs, PAHs, and/or lead. These data are of sufficient quality for use in risk assessment, FS, and cleanup level determination. Screening of chemical data for the 2010 RI identified the chemicals of potential concern (COPCs) in soil and groundwater at the Site to be petroleum hydrocarbons (gasoline and diesel), BTEX, and MTBE (Ash Creek, 2010). MTBE has not been detected above MTCA Level A criteria in soil or groundwater sampling conducted at the property since 2015 and is no longer considered a COPC. However, recent soil and groundwater analyses have identified naphthalene above MTCA Level A criteria, and it is now considered a Site COPC.

5.3 SUMMARY OF CHEMICAL FATE AND EXTENT

5.3.1 Soil

Site investigations have identified five areas of localized soil impacts:

- Truck Loading Rack Area;
- VRU Area;
- Northwest tank farm containment area around well MW-5 (referred to as the MW-5 Area);
- Southwest tank farm containment area in the vicinity of well MW-6 and boring B-18 (referred to as the MW-6 Area); and
- Overflow Storm Pond.

Figure 12 identifies the approximate location of these areas at the Facility. This section describes the distribution and extent of COPCs in each of these areas.

Truck Loading Rack Area

Investigations conducted between 2002 and 2005 indicated the presence of residual petroleum hydrocarbons in soil between the depths of approximately 6 to 12 feet in the Truck Loading Rack Area. Additional investigation was conducted in 2019 to assess current conditions in this area (Cascadia, 2019b). As a part of the 2019 investigation, borings B-23, B-24, B-25, and B-27 were advanced to assess current conditions at historical boring locations GP-34, GP-14, GP-33, and GP-32, where previous petroleum hydrocarbon concentrations were above MTCA Method A Cleanup Levels. With the exception of boring B-27, the 2019 results were well below historical concentrations and/or below MRLs (Cascadia, 2019b).

A table comparing the 2002 and 2019 results is provided below.

Table 5.3.1A

Comparison of Historical (2002) and Recent (2019) Soil Samples in Truck Loading Rack Area

Sample ID (Depth ft bgs)	Sample year	TPHg	TPHd	Benzene	Toluene	Ethyl-benzene	Xylenes
GP-34 (6-8)	2002	728	13,600	< 0.500	< 0.500	0.717	16.9
B-23 (6.5 – 7.5)	2019	< 7.26	< 25.0	< 0.0145	< 0.0726	< 0.0363	< 0.109
GP-14 (10-12)	2002	3,230	19,700	--	--	--	--
B-24 (10.5-11.5)	2019	< 7.19	< 26.5	< 0.0144	< 0.0719	< 0.0359	< 0.108
GP-33 (8-10)	2002	363	31,500	< 0.500	< 0.500	7.2	33.9
B-25 (8.5 – 9.5)	2019	88.6	7,650	< 0.0148	< 0.0739	< 0.0369	< 0.111
GP-32 (6.5 – 8)	2002	910	2,530	< 5	< 5	< 5	16
B-27 (7 - 8)	2019	1,910	6,620	< 0.0725	< 0.363	1.89	11.1

Shading indicates exceedance of MTCA Method A Cleanup Level. Concentrations in milligrams per kilogram (mg/kg).
"--" indicates sample not analyzed for constituent.
"<" indicates analyte not detected at or above the specified laboratory MRL.

It should be noted that the 2019 soil sample collected from a depth of 10 feet at boring B-27 contained TPHg at a concentration of 11,500 mg/kg and TPHd at 23,000 mg/kg. Samples were not collected from this depth historically; therefore, a data comparison cannot be made to assess whether attenuation has occurred. However, as shown in the table below, photoionization detector (PID) readings collected below 10 feet in all of the 2019 borings except B-27 were below 5 parts per million per volume (ppmv), and the readings in boring B-27 decreased rapidly below a depth of 12 feet and were below measurement levels below a depth of 18 feet. These results support that the residual petroleum hydrocarbons in the Truck Loading Rack Area are predominantly limited to a vertical depth interval of approximately 6 to 13 feet.

Table 5.3.1B

PID Measurements for 2019 Soil Samples in Truck Loading Rack Area

2019 Boring	PID Measurement (ppmv)					
	0 to 6 feet	6 to 10 feet	11 to 13 feet	14 to 16 feet	17 to 18 feet	19 to bottom of boring
B-23	< 5	< 5	< 5	< 5	BOB at 15 feet	BOB at 15 feet
B-24	< 5	< 5	< 5	< 5	BOB at 15 feet	BOB at 15 feet
B-25	< 5	1.2 - 21.5	< 5	< 5	BOB at 15 feet	BOB at 15 feet
B-26	< 5	< 5	< 5	< 5	< 5	< 5
B-27	< 5	97 - 773	679	25 - 50	5.6	< 5
B-28	< 5	< 5	< 5	< 5	BOB at 15 feet	BOB at 15 feet

BOB = bottom of boring

The results of the 2019 investigation of the Former Truck Loading Rack indicate that the residual hydrocarbons have attenuated significantly in this area since it was last investigated in 2002. Residual petroleum hydrocarbons in this area are limited to the vicinity of boring B-25 and B-27 and are constrained to the east and west by borings B-23 and B-24, to the north by borings GP-37 and GP-18, and to the south by borings GP-15 and GP-16, as shown on Figure 9. Vertically, the residual petroleum hydrocarbons are limited to the depth interval between 6 and 13 feet bgs.

VRU Area

Investigations conducted in 2002 and 2003 identified petroleum hydrocarbons in soil and groundwater near the VRU and its ancillary decommissioned UST. The UST and soil around the UST were removed. Sampling conducted around the excavation area supported that the excavation removed the majority of the soil containing petroleum hydrocarbons (Ash Creek, 2010). Figure 4 of the 2010 RI summarized the historical soil sampling results in this area and is contained in Appendix C for reference.

MW-5 Area

Investigations conducted within the MW-5 Area focused on assessing the extent of COPCs in groundwater; soil samples were not collected for chemical analysis in this area during recent investigations. However, PID measurements and field screening for visual evidence (e.g., sheen) were conducted and, with the exception of boring B-6, indicate that COPCs are not present in vadose zone soil above seasonal high groundwater which can be as shallow as 9 feet bgs in this area. Field screening in boring B-6 indicated PID measurements up to 680 ppmv between depths of 7 and 10 feet bgs. Boring logs with field screening results are contained in Appendix A for reference. PID measurements are also shown on the geologic cross-section (Figure 3) that aligns southwest to northeast through this area.

MW-6 Area

Investigations were conducted between 2014 and 2020 to delineate the lateral and vertical extent of COPCs within this southwest portion of the tank farm. Investigations conducted around monitoring well MW-6 focused on assessing the extent of COPCs in groundwater; however, the PID readings from the boring logs installed in this area provide information on the extent of soil impacts in the vadose zone. As depicted on Figure 3 and supported by the boring logs in Appendix A, there is limited presence of petroleum hydrocarbons in the upper 10 feet of soil in the MW-6 Area, and PID readings are below 20 ppmv at depths below approximately 21 feet bgs. As also shown on Figure 3, the hydrocarbon mass is limited to the silt layer of the upper RAA beneath the Facility.

B-18 Area

Shallower impacts were noted in and around boring B-18 in 2019, and the February 2020 investigation was conducted to better assess the extent of COPCs in soil and groundwater in this area. The inferred lateral extent of TPHg and TPHd in soil around boring B-18 above MTCA Level A cleanup levels appears to be approximately 100 feet by 80 feet as illustrated on Figure 4.

Near borings B-18 and B-30, the petroleum hydrocarbons were identified in shallower soil, in the 3- to 6-foot depth range, and extended to approximately 22 feet bgs based on analytical data and PID measurements collected in the field. In the remaining borings at which TPH was identified above MTCA Level A criteria, petroleum hydrocarbons were typically observed at depths starting at approximately 12 feet bgs and extending to 21 or 22 feet bgs. Historical high groundwater level in this area is around 8 1/2 feet bgs and support that the petroleum hydrocarbon containing soil below 9 feet is not a part of the vadose zone. The extent of petroleum hydrocarbon containing soil in the vadose zone is defined by borings B-29, B-31, B-32, and B-33, and covers a lateral extent less than approximately 50 feet by 70 feet. Boring logs with field screening results are contained in Appendix A for reference.

As shown in Table 2, ethylbenzene, xylenes, and naphthalene are co-located with the TPH and therefore, the extent of these COPCs in soil is the same as TPH in this area. Toluene was not detected and benzene concentrations, where detected, were typically one or two orders of magnitude less than the ethylbenzene, toluene, and naphthalene concentrations.

Overflow Storm Pond

In 2003, soil samples collected at depths of 3 and 6 feet bgs from one of three hand-augered borings, HA-5, installed in the overflow Storm Pond indicated the presence of TPHg and TPHd at concentrations above MTCA cleanup levels. TPHg and TPHd were non-detect in the soil samples collected from the two other hand auger locations, HA-4 and HA-6. Figure 4 of the 2010 RI summarized these results and is contained in Appendix C for reference.

Hydrocarbons in the overflow Storm Pond have attenuated significantly since 2003, as exemplified by the results at boring B-16. Boring B-16 was advanced in 2019 in the same location as historical boring HA-5 and a sample was collected at 6 feet to assess current concentrations. As shown in the table below, COPC concentrations are much less than those observed in 2003.

Table 5.3.1C

Comparison of Historical (2003) and Recent (2019) Soil Samples in Storm Pond

Sample ID (Depth feet bgs)	Sample year	TPHg	TPHd	Benzene	Toluene	Ethyl-benzene	Xylenes
HA-5 (6)	2003	2,290	10,700	6.7	216	177	1,204
B-16 (5 - 6)	2019	1,900	483	<0.0683	<0.342	0.171	<0.513

Shading indicates exceedance of MTCA Method A Cleanup Level. Concentrations in mg/kg.

In February 2020, additional soil samples were collected in the overflow Storm Pond to further assess soil in the overflow storm pond. Soil samples from three depth intervals were collected from borings B-35 and B-36; boring locations are shown on Figure 2. COPCs were not detected in any of these samples above MRLs. Therefore, based on recent soil sampling, COPCs in soil underlying the Storm Pond appear to be limited to TPHg, at depths above 7 feet, and laterally localized around boring B-16. Groundwater samples from this area did not contain COPCs, demonstrating that the limited residual TPHg in soil is not leachable.

5.3.2 Groundwater

Groundwater data have been collected over the period from 2002 to 2020. Results indicate the presence of three localized areas of groundwater containing one or more Site COPCs at concentrations above MTCA Level A concentrations. These are:

- MW-5 Area;
- MW-6 Area; and
- Well MW-11 located within the VRU Area.

It is noted that the VRU Area was the subject area in the 2012 draft FS. At that time, the extent of BTEX and MTBE was present in three wells, MW-1 through MW-3 surrounding the VRU. MNA has successfully remediated this area so that now it is a small area localized around new well MW-11, and BTEX/MTBE concentrations are below MTCA Level A criteria in wells MW-1 though MW-3.

Grab groundwater samples collected in the overflow Storm Pond and groundwater samples collected from well MW-4, which is located in the Truck Loading Rack Area, are non-detect for Site COPCs and demonstrate that the limited amount of residual petroleum impacted soil in these areas is not adversely affecting groundwater.

MW-5 Area

Well MW-5 was installed in the northwestern area of the Facility to monitor petroleum hydrocarbons identified in boring SB-8R, advanced in this area in 2003. Groundwater investigations conducted between 2014 and 2019 have defined the lateral and vertical extent of COPCs in groundwater around well MW-5, as shown on Figures 10 and 11 for TPH and BTEX, respectively. Three shallow wells, MW-5, MW-8, and MW-9, screened from 10 to 25 feet bgs and two deeper wells, MW-5D and MW-8D, screened from 35 to 45 feet bgs have been installed in the area to monitor concentration trends in groundwater.

As illustrated on Figure 9, the inferred lateral extent of TPH in first encountered groundwater beneath the MW-5 Area is approximately 100 by 200 feet. The vertical extent of TPH is less than 55 feet bgs and, with the exception of a limited area of low TPH concentrations near borings B-9 and B-20, is generally less than 35 feet bgs in this area (Figure 7).[1]

Benzene and toluene are not present in groundwater above MRLs in the MW-5 Area and ethylbenzene and xylenes are limited both laterally and vertically (Table 3). Figure 10 summarizes BTEX results for first encountered groundwater and illustrates that ethylbenzene and xylenes are

[1] TPH was detected in groundwater down to 40 feet at location B-5 at concentrations above MTCA Level A criteria; however, TPH has not been detected above MTCA Level A criteria in groundwater samples from deeper monitoring well MW-5D installed adjacent to this boring.

limited to an area directly around well MW-5. The vertical extent of ethylbenzene and xylenes appears to be less than 30 feet bgs (Figure 8). Although the grab groundwater sample collected at boring B-5 from 35 to 40 feet bgs indicated the presence of ethylbenzene and xylenes (Figure 8), samples from well MW-5D which was installed adjacent to this boring and screened from 35 to 45 feet bgs have not exhibited the presence of BTEX, including ethylbenzene and xylenes (Table 4). No other groundwater samples collected below a depth of 30 feet in this area exhibited BTEX above MRLs (Figure 8).

MW-6 Area

Well MW-6 was installed in the southwestern area of the Facility to monitor petroleum hydrocarbons identified in a boring, SB-9, advanced in this area in 2003. Groundwater investigations conducted between 2015 and 2019 defined the vertical extent of COPCs in groundwater around well MW-6, as shown on Figures 7 and 8 for TPH and BTEX, respectively. As shown on these figures, concentrations decrease rapidly below a depth of 25 to 30 feet bgs and the vertical extent of petroleum hydrocarbons above MTCA Level A criteria does not extend below 40 feet bgs.

Petroleum hydrocarbons were encountered in shallow soil and groundwater samples obtained from boring B-18 in 2019. Additional investigation was conducted in 2020 to better define the lateral extent of petroleum hydrocarbons in soil and groundwater around this boring. As shown on Figure 9, the lateral extent of TPH in first encountered groundwater in the MW-6 Area is approximately 125 feet by 225 feet and incorporates the boring B-18 Area. The extent of BTEX in this area is more limited and is not connected between well MW-6 and boring B-18, as shown on Figure 10.

VRU Area

Wells MW- 1 through MW-4 were installed in 2002 to monitoring groundwater in the area around the former VRU and decommissioned UST. Groundwater samples from these wells have been below MTCA Level A criteria since 2010. In 2019, it was noted that historical grab groundwater samples directly adjacent to the former VRU in 2003 contained petroleum constituents at concentrations above MTCA Level A criteria and an additional soil boring, B-22, and monitoring well, MW-11, were installed in this area to better assess current conditions. Monitoring well MW-11 has been monitored for four quarters and the results are tabulated in Table 4 for TPH, BTEX, and naphthalene. As can be seen in Table 4, TPH, BTEX, and naphthalene concentrations in groundwater remain below MTCA Level A criteria in wells MW-1 through MW-4, but TPHg, benzene, ethylbenzene, xylenes, and naphthalene were above MTCA Level A criteria during one or more monitoring events in well MW-11, indicating that a localized area of approximately 50 feet by 50 feet around well MW-11 contains petroleum hydrocarbons in groundwater above MTCA Level A criteria.

5.4 CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

A CSM and RA were prepared for the Facility in 2010 (Ash Creek, 2010). The RA evaluated reasonably likely exposure pathways based on the evaluation of land and water use as presented in the RI/RA report (Ash Creek, 2010). Potential receptors included industrial, construction, and excavation workers and potential future residential drinking water consumption from the CPU wellfield. Exposure pathways evaluated included direct contact with soil and groundwater, inhalation of vapors from soil or groundwater, future drinking water use of groundwater, and soil leaching to groundwater with subsequent use of groundwater. Exposure media included soil, groundwater, and air. The assessment evaluated risk using the COPCs identified in the RI/RA. This section updates the CSM and RA findings based on current Site conditions. The CSM is shown graphically on Figure 11.

5.4.1 Exposure Pathways and Risk Analysis

Exposure pathways were evaluated for both current and potential future on-site and off-site receptors. On-site receptors include industrial workers, construction workers, and excavation (utility) workers. Off-site receptors include current and potential future residents utilizing the CPU wellfield. If an exposure pathway was deemed complete, a risk analysis was performed to assess whether or not residual contamination could adversely impact on-site and off-site receptors. The following summarizes the complete pathways and associated risk.

Direct Contact with Surface Soil. Investigations conducted since 2003 support that soil shallower than 3 feet does not contain petroleum hydrocarbons at concentrations of potential concern for direct contact.

Direct Contact with Subsurface Soil. In the five localized areas discussed in Section 4.3.1, there is a potential for construction and/or excavation workers to encounter contaminated subsurface soils. However, on-site excavation activities are rare and standard operating procedures (SOPs) at the terminal limit potential exposure. Facility workers are aware of the potential for encountering impacted soils at the Facility and are required to wear personal protective equipment (PPE), which significantly reduces the potential for direct contact with Facility soils. Additionally, Facility workers are trained in the appropriate handling of petroleum products. Based on these protective measures, the potential presence of residual hydrocarbons in soil is not anticipated to present an unacceptable risk to on-site construction and excavation workers.

Leaching of Petroleum Hydrocarbons in Soil to Groundwater. With the exception of limited areas in the overflow Storm Pond, the Truck Loading Rack, and around boring B-18, petroleum hydrocarbons are not present in vadose zone soil at concentrations above MTCA Level A criteria. Grab groundwater samples collected in the overflow Storm Pond and near the Truck Loading Rack were non-detect for Site COPCs, demonstrating that residual TPH in vadose zone soil is not adversely impacting shallow groundwater.

However, TPH in vadose zone soil is present in a localized area near MW-5 at depths between approximately 7 and 9 feet and around boring B-18 at depths between 3 and 9 feet bgs, and these soils could represent an ongoing source of hydrocarbons to underlying groundwater in these areas. In addition, TPH is present in saturated soil in the 9- to 22-foot depth interval in the MW-5 and MW-6 Areas. Investigation completed within the VRU Area suggests that a limited amount of saturated soil containing TPH and BTEX exists around well MW-11 between 20 and 22 feet bgs.

Ingestion of Groundwater. The extent of dissolved phase constituents in groundwater has been characterized horizontally and vertically and is limited laterally to three localized areas: one in the southwest around well MW-6; a second in the northwest localized around well MW-5; and a third in the central eastern area around well MW-11. Petroleum hydrocarbon concentrations above MTCA Level A criteria are, for the most part, confined to shallow groundwater within fine-grained soils located between 9 and 25 feet bgs. Currently, there is no domestic use of groundwater from these depths at or in the vicinity of the Facility. However, the CPU plans to install production wells within the PAA, accessing groundwater from depths between 55 and 180 feet bgs, at their wellfield located approximately 500 feet north of the Site.

Summary of Risk Analysis. As identified above, direct contact with soil containing petroleum hydrocarbons does not present an unacceptable risk at the Facility, and the potentially complete exposure pathways appear to be vadose zone soil leaching to groundwater in the boring B-18 Area and future ingestion of groundwater. As noted above, CPU plans to install production wells in the PAA for groundwater withdrawal in 2021. According to Ecology, withdrawal of groundwater from the PAA has the potential to induce groundwater migration from the RAA beneath the Facility towards the CPU wellfield.

5.4.2 Ecological Risk Assessment

A Simplified Terrestrial Ecological Evaluation was conducted and the results documented in a September 21, 2020 memorandum; a copy of the Simplified TEE is contained in Appendix F. Site conditions at the Facility were evaluated consistent with WAC 173-340-7492, with the following conclusions:

- The four criteria: natural areas, vulnerable species, extensive habitat, and risk to significant wildlife populations, do not apply to the site; and therefore, a Simplified TEE is applicable.
- A Simplified TEE was performed and identified three subsurface soil locations with TPHd concentrations above ecological levels of concern listed in Table 4.1 of the TEE Guidance. However, all three locations are below 8 feet in depth, are beneath a paved area that is operated on a continuous basis as a truck loading rack precluding any habitat for birds or small mammals, and will be managed by an institutional control and soil management plan to eliminate the potential for future ecological exposure.

The Simplified TEE supports that the presence of TPH at the site will not present an unacceptable ecological health risk. The Simplified TEE was approved by Ecology on October 8, 2020.

6.0 APPLICABLE FEDERAL, STATE, AND LOCAL LAWS

The MTCA rules (WAC-173-340-710) require that cleanup actions comply with applicable state and federal laws, which are defined as "legally applicable requirements and those requirements that the department determines…are relevant and appropriate requirements" (i.e., ARARs). A cleanup action performed under MTCA authority (e.g., an Agreed Order) is exempt from the procedural requirements of certain state and local environmental laws, although the cleanup action must still comply with the substantive requirements of applicable federal, state, and local laws.

"Legally applicable" requirements include cleanup standards or environmental protection requirements under state or federal laws that specifically address a hazardous substance or cleanup action for a site. "Relevant and appropriate" requirements include cleanup standards or environmental requirements (e.g., cleanup standards, standards of control, environmental criteria, environmental limits, etc.) under state and federal law that, while not legally applicable to the cleanup action, address problems or situations that are considered sufficiently similar to those encountered at the Site. The ARARs applicable for the Site are as follows:

- **Safe Drinking Water Act (42 USC Section 300f).** The Safe Drinking Water Act (SDWA) sets a framework for the Underground Injection Control (UIC) Program to control the injection of wastes into groundwater. EPA and individual states implement the UIC program, which sets standards for safe waste injection practices and bans certain types of injection altogether.

- **Resource Conservation and Recovery Act.** The Resource Conservation and Recovery Act (RCRA) is the principal federal law in the United States governing the disposal of solid waste and hazardous waste. RCRA handles many regulatory functions of hazardous and non-hazardous waste. In the State of Washington, RCRA is implemented by Ecology under the Dangerous Waste Regulations (WAC 173-303).

- **State Environmental Policy Act (43.21C Revised Code of Washington [RCW]; WAC 197-11).** The State Environmental Policy Act (SEPA) was created to ensure that state and local government officials consider potential environmental impacts when making decisions. These decisions may be related to issuing permits for private projects, constructing public facilities, or adopting regulations, policies, or plans. The SEPA process begins when an application for a permit is submitted to a state or local government agency, or when an agency proposes to take an action such as the implementation of a remedial action. One agency is identified as the "lead agency" under the SEPA Rules (WAC 197-11-924-938) and is responsible for conducting the environmental review for a proposal and documenting that review in the appropriate SEPA documents.

- **Washington Hydraulic Code (Chapter 77.55 of RCW; WAC 220-110).** Under this code, any organization or agency wishing to conduct any construction activity that will use, divert, obstruct, or change the natural flow or bed of state waters must do so under the terms of a permit (called the Hydraulic Project Approval [HPA]) issued by the Washington Department of Fish and Wildlife.

- **Washington Solid Waste Management – Reduction and Recycling Act (Chapter 70.95 RCW; Chapter 173-350 WAC).** This act establishes a state-wide program for solid waste handling, recovery, and/or recycling to prevent land, air, and water pollution and conserve the natural and economic resources of the state.
- **Underground Injection Control Program (Chapter 173-218 WAC).** The program was designed to protect groundwater quality by preventing groundwater contamination by regulating the discharge of fluids into UIC wells. The program satisfies the intent and requirements of Washington State Water Pollution Control Act (Chapter 90.48 RCW) as well as Part C of the SDWA.
- **State of Washington Water Pollution Control Law (Chapter 90.48 RCW).** This legislation defines Ecology's authority and obligations for the wastewater discharge permit program. The Facility's stormwater discharges to ground must comply with State Waste Discharge Permit Number ST 6255 (Permit). The Permit is effective on May 1, 2020, and expires on April 30, 2025. The cleanup action would need to be consistent with the substantive requirements of the Permit, which include effluent limits for authorized discharges to ground, groundwater quality monitoring, and a best management practice that precludes any discharge in excess of the hydraulic capacity of the evaporative/ infiltration ponds, so that the surge pond overflows.
- **Water Resources Act (Chapter 90.54 RCW).** This act establishes fundamental policies for the utilization and management of the waters of the State of Washington. If construction-generated dewatering water or stormwater from the cleanup action is treated for discharge to water of the State of Washington, such discharge would need to comply with the requirements of the Facility's stormwater Permit and/or a National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit.

7.0 DEVELOPMENT OF CLEANUP STANDARDS

This section identifies the cleanup standards for the Site. In accordance with WAC 173-340-700(3), cleanup standards consist of the following components:

- Cleanup Level – Hazardous substance concentration that protects human health and the environment;
- Point of Compliance – The location on the Site where the cleanup level must be attained; and
- Additional Regulatory Requirements – Other requirements that apply to a cleanup action because of the type of action and/or the location of the Site.

No unacceptable risks were identified for current exposure pathways. Cleanup standards were developed in accordance with WAC 173-340-720 through WAC 173-340-760 for the potential future exposure pathway completed by withdrawal of groundwater from the PAA at the CPU wellfield. CPU plans to begin withdrawing groundwater from the PAA within the next year. This section develops cleanup standards for soil leaching to groundwater and for the domestic use of groundwater (i.e., drinking water).

7.1 SOIL LEACHING TO GROUNDWATER

For soil, Method A was used to develop the soil cleanup levels in accordance with WAC 173-340-704(1)(b).

7.1.1 Soil Cleanup Levels

Petroleum hydrocarbons have been identified in two limited areas in vadose zone soil at a depth interval of approximately 6 to 12 feet in the MW-5 and MW-6 Areas. Additionally, saturated silty soil in the 12- to 22-foot depth interval, which represents the zone of seasonal water table fluctuation, has been identified as containing petroleum hydrocarbons above MTCA Level A criteria across much of the area of groundwater impact in the MW-5 and MW-6 Areas. These petroleum hydrocarbons are weathered with little volatile compounds remaining but may have the potential to leach petroleum hydrocarbons to groundwater at concentrations of potential concern. Therefore, soil cleanup levels need to be developed based on protecting groundwater and established based on the highest beneficial use of groundwater. Based on WAC 173-340-720(1)(a), the highest potential beneficial use of groundwater is assumed to be drinking water unless it can be otherwise demonstrated. Method A levels for soil have been developed to be protective of groundwater based on a soil leaching pathway. Subsequently, the proposed MTCA cleanup levels for constituents of concern (COCs) in soil are as follows:

- TPHg – 30 mg/kg;
- Benzene – 0.03 mg/kg;
- Ethylbenzene – 6 mg/kg;

- Toluene – 7 mg/kg; and
- Xylenes – 9 mg/kg.

7.2 GROUNDWATER

For groundwater, Method A was used to develop the groundwater cleanup levels in accordance with WAC 173-340-704(1)(b).

7.2.1 Groundwater Cleanup Levels

Groundwater cleanup levels must be established based on the highest beneficial use of groundwater, which is assumed to be drinking water unless it can be otherwise demonstrated (WAC 173-340-720(1)(a)). Given that CPU plans to install wells and withdraw groundwater for municipal use from the PAA within the next year, potentially inducing Site COC migration, the highest beneficial use of groundwater at the Site is assumed to be drinking water (WAC 173-340-720(2)). Subsequently, the proposed MTCA cleanup levels for COCs in groundwater are as follows:

- TPHg – 800 µg/L (because benzene is or has been present in groundwater);
- TPHd – 500 µg/L;
- Benzene – 5 µg/L;
- Ethylbenzene – 700 µg/L;
- Naphthalene – 160 µg/L;
- Toluene – 1,000 µg/L; and
- Xylenes – 1,000 µg/L.

7.2.2 Groundwater Point of Compliance

Per WAC 173-340-720(8)(b), the standard point of compliance is throughout the Site and throughout the saturated zone. The conditional point of compliance for groundwater shall be monitoring wells MW-1 through MW-11.

8.0 CLEANUP ACTION EVALUATION CRITERIA

Cleanup actions were evaluated and selected based on the requirements of WAC 173-340-360. The following summarizes these MTCA requirements.

8.1 MTCA THRESHOLD REQUIREMENTS

Cleanup action selected under MTCA must meet four “threshold” requirements identified in WAC 173-340-360(2)(a) to be accepted by Ecology. All cleanup must:

- Protect human health and the environment;
- Comply with cleanup standards;
- Comply with ARARs; and
- Provide for compliance monitoring.

8.2 MTCA SELECTION CRITERIA

When selecting from remedial alternatives that meet the threshold requirements, the following criteria, identified in WAC 173-340-360(2)(b), must be evaluated:

- Use permanent solutions to the maximum extent practicable (see Section 7.2.1);
- Provide for a reasonable restoration time frame (see below);
- Consider public concerns;
- Prevent or minimize present and future releases and migration of hazardous substances in the environment; and
- Do not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures over the benefits of dilution and dispersion.

For groundwater cleanup actions:

- If practicable, a permanent cleanup action shall be used to achieve the cleanup levels for groundwater at the standard point of compliance; or
- Where a permanent cleanup action is not practicable, the following measures shall be taken:
  - Conduct treatment or removal of the source; and
  - To the maximum extent practicable, implement groundwater containment, including barriers or hydraulic control through groundwater pumping, or both, to avoid lateral and vertical expansion of the groundwater volume affected by the hazardous substance.

- Institutional controls shall be used if concentrations above Method A or B cleanup levels remain at the Site.

8.2.1 Use of Permanent Solutions and Disproportionate Cost Analysis

A disproportionate cost analysis (DCA) is conducted to determine whether a cleanup action uses permanent solutions to the maximum extent practicable. This is done by evaluating the relative benefits and costs of the cleanup action alternatives using the following process.

- Rank the potential alternatives from most to least permanent using the following criteria specified in WAC 173-340-360(3)(f).
  - Protectiveness – Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the Facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.
  - Permanence – The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.
  - Cost – The cost to implement the alternative, including the cost of construction, the net present value of any long-term costs, and agency oversight costs that are cost-recoverable. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls. Cost estimates for treatment technologies shall describe pretreatment, analytical, labor, and waste management costs. The design life of the cleanup action shall be estimated, and the cost of replacement or repair of major elements shall be included in the cost estimate.
  - Long-Term Effectiveness – Long-term effectiveness includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or off-site disposal in an engineered, lined, and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

- – Management of Short-Term Risks – The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.
- – Technical and Administrative Implementability – Ability to be implemented, including consideration of whether the alternative is technically possible; availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations and other current or potential remedial actions.
- – Consideration of Public Concerns – Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

- The most permanent cleanup action alternative shall be the initial baseline cleanup action.
- Compare the next most permanent cleanup action alternative to the baseline cleanup alternative. The alternative whose costs are disproportionate to the benefits shall be eliminated. Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower-cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower-cost alternative. The comparison of benefits and costs may be quantitative but will often be qualitative and require the use of best professional judgment.
- Repeat until only one alternative remains.

8.2.2 Determination of Reasonable Restoration Time Frame

To determine whether a cleanup action provides for a reasonable restoration time frame, the following factors from WAC 173-340-360(4) were considered:

- Potential risks posed by the Site to human health and the environment;
- Practicability of achieving a shorter restoration time frame;
- Current and potential future uses of the Site, surrounding areas, and associated resources that are or may be affected by releases from the Site;
- Availability of alternative water supplies;
- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the Site;

- Toxicity of the hazardous substances at the Site; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar site conditions.

A longer period of time may be used for the restoration time frame for a site to achieve cleanup levels at the point of compliance if the cleanup action selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options.

8.2.3 Qualitative Factors Considered in Evaluating Cleanup Actions

In evaluating potential cleanup actions, the following factors from WAC 173-340-370 were considered.

- Treatment technologies should be emphasized at sites containing liquid wastes, areas with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances that lend themselves to treatment.
- For sites with small volumes of hazardous substances, hazardous substances should be destroyed, detoxified, and/or removed to concentrations below cleanup levels throughout the Site.
- For portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable, engineering controls—such as containment—may be needed.
- Active measures should be taken to prevent precipitation and runoff from coming into contact with COCs in soils and waste materials.
- When hazardous substances remain on site at concentrations that exceed cleanup levels, those hazardous substances should be consolidated to the maximum extent practicable.
- For facilities within wellhead protection areas and/or overlying groundwater aquifers used for domestic water supply, active measures should be taken to prevent/minimize releases to groundwater via surface infiltration in excess of cleanup levels. Dilution should not be the sole method for demonstrating compliance with cleanup standards in these instances.
- Natural attenuation of hazardous substances may be appropriate at sites where:
  - Source control (including removal and/or treatment of hazardous substances) has been conducted to the maximum extent practicable;
  - Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health or the environment;
  - There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

- Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

9.0 TECHNOLOGY EVALUATION AND CLEANUP ACTION ALTERNATIVE DEVELOPMENT - MW-5, MW-6, AND VRU AREAS

This section screens technologies to assess whether they might be feasible for the conditions in the MW-5, MW-6, and VRU Areas, and describes the development of the cleanup action alternatives to be evaluated. The alternative development process includes identifying general response actions and corresponding technologies, screening technologies to eliminate technologies that are clearly not feasible, and assembling remaining technologies into a list of site-specific cleanup action alternatives.

9.1 TECHNOLOGY SCREENING

Technologies have been screened for soil and groundwater response actions. Table 5 presents the preliminary screening of the technologies with shaded options eliminated for further consideration. The technologies are discussed further below.

9.1.1 Preliminary Screening for Soil

The list of considered general response actions for **soil** includes:

- **Institutional Controls.** Institutional controls (e.g., land use restrictions and contaminated media management programs) are effective administrative tools for managing residual contamination. Given that some of the soil contamination is near and/or beneath existing infrastructure and therefore not accessible, institutional controls will be included as a component in all remedial alternatives, except for the no action alternative.
- ***In Situ* Solidification/Stabilization.** *In situ* solidification/stabilization (S/S) can be performed to lower the permeability of saturated soil, thus increasing its capacity to hold and immobilize petroleum hydrocarbons. Based on the American Petroleum Institute (API) residual saturation estimates, the silt unit encountered beneath the Facility can likely retain up to 10,000 mg/kg of TPHg and over 20,000 mg/kg of TPHd. To date, detected concentrations of TPH in soil beneath the Site are well below these estimates of residual saturation, indicating that the downward migration of residual contamination is unlikely. Since the Site is underlain by tight fine-grained soils up to depths of 35 feet, *in situ* S/S appears to be unnecessary and not retained as a technology for development of remedial alternatives.
- ***In Situ* Treatment.** *In situ* treatment systems, including soil vapor extraction, enhanced bioremediation, chemical oxidation, and thermal conductive heating are generally not technically viable or economical in the fine-grained soils underlying the Facility. Also, in-place soil vapor extraction was not retained because residual contamination is highly weathered and lacks a significant volatile fraction.

- **Soil Excavation and Off-Site Disposal.** An interim removal action was performed in April 2002, in which 60 to 100 cubic yards of petroleum-impacted soil surrounding an underground gasoline-vapor recovery tank were excavated and transported off-site for disposal in a subtitle D landfill. Excavation and off-site disposal could likewise be used to address accessible petroleum hydrocarbon containing materials (PCM) in other areas of the Facility. The extent of the PCM in soil has been delineated using exploratory borings, as detailed in Sections 2 through 4.3. Some of the PCM in soil is not accessible due to the presence of the existing infrastructure (e.g., ASTs, containment berms, Fire Suppression Water Reservoir). Excavations below a depth of 12 feet would likely require shoring and groundwater management. The excavation and off-site disposal of accessible PCM has been retained as a technology for development of remedial alternatives.

9.1.2 Preliminary Screening for Groundwater

The list of considered general response actions for **groundwater** includes:

- **Institutional Controls.** Institutional controls (e.g., water use restrictions and contaminated media management programs) can be effective in mitigating direct contact with COCs in shallow groundwater. However, the proximity of the Facility to the CPU's drinking water wellfield greatly incumbers water use restrictions as a general response to managing the COCs in shallow groundwater. Therefore, institutional controls designed to ensure the proper management, disposal, and protection of workers contacting COCs in groundwater will be retained as a component of all groundwater remedial alternatives.

- **Monitored Natural Attenuation.** Petroleum hydrocarbons can naturally attenuate in groundwater via dispersion, sorption, and biodegradation, each of which can occur as groundwater migrates from source areas. Hydrocarbons are preferentially biodegraded under aerobic conditions. Natural attenuation of contamination in groundwater is retained as a technology for development of remedial alternatives and due to its demonstrated success in the eastern area of the Site. When using natural attenuation as a cleanup component, it is termed MNA to reflect the fact that it must be monitored to ensure its performance.

- **Plume Control/Containment.** Groundwater pumping and/or the *in-situ* delivery of colloidal activated carbon (e.g., PlumeStop or PetroFix) could be used to contain the COCs in the silt unit beneath the Site. The need for hydraulic control or plume containment as a remedial component is uncertain. The results of quarterly groundwater quality monitoring within the shallow and deeper water bearing zones beneath the Site indicate that petroleum-impacted groundwater is limited to the silt zone, not migrating, and concentrations are relatively low. However, CPU plans to initiate extraction of groundwater from the PAA which underlies the RAA; the silt unit containing COCs at the Site makes up the upper portion of the RAA. It is possible that the CPU's extraction of groundwater from the PAA could influence the groundwater gradients at the Site and cause migration of this currently stable plume. Therefore, hydraulic containment via groundwater pumping or plume control via direct injections of plume stabilizing reagents have been retained as technologies for development of remedial alternatives.

- ***In Situ* Treatment.** In October/November 2017, direct injections of RegenOx® (a proprietary *in situ* chemical oxidation substrate manufactured by Regenesis) and ORCAdvanced (an oxygen releasing formulation also manufactured by Regenesis) were pilot tested within the MW-5 Area. The RegenOx®/ORCAdvanced mixture was injected between depths of 15 and 25 feet in 24 direct-push borings spaced 15 feet apart. After the injections were completed, one year of groundwater monitoring was conducted to assess the effectiveness of contaminant mass reduction. The results of the pilot test determined that the tight fine-grained soils beneath the MW-5 Area significantly limited the effective distribution of chemical oxidation and enhanced bioremediation reagents using direct injection. The pilot study was beneficial in identifying physical issues that could be overcome for *in-situ* injection technologies to be successful at the Facility. For example, the lateral spacing between injection points needs to be less (e.g., 6 to 8 feet) and injection rate and pressures decreased to ensure lateral and vertical distribution through the thin fine-grained sand lenses present within the silt.

  Therefore, i*n situ* enhanced bioremediation has been retained as a technology for development of remedial alternatives. Specifically, the *in-situ* delivery of dissolved oxygen, and/or other biostimulants to speed up the natural degradation of dissolved phase petroleum hydrocarbons has been retained for remedial alternative development. However, the use of strong oxidants (e.g., Fenton's reagent) produce heat and pressure and can be corrosive on underground infrastructure such as tank bottoms and pipelines. Similarly, the use of thermal conductive heating in soil below steel petroleum storage and conveyance systems is neither safe nor appropriate. The high implementation risks associated using strong oxidants or thermal conductive heating beneath the Facility is reason for not retaining these types of *in situ* treatment technologies.

- ***Ex Situ* Treatment.** Groundwater extraction/pumping could be used to provide hydraulic containment in the MW-5, MW-6, and/or MW-11 Areas. Extracted groundwater would be treated aboveground (*ex situ*) using a combination of oil/water separation, volatilization, and/or carbon adsorption before discharge. The treated water could be discharged to the municipal sanitary system. Alternatively, the treated water could be reinjected if a suitable injection area could be accessed. It is also possible that the treated water could be amended with biostimulants (*ex situ*) and reinjected within the center of the plume areas to promote *in-situ* microbial degradation (i.e., groundwater recirculation). Groundwater extraction and *ex situ* treatment has been retained for remedial alternative development.

9.2 DEVELOPMENT OF CLEANUP ACTION ALTERNATIVES

Common Technologies. Some technologies are potentially applicable to any selected remedy. Common technologies include institutional controls and monitoring and are summarized below.

- Institutional Controls – Institutional controls are mechanisms for ensuring the long-term performance of cleanup actions. Institutional controls are often an integral component of remedies where contaminants exceeding cleanup levels remain at the Site. Institutional controls involve administrative/legal tools to provide notification regarding the presence of COCs, regulate the disturbance/management of these materials and the cleanup action components including prohibiting creation of preferential pathways for contaminant migration, and provide for long-term care of cleanup action including long-term monitoring. Under MTCA, the legal instruments for applying institutional controls are termed environmental covenants, equivalent to restrictive covenants for a specific property or portion of a property.

- Monitoring – Monitoring includes the sampling and laboratory analysis of various media to assess current risks and evaluate the effectiveness of implemented cleanup actions. Monitoring would focus on groundwater sampling to assess progress in groundwater cleanup. A groundwater monitoring well network already exists at the Site, so groundwater samples would be easy to collect at a low to moderate cost. Monitoring does not address impacts to soil or groundwater but allows an assessment of Site conditions at the time of the sampling.

The Common Technologies will be incorporated into each cleanup action alternative discussed in the sections below. When the specifics of these Common Technologies deviate from the general discussion, they will be elaborated on; otherwise, they may not be explicitly discussed in the evaluation of the alternatives.

Supporting Technologies. Technologies that are applicable only in support of specific cleanup technologies, such as treatment of waste streams, are not evaluated separately but are paired with the appropriate technologies: *ex situ* treatment of groundwater is paired with groundwater pumping, and the base of excavation may be lined with biostimulants prior to backfilling.

Cleanup Action Alternatives for Soil. Retained technologies were combined to form functional alternatives (such as combining the excavation of accessible vadose soil with an *in situ* treatment technology such as enhanced bioremediation). Review of the soil cleanup technologies identified two remedial alternatives for further evaluation:

- Excavation and off-site disposal of PCM; and
- Enhanced bioremediation.

Cleanup Action Alternatives for Groundwater. Technologies were combined to form functional alternatives (such as combining groundwater pumping with an *ex situ* treatment technology such as carbon adsorption). Review of the technologies identified four remedial alternatives for further evaluation:

- Excavation of PCM in the saturated zone and backfilling remedial excavations with slow release biostimulants to promote bioremediation of remaining COCs in groundwater;
- Direct injection of liquid micron-scale adsorbents and biostimulants to stabilize the dissolved phase plume, mitigate mass flux, and stimulate in-place hydrocarbon biodegradation;
- Groundwater recirculation to contain the plumes and enhance *in situ* biodegradation of residual petroleum hydrocarbons; and
- Groundwater pumping for hydraulic containment and mass removal throughout the source areas, *ex situ* treatment, and discharge to the municipal sanitary sewer system.

The no action alternative is also kept through the screening process to serve as a baseline for comparison.

10.0 EVALUATION OF CLEANUP ACTION ALTERNATIVES - MW-5, MW-6, AND VRU AREAS

In this section, the retained remedial technologies are assembled into cleanup action alternatives developed to meet the cleanup standards for the Facility discussed in Section 6. The alternatives were then evaluated with the Site conditions in mind, as presented in the fate and transport sections in Section 6. Namely,

- The COPCs are predominantly limited to TPH.
- BTEX and MTBE are either not present or present at low concentrations in small localized areas.
- TPH in soil are present in the saturated silty soil from depths of 12 to 22 feet in the water table fluctuation zone; the occurrence of petroleum hydrocarbons in soil above the water table is limited to a small area to the east of well MW-6 and a small area to the south of MW-5.
- TPH in groundwater are predominantly limited to the silty soil that is present to depths of 30 to 35 feet below the Site. The petroleum hydrocarbons are limited in extent and have not migrated in more than 15 years. Soil investigations and groundwater monitoring have demonstrated that natural attenuation is occurring at the Facility.

Alternative No. 1 (no action) was included as a baseline for comparison. Cleanup action alternatives were identified by arranging the retained components into sequential treatment approaches designed to achieve cleanup standards. In general, the order of selected alternatives ranks from least likely to meet the MTCA Method A cleanup criteria within a reasonable time frame and least permanent (i.e., Alternative No. 1 - No Action) to most likely and most permanent action (i.e., Alternative No. 6 - Removal of Accessible Petroleum-Impacted Soil and Enhanced Bioremediation). Table 6 provides descriptions of the cleanup action alternatives, and provides additional information regarding design assumptions, additional unknowns that may affect the design assumptions, and advantages and disadvantages associated with each alternative. In accordance with WAC 173-340-350(8)(b)(ii)(A), the cleanup action selection process (i.e., FS) includes at least one permanent cleanup action alternative to serve as a baseline against which other alternatives are evaluated for the purposes of determining whether the cleanup action selected is permanent to the maximum extent practicable.

10.1 ALTERNATIVE 1: NO ACTION

The no action alternative is presented to serve as a baseline for comparison.

Description. The no action alternative assumes that no actions are taken to treat, remove, or monitor COCs in soil and groundwater at the Site.

Threshold Requirements. The no action alternative provides no mechanism for compliance monitoring and thus does not meet the threshold requirements.

Use of Permanent Solutions. The no action alternative meets the use of permanent solutions; however, it does not provide the mechanism to document the permanent reduction. Natural processes that reduce concentrations of the COCs have been documented to occur at the Site; however, the proposed action does not provide for the ability to monitor the COCs.

Restoration Time Frame. The no action alternative does not provide for a method to document that this alternative will meet cleanup levels in a reasonable restoration.

Public Concerns. It is anticipated that public stakeholder concern would be significant for any alternative that does not include an active cleanup action.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. The no action alternative does not prevent/minimize releases at the Facility or reduce migration of COCs in groundwater.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. The no action alternative relies upon the benefit of natural attenuation from dilution and dispersion, but the primary mechanism for natural attenuation at this Site appears to be biological breakdown.

10.2 ALTERNATIVE 2: MNA

Description. MNA is a remedial approach that relies on naturally-occurring bacteria to degrade petroleum in soil and groundwater to concentrations less than cleanup levels. MNA is not a "do nothing" component of the cleanup process. Rather, to apply the MNA approach, it is necessary to demonstrate through several lines of evidence that degradation of residual contamination is occurring as a result of bacteriological processes. To demonstrate that MNA is occurring, groundwater samples would be collected on a quarterly basis (from existing monitoring wells) to evaluate the rate of contaminant breakdown and to confirm compliance with MTCA Method A cleanup levels. In compliance with Ecology's MNA guidance, long-term sources of groundwater contamination generally need to be removed or significantly reduced as a condition for the use of MNA as a remedial alternative.

Alternative 2 consists of institutional controls and long-term groundwater quality monitoring. The application of institutional controls provides notification regarding the presence of contaminated materials, regulates the disturbance/management of these materials, and prohibits the creation of preferential pathways for contaminant migration.

The principal assumption of Alternative 2 is that reductions of COCs within the shallow water bearing zone (silt unit) will occur through natural processes such as biodegradation, diffusion, dispersion, hydrolysis, and sorption.

There are no operation and maintenance requirements for this alternative.

The estimated present worth cost for this alternative is $900,000. These costs include filing institutional controls, groundwater monitoring, Ecology oversight, and a 15 percent contingency over a 30-year period. A detailed breakdown of these costs is presented in Appendix G.

Threshold Requirements. This alternative is not expected to meet two (denoted by "X") of the four minimum MTCA cleanup requirements as described below:

- X Protect human health and the environment if CPU initiates pumping from the PAA (e.g., expanded CPU pumping of the PAA might mobilize COCs in Site groundwater);
- ✓ Comply with cleanup standards (e.g., the natural attenuation of petroleum hydrocarbons in soil and groundwater has already been demonstrated at the Facility);
- X Comply with applicable federal and state laws (e.g., detected concentrations of COCs in groundwater beneath the Site are potentially not protective of human health if mobilized and captured by an expanded CPU wellfield); and
- ✓ Provide for compliance monitoring.

Use of Permanent Solutions. Natural processes that reduce concentrations of the COC have been documented to occur at the Site. Therefore, this alternative meets the use of permanent solutions threshold.

Restoration Time Frame. This alternative is not expected to meet cleanup levels within a reasonable time frame. This determination is because CPU has an active drinking water source wellfield within 500 feet of the Facility leading to an added emphasis on the alternative's ability to adequately control and monitor contaminant migration during the restoration time frame.

Public Concerns. It is anticipated that public stakeholder concern could be significant for an alternative that does not include a more active soil and/or groundwater cleanup action.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. This alternative does not prevent or minimize future releases at the Facility.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. This alternative relies upon the benefit of natural attenuation from dilution and dispersion, but the primary mechanism for natural attenuation at this Site appears to be biological breakdown.

10.3 ALTERNATIVE 3: HYDRAULIC CONTAINMENT

Description. Alternative 3 provides for the hydraulic control and containment of COCs in groundwater detected beneath the Site. Gradient control would be accomplished through the installation of approximately nineteen 35-foot-deep groundwater extraction wells throughout the defined extent of TPH in shallow groundwater. The estimate of 19 extraction wells is based on an assumed radius of influence of 25 feet while pumping from a 4-inch-diameter well at approximately 1 gpm. A pump test would be needed to develop the final design of the hydraulic containment system. Using submersible pumps, extracted groundwater would be routed to a common holding tank(s) and treatment enclosure. A typical treatment system for groundwater with TPH and relatively low levels of BTEX would likely consist of a coalescing plate separator and granulated carbon adsorption. Treated groundwater would likely be discharged to the municipal sanitary sewer system under permit with the publicly owned treatment works (POTW). In the event air stripping or sparging is needed to remove volatiles from the water before discharge, an air permit would have to be obtained from the Southwest Clean Air Agency.

A conceptual deployment scenario for Alternative 3 is presented on Figure 13.

The pump and treat system equipment would be routinely inspected for proper operation. These inspections would include verifying the operation of system components and the collection of system samples to ensure compliance with discharge criteria. Routine maintenance of the system would include checking equipment performance and providing maintenance, as needed. Frequency of these maintenance tasks is dependent upon pump testing and final design.

The estimated present worth cost for this alternative is approximately $8,000,000 and includes a 15 percent contingency and assumes that the system will need to be operated for at least 30 years to achieve goals. The design/installation cost (i.e., capital costs) is estimated to be approximately $900,000. The present worth of the treatment system operation, data analysis, and maintenance costs with long-term groundwater is estimated to be $7,100,000 over a 30-year period. A detailed breakdown of the cost estimate for Alternative 3 is provided in Appendix G.

Threshold Requirements. This alternative is expected to meet the threshold requirements as follows:

- Protects human health and the environment by controlling the migration of COCs, reducing residual contaminant levels by extracting source area groundwater for *ex situ* treatment, and implementing institutional controls.
- Hydraulic control concurrent with MNA is expected to reduce COC concentrations in soil and groundwater to below MTCA Method A cleanup criteria;
- Numerical standard ARARs were incorporated into the cleanup level determination. Procedural ARARs applicable to this alternative include the following,
  - State Water Resources Act – The state has jurisdiction over water resources. Withdrawal of groundwater for treatment would be conducted in accordance with water resources requirements.; and
  - SEPA – In accordance with WAC 197-11-253 through -268, Ecology, as the lead agency, would conduct an environmental review to make a determination as to whether the project would have a significant adverse environmental impact. It is unlikely that the project would have an adverse impact, but if necessary, changes could be made to address identified adverse impacts.

- This alternative includes routine groundwater quality monitoring to assess progress of the remedy.

Use of Permanent Solutions. This alternative removes petroleum mass from the subsurface via groundwater extraction and treatment. In addition, natural biodegradation has been demonstrated at this Site within the vadose and saturated zones, which will also provide permanent reduction of COCs.

Restoration Time Frame. It is anticipated that this alternative could take 30 or more years to achieve cleanup levels; therefore, it is not expected to meet cleanup levels within a reasonable time frame.

Public Concerns. This alternative is anticipated to have the highest support from public stakeholders because it is a commonly used remedial method and hydraulic containment could likely be achieved relatively quickly upon implementation.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. This alternative does not prevent or minimize future releases at the Facility. However, it is designed to mitigate the off-site migration of COCs.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. This alternative does not rely on dilution or dispersion; however, its effectiveness will be enhanced by the natural degradation of COCs that has been demonstrated to occur at the Facility.

10.4 ALTERNATIVE 4: PLUME STABILIZATION, ENHANCED BIOREMEDIATION

Description. Alternative 4 includes the direct injection of liquid activated carbon and biostimulants throughout residual source areas to minimize migration of the dissolved phase hydrocarbons and promote biodegradation. Specifically, this alternative assumes direct injection of PetroFix throughout the saturated silt zones in the MW-5, MW-6, B-18, and VRU Areas. The Alternative 4 cost estimate assumes the injection of PetroFix every 6 feet between depths of 15 and 25 feet using direct-push drilling equipment. The exact number and spacing of injection points, and reagent volumes, would be determined through pilot study. The injection of liquid activated carbon (1-2 micron in size) throughout the saturated silt zones is intended to stabilize the dissolved phase hydrocarbons within the silt and limit diffusion out of the silt. The injection of nitrate and/or sulfate electron receptors is designed to stimulate anaerobic biodegradation within subsurface regions exhibiting low levels of dissolved oxygen. The cost estimate assumes 10 years of MNA following the injection program.

A conceptual deployment scenario for Alternative 4 is presented on Figure 14.

The estimated present worth cost for this alternative is $2,600,000 (including a 15 percent contingency). The PetroFix injections are estimated to be approximately $1,900,000. The present worth of groundwater monitoring costs is estimated to be $700,000 over a 10-year period. A detailed breakdown of the cost estimates is provided in Appendix G.

Threshold Requirements. This alternative is expected to meet the threshold requirements as follows:

- ✓ Protects human health and the environment by controlling the migration of COCs and reducing residual contaminant levels through direct injections of plume stabilizing liquid activated carbon and biostimulants to enhanced bioremediation.
- ✓ Efforts to mitigate dissolved phase mass flux concurrent with enhanced biodegradation are expected to reduce COC concentrations in soil and groundwater to below MTCA Method A cleanup criteria;
- ✓ Numerical standard ARARs were incorporated into the cleanup level determination. Procedural ARARs applicable to this alternative include the following:
  - State Water Resources Act – The state has jurisdiction over water resources. The injection of biostimulants in shallow groundwater for treatment would be conducted in accordance with water resources requirements;
  - UIC Program – Ecology regulates underground injection through its UIC program. The injection of liquid activated carbon and biostimulants in shallow groundwater for plume stabilization and enhanced bioremediation would be conducted in accordance with Ecology's UIC program; and
  - SEPA – In accordance with WAC 197-11-253 through -268, Ecology, as the lead agency, would conduct an environmental review to make a determination as to whether the project would have a significant adverse environmental impact. It is unlikely that the project would have an adverse impact, but if necessary, changes could be made to address identified adverse impacts.
- ✓ Provide for compliance monitoring (includes MNA).

Use of Permanent Solutions. Injections of anaerobic electron acceptors to enhance the natural degradation of residual contamination constitutes a permanent solution.

Restoration Time Frame. It is estimated that Alternative 4 would require approximately 10 years to achieve cleanup levels. For the following reasons, this restoration time frame is considered to be reasonable.

- The potential risks associated with off-site pumping in the PAA would be mitigated through on-site plume control.
- In general, the Site impacts do not have a substantive impact on Site use or resources.
- Because municipal water is available, shallow impacted groundwater beneath the Site is not currently used for drinking water.

- Institutional controls to address the shallow impacted groundwater would include restrictions on groundwater use beneath the Facility. This type of institutional control is effective and reliable.
- There is a long history of groundwater monitoring at the Site.
- Natural biodegradation has been demonstrated beneath the Site.

Public Concerns. The proposed action would be submitted for public comment and concerns raised would be addressed prior to design and implementation.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. This alternative does not prevent or minimize future releases at the Facility. However, it does reduce petroleum hydrocarbon mobility in the underlying silt.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. The alternative does not rely upon dilution and dispersion. MNA will occur via biodegradation.

10.5 ALTERNATIVE 5: GROUNDWATER RECIRCULATION

Description. Alternative 5 includes removal of readily accessible PCM, hydraulic containment of containment of the dissolved phase plumes, and reinjection/recirculation of treated/amended water inside the plumes to stimulate bioremediation.

PCM would be removed from the vadose zone down to 12 feet in two areas where shallower soil impacts were observed in the MW-5 and MW-6 Areas. The areal extent of each excavation is approximately 50 by 75 feet; excavation locations are shown on Figure 15. PCM would be removed to a depth of approximately 12 feet and the excavation would be backfilled with gravel to approximately 2 feet below grade. The upper 2 feet would be capped with a low permeability clay fill cap. An injection gallery would be constructed within each excavated area during the backfill process to allow injection of treated, amended water.

Alternative 5 assumes that hydraulic control and containment would be conducted using the same groundwater pump and treat system as described for Alternative 3. Following extraction and treatment, the extracted groundwater would be amended with biostimulants and reinjected into the backfilled excavations via the injection gallery for infiltration. These inground discharges of treated/amended water would be permitted and monitored in accordance with the state's UIC program. The groundwater extraction points would then pull this amended water through the impacted zone, forming a recirculation treatment cell. The continuous recirculation of oxygen/nutrient-rich water through the impacted zones is designed to actively enhance the biodegradation of residual COCs in soil and groundwater. A pilot test would be needed to develop the final design of the recirculation system.

To address the impacted groundwater in the VRU Area, the alternative would utilize plume stabilizing injections such as described for Alternative 4. This would entail multiple direct injections of liquid micron-scale adsorbents and biostimulants throughout the silt zone surrounding MW-11 within the VRU Area. An estimated 6-foot by 6-foot injection grid would be used in this area and reagents would be slowly injected at multiple depth intervals through direct-push injection points equipped with a surface seal to preclude daylighting.

A conceptual deployment scenario for Alternative 5 is presented on Figure 15.

The system equipment would be routinely inspected for proper operation. These inspections would include verifying the operation of system components and collection of a system sample to measure dissolved oxygen and hydrocarbon concentrations. Routine maintenance of the system would include checking nutrient supplies (and supplanting as necessary) and equipment maintenance, as needed. Frequency of these maintenance tasks is dependent upon the pilot testing and final design.

The estimated present worth cost for this alternative is $3,800,000 (including a 15 percent contingency). The design/installation cost (i.e., capital costs) is estimated to be approximately $1,600,000. It is assumed that the recirculation system would require 5 years to achieve goals, followed by 2 years of monitoring to demonstrate compliance. The present worth of the operation/maintenance, data analysis, and groundwater monitoring costs are estimated to be $2,200,000 over a 7-year period. A detailed breakdown of the cost estimates is provided in Appendix G.

Threshold Requirements. Alternative 5 meets the threshold requirements as follows.

- This alternative protects human health and the environment by controlling the migration of COCs and reducing residual contaminant levels through targeted removal actions, pumping and treating COCs in groundwater, and treating residual contamination *in situ* through groundwater recirculation and enhanced bioremediation.
- The alternative complies with the cleanup standards by reducing the COC concentration throughout the Site groundwater to below cleanup levels (using a combination of removal actions and *in-situ* treatment).
- Numerical standard ARARs were incorporated into the cleanup level determination. Procedural ARARs applicable to this alternative include the following.
  - <u>Underground Injection Control (UIC)</u> – The injection program would be permitted under the state UIC program.
  - <u>State Water Resources Act</u> – The state has jurisdiction over water resources. Withdrawal of groundwater for treatment would be conducted in accordance with water resources requirements.
  - <u>SEPA</u> – In accordance with WAC 197-11-253 through -268, Ecology, as the lead agency, would conduct an environmental review to make a determination as to whether the project would have a significant adverse environmental impact. As presented above, it is

unlikely that the project would have an adverse impact, but if necessary, changes could be made to address identified adverse impacts.

- The alternative includes compliance monitoring to verify that cleanup levels have been achieved.

Use of Permanent Solutions. Removal and off-site disposal of accessible PCM, removal and treatment of COC-containing groundwater, and enhanced bioremediation of residual contamination all constitute permanent solutions.

Restoration Time Frame. It is estimated that Alternative 5 would require approximately 5 to 7 years to achieve cleanup levels. For the reasons mentioned in the preceding alternative, this restoration time frame is considered to be reasonable.

Public Concerns. The proposed action would be submitted for public comment and concerns raised would be addressed prior to design and implementation.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. This alternative does not prevent or minimize future releases at the Facility. However, it provides hydraulic containment and both *ex-situ* and *in-situ* treatment of dissolved phase COCs.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. This alternative does not rely on dilution/dispersion; rather, it relies upon active removal and treatment of the COCs.

10.6 ALTERNATIVE 6: REMOVAL OF ACCESSIBLE SOIL, ENHANCED BIOREMEDIATION (ACTIVE)

Description. Alternative 6 includes the removal of all accessible petroleum-impacted soil and the placement of ORCs in the completed excavations to enhance aerobic biodegradation of residual contamination.

The removal actions will attempt to remove all PCM to an approximate depth of 22 feet bgs (i.e., both saturated and unsaturated PCM) within the MW-5 and MW-6 Areas. Clean overburden would be separately stockpiled based on field screening results. Contaminated soil would be placed in trucks and transported offsite for disposal under permit with a subtitle D landfill. The depth of excavation will require shoring (e.g., interlocking sheet piling) and excavation dewatering since excavation will extend into the saturated zone. It is assumed that extracted groundwater would be treated with duplex (or more) sand filtration and granular activated carbon vessels and discharged under an NPDES Construction Stormwater General permit. Following completion of the remedial excavations, confirmation soil samples would be collected from the sidewalls and base of the excavation to evaluate the effectiveness of each removal action. The excavations would be backfilled with structural fill and capped with impervious material.

It is assumed that some PCM may be left adjacent to and beneath ASTs, piping, and other immovable infrastructure. Therefore, this alternative includes the placement of ORCs at the final limits of the remedial excavations prior to backfilling to stimulate the growth of aerobic bacteria and enhance the degradation of residual petroleum hydrocarbons.

Because soil in the VRU Area is, for the most part, inaccessible, this alternative would utilize plume stabilizing injections such as described for Alternative 4 in the VRU Area. This would entail multiple direct injections of liquid micron-scale adsorbents and biostimulants throughout the silt zone surrounding MW-11 within the VRU Area. An estimated 6-foot by 6-foot injection grid would be used in this area, and reagents would be slowly injected at multiple depths intervals through direct-push injection points equipped with a surface seal to preclude daylighting.

A conceptual deployment scenario for Alternative 6 is presented on Figure 16.

The estimated present worth cost for this alternative is $4,300,000, including a 15 percent contingency and assuming that five years of monitoring will be required following removal to demonstrate compliance. The excavation and injection costs (i.e., capital costs) are estimated to be approximately $3,900,000. The present worth of groundwater quality monitoring costs are estimated to be $400,000 over a 5-year period. A detailed breakdown of the cost estimates is provided in Appendix G.

Threshold Requirements. Alternative 6 meets the threshold requirements as follows.

- This alternative protects human health and the environment by reducing residual contaminant levels through targeted removal actions and treating residual contamination *in situ* through the placement of ORCs in the excavations prior to backfilling.
- This alternative complies with the cleanup standards by reducing the COC concentrations throughout the Site groundwater to below cleanup levels (using a combination of removal actions and *in-situ* treatment).
- Numerical standard ARARs were incorporated into the cleanup level determination. Procedural ARARs applicable to this alternative include the following.
    - UIC – The injection program beneath the VRU Area would be permitted under the state UIC program.
    - State Water Resources Act – The state has jurisdiction over water resources. Withdrawal of groundwater for treatment would be conducted in accordance with water resources requirements.
    - SEPA – In accordance with WAC 197-11-253 through -268, Ecology, as the lead agency, would conduct an environmental review to make a determination as to whether the project would have a significant adverse environmental impact. As presented above, it is unlikely that the project would have an adverse impact, but if necessary, changes could be made to address identified adverse impacts.

- This alternative includes compliance monitoring to verify that cleanup levels have been achieved.

Use of Permanent Solutions. Removal and off-site disposal of PCM and enhanced bioremediation of residual contamination constitutes a permanent solution.

Restoration Time Frame. It is estimated that Alternative 6 would require approximately five years to achieve cleanup levels. This restoration time frame is considered to be reasonable.

Public Concerns. The proposed action would be submitted for public comment and concerns raised would be addressed prior to design and implementation.

Prevent/Minimize Releases and Migration of Hazardous Substances in the Environment. This alternative does not prevent or minimize future releases at the Facility. However, it does remove the majority of the PCM and promotes the biodegradation of residual contamination.

Degree to Which Cleanup Action Relies on Dilution/Dispersion. This alternative relies upon active removal and treatment of the COCs.

10.7 COMPARATIVE ANALYSIS OF THE CLEANUP ALTERNATIVES

The potential cleanup action alternatives were subjected to a comparative analysis based on the criteria from WAC 173-340-360(3)(f) as summarized in Section 7. The comparative analysis is a one-to-one assessment of the relative merits of each alternative for each of the evaluation criteria[2]. Table 7 summarizes the comparative analysis. Each alternative has been assigned an MTCA benefits ranking (i.e., numerical score between 1 and 5) relative to the balancing factors. The scores are summed at the bottom of the table for each alternative, and then the alternatives are assigned a benefit/cost ratio using the ranking divided by their estimated cost (present net value). The DCA was performed to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable. Specifically, the DCA quantifies the environmental benefits of each remedial alternative, and then compares alternative benefits versus costs. Costs are disproportionate to benefits if the incremental cost of a more permanent alternative over that of a lower-cost alternative exceeds the incremental benefits achieved by the alternative. The following discussion provides a rationale for the comparative evaluation presented in Table 7.

10.7.1 Protectiveness

The cleanup alternatives (excluding Alternatives 1 and 2) would all be protective of human health and the environment but vary in the technologies used to achieve that protectiveness. Although there is no evidence that dissolved phase COCs extend beyond the property boundaries, or that the COCs are migrating, Alternatives 3 and 5 include hydraulic containment within the Shallow Zone to prevent future migration should pumping from the PAA at the CPU wellfield change current

[2] Criteria to evaluate use of permanent solutions to the maximum extent practicable.

groundwater gradients, inducting mass flux from the silt zone. Alternative 3 would address the migration potential to the CPU wellfield using hydraulic containment but mass removal via extraction and *ex situ* treatment would be slow. In addition to hydraulic containment, Alternative 5 includes the removal of accessible vadose zone PCM and recirculation to enhance *in situ* bioremediation. Alternative 4 includes the injections of liquid activated carbon and biostimulants to further immobilize dissolved phase COCs and enhance bioremediation. Alternative 6 includes the removal of accessible PCM within the silt zone of the MW-5 and MW-6 Areas which may act as an ongoing source of COCs to groundwater followed by enhanced aerobic biodegradation at the limits of the excavations, and stabilization of the plume in the VRU Area.

Based on the above considerations, Alternatives 5 and 6 were given ratings of 4 for overall protectiveness (5 = high protectiveness). Alternatives 3 and 4 were assigned ratings of 3 since no source area removal is proposed. Alternatives 1 and 2 were assigned protectiveness ratings of 1 and 2, respectively.

10.7.2 Permanence

Alternative 6 is considered the most permanent alternative because it provides for the most removal PCM via excavation and off-site disposal. Landfill disposal addresses contaminant mobility but does not reduce toxicity or volume (although contaminants may continue to naturally attenuate in the landfill). Alternative 5 would include targeted removal and landfill disposal of readily accessible PCM in the vadose zone. Natural attenuation is reducing soil and groundwater concentrations beneath the Site and will continue to do so in all of the alternatives (including Alternatives 1 and 2). Based on the restoration time frame, Alternatives 5 and 6 were given a rating of 4 for the permanence criterion. Hydraulic containment of groundwater as proposed in Alternatives 3 and 4 would reduce contaminant mobility over Alternatives 1 and 2, and subsequently they were assigned ratings of 3. Alternatives 1 and 2 were assigned ratings of 1 and 2, respectively.

10.7.3 Long-Term Effectiveness

Alternative 6 has the highest certainty for long-term effectiveness because it provides for the removal and off-site disposal of the most PCM in the silt zone. Alternatives 3 and 5 are also anticipated to have high long-term effectiveness via active hydraulic containment and biodegration, both natural via Alternative 3 or enhanced via Alternative 5. The long-term effectiveness of Alternative 4 is less certain as this technology, stabilizing the plume via injection of micro-carbon, is relatively new. Alternative 2 is anticipated to have long-term effectiveness unless pumping from the PAA at the CPU wellfield were to change groundwater gradients.

Based on the above considerations, Alternative 6 was given a rating of 5 for long-term effectiveness. Alternatives 3 and 5 were assigned a rating of 4. Alternative 4 was assigned a rating of 3. Alternative 2 was assigned a rating of 2 based on the CPU plans for pumping from the PAA.

10.7.4 Management of Short-Term Risks

Alternatives 1 and 2 were given low ratings of 1 and 2, respectively, because they do not address the potential for migration of COCs should pumping from the PAA at the CPU wellfield change groundwater gradients and induce COC migration. Alternative 6 was also rated low with a rating of 1, because the excavation in tank farms and around ASTs, piping, and other infrastructure carries high implementation risk. Alternative 4 will require an injection subcontractor to be on site working in the active tank farm areas for an extended amount of time, which also increases short-term risks; therefore, this alternative was also rated relatively low at 2. Alternatives 3 and 5 would require time to install the extraction and treatment systems at the Facility, but this will take significantly less time than the other alternatives, so Alternatives 3 and 5 were given a rating of 4.

10.7.5 Implementability

Alternatives 1 and 2 were given ratings of 5 and 4, respectively, for implementability since they don't involve active cleanup. Of the four active cleanup alternatives, Alternative 6 has the lowest rating of 2 because of the depth of excavation and the difficulties of excavation within an active fuel terminal. Alternative 4 was assigned a slightly higher implementability rating of 3, but installing numerous injection points throughout an active terminal will also carry relatively high implementation difficulties. Alternatives 3 and 5 were assigned an implementability rating of 4 to recognize that installation of the hydraulic containment system will not be without difficulty but will likely be easier than the other active alternatives.

10.7.6 Consideration of Public Concerns

Alternative 6 was given the highest rating of 5 because it is expected to meet the MTCA Method A cleanup levels within the shortest amount of time. Alternative 3 was given the next highest rating at 4 because hydraulic containment through groundwater extraction and treatment is a reliable, well-known technology. Alternatives 4 and 5 were given neutral ratings of 3 because they could provide significant public benefit but are newer technologies. Alternatives 1 and 2 were provided ratings of 1 and 2, respectively, as it is anticipated that they would have the least public acceptance.

10.7.7 Benefits Rankings, Estimated Costs, and Benefit/Cost Ratios

The MTCA benefits rankings, estimated costs, and benefit/cost ratios for five of the alternatives (except Alternative 1) are presented at the bottom of Table 7. MTCA benefits ranking is obtained for each alternative by summing the ratings. The benefit rankings range from a low of 12 for Alternative 1 to a high of 27 for Alternative 6.

The total present worth costs for the alternatives are summarized as follows:

- Alternative 1: $ 0
- Alternative 2: $ 900,000
- Alternative 3: $ 8,000,000

- Alternative 4: $ 2,600,000
- Alternative 5: $ 3,800,000
- Alternative 6: $ 4,300,000

The most permanent alternatives (Alternatives 4-6) appear to offer equal protectiveness. Therefore, the additional cost of removing accessible petroleum-contaminated soil (PCS) appears to be disproportionate to the benefit. It is important to note, that changes in assumptions regarding the duration of hydraulic containment and MNA, and their associated treatment system operation/maintenance and groundwater quality monitoring, significantly impact the cleanup alternative costs estimated in the FS. For instance, it is difficult to accurately forecast the differences in biodegradation restoration time between: (a) the placement of biostimulants in the remedial excavations prior to backfilling; versus (b) the recirculation of water amended with biostimulants between the backfilled remedial excavations and extraction wells; versus (c) the direct injections of plume stabilization and biostimulants throughout residual contamination.

The benefit/cost ratio, which is a relative measure of cost effectiveness, is obtained by dividing each alternative's benefits ranking by its estimated cost. Because the cost of Alternative 2 (MNA) is the lowest relative to the other alternatives, its benefit/cost ratio (1.78) is the highest. The next highest benefit/cost ratio is Alternative 4 at 0.69 with Alternative 5 essentially tied at 0.68. The remaining alternatives achieved the following benefit/cost ratios in descending order: Alternative 6 (0.60) and Alternative 3 (0.33).

Conclusion of Comparative Analysis. Based on the results of the DCA presented above, Alternatives 4 and 5 are the most cost effective of the five cleanup alternatives in this FS. However, Alternative 5 is a more proven technology and therefore, under MTCA, Alternative 5 is identified as the alternative that is permanent to the maximum extent practicable.

10.7.8 Evaluation with Respect to Reasonable Restoration Time Frame

A cleanup action is considered to have achieved restoration once cleanup standards have been met. Alternatives 3 through 6 are expected to comply with cleanup standards. The restoration time frame for these alternatives to meet groundwater cleanup levels beneath the Site has been estimated as follows:

- Alternatives 2 and 3: 30 years
- Alternative 4: 10 years
- Alternative 5: 7 years
- Alternative 6: 5 years

WAC 173-340-360(4)(b) provides a list of factors to be considered to determine whether a cleanup action provides for a reasonable restoration time frame. Table 8 presents an evaluation of the cleanup alternatives with respect to these factors. Based on that evaluation, Alternatives 4 through 6 are expected to provide for a reasonable restoration time frame.

11.0 TECHNOLOGY AND CLEANUP ALTERNATIVE EVALUATION – TRUCK LOADING RACK AREA

This section screens technologies to assess whether they might be feasible for the conditions in the Truck Loading Rack Area and describes the development of the cleanup action alternatives to be evaluated. The alternative development process includes identifying general response actions and corresponding technologies, screening technologies to eliminate technologies that are clearly not feasible, and assembling remaining technologies into a list of potentially viable cleanup action alternatives for soil in the Truck Loading Rack Area.

11.1 TECHNOLOGY SCREENING AND CLEANUP ALTERNATIVES DEVELOPMENT

Table 9 presents the technology screening and evaluation for possible cleanup technologies for the Truck Loading Rack Area. Following the technology screening process for remedial alternatives applicable to the Truck Loading Rack Area, the following technologies were retained:

1. No Action (retained for comparison purposes)
2. Institutional Controls
3. Excavation
4. Off-Site Disposal

Three cleanup alternatives were developed based on the technologies retained. The cleanup alternatives developed for more detailed evaluation are:

1. No Action (retained for comparison purposes)
2. Institutional Controls – Deed Restrictions and Soil Management Plan
3. Excavation with Off-Site Disposal

11.2 EVALUATION OF CLEANUP ALTERNATIVES

This section evaluates the cleanup alternatives developed for the Truck Loading Rack Area for protectiveness, permanence, long-term effectiveness, management of short-term risks, implementability, and consideration of public concerns. The evaluation was based on the following summary of conditions and assumptions relevant for the cleanup alternatives evaluation:

- Based on soil borings completed in the Truck Loading Rack Area, the petroleum impacted soil with concentrations of TPH above MTCA Method A cleanup levels is limited to the vadose zone from approximately 6 feet bgs to approximately 16 feet bgs. The extent of soil above MTCA Method A cleanup levels is approximately 40 feet by 90 feet.

- Seasonally high groundwater is encountered at monitoring well MW-4 at approximately 22 feet bgs; therefore, soil containing petroleum hydrocarbons is at least 6 feet above the water table.

- Based on groundwater monitoring conducted to date, there is no leachable fraction remaining in the PCM in the Truck Loading Rack Area, and groundwater in this area is not affected.

Table 10 provides a summary of the ranking of each of the alternatives relative to the others for each of the evaluation criteria. The basis for the rankings is discussed below.

11.2.1 Protectiveness

Alternatives 2 and 3 are scored equally for protectiveness. Alternative 3 would remove the PCS for off-site disposal. However, the PCS in the Truck Loading Rack Area is covered by approximately 6 feet of clean overburden soil, which provides protection to human health and the environment, and can be managed safely in place. Alternative 2 would require that a deed restriction be amended to the property deed. The deed restriction would identify the presence of PCS in the subsurface and require implementation of a soil management plan to manage the PCS should excavations occur in the area. Most often, the soil management plan is prepared and amended to the deed via the deed restriction to ensure its future implementation. The deed restriction and soil management plan included in Alternative 2 would assure protectiveness by preventing inadvertent exposure to or movement of the PCS.

11.2.2 Permanence

Alternative 3 scores higher for permanence because the alternative involves the removal of PCS from the Truck Loading Rack Area. The excavated PCS would be transported off-site to a permitted disposal facility. Alternative 2 would establish restrictions on future uses of the portion of the property at the Truck Loading Rack. The deed restriction would be a legal document, recorded with Clark County and would remain in-place until it could be demonstrated that soil with petroleum hydrocarbon concentrations above MTCA Level A cleanup levels no longer were present in the area. Furthermore, the soil management plan would establish requirements for training personnel on the presence of the PCS remaining in the subsurface and identifying when protective measures described in the soil management plan apply to future excavation activities. The soil management plan would describe protocols that would need to be followed should soil in the restricted area need to be accessed.

11.2.3 Long-Term Effectiveness

Alternative 3 scores higher for long-term effectiveness because the alternative involves the removal of PCS from the Truck Loading Rack Area, whereas Alternative 2 would manage the PCS in place. However, given that the PCS in the vadose zone is not mobile and does not pose a human health or ecological risk unless accessed, Alternative 2 would also provide long-term effectiveness via the implementation of a soil management plan. Soil management plans are well-established tools for managing potential risks of in-place PCS. Amending the soil management plan to the property deed provides a mechanism for its long-term effectiveness.

11.2.4 Management of Short-Term Risks

Alternative 2 has the lowest short-term risk because it is a non-invasive alternative. Alternative 3 would involve the use of heavy construction equipment to excavate soil in close proximity to the Truck Loading Rack, ASTs, and underground piping. The operation of the heavy construction equipment has the potential to damage facility infrastructure. Furthermore, off-site disposal involves the transportation of PCS in dump trucks on public roadways to an approved disposal facility, including risk due to the potential for a traffic accident or release of PCM during transport.

11.2.5 Implementability

Alternative 2 was rated the most implementable alternative because it is a non-invasive alternative. In addition to the logistics of implementing the excavation activities anticipated with Alternative 3, the Truck Loading Rack is a critical element of the Facility operations, and it is anticipated that the Facility would be required to shut-down during the soil excavation. In addition, the ASTs at the Truck Loading Rack would likely need to be emptied for the duration of the excavation activities of Alternative 3.

11.2.6 Consideration of Public Concern

Alternatives 2 and 3 scored the same of consideration of public concern. While Alternative 3 involves removing the PCS, it also requires the PCS be transported off-site for disposal, which will incur significant truck traffic and could cause short-term disruptions to adjacent businesses and residents. Alternative 2 leaves PCS to be managed in place but would not involve any disruptions to local businesses or residents.

11.2.7 Benefits Rankings, Estimated Costs, and Benefit/Cost Ratios

As shown in Table 10, Alternative 2 has a slightly higher score of 4 over the score of 2 for Alternative 3, based on the comparison of the alternatives with respect to protectiveness, permanence, long-term effectiveness, management of short term risks, implementability, and consideration of public concern. The comparison shows that while removal of PCS in Alternative 3 is likely the more permanent alternative, the removal includes significant short-term and implementability risks given the proximity of the excavation area to the truck loading rack, ASTs, and underground piping. Both alternatives would be equally protective; however, the significant disruption to the neighborhood due to increased truck traffic would likely concern the public more than the management of the PCS in place.

The benefit/cost ratio, which is a relative measure of cost effectiveness, is obtained by dividing each alternative’s benefits ranking by its estimated cost.

The total present worth costs for the alternatives are summarized as follows:

- Alternative 1: $ 0
- Alternative 2: $ 34,455
- Alternative 3: $ 584,670

Alternative 2 has the highest benefit/cost ratio at 11.6, compared to 0.34 for Alternative 3. The significant difference between the cost/benefit ratios for the two alternatives demonstrates that the added permanence of Alternative 3 resulting from the excavation of PCS is disproportionate to the costs associated with implementation of Alternative 3. Given that petroleum hydrocarbons present in the vadose zone at the Truck Loading Rack Area are not migrating nor leaching to groundwater, and the PCS is capped by 6 feet of clean overburden, there is minimal risk to human health or the environment to manage the PCS in place using a deed restriction and soil management plan. Based on this evaluation, the recommended alternative for the Truck Loading Rack Area is Alternative 2: Institutional Controls utilizing a deed restriction on the property to restrict access to the PCS and effectively manage this soil in place.

12.0 RECOMMENDED CLEANUP ACTION ALTERNATIVE

Based on the results of this FS, the recommended cleanup action alternative for the MW-5, MW-6, and VRU Areas is Alternative 5 – Groundwater Recirculation, and for the Truck Loading Rack Area is Institutional Control. These alternatives includes the following treatment technologies:

- Removal of readily accessible PCM in vadose zone soil in the MW-5 and MW-6 Areas;
- Hydraulic containment of the dissolved phase plumes in the MW-5 and MW-6 Areas;
- Reinjection/recirculation of treated/amended water inside the plumes to stimulate bioremediation;
- Injection of plume stabilizing liquid micron-scale adsorbents and biostimulants throughout the silt zone surrounding MW-11 within the VRU Area; and
- Institutional controls for soil in the Truck Loading Rack Area.

This cleanup action was selected for the following reasons.

- The cleanup action meets the threshold requirements: protecting human health and the environment, complying with cleanup standards and ARARs, and providing for compliance monitoring.
- The restoration time frame is equivalent to other cleanup actions evaluated.
- Based on comparative costs, to the extent practicable, the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances.
- The cleanup action addresses the potential for present and future releases or migration of hazardous substances.
- Leaving contaminants on site during the restoration time frame does not pose an unacceptable threat to human health or the environment based on current exposure pathways.
- There is evidence that the indigenous microorganisms are naturally degrading residual petroleum hydrocarbons in soil and groundwater and can be enhanced following the removal of highly concentrated source areas.
- Appropriate monitoring requirements will be implemented to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

The final design of the cleanup action will be determined at the time of development of the cleanup action plan and will be based on the conditions present at the time of design.

13.0 REFERENCES

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TABLES

Table 1
Depth to Groundwater and Groundwater Elevations
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Well Number	Date of Measurement	Top of Casing Elevation (feet above MSL)	Screened Interval (feet bgs)	Depth To SPH (feet)	Depth to Groundwater (feet)	SPH Thickness (feet)	Groundwater Elevation (feet)
MW-1	05/14/2002	NS	14.5 - 24.5	--	16.00	--	NS
	05/25/2007	26.66		--	14.92	--	11.74
	08/24/2007	26.66		--	18.67	--	7.99
	11/26/2007	26.66		--	17.91	--	8.75
	02/27/2008	26.66		--	16.92	--	9.74
	03/30/2010	26.66		--	17.09	--	9.57
	09/01/2010	26.66		--	19.19	--	7.47
	12/16/2014	26.66		--	16.19	--	10.47
	03/25/2015	26.66		--	15.25	--	11.41
	06/24/2015	26.66		--	18.43	--	8.23
	09/15/2015	26.66		--	19.05	--	7.61
	11/30/2017	26.72		--	16.16	--	10.56
	02/28/2018	26.72		--	15.07	--	11.65
	05/29/2018	26.72		--	8.43	--	18.29
	08/30/2018	26.72		--	18.37	--	8.35
	02/18/2019	26.72		--	16.51	--	10.21
	05/20/2019	26.72		--	13.22	--	13.50
	08/28/2019	26.72		--	19.04	--	7.68
	11/18/2019	26.72		--	18.64	--	8.08
MW-2	05/14/2002	NS	20 - 35	--	27.46	--	NS
	05/25/2007	38.21		--	26.46	--	11.75
	08/24/2007	38.21		--	30.17	--	8.04
	11/26/2007	38.21		--	29.42	--	8.79
	02/27/2008	38.21		--	28.50	--	9.71
	03/30/2010	38.21		--	28.66	--	9.55
	09/01/2010	38.21		--	30.74	--	7.47
	12/16/2014	38.21		--	27.77	--	10.44
	03/25/2015	38.21		--	26.79	--	11.42
	06/24/2015	38.21		--	30.05	--	8.16
	09/15/2015	38.21		--	30.65	--	7.56
	11/30/2017	38.27		--	27.66	--	10.61
	02/28/2018	38.27		--	26.70	--	11.57
	05/29/2018	38.27		--	19.96	--	18.31
	08/30/2018	38.27		--	29.94	--	8.33
	02/18/2019	38.27		--	28.04	--	10.23
	05/20/2019	38.27		--	24.73	--	13.54
	08/28/2019	38.27		--	30.63	--	7.64
	11/18/2019	38.27		--	30.16	--	8.11

Please refer to notes at end of table.

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MW-3	05/14/2002	NS	24.5 - 34.5	--	28.15	--	NS
MW-3	05/25/2007	39.11	24.5 - 34.5	--	27.17	--	11.94
MW-3	08/24/2007	39.11	24.5 - 34.5	--	31.04	--	8.07
MW-3	11/06/2007	39.11	24.5 - 34.5	--	30.36	--	8.75
MW-3	02/27/2008	39.11	24.5 - 34.5	--	28.71	--	10.40
MW-3	03/30/2010	39.11	24.5 - 34.5	--	29.55	--	9.56
MW-3	09/01/2010	39.11	24.5 - 34.5	--	31.65	--	7.46
MW-3	12/16/2014	39.11	24.5 - 34.5	--	28.54	--	10.57
MW-3	03/25/2015	39.11	24.5 - 34.5	--	27.72	--	11.39
MW-3	06/24/2015	39.11	24.5 - 34.5	--	30.85	--	8.26
MW-3	09/15/2015	39.11	24.5 - 34.5	--	31.52	--	7.59
MW-3	11/30/2017	39.17	24.5 - 34.5	--	28.61	--	10.56
MW-3	02/28/2018	39.17	24.5 - 34.5	--	27.18	--	11.99
MW-3	05/29/2018	39.17	24.5 - 34.5	--	20.91	--	18.26
MW-3	08/30/2018	39.17	24.5 - 34.5	--	30.80	--	8.37
MW-3	02/18/2019	39.17	24.5 - 34.5	--	28.94	--	10.23
MW-3	05/20/2019	39.17	24.5 - 34.5	--	26.03	--	13.14
MW-3	08/28/2019	39.17	24.5 - 34.5	--	31.51	--	7.66
MW-3	11/18/2019	39.17	24.5 - 34.5	--	31.06	--	8.11
MW-4	05/14/2002	NS	20 - 35	--	29.40	--	NS
MW-4	05/25/2007	40.17	20 - 35	--	28.35	--	11.82
MW-4	08/24/2007	40.17	20 - 35	--	32.12	--	8.05
MW-4	11/06/2007	40.17	20 - 35	--	31.40	--	8.77
MW-4	02/27/2008	40.17	20 - 35	--	30.40	--	9.77
MW-4	03/30/2010	40.17	20 - 35	--	30.77	--	9.40
MW-4	09/01/2010	40.17	20 - 35	--	32.62	--	7.55
MW-4	12/16/2014	40.17	20 - 35	--	29.63	--	10.54
MW-4	03/25/2015	40.17	20 - 35	--	28.76	--	11.41
MW-4	06/24/2015	40.17	20 - 35	--	31.92	--	8.25
MW-4	09/15/2015	40.17	20 - 35	--	32.61	--	7.56
MW-4	11/30/2017	40.23	20 - 35	--	29.59	--	10.64
MW-4	02/28/2018	40.23	20 - 35	--	28.60	--	11.63
MW-4	05/29/2018	40.23	20 - 35	--	21.88	--	18.35
MW-4	08/30/2018	40.23	20 - 35	--	31.86	--	8.37
MW-4	02/18/2019	40.23	20 - 35	--	30.04	--	10.19
MW-4	05/20/2019	40.23	20 - 35	--	26.74	--	13.49
MW-4	08/28/2019	40.23	20 - 35	--	32.59	--	7.64
MW-4	11/18/2019	40.23	20 - 35	--	32.09	--	8.14
MW-5	12/16/2014	27.03	10 - 25	--	16.60	--	10.43
MW-5	03/25/2015	27.03	10 - 25	--	15.37	--	11.66
MW-5	06/24/2015	27.03	10 - 25	--	18.89	--	8.14
MW-5	09/15/2015	27.03	10 - 25	--	19.35	--	7.68
MW-5	10/23/2017	27.03	10 - 25	--	17.82	--	9.21
MW-5	11/30/2017	27.03	10 - 25	--	16.39	--	10.64
MW-5	02/28/2018	27.03	10 - 25	--	15.41	--	11.62
MW-5	05/29/2018	27.03	10 - 25	--	8.68	--	18.35
MW-5	08/30/2018	27.03	10 - 25	--	18.55	--	8.48
MW-5	02/18/2019	27.03	10 - 25	--	16.70	--	10.33
MW-5	05/20/2019	27.03	10 - 25	--	13.19	--	13.84
MW-5	08/28/2019	27.03	10 - 25	--	19.31	--	7.72
MW-5	11/18/2019	27.03	10 - 25	--	18.92	--	8.11

Please refer to notes at end of table.

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MW-5D	10/24/2017	26.71	35 - 45	--	17.50	--	9.21
	11/30/2017	26.71		--	16.21	--	10.50
	02/28/2018	26.71		--	15.20	--	11.51
	05/29/2018	26.71		--	8.37	--	18.34
	08/30/2018	26.71		--	18.51	--	8.20
	02/18/2019	26.71		--	16.43	--	10.28
	05/20/2019	26.71		--	12.72	--	13.99
	08/28/2019	26.71		--	19.01	--	7.70
	11/18/2019	26.71		--	18.62	--	8.09
MW-6	12/16/2014	27.33	10 - 25	--	16.93	--	10.40
	03/25/2015	27.33		--	15.73	--	11.60
	06/24/2015	27.33		--	19.34	--	7.99
	09/15/2015	27.33		--	19.70	--	7.63
	10/24/2017	27.33		--	18.12	--	9.21
	11/30/2017	27.33		--	16.71	--	10.62
	02/28/2018	27.33		--	15.77	--	11.56
	05/29/2018	27.33		--	9.03	--	18.30
	08/30/2018	27.33		--	18.99	--	8.34
	02/18/2019	27.33		--	16.99	--	10.34
	05/20/2019	27.33		--	13.56	--	13.77
	08/28/2019	27.33		--	19.66	--	7.67
	11/18/2019	27.33		--	19.31	--	8.02
MW-7	11/30/2017	21.67	10 - 25	--	11.12	--	10.55
	02/28/2018	21.67		--	10.19	--	11.48
	05/29/2018	21.67		--	3.4	--	18.27
	08/30/2018	21.67		--	13.26	--	8.41
	02/18/2019	21.67		--	11.41	--	10.26
	05/20/2019	21.67		--	7.73	--	13.94
	08/28/2019	21.67		--	13.99	--	7.68
	11/18/2019	21.67		--	13.76	--	7.91
MW-8	11/30/2017	27.68	10 - 25	--	16.91	--	10.77
	02/28/2017	27.68		--	16.01	--	11.67
	05/29/2018	27.68		--	9.31	--	18.37
	08/30/2018	27.68		--	19.22	--	8.46
	02/18/2019	27.68		--	17.28	--	10.40
	05/20/2019	27.68		--	13.93	--	13.75
	08/28/2019	27.68		--	19.94	--	7.74
	11/18/2019	27.68		--	19.57	--	8.11
MW-8D	11/30/2017	27.87	35 - 45	--	17.36	--	10.51
	02/28/2018	27.87		--	16.35	--	11.52
	05/29/2018	27.87		--	9.53	--	18.34
	08/30/2018	27.87		--	19.41	--	8.46
	02/18/2019	27.87		--	17.59	--	10.28
	05/20/2019	27.87		--	13.9	--	13.97
	08/28/2019	27.87		--	20.21	--	7.66
	11/18/2019	27.87		--	19.80	--	8.07

Please refer to notes at end of table.

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MW-9	11/30/2017	29.39	10 - 25	--	18.78	--	10.61
	02/28/2018	29.39		--	17.79	--	11.60
	05/29/2018	29.39		--	11.09	--	18.30
	08/30/2018	29.39		--	21.04	--	8.35
	02/18/2019	29.39		--	19.13	--	10.26
	05/20/2019	29.39		--	14.63	--	14.76
	08/28/2019	29.39		--	21.74	--	7.65
	11/18/2019	29.39		--	21.28	--	8.11
MW-10	11/30/2017	28.71	10 - 25	--	18.16	--	10.55
	02/28/2018	28.71		--	17.19	--	11.52
	05/29/2018	28.71		--	10.38	--	18.33
	08/30/2018	28.71		--	20.3	--	8.41
	02/18/2019	28.71		--	18.42	--	10.29
	05/20/2019	28.71		--	14.76	--	13.95
	08/28/2019	28.71		--	21.02	--	7.69
	11/18/2019	28.71		--	20.67	--	8.04
MW-11	02/18/2019	NS	10 - 25	--	17.27	--	NS
	05/20/2019	NS		--	14.32	--	NS
	08/28/2019	NS		--	19.55	--	NS
	11/18/2019	NS		--	19.36	--	NS

Notes:

1. Survey elevations determined by Bluedot Group surveying, November 2017.
2. Reference elevation (i.e., top of casing) relative to NAVD 88, feet above mean sea level.
3. feet above MSL = feet above mean sea level.
4. NS = Not surveyed.
5. -- = SPH not measured/observed.
6. bgs = below ground surface.
7. SPH = separate phase hydrocarbon.

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Table 2
Soil Analytical Results: TPH and VOCs
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

				Concentrations in mg/kg (ppm)																	
Sample Location	Sample Date	Depth	TPH-HCID	TPHg	TPHd	TPHho	Benzene	Toluene	Ethylbenzene	Xylenes	1,2-Dibromo-ethane	1,2-Dichloro-ethane	Methyl tert-butyl ether (MTBE)	Naphthalene	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Isopropyl-benzene	n-Propyl-benzene	n-Butyl-benzene	Chloroform	Diehtylene glycol monomethyl ether
Soil Borings																					
GP-2	04/10-04/11/2002	10-12	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-3	04/10-04/11/2002	10-12	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-5	04/10-04/11/2002	17-19	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-7	04/10-04/11/2002	14-16	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-8	04/10-04/11/2002	6-8	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-9	04/10-04/11/2002	16-18	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-12	04/10-04/11/2002	22-24	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP14	05/09/2002	10-12	DET	**3,230**	**19,700**	<1,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP16	05/09/2002	10-12	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MW2	05/09/2002	25-26.5	ND	**314**	<25	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP26	06/26/2002	6-8	--	**5,850**	--	--	<2.5	**9.74**	**91.3**	**825**	<2.5	<2.5	<10	124	891	293	29.7	125	--	--	--
GP27	06/26/2002	10-12	--	**4.96**	--	--	<0.0050	<0.0050	<0.0050	<0.1	<0.05	<0.05	<0.2	<0.5	<0.1	<0.05	<0.2	<0.05	--	--	--
GP31	06/26/2002	22-24	--	<2.5	<25	<50	<0.0050	<0.0050	<0.0050	<0.0050	--	--	--	--	--	--	--	--	--	--	--
GP32	06/26/2002	6.5-8	--	**910**	**2,530**	<50	<5	<5	<5	**16**	--	--	--	--	--	--	--	--	--	--	--
GP33	06/26/2002	8-10	--	**363**	**31,500**	<2,500	<0.500	<0.500	**7.2**	**33.9**	--	--	--	--	--	--	--	--	--	--	--
GP34	06/26/2002	6-8	--	**728**	**13,600**	<1,000	<0.500	<0.500	0.717	**16.9**	--	--	--	--	--	--	--	--	--	--	--
GP35	06/26/2002	8-10	--	10.3	<25	<50	<0.0050	<0.0050	<0.0050	<0.0050	--	--	--	--	--	--	--	--	--	--	--
SB-2	04/17/2003	4	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-2	04/17/2003	22	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-4	04/17/2003	3	ND	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-4	04/17/2003	27	ND	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-5	04/17/2003	11	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-6	04/16/2003	3	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-6	04/16/2003	16	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-7	04/17/2003	12	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-8	04/17/2003	8	DET	**1,020**	**7,890**	<1,000	<0.500	<0.500	<0.500	7.45	--	--	--	6.14	31	20.4	<1	3.22	3.54	<0.5	--
SB-8	04/17/2003	16	DET	**369**	1,440	<50	<0.500	<0.500	<0.500	<1,000	--	--	--	6.47	1.67	<0.5	1.13	0.837	<2.5	0.539	--
SB-8R	09/30/2014	12	--	<5.0	<5.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9	04/18/2003	12	DET	**504**	1,890	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9	04/18/2003	15	DET	**168**	1,210	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9R	09/30/2014	12	--	**1,000**	**4,000**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9R	09/30/2014	13.5	--	--	**3,400**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-11	04/16/2003	2.5	ND	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-11	04/16/2003	14	ND	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-12	04/22/2003	3	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-12	04/18/2003	12	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-13	04/22/2003	2	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-13	04/22/2003	5	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Washington DOE MTCA Method A cleanup level[12.]				100/30[11.]	2,000	2,000	0.03	7	6	9	NA	NA	NA	5	NA	NA	NA	NA	NA	NA	NA

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 2
Soil Analytical Results: TPH and VOCs
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth	TPH-HCID	Concentrations in mg/kg (ppm) TPHg	TPHd	TPHho	Benzene	Toluene	Ethylbenzene	Xylenes	1,2-Dibromo-ethane	1,2-Dichloro-ethane	Methyl tert-butyl ether (MTBE)	Naphthalene	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Isopropyl-benzene	n-Propyl-benzene	n-Butyl-benzene	Chloroform	Diehtylene glycol monomethyl ether
Soil Borings (continued)																					
B-15	01/31/2019	4.5 - 5.5	--	<7.94	<28.2	<56.5	<0.0159	<0.0794	<0.0397	<0.119	--	--	<0.0794	<0.159	--	--	--	--	--	--	--
B-16-1	01/30/2019	3 - 4	--	<7.80	27.8 F-11	<52.2	<0.0156	<0.0780	<0.0390	<0.117	--	--	<0.0780	<0.156	--	--	--	--	--	--	--
B-16-2	01/30/2019	5 - 6	--	**1,900**	483 F-20	<52.0	<0.0683	<0.342	<0.171	<0.513	--	--	<0.342	1.53	--	--	--	--	--	--	--
B-17-1	01/31/2019	11.5 - 12.5	--	<9.32	<28.5	<56.9	<0.0186	<0.0932	<0.0466	<0.140	--	--	<0.0932	<0.186	--	--	--	--	--	--	--
B-17-2	01/31/2019	15 - 16	--	**38.7**	323 F-13	<61.2	<0.0174	<0.0872	<0.0436	<0.131	--	--	<0.0872	<0.174	--	--	--	--	--	--	--
B-18-1	01/30/2019	6.5 - 7.5	--	**5,100**	**12,800**	<1100	**0.295**	<0.777	**24.5**	**88.7**	--	--	<0.777	**60.7**	--	--	--	--	--	--	--
B-18-2	01/30/2019	**14 - 15**	--	**10,800**	**7,460**	<501	**4.05**	**67.6**	**98**	**524**	--	--	<3.07	**111**	--	--	--	--	--	--	--
B-19	01/29/2019	10 - 11	--	<7.59	<27.8	<55.6	<0.0152	<0.0759	<0.0380	<0.114	--	--	<0.0759	<0.152	--	--	--	--	--	--	--
B-20-1	02/04/2019	10 - 11	--	**302**	89.4	<50.0	<0.0139	<0.0696	<0.0348	<0.104	--	--	<0.0696	<.0.348	--	--	--	--	--	--	--
B-20-2	02/04/2019	12 - 13	--	**35.1**	<27.4	<54.7	<0.0157	<0.0836	<0.0418	<0.125	--	--	<0.0836	<0.157	--	--	--	--	--	--	--
B-21-1	02/01/2019	13 - 14	--	<8.11	<27.1	<54.3	<0.0162	<0.0811	<0.0405	<0.122	--	--	<0.0811	<0.162	--	--	--	--	--	--	--
B-21-2	02/01/2019	15.5 - 16.5	--	10.5	<25.0	<50.0	<0.0131	<0.0656	<0.0328	<0.0983	--	--	<0.0656	<0.131	--	--	--	--	--	--	--
B-23	01/29/2019	6.5 - 7.5	--	<7.26	<25.0	<50.0	<0.0145	<0.0726	<0.0363	<0.109	--	--	<0.0726	<0.145	--	--	--	--	--	--	--
B-24	01/28/2019	10.5 - 11.5	--	<7.19	<26.5	<53.1	<0.0144	<0.0719	<0.0359	<0.108	--	--	<0.0719	<0.144	--	--	--	--	--	--	--
B-25-1	01/28/2019	6 - 7	--	10.8	**5,540**	<534	<0.0146	<0.0728	<0.0364	<0.109	--	--	<0.0728	<0.146	--	--	--	--	--	--	--
B-25-2	01/28/2019	8.5 - 9.5	--	**88.6**	**7,650**	<518	<0.0148	<0.0739	<0.0369	<0.111	--	--	<0.0739	0.394	--	--	--	--	--	--	--
B-26	01/28/2019	8 - 9	--	<8.16	<27.3	<54.6	<0.0163	<0.0816	<0.0408	<0.122	--	--	<0.0816	<0.163	--	--	--	--	--	--	--
B-27	01/28/2019	7 - 8	--	**1,910**	**6,620**	<493	<0.0725	<0.363	**1.89**	**11.1**	--	--	<0.363	**11.2**	--	--	--	--	--	--	<10.5
B-27-2	01/28/2019	9 - 10	--	**11,500**	**23,700**	<1190	<0.597	<2.99	**71.2**	**573**	--	--	<2.99	**168**	--	--	--	--	--	--	--
B-28	01/28/2019	8 - 9	--	<8.95	<30.2	<60.4	<0.0179	<0.0895	<0.0359	<0.134	--	--	<0.0895	<0.179	--	--	--	--	--	--	--
B-29(6.5)	02/18/2020	6.5	--	<6.89	<25.6	<51.3	<0.0138	<0.0689	<0.0344	<0.103	--	--	--	<0.138	--	--	--	--	--	--	--
B-29(11)	02/18/2020	11	--	<7.69	<27.1	<54.1	<0.0154	<0.0769	<0.0384	<0.115	--	--	--	<0.154	--	--	--	--	--	--	--
B-29(21)	02/18/2020	21	--	<7.04	<26.3	<52.5	<0.0141	<0.0704	<0.0352	<0.106	--	--	--	<0.141	--	--	--	--	--	--	--
B-30(4.5)	02/18/2020	4.5	--	**6,510**	**14,700**	<1010	<0.246	<1.23	**23.8**	**223**	--	--	--	**82.2**	--	--	--	--	--	--	--
B-30(16)	02/19/2020	16	--	**2,930**	**2,630**	<52	**0.148**	<0.708	**18.6**	**51.9**	--	--	--	**26.3**	--	--	--	--	--	--	--
B-30(21.5)	02/19/2020	21.5	--	**1,660**	208	<51.5	**0.147**	<0.271	**15.4**	**12.9**	--	--	--	**14.3**	--	--	--	--	--	--	--
B-31(6.5)	02/18/2020	6.5	--	<7.31	<25.8	<51.6	<0.0146	<0.0731	<0.0366	<0.11	--	--	--	<0.146	--	--	--	--	--	--	--
B-31(14)	02/18/2020	14	--	**3,940**	**6,170**	<523	**0.199**	0.154	**16.6**	**30.2**	--	--	--	**42.2**	--	--	--	--	--	--	--
B-31(21.5)	02/18/2020	21.5	--	19.0	54.1	<50	<0.0141	<0.0707	0.289	0.645	--	--	--	0.354	--	--	--	--	--	--	--
B-32(9)	02/18/2020	9	--	<7.23	<25	<50	<0.0145	<0.0723	<0.0361	<0.108	--	--	--	<0.145	--	--	--	--	--	--	--
B-32(12)	02/18/2020	12	--	<7.9	<25.9	<51.7	<0.0158	<0.079	<0.0395	<0.119	--	--	--	<0.158	--	--	--	--	--	--	--
B-32(21)	02/18/2020	21	--	<6.05	<25.5	<50.9	<0.0121	<0.0605	<0.0303	<0.0908	--	--	--	<0.121	--	--	--	--	--	--	--
B-33(6.5)	02/18/2020	6.5	--	<7.49	<26.8	<53.7	<0.015	<0.0749	<0.0375	<0.112	--	--	--	<0.15	--	--	--	--	--	--	--
B-33(18)	02/19/2020	18	--	**437**	261	<54.5	<0.0154	<0.0771	<0.0386	<0.116	--	--	--	0.41	--	--	--	--	--	--	--
B-33(20)	02/19/2020	20	--	<7.61	<26.1	<52.2	<0.0152	<0.0761	<0.038	<0.114	--	--	--	<0.152	--	--	--	--	--	--	--
B-34(6.5)	02/19/2020	6.5	--	<7.45	<25.1	<50.3	<0.0149	<0.0745	<0.0373	<0.112	--	--	--	<0.149	--	--	--	--	--	--	--
B-34(18)	02/19/2020	18	--	28.7	47.8	<52.3	<0.0139	<0.0696	<0.0348	<0.104	--	--	--	<0.139	--	--	--	--	--	--	--
B-34(20)	02/19/2020	20	--	<7.82	<27.3	<54.5	<0.0156	<0.0782	<0.0391	<0.117	--	--	--	<0.156	--	--	--	--	--	--	--
B-35(6)	02/21/2020	6	--	<7.1	<26.7	<53.5	<0.0142	<0.071	<0.0355	<0.106	--	--	--	<0.142	--	--	--	--	--	--	--
B-35(9)	02/21/2020	9	--	<8.17	<26.8	<53.6	<0.0163	<0.0817	<0.0409	<0.123	--	--	--	<0.163	--	--	--	--	--	--	--
B-35(19)	02/21/2020	19	--	<7.51	<27.7	<55.4	<0.015	<0.0751	<0.0375	<0.113	--	--	--	<0.15	--	--	--	--	--	--	--
B-36(6)	02/21/2020	6	--	<8.52	<27.5	<55	<0.017	<0.0852	<0.0426	<0.128	--	--	--	<0.17	--	--	--	--	--	--	--
B-36(14)	02/21/2020	14	--	<7.54	<26	<52.1	<0.0151	<0.0754	<0.0377	<0.113	--	--	--	<0.151	--	--	--	--	--	--	--
B-36(20)	02/21/2020	20	--	<6.91	<25.6	<51.2	<0.0138	<0.0691	<0.0345	<0.104	--	--	--	<0.138	--	--	--	--	--	--	--
B-37(6)	02/21/2020	6	--	<7.92	<27.1	<54.2	<0.0158	<0.0792	<0.0396	<0.119	--	--	--	<0.158	--	--	--	--	--	--	--
B-37(13)	02/21/2020	13	--	**2,170**	**2,300**	<53.7	<0.163	<0.817	0.598	2	--	--	--	4.3	--	--	--	--	--	--	--
B-37(21)	02/21/2020	21	--	**454**	98.8	<55.2	<0.0223	<0.112	0.186	0.491	--	--	--	0.778	--	--	--	--	--	--	--
B-38(6)	02/21/2020	6	--	<8.46	<26.8	<53.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B-38(13)	02/21/2020	13	--	**940**	**3,900**	<283	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B-38(21.5)	02/21/2020	21.5	--	**208**	122	<51.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B-39(6)	02/21/2020	6	--	<8.41	<27.2	<54.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B-39(13.5)	02/21/2020	13.5	--	<9.14	<26.5	<53.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B-39(21)	02/21/2020	21	--	<8	<26.2	<52.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Washington DOE MTCA Method A cleanup level[12.]				100/30[11.]	2,000	2,000	0.03	7	6	9	NA	NA	NA	5	NA	NA	NA	NA	NA	NA	NA

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 2
Soil Analytical Results: TPH and VOCs
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

				Concentrations in mg/kg (ppm)																	
Sample Location	**Sample Date**	**Depth**	**TPH-HCID**	**TPHg**	**TPHd**	**TPHho**	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**1,2-Dibromo-ethane**	**1,2-Dichloro-ethane**	**Methyl tert-butyl ether (MTBE)**	**Naphthalene**	**1,2,4-Trimethyl-benzene**	**1,3,5-Trimethyl-benzene**	**Isopropyl-benzene**	**n-Propyl-benzene**	**n-Butyl-benzene**	**Chloroform**	**Diehtylene glycol monomethyl ether**
Hand Augers																					
HA-1	04/17/2003	3	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-1	04/17/2003	6	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-2	04/18/2003	2	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-2	04/18/2003	5	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-3	04/17/2003	2	--	--	--	--	<0.1	<0.1	<0.1	<300	--	--	--	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
HA-3	04/17/2003	5.5	--	--	--	--	<0.1	<0.1	<0.1	<300	--	--	--	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
HA-4	04/18/2003	2	ND	--	--	--	<0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-4	04/18/2003	5	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-5	04/18/2003	3	DET	**3,320**	**4,780**	<50	<5.0	**10.5**	**48.5**	**500**	--	--	--	76.4	341	109	<10	39.1	<25	6.6	--
HA-5	04/18/2003	5	DET	**2,290**	**10,700**	<250	**6.7**	**216**	**177**	**1,204**	--	--	--	141	576	176	20.8	83.3	34	<5	--
HA-6	04/18/2003	2	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-6	04/18/2003	5	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-7	04/14/2003	6	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HA-8	04/14/2003	6	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil Sample from Advancement of Temporary Monitoring Wells																					
PMW-5	04/16/2003	8	ND		31	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-5	04/16/2003	10	DET	--	146	<50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-6	04/16/2003	3	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-6	04/16/2003	12	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-7	04/16/2003	3	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-7	04/16/2003	16	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Soil Samples from Excavation Confirmation																					
N. Wall	05/20/2002	10	--	--	--	--	<0.100	<0.100	<0.100	<0.2	--	--	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
N. Wall	05/20/2002	3	--	--	--	--	<0.100	<0.100	<0.100	<0.2	--	--	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
E. Wall	05/21/2002	10	--	--	--	--	<0.100	<0.100	<0.100	<0.2	--	--	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
E. Wall	05/21/2002	3	--	--	--	--	<0.100	<0.100	<0.100	<0.2	--	--	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.5	<0.1	--
Washington DOE MTCA Method A cleanup level[12.]				100/30[11.]	2,000	2,000	0.03	7	6	9	NA	NA	NA	5	NA	NA	NA	NA	NA	NA	NA

Notes:

1. TPH-HCID = Total petroleum hydrocarbons hydrocarbon identification by NW-TPH-HCID
2. TPHg = Total petroleum hydrocarbons in the gasoline carbon range by NW-TPH-Gx method.
3. TPHd = Total petroleum hydrocarbons in the diesel carbon range by NW-TPH-Dx method with silica gel cleanup.
4. TPHho = Total petroleum hydrocarbons in the heavy oil carbon range by NW-TPH-Dx method with silica gel cleanup.

Note: Flags in the lab reports indicate that TPHg and TPHd results do not fall under the (respective) standard gasoline or diesel ranges, but typically represent an overlap of diesel and gasoline ranges. Specific notes for individual samples can be found in the attached laboratory anlaytical reports.

5. mg/kg (ppm) = Milligrams per kilogram (parts per million).
6. -- = Not analyzed or not available.
7. < = Not detected at or above the specified laboratory method reporting limit (MRL).
8. ND = Not detected; MRL not available.
9. DET = Gasoline-, diesel-, and/or heavy oil-range hydrocarbons was detected using NWTPH-HCID. Follow-up analysis was completed.
10. **Boldface** values represent concentration that exceeds MTCA Method A cleanup level.
11. TPHg cleanup level dependent on presence of benzene in soil. Cleanup level = 30 mg/kg if benzene is present and 100 mg/kg if benzene is not present.
12. Washington DOE MTCA = Washington Department of Ecology Model Toxics Control Act.
13. NA = Cleanup level not available.

Cascadia Associates, LLC

Table 3
Groundwater Analytical Data - Grab Groundwater Sampling
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth (feet bgs)	TPH-HCID	TPHg	TPHd[16]	TPHo[16]	Benzene	Toluene	Ethyl-benzene	Xylenes	Methyl tert-butyl ether (MTBE)	Tert-Amyl Methyl Ether (TAME)	Naphthalene	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Isopropyl-benzene	n-Propylbenzene	n-Butyl-benzene	sec-Butyl-benzene	Chloroform	Diethylene glycol monomethyl ether	Dissolved Lead
				Concentrations in mg/L (ppm)																		
Groundwater Samples from Soil Borings																						
B-1(1)	10/22/2015	21-25	--	0.483	**0.51**	<0.28	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-1(2)	10/22/2015	26-30	--	<0.250	0.24	0.38	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-1(3)	10/22/2015	36-40	--	0.687	0.35	<0.24	<0.00050	<0.00050	0.00053	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-2(1)	10/23/2015	16-20	--	**4.02**	**0.77**	<0.30	**0.0104**	0.0155	**1.31**	**3.18**	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-2(2)	10/23/2015	26-30	--	<0.250	0.2	<0.23	<0.00050	<0.00050	0.0057	0.0108	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-2(3)	10/23/2015	36-40	--	**2.37**	**3.5**	<0.28	0.0022	0.0019	0.122	0.184	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-3(1)	10/23/2015	16-20	--	**22.3**	**15.9/3.2**[16]	**0.69**/<0.003[16]	**3.94**	0.112	**1.24**	**3.9**	<0.010	--	--	--	--	--	--	--	--	--	--	--
B-3(2)	10/23/2015	26-30	--	**25.6**	**37.4**	0.46	**3.91**	0.104	**1.23**	**3.52**	<0.010	--	--	--	--	--	--	--	--	--	--	--
B-4(1)	10/23/2015	16-20	--	**10.3**	**6.2**	<0.300	<0.0012	<0.0012	0.26	0.321	<0.0012	--	--	--	--	--	--	--	--	--	--	--
B-4(2)	10/23/2015	26-30	--	**9.88**	**2.1**	<0.260	0.0012	0.001	0.255	0.214	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-5(1)	10/27/2015	16-20	--	**34.7**	**68.4**	**3.8**	<0.025	<0.025	**2.77**	**5.24**	<0.025	--	--	--	--	--	--	--	--	--	--	--
B-5(2)	10/27/2015	36-40	--	**20.6**	**0.89**	<0.30	<0.0031	0.0097	**0.955**	**1.26**	<0.0031	--	--	--	--	--	--	--	--	--	--	--
B-6(1)	10/27/2015	19-23	--	**48.6**	**117/67.7**[16]	**0.77/0.62**[16]	<0.0025	0.005	0.0743	0.0245	<0.0025	--	--	--	--	--	--	--	--	--	--	--
B-6(2)	10/27/2015	51-55	--	<0.250	0.35	0.31	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-6(3)	10/27/2015	61-65	--	<0.250	0.35	<0.30	<0.00050	<0.00050	<0.00050	<0.0010	0.0025	--	--	--	--	--	--	--	--	--	--	--
B-7 (1)	10/28/2015	21-25	--	<0.250	<0.170	<0.260	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-7(2)	10/28/2015	26-30	--	<0.250	<0.190	<0.280	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-8(1)	10/28/2015	16-20	--	<0.250	<0.190	<0.290	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-8(2)	10/28/2015	21-25	--	<0.250	<0.190	<0.290	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-9(1)	10/20/2015	16-20	--	**1.63**	0.24	0.28	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-9(2)	10/29/2015	36-40	--	**3.03**	0.38	**0.62**	<0.00050	<0.00050	<0.00050	<0.0010	0.0039	--	--	--	--	--	--	--	--	--	--	--
B-9(3)	10/29/2015	46-50	--	**1.55**	**0.56**	<0.300	<0.00050	<0.00050	<0.00050	<0.0010	0.0048	--	--	--	--	--	--	--	--	--	--	--
B-10(1)	10/29/2015	16-20	--	**32.7**	**284**	**0.58**	<0.0012	<0.0012	0.377	0.495	<0.0012	--	--	--	--	--	--	--	--	--	--	--
B-10(2)	10/29/2015	36-40	--	0.421	**2.2**	0.37	<0.00050	<0.00050	0.0022	0.003	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-11(1)	10/30/2015	21-25	--	**19.2**	**46.7**	**0.92**	<0.0025	<0.0025	0.455	0.701	<0.0025	--	--	--	--	--	--	--	--	--	--	--
B-11(2)	10/30/2015	36-40	--	**1.58**	**6.9**	**0.62**	<0.00050	<0.00050	0.0112	0.0187	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-11(3)	10/30/2015	41-45	--	<0.250	0.28	0.3	<0.00050	<0.00050	0.00052	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-12(1)	10/30/2015	16-20	--	0.265	<0.200	0.36	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-12(2)	10/30/2015	36-40	--	<0.250	0.29	<0.260	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	--	--	--	--	--	--	--	--	--	--	--
B-12(3)	10/30/2015	41-45	--	<0.250	<0.200	<0.300	<0.00050	<0.00050	<0.00050	<0.0010	0.001	--	--	--	--	--	--	--	--	--	--	--
B-13 (1)	07/07/2016	15-20	--	<0.250	<0.18	<0.27	<0.00050	<0.00050	<0.00050	<0.0015	--	--	--	--	--	--	--	--	--	--	--	--
B-13 (2)	07/07/2016	25-30	--	<0.250	<0.18	<0.27	<0.00050	<0.00050	<0.00050	<0.0015	--	--	--	--	--	--	--	--	--	--	--	--
B-14 (1)	07/07/2016	15-20	--	<0.250	<0.18	<0.27	<0.00050	<0.00050	<0.00050	<0.0015	--	--	--	--	--	--	--	--	--	--	--	--
B-14 (2)	07/07/2016	25-30	--	<0.250	<0.17	<0.26	<0.00050	<0.00050	<0.00050	<0.0015	--	--	--	--	--	--	--	--	--	--	--	--
B-17-40	01/31/2019	40-45	--	0.187	0.233 F-13	<0.154	<0.0002	<0.001	0.000816	<0.0015	<0.001	--	0.00261	--	--	--	--	--	--	--	--	--
B-17-50	01/31/2019	50-55	--	0.741 Q-42	0.397 F-13	<0.162	<0.0002	<0.001	0.00508	0.00574	<0.001	--	0.011	--	--	--	--	--	--	--	--	--
B-18-40	01/31/2019	40-45	--	<0.100	<0.0792	<0.158	<0.0002	<0.001	0.000981	0.00458	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-18-50	01/31/2019	50-55	--	0.154	<0.0784	<0.157	<0.0002	0.00148	0.00194	0.00972	<0.001	--	0.0023	--	--	--	--	--	--	--	--	--
B-19-15	01/29/2019	15-20	--	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-19-30	01/29/2019	30-35	--	<0.100	<0.0784	<0.157	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-19-40	01/29/2019	40-45	--	<0.100	<0.0769	<0.154	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-19-50	01/29/2019	50-55	--	<0.100	<0.0800	<0.160	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-20-50	02/04/2019	50-55	--	**2.47**	0.214 F-18	<0.167	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.003	--	--	--	--	--	--	--	--	--
B-20-60	02/04/2019	60-65	--	<0.100	<0.0800	<0.160	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-21-50	02/01/2019	50-55	--	<0.100	<0.0784	<0.157	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-21-60	02/01/2019	60-65	--	<0.100	<0.0777	<0.155	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--	<0.002	--	--	--	--	--	--	--	--	--
B-22	01/29/2019	20-25	--	**18.8**	0.500 L	<0.490	**0.017**	0.018	**2.2**	**2.5**	<0.0025	--	<0.010	--	--	--	--	--	--	--	--	--
B-27	01/28/2019	30-35	--	0.161	0.109 F-18	<0.160	<0.0002	<0.001	0.00119	0.00858	<0.001	--	<0.002	--	--	--	--	--	--	--	<0.0187	--
B-29 GW	02/18/2020	14-19	--	<0.1	<0.0748	<0.15	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-30 GW	02/19/2020	14-19	--	**24.8**	**2.81**	<0.15	**0.0378**	<0.05	**0.721**	**1.63**	--	--	**0.475**	--	--	--	--	--	--	--	--	--
B-31 GW	02/18/2020	14-19	--	**47**	**10.3**	<1.5	**0.0503**	0.0578	**1.02**	**2.88**	--	--	**1.04**	--	--	--	--	--	--	--	--	--
B-32 GW	02/18/2020	14-19	--	<0.1	0.11	<0.158	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-33 GW	02/19/2020	14-19	--	**2.4**	**1.11**	<0.151	<0.0002	<0.001	0.00167	<0.0015	--	--	0.0122	--	--	--	--	--	--	--	--	--
B-34 GW	02/19/2020	14-19	--	<0.1	0.31	<0.15	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-35 GW	02/21/2020	6-10	--	<0.1	<0.0825	<0.165	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-36 GW Shallow	02/21/2020	6-10	--	<0.1	0.107	<0.158	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-36 GW Deep	02/21/2020	16-20	--	<0.1	0.0927	<0.167	<0.0002	<0.001	<0.0005	<0.0015	--	--	<0.002	--	--	--	--	--	--	--	--	--
B-37 GW	02/21/2020	14-19	--	**4.96**	**0.831**	<0.15	<0.002	<0.01	0.0133	0.0384	--	--	0.03	--	--	--	--	--	--	--	--	--
B-38 GW	02/21/2020	14-19	--	**53.3**	**8.65**	<0.748	<0.002	0.0142	**1.78**	**3.26**	--	--	**1.22**	--	--	--	--	--	--	--	--	--
Washington DOE MTCA Method A cleanup level[12.]				0.800[11.]	0.5	0.5	0.005	1	0.7	1	0.02	NA	0.16	NA	NA	NA	NA	NA	NA	NA	NA	0.015

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 3
Groundwater Analytical Data - Grab Groundwater Sampling
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth (feet bgs)	TPH-HCID	Concentrations in mg/L (ppm)																		
				TPHg	TPHd[16]	TPHo[16]	Benzene	Toluene	Ethyl-benzene	Xylenes	Methyl tert-butyl ether (MTBE)	Tert-Amyl Methyl Ether (TAME)	Naphthalene	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Isopropyl-benzene	n-Propylbenzene	n-Butyl-benzene	sec-Butyl-benzene	Chloroform	Diethylene glycol monomethyl ether	Dissolved Lead
Historical Grab Groundwater Samples from Soil Borings																						
GP-1	04/10-04/11/2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-2	04/10-04/11/2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-3	04/10-04/11/2002	24	--	**25.1**	ND	--	**5.2**	**1.03**	**1.41**	**1.258**	--	--	0.14	0.338	0.128	--	0.113	--	--	--	--	--
GP-4	04/10-04/11/2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-5	04/10-04/11/2002	22	--	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-6	04/10-04/11/2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-7	04/10-04/11/2002	24	--	**60.2**	ND	--	**3.97**	**16.2**	**2.17**	**9.69**	--	--	**0.212**	0.914	0.228	--	0.113	--	--	--	--	--
GP-8	04/10-04/11/2002	23	--	--	--	--	**15**	**32.9**	**4.51**	**19.57**	--	--	**0.462**	2.11	0.55	--	0.268	--	--	--	--	--
GP-9	04/10-04/11/2002	24	--	0.536	--	--	ND	ND	**0.00135**	0.01153	--	--	0.0782	0.0102	0.0114	--	0.0031	0.0017	--	--	--	--
GP-10	04/10-04/11/2002	23	--	**159**	ND	--	**4.44**	**28.1**	**5.09**	**23.07**	--	--	**0.476**	2.79	0.728	--	0.358	--	--	--	--	--
GP-11	04/10-04/11/2002	32	--	--	--	--	**14.2**	**48.3**	**8.25**	**36.6**	--	--	**1.91**	6.4	1.76	--	0.835	--	--	--	--	--
GP-12	04/11/2002	32	--	--	--	--	**0.698**	**1.64**	0.363	0.999	--	--	--	0.11	0.0318	--	0.0244	--	--	--	--	--
GP-13	05/09-05/10/2002	--	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
GP-14	05/09/2002	--	--	--	--	--	<0.001	<0.001	<0.001	0.00518	<0.001	--	<0.002	0.00219	<0.001	<0.002	<0.001	<0.005	<0.001	<0.001	--	--
GP-15	05/09-05/10/2002	--	--	--	--	--	<0.0005	<0.0005	0.0019	0.0186	--	--	--	--	--	--	--	--	--	--	--	--
GP-16	05/09/2002	--	--	--	--	--	<0.0005	<0.0005	0.00515	0.0522	--	--	--	--	--	--	--	--	--	--	--	--
GP-17	05/09-05/10/2002	--	--	--	--	--	**0.0243**	0.00056	0.00186	0.0146	--	--	--	--	--	--	--	--	--	--	--	--
GP-18	05/09-05/10/2002	--	--	--	--	--	0.00064	0.00053	0.00051	0.00411	--	--	--	--	--	--	--	--	--	--	--	--
GP-19	05/09/2002	34	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
GP-20	05/09/2002	34	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
GP-21	05/10/2002	34	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
GP-22	05/10/2002	34	--	--	--	--	**5.81**	**29.2**	**6.31**	**28.6**	--	--	--	--	--	--	--	--	--	--	--	--
GP-23	05/10/2002	34	--	--	--	--	**0.00544**	0.101	0.0667	0.302	--	--	--	--	--	--	--	--	--	--	--	--
GP-24	05/10/2002	24	--	--	--	--	0.00094	0.0144	0.00846	0.0424	--	--	--	--	--	--	--	--	--	--	--	--
GP-25	05/10/2002	24	--	--	--	--	0.00062	0.00882	0.00398	0.0193	--	--	--	--	--	--	--	--	--	--	--	--
GP-28	06/26/2002	26	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
GP-29	06/26/2002	50	--	--	--	--	**0.538**	**6.14**	**1.55**	**7.14**	--	--	--	--	--	--	--	--	--	--	--	--
GP-30	06/26/2002	26	--	--	--	--	<0.0005	0.000626	0.000507	<0.001	--	--	--	--	--	--	--	--	--	--	--	--
SB-1	04/17/2003	36	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-2	04/17/2003	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-3	04/18/2003	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-4	04/17/2003	--	ND	--	<0.526	<1.05	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-5	04/17/2003	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-6	04/18/2003	24	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-7	04/17/2003	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-8	04/17/2003	--	DET[7.]	--	**20.9**	<1.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-8R	09/30/2014	--	--	**45**	**9.8**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9	04/18/2003	--	DET[7.]	--	**66.2**	<1.05	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-9R	09/30/2014	--	--	**26**	**3.6**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-10	04/18/2003	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-11	04/16/2003	--	ND	--	<0.500	<1.00	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-12	04/18/2003	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SB-18	04/18/2003	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GP-1	06/11/2007	70-72	--	--	--	--	<0.001	<0.001	<0.001	<0.002	0.0137	<0.001	<0.002	<0.001	<0.001	<0.002	<0.001	--	--	--	--	--
GP-2	06/11/2007	64-66	--	--	--	--	<0.001	<0.001	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.001	<0.002	<0.001	--	--	--	--	--
DP-1 GRAB	03/30/2010	60.7-64.7	--	--	--	--	<0.0005	<0.0005	<0.0005	<0.0015	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	--	<0.00100
Washington DOE MTCA Method A cleanup level[12.]				0.800[11.]	0.5	0.5	0.005	1	0.7	1	0.02	NA	0.16	NA	NA	NA	NA	NA	NA	NA	NA	0.015

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 3
Groundwater Analytical Data - Grab Groundwater Sampling
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth (feet bgs)	TPH-HCID	Concentrations in mg/L (ppm)																			
				TPHg	TPHd[16]	TPHo[16]	Benzene	Toluene	Ethyl-benzene	Xylenes	Methyl tert-butyl ether (MTBE)	Tert-Amyl Methyl Ether (TAME)	Naphthalene	1,2,4-Trimethyl benzene	1,3,5-Trimethyl benzene	Isopropyl-benzene	n-Propylbenzene	n-Butyl-benzene	sec-Butyl-benzene	Chloroform	Diethylene glycol monomethyl ether	Dissolved Lead
Groundwater Samples from Temporary Monitoring Wells																							
PMW-5	04/16/2003	10-20	DET[7]	--	**1.88**	<0.943	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-6	04/16/2003	5-20	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PMW-7	04/16/2003	9-24	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Groundwater Sample from Irrigation Well																							
IRRIG WELL	04/17/2003	--		--	--	--	<0.001	<0.001	<0.001	<0.002	<0.001	--	<0.002	<0.001	<0.001	<0.002	<0.001	<0.005	<0.001	<0.001		--
Washington DOE MTCA Method A cleanup level[12]				0.800[11]	0.5	0.5	0.005	1	0.7	1	0.02	NA	0.16	NA	NA	NA	NA	NA	NA	NA	NA	0.015

Notes:
1. TPH-HCID = Total petroleum hydrocarbons hydrocarbon identification by method NWTPH-HCID.
2. TPHg = Total petroleum hydrocarbons in the gasoline carbon range by NW-TPH-Gx method.
3. TPHd = Total petroleum hydrocarbons in the diesel carbon range by NW-TPH-Dx method. September 2014 samples were analyzed using silica gel cleanup method.
4. TPHho = Total petroleum hydrocarbons in the heavy oil carbon range by NW-TPH-Dx method.

Note: Flags in the lab reports indicate that TPHg and TPHd results do not fall under the (respective) standard gasoline or diesel ranges, but typically represent an overlap of diesel and gasoline ranges (i.e., F-13, F-18, L) . Specific notes for individual samples can be found in the attached laboratory analytical reports and quality review summary report.

5. Benzene, toluene, ethylbenzene, and total xylenes (BTEX) analysis per EPA Method 8260B.
6. Volatile organic compounds (VOCs) analysis per EPA Method 8260B.
7. DET = Gasoline-, diesel-, and/or heavy oil-range hydrocarbons was detected using NWTPH-HCID. Follow-up analysis was completed.
8. ND = Not detected; method reporting limit (MRL) not available.
9. < = Not detected at or above the specified laboratory method reporting limit (MRL).
10. mg/L (ppm) = Milligrams per liter (parts per million).
11. TPHg cleanup level dependent on presence of benzene in groundwater. Cleanup level = 0.800 mg/L if benzene is present and 1.00 mg/L if benzene is not present.
12. Washington DOE MTCA = Washington Department of Ecology Model Toxics Control Act.
13. **Boldface** values represent concentration that exceeds MTCA Method A cleanup level.
14. NA = Cleanup level not available.
15. The screened intervals for the October 2015 samples are shown. Sample intake was generally from the centerpoint of each interval - see boring logs for more detail.
16. For TPHd and TPHo, the first value represents with silica gel cleanup and the second without (i.e., 15.9/3.2).
17. DGME = Diethylene glycol monomethyl ether
18. L = The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.

Cascadia Associates, LLC

Table 4
Groundwater Analytical Data - Monitoring Well Sampling
NuStar Terminals Operations Partnership, L.P. – Annex Terminal
Vancouver, Washington

Well Number	Sample Date	TPHg Gasoline (mg/L)	TPHd Diesel (mg/L)	TPHo Heavy Oil (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylenes (mg/L)	MTBE (mg/L)	Naphthalene (mg/L)
MW-1	05/14/2002	<0.080	0.455 [5.]	<0.500	<0.0005	<0.0005	<0.0005	<0.001	--	--
	05/19/2003	--	--	--	<0.001	<0.001	<0.001	<0.002	--	--
	05/25/2007	<0.080	<0.238	<0.476	<0.0002	<0.0005	<0.0005	<0.001	--	--
	08/24/2007	<0.1	<0.238	<0.476	<0.001	<0.002	<0.002	<0.006	--	--
	11/26/2007	<0.080	<0.236	<0.472	<0.001	<0.002	<0.002	<0.006	--	--
	02/27/2008	<0.080	<0.294	<0.588	<0.0005	<0.0005	<0.0005	<0.001	--	--
	03/31/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	09/01/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	12/16/2014	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0005	--	--
	03/25/2015	<0.250	<0.046	<0.093	<0.0005	<0.0005	<0.0005	<0.001	--	--
	06/24/2015	<0.250	<0.100	<0.250	<0.0005	<0.0005	<0.0005	<0.001	--	--
	09/15/2015	<0.250	<0.130	<0.340	<0.0005	<0.0005	0.0015	0.0022	--	--
	02/19/2019	<0.100	<0.0762	<0.152	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/20/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/29/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/19/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-2	05/14/2002	**41.4**	<0.250	<0.500	**4.35**	**2.68**	**1.84**	**8.72**	--	--
	05/19/2003	--	--	--	**0.534**	0.00975	0.194	0.876	--	--
	05/25/2007	0.439	<0.238	<0.476	**0.071**	0.00114	0.0361	0.0453	--	--
	08/24/2007	0.102	<0.238	<0.476	<0.001	<0.002	<0.002	<0.006	--	--
	11/26/2007	<0.080	<0.236	<0.472	<0.001	<0.002	<0.002	<0.006	--	--
	02/27/2008	0.0817	<0.294	<0.588	0.005	<0.0005	<0.0005	<0.001	--	--
	03/31/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	09/01/2010	<0.250	<0.250	<0.500	0.0016	<0.0005	<0.0005	<0.0015	--	--
	12/16/2014	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0005	--	--
	03/25/2015	<0.250	<0.046	<0.091	<0.0005	<0.0005	<0.0005	<0.001	--	--
	06/24/2015	<0.250	<0.100	<0.250	<0.0005	<0.0005	<0.0005	<0.001	--	--
	09/15/2015	<0.250	0.17 D	0.37	<0.0005	<0.0005	<0.0005	<0.001	--	--
	02/19/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.00015	0.00121	--
	05/20/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	**0.0031**	--
	08/29/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	0.00069	<0.00075	0.00125	<0.002
	11/19/2019	<0.100	<0.0762	<0.152	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-3	05/14/2002	**4.5**	<0.250	<0.500	**0.0419**	0.0096	0.293	0.521	--	--
	05/19/2003	--	--	--	**0.0908**	0.0097	0.338	0.5382	--	--
	05/25/2007	0.361	<0.238	<0.476	<0.0005	<0.0005	0.0132	0.0145	--	--
	08/24/2007	<0.1	<0.238	<0.476	<0.001	<0.002	<0.002	<0.006	--	--
	11/26/2007	<0.080	<0.236	<0.472	0.0011	<0.002	0.0066	<0.006	--	--
	02/27/2008	**2.14**	0.387 [6.]	<0.500	<0.0005	<0.0005	0.17	0.17	--	--
	2/27/2008 DUP	**1.85**	0.342	<0.485	0.0011	<0.0005	0.19	0.2	--	--
	03/31/2010	**2.10**	<0.250	<0.500	<0.0005	<0.0005	0.018	0.021	--	--
	3/31/2010 DUP	**1.90**	<0.250	<0.500	<0.0015	<0.0015	0.018	0.020	--	--
	09/01/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	9/1/2010 DUP	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	12/16/2014	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0005	--	--
Washington DOE MTCA Method A Cleanup Level		0.8	0.5	0.5	0.005	1	0.7	1	0.02	0.16

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 4
Groundwater Analytical Data - Monitoring Well Sampling
NuStar Terminals Operations Partnership, L.P. – Annex Terminal
Vancouver, Washington

Well Number	Sample Date	TPHg Gasoline (mg/L)	TPHd Diesel (mg/L)	TPHo Heavy Oil (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylenes (mg/L)	MTBE (mg/L)	Naphthalene (mg/L)
MW-3	03/25/2015	<0.418	<0.046	<0.092	<0.0005	<0.0005	<0.0005	<0.001	--	--
	06/24/2015	<0.250	0.120	<0.026	<0.0005	<0.0005	<0.0005	<0.001	--	--
	09/15/2015	<0.250	0.140	<0.250	<0.0008	<0.0008	<0.0008	<0.001	--	--
	02/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/20/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/29/2019	--	--	--	--	--	--	--	--	--
	11/19/2019	0.114	<0.0769	<0.154	<0.0002	<0.001	0.00661	0.0113	<0.001	<0.002
MW-4	05/14/2002	<0.080	0.358[5.]	<0.500	<0.0005	<0.0005	<0.0005	<0.001	--	--
	05/19/2003	--	--	--	<0.001	<0.001	<0.001	<0.002	--	--
	05/25/2007	<0.080	<0.238	<0.476	<0.0002	<0.0005	<0.0005	<0.001	--	--
	08/24/2007	<0.1	<0.238	<0.476	<0.001	<0.002	<0.002	<0.006	--	--
	11/26/2007	<0.080	<0.236	<0.472	<0.001	<0.002	<0.002	<0.006	--	--
	02/27/2008	<0.080	<0.248	<0.495	<0.0005	<0.0005	<0.0005	<0.001	--	--
	03/31/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	09/01/2010	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0015	--	--
	12/16/2014	<0.250	<0.250	<0.500	<0.0005	<0.0005	<0.0005	<0.0005	--	--
	03/25/2015	<0.250	0.074	<0.091	<0.0005	<0.0005	<0.0005	<0.001	--	--
	06/24/2015	<0.250	<0.099	<0.250	<0.0005	<0.0005	<0.0005	<0.001	--	--
	09/15/2015	<0.250	<0.130	<0.340	<0.0005	<0.0005	<0.0005	<0.001	--	--
	02/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.00150	<0.001	--
	05/20/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/29/2019	--	--	--	--	--	--	--	--	--
	11/19/2019	<0.100	<0.0784	<0.157	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-5	12/16/2014	**15**	0.350	<0.500	0.00070	0.00066	0.12	**1.2**	--	--
	12/16/2014 DUP	**15**	<0.250	<0.500	0.00088	0.00081	0.18	**1.3**	--	--
	03/25/2015	**18.1**	<0.045	<0.091	<0.00050	0.00061	0.218	**1.45**	--	--
	3/25/2015 DUP	**17.2**	<0.046	<0.092	0.0005	0.00065	0.236	**1.22**	--	--
	06/24/2015	**15**	0.33 D	<0.250	<0.0012	<0.0012	0.228	**1.51**	--	--
	6/24/2015 DUP	**16.8**	**0.560 D**	<0.250	<0.0012	<0.0012	0.232	**1.49**	--	--
	09/15/2015	**17.3**	**0.82 D**	<0.34	<0.00050	0.00060	0.289	**1.92**	--	--
	07/11/2016	**19.4**	**0.310**	<0.29	<0.00084	0.00100	0.215	**1.17**	--	--
	10/23/2017	**7.93 J-**	**1.26**	<0.25	<0.0010	0.00117	0.174	0.99	--	--
	11/30/2017	**11.3**	**1.63**	<0.25	<0.0250	<0.0250	0.187	**1.21**	--	--
	11/30/17 DUP	**10.9**	**1.75**	<0.25	<0.0010	0.00112	0.187	**1.48**	--	--
	02/28/2018	**9.86**	**1.77**	<0.25	<0.0010	0.00115	0.145	0.877	--	--
	05/29/2018	**13.2**	**2.20**	<0.25	<0.0010	0.00130	0.271	**1.15**	--	--
	08/30/2018	**18.6**	**0.819 F-18**	<0.151	<0.00200	<0.0100	0.190	0.936	--	--
	8/30/2018 DUP	**20.8**	**0.631 F-18**	<0.151	<0.00200	<0.0100	0.212	**1.06**	--	--
	02/18/2019	**29.2**	**1.06 F-18**	<0.151	<0.00200	<0.0100	0.187	**1.06**	<0.010	--
	05/21/2019	**22**	**0.722**	<0.0784	<0.002	<0.01	0.252	**1.04**	<0.010	--
	08/28/2019	**24.8**	**0.963**	<0.0769	<0.002	<0.01	0.239	**1.1**	<0.01	**2.07**
	8/28/2019 DUP	**21.7**	**0.879**	<0.0769	<0.002	<0.01	0.179	0.836	<0.01	**1.44**
	11/18/2019	**23.5**	**0.771**	<0.152	<0.004	<0.02	0.257	**1.19**	<0.02	**1.62**
	11/18/2019 DUP	**20.0**	**0.696**	<0.152	<0.01	<0.05	0.284	**1.46**	<0.05	**1.51**
Washington DOE MTCA Method A Cleanup Level		0.8	0.5	0.5	0.005	1	0.7	1	0.02	0.16

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 4
Groundwater Analytical Data - Monitoring Well Sampling
NuStar Terminals Operations Partnership, L.P. – Annex Terminal
Vancouver, Washington

Well Number	Sample Date	TPHg Gasoline (mg/L)	TPHd Diesel (mg/L)	TPHo Heavy Oil (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylenes (mg/L)	MTBE (mg/L)	Naphthalene (mg/L)
MW-5D	10/24/2017	0.42	0.147 J	<0.25	<0.0010	<0.0010	0.00138	0.00296 J	--	--
	11/30/2017	0.41	0.49	<0.25	<0.0010	<0.0010	<0.0010	<0.0030	--	--
	02/28/2018	0.589	0.249	<0.25	<0.0010	<0.0010	0.00508	0.00204	--	--
	05/29/2018	0.68	<0.38	<0.38	<0.0010	<0.0010	0.00220	<0.0030	--	--
	08/30/2018	0.673	<0.0755	<0.151	<0.000200	<0.00100	<0.00050	<0.00150	--	--
	02/18/2019	0.165	<0.0748	<0.150	<0.000200	<0.00100	<0.00050	<0.00150	<0.001	--
	05/21/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/28/2019	**0.309**	<0.0374	<0.0748	<0.0001	<0.0005	0.00078	<0.00075	<0.0005	<0.002
	11/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-6	12/16/2014	**15**	<0.250	<0.500	**0.47**	0.065	**1.3**	**2.6**	--	--
	03/25/2015	**13.7**	0.047	<0.092	**0.516**	0.0756	**1.40**	**2.26**	--	--
	06/24/2015	**17.7**	**1.2 D**	<0.250	**0.423**	0.0582	**1.58**	**1.92**	--	--
	09/15/2015	**15.1**	**0.54 D**	<0.34	**0.306**	0.0672	**1.23**	**1.92**	--	--
	9/15/2015 DUP	**14**	0.44 D	<0.35	**0.328**	0.0684	**1.32**	**2.07**	--	--
	07/11/2016	**15.5**	0.23	<0.28	**0.358**	0.0616	**1.63**	**1.82**	--	--
	10/24/2017	**7.73**	**5.07**	0.111 J	**0.194**	0.051	**1.51**	**1.29**	--	--
	10/24/2017 DUP	**4.19 J**	**8.96 QJ**	**1.19 QJ**	**0.153**	0.046	**1.18**	**1.04**	--	--
	11/30/2017	**9.42**	**7.44**	**0.69**	**2.223**	0.053	**1.71**	**1.12**	--	--
	02/28/2018	**7.72**	**3.57**	0.152	**0.256**	0.0423	**1.44**	0.735	--	--
	05/29/2018	**1.5**	**9.30**	**0.570**	**0.23**	0.0444	**1.38**	0.891	--	--
	08/30/2018	**20.1**	**1.24 F-18**	<0.151	**0.212**	0.0452	**1.59**	**1.15**	--	--
	02/18/2019	**18.2**	**2.15 F-20**	<0.151	**0.249**	0.0408	**1.74**	0.577	<0.010	--
	05/20/2019	**20**	**1.23**	<0.0755	**0.218**	0.0426	**1.86**	0.937	<0.010	--
	08/29/2019	**16.8**	**1.64**	<0.0755	**0.177**	0.0394	**1.69**	0.585	<0.01	**0.561**
	11/19/2019	**6.30**	**1.95**	<0.150	**0.0712**	<0.02	**0.709**	0.127	<0.02	**0.163**
MW-7	07/11/2016	<0.250	<0.19	<0.29	<0.00050	<0.00050	<0.00050	<0.00015	--	--
	02/19/2019	<0.100	<0.0748	<0.150	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/20/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/28/2019	<0.05	<0.0388	<0.0777	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/18/2019	<0.100	<0.0748	<0.150	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-8	07/11/2016	<0.250	<0.19	<0.29	<0.00050	<0.00050	<0.00050	<0.00015	--	--
	7/11/16 DUP	<0.250	<0.19	<0.29	<0.00050	<0.00050	<0.00050	<0.00015	--	--
	02/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/21/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/28/2019	<0.05	<0.0412	<0.0825	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-8D	02/18/2019	<0.100	<0.0755	<0.151	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/21/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/28/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/18/2019	<0.100	<0.0762	<0.152	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
Washington DOE MTCA Method A Cleanup Level		0.8	0.5	0.5	0.005	1	0.7	1	0.02	0.16

Please refer to notes at end of table.

Table 4
Groundwater Analytical Data - Monitoring Well Sampling
NuStar Terminals Operations Partnership, L.P. – Annex Terminal
Vancouver, Washington

Well Number	Sample Date	TPHg Gasoline (mg/L)	TPHd Diesel (mg/L)	TPHo Heavy Oil (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylenes (mg/L)	MTBE (mg/L)	Naphthalene (mg/L)
MW-9	07/11/2016	<0.250	<0.19	<0.29	<0.00050	<0.00050	<0.00050	<0.00015	--	--
	02/18/2019	<0.100	<0.0748	<0.150	<0.0002	<0.001	<0.0005	<0.0015	<0.001	--
	05/21/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/28/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/18/2019	<0.100	<0.0762	<0.152	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-10	07/11/2016	<0.250	<0.19	<0.29	<0.00050	<0.00050	<0.00050	<0.00015	--	--
	02/19/2019	<0.100	<0.0748	<0.150	<0.0002	<0.001	<0.0005	<0.00015	<0.001	--
	05/21/2019	<0.05	<0.0377	<0.0755	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	--
	08/29/2019	<0.05	<0.0374	<0.0748	<0.0001	<0.0005	<0.00025	<0.00075	<0.0005	<0.002
	11/19/2019	<0.100	<0.0762	<0.152	<0.0002	<0.001	<0.0005	<0.0015	<0.001	<0.002
MW-11	02/19/2019	0.727	<0.0748	<0.150	0.00162	0.00176	0.083	0.0652	<0.001	--
	05/21/2019	**3.05**	<0.0374	<0.0748	**0.0643**	0.00843	0.359	0.0355	<0.0005	--
	08/29/2019	**17.4**	0.094	<0.0748	0.0038	0.24	**1.18**	**2.52**	<0.005	0.121
	11/19/2019	**45.0**	0.239	<0.151	**0.0526**	0.159	**4.33**	**7.73**	<0.02	**0.414**
Washington DOE MTCA Method A Cleanup Level		0.8	0.5	0.5	0.005	1	0.7	1	0.02	0.16

Notes:

1. TPHg = Total petroleum hydrocarbons in gasoline carbon range by NW-TPHgx method.
2. TPHd = Total petroleum hydrocarbons in diesel carbon range by NW-TPHdx method with silica gel cleanup.
3. TPHho = Total petroleum hydrocarbons ion heavy oil carbon range NW-TPHdx method with silica gel cleanup.
4. **Bold** values represent concentration that exceeds MTCA Method A cleanup level.
5. Analysis completed without silica gel cleanup. Lab detected hydrocarbons with non-petroleum peaks or elution pattern that suggests the presence of biogenic interference.
6. Hydrocarbon pattern most closely resembles a blend of heavy gas-/light diesel-range components.
7. mg/L (ppm) = Milligrams per liter (parts per million).
8. TPHg cleanup level dependent on presence of benzene in groundwater. Cleanup level = 0.800 mg/L if benzene is present and 1.00 mg/L if benzene is not present.
9. Washington DOE MTCA Method A cleanup level = Washington Department of Ecology Model Toxics Control Act Method A cleanup level.
10. < = Not detected at or above the specified laboratory method reporting limit (MRL).
11. bgs = below ground surface
12. -- = Sample not analyzed for constituent.

Quality Assurance/Quality Control Data Qualifiers

J = Reported result is an estimated value.
J- = Reported result is estimated and biased low.
Q = Sample prepared and/or analyzed outside of recommended holding time. Result is considered biased low.
F-18 = Result for Diesel (Diesel Range Organics, C12-C24) is due to overlap from Gasoline or a Gasoline Range product.
F-20 = Result for Diesel is estimated due to overlap from Gasoline Range Organics or other VOCs.
D = Laboratory report noted discreet peaks that are not indicative of diesel. The laboratory chemist confirmed the peaks were from non-petroleum organic material.

Table 5
Initial Screening of Cleanup Technologies - MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

General Response Action	Remedial Technology	Effectiveness	Implementability	Reasonableness of Cost	Retained?	Reason for Retaining or Eliminating
No Action	None	Low	High	High	Yes	Does not meet remedial action objectives, but will be used as a baseline to compare other alternatives.
Institutional Controls	Activity Restrictions (Deed Restrictions/CMMP)	Medium	High	High	Yes	No long-term reduction of contaminant concentrations. To be used in conjunction with cleanup actions to break potentially complete exposure pathways (e.g., direct contact by trench worker and preclude use of shallow groundwater beneath the Facility).
	Monitoring	Low	High	Medium	Yes	Monitoring is not a treatment technology; however, groundwater quality monitoring is necessary to document current Site conditions and risks. Repeated sampling events will likely be needed to document progress of implemented remedial technology or contaminant migration. Costs will be dependent on the number of mobilizations and the frequency of monitoring.
Engineering Controls	Access Restrictions	Low	High	High	No	This technology is not retained because the access to the Site is already controlled with fencing. Access restrictions are not treatment technologies and will not reduce contamination present.
	Control of Building HVAC System, Vapor Barriers. Sub-Slab Depressurization or Sub-Floor Venting, Alternative Water Supply, Wellhead Treatment	High	Medium	Medium	No	No long-term reduction of contaminant concentrations. To be used in conjunction with cleanup actions to break potentially complete exposure pathways (e.g., vapor intrusion into buildings overlying subsurface contamination). The contamination is highly weathered and vapor intrusion concerns are not an issue. The Facility is serviced by municipal water. Shallow groundwater beneath the Site is not used for domestic purpose, nor does it appear to be hydrogeologically connected to the water bearing zones utilized by the CPU well field.
Petroleum Contaminated Soil						
***Ex Situ* Treatment Technologies**						
Removal and Disposal	Excavation	High	Medium	Low	Yes	The existing infrastructure and operations limit the ability to safely excavate all of the petroleum-impacted soil. Limited petroleum impacts have been observed in the vadose zone, with most impacted areas being in the saturated zone from 12 to 22 feet bgs.
	On-Site Disposal	Low	Low	Medium	No	This technology is not retained because it does not remove this long-term source of groundwater contamination, and the placement of the soil onsite would reduce available secondary containment at the Site. Placement of impacted soil onsite would not be compatible with the Facility's industrial stormwater permit.
	Off-Site Disposal	High	High	Low	Yes	
Biological	Landfarming	Medium	Low	Low to Medium	No	This technology is not retained because the placement of the soil onsite for treatment would reduce available secondary containment at the Site.
***In Situ* Treatment Technologies**						
Physical	Soil Vapor Extraction (SVE)	Medium	Medium	Low	No	This technology was not retained because most of the contaminated soil is highly weathered, lacking a significant volatile fraction, and situated within the seasonal water table smear zone. Also, its effectiveness is expected to be severely reduced in the lower permeability soils beneath the Site.
	Low Temperature Thermal Desorption	Medium	Low	Low	No	Cost prohibitive. The technology is not compatible with facility operations due to underground infrastructure.
Biological	Enhanced Bioremediation (Bioaugmentation, Biostimulation)	Medium	Medium to High	Medium	Yes	Natural attenuation of petroleum-impacted soil has been documented at the Site. This natural process can be enhanced by introducing nutrients (biostimulation) and/or microorganisms (bioaugmentation) into the contaminated subsurface zone.

Please refer to notes on last page of table.

Table 5
Initial Screening of Cleanup Technologies - MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

General Response Action	Remedial Technology	Effectiveness	Implementability	Reasonableness of Cost	Retained?	Reason for Retaining or Eliminating
Petroleum Contaminated Groundwater						
***Ex Situ* Treatment Technologies**						
Removal/Discharge or Disposal	Groundwater Extraction and *Ex Situ* Treatment	Medium	Medium	Low	Yes	Retained for hydraulic control. Extraction wells with submersible pumps to create hydraulic gradients that direct contaminant migration into the extraction well. While not efficient, it does reduce contaminant mass in groundwater. Ancillary benefit is that it lowers the water table, which may promote/enhance natural degradation. Aboveground treatment of water is required, with possibilities including oil/water separation, air-stripping, granular activated carbon before discharge to local publicly owned treatment works (POTW).
	Dual Phase Extraction (DPE) with *Ex Situ* Treatment	Low	Medium	Low	No	Not retained because its designed to remove free product and volatiles from the subsurface. The contamination at the Site is highly weathered and lacks a significant volatile fraction. Also, there's no evidence that free product exists beneath the Site. The DPE is not an efficient technology for providing hydraulic control. Secondary treatment of extracted vapor and groundwater will likely be required, such as including air-stripping or granular activated carbon prior to discharge.
Biological	Enhanced Bioremediation (Bioaugmentation, Biostimulation)	Medium	Medium	Medium	Yes	Natural attenuation of petroleum-impacted soil has been documented at the Site. This natural process can be enhanced by introducing nutrients (biostimulation) and/or microorganisms (bioaugmentation) into extracted groundwater prior to recirculation and/or off-site disposal.
Physical	Coalescing Plate Separator	High	Medium	Medium	Yes	Not a standalone treatment technology, but would be used to treat extracted groundwater prior to reinjection or discharge. Effective at removing petroleum separate phase hydrocarbons (SPH) from extracted groundwater stream. Removed SPH would be transported offsite for disposal. Additional treatment of extracted groundwater may be needed prior to re-injection or disposal.
	Solids Separation	High	Medium	Medium	Yes	Not a stand alone treatment technology, but would be used treat extracted groundwater prior to reinjection or discharge. Effective at removing TSS from extracted groundwater stream. Removed TSS will be transported offsite for disposal. Additional treatment of extracted groundwater may be needed prior to re-injection or disposal.
Chemical	Activated Carbon	High	Medium	Low to Medium	Yes	Not a standalone treatment technology, but would be used to treat extracted groundwater or vapor prior to reinjection or discharge. Spent carbon would require off-site disposal or treatment to reactivate.

Please refer to notes on last page of table.

Table 5
Initial Screening of Cleanup Technologies - MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

General Response Action	Remedial Technology	Effectiveness	Implementability	Reasonableness of Cost	Retained?	Reason for Retaining or Eliminating
***In Situ* Treatment Technologies**						
Physical	Air Sparging	Low	Medium	Medium	No	Proven to be effective at reducing volatile concentrations in groundwater, but its effectiveness is reduced in lower permeability soils. Typically is used in conjunction with SVE. Site contamination is highly weathered and its volatile content low. Therefore, not appropriate for use at the Site.
	Vertical Barrier	Low	Low	Low	No	Installation of vertical barriers (sheet piling, soil-bentonite slurry wall, grout, etc.) to prevent migration of groundwater contamination. Effective at preventing lateral migration. Requires keying into an underlying confining unit. Otherwise, cannot prevent downward migration. Site lacks suitable confining unit. Several more cost-effective technologies are available.
	Thermal Treatment (electrical resistive heating)	Medium	Low	Low	No	Cost prohibitive. The technology is not compatible with facility operations due to underground infrastructure.
Biological	Monitored Natural Attenuation	Medium	High	High	Yes	The natural attenuation of petroleum hydrocarbons is well documented at the Site. However, it is not considered a stand alone treatment technology since some source areas are expected to require long restoration time frames.
	Enhanced Bioremediation	medium	Medium	Low to Medium	Yes	This technology is retained because the delivery and effective distribution of electron acceptors, nutrients, and/or microbes that are acclimated to the contaminated groundwater can enhance in situ bioremediation. It radius of influence is expected to be relatively small in the tight fine grained soils beneath the Site.
	Micron-Scale Activated Carbon (PlumeStop, PetroFix)	Medium	Medium	Low to Medium	Yes	This technology has been retained because it should further reduce the migration of dissolved phase contaminants. Dissolved phase contaminants adsorb to the activated carbon, slowing migration of the contaminants. It appears that the liquid carbon can be injected into the subsurface more efficiently than other reagents (e.g., ORC, RegenOx).
Chemical	Oxidant Injection (e.g., Fenton's reagent, persulfate)	Low	Low	Low	No	Contaminants are treated chemically (oxidized) rather than reduced using biological processes. The delivery and effective distribution of oxidant and catalysts would be severely limited in the low permeability silt lenses present in the soil at the Site. Also, high natural organic content of soil may limit the effectiveness of this technology. The chemicals create a strong, exothermic reaction, would be difficult to control, and may be harmful to Site infrastructure.

Notes:
VRU = Vapor Recovery Unit
CPU = Clark Public Utilities
CMMP = Contaminated Media Management Plan
Ex Situ = above ground
In Situ = below ground
bgs = below ground surface
TSS = total suspended solids
ORC = Oxygen Release Compounds
Gray shading indicates that the technology has been eliminated from further consideration.

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Table 6
Description of Cleanup Action Alternatives - MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Alternative	Cleanup Action Description	Unknowns	Comments	
			Advantages	Disadvantages
Alternative 1 No Action	This alternative assumes that no actions are taken to treat, remove, or monitor contaminated soil and groundwater at the Site.	Future distribution of contaminants in soil and groundwater. Mobility of dissolved phase COCs in shallow groundwater. Risks posed by residual contamination (e.g., future contact by earth workers, migration to CPU wellfield). Site conditions (e.g., soil permeability, degree of heterogeneity, preferential pathways) affecting contaminant mobility, plume expansion, and rate of natural attenuation. Cleanup levels and regulatory enforcement action(s).	No cost.	Does not meet the minimum requirements of Washington Administrative Code (WAC) 173-340-360 "Selection of Cleanup Actions." Does not provide a mechanism for compliance monitoring and therefore cannot assess effectiveness, permanence, and reasonableness of the restoration time frame.
Alternative 2 MNA	This alternative consists of institutional controls (IC) and long-term groundwater quality monitoring. The application of IC provide notification regarding the presence of contaminated materials, regulate the disturbance/management of these materials, and prohibit the creation of preferential pathways for contaminant migration. The principal assumption of Alternative 2 is that reductions of COCs within the shallow water bearing zone (silt unit) will occur through natural processes such as biodegradation, diffusion, dispersion, hydrolysis, and sorption.	Same as Alternative 1 (No Action).	Highest benefit to cost ratio relative to other alternatives. Provides compliance monitoring through MNA.	Does not meet remedial threshold requirements. The alternative is not protective of human health or the environment and the alternative does not provide any additional reduction of existing risks at the Site or provide containment to prevent offsite migration for when the expanded CPU pumping of the PAA becomes operational.
Alternative 3 Hydraulic Containment	In addition to the implementation of IC and MNA, this alternative is designed to hydraulically control and contain contaminated groundwater detected beneath the Site. Gradient control would be accomplished through the installation of nineteen 35-foot-deep extraction wells throughout the defined extent of TPH in shallow groundwater in beneath the MW-5, MW-6, and MW-11 Areas. The estimate of 19 extraction wells is based on an assumed radius of influence of 25 feet while pumping from a 4-inch-diameter well at 1 gpm. Using submersible pumps, extracted groundwater would be routed to a common treatment system consisting of a coalescing plate oil-water-separator followed by GAC treatment prior to discharge to the POTW. At a total system pumping rate of 19 gpm, the system would treat and discharge up to 10,000,000 gallons of water annually. Its is assumed that cleanup goals would be met in 30 years.	Pumping tests would be needed to verify drawdown, radius of influence, flow rate, well depth, well locations, and the number of extraction wells needed to provide full hydraulic containment within each area of interest. During the pump test, an aboveground treatment system would be pilot tested to verify the treat train necessary to meet discharge criteria and to establish a maintenance schedule. During full-scale implementation, the following unknowns could have a significant impact on cleanup costs: (a) the amount and degree of maintenance required to keep the full-scale pump & treat system operational; (b) the need for deeper hydraulic containment; (c) the need for significant changes to the *ex situ* treatment processes and the discharge of treated water (e.g., on-site infiltration); (d) the restoration time frame; (e) changes to cleanup levels; and (f) regulatory enforcement action(s).	If the system is able to remain operational, this alternative is expected to meet the threshold requirements as it protects human health and environment by containing COCs in groundwater, removing dissolved phase contaminants, and improving MNA by lowering the water table.	Low benefit to cost ratio. The alternative does not remove contaminant mass present in vadose zone soil. The effectiveness of dissolve phase contaminant mass removal is expected to diminish relatively quickly if preferential pathways develop with system operation. Groundwater pump & treat systems typically require a significant amount of maintenance and are difficult to keep operational for sustained periods of time. Once operational, it could be difficult to obtain regulatory approval to discontinue hydraulic containment. The long restoration time frame means there that could be new or ongoing releases, further expansion of CPU wellfield, new COCs, and/or lowering of cleanup standards.
Alternative 4 Plume Stabilization Enhanced Bioremediation	In addition to the implementation of IC and MNA, this alternative includes the direct injection of micron-scale activated carbon (plume stabilization) and biostimulants (enhanced bioremediation) throughout contaminated smear zones beneath the MW-5, MW-6, and VRU Areas. This alternative assumes 10 years of MNA.	Remedial design investigations would be needed to verify: (a) the lateral and vertical extent of PCM in select areas; and (b) the effectiveness of PetroFix injections on groundwater quality and enhanced bioremediation. Other unknowns include the remedy's impact on terminal operations and regulatory UIC approval of biostimulant injections (e.g., nitrate and sulfate electron acceptors).	The combination of an injectable form of activated carbon that can adsorb contaminants and contain them in a finite zone with electron acceptors that will initially degrade the contaminants via anaerobic pathways and promote syntrophic conditions that sustain degradation will expedite the natural attenuation process and protect downgradient receptors (CPU wellfield). Direct injections are less disruptive to facility operations and carry a lower implementation risk than removal of all accessible PCM.	The *in situ* stabilization of dissolved phase COCs using liquid activated carbon is a relatively new and untested remedial technology. Additional Site investigations and technology pilot studies are needed to confirm that plume stabilization and enhanced bioremediation will occur within residual source areas as required to meet remedial action objectives.
Alternative 5 Removal of Accessible Vadose Zone PCM Hydraulic Containment and Recirculation Enhanced Bioremediation	In addition to the implementation of IC, MNA, the removal of readily accessible PCS (i.e., 12-foot removal actions near B-6 and B-30), and the hydraulic containment beneath the MW-5 and MW-6 Areas, this alternative includes the on-site recirculation of treated/amended water. Gradient control would be accomplished through the installation of eighteen 35-foot-deep extraction wells throughout the defined extent of TPH in shallow groundwater. The estimate of 18 extraction wells is based on an assumed radius of influence of 25 feet while pumping from a 4-inch-diameter well at 1 gpm. Using submersible pumps, extracted groundwater would be routed to a common treatment system consisting of a coalescing plate oil-water-separator followed by GAC treatment to remove COCs. Following the removal of COCs, the extracted groundwater would be amended with biostimulants and discharged into the backfilled excavations for infiltration. The continuous recirculation of oxygen/nutrient-rich water through the COC-containing silt zones is designed to actively enhance the biodegradation of residual COCs in soil and groundwater. This alternative includes the direct injection of liquid micron-scale adsorbents and biostimulants (PetroFix) throughout the impacted silt zone surrounding MW-11 within the VRU Area. This alternative assumes 5 years of groundwater recirculation and 2 years of MNA.	Remedial design investigations would be needed to verify: (a) the lateral and vertical extent of PCM in select area; (b) temporary shoring requirements associated with 12-foot-deep excavations; (c) the radius of influence of extraction wells; (d) treatability of extracted groundwater; (e) the ability to infiltrate treated/amended water within the backfilled excavations; (f) the ability to stimulate biodegradation between water injection and groundwater extraction points; and (g) the ability to control plume migration. Other unknowns include the remedy's impact on terminal operations and regulatory approval of groundwater recirculation. As mentioned, pilot testing within both source areas would be needed to develop the final design of the recirculation system. During full-scale implementation, the following unknowns could have a significant impact on cleanup costs: (a) the amount and degree of maintenance required to keep recirculation system operational; (b) the potential mobilization of undetected free product; (c) the ability to maintain hydraulic containment; (d) the restoration time frame; and (e) the effectiveness of direct injections of adsorbents and biostimulants beneath the VRU Area to achieve cleanup levels.	Same as Alternative 3, plus the added benefit of actively enhancing bioremediation within the residual smear zones and shorter anticipated restoration time frame.	Groundwater recirculation is expected to mobilize sorbed contamination and it may prove difficult to demonstrate hydraulic containment. Additional Site investigations and extensive technology pilot testing will be needed to demonstrate plume control.
Alternative 6 Removal of Accessible PCM Enhanced Bioremediation	In addition to the implementation of IC and MNA, this alternative includes the removal of accessible PCM beneath the MW-5 Area and MW-6/B-18 Areas (i.e., 22 feet bgs) and backfill with hydrocarbon degradation stimulating amendments (e.g., ORC). The soil removal actions would require excavation shoring and dewatering. Following excavation, this alternative includes the direct injection of liquid micron-scale adsorbents and	(a) The amount of accessible PCM; (b) the quantity and quality of excavation water; (c) excavation wall stability and degree of shoring required to limit settlement and damage to surrounding structures; (d) type of excavation equipment required; (e) permit requirements; (f) the effectiveness of placing ORC at the limits of the excavation to stimulate biodegradation; and (g) restoration time frame.	The alternative provides for the largest immediate reduction in PCM. Relative to the other alternatives, Alternative 6 is designed to meet MTCA Method A cleanup levels within the shortest amount of time (5 years).	Low benefit to cost ratio. Significant interruption to facility operations and likelihood of needing to relocate on-site infrastructure. Risk to damaging infrastructure during excavation resulting in release of petroleum products.

Notes:

MNA	Monitored Natural Attenuation
PCM	Petroleum Containing Material (TPH > MTCA Method A)
gpm	gallons per minute
bgs	below ground surface
COCs	Contaminants of Concern
POTW	publicly owned treatment works
VRU	Vapor Recovery Unit
ORC	Oxygen Release Compounds
CPU	Clark Public Utilities
PAA	Pleistocene Alluvial Aquifer
TPH	total petroleum hydrocarbons
GAC	Granular Activated Carbon
UIC	underground injection control
PCS	Petroleum Contaminated Soil

General Assumptions

Site groundwater flow is generally flat with a slight gradient to the southwest.
Treatment standards for the Site are protective of MTCA Method A Cleanup Levels.
Worker health and safety will be monitored, and a health and safety plan will be adopted for the Site and communicated to workers during cleanup implementation
Constituents of concern potentially include TPH, BTEX and PAHs.
No additional contaminant sources will be encountered during the implementation of remedial action at the Site.
Soil disposal is permitted at Subtitle D landfill, as non-hazardous waste.
No ecological receptors will be exposed to COCs above applicable screening levels.
The final remedial approach will require the approval or oversight of the Washington Department of Ecology
No costs included for potential third party liability or natural resource damages.
Cost estimates based on time and materials cost using Cascadia Associates rates and markups.

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Table 7
Comparative Analysis of Cleanup Alternatives- MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Hydraulic Containment	Alternative 4 Plume Stabilization Enhanced Bioremediation	Alternative 5 Removal of Accessible Vadose Zone PCM Hydraulic Containment and Recirculation Enhanced Bioremediation	Alternative 6 Removal of Accessible PCM Enhanced Bioremediation
Protectiveness **5 = high protectiveness**	**1 No reduction of risks or improvement of overall environmental quality**	**2 Low/Medium**	**3 Medium**	**3 Medium**	**4 Medium/High**	**4 Medium/High**
Permanence **5 = high permanence**	**1 Low/Medium**	**2 Low/Medium**	**3 Medium**	**3 Medium**	**4 Medium/High**	**4 Medium/High**
Reduction of Toxicity	Low. Natural attenuation but no IC to limit exposure	Medium. IC to limit exposure. Petroleum hydrocarbons amenable to natural attenuation.	Medium. IC to limit exposure, GWE and MNA to slowly reduce source area concentrations.	Medium. Reduction in plume mobility and enhanced biodegradation if reagents can be effectively distributed throughout the residual source areas.	Medium/High. Removal and off-site disposal of accessible vadose zone PCS. The active recirculation of biostimulants through residual source areas is expected to enhance biodegradation of residual PCS faster than Alternative 4.	High. Removal and off-site disposal of accessible vadose and smear zone PCS. Placement of ORC in the final limits of the excavation may or may not enhance biodegradation.
Reduction of Mobility	Low. No hydraulic control/containment	Low. No hydraulic control/containment.	Medium. During operation, GWE would influence gradient and limit contaminant plume migration if occurring. May be difficult to keep GWE system continually operational over 28-year restoration time frame.	Medium/High. Closely spaced injections of liquid activated carbon should effectively limit plume migration if occurring.	Medium. GWE, treatment, and recirculation should limit plume migration. However, infiltration could lead to short-term contaminant spreading.	High. Larger source area removal is expected to further reduce plume migration if occurring. Smaller source area footprint and shorter restoration time frame.
Effectiveness Over The Long Term **5 = high effectiveness**	**1 Low**	**2 Low/Medium**	**4 Medium/High**	**3 Medium**	**4 Medium/High**	**5 High**
Nature, Degree, and Certainties or Uncertainties of Alternative to be Successful	No source removal or monitoring of contaminant reduction and/or mobility.	No source removal or plume containment. Groundwater quality monitoring would inform need for active cleanup measures.	Anticipated high degree of effectiveness due to a well known technology; however, long restoration time frame reduces overall effectiveness.	Inherent, high degree of uncertainty associated with the volume and extent of residual PCS, effectiveness of PetroFix to reduce dissolved phase mobility and enhance bioremediation, risks/liability posed by residual contaminants, impact to Facility operations, restoration time frame.	Medium/High: Containment via reliable technology, but high degree of uncertainty associated with recirculation radius of influence, ability to establish and maintain hydraulic control, effectiveness of bioenhancement impact to Facility operations, system O&M, restoration time frame.	Some degree of uncertainty with permitting requirements, shore requirements, dewatering requirements, volume and extent of accessible PCS, impact on Facility operations.
Reliability	None	Low/Medium. IC are generally effective. Slow MNA in smear zone. Plume not contained.	High. Reliable technology.	Medium. Provided residual contamination is amenable to natural attenuation/biodegradation.	Medium. Provided recirculation influences gradient and PCS in tight soils are amenable to enhanced biodegradation.	High. Proven source area removal method provided the majority of PCS is accessible.
Magnitude of Residual Risk	Potential direct exposure to COCs in soil and groundwater at concentrations posing an unacceptable risk to human health.	Low/Medium. No source removal. Relies completely on MNA.	Low/Medium. Slow reduction in source area concentrations. Heavy reliance on plume containment.	Medium. Less than preceding alternatives because contaminants are contained in a finite zone with electron acceptors that will initially degrade via anaerobic pathways and promote syntrophic conditions that should sustain complete degradation.	Medium/High. Active implementation of enhanced bioremediation should reduce residual concentrations faster than the passive implementation used in Alternative 3.	High. Less contamination left in place, which reduces reliance on enhanced and/or natural biodegradation.
Effectiveness of Controls Required to Manage Treatment Residues	None	Low/Medium. Heavy reliance on institutional controls.	Medium/High. Hydraulic containment lessens dependence on institutional controls.	Medium/High. The combination of liquid activated carbon with biostimulants should be effective if the reagents can be evenly distributed throughout the source areas.	Medium/High. Faster reduction of contaminant mass reduces dependence on hydraulic containment. However, on-site infiltration may spread the plume vertically.	Medium/High. Further reduction of contaminant mass reduces dependence on bioremediation and MNA.

Please refer to notes on last page of table

Table 7
Comparative Analysis of Cleanup Alternatives- MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Hydraulic Containment	Alternative 4 Plume Stabilization Enhanced Bioremediation	Alternative 5 Removal of Accessible Vadose Zone PCM Hydraulic Containment and Recirculation Enhanced Bioremediation	Alternative 6 Removal of Accessible PCM Enhanced Bioremediation
Management of Short-Term Risks 5 = effective risk management	**1 Low**	**2 Low/Medium**	**4 Medium/High**	**2 Low/Medium**	**3 Medium**	**1 Low/Medium**
Implementation Risks	High risk and liability associated with No Action.	High risk and liability posed by long restoration time frame.	Medium/High: Some potetential risk due to installation of system in an active terminal.	Low/Medium. Injection contractor will be onsite for a long time increasing risk of damage to Facility infrastructure and activity. Depends on effective distribution of reagents of reagents throughout source areas.	Medium/High. More infrastructure needed than Alternative 3 therefore, there is more potential for damage to surrounding structures, worker safety, impact Facility operations.	Low/Medium. Potential damage to surrounding structures, worker safety, high cost/benefit ratio, may impact Facility operations.
Effectiveness of Risk Mitigation Measures	None	Medium. No evidence that groundwater contamination extends beyond the Facility, or that contaminant plumes are advancing.	Medium. Further demonstration that off-site plume migration is not occurring.	Medium. Further demonstration that off-site plume migration is not occurring.	Medium. Focused source removal and actively enhanced bioremediation will effectively mitigate toxicity of residual contamination. Infiltration of water through residual contamination could lead to short-term spreading of contamination that may not be contained by GWE.	Low/Medium. Shoring, larger source area removal.
Implementability 5 = high implementability	**5 High**	**4 High/Medium**	**4 Medium/High**	**3 Medium**	**3 Medium**	**2 Low/Medium**
Difficulties and Unknowns Associated with Implementation	Does not constitute a cleanup action.	Easy to implement.	High. Easy to Implement	Medium. Potential difficult permitting requirements, potential damage to infrastructure, impact on Facility operations, radius of influence, actual treatment and infiltration requirements, long-term treatment O&M.	Medium/High. Potential difficult permitting requirements, radius of influence, actual treatment and infiltration requirements, long-term treatment O&M.	Low. Difficult permitting requirements, shoring, excavation, disposal, potential damage to infrastructure, impact on Facility operations.
Ability to Monitor Effectiveness of Remedy	Does not constitute a cleanup action.	High	Medium	Medium	Medium	Medium
Consistency with State, Federal, and Local Requirements	None	Low	Medium	Medium	Medium	Medium
Approval of Other Agencies or Governmental Bodies	Low	Low	Medium	Medium	Medium	Medium
Availability of Equipment, Specialists, and Services	Does not constitute a cleanup action.	High	Medium	Medium	Low/Medium	Medium
Consideration of Public Concerns 5 = high degree of consideration	**1 Low**	**2 Low/Medium**	**4 Medium/High**	**3 Medium**	**3 Medium**	**5 High**

Please refer to notes on last page of table

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Table 7
Comparative Analysis of Cleanup Alternatives- MW-5, MW-6, and VRU Areas
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA	Alternative 3 Hydraulic Containment	Alternative 4 Plume Stabilization Enhanced Bioremediation	Alternative 5 Removal of Accessible Vadose Zone PCM Hydraulic Containment and Recirculation Enhanced Bioremediation	Alternative 6 Removal of Accessible PCM Enhanced Bioremediation
Acceptance by WDOE 5 = high likelihood of State acceptance	**1 Low**	**2 Low**	**4 Medium/High**	**3 Medium**	**4 Medium/High**	**5 High**
Treatment Preference for High Levels of Mobile Contaminants	None	No active treatment, but IC to prevent exposure and monitoring to assess progress and migration potential.	Contains and treats COCs. Reliable technology. Easy and relatively quick to implement.	Stabilizes and treats COCs.	Removal and off-site disposal of PCM in vadose zone. Hydraulic containment limits mobility. Bioenhancement reduces treatment time.	Removal of accessible PCM to 22 feet and expected large reduction of COCs in groundwater.
Minimize Long-Term Management	None	Does not meet cleanup levels within a reasonable time frame.	Low to moderate potential to meet cleanup levels within a reasonable time frame.	Moderate potential to meet cleanup levels within a reasonable time frame.	Moderate potential to meet cleanup levels within a reasonable time frame.	High potential to meet cleanup levels within a reasonable time frame.
Minimize Risk	None	Residual contaminant concentrations will likely remain above MTCA Method A Standards for long time.	Residual contaminant concentrations will likely remain above MTCA Method A Standards for long time. Mitigates off-site migration.	Plume stabilization further reduces threats to CPU wellfield.	Focused source removal, hydraulic containment, and enhanced bioremediation reduces threats to CPU wellfield.	Rapid and proven reduction of soil and groundwater contaminant concentrations.
MTCA Benefit Ranking [1]	*11* **Alternative 1**	*16* **Alternative 2**	*26* **Alternative 3**	*20* **Alternative 4**	*25* **Alternative 5**	*26* **Alternative 6**
Estimate of Cost Net Present Value [2]	**$0**	**$900,000**	**$8,000,000**	**$2,600,000**	**$3,800,000**	**$4,300,000**
Uncertainty of Costs	N/A	Cost to file institutional controls, time for MNA, and GWM frequency/duration.	Radius of influence, volume of water, discharge and treatment requirements, O&M requirements, and restoration time frame.	Volume of PetroFix required to stabilize plume, ability to effectively distribute reagents into source areas beneath existing infrastructure (e.g., tanks), radius of influence, ability to enhance anaerobic degradation, and restoration time frame.	Volume and disposal of excavated material, impact on Facility operations, *in situ* treatment efficiency, radius of influence, volume of water, infiltration and treatment requirements, O&M requirements, and restoration time frame.	Volume and disposal of excavated material, shoring and dewatering requirements, impact on Facility operations, MNA of residual contamination, injection radius of influence (VRU area), and restoration time frame.
Benefit/Cost Ratio [3]	**N/A**	**1.78**	**0.33**	**0.77**	**0.66**	**0.60**
Restoration Time Frame	Unknown	30 Years	30 Years	10 Years	7 Years	5 Years

Notes:
[1] The MTCA benefits ranking is obtained by summing the results of the five criteria.
[2] Net present value costs are estimated in 2020 dollars and then were discounted against a 3% inflation factor. The costs shown are rounded to two significant figures. Itemized estimates are provided in Appendix E.
[3] The benefit/cost ratio is obtained by dividing the alternative's MTCA benefits ranking by its estimated cost (in $million).

IC = Institutional Controls
GWE = Groundwater Extraction
O&M = Operations and Maintenance
CPU = Clark Public Utilities
ORC = Oxygen Release Compounds
GWM = Groundwater Monitoring
PCS = Petroleum Contaminated Soil
MNA = Monitored Natural Attenuation
MTCA = Model Toxics Control Act
COCs = Contaminants of Concern
N/A = not applicable
WDOE = Washington Department of Ecology
VRU = Vapor Recovery Unit
PCM = Petroleum Contaminated Media

Example of Criteria Scoring and Relationship Between Numbers and Text: 1 = low, 2 = low/medium, 3 = medium, 4 = medium/high, 5 = high.

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Table 8
Evaluation of Reasonable Restoration Time Frame
NuStar Terminals Operations Partnership L.P. – Annex Terminal
Vancouver, Washington

Design Concept		**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Estimated Restoration Time Frame		**30 years**	**30 years**	**10 years**	**5 to 7 years**	**3 to 5 years**
Factors Used to Determine Whether the Restoration Time Frame is Reasonable (WAC 173-340-360(4)(b))	*Potential risks posed by the Site to human health and the environment*	Risk is low because: petroleum-impacted soil and groundwater can be managed in place, and plume does not currently reach water bearing zones utilized by the CPU wellfield and is not expected to.	Risk is low for the reasons mentioned in Alternative 2 and hydraulic containment will ensure residual contamination is stable.	Risk is low for the reasons mentioned in Alternative 2 and injections of liquid activated carbon should ensure that residual contamination is stable.	Risk is low because: for the reasons mentioned in Alternative 2 and hydraulic containment will ensure residual contamination is stable.	Risk is low because: for the reasons mentioned in Alternative 2 and direct injections plume stabilizer to ensure residual contamination is stable.
	Practicability of achieving shorter restoration time frame	Alternatives 4, 5, and 6 would likely achieve a shorter restoration time frame.	Alternatives 4, 5, and 6 would likely achieve a shorter restoration time frame.	Alternatives 5 and 6 would likely achieve a shorter restoration time frame.	Alternative 6 would likely achieve a shorter restoration time frame.	This alternative would likely achieve the shortest restoration time frame.
	Current and potential future use of Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site	Current and future use of the Site is petroleum storage and distribution. Current and future use of the surrounding areas is industrial and greenway. Current and future use of deeper groundwater beneath the surrounding area to the north/northwest is domestic water supply (Carol Curtis Wellfield).	Current and future use of the Site is petroleum storage and distribution. Current and future use of the surrounding areas is industrial and greenway. Current and future use of deeper groundwater beneath the surrounding area to the north/northwest is domestic water supply (Carol Curtis Wellfield).	Current and future use of the Site is petroleum storage and distribution. Current and future use of the surrounding areas is industrial and greenway. Current and future use of deeper groundwater beneath the surrounding area to the north/northwest is domestic water supply (Carol Curtis Wellfield).	Current and future use of the Site is petroleum storage and distribution. Current and future use of the surrounding areas is industrial and greenway. Current and future use of deeper groundwater beneath the surrounding area to the north/northwest is domestic water supply (Carol Curtis Wellfield).	Current and future use of the Site is petroleum storage and distribution. Current and future use of the surrounding areas is industrial and greenway. Current and future use of deeper groundwater beneath the surrounding area to the north/northwest is domestic water supply (Carol Curtis Wellfield).
	Availability of alternate water supplies	The Facility is connected to the municipal water supply.	The Facility is connected to the municipal water supply.	The Facility is connected to the municipal water supply.	The Facility is connected to the municipal water supply.	The Facility is connected to the municipal water supply.
	Likely effectiveness and reliability of institutional controls	IC are expected to be effective and reliable at maintaining protectiveness of managing soil contamination in place.	IC are expected to be effective and reliable at maintaining protectiveness of managing soil contamination in place.	IC are expected to be effective and reliable at maintaining protectiveness of managing soil contamination in place.	IC are expected to be effective and reliable at maintaining protectiveness of managing soil contamination in place.	IC are expected to be effective and reliable at maintaining protectiveness of managing soil contamination in place.
	Ability to control and monitor migration of hazardous substances from the Site	Remedial investigation results indicate that there is no migration of hazardous substances from the Site.	Remedial investigation results indicate that there is no migration of hazardous substances from the Site.	Remedial investigation results indicate that there is no migration of hazardous substances from the Site.	Remedial investigation results indicate that there is no migration of hazardous substances from the Site.	Remedial investigation results indicate that there is no migration of hazardous substances from the Site.
	Toxicity of the hazardous substances at the Site	The hazardous substances at the Site have a relatively low toxicity.	The hazardous substances at the Site have a relatively low toxicity.	The hazardous substances at the Site have a relatively low toxicity.	The hazardous substances at the Site have a relatively low toxicity.	The hazardous substances at the Site have a relatively low toxicity.
	Natural processes which reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions	Natural processes which reduce concentrations of hazardous substances have been documented to occur at the Site.	Natural processes which reduce concentrations of hazardous substances have been documented to occur at the Site.	Natural processes which reduce concentrations of hazardous substances have been documented to occur at the Site.	Natural processes which reduce concentrations of hazardous substances have been documented to occur at the Site.	Natural processes which reduce concentrations of hazardous substances have been documented to occur at the Site.
Conclusions Regarding Reasonableness of Restoration Time Frame		The restoration time frame estimated for this alternative may not be reasonable if increased pumping in the PAA influences the migration of Site COCs in groundwater.	The restoration time frame estimated for this alternative may not be reasonable if increased pumping in the PAA influences the migration of Site COCs in groundwater.	The restoration time frame estimated for this alternative is reasonable.	The restoration time frame estimated for this alternative is reasonable.	The restoration time frame estimated for this alternative is reasonable.

Notes

IC	Institutional Controls
COCs	Contaminants of Concern
CPU	Clark Public Utilities
PAA	Pleistocene Alluvial Aquifer

General Assumptions

Site groundwater flow is generally flat with a slight gradient to the southwest.
Treatment standards for the Site are protective of MTCA Method A Cleanup Levels.
Worker health and safety will be monitored, and a health and safety plan will be adopted for the Site and communicated to workers during cleanup implementation.
Constituents of concern potentially include total petroleum hydrocarbons (TPH); benzene, toluene, ethylbenzene, and xylenes (BTEX); and petroleum aromatic hydrocarbons (PAHs).
No additional contaminant sources will be encountered during the implementation of remedial action at the Site.
No ecological receptors will be exposed to COCs above applicable screening levels.
The final remedial approach will require the approval or oversight of the Washington Department of Ecology.

Table 9
Initial Screening of Cleanup Technologies - Truck Loading Rack Area
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

General Response Actions	Technology	Description	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Screening Comments
Petroleum Contaminated Soil						
NO ACTION	None	No Action	Not effective in achieving remedial action objectives.	Easy to implement.	No capital or O&M costs incurred.	Retained as a baseline for comparison.
INSTITUTIONAL CONTROLS	Deed Restrictions/ Soil Management Plan (SMP)	Prevents disturbance of any cap (soil cap or asphalt concrete) or other engineering control and ensures appropriate measures are taken during future Site work. Establishes procedure for handling and managing contaminated soils to protect human health and the environment.	Effective at preventing direct contact, but not effective at preventing migration or addressing contaminant reduction.	Deed restriction and SMP easy to implement. SMP would need to be prepared and maintained until it is demonstrated that petroleum hydrocarbons have attenuated below cleanup levels.	Low costs associated with implementing restrictions and/or SMP.	Applicable technology used in conjunction with other technologies.
	Monitoring	Laboratory analyses of samples.	Effective for documenting Site conditions to evaluate migration and current Site risks. Does not reduce contaminant concentrations.	Easy to implement. On-site and off-site monitoring wells already exist.	Low to moderate costs for monitoring.	Not a standalone technology. Applicable to document Site conditions and effectiveness of any treatment.
ENGINEERING CONTROLS	Access Restrictions	The use of fencing and signage to prevent access to contaminated media.	Effective at preventing direct contact by humans. Not effective at preventing exposure to ecological receptors or preventing migration.	Easy to implement.	Low costs associated with installation of fencing or signage.	Access to the facility is already controlled by fencing. The use of further fencing is likely incompatible with operations and does not add further protection as personnel and contractors are aware of the presence of petroleum and are required to utilize personal protection equipment.
	Control of Building HVAC System	Use HVAC system to maintain positive pressure in buildings.	May be effective in preventing migration of volatile contaminants from soil to indoor air as long as a pressure differential is maintained between building and subsurface soil. Does not address contaminant reduction.	Can be easy to implement in buildings with existing HVAC systems. Not applicable to impacted area (outdoor space).	Low costs associated with implementing these controls. Operational costs include additional heating of outdoor air.	Is generally used in conjunction with other engineering controls. Not applicable since there are no buildings present at the Truck Loading Rack.
	Vapor Barriers	Installation of low-permeable barriers beneath buildings to prevent vapor intrusion.	Effective in preventing migration of volatile contaminants from soil into indoor air. Does not address contaminant reduction.	Easy to implement for new construction. Not applicable to impacted area (outdoor space).	Moderate cost for surface application. High cost for sub-floor installation (removal and replacement of slab floor).	Not applicable since there are no buildings present at the Truck Loading Rack.
CONTAINMENT	Capping	Installation of an engineered cap such as a soil cap or paved with asphalt concrete over the impacted soils.	Effective at preventing direct contact with contaminated soils. Does not address contaminant reduction.	Reasonably easy to implement. Much of the area around the Truck Loading Rack is already paved.	Moderate cost to implement.	Impacted soil is approximately 6 feet below ground surface and is already effectively capped with clean overburden.

Please refer to note at end of table.

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Table 9
Initial Screening of Cleanup Technologies - Truck Loading Rack Area
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
REMOVAL/DISCHARGE	Excavation	Excavation of some or all of the impacted soil for further treatment or disposal.	Effective at removing source material from the Site. Addresses direct exposure pathway and potential for migration by reducing contaminant mass present in the subsurface.	The Site is developed as a truck loading rack with a number aboveground storage tanks and underground infrastructure such as piping present adjacent to the impacted area which would likely need to be removed or protected to facilitate excavation. Excavation could be completed with readily available construction equipment and methods.	High costs depending on soil volume excavated.	Applicable to the Site.
	Off-Site Disposal	Excavated soil would be transported by truck to an off-site permitted disposal facility. Soils would require waste profiling and approval by the disposal facility.	Effective for containing contaminated soils and reducing risks associated with direct exposure.	Implementation involves transportation of contaminated soils on public roads.	Moderate to high costs depending on soil volume transported, waste characterization, and distance to disposal facility.	Applicable to the Site.
	On-Site Disposal	Consolidate excavated soil in an on-site, capped disposal area.	No effective at removing the long-term source of groundwater contamination at the Site.	Implementation would involve conventional construction equipment and methods. Much of the Facility is developed as containment areas for aboveground storage tanks, placement of the soil onsite would reduce available secondary containment at the Site.	Moderate to high costs depending on soil volume.	This technology is not retained because there is insufficient space and permitting would likely be prohibitive. Additionally, placement of the soil on-site would reduce available secondary containment at the Site. Placement of impacted soil on-site would not be compatible with the Facility's industrial stormwater permit. Placement of soil on-site would require construction of a cap to prevent direct contact.
EX-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Chemical Extraction	Includes the application of chemical oxidants for the purpose of remediating excavated soils. Generally involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms. Possible oxidants can include peroxides, permanganates, or ozone.	Effective at destroying organic contaminants and oxidizing inorganic contaminants.	Risks associated with handling of oxidant in above-ground application. Bench-scale testing would be required during design. Requires staging area for treatment or transport to off-site facility. Air quality standards for site workers may be affected by open-air treatment methods.	High.	Not retained because technology has relatively high implementation risks to workers and less costly options are equally protective and available.
	Solidification/ Stabilization	Contaminants present in excavated soils are immobilized through the addition of binding agents which are mixed into the soil to decrease the permeability of the soil (solidification) or reduce the solubility of the contaminants (stabilization).	Effective at reducing the leaching of contaminants present in the excavated soil prior to disposal. Technology is typically used to stabilize inorganic contamination and is limited in effectiveness in treating organic compounds and fuels.	Implementation would involve conventional construction equipment and methods and could be useful in controlling water present in the excavated material if necessary prior to disposal at a permitted facility.	Low to Moderate.	Not retained because more effective technologies are present for organics and the PCM is present above the water table and is not leaching.
	Incineration	Organic contaminants are destroyed through the use of high temperature combustion (in the presence of oxygen).	Effective at removing organic contaminants from soil.	Would require transportation of excavated soils to a permitted incineration facility. No facility is nearby.	High cost to implement due to transportation costs.	Not retained because more cost effective technologies are present for treatment/removal of organics.
	Soil Washing	Contaminants are separated from the excavated soil by washing with amended water to remove organic compounds.	Extracted contaminants would be disposed of as a concentrated liquid waste and treated soil could be reused as backfill. Most suitable to removal of semi-volatile and inorganic contamination from excavated soil.	Requires area for soil treatment or transport to off-site facility. Resultant fluid would need subsequent treatment process or disposal. High implementation risk.	High cost to implement.	Not retained because other more suitable, cost effective and lower implementation risk technologies are available.
	Solar Detoxification	The technology utilizes ultraviolet (UV) light from the sunlight (or artificial) to destroy contaminants through photochemical and thermal reactions.	Can be effectively used for treating organic contaminants.	Requires dry conditions and typically sunlight and enough space to spread soil out.	Low to moderate cost to implement.	Not retained because the technology is not compatible with Site characteristics or operations. Would require a large area to spread out soil and would only be effective during dry summer months.

Please refer to note at end of table.

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Table 9
Initial Screening of Cleanup Technologies - Truck Loading Rack Area
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
EX-SITU BIOLOGICAL TREATMENT	Biopiles	Excavated soils are amended with agents to enhance natural aerobic processes and the pile is aerated with vacuum pumps/blowers.	Effective at removing organic contaminants from the excavated soil. Generally a long-term process	Requires dry conditions, typically done within an enclosure.	Low to moderate.	Not retained because the technology is not compatible with Site operations as it would require space for the long-term operation of the biopile.
	Land Farming	Excavated soils are stockpiled and are tilled to aerate the soil and promote naturally occurring aerobic degradation.	Can be effectively used for treating organic contaminants.	Implementation is relatively easy with common equipment and methods. Requires enough space to spread soil out.	Low to moderate.	Not retained because the storage of large stockpiles of soil on-site is not compatible with Facility operations.
IN-SITU BIOLOGICAL TREATMENT	Bioventing	The introduction of air or oxygen into the unsaturated subsurface to promote aerobic degradation of organic contaminants.	Can be effective removing volativle compounds. Not effective at treating inorganics or low volatility organics.	Relatively easy to implement and maintain.	Low to moderate.	Not retained because the PCM at the Facility has limited volatility remaining; therefore this technology would not be effective nor efficient.
	Land Treatment	Near surface soils are tilled to aerated to enhance naturally occurring bioremediation processes in the soil. Soil can be amended to further enhance the bioremediation processes.	Effective at promoting bioremediation of organic contaminants that are suited to aerobic degradation. Not effective at deeper contamination or inorganics.	Implementation is relatively easy with common equipment and methods.	Low to moderate.	Not retained because the technology is not compatible with Site characteristics. The contaminated soil is covered by 6 feet of clean soil.
	Phytoremediation	Technology uses plants to remove, transfer, stabilize, and destroy contaminants in soil.	Can be effective at removing a variety of contaminants (both organic and inorganic) from near surface soil. Not effective at deeper depths because uptake occurs at the roots.	Implementation is relatively easy if contamination is present near the root zone of the plants. Likely requires a large area for treatment.	Low to moderate	Not retained because the technology is not compatible with Site characteristics. The contaminated soil is covered by 6 feet of clean soil.
IN-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Soil Vapor Extraction (SVE)	This technology vacuum pumps/blowers to induce a vacuum on extraction wells or piping. The extracted vapors are discharged to the air. Treatment may be necessary prior to discharge.	Effective at removing volatile organic contaminants from the subsurface. Efficiency is dependent on soil porosity and the ability to induce a vacuum within the subsurface soil to remove the volatile contaminants.	SVE technology is an established treatment technology and installation uses readily available drilling and construction equipment. Would require ongoing operations and maintenance (O&M).	Moderate capital costs for installation and O&M.	Not retained because the technology is not well suited for removal of contaminants in silty environments such as the Site. Additionally the volatile fraction is not a significant part of the Site PCM.
	Chemical Oxidation	Includes the application of chemical oxidants for the purpose of remediating excavated soils. Generally involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to less toxic or less mobile forms. Possible oxidants can include peroxides, permanganates, or ozone.	Effective at destroying organic contaminants and oxidizing inorganic contaminants. Complete coverage can be challenging with *in-situ* application due to soil heterogeneity, varying lithology, and short-circuiting.	The technology uses readily available equipment to inject oxidants in the subsurface and a number of vendors are available. Pilot testing at the Site indicated that *in-situ* application within the vadose zone likely did not achieve complete coverage.	High.	Not retained based on past pilot testing experience at the Site. Additionally, this technology can be corrosive to piping and therefore is not compatible for use in the Truck Loading Rack setting.
	Soil Flushing	Water or water with an amendment (such as a surfactant, cosolvent, or other agents) are introduced to the vadose zone and/or the saturated zone. Contaminants are removed by partioning to the flushing solution which is then extracted by one or more extraction wells for treatment and disposal at the surface.	Can be effective at removing a wide range of contaminants, including organic contaminants and light non-aqueous phase liquid.	Can be difficult to achieve full coverage in heterogeneous soils due to preferential pathways. Investigations indicate that the impacted soil in the vadose zone is not impacting groundwater, soil flushing would flush contaminants into the shallow groundwater table.	High capital costs for installation, treatment, and O&M.	Not retained because technology could mobilize currently immobile petroleum hydrocarbons and result in migration of contaminants from the vadose zone to the saturated zone. Heterogeneous lithology would likely result in preferential pathways for flushing and incomplete coverage.
	Thermally-Enhanced Removal	High-energy injection of steam/hot air, electrical resistance, electromagnetic, fiber optic, radio frequency) is used to increase the recovery rate of semi-volatile or non-volatile compounds to facilitate extraction (enhanced volatilization or decreased viscosity)	Effective with semi-volatile organic contaminants or viscous compounds that are not otherwise extractable with vapor extraction or fluid extraction technologies.	Usually not a standalone technology, typically used with SVE or other treatment technology to enhance removal of semi-volatile compounds.	High costs to high energy costs and O&M.	Not retained because it is not well suited for the Site contaminants and other less expensive and effective technologies are available.
	Solidification/ Stabilization	Contaminants present in the subsurface are immobilized through the addition of binding agents which are mixed or injected into the soil to decrease the permeability of the soil (solidification) or reduce the solubility of the contaminants (stabilization)	Technology is typically used to stabilize inorganic contamination to prevent leaching and is limited in effectiveness in treating organic compounds and fuels.	Implementation would involve conventional construction equipment and methods.	Low to Moderate.	Not retained because more effective technologies are present for organics.

Notes:
1. Shading indicates technologies that have been eliminated from consideration.
2. PCM = Petroleum hydrocarbon containing material
3. O&M = operations and maintenance

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Table 10
Comparative Analysis of Cleanup Alternatives - Truck Loading Rack Area
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Groundwater Alternatives	**Ranking Criteria**																		**Score**	**Rank**	**Cost/Benefit**
	Protectiveness			**Permanence**			**Long-Term Effectiveness**			**Management of Short-Term Risks**			**Implementability**			**Public Concerns**					
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C			
A No Action		-	-		-	-		-	-		0	+		0	+		-	-	-6	**3**	NA
B Institutional Controls	+		0	+		-	+		-	0		+	0		+	+		0	4	**1**	11.6
C Excavation and Off-Site Disposal of Impacted Soil	+	0		+	+		+	+		-	-		-	-		+	0		2	**2**	0.34

Notes:

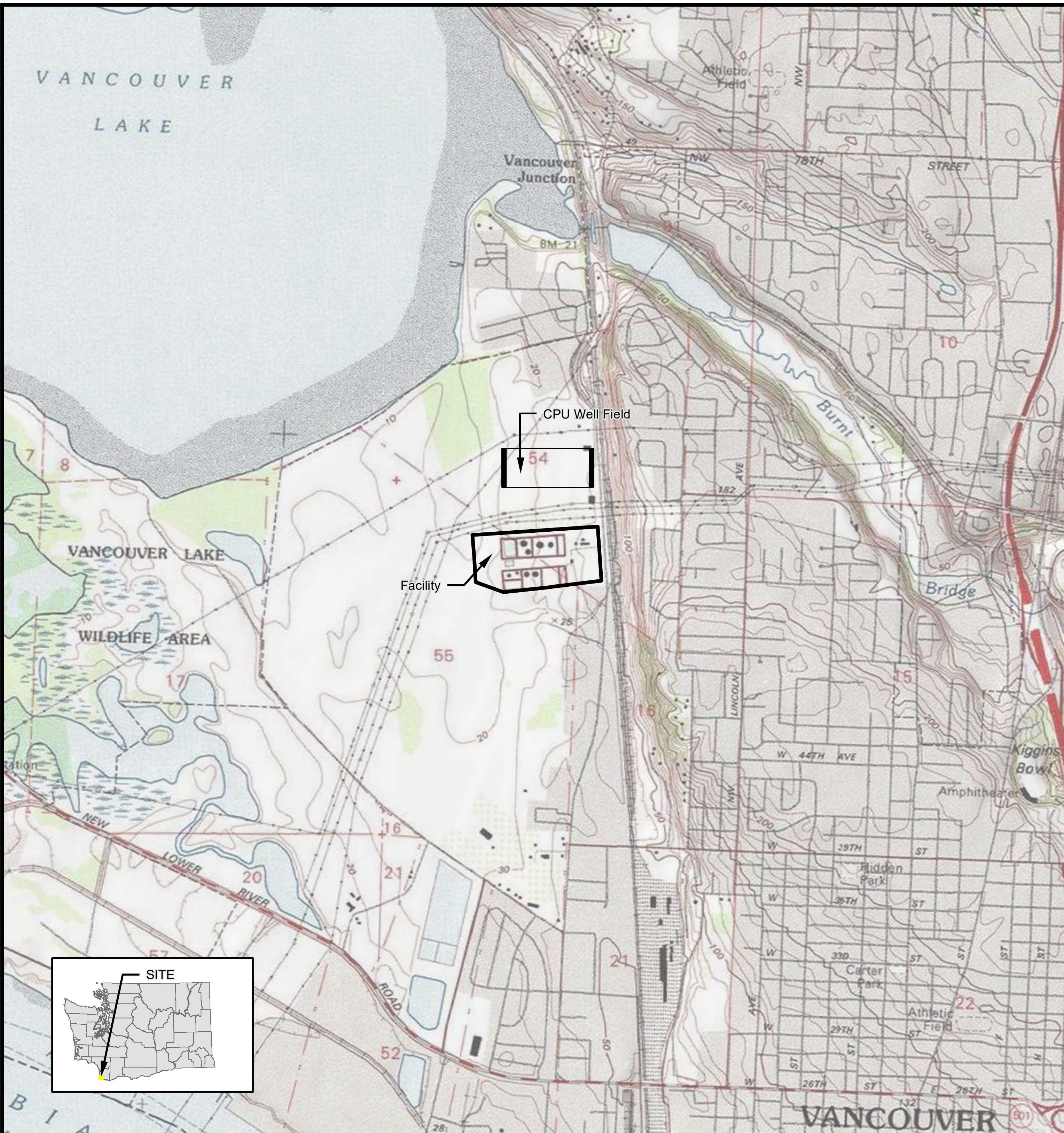
+ = The alternative is favored over the compared alternative (score = 1).

0 = The alternative is equal with the compared alternative (score = 0).

- = The alternative is less favorable than the compared alternative (score = -1).

vs. Alternative			
Alternative A		B	C
Alternative B	A		C
Alternative C	A	B	

FIGURES



Path: C:\DATA\C0060_005_NuStar_Vannex\Projects\Updated_FS\VicinityMap.mxd

Print Date: 4/27/2020

Approved By:

Produced By: ErikStrandhagen

Project:

Source: USGS Map obtained from Esri ArcGIS Online

Facility Boundary

0 1,000 2,000
Feet

Facility Location Map

NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure

1

Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).

Locations of roads and containments are approximate.

Source:
Aerial from Mapbox.

Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)

Historical Temporary Well Location (Approximate)

GP-1 Historical Direct-Push Boring Location (2002/2003)

HA-1 Historical Hand Auger Location (2002/2003)

GP-1 Sample Location (2008)

DP-1 Sample Location (2009)

SB-8R Soil Boring Location (September 2014)

B-1 Soil Boring Location (October 2015)

B-1 Soil Boring Location (February 2019)

B-29 Soil Boring Location (February 2020)

Facility Boundary

Cross Section Location (A – A')

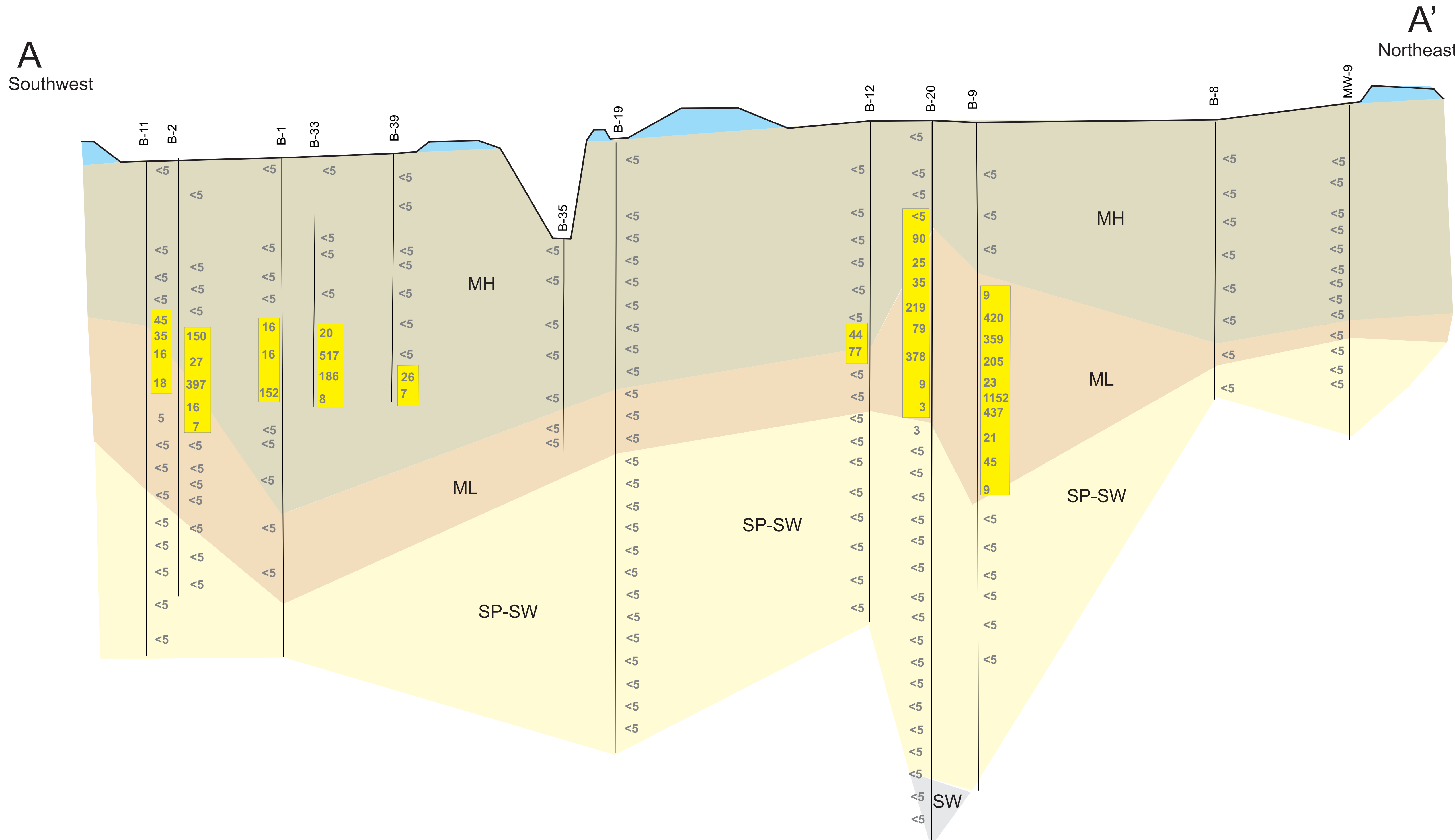
0 25 50 100 Feet

Facility Site Plan

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	May 2020	2



Vertical Exaggeration 6x
<5 Photo Ionization Detector (PID) Measurement
101 PID Reading >5

0 50 100
Approximate Horizontal Scale in Feet

0 5 10
Approximate Vertical Scale in Feet

- Fill
- MH - Elastic SILT with trace fine sand
- ML - Sandy SILT with trace clay
- SP-SM - Sandy SILT with trace clay
- SW - Coarse well-graded SAND with gravel

Note: the topography between borings is estimated based on site observation.

Geologic Cross Section A-A'

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Vancouver, Washington

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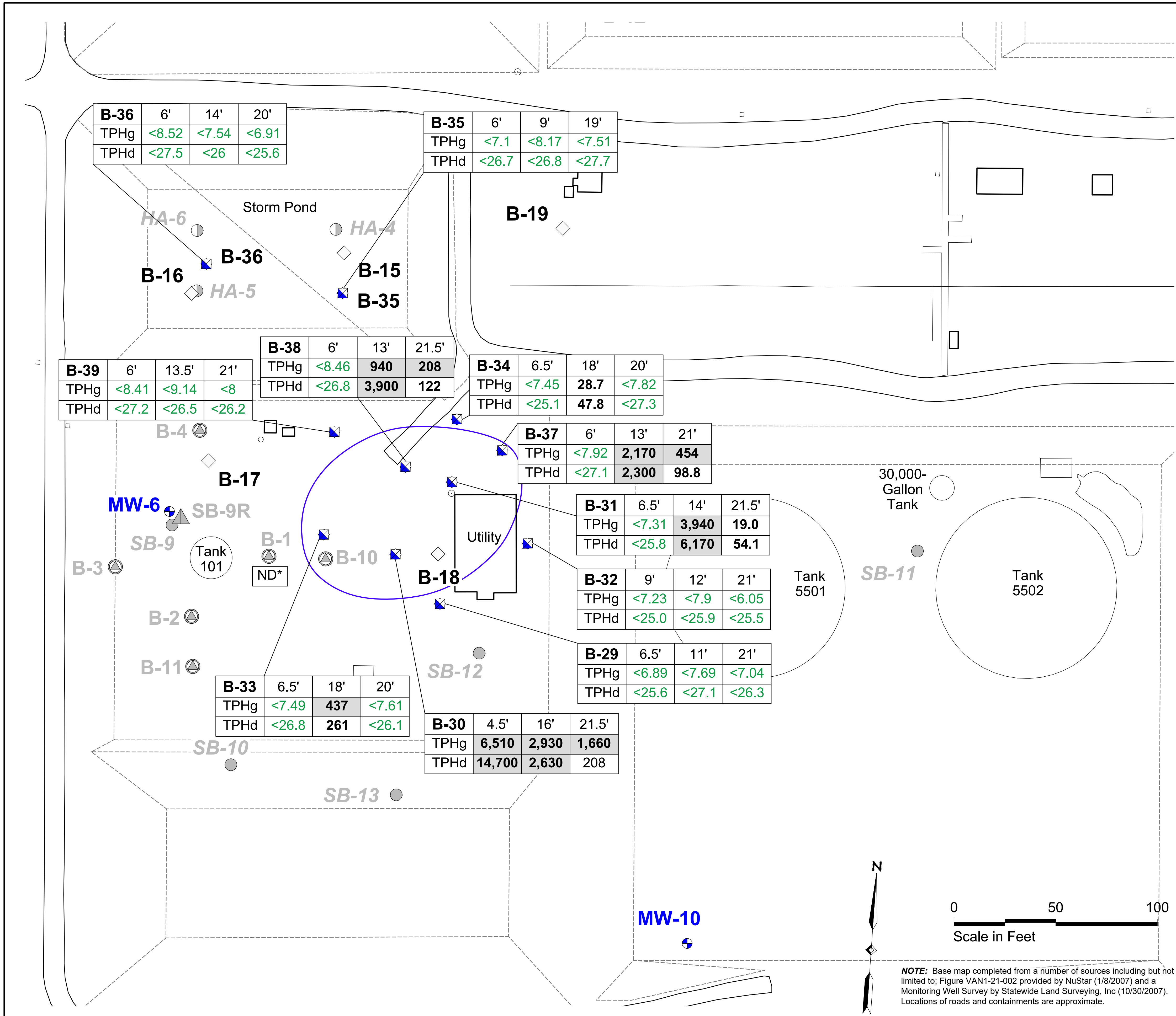
Project Number	0060-001-006	Figure
	April 2020	3



Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- GP-1 Historical Direct-Push Boring Location (2002/2003)
- HA-1 Historical Hand Auger Location (2002/2003)
- GP-1 Sample Location (2008)
- DP-1 Sample Location (2009)
- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)
- B-29 Soil Boring Location (February 2020)

B-30	4.5'
TPHg	6,510
TPHd	14,700

- Soil and Groundwater Sampling Location and Name
- Depth in Feet Below Ground Surface
- Concentration in Milligrams per Kilogram (mg/kg)
- Highlighted Concentration Exceeds MTCA Method A Cleanup Level
- GREEN Text Indicates Non-Detect Results
- Approximate Extent of TPH in Soil Greater than MTCA Level A Criteria

Abbreviations		MTCA Method A Cleanup Level (mg/kg)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	30
TPHd	Total Petroleum Hydrocarbons Diesel-Range	2,000

TPH in Soil in Southwest Area - February 2020

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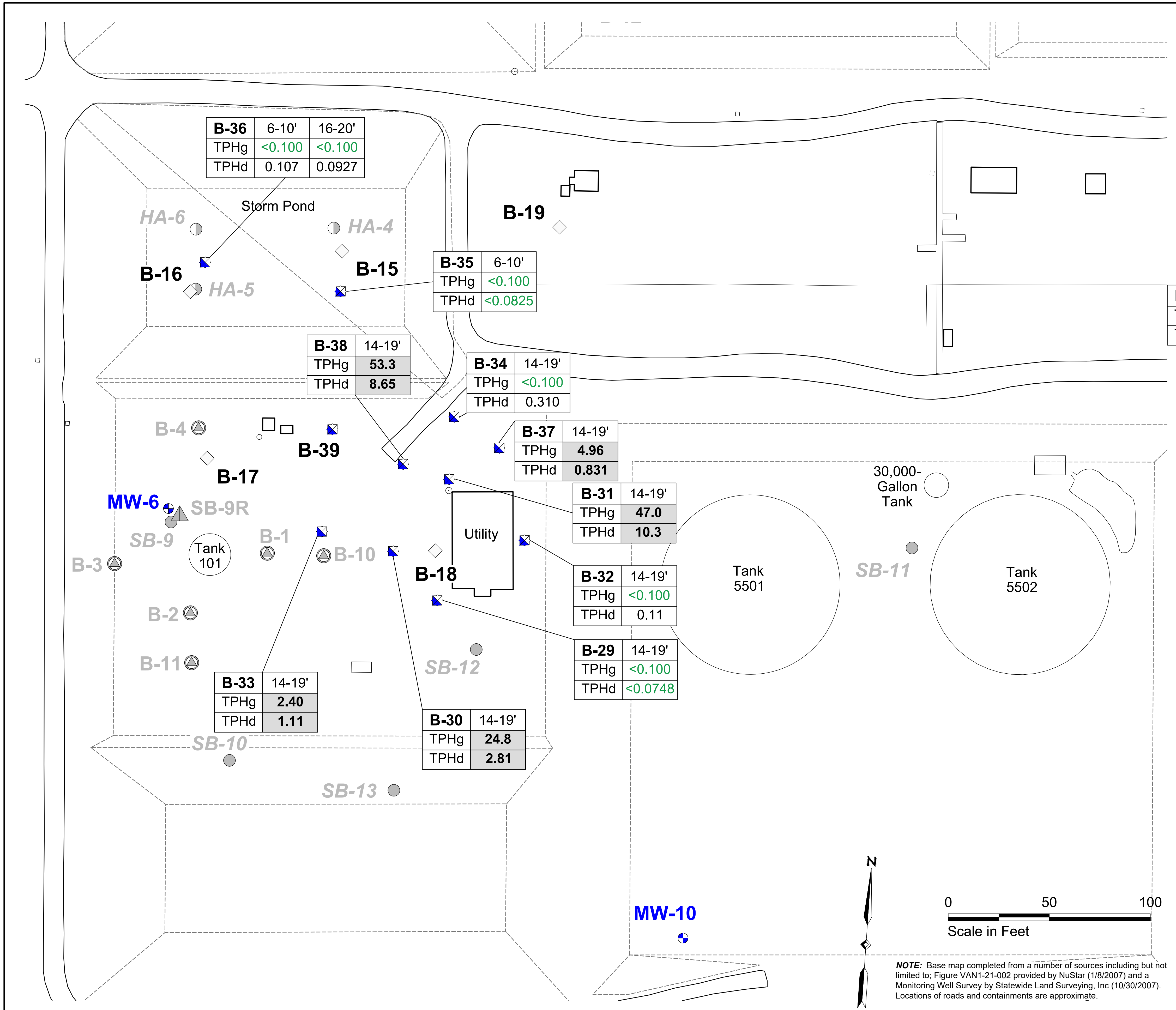
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	April 2020	4



Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- GP-1 Historical Direct-Push Boring Location (2002/2003)
- HA-1 Historical Hand Auger Location (2002/2003)
- GP-1 Sample Location (2008)
- DP-1 Sample Location (2009)
- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)
- B-29 Soil Boring Location (February 2020)

B-30	14-19'
TPHg	24.8
TPHd	2.81

- Grab Groundwater Sampling Location and Name
- Depth Interval in Feet Below Ground Surface
- Concentration in Milligrams per Liter (mg/L)
- Highlighted Concentration Exceeds MTCA Method A Cleanup Level
- GREEN Text Indicates Non-Detect Results

Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

TPH in Grab Groundwater Samples - February 2020

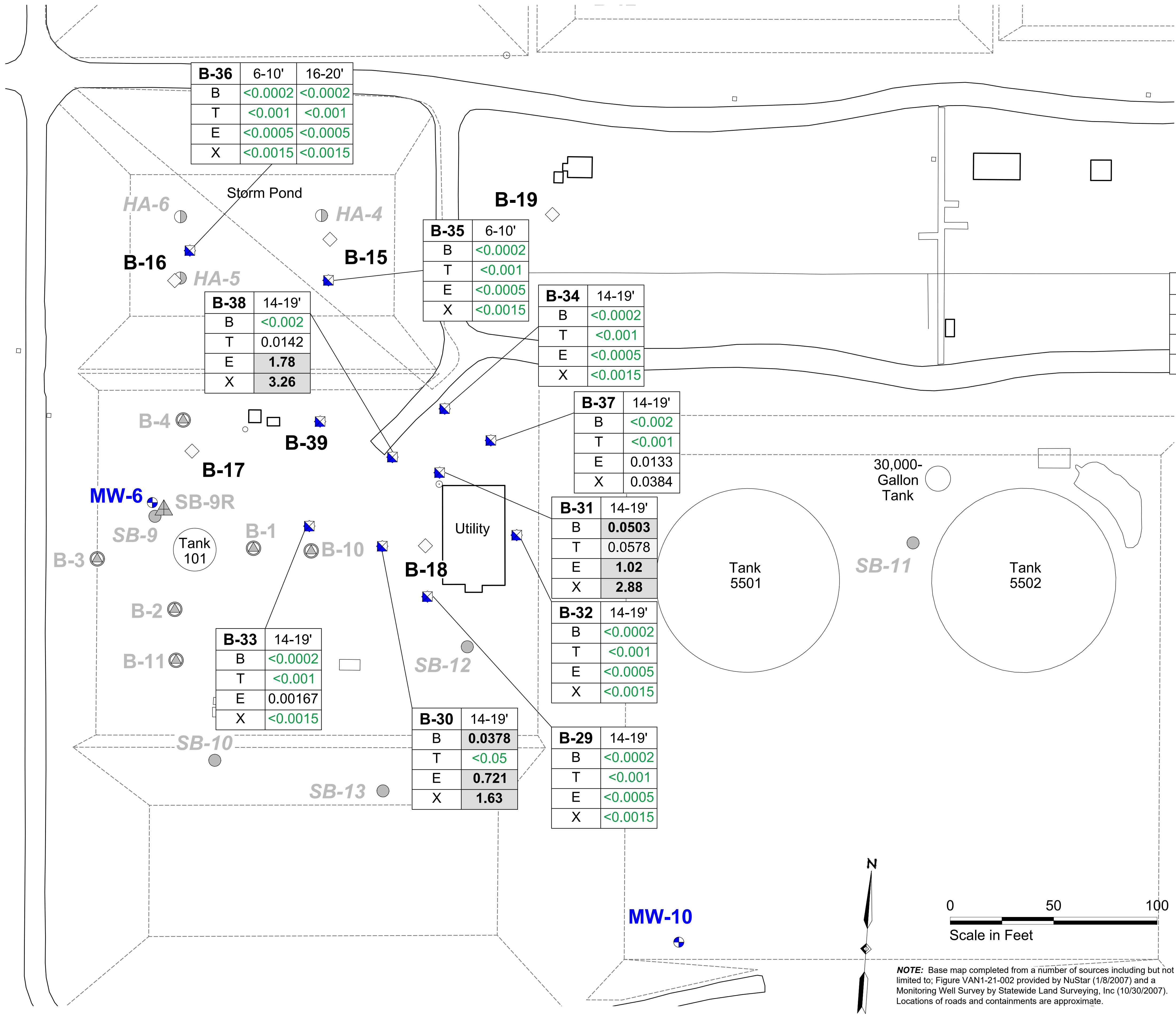
Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-006

April 2020

Figure 5



NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- GP-1 Historical Direct-Push Boring Location (2002/2003)
- HA-1 Historical Hand Auger Location (2002/2003)
- GP-1 Sample Location (2008)
- DP-1 Sample Location (2009)
- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)
- B-29 Soil Boring Location (February 2020)

B-30	14-19'
B	0.0378
T	<0.05
E	0.721
X	1.63

- Grab Groundwater Sampling Location and Name
- Depth Interval in Feet Below Ground Surface
- Concentration in Milligrams per Liter (mg/L)
- Highlighted Concentration Exceeds MTCA Method A Cleanup Level

GREEN Text Indicates Non-Detect Results

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1

BTEX in Grab Groundwater Samples - February 2020

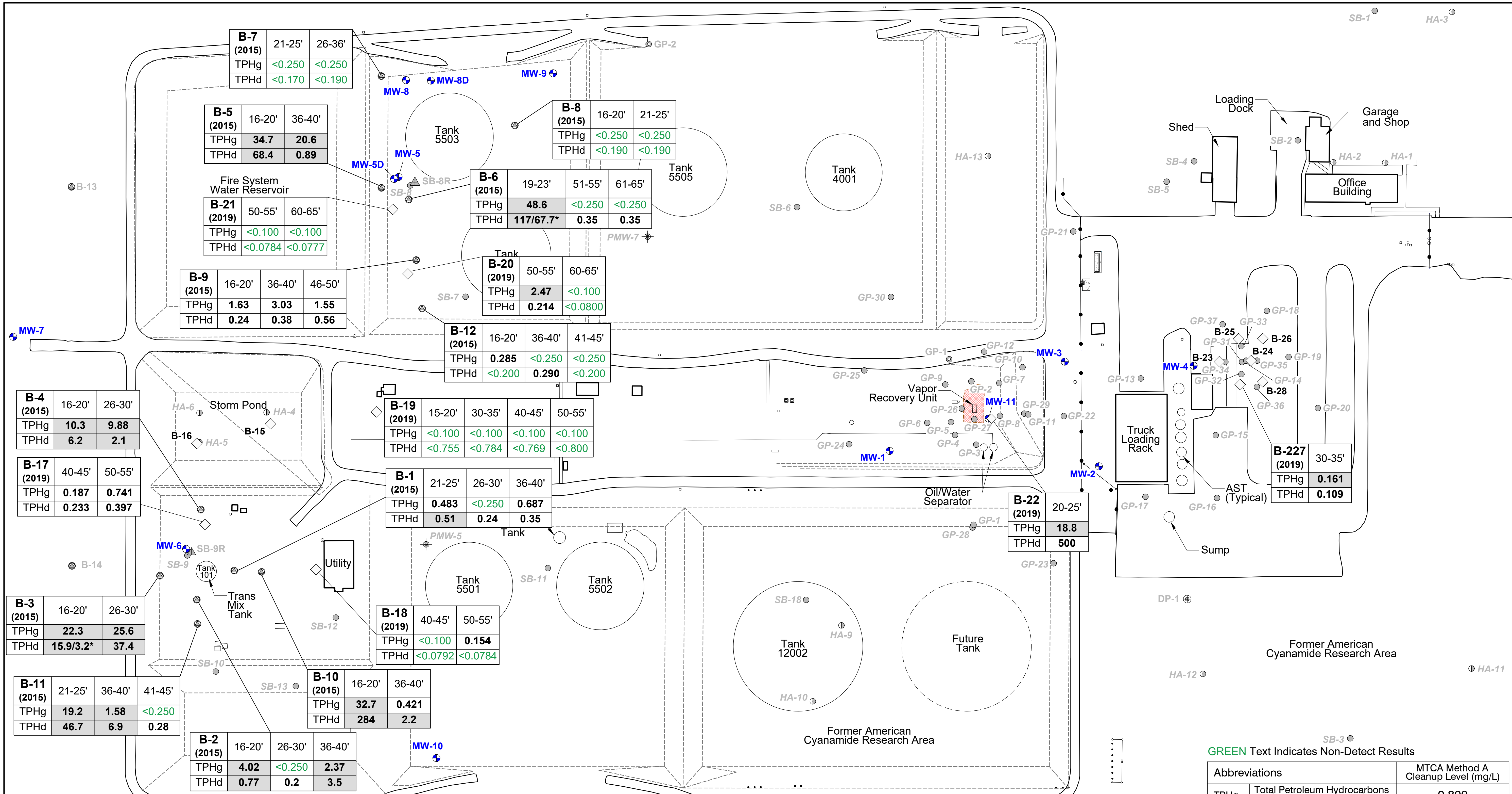
Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-006

April 2020

Figure 6



B-7 (2015)	21-25'	26-36'
TPHg	<0.250	<0.250
TPHd	<0.170	<0.190

B-5 (2015)	16-20'	36-40'
TPHg	34.7	20.6
TPHd	68.4	0.89

B-8 (2015)	16-20'	21-25'
TPHg	<0.250	<0.250
TPHd	<0.190	<0.190

B-6 (2015)	19-23'	51-55'	61-65'
TPHg	48.6	<0.250	<0.250
TPHd	117/67.7*	0.35	0.35

B-21 (2019)	50-55'	60-65'
TPHg	<0.100	<0.100
TPHd	<0.0784	<0.0777

B-9 (2015)	16-20'	36-40'	46-50'
TPHg	1.63	3.03	1.55
TPHd	0.24	0.38	0.56

B-20 (2019)	50-55'	60-65'
TPHg	2.47	<0.100
TPHd	0.214	<0.0800

B-12 (2015)	16-20'	36-40'	41-45'
TPHg	0.285	<0.250	<0.250
TPHd	<0.200	0.290	<0.200

B-4 (2015)	16-20'	26-30'
TPHg	10.3	9.88
TPHd	6.2	2.1

B-19 (2019)	15-20'	30-35'	40-45'	50-55'
TPHg	<0.100	<0.100	<0.100	<0.100
TPHd	<0.755	<0.784	<0.769	<0.800

B-17 (2019)	40-45'	50-55'
TPHg	0.187	0.741
TPHd	0.233	0.397

B-1 (2015)	21-25'	26-30'	36-40'
TPHg	0.483	<0.250	0.687
TPHd	0.51	0.24	0.35

B-227 (2019)	30-35'
TPHg	0.161
TPHd	0.109

B-22 (2019)	20-25'
TPHg	18.8
TPHd	500

B-3 (2015)	16-20'	26-30'
TPHg	22.3	25.6
TPHd	15.9/3.2*	37.4

B-18 (2019)	40-45'	50-55'
TPHg	<0.100	0.154
TPHd	<0.0792	<0.0784

B-10 (2015)	16-20'	36-40'
TPHg	32.7	0.421
TPHd	284	2.2

B-11 (2015)	21-25'	36-40'	41-45'
TPHg	19.2	1.58	<0.250
TPHd	46.7	6.9	0.28

B-2 (2015)	16-20'	26-30'	36-40'
TPHg	4.02	<0.250	2.37
TPHd	0.77	0.2	3.5

GREEN Text Indicates Non-Detect Results

Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- GP-1 Historical Direct-Push Boring Location (2002/2003)
- HA-1 Historical Hand Auger Location (2002/2003)
- GP-1 Sample Location (2008)
- DP-1 Sample Location (2009)
- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)
- B-29 Soil Boring Location (February 2020)

B-20 (2019)	50-55'
TPHg	2.47
TPHd	0.214

- Sampling Location and Date
- Depth Interval in Feet Below Ground Surface
- Concentration in Milligrams per Liter (mg/L)
- Highlighted Concentration Exceeds MTCA Method A Cleanup Level

* For TPHd, the first value is the concentration with silica gel cleanup and the second without (i.e. 117/67.7). At the request of Ecology, select samples were analyzed with and without silica gel cleanup for comparison.

N

0 100 200

Scale in Feet

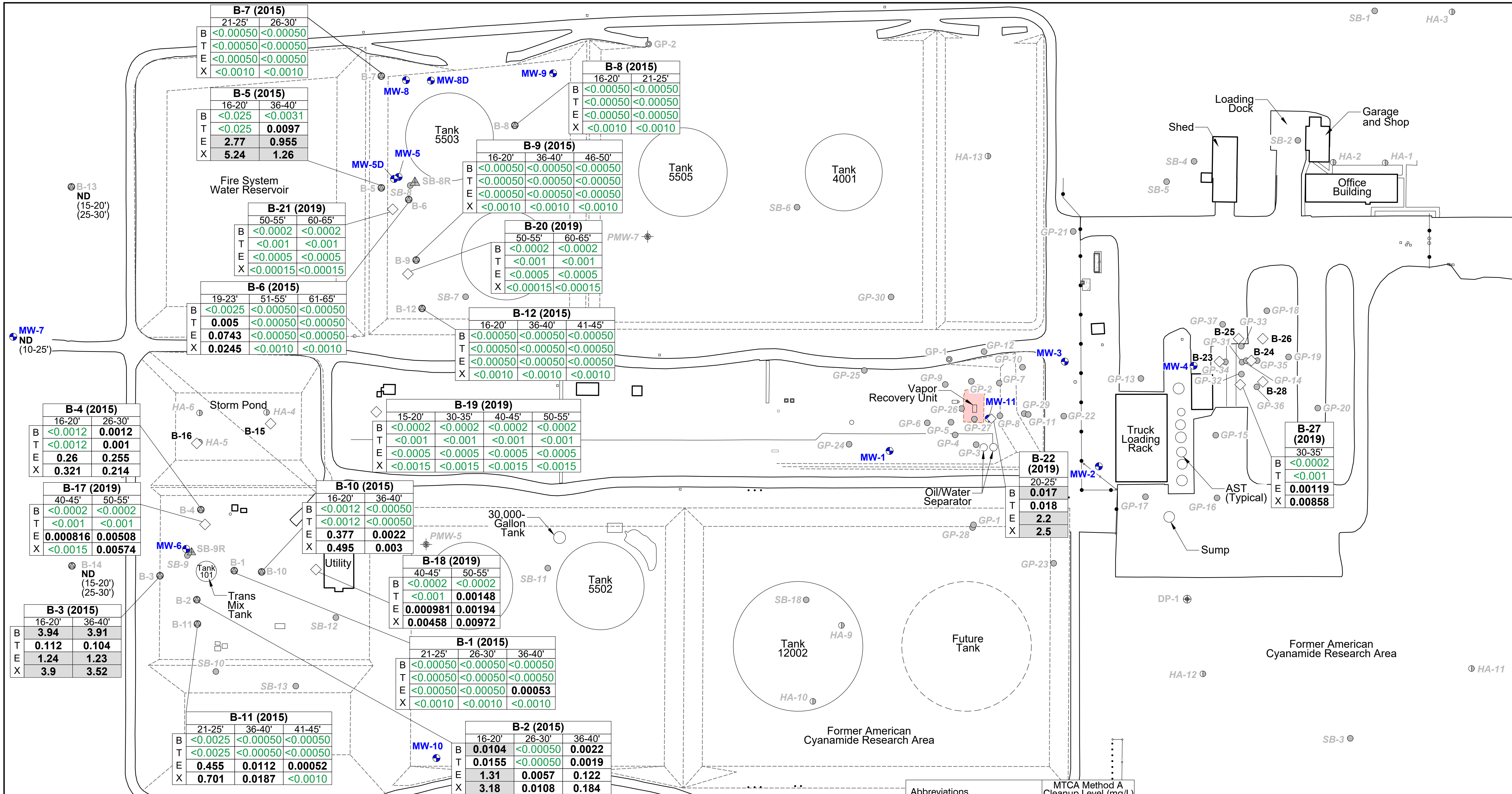
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

TPHg and TPHd Grab Groundwater Results - 2015 to 2019

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	April 2020	7



Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- GP-1 Historical Direct-Push Boring Location (2002/2003)
- HA-1 Historical Hand Auger Location (2002/2003)
- GP-1 Sample Location (2008)
- DP-1 Sample Location (2009)
- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)
- B-29 Soil Boring Location (February 2020)

B-22 (2019)	Sampling Location and Date
20-25'	Depth Interval in Feet Below Ground Surface
B 0.017	Concentration in Milligrams per Liter (mg/L)
T 0.018	
E 2.2	Highlighted Concentration Exceeds MTCA Method A Cleanup Level
X 2.5	

GREEN Text Indicates Non-Detect Results

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1

N

0 100 200
Scale in Feet

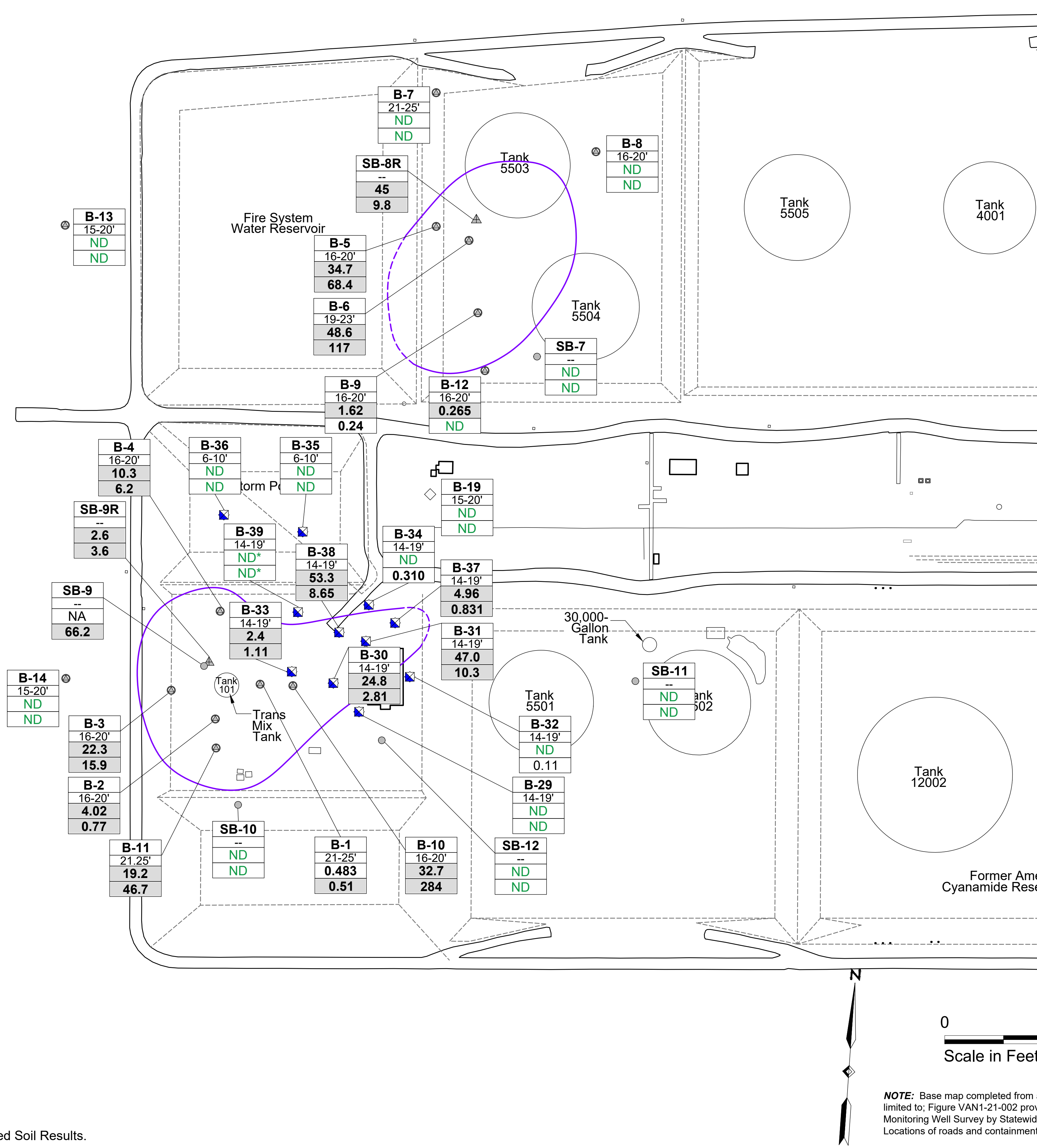
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX Grab Groundwater Results - 2015 to 2019

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	April 2020	8



Legend:

- Historical Direct-Push Boring Location (2002/2003)
- Soil Boring Location (September 2014)
- Soil Boring Location (October 2015)
- Soil Boring Location (February 2019)

B-9	Location Sampled
16-20'	Depth Interval in Feet Below Ground Surface
1.62	TPHg Concentration in Milligrams per Liter (mg/L)
0.24	TPHd Concentration in Milligrams per Liter (mg/L)

Highlighted Concentration Exceeds MTCA Method A Cleanup Level

ND Not Detected Above Method Reporting Limits.

Extent of TPH Greater Than MTCA Method A Cleanup Levels (Dashed Where Inferred)

NOTE: Groundwater data presented on this figure are first encountered groundwater, unless otherwise noted.

GREEN Text Indicates Non-Detect Results

Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

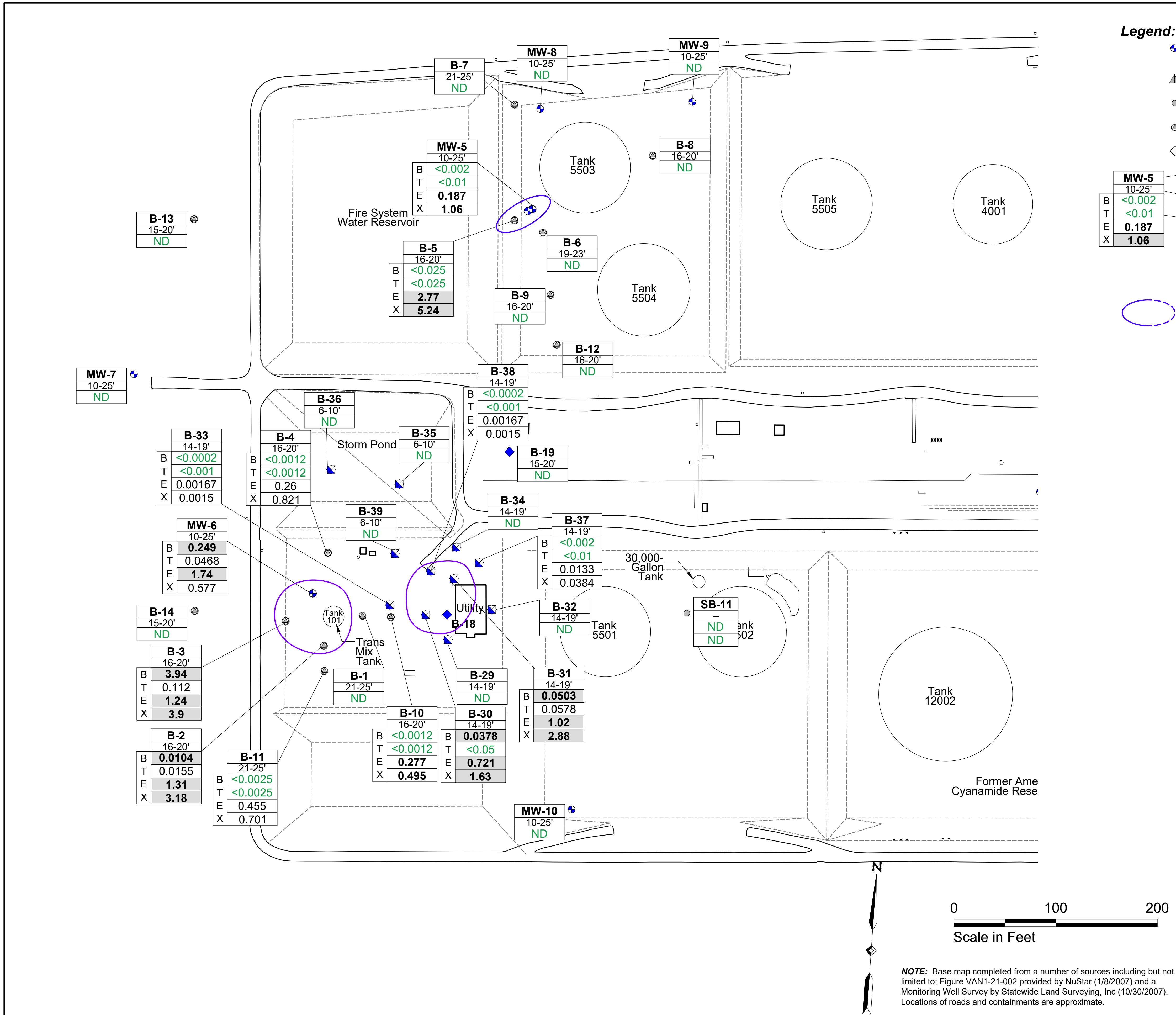
*Based on Saturated Soil Results.

TPH in First Encountered Groundwater - Western Area

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	April 2020	9



Legend:

- Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- Historical Direct-Push Boring Location (2002/2003)
- Soil Boring Location (September 2014)
- Soil Boring Location (October 2015)
- Soil Boring Location (February 2019)

MW-5 — Location Sampled
10-25' — Depth of Sample in Feet BGS
B <0.002, T <0.01, E 0.187, X 1.06 — Concentration in mg/L

Highlighted Concentration Exceeds MTCA Method A Cleanup Level - February 2019

GREEN Text Indicates Non-Detect Results

Extent of BTEX Above MTCA Method A Cleanup Levels (Dashed Where Uncertain)

NOTES: Groundwater data presented on this figure are first encountered groundwater, unless otherwise noted.

MTBE not detected in any samples, so data are not included on this figure.

If BTEX constituents are all below reporting limits, results are presented as 'ND' (Not Detected).

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1

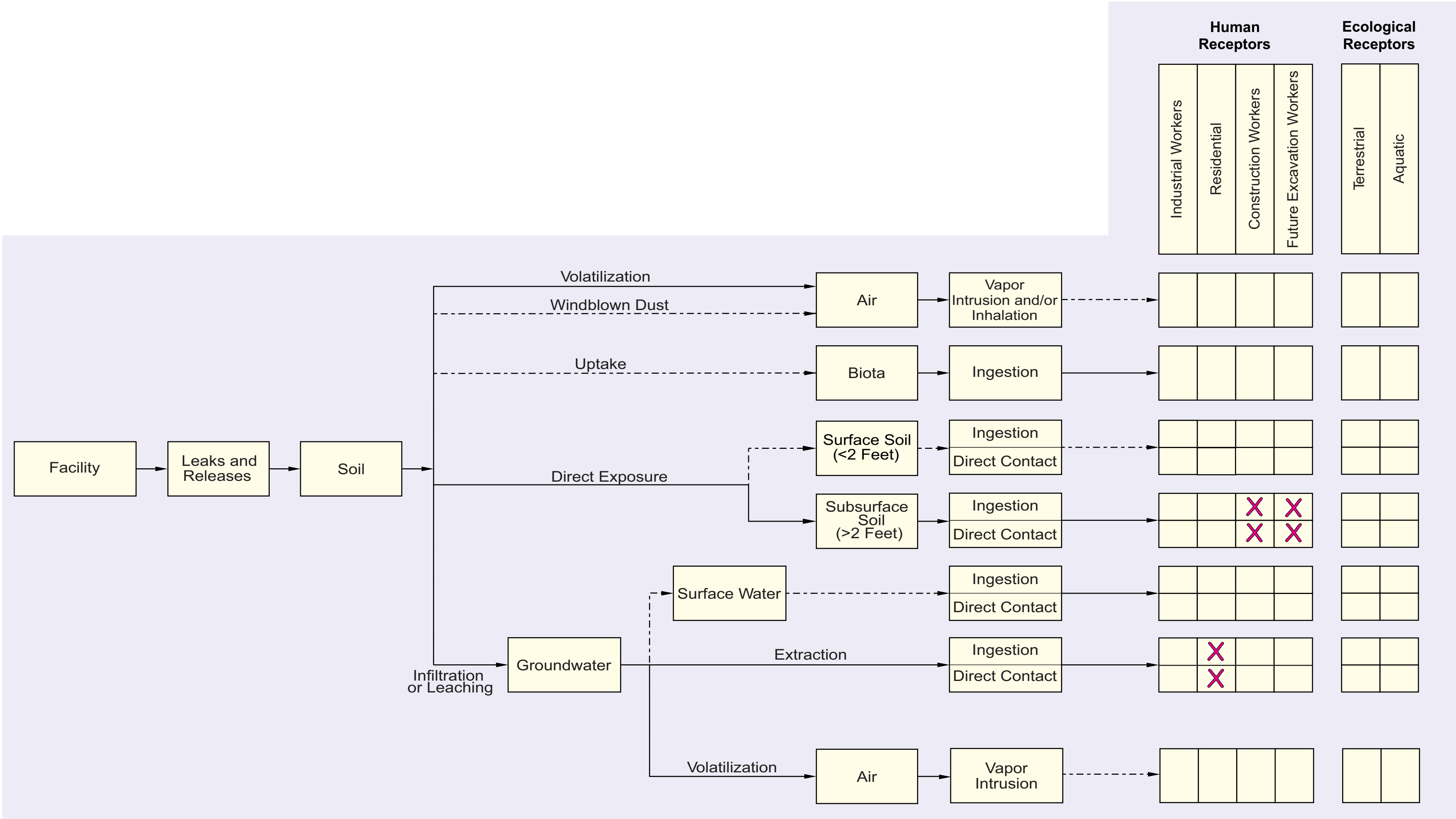
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX in First Encountered Groundwater - Western Area

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	April 2020	10



Legend:

X Potentially Complete Exposure Pathway

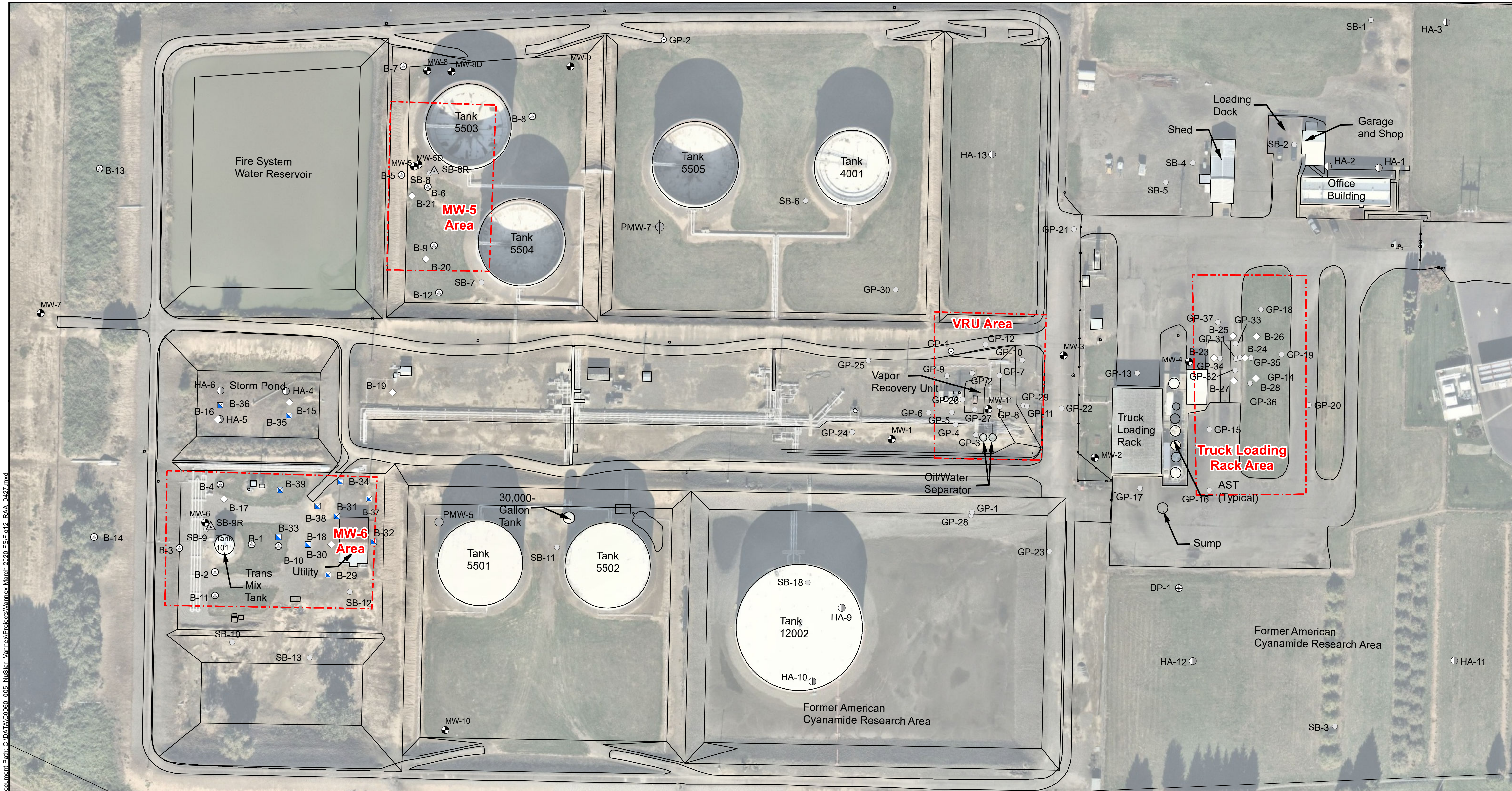
- - - -► Contaminant Pathway not Present or Complete

Conceptual Site Exposure Model

Feasibility Study Report
NuStar Terminals Operations Partnership L.P.- Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
April 2020		11



Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).

Locations of roads and containments are approximate.

Source:
Aerial from Mapbox.

Symbol	Description
	Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
	Historical Temporary Well Location (Approximate)
GP-1	Historical Direct-Push Boring Location (2002/2003)
HA-1	Historical Hand Auger Location (2002/2003)
GP-1	Sample Location (2008)
DP-1	Sample Location (2009)
SB-8R	Soil Boring Location (September 2014)
B-1	Soil Boring Location (October 2015)
B-1	Soil Boring Location (February 2019)
B-29	Soil Boring Location (February 2020)
	Remediation Areas

0 25 50 100
Feet

Remediation Areas

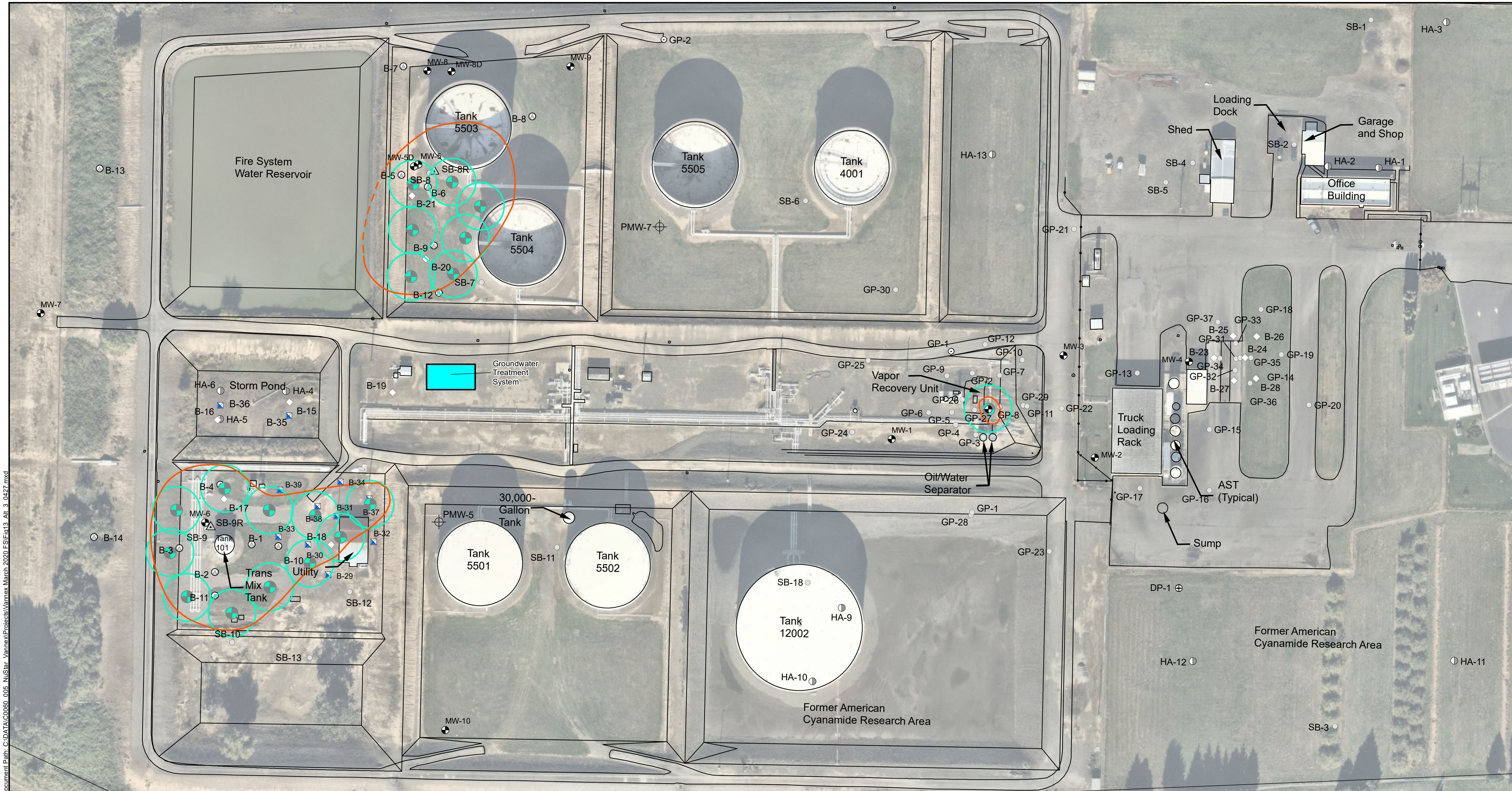
Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-006

May 2020

Figure 12



Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)	
Historical Temporary Well Location (Approximate)	
GP-1 Historical Direct-Push Boring Location (2002/2003)	
HA-1 Historical Hand Auger Location (2002/2003)	
GP-1 Sample Location (2008)	
DP-1 Sample Location (2009)	
SB-8R Soil Boring Location (September 2014)	
B-1 Soil Boring Location (October 2015)	
B-1 Soil Boring Location (February 2019)	
B-29 Soil Boring Location (February 2020)	
Shallow Groundwater Extraction Well and Estimated Radius of Influence	
Extent of TPH in Groundwater Greater Than MTCA Method A Cleanup Levels (Dashed Where Inferred)	

0 25 50 100 Feet

Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.
Source: Aerial from Mapbox.

Alternative 3
Hydraulic Containment

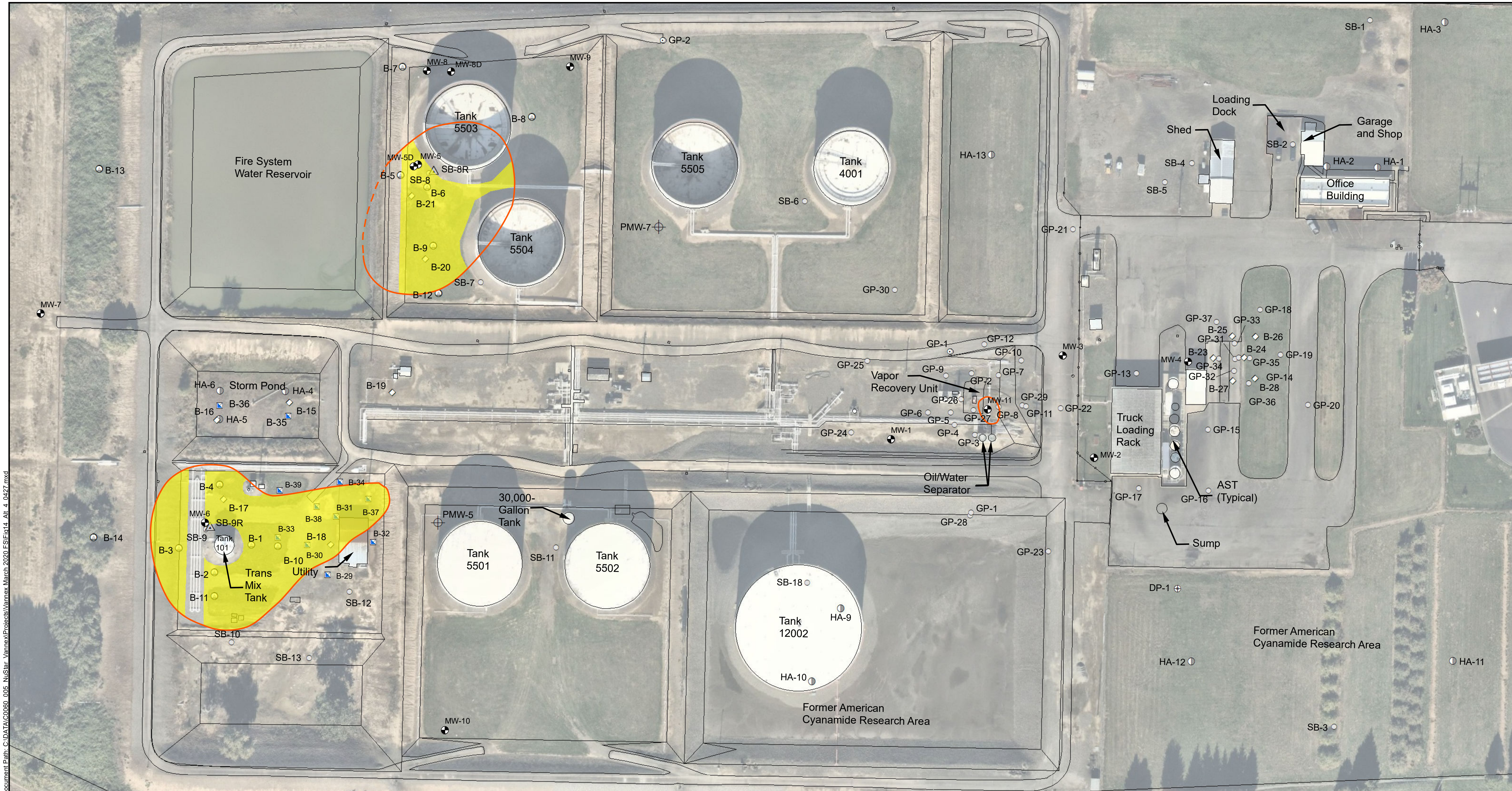
Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-006

May 2020

Figure 13



Document Path: C:\DATA\C0060_005_NuStar_Vannex\Projects\Vannex March 2020 FS\Fig14_Alt_4_0427.mxd

Symbol	Description	Symbol	Description	Symbol	Description
	Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep	GP-1	Sample Location (2008)	B-29	Soil Boring Location (February 2020)
	Historical Temporary Well Location (Approximate)	DP-1	Sample Location (2009)		Extent of TPH in Groundwater Greater Than MTCA Method A Cleanup Levels (Dashed Where Inferred)
GP-1	Historical Direct-Push Boring Location (2002/2003)	SB-8R	Soil Boring Location (September 2014)		PetroFix Injection
HA-1	Historical Hand Auger Location (2002/2003)	B-1	Soil Boring Location (October 2015)		
		B-1	Soil Boring Location (February 2019)		

0 25 50 100 Feet

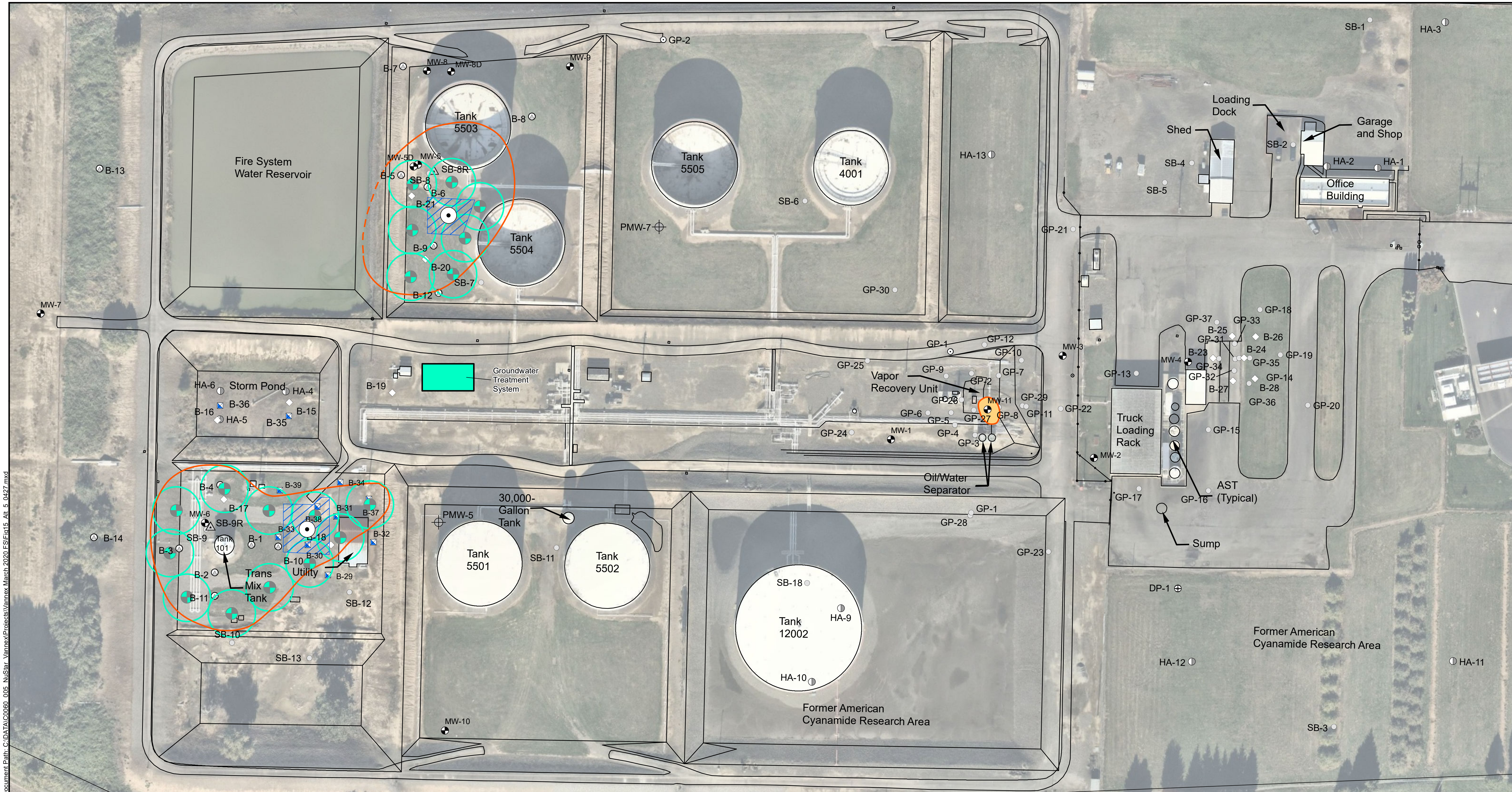
Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.
Source: Aerial from Mapbox.

Alternative 4
Stabilization and Bioremediation via Petrofix

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	May 2020	**14**



Document Path: C:\DATA\C0060_005_NuStar_Vannex\Projects\Vannex March 2020 FS\Fig15_Alt_5_0427.mxd

Symbol	Description	Symbol	Description	Symbol	Description	Symbol	Description
	Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep	GP-1	Sample Location (2008)	B-29	Soil Boring Location (February 2020)		Excavate Soil to 12 feet
	Historical Temporary Well Location (Approximate)	DP-1	Sample Location (2009)		Shallow Groundwater Extraction Well and Estimated Radius of Drawdown		Direct Injection Area
GP-1	Historical Direct-Push Boring Location (2002/2003)	SB-8R	Soil Boring Location (September 2014)		Extent of TPH in Groundwater Greater Than MTCA Method A Cleanup Levels (Dashed Where Inferred)		Recirculation Gallery
HA-1	Historical Hand Auger Location (2002/2003)	B-1	Soil Boring Location (October 2015)				
		B-1	Soil Boring Location (February 2019)				

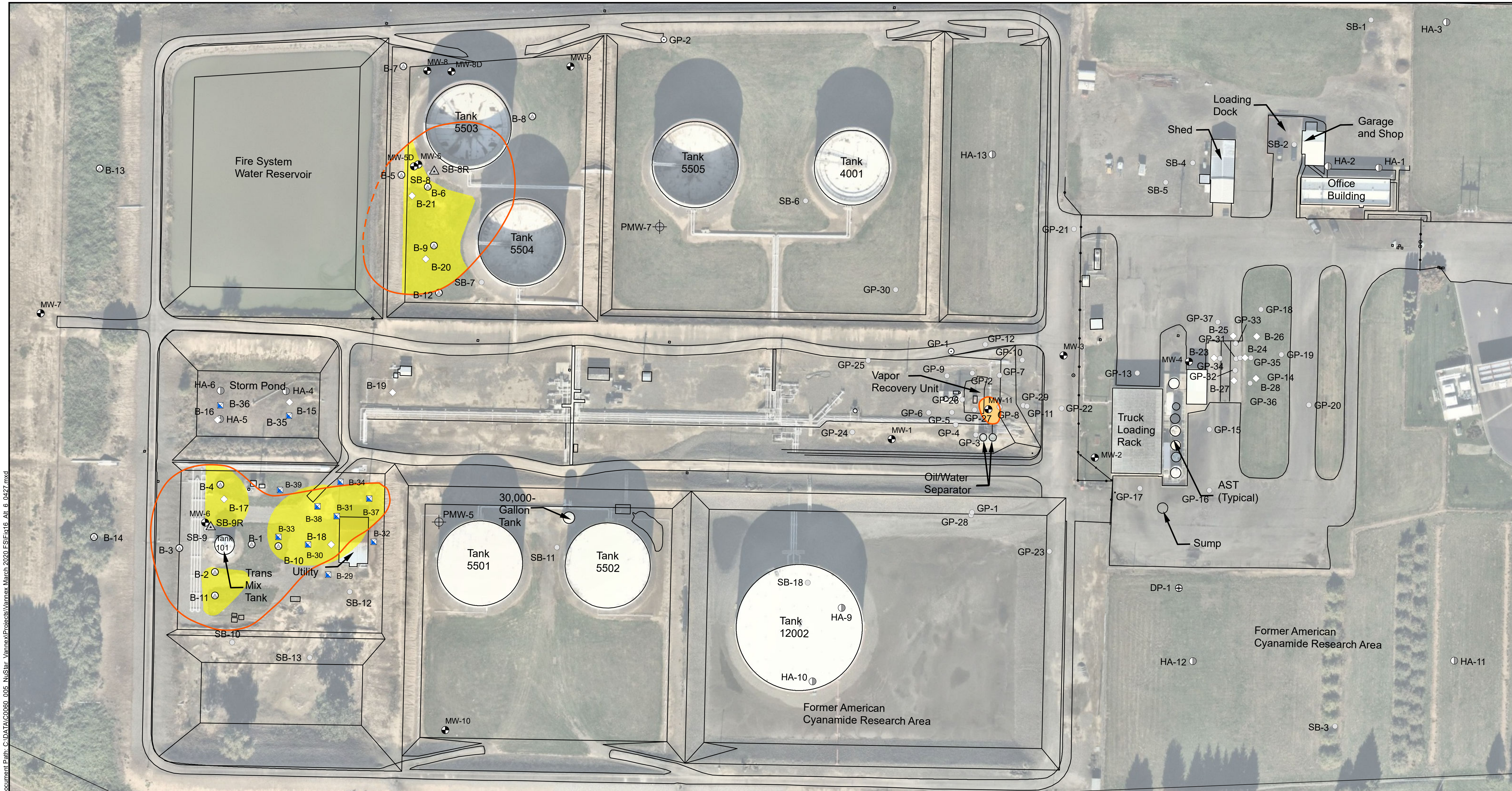
0 25 50 100
Feet

Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.
Source: Aerial from Mapbox.

Alternative 5
Removal of Readily Accessible Soil; Hydraulic Recirculation and Enhanced Bioremediation
Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	May 2020	15



Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep

Historical Temporary Well Location (Approximate)

GP-1 Historical Direct-Push Boring Location (2002/2003)

HA-1 Historical Hand Auger Location (2002/2003)

GP-1 Sample Location (2008)

DP-1 Sample Location (2009)

SB-8R Soil Boring Location (September 2014)

B-1 Soil Boring Location (October 2015)

B-1 Soil Boring Location (February 2019)

B-29 Soil Boring Location (February 2020)

Extent of TPH in Groundwater Greater Than MTCA Method A Cleanup Levels (Dashed Where Inferred)

Deep Excavation Area (0 - 22 feet bgs)

Direct Injection Area

0 25 50 100 Feet

Notes:
Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.
Source: Aerial from Mapbox.

Alternative 6
Removal of All Accessible Soil

Feasibility Study Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	May 2020	16

APPENDIX A

BORING LOGS

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	SB-8R
Project Number:	1569-04
Logged By:	M. Whitson
Date:	September 30, 2014
Site Conditions:	Partly Cloudy, 60s (°F)
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe 7720DT
Sampler Type:	Macro Core
Depth to Water (ATD):	12.5'
Surface Elevation:	Not Surveyed

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	PID	Sheen	Lithologic Description	Boring Details and Notes
0–8.5	Hand Auger				Clayey SILT to SILT with clay (ML); yellowish brown (10YR 5/4), slightly moist, trace sand, medium stiff.	
5		SB-8R(5.0)	<5	NS		
8.5					SILT (ML); light olive brown (2.5Y 5/3) with rust orange mottling, moist, medium stiff.	
9		SB-8R(9.0)	<5	NS		
12		SB-8R(12.0)	<5	NS		
12.5					Becomes wet, soft.	ATD ▽ At Time of Drilling
13			102	MS	Becomes very dark greenish gray (GLEY 1 3/10Y).	
17.5			132	MS		
19						ATS ▽ SB-8R (Water Sample) At Time of Sampling
22.5			124	MS		
25					Bottom of Boring at 25.0' BGS.	

Note: Groundwater sample collected from 3/4" PVC temporary well using a peristaltic pump.

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NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	SB-9R
Project Number:	1569-04
Logged By:	M. Whitson
Date:	September 30, 2014
Site Conditions:	Partly Cloudy, 60s (°F)
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe 7720DT
Sampler Type:	Macro Core
Depth to Water (ATD):	13.0'
Surface Elevation:	Not Surveyed

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	PID	Sheen	Lithologic Description	Boring Details and Notes
0	Hand Auger				Loose coarse gravel surface over SILT with clay (ML); dark yellowish brown (10YR 4/4), moist, medium stiff.	
3			<5	NS		
5			<5	NS		
8					With very fine sand.	
9			<5	NS	Becomes very dark gray (2.5Y 3/1), soft.	
11					SAND (SP); very dark greenish gray (GLEY 1 3/5GY), moist, very fine-grained sand, no fines, medium dense.	
12		SB-9R(12.0)	102	HS		
12.5					SAND with silt (SP); very dark greenish gray (GLEY 1 3/5GY), wet, very fine-grained sand, silt fines, loose to medium dense.	ATD ▽ At Time of Drilling
13.5		SB-9R(13.5)	399	HS		
15					SILT (ML); very dark greenish gray (GLEY 1 3/5GY), wet, trace very fine sand, soft.	
17.5			349	HS		ATS ▽ SB-9R (Water Sample) At Time of Sampling
22.5			323	MS		
25					Bottom of Boring at 25.0' BGS.	

Bottom of Boring at 25.0' BGS.

Note: Groundwater sample collected from 3/4" PVC temporary well using a peristaltic pump.

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, and grain size, and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
MAJOR CONSTITUENT with additional remarks; color, moisture, minor constituents, density/consistency.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and push probe explorations is estimated based on visual observation and is presented parenthetically on test pit and push probe exploration logs.

SAND and GRAVEL Density	Standard Penetration Resistance in Blows/Foot
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

SILT or CLAY Density	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very soft	0 - 2	<0.125
Soft	2 - 4	0.125 - 0.25
Medium stiff	4 - 8	0.25 - 0.5
Stiff	8 - 15	0.5 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture.
Sl. Moist	Some perceptible moisture, probably below optimum.
Moist	Probably near optimum moisture content.
Wet	Much perceptible moisture, probably above optimum.

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Sampling Symbols

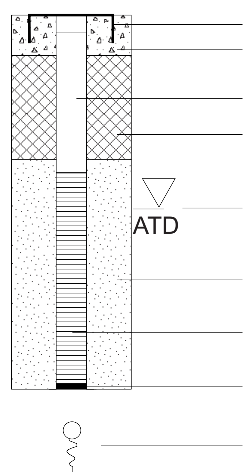
BORING AND PUSH-PROBE SYMBOLS

Symbol	Description
	Recovery
	No Recovery
	Temporarily Screened Interval
PID	Photoionization Detector Reading
W	Water Sample
	Sample Submitted for Chemical Analysis
NS	No Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
BF	Biogenic Film

TEST PIT SOIL SAMPLES

Symbol	Description
	Grab (Jar)
	Bag
	Shelby Tube

Groundwater Observations and Monitoring Well Construction



Key to Exploration Logs

NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

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Project Number	1569-04	Figure
October 2014		Key

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NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	SB-8R
Project Number:	1569-04
Logged By:	M. Whitson
Date:	September 30, 2014
Site Conditions:	Partly Cloudy, 60s (°F)
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe 7720DT
Sampler Type:	Macro Core
Depth to Water (ATD):	12.5'
Surface Elevation:	Not Surveyed

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	PID	Sheen	Lithologic Description	Boring Details and Notes
0	Hand Auger				Clayey SILT to SILT with clay (ML); yellowish brown (10YR 5/4), slightly moist, trace sand, medium stiff.	
5		SB-8R(5.0)	<5	NS		
8.5					SILT (ML); light olive brown (2.5Y 5/3) with rust orange mottling, moist, medium stiff.	
9		SB-8R(9.0)	<5	NS		
12		SB-8R(12.0)	<5	NS		
12.5					Becomes wet, soft.	ATD — At Time of Drilling
13			102	MS	Becomes very dark greenish gray (GLEY 1 3/10Y).	
17			132	MS		
18.5						ATS — SB-8R (Water Sample) At Time of Sampling
22			124	MS		
25					Bottom of Boring at 25.0' BGS.	

Bottom of Boring at 25.0' BGS.

Note: Groundwater sample collected from 3/4" PVC temporary well using a peristaltic pump.

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NuStar Terminals Operations Partnership, L.P. - Annex Terminal
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Boring Number:	SB-9R
Project Number:	1569-04
Logged By:	M. Whitson
Date:	September 30, 2014
Site Conditions:	Partly Cloudy, 60s (°F)
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe 7720DT
Sampler Type:	Macro Core
Depth to Water (ATD):	13.0'
Surface Elevation:	Not Surveyed

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	PID	Sheen	Lithologic Description	Boring Details and Notes
0	Hand Auger				Loose coarse gravel surface over SILT with clay (ML); dark yellowish brown (10YR 4/4), moist, medium stiff.	
3			<5	NS		
5			<5	NS		
8					With very fine sand.	
9			<5	NS	Becomes very dark gray (2.5Y 3/1), soft.	
11					SAND (SP); very dark greenish gray (GLEY 1 3/5GY), moist, very fine-grained sand, no fines, medium dense.	
12		SB-9R(12.0)	102	HS		
12.5					SAND with silt (SP); very dark greenish gray (GLEY 1 3/5GY), wet, very fine-grained sand, silt fines, loose to medium dense.	ATD — At Time of Drilling
13.5		SB-9R(13.5)	399	HS		
15					SILT (ML); very dark greenish gray (GLEY 1 3/5GY), wet, trace very fine sand, soft.	
17.5			349	HS		ATS — SB-9R (Water Sample) At Time of Sampling
22.5			323	MS		
25					Bottom of Boring at 25.0' BGS. *Note:* Groundwater sample collected from 3/4" PVC temporary well using a peristaltic pump.	

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, and grain size, and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
MAJOR CONSTITUENT with additional remarks; color, moisture, minor constituents, density/consistency.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and push probe explorations is estimated based on visual observation and is presented parenthetically on test pit and push probe exploration logs.

SAND and GRAVEL Density	Standard Penetration Resistance in Blows/Foot
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

SILT or CLAY Density	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very soft	0 - 2	<0.125
Soft	2 - 4	0.125 - 0.25
Medium stiff	4 - 8	0.25 - 0.5
Stiff	8 - 15	0.5 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture.
Sl. Moist	Some perceptible moisture, probably below optimum.
Moist	Probably near optimum moisture content.
Wet	Much perceptible moisture, probably above optimum.

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Sampling Symbols

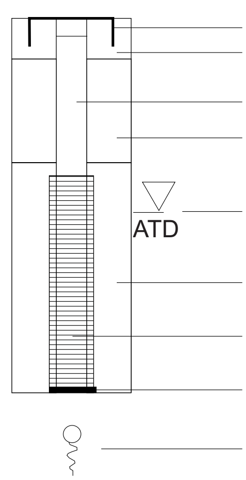
BORING AND PUSH-PROBE SYMBOLS

- Recovery
- No Recovery
- Temporarily Screened Interval
- PID Photoionization Detector Reading
- W Water Sample
- NS No Sheen
- SS Slight Sheen
- MS Moderate Sheen
- HS Heavy Sheen
- BF Biogenic Film

TEST PIT SOIL SAMPLES

- Grab (Jar)
- Bag
- Shelby Tube

Groundwater Observations and Monitoring Well Construction



Key to Exploration Logs

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

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Project Number	1569-05	Figure
November 2015		Key

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APEX

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**B-1**
Project Number:	**1569-05**
Logged By:	J. Mattecheck/C. Clough
Date:	October 22, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	23'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes
0	Hand Auger				Grass/organics.	
			NS	<5	SILT; light brown, dry, medium stiff to very stiff.	
					Becomes clayey.	
			NS	<5		
5			NS	<5	Silty CLAY (LP); light brown, slightly moist, medium stiff.	
			NS	<5		
10			NS			
				<5		
			NS	<5	Clayey SILT with trace fine sand (~10%); light brown, moist, medium plasticity, medium stiff.	
15			NS	16	Becomes medium gray.	
			NS	16		
20						
		W	NS	152		B-1 (1) (Water Sample)
			NS	<5		
25			NS	<5		
		W				B-1 (2) (Water Sample)
30			NS	<5		
					Becomes coarser material.	
			NS	<5	Fine sand increasing.	
35					Poor recovery. Sandy SILT; medium brown, wet.	
		W				B-1 (3) (Water Sample)
			NS	<5		

Bottom of Boring at 40.0' BGS.

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number: B-2

Project Number: 1569-05
Logged By: C. Clough
Date: October 23, 2015
Site Conditions: --
Drilling Contractor: Cascade Drilling
Drilling Equipment: Track-Mounted Push Probe
Sampler Type: Push Probe
Depth to Water (ATD): 16'
Surface Elevation: --

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes
0	Hand Auger				Grass/organics.	
					Silty CLAY; light brown, dry, medium stiff to very stiff.	
5						
8			NS	<5	Silty CLAY; light brown to medium brown, dry, medium stiff.	
			NS	<5		
10						
			NS	<5		
			NS	<5	Becomes gray.	
15						
16			HS	150	SILT with fine sand; dark gray, wet, very soft.	
		W	SS	27		B-2 (1) (Water Sample)
20			NS	397	Sandy SILT; dark gray, slightly moist to moist, medium stiff.	
			NS	16	Becomes wet.	
			NS	7		
25			NS	<5	Becomes light brown.	
		W	NS	<5		B-2 (2) (Water Sample)
			NS	<5		
30			NS	<5		
			NS	<5	4-Inch coarse SAND lens; medium brown, wet.	
			NS	<5		
35						
38		W	NS	<5	Coarse SAND with fines; medium brown, slightly moist to moist.	B-2 (3) (Water Sample)

Bottom of Boring at 40.0' BGS.

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**B-3**
Project Number:	**1569-05**
Logged By:	C. Clough
Date:	October 23, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	18'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
0					Gravel/organics.
	Hand Auger		NS	<5	Silty CLAY; medium brown, slightly moist, medium stiff.
5					
			NS	5	Silty SAND; light gray, slightly moist, medium dense.
			SS	133	
10					
			SS	139	
					Becomes soft, moisture increasing.
			SS	339	
15					
			SS	177	
		W	NS	47	Becomes wet.
			NS	10	
20					
25			NS	9	
		W			
			NS	<5	
30					Bottom of Boring at 30.0' BGS.
35					

Temporary Screen Details and Notes:

B-3 (1) (Water Sample)

B-3 (2) (Water Sample)

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**B-4**
Project Number:	**1569-05**
Logged By:	C. Clough
Date:	October 23, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	13'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
0–5	Hand Auger					
~7.5			NS	<5	SILT with fine sand; medium brown, slightly moist, medium stiff.	
~9			NS	<5	Becomes very stiff.	
~11			NS	<5		
~12			NS	<5	Becomes soft, moist.	
13					Becomes gray, wet.	▽
~14			SS	51		
15					SILT with sand; medium gray, wet, soft.	
~17			SS	268		
~18		W				B-4 (1) (Water Sample)
~19			SS	284		
~21					Increasing sand.	
~21.5			NS	6		
~24			NS	<5		
25					Becomes sandy SILT.	
~26.5			NS	<5		
~28		W				B-4 (2) (Water Sample)
~29			NS	<5		
30					Bottom of Boring at 30.0' BGS.	

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Additional Groundwater Investigation Report
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Vancouver, Washington

Boring Number:	**B-5**
Project Number:	**1569-05**
Logged By:	J. Mattecheck
Date:	October 27, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	18'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
0	Hand Auger				Grass.	
					Silty CLAY; light brown, slightly moist, low plasticity. medium stiff to stiff.	
5					Becomes medium stiff.	
			NS			
				<5		
			NS			
				<5		
10						
			NS	<5		
			NS	474	Becomes light gray, medium plasticity.	
			NS	400		
15						
			NS	517		
		W	NS	153	Becomes wet.	B-5 (1) (Water Sample)
			NS	120		
20					Trace fine sand.	
			NS	210		
			NS	617		
			NS	50		
25						
			NS	64		
			NS	90		
			NS	35	SAND; light gray, moist to wet, coarse to fine-grained, well graded, medium dense.	
30						
			NS	125		
			NS	60		
			NS	5	Becomes light brown.	
35						
			NS	5		
		W	NS	5		B-5 (2) (Water Sample)

Bottom of Boring at 40.0' BGS.

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**B-6**
Project Number:	1569-05
Logged By:	J. Mattecheck
Date:	October 27, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	19.5'
Surface Elevation:	--

Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
Hand Auger				Grass/organics.
				Silty CLAY; light brown, slightly moist, low plasticity, trace fine sand (<10%), stiff.
		NS	47	
				Becomes light gray.
		NS	530	
		NS	681	
		NS	461	
		NS	800	Becomes moderately plastic.
		NS	137	Becomes moist to wet, medium stiff.
		MS	507	
		MS	675	Becomes wet.
	W	MS	690	
		NS	272	
		NS	182	
		MS	784	SAND; light gray, wet, coarse to fine-grained, well graded, medium dense.
		MS	793	
		NS	122	
		MS	800	Becomes slightly moist.
		NS	37	
		LS	240	
		NS	21	
		NS	12	
		NS	<5	

Depth, feet: 5, 10, 15, 20, 25, 30, 35

Temporary Screen Details and Notes:

B-6 (1) (Water Sample)

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-6
Project Number:	1569-05
Logged By:	J. Mattecheck
Date:	October 27, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	19.5'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
			NS	12		
			NS	23		
			NS	8		
45					No recovery; sampler pushed too far.	
50						
			NS	<5		
			NS	<5		
		W				B-6 (2) (Water Sample)
			NS	<5		
55						
			NS	<5		
			NS	<5		
			NS	<5	Angular to subangular GRAVEL with trace silt; light brown/gray, wet, coarse-grained, dense.	
60						
			NS	<5		
			NS	<5		
		W				B-6 (3) (Water Sample)
			NS	<5		
65					Bottom of Boring at 65.0' BGS.	
70						
75						

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-7
Project Number:	1569-05
Logged By:	J. Mattecheck
Date:	October 28, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	22.5'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
0	Hand Auger				SILT with trace gravel.	
					Silty CLAY; light brown, slightly moist, low plasticity, medium stiff to stiff.	
5					Becomes stiff.	
			NS	<5		
			NS	<5		
			NS	<5		
10						
			NS	<5		
			NS	<5		
			NS	<5		
15						
			NS	<5		
			NS	<5	Becomes moderately plastic.	
			NS	<5		
20						
			NS	<5		
		W	NS	<5	Becomes wet.	B-7 (1) (Water Sample)
			NS	<5		
25						
			NS	<5		
		W	NS	<5		B-7 (2) (Water Sample)
			NS	<5	SAND; light gray, wet, coarse to fine-grained, well graded, medium dense.	
30					Bottom of Boring at 30.0' BGS.	
35						

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number: **B-8**

Project Number:	1569-05
Logged By:	J. Mattecheck
Date:	October 28, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	18'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
0	Hand Auger				Grass/organics.
					Silty CLAY; light brown, slightly moist, low plasticity, stiff to medium stiff.
5			NS	<5	
			NS	<5	
			NS	<5	
10			NS	<5	
			NS	<5	Trace fine sand (<10%).
			NS	<5	
15			NS	<5	
		W	NS	<5	Becomes wet.
			NS	<5	
20			NS	<5	
		W	NS	<5	SAND; light gray, wet, coarse to fine-grained, well graded, medium dense to dense.
			NS	<5	
25					Bottom of Boring at 25.0' BGS.
30					
35					

Temporary Screen Details and Notes:

B-8 (1) (Water Sample)

B-8 (2) (Water Sample)

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-9
Project Number:	1569-05
Logged By:	C. Clough
Date:	October 29, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	16'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
0–5	Hand Auger					
5					Silty CLAY; light brown, slightly moist, medium stiff.	
			NS	<5		
			NS	<5		
10						
			NS	<5		
			NS	<5	Becomes slightly moist to moist.	
15						
			NS	9	Becomes wet.	
		W	SS	420	Becomes light gray, sand increasing.	B-9 (1) (Water Sample)
			SS	359		
20						
			NS	205		
			NS	23		
			SS	1,152	Sandy SILT; light gray.	
25						
			SS	437		
			NS	21	Becomes fine sand.	
30						
			NS	45		
					Becomes light brown.	
			NS	9		
35					Silty SAND; light brown, wet.	
			NS	<5		
		W				B-9 (2) (Water Sample)
			NS	<5		

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Additional Groundwater Investigation Report
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Vancouver, Washington

Boring Number:	**B-9**
Project Number:	**1569-05**
Logged By:	C. Clough
Date:	October 29, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	16'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
			NS	<5		
			NS	<5		
45						
			NS	<5		
		W				B-9 (3) (Water Sample)
			NS	<5		
50					Bottom of Boring at 65.0' BGS.	
55						
60						
65						
70						
75						

Apex Companies, LLC
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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number: B-10

Project Number: 1569-05
Logged By: C. Clough
Date: October 22, 2015
Site Conditions: --
Drilling Contractor: Cascade Drilling
Drilling Equipment: Track-Mounted Push Probe
Sampler Type: Push Probe
Depth to Water (ATD): 17'
Surface Elevation: --

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
	Hand Auger				Grass surface and some gravel.	
5						
			NS	<5	Silty CLAY; light brown, slightly moist, medium stiff.	
			NS	<5		
10			NS	<5		
			NS	<5	Becomes moist.	
15			NS	6		
					Becomes gray, wet.	
		W	NS	41		B-10 (1) (Water Sample)
					Trace sands.	
20						
			NS	54		
			NS	49	Sand increasing.	
25			NS	94	Silty CLAY with sand; light brown, wet, medium stiff.	
			NS	14		
					Sand increasing.	
30			NS	<5	Silty SAND; light brown, wet, loose.	
			NS	<5		
			NS	12	Coarse SAND; light brown with gray, wet, dense.	
35			NS	11		
			NS	7		
		W	NS	<5		B-10 (2) (Water Sample)

Bottom of Boring at 40.0' BGS.

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number: **B-11**
Project Number: 1569-05
Logged By: C. Clough
Date: October 30, 2015
Site Conditions: --
Drilling Contractor: Cascade Drilling
Drilling Equipment: Track-Mounted Push Probe
Sampler Type: Push Probe
Depth to Water (ATD): 15'
Surface Elevation: --

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes
0–5	Hand Auger					
5			NS	<5	Silty CLAY; light brown, moist, medium stiff.	
			NS	<5		
10			NS	<5		
			NS	<5	Becomes medium gray.	
					Moisture increases.	
			SS	45		
15			NS	35	SILT with fine sand; dark gray, wet, medium stiff.	▽
			SS	16		
20			NS	18	Becomes loose.	
		W	NS	5		B-11 (1) (Water Sample)
25			NS	<5		
					Becomes light brown, moist.	
			NS	<5		
30			NS	<5	Silty SAND; light brown, moist.	
			NS	<5	4-Inch coarse sand lens.	
			NS	<5	Becomes wet.	
35			NS	<5		
		W	NS	<5		B-11 (2) (Water Sample)

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APEX

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-11
Project Number:	1569-05
Logged By:	C. Clough
Date:	October 30, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	15'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
			NS	<5		
		W				B-11 (3) (Water Sample)
			NS	<5		
45					Bottom of Boring at 45.0' BGS.	45
50						50
55						55
60						60
65						65
70						70
75						75

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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-12
Project Number:	1569-05
Logged By:	C. Clough
Date:	October 30, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	17'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
0–5	Hand Auger					
5			NS	<5	Silty CLAY to clayey SILT with sand; light brown, dry to slightly moist, stiff.	
			NS	<5		
10			NS	<5		
			NS	<5	Becomes moist.	
15			NS	<5		
					Becomes wet, sand increasing.	
		W	NS	<5		B-12 (1) (Water Sample)
			NS	44	Becomes light to dark gray.	
20			NS	77	Silty SAND; dark gray, wet, loose.	
			NS	<5	Becomes coarse sand, light brown,.	
			NS	<5		
25			NS	<5	SAND with silt; dark gray, wet, dense.	
			NS	<5		
30			NS	<5		
			NS	<5		
35			NS	<5		
		W	NS	<5		B-12 (2) (Water Sample)

Apex Companies, LLC
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Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-12
Project Number:	1569-05
Logged By:	C. Clough
Date:	October 30, 2015
Site Conditions:	--
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Track-Mounted Push Probe
Sampler Type:	Push Probe
Depth to Water (ATD):	17'
Surface Elevation:	--

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
			NS	<5		
		W	NS	<5		B-12 (3) (Water Sample)
45					Bottom of Boring at 45.0' BGS.	45
50						50
55						55
60						60
65						65
70						70
75						75

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, and grain size, and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
MAJOR CONSTITUENT with additional remarks; color, moisture, minor constituents, density/consistency.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and push probe explorations is estimated based on visual observation and is presented parenthetically on test pit and push probe exploration logs.

SAND and GRAVEL Density	Standard Penetration Resistance in Blows/Foot
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

SILT or CLAY Density	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very soft	0 - 2	<0.125
Soft	2 - 4	0.125 - 0.25
Medium stiff	4 - 8	0.25 - 0.5
Stiff	8 - 15	0.5 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture.
Sl. Moist	Some perceptible moisture, probably below optimum.
Moist	Probably near optimum moisture content.
Wet	Much perceptible moisture, probably above optimum.

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Sampling Symbols

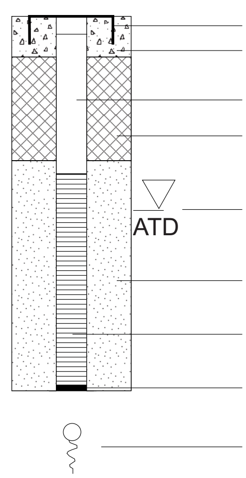
BORING AND PUSH-PROBE SYMBOLS

	Recovery
	No Recovery
	Temporarily Screened Interval
PID	Photoionization Detector Reading
W	Water Sample
NS	No Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
BF	Biogenic Film

TEST PIT SOIL SAMPLES

- Grab (Jar)
- Bag
- Shelby Tube

Groundwater Observations and Monitoring Well Construction



Key to Exploration Logs

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX
Apex Companies, LLC
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Project Number 1569-05
August 2016
Figure Key

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Portland, Oregon 97201

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	B-13
Project Number:	1569-09
Logged By:	J. Mattecheck
Date:	July 7, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	15.5'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
1	Hand Auger		NS	<5	Grass/topsoil surface.	
2	Hand Auger		NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.	
3	Hand Auger		NS	<5		
5						
5–6			NS	<5	Silty CLAY; light brown (7.5YR 6/3), slightly moist, medium stiff.	
7			NS	<5	Becomes gray (7.5YR 5/1). Becomes light brown (7.5YR 6/3).	
9			NS	<5		
10					Becomes medium stiff to soft.	
11			NS	<5		
12			NS	<5		
14			NS	<5		
15					With trace fine sand, medium stiff to soft. Becomes wet.	▽ (15.5')
16			NS	<5		
17		W	NS	<5		B-13 (1) (Water Sample)
19			NS	<5		
21			NS	<5		
22			NS	<5		
24			NS	<5	Silty CLAY with fine sand; brown (7.5YR 4/8), wet, medium stiff to stiff.	
26			NS	<5		
27		W	NS	<5		B-13 (2) (Water Sample)
29			NS	<5	Fine SAND with trace silt; gray (7.5YR 5/1), wet, poorly graded, dense.	
30					Bottom of Boring at 30.0' BGS.	

Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	2016 Well Installation and Additional Delineation Work Plan NuStar Terminals Operations Partnership, L.P. - Annex Terminal Vancouver, Washington	Boring Number: **B-14**

Project Number:	1569-09
Logged By:	J. Mattecheck
Date:	July 7, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	15.7'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description	Temporary Screen Details and Notes:
			NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.	
			NS	<5		
	Hand Auger		NS	<5		
			NS	<5		
5			NS	<5		5
			NS	<5	SILT with clay; light brown (7.5YR 6/3), slightly moist, medium stiff.	
			NS	<5		
			NS	<5		
10			NS	6		10
			NS	6		
			NS	6		
			NS	6	SILT with clay and fine sand; light brown (7.5YR 6/3), slightly moist, medium stiff to soft.	
15			NS	<5	Becomes wet.	15 ▽
			NS	<5		
		W	NS	<5		B-14 (1) (Water Sample)
			NS	<5		
20			NS	<5		20
			NS	<5	SILT with clay and poorly graded fine sand; light brown (7.5YR 6/3) slightly moist, wet.	
			NS	<5		
			NS	<5		
25			NS	<5		25
			NS	<5		
		W	NS	<5		B-14 (2) (Water Sample)
			NS	<5	Coarse to fine SAND; gray (7.5YR 5/1), wet, well-graded, dense.	
30					Bottom of Boring at 30.0' BGS.	30
35						35

Cascadia Associates, LLC

PROJECT: **Additional Soil and Groundwater Investigation**		BORING ID: **B-15**	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**		WELL ID: **NA**	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**		NORTHING:	EASTING: **24**
DRILLING EQUIPMENT: **Hand Auger**		SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
DRILLING METHOD: **Direct-Push**		TOTAL DEPTH: **10**	DEPTH TO WATER: **Not encountered**
LOGGED BY:	SAMPLING METHOD: **1.25-Inch Single Tube Sampler**	DATE STARTED: **1/31/19**	DATE COMPLETED: **1/31/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		Clayey SILT with trace fine sand, brown, slightly moist, stiff.	2.0/2.0	<5	NS			
	ML		Fine sand increasing, becomes moist.						
2	ML		Clayey SILT with sand, brown, wet, medium stiff.	2.0/2.0	<5	NS			
4	ML		Clayey SILT with trace sand, brown, moist, stiff.	2.0/2.0	<5	NS		☒	
	ML		Becomes medium stiff.	2.0/2.0	<5	NS			
8	ML		Becomes wet.	2.0/2.0	<5	NS			
10									

NOTES: Bottom of boring at 10 feet bgs.

	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-16**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
Cascadia Associates, LLC	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand Auger**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **10**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **1.25-Inch Single Tube Sampler**	DATE STARTED: **1/30/19**	DATE COMPLETED: **1/30/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0–2	ML		Clayey SILT, with trace fine sand, brown with grey mottles, slightly moist, stiff.	2.0/2.0	<5	NS			
2–4	ML		Becomes moist.	2.0/2.0	<5	NS			
					<5	NS	B-16 (1)	☒	
4–10	ML		Clayey SILT, with trace fine sand, gray, wet, stiff.	2.0/2.0	100	MS			
					120	MS	B-16 (2)	☒	
				2.0/2.0	112	MS			
					61	MS			
				2.0/2.0	10.7	NS			

Depth scale: 0, 2, 4, 6, 8, 10

NOTES: Bottom of boring at 10 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-17**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **55** / DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/31/19** / DATE COMPLETED: **1/31/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		Clayey SILT, with trace fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
2	ML		Becomes stiff.	2.0/2.0	<5	NS			
			Clay increasing, becomes moist.						
4	ML			2.0/2.0	<5	NS			
6	ML		Clayey SILT, with fine sand, gray/brown, moist, stiff.	2.0/2.0		NS			
	ML		Becomes slightly moist, medium stiff.		<5				
8				0/1.5					
	ML		Clayey SILT, with fine sand, brown, slightly moist, medium stiff.	0.5/0.5		NS			
10	ML		Becomes moist.	5.0/5.0	<5	NS			
	ML		Clayey SILT, with fine sand, brown, moist, medium stiff.						
12			Fine sand increasing, becomes wet.		<5		B-17 (1)	☒	
	ML					NS			
14					<5	MS			
			Clayey SILT, with fine sand, gray, wet, medium stiff.	5.0/5.0			B-17 (2)	☒	
16	ML				377	MS			
18			Clay increasing, becomes stiff.		350				
	ML				340	MS			
20			Clayey SILT, with fine sand, gray, wet, medium stiff.		141	MS			

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-17**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **55**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/31/19**	DATE COMPLETED: **1/31/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	ML			5.0/5.0	13.7	NS			
24	ML		Increasing clay, becomes stiff.						
			Becomes brown.		31	NS			
26	ML								
	ML		Increasing sand.	5.0/5.0					
28			Sandy SILT with clay, brown, wet, medium stiff.		5.1	NS			
30					4.1	NS			
32	ML			5.0/5.0	25.8	NS			
34									
			SAND with silt, gray, wet, medium-grained, medium dense.		26.6	NS			
36									
					49.1	NS			
38	SM			5.0/5.0					
					6.7	NS			
40	SM		SAND with silt, gray, wet, medium-grained, medium dense.						
42	SM		Becomes coarser material.	5.0/5.0	18	NS			

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC	PROJECT: Additional Soil and Groundwater Investigation	BORING ID: B-17	
	LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
	DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
	DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: NA
	DRILLING METHOD: Direct-Push	TOTAL DEPTH: 55	DEPTH TO WATER: Not encountered
LOGGED BY: LW	SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 1/31/19	DATE COMPLETED: 1/31/19

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
44	SM		SAND with trace silt, grey, wet, coarse-grained, medium dense.		8.3	NS			
46					24.5	NS			
48				5.0/5.0	6.6	NS			
50					0.9	NS			
52	SM		Silt increasing.	5.0/5.0	1.9	NS			
54					25.8				

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC

PROJECT: Additional Soil and Groundwater Investigation	BORING ID: B-18	
LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: NA
DRILLING METHOD: Direct-Push	TOTAL DEPTH: 55	DEPTH TO WATER: Not encountered
LOGGED BY: LW	SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 1/30/19
		DATE COMPLETED: 1/30/19

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT with gravel, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
	ML		Clayey SILT with trace fine sand, brown, slightly moist, medium stiff.						
2	ML		Clayey SILT with fine sand, gray, slightly moist, stiff.	2.0/2.0	<5	NS			
4				2.0/2.0	<5	NS			
			Fine sand increasing.						
6				2.0/2.0	246	MS			
	ML				455	MS	B-18 (1)	☒	
8				2.0/2.0	451	MS			
10			Becomes moist.	5.0/5.0	356	MS			
12	ML				604	MS			
14	ML		Becomes wet.				B-18 (2)	☒	
			Clayey SILT with fine sand, gray, wet, stiff.	5.0/5.0	647	MS			
16									
18	ML				376	MS			
20			Clayey SILT with trace fine sand, gray, wet, medium stiff.		431	MS			

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC

PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-18**	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **55**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW** / SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/30/19**	DATE COMPLETED: **1/30/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	ML			5.0/5.0	180	NS			
	ML		Clay increasing.						
24	ML		Becomes brown.		14.3	NS			
26			Clayey SILT with trace fine sand, brown, wet, medium stiff.		<5	NS			
28	ML			5.0/5.0	<5	NS			
					<5	NS			
30			SAND with trace silt, brown, wet, medium to fine-grained, medium dense.		13.4	NS			
32	SM			5.0/5.0	<5	NS			
34			SAND with silt, brown, wet, coarse to medium-grained, medium dense.		<5	NS			
36	SM				<5	NS			
				5.0/5.0					
38	SM		Becomes coarser material.		<5	NS			
40	SM		SAND with silt, brown, wet, coarse to medium-grained, medium dense.		<5	NS			
42			Becomes finer material.	5.0/5.0					

NOTES: Bottom of boring at 55 feet bgs.

PROJECT:	BORING ID:	
Additional Soil and Groundwater Investigation	**B-18**	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **55**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW** / SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/30/19**	DATE COMPLETED: **1/30/19**

Cascadia Associates, LLC

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
	SM				<5	NS			
44									
					<5	NS			
46			SAND with trace silt, brown, wet, medium-grained, medium dense						
					<5	NS			
48	SM			5.0/5.0					
					<5	NS			
50									
	SM		SAND with silt, brown, wet, medium-grained, medium dense.		<5	NS			
52									
			SAND with trace gravel, brown, wet, coarse to medium-grained, medium dense.	5.0/5.0					
54	SW				<5	NS			

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC

PROJECT: Additional Soil and Groundwater Investigation	BORING ID: B-19	
LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: NA
DRILLING METHOD: Direct-Push	TOTAL DEPTH: 55	DEPTH TO WATER: 17
LOGGED BY: LW / SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 1/29/19	DATE COMPLETED: 1/29/19

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT with clay and trace fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
2			Clayey SILT with trace fine sand, brown, slightly moist, stiff.	2.0/2.0	<5	NS			
4	ML			2.0/2.0	<5	NS			
6	ML		Becomes moist.	2.0/2.0	<5	NS			
8	ML		SILT with clay and fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
10	ML		Clayey SILT with trace fine sand, brown, moist, medium stiff.	5.0/5.0	<5	NS	B-19 (1)	☒	
12	ML		Becomes wet.			NS			
14			Clayey SILT with trace fine sand, gray, wet, medium stiff.		<5	NS			
16	ML			5.0/5.0	<5	NS			
18					<5	NS			
20			Clayey SILT with trace fine sand, gray, wet, soft.		1.2	NS			

NOTES: Bottom of boring at 55 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-19**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **55** / DEPTH TO WATER: **17**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/29/19** / DATE COMPLETED: **1/29/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	ML			5.0/5.0	<5	NS			
24	ML		Becomes brown and medium stiff.		<5	NS			
26					<5	NS			
28	SM		SAND; gray, wet, coarse-grained, medium dense	5.0/5.0	<5	NS			
30			Silty SAND; gray, wet, medium-grained, medium dense.		<5	NS			
32				5.0/5.0	<5	NS			
34	SM				<5	NS			
36					<5	NS			
38	SM		Increasing silt.	5.0/5.0	<5	NS			
40			Silty SAND; dark gray ,wet, medium-grained, medium dense		<5	NS			
42	SM			5.0/5.0					

NOTES: Bottom of boring at 55 feet bgs.

PROJECT:	BORING ID:	
Additional Soil and Groundwater Investigation	B-19	
LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: NA
DRILLING METHOD: Direct-Push	TOTAL DEPTH: 55	DEPTH TO WATER: 17
LOGGED BY: LW / SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 1/29/19	DATE COMPLETED: 1/29/19

Cascadia Associates, LLC

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
					<5	NS			
44									
			Silty SAND; dark gray ,wet, medium-grained, medium dense.		<5	NS			
46									
	SM			5.0/5.0	<5	NS			
48									
			Becomes dense.		<5	NS			
50									
					<5	NS			
52	SM			5.0/5.0					
					<5	NS			
54					<5	NS			

NOTES: Bottom of boring at 55 feet bgs.

	PROJECT:	BORING ID:	
Cascadia Associates, LLC	**Additional Soil and Groundwater Investigation**	**B-20**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **60**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **2/4/19**	DATE COMPLETED: **2/4/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT with clay and fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
2				2.0/2.0	<5	NS			
3	ML		Clayey SILT with trace fine sand, brown, slightly moist, medium stiff.						
4				2.0/2.0	<5	NS			
6				2.0/2.0	<5	NS			
7	ML		Fine sand increasing.						
8				2.0/2.0	<5	NS			
9	ML		Sandy SILT with clay, gray, slightly moist, medium stiff.						
10				5.0/5.0	82.9	NS	B-20 (1)	☒	
12	ML		Becomes wet.				B-20 (2)	☒	
14	ML		Clayey SILT with fine sand, gray, wet, soft.						
15				5.0/5.0	35				
16					219	MS			
18					78.5	MS			
20			Sandy SILT with clay, gray, wet, soft.						

NOTES: Bottom of boring at 60 feet bgs.

PROJECT:	**Additional Soil and Groundwater Investigation**
BORING ID:	**B-20**
LOCATION:	**5420 NW Fruit Valley Rd, Vancouver, WA.**
WELL ID:	**NA**
DRILLING CONTRACTOR:	**NuStar Vancouver Annex Facility**
NORTHING:	
EASTING:	
DRILLING EQUIPMENT:	**Hand auger to 8', Geoprobe 7730 to depth**
SURFACE ELEV. (NAVD88):	**Not measured**
TOC ELEVATION:	**NA**
DRILLING METHOD:	**Direct-Push**
TOTAL DEPTH:	**60**
DEPTH TO WATER:	**Not encountered**
LOGGED BY:	**LW**
SAMPLING METHOD:	**2.25-Inch Single Tube Sampler**
DATE STARTED:	**2/4/19**
DATE COMPLETED:	**2/4/19**

Cascadia Associates, LLC

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22					378	MS			
	ML			5.0/5.0					
24					9.4	NS			
			Clayey SILT with fine sand, gray, wet, soft.						
26	ML				3.4	NS			
			SAND with trace silt, dark gray, wet, coarse to medium-grained, medium dense.	5.0/5.0					
28	SM				6.1	NS			
			SAND with trace silt, gray, wet, mediumto fine-grained, medium dense.						
30					3	NS			
	SM								
32					1.4	NS			
				5.0/5.0					
			SAND with trace silt, brown, wet, mediumto fine-grained, medium dense.						
34					1.6	NS			
	SM								
36					<5	NS			
			SAND with trace silt, brown, wet, coarse to medium-grained, medium dense.	5.0/5.0					
38					<5	NS			
	SM								
					<5	NS			
40			SAND with trace silt, brown, wet, medium-grained, medium dense.						
					<5	NS			
42									
				5.0/5.0					

NOTES: Bottom of boring at 60 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-20**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **60**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **2/4/19**	DATE COMPLETED: **2/4/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
	SM				<5	NS			
44									
					<5	NS			
46	SW		SAND with gravel, dark gray, wet, loose.						
				5.0/5.0	<5	NS			
48									
					<5	NS			
50									
					<5	NS			
52									
				5.0/5.0	<5	NS			
54									
					<5	NS			
56									
				5.0/5.0	<5	NS			
58									
60									

NOTES: Bottom of boring at 60 feet bgs.

Cascadia Associates, LLC

PROJECT: Additional Soil and Groundwater Investigation	BORING ID: B-21	
LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION:
DRILLING METHOD: Direct-Push	TOTAL DEPTH: 65	DEPTH TO WATER: Not encountered
LOGGED BY: LW / SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 2/1/19	DATE COMPLETED: 2/1/19

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		Clayey SILT with trace fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
2				2.0/2.0	<5	NS			
4				2.0/2.0	<5	NS			
6				2.0/2.0	<5	NS			
8				2.0/2.0	<5	NS			
10	ML		Becomes light gray with red/orange mottles.	5.0/5.0	<5	NS			
12	ML		Fine sand increasing.		<5	NS	B-21 (1)	☒	
14					0.8	NS			
15	ML		Clayey SILT with fine sand, gray, moist, medium stiff.	5.0/5.0					
16	SW		SAND; grey, wet, medium grained, dense		160.7	MS	B-21 (2)	☒	
18					389	MS			
20	ML		Clayey SILT with fine sand, gray, wet, soft.		504	MS			

NOTES: Bottom of boring at 65 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-21**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **65**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **2/1/19**	DATE COMPLETED: **2/1/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	ML		Clay increasing.	5.0/5.0	388	MS			
24					185	MS			
26	ML		Fine sand increasing.	5.0/5.0	23	NS			
28					7.7	NS			
30	SM		SAND with silt, gray, wet, coarse to medium-grained, medium dense.		71	NS			
32				5.0/5.0	40	NS			
34	SM		Becomes finer material.		13	NS			
36				5.0/5.0	<5	NS			
38					<5	NS			
40					<5	NS			
42				5.0/5.0					

NOTES: Bottom of boring at 65 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-21**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **65** / DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **2/1/19** / DATE COMPLETED: **2/1/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
	SM		Becomes brown.		<5	NS			
44					<5	NS			
46				5.0/5.0	<5	NS			
48					<5	NS			
50	SM				<5	NS			
52				5.0/5.0	<5	NS			
54					<5	NS			
56				5.0/5.0	<5	NS			
58					<5	NS			
	SM		SAND with silt and gravel, gray, wet, coarse to medium-grained, medium dense.						
60					<5	NS			
				5.0/5.0	<5	NS			

NOTES: Bottom of boring at 65 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-21**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **65** / DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **2/1/19** / DATE COMPLETED: **2/1/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes

NOTES: Bottom of boring at 65 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-22**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **25**	DEPTH TO WATER: **17.9**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/29/19**	DATE COMPLETED: **1/29/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		Clayey SILT with trace fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
			SILT with trace clay and fine sand, brown, slightly moist, medium stiff.						
2				2.0/2.0	<5	NS			
	ML								
4				2.0/2.0	<5	NS			
6	ML		Sand increasing.	2.0/2.0	<5	NS			
	SM		SAND with silt, brown, slightly moist, medium-grained, medium dense.						
8				2.0/2.0	<5	NS			
			Becomes dark gray.						
10	SM			5.0/5.0	<5	NS			
12					<5	NS			
	ML		Clayey SILT lens with trace fine sand, brown, wet, medium stiff.						
14	SM		SAND with silt, gray, slightly moist, medium-grained, medium dense.		<5	NS			
16	SM		Silt increasing.	5.0/5.0	<5	NS			
18	SM		Becomes moist.		<5	NS			
20			Silty SAND; gray, wet, medium grained, medium dense		<5	NS	B-22 (1)	☒	

NOTES: Bottom of boring at 25 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-22**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **25**	DEPTH TO WATER: **17.9**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/29/19**	DATE COMPLETED: **1/29/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	SM			5.0/5.0	65	NS			
24					45	NS			

NOTES: Bottom of boring at 25 feet bgs.

Cascadia Associates, LLC

PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID:	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID:	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
DRILLING EQUIPMENT:	SURFACE ELEV. (NAVD88):	TOC ELEVATION:
DRILLING METHOD:	TOTAL DEPTH:	DEPTH TO WATER:
LOGGED BY: SAMPLING METHOD:	DATE STARTED:	DATE COMPLETED:

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0									
2									
4									
6									
8									
10									
12									
14									
16									
18									
20									

NOTES:

PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID:	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID:	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
DRILLING EQUIPMENT:	SURFACE ELEV. (NAVD88):	TOC ELEVATION:
DRILLING METHOD:	TOTAL DEPTH:	DEPTH TO WATER:

LOGGED BY:	SAMPLING METHOD:	DATE STARTED:	DATE COMPLETED:

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22									
24									

NOTES:

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-23**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:
		EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**
		TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **15**
		DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/29/19**
		DATE COMPLETED: **1/29/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		Clayey SILT with trace fine sand, brown, slightly moist, stiff.	2.0/2.0	<5	NS			
2				2.0/2.0	<5	NS			
4	ML		SILT with clay, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
5	ML		Sand increasing.		<5	NS			
6				2.0/2.0	<5	NS	B-23 (1)	☒	
7					<5	NS			
8				2.0/2.0	<5	NS			
10				5.0/5.0	<5	NS			
11	ML		Clayey SILT with trace fine sand, brown, moist, medium stiff.		<5	NS			
12	ML		SILT with trace fine sand and clay, brown, dry, medium stiff.						
14					<5	NS			

NOTES: Bottom of boring at 15 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-24**	
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **15**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19**	DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT with trace clay, light brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
	ML		Trace angular to subangular gravel.						
2	ML		Clayey SILT; light brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
4				2.0/2.0	<5	NS			
6				2.0/2.0	<5	NS			
8	ML		Becomes brown.	2.0/2.0	<5	NS			
10	ML		Clayey SILT with trace fine sand, brown, moist, medium stiff.	5.0/5.0	<5	NS	B-24 (1)	☒	
12					<5	NS			
14	ML		Sandy SILT; brown, slightly moist, medium stiff.		<5	NS			

NOTES: Bottom of boring at 15 feet bgs.

PROJECT: Additional Soil and Groundwater Investigation	BORING ID: B-25	
LOCATION: 5420 NW Fruit Valley Rd, Vancouver, WA.	WELL ID: NA	
DRILLING CONTRACTOR: NuStar Vancouver Annex Facility	NORTHING:	EASTING:
DRILLING EQUIPMENT: Hand auger to 8', Geoprobe 7730 to depth	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION:
DRILLING METHOD: Direct-Push	TOTAL DEPTH: 15	DEPTH TO WATER: Not encountered
LOGGED BY: LW / SAMPLING METHOD: 2.25-Inch Single Tube Sampler	DATE STARTED: 1/28/19	DATE COMPLETED: 1/28/19

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT with gravel, dark gray, dry, medium stiff	2.0/2.0	9.2	NS			
			Clayey SILT with trace fine sand, dark brown, slightly moist, medium stiff.		<5	NS			
2	ML			2.0/2.0	<5	NS			
4				2.0/2.0	<5	NS			
6	ML		Becomes gray and brown.	2.0/2.0	13.5	NS	B-25 (1)	☒	
					1.2	NS			
8	ML		SILT with clay, brown to gray, dry, medium stiff.	2.0/2.0	21.5	MS	B-25 (2)	☒	
10				5.0/5.0	13.1	NS			
					<5	NS			
12	ML		Becomes light brown.						
14					<5	NS			

NOTES: Bottom of boring at 15 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-26**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **35** / DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19** / DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0			SILT; brown, slightly moist, medium stiff.						
	ML			2.0/2.0	<5	NS			
2									
			Clay increasing.	2.0/2.0	<5	NS			
4	ML								
			Clayey SILT, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
6									
				2.0/2.0	<5	NS			
8							B-26 (1)	☒	
	ML			2.0/2.0	<5	NS			
10									
					<5	NS			
12				5.0/5.0					
					<5	MS			
14			Becomes moist.						
	ML				<5	NS			
16			Sand increasing.						
	ML			5.0/5.0	<5	NS			
18									
	SM		SAND with silt, brown, slightly moist, medium grained, medium dense.		<5	NS			
20			Clayey SILT lens, brown, slightly moist, medium stiff.						
					<5	NS			

NOTES: Bottom of boring at 35 feet bgs.

Cascadia Associates, LLC

PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-26**	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **35**	DEPTH TO WATER: **Not encountered**
LOGGED BY: **LW** / SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19**	DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22	ML			5.0/5.0	<5	NS			
24	SM		SAND with silt, brown, slightly moist, medium grained, medium dense.		<5	NS			
26			SAND with trace silt, dark brown to gray, moist, coarse grained, medium dense.	5.0/5.0	<5	NS			
28	SM				<5	NS			
30	ML		Clayey SILT lens, brown, moist, medium stiff.	5.0/5.0	<5	NS			
32	SM		SAND with trace silt, dark brown to gray, moist, coarse-grained, medium dense.		<5	MS			
34	SM		Becomes wet.		<5	NS			

NOTES: Bottom of boring at 35 feet bgs.

Cascadia Associates, LLC

PROJECT: **Additional Soil and Groundwater Investigation**		BORING ID: **B-27**	
LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**		WELL ID: **NA**	
DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**		NORTHING:	EASTING:
DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**		SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION:
DRILLING METHOD: **Direct-Push**		TOTAL DEPTH: **35**	DEPTH TO WATER: **30.8**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19**	DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0			Asphalt						
	ML		Clayey SILT with trace fine sand, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
2				2.0/2.0	<5	NS			
4					<5	NS			
				2.0/2.0	<5	NS			
6	ML		Becomes gray.	2.0/2.0	97.2	MS			
	ML		Becomes moist.		170	MS	B-27 (1)	☒	
8	ML		Becomes slightly moist.	2.0/2.0	697	MS			
							B-27 (2)	☒	
10					773	MS			
12				5.0/5.0	679	MS			
14					25	MS			
16	ML		Clayey SILT with trace fine sand, brown to gray, wet, medium stiff.	5.0/5.0	50	MS			
18			SAND with silt, brown, moist, medium grained, medium dense.		21	NS			
					5.6	NS			
20					<5	NS			

NOTES: Bottom of boring at 35 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-27**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION:
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **35** / DEPTH TO WATER: **30.8**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19** / DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
22									
	SM			5.0/5.0	<5	NS			
24									
					<5	NS			
26									
				5.0/5.0	<5	NS			
28			Becomes gray.						
					<5	NS			
30	SM								
					<5	NS			
32			Becomes wet.	5.0/5.0					
	SM				<5	NS			
34									
					<5	NS			

NOTES: Bottom of boring at 35 feet bgs.

	PROJECT: **Additional Soil and Groundwater Investigation**	BORING ID: **B-28**
	LOCATION: **5420 NW Fruit Valley Rd, Vancouver, WA.**	WELL ID: **NA**
Cascadia Associates, LLC	DRILLING CONTRACTOR: **NuStar Vancouver Annex Facility**	NORTHING:
	DRILLING EQUIPMENT: **Hand auger to 8', Geoprobe 7730 to depth**	SURFACE ELEV. (NAVD88): **Not measured**
	DRILLING METHOD: **Direct-Push**	TOTAL DEPTH: **15**
LOGGED BY: **LW**	SAMPLING METHOD: **2.25-Inch Single Tube Sampler**	DATE STARTED: **1/28/19**

EASTING:	TOC ELEVATION:
DEPTH TO WATER: **Not encountered**	DATE COMPLETED: **1/28/19**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Sheen	Soil Sample	Sample Depth	Notes
0	ML		SILT; light brown, dry, medium stiff.	2.0/2.0	<5	NS			
			Becomes dark brown, slightly moist.						
2	ML			2.0/2.0	<5	NS			
4			SILT with clay, light brown, slightly moist, medium stiff.	2.0/2.0	<5	NS			
6	ML			2.0/2.0	<5	NS			
8	ML		SILT with fine sand and trace clay, brown, slightly moist, medium stiff.	2.0/2.0	<5	NS	B-28 (1)	☒	
			Clay increasing.						
10					<5	NS			
12	ML			5.0/5.0	<5	NS			
14					<5	NS			

NOTES: Bottom of boring at 15 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-29**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22.5**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020**	DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0			Gravel					
	ML		SILT, brown (10YR 5/3), slightly moist, medium stiff, low plasticity	2.0/2.0				
2				2.0/2.0				
4				2.0/2.0	<5	NS		
6				2.0/2.0	<5	NS	☒	B-29(6.5)
8			Trace fine sand	2.0/2.0	<5	NS		
10	ML		SILT with fine sand, dark yellowish brown (10 YR 4/4), slightly moist, medium stiff				☒	B-29(11)
			Becomes wet		<5	NS		
12			Becomes soft	5.0/5.0				
14					<5	NS		
					<5	NS		
16								
18				5.0/3.5	<5	NS		
20					<5	NS		

NOTES: Bottom of boring at 22.5 feet below ground surface (bgs).

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-29**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22.5**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020**	DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
	ML		SILT, brown (10YR 5/3), wet, soft	2.0/2.0	<5	NS		
22			Trace wood debris		<5	NS		

NOTES: Bottom of boring at 22.5 feet below ground surface (bgs).

PROJECT:	BORING ID:	
Additional Western Area Investigation	**B-30**	
LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM** / SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020**	DATE COMPLETED: **2/18/2020**

Cascadia Associates, LLC

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0			Gravel					
	ML		SILT, dark greenish grey (GLEY 1, 4/1), slightly moist, medium stiff	2.0/2.0				
2			Poorly-graded, medium-grained sand	2.0/2.0				
4	ML		SILT with trace fine sand, very dark greenish gray (GLEY 1, 3/1), slightly moist, medium stiff, non-plastic	2.0/2.0	740	MS	☒	B-30(4.5)
6				2.0/2.0				
8				2.0/2.0	100	MS		
10			Becomes moist					
					<5			
12			Becomes wet	5.0/4.0				
					5.9	NS		
14					84.3	SS		
16	SM		Silty SAND, very dark gray (GLEY 1, 3/1), wet, loose, fine-grained		157	SS	☒	B-30(16.5)
				5.0/4.1	161			
18					44	NS		
					345	MS		
20								

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-30**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020**	DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
				2.0/2.0	97	SS		
					42	NS	☒	B-30(21.5)
22								

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-31**
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22** / DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020** / DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0			Gravel					
	ML		SILT with fine sand, brown (10YR 5/3), slightly moist, medium stiff	2.0/2.0				
2				2.0/2.0				
4				2.0/2.0	<5	NS		
6				2.0/2.0	<5	NS	☒	B-31(4.5)
8			Red and gray mottles	2.0/2.0				
	SM		Silty SAND, dark greenish gray (GLEY 1, 4/1), dry, medium dense, poorly-graded, fine-grained		24	NS		
10								
	ML		SILT with fine sand, very dark greenish gray (GLEY 1, 3/1), moist, soft, slight plasticity		27.7			
12			Becomes wet	5.0/4.0	133.3			
14			Becomes medium stiff		590	MS	☒	B-31(14)
16					380	SS		
18				5.0/4.0	343	SS		
20					140	NS		

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-31**
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22** / DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020** / DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
				2.0/2.0	22.6	NS		
					23.5	NS	☒	B-31(21.5)
22					61.1			

NOTES: Bottom of boring at 22 feet bgs.

PROJECT:	BORING ID:	
Additional Western Area Investigation	**B-32**	
LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM** / SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/18/2020**	DATE COMPLETED: **2/18/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT, dark yellowish brown (10 YR 4/4), slightly moist, soft, slight plasticity	2.0/2.0				
2				2.0/2.0				
4			Becomes stiff	2.0/2.0				
6				2.0/2.0				
8	ML		SILT with poorly-graded fine sand, dark yellowish brown (10 YR 4/4), slightly moist, medium stiff	2.0/2.0	<5	NS		
10					<5	NS		
12			Becomes wet	5.0/4.5				
					<5	NS		
14								
					<5	NS		
16								
			Becomes soft	5.0/4.9				
18					<5	NS		
20								

NOTES: Bottom of boring at 22 feet bgs.

PROJECT: Additional Western Area Investigation	BORING ID: B-32		
LOCATION: 5420 Fruit Valley Road, Vancouver, WA	WELL ID:		
DRILLING CONTRACTOR: Cascade Environmental LP	NORTHING:	EASTING:	
DRILLING EQUIPMENT: Geoprobe 7720 DT Track Mount	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: Not measured	
DRILLING METHOD: Direct-push	TOTAL DEPTH: 22	DEPTH TO WATER: Not measured	
LOGGED BY: IM	SAMPLING METHOD: 5' push probe sleeve	DATE STARTED: 2/18/2020	DATE COMPLETED: 2/18/2020

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
22				2.0/2.0	<5	NS		

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-33**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22.5**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/19/2020**	DATE COMPLETED: **2/19/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT with trace fine sand, brown (10 YR 4/3), slightly moist, medium stiff, slight plasticity					
1				2.0/2.0				
2								
3				2.0/2.0				
4								
4.5					<5	NS		
5				2.0/2.0				
6								
6.5					<5	NS	☒	B-33(6.5)
7				2.0/2.0				
8								
8.5					<5	NS		
9				2.0/2.0				
9.5					<5	NS		
10								
12								
12.5				5.0/1.5				
13			Becomes softer					
13.5	ML		SILT, with trace fine sand, very dark gray (GLEY 1, 4/1), wet, soft		<5			
14								
14.5					<5	NS		
15.5					20.2	NS		
16								
16.5					517	NS		
17.5				5.0/4.9	186	NS	☒	B-33(17.5)
18								
19.5					8	NS		
20							☒	B-33(20)

NOTES: Bottom of boring at 22.5 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-33**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22.5**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/19/2020**	DATE COMPLETED: **2/19/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
	ML		SILT with sand, dark greenish gray (GLEY 1, 4/1), wet, soft	2.0/2.0	20	NS		B-33(20)
22					<5	NS		

NOTES: Bottom of boring at 22.5 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-34**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **IM**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/19/2020**	DATE COMPLETED: **2/19/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT, brown (10 YR 5/3), slightly moist, medium stiff	2.0/2.0				
2				2.0/2.0	<5	NS		
4				2.0/2.0				
6			Trace fine sand	2.0/2.0	<5	NS	☒	B-34(6.5)
8				2.0/2.0	<5	NS		
					<5	NS		
10	ML		SILT with fine sand, brown (10 YR 4/3), slightly moist, medium stiff	5.0/4.9				
					<5	NS		
12								
					<5	NS		
14			Becomes stiff		<5	NS		
			Becomes wet	5.0/4.9	<5	NS		
16								
			Becomes dark gray (GLEY 1, 4/1)		40.1	NS		
18							☒	B-34(18)
			Becomes grayish brown (10 YR 5/2)					
			Decreasing sand		2.4	NS		
20								

NOTES: Bottom of boring at 22 feet bgs.

PROJECT: Additional Western Area Investigation	BORING ID: B-34	
LOCATION: 5420 Fruit Valley Road, Vancouver, WA	WELL ID:	
DRILLING CONTRACTOR: Cascade Environmental LP	NORTHING:	EASTING:
DRILLING EQUIPMENT: Geoprobe 7720 DT Track Mount	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: Not measured
DRILLING METHOD: Direct-push	TOTAL DEPTH: 22	DEPTH TO WATER: Not measured
LOGGED BY: IM / SAMPLING METHOD: 5' push probe sleeve	DATE STARTED: 2/19/2020	DATE COMPLETED: 2/19/2020

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
				2.0/2.0	<5	NS		
22			Becomes gray brown (10 YR 5/2)		<5	NS		

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC

PROJECT: Additional Western Area Investigation		BORING ID: B-35	
LOCATION: 5420 Fruit Valley Road, Vancouver, WA		WELL ID:	
DRILLING CONTRACTOR: Cascade Environmental LP		NORTHING:	EASTING:
DRILLING EQUIPMENT: Geoprobe 7720 DT Track Mount		SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: Not measured
DRILLING METHOD: Direct-push		TOTAL DEPTH: 20	DEPTH TO WATER: Not measured
LOGGED BY: JW	SAMPLING METHOD: 5' push probe sleeve	DATE STARTED: 2/21/2020	DATE COMPLETED: 2/21/2020

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT, dark brown (7.5 YR 3/2), moist, medium stiff	2.0/2.0	<5	NS		
2				2.0/2.0	<5	NS		
4				2.0/2.0				
6	ML		SILT with fine sand, dark brown (7.5 YR 3/2), wet, stiff	2.0/2.0	<5	NS	☒	B-35(6)
8				2.0/2.0			☒	B-35(9)
			Becomes medium stiff		<5	NS		
10				5.0/5.0	<5	NS		
12					<5	NS		
14								
15				5.0/5.0	<5	NS		
16					<5	NS		
18							☒	B-35(19)
20					<5	NS		

NOTES: Bottom of boring at 20 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-36**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **20**	DEPTH TO WATER: **Not measured**
LOGGED BY: **JW**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020**	DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT with trace fine sand, dark gray (7.5 YR 4/1), slightly moist, medium stiff	2.0/2.0	<5	NS		
2				2.0/2.0	<5	NS		
4				2.0/2.0	<5	NS		
6							☒	B-36(6)
				2.0/2.0	<5	NS		
8			Becomes wet	2.0/2.0	<5	NS		
10					<5	NS		
12				5.0/5.0				
			Increasing fine sand		<5	NS		
14							☒	B-36(14)
16								
				5.0/5.0	<5	NS		
18					<5	NS		
					<5	NS		
20							☒	B-36(20)

NOTES: Bottom of boring at 20 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-37**	
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **JW**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020**	DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT with trace fine sand, brown (7.5 YR 4/2), slightly moist, medium stiff	2.0/2.0	<5	NS		
2				2.0/2.0	<5	NS		
4				2.0/2.0	<5	NS		
6							⊠	B-37(6)
				2.0/2.0	<5	NS		
8				2.0/2.0	<5	NS		
10			Becomes wet		<5	NS		
12				5.0/5.0			⊠	B-37(13)
					<5	NS		
14								
16	ML		SILT, gray (10 YR 5/1), wet, medium stiff		101	SS		
				5.0/4.0	394	SS		
18								
					261	SS		
20								

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-37**
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22** / DEPTH TO WATER: **Not measured**
LOGGED BY: **JW**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020** / DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
22			Becomes stiff	2.0/2.0	49	SS	☒	B-37(21)

NOTES: Bottom of boring at 22 feet bgs.

	PROJECT: Additional Western Area Investigation	BORING ID: B-38
	LOCATION: 5420 Fruit Valley Road, Vancouver, WA	WELL ID:
Cascadia Associates, LLC	DRILLING CONTRACTOR: Cascade Environmental LP	NORTHING: / EASTING:
	DRILLING EQUIPMENT: Geoprobe 7720 DT Track Mount	SURFACE ELEV. (NAVD88): Not measured / TOC ELEVATION: Not measured
	DRILLING METHOD: Direct-push	TOTAL DEPTH: 22 / DEPTH TO WATER: Not measured
LOGGED BY: JW	SAMPLING METHOD: 5' push probe sleeve	DATE STARTED: 2/21/2020 / DATE COMPLETED: 2/21/2020

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT, brown (7.5 YR 4/2), slightly moist, medium stiff	2.0/2.0	<5	NS		
2				2.0/2.0	<5	NS		
4				2.0/2.0	<5	NS		
6				2.0/2.0	<5	NS	⊠	B-38(6)
8			Becomes reddish brown (5 YR 5/4)	2.0/2.0	<5	NS		
			Trace fine sand					
10				5.0/5.0	27	NS		
12	ML		SILT, gray (10 YR 5/1), wet, soft		584	SS	⊠	B-38(13)
14								
16				5.0/3.0	220	HS		
18					15	SS		
20								

NOTES: Bottom of boring at 22 feet bgs.

PROJECT: **Additional Western Area Investigation**	BORING ID: **B-38**	
LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:	
DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **JW** / SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020**	DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
22				2.0/2.0	721	SS	⊠	B-38(21.5)

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-39**
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:
	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22** / DEPTH TO WATER: **Not measured**
LOGGED BY: **JW**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020** / DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
0	ML		SILT, brown (7.5 YR 5/3), slightly moist, medium stiff	2.0/2.0	<5	NS		
2				2.0/2.0	<5	NS		
4			Trace fine sand	2.0/2.0	<5	NS		
6				2.0/2.0	<5	NS	☒	B-39(6)
8	ML		SILT with trace fine sand, brown (7.5 YR 4/4), slightly moist, medium stiff	2.0/2.0	<5	NS		
10					<5	NS		
12				5.0/4.0				
			Becomes wet		<5	NS	☒	B-39(13.5)
14								
16								
			Becomes dark gray (10 YR 4/1)	5.0/4.0	<5	NS		
18								
20					26	NS		

NOTES: Bottom of boring at 22 feet bgs.

Cascadia Associates, LLC	PROJECT: **Additional Western Area Investigation**	BORING ID: **B-39**
	LOCATION: **5420 Fruit Valley Road, Vancouver, WA**	WELL ID:

	DRILLING CONTRACTOR: **Cascade Environmental LP**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7720 DT Track Mount**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **Not measured**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **22**	DEPTH TO WATER: **Not measured**
LOGGED BY: **JW**	SAMPLING METHOD: **5' push probe sleeve**	DATE STARTED: **2/21/2020**	DATE COMPLETED: **2/21/2020**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor(ppm)	Sheen	Sample Depth	Notes
22				2.0/2.0	4.7	NS	☒	B-39(21)

NOTES: Bottom of boring at 22 feet bgs.

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, and grain size, and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT with additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and Geoprobe® explorations is estimated based on visual observation and is presented parenthetically on test pit and Geoprobe® exploration logs.

SAND and GRAVEL Density	Standard Penetration Resistance in Blows/Foot
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

SILT or CLAY Density	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very soft	0 - 2	<0.125
Soft	2 - 4	0.125 - 0.25
Medium stiff	4 - 8	0.25 - 0.5
Stiff	8 - 15	0.5 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture.
Damp	Some perceptible moisture, probably below optimum.
Moist	Probably near optimum moisture content.
Wet	Much perceptible moisture, probably above optimum.

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Symbols

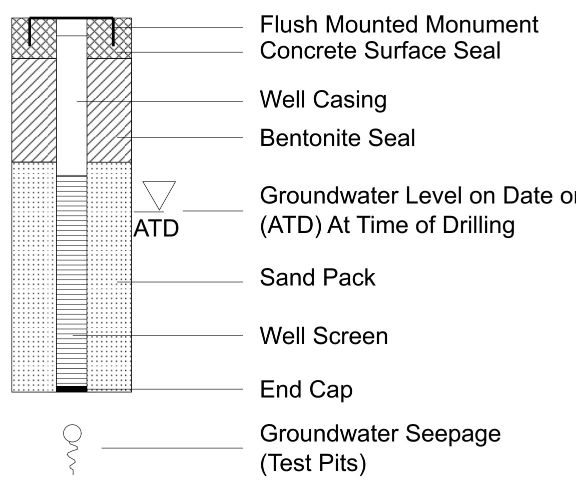
BORING AND GEOPROBE® SYMBOLS

- ☒ Split Spoon
- ⧅ Tube (Shelby, Geoprobe®)
- ▥ Cuttings
- ◫ Core Run
- ▤ Temporarily Screened Interval
- N Standard Penetration Resistance
- * No Sample Recovery
- P Tube Pushed, Not Driven
- PID Photoionization Detector Reading
- W Water Sample
- ⬭ Sample Submitted for Chemical Analysis

TEST PIT SOIL SAMPLES

- ☒ Grab (Jar)
- ⧄ Bag
- ⧅ Shelby Tube

Groundwater Observations and Monitoring Well Construction



Key to Exploration Logs

Direct-Push Groundwater Assessment
Support Terminal Operating Partners - Vancouver Terminal #2
Vancouver, Washington

Ash Creek Associates, Inc. Environmental and Geotechnical Consultants	Project Number	1126-02	Figure
	July 2007		Key

Ash Creek Associates, Inc. Environmental and Geotechnical Consultants	ST Services - Vancouver Annex Vancouver, Washington	Log Of Well Number	**GP-1**
		Project Number	**1126-02**

Boring Location: See Figure 2	Surface Elevation: Not Surveyed
Drilling Contractor: Environmental Services Network	Date Started: 6/11/07
Drilling Method: 4 Foot Push Probe (Acetate Lined)	Date Finished: 6/11/07
Drilling Equipment: Strataprobe	Logged By: A. Schmidt
	Depth to Water (ATD): 26.0'

Depth, feet	Sample ID	Sample	Recovery	Sheen	PID	Material Description	Remarks:
						GRAVEL Fill.	
				No	<5	SILT; brown, moist, trace sand, (medium stiff).	
5				No	<5	Silty SAND; brown, moist, fine-grained, poorly sorted, (loose).	5
				No	<5		
10				No	<5		10
				No	<5	SAND; brown, moist, fine- to medium-grained, poorly sorted, (medium dense).	
15							15
				No	<5		
				No	<5	SAND; gray to black, moist, medium-grained, poorly sorted, no grading, trace silts, (medium dense).	
20							20
				No	<5		
25				No	<5		25
				No	<5		
				No	<5		
30				No	<5		30
				No	<5		
35							35
				No	<5		
				No	<5		

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

ST Services - Vancouver Annex
Vancouver, Washington

Log Of Well Number **GP-1**

Project Number **1126-02**

Boring Location: See Figure 2	Surface Elevation: Not Surveyed
Drilling Contractor: Environmental Services Network	Date Started: 6/11/07
Drilling Method: 4 Foot Push Probe (Acetate Lined)	Date Finished: 6/11/07
Drilling Equipment: Strataprobe	Logged By: A. Schmidt
	Depth to Water (ATD): 26.0'

Depth, feet	Sample ID	Sample	Recovery	Sheen	PID	Material Description	Remarks:
						No recovery. Crushed liner.	
45						No recovery.	45
				No	<5		
50				No	<5		50
						No samples collected from 52.0 to 72.0 feet.	
55							55
60							60
65							65
70							70 GP-1-1
						Boring Terminated at 72.0' BGS.	
75							75

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

ST Services - Vancouver Annex
Vancouver, Washington

Log Of Well Number	**GP-2**
Project Number	**1126-02**

Boring Location: See Figure 2	Surface Elevation: Not Surveyed
Drilling Contractor: Environmental Services Network	Date Started: 6/11/07
Drilling Method: 4 Foot Push Probe (Acetate Lined)	Date Finished: 6/11/07
Drilling Equipment: Strataprobe	Logged By: A. Schmidt
	Depth to Water (ATD): --

Depth, feet	Sample ID	Sample	Recovery	Sheen	PID	Material Description	Remarks:
						No soil logging. Groundwater sample only.	
5							5
10							10
15							15
20							20
25							25
30							30
35							35

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

ST Services - Vancouver Annex
Vancouver, Washington

Log Of Well Number **GP-2**

Project Number **1126-02**

Boring Location: See Figure 2	Surface Elevation: Not Surveyed
Drilling Contractor: Environmental Services Network	Date Started: 6/11/07
Drilling Method: 4 Foot Push Probe (Acetate Lined)	Date Finished: 6/11/07
Drilling Equipment: Strataprobe	Logged By: A. Schmidt
	Depth to Water (ATD): --

Depth, feet	Sample ID	Sample	Recovery	Sheen	PID	Material Description	Remarks:
45							45
50							50
55							55
60							60
65							65 GP-2-1
						Boring Terminated at 66.0' BGS.	
70							70
75							75

Cascadia Associates, LLC	PROJECT: **NuStar Vancouver Annex Terminal Pilot Study**	BORING ID: **MW-5D**	
	LOCATION: **5420 NW Fruit Valley Road, Vancouver, WA**	WELL ID: **MW-5D**	
	DRILLING CONTRACTOR: **Cascade Drilling**	NORTHING:	EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7822DT**	SURFACE ELEV. (NAVD88): **Not measured**	TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **45**	DEPTH TO WATER: **17.3**
LOGGED BY: **Ian Maguire**	SAMPLING METHOD: **4-Inch Dual Tube Sampler**	DATE STARTED: **10/19/2017**	DATE COMPLETED: **10/20/2017**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Depth	Well Construction	Water Level
0			Physical Clearance - Not logged.	NA		0		
8			No recovery.			8		
10	ML		SILT with fine sand; light brown with dark brownish red mottling; slightly moist, medium stiff.	5.0/5.0	<5 <5	12		
	ML		Becomes gray SILT; moist; medium stiff; odor observed.					
14	ML		Becomes wet.		110			
	ML		SILT with fine sand; gray; wet; medium stiff.	5.0/5.0	63 340	16		▽
20						20		

Cascadia Associates, LLC	PROJECT: **NuStar Vancouver Annex Terminal Pilot Study**	BORING ID: **MW-5D**
	LOCATION: **5420 NW Fruit Valley Road, Vancouver, WA**	WELL ID: **MW-5D**
	DRILLING CONTRACTOR: **Cascade Drilling**	NORTHING: / EASTING:
	DRILLING EQUIPMENT: **Geoprobe 7822DT**	SURFACE ELEV. (NAVD88): **Not measured** / TOC ELEVATION: **NA**
	DRILLING METHOD: **Direct-push**	TOTAL DEPTH: **45** / DEPTH TO WATER: **17.3**
LOGGED BY: **Ian Maguire**	SAMPLING METHOD: **4-Inch Dual Tube Sampler**	DATE STARTED: **10/19/2017** / DATE COMPLETED: **10/20/2017**

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Depth	Well Construction	Water Level
20						20		
					625			
22				2.5/5.0				
	SP		Fine grained SAND; gray; wet; loose; slight odor					
24					10	24		
26				2.5/5.0				
	SP		Sand becomes well graded medium to coarse grained; dark gray to black; medium dense; moist.		10			
			No recovery.		33			
28						28		
30				1.8/5.0				
32						32		
34	SP		SAND; gray; wet; medium dense; well graded fine to medium; mica present; 10-15% fines.		<5, <5			
36	SP		SAND; brown; moist to wet; medium dense; poorly graded fine sand with 10% silt.	5.0/5.0	<5, <5	36		
38	SP		Becomes wet.					
			SAND; dark gray, wet, medium dense; well graded fine to medium sand with little to no fines.		<5			
40						40		

PROJECT: NuStar Vancouver Annex Terminal Pilot Study	BORING ID: MW-5D	
LOCATION: 5420 NW Fruit Valley Road, Vancouver, WA	WELL ID: MW-5D	
DRILLING CONTRACTOR: Cascade Drilling	NORTHING:	EASTING:
DRILLING EQUIPMENT: Geoprobe 7822DT	SURFACE ELEV. (NAVD88): Not measured	TOC ELEVATION: NA
DRILLING METHOD: Direct-push	TOTAL DEPTH: 45	DEPTH TO WATER: 17.3
LOGGED BY: Ian Maguire	SAMPLING METHOD: 4-Inch Dual Tube Sampler	DATE STARTED: 10/19/2017
		DATE COMPLETED: 10/20/2017

Elev. (feet)	USCS	Graphic Log	Description	Driven/Rec. (ft.)	Headspace Vapor (ppm)	Depth	Well Construction	Water Level
40	SP			5.0/5.0	<5	40		
42								
44					<5	44		
					<5			

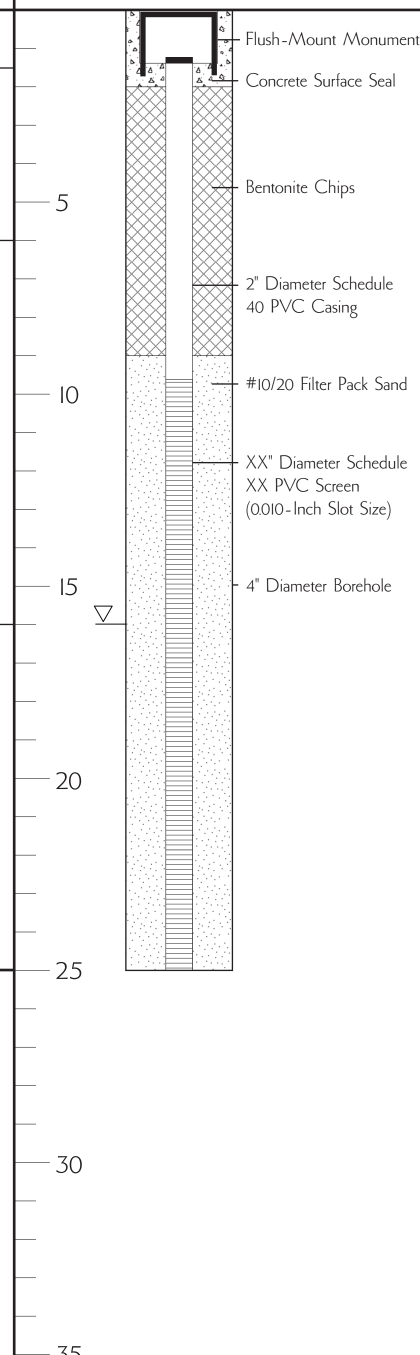
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**MW-7**
Project Number:	**1569-09**
Logged By:	J. Mattecheck
Date:	July 7, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	16'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
	Hand Auger		NS	<5	Topsoil and trace organics.
			NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.
			NS	<5	
5			NS	<5	
			NS	<5	SILT with clay; gray (7.5YR 5/1), slightly moist, medium stiff.
			NS	<5	
10					
					Becomes medium stiff to soft. Trace angular gravels.
			NS	<5	
			NS	<5	
15			NS	<5	Becomes wet.
			NS	<5	Silt CLAY with trace fine sand; brown (7.5YR 4/3), wet, medium stiff to stiff.
			NS	<5	
20					Becomes medium stiff to soft.
25					Bottom of Boring at 30.0' BGS.
30					
35					

Well Details and Notes:



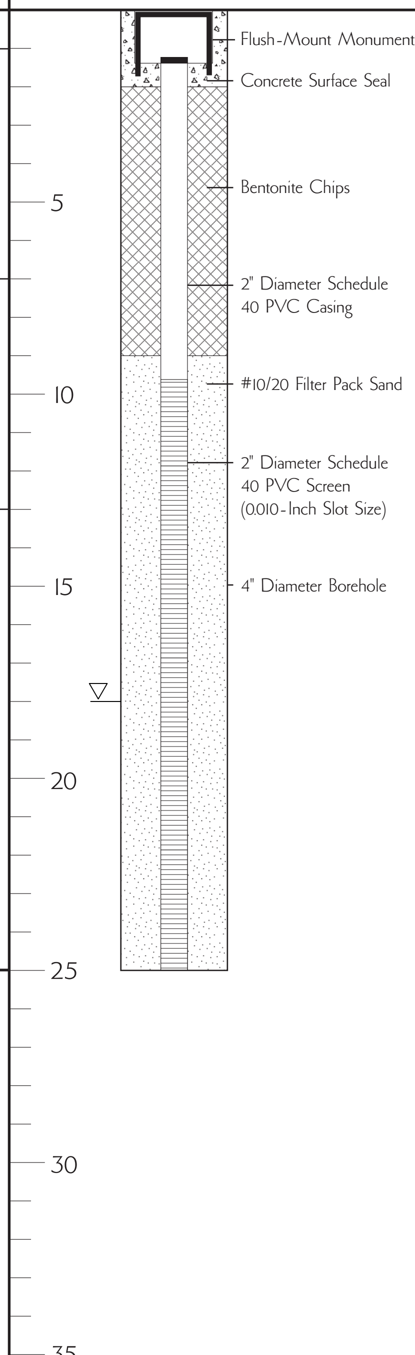
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**MW-8**
Project Number:	**1569-09**
Logged By:	J. Mattecheck
Date:	July 6, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	18'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
	Hand Auger				Grass/organics.
			NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.
			NS	<5	
			NS	<5	
5			NS	<5	
			NS	<5	SILT with sand; light brown (7.5YR 6/3), slightly moist, medium stiff.
			NS	<5	
10			NS	<5	
			NS	<5	
			NS	<5	SILT with trace fine sand and clay; brown (7.5YR 6/3), slightly moist, soft to medium stiff.
15					
			NS	<5	Becomes wet.
			NS		
20			NS	61	Becomes gray (7.5YR 5/1).
			NS	37	
			NS	<5	
25					Bottom of Boring at 30.0' BGS.
30					
35					

Well Details and Notes:



Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	2016 Well Installation and Additional Delineation Work Plan NuStar Terminals Operations Partnership, L.P. - Annex Terminal Vancouver, Washington	Boring Number: **MW-8D**

Project Number:	1569-09
Logged By:	J. Mattecheck
Date:	July 6, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	16.2'
Surface Elevation:	Not Measured

Depth, feet | Core Interval/Recovery | Laboratory Sample ID | Sheen | PID

Lithologic Description

Well Details and Notes:

Hand Auger

Rounded cobbles over gravel.

SILT; light brown (7.5YR 6/3), dry, medium stiff.

SILT with fine sand; light brown (7.5YR 6/3), slightly moist, medium stiff to soft.

SILT with trace fine sand and clay; light brown (7.5YR 6/4), wet, medium stiff to soft.

Becomes gray (7.5YR 5/1).

Coarse to fine, well-graded SAND in a SILT matrix; gray (7.5YR 5/1), wet, soft to medium dense.

Fine to medium-coarse, well-graded SAND; very dark gray (7.5YR 3/1), wet, medium dense to dense.

1.5-foot lens fine, poorly graded SAND; light brown (7.5YR 6/3), wet, dense.

Sheen	PID
	<5
NS	
	<5
NS	
	<5
	<5
NS	
	<5
NS	
	<5
NS	
	<5
	<5
NS	
	<5
NS	
	<5
NS	
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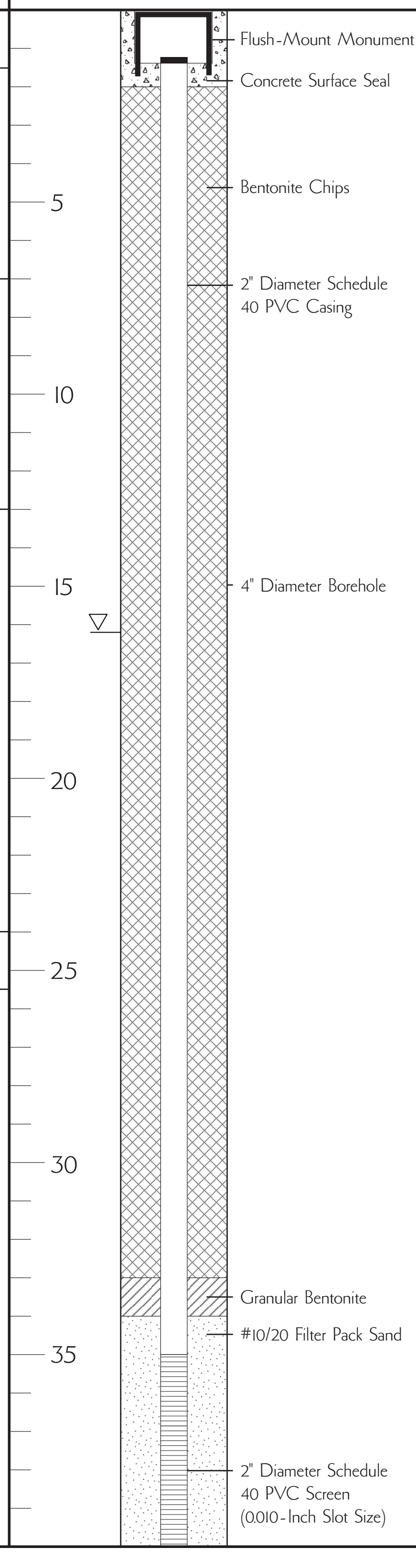


Bottom of Boring at 40.0' BGS.

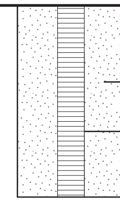
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**MW-8D**
Project Number:	**1569-09**
Logged By:	J. Mattecheck
Date:	July 6, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	16.2'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
			NS	<5	
			NS	<5	
			NS	<5	
45					Bottom of Boring at 45.0' BGS.
50					
55					
60					
65					
70					
75					

Well Details and Notes:



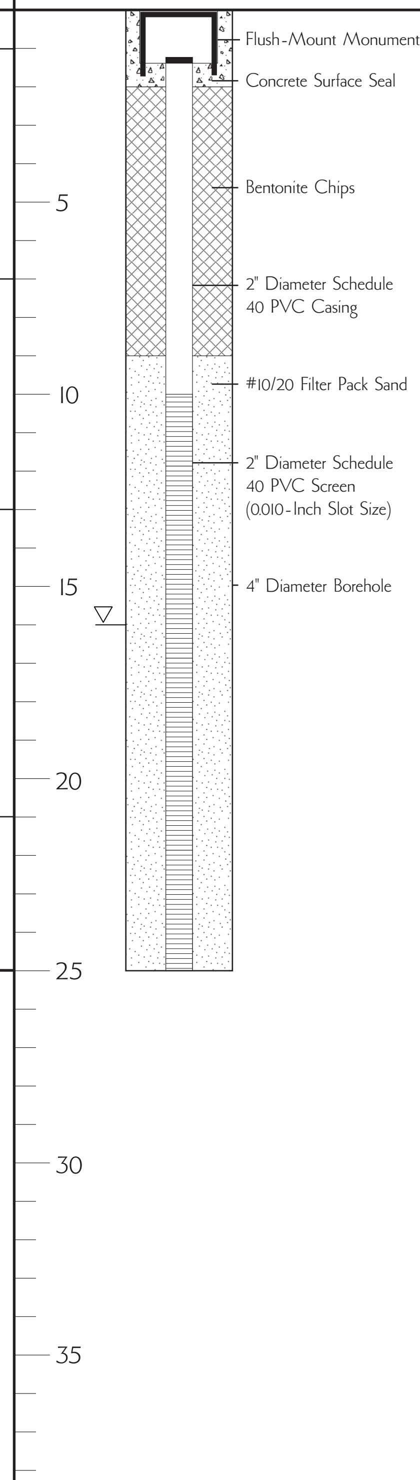
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number:	**MW-9**
Project Number:	**1569-09**
Logged By:	J. Mattecheck
Date:	July 6, 2016
Site Conditions:	Overcast
Drilling Contractor:	Cascade Drilling
Drilling Equipment:	Geoprobe
Sampler Type:	5' Push Probe
Depth to Water (ATD):	16'
Surface Elevation:	Not Measured

Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
	Hand Auger		NS	<5	Grass/organics.
			NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.
			NS	<5	
5			NS	<5	
			NS	<5	
			NS	<5	SILT with fine sand; light brown (7.5YR 6/3), dry, medium stiff.
			NS	<5	
10			NS	<5	
			NS	<5	
			NS	<5	
			NS	<5	SILT with trace fine sand and clay; brown (7.5YR 6/3), slightly moist, soft to medium stiff.
15				<5	Becomes wet.
			NS	<5	
			NS	<5	
			NS	<5	
20				<5	
			NS	<5	Coarse to fine, well-graded SAND; dark brown to black (7.5YR 2.5/1), wet, medium dense to dense.
			NS	<5	
			NS	<5	
25					Bottom of Boring at 30.0' BGS.
30					
35					

Well Details and Notes:



Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

2016 Well Installation and Additional Delineation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Boring Number: **MW-10**

Project Number: **1569-09**

Logged By: J. Mattecheck

Date: July 6, 2016

Site Conditions: Overcast

Drilling Contractor: Cascade Drilling

Drilling Equipment: Geoprobe

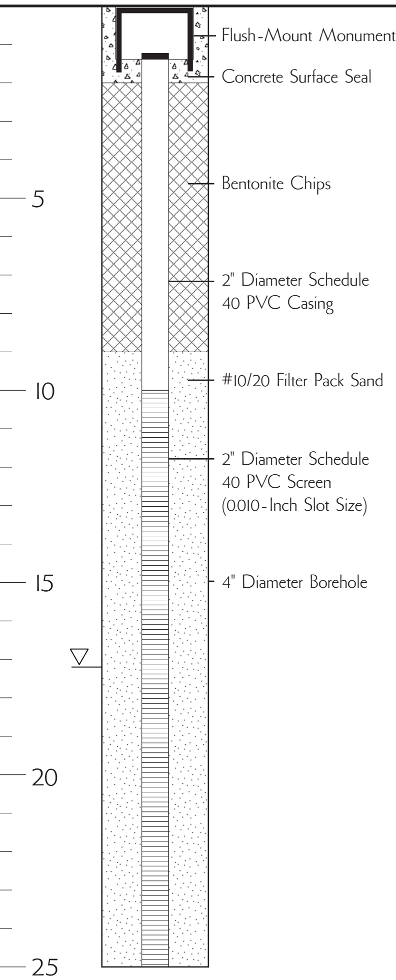
Sampler Type: 5' Push Probe

Depth to Water (ATD): 17.25'

Surface Elevation: Not Measured

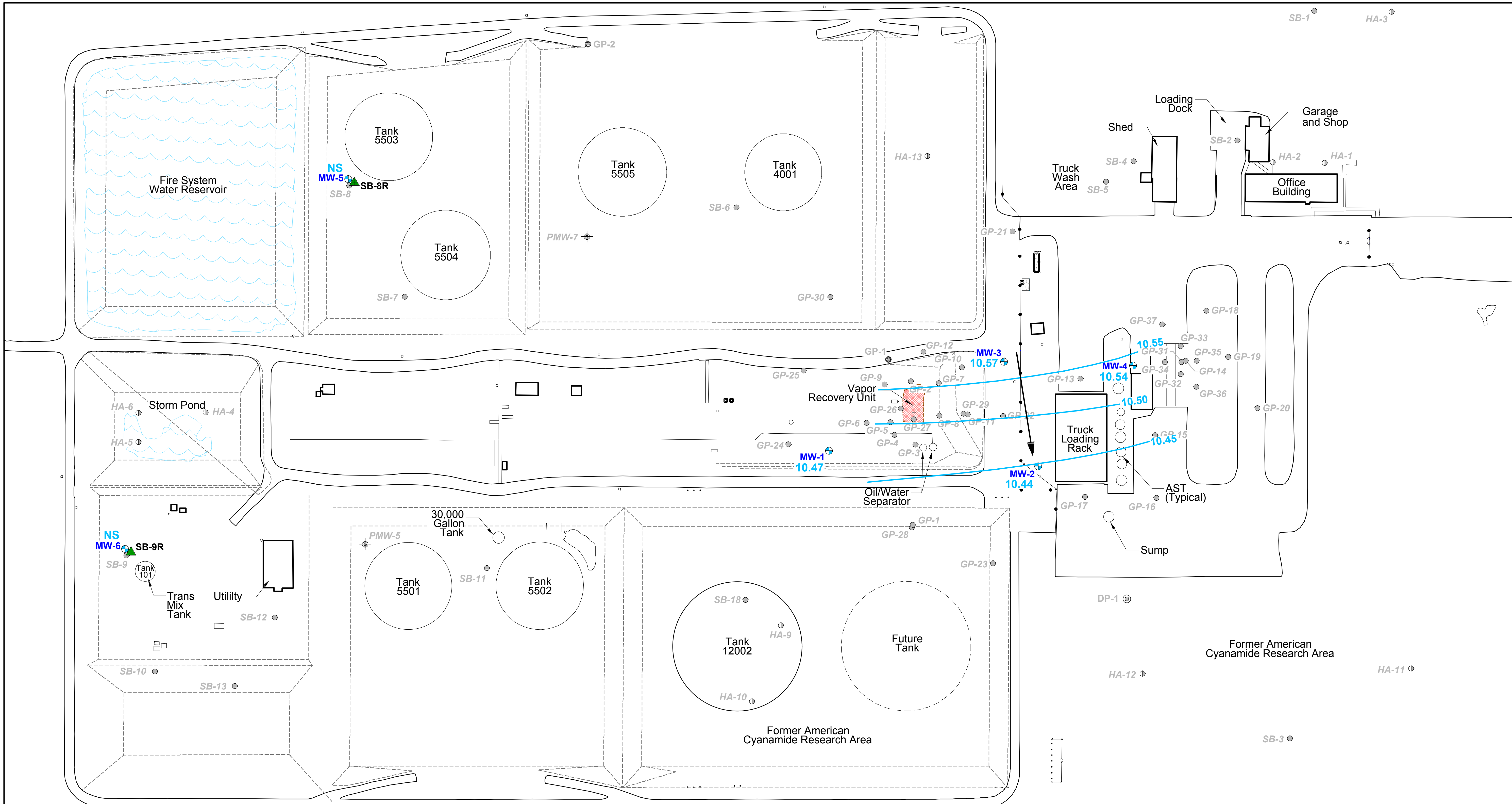
Depth, feet	Core Interval/Recovery	Laboratory Sample ID	Sheen	PID	Lithologic Description
0			NS	<5	Grass/organics.
			NS	<5	SILT; light brown (7.5YR 6/3), dry, medium stiff.
			NS	<5	
5	Hand Auger		NS	<5	
			NS	<5	
			NS	<5	
			NS	<5	
			NS	<5	
10			NS	<5	Silty CLAY; light brown (7.5YR 6/3), slightly moist, medium stiff.
			NS	<5	
			NS	<5	
			NS	<5	
15			NS	<5	Silty CLAY with fine sand; light brown (7.5YR 6/3), slightly moist, medium stiff.
					Becomes wet.
			NS	<5	
			NS	<5	
			NS	<5	
20			NS	<5	Coarse to fine, well-graded SAND; dark brown to black (7.5YR 2.5/1), wet, medium dense to dense.
			NS	<5	
			NS	<5	
			NS	<5	Coarse to fine, well-graded SAND; gray (7.5YR 5/1), wet, dense.
25					Bottom of Boring at 30.0' BGS.
30					
35					

Well Details and Notes:



APPENDIX B

GROUNDWATER CONTOUR MAPS



Legend:

- MW-1 10.47 — Groundwater Monitoring Well Location and Groundwater Elevation in Feet Above Mean Sea Limit (MSL)
- 10.5 — Groundwater Elevation Contour
- NS — Not Surveyed
- Inferred Groundwater Flow Direction
- SB-8R — Direct-Push Geoprobe Location
- GP-1 — Soil Boring Location (September 2014)
- DP-1 — Grab Groundwater Sample Location
- GP-1 — Historical Direct-Push Boring Location (Approximate)
- PMW-5 — Historical Temporary Well Location (Approximate)
- HA-1 — Historical Hand Auger Location (Approximate).
- Excavation

N

0 100 200

Scale in Feet

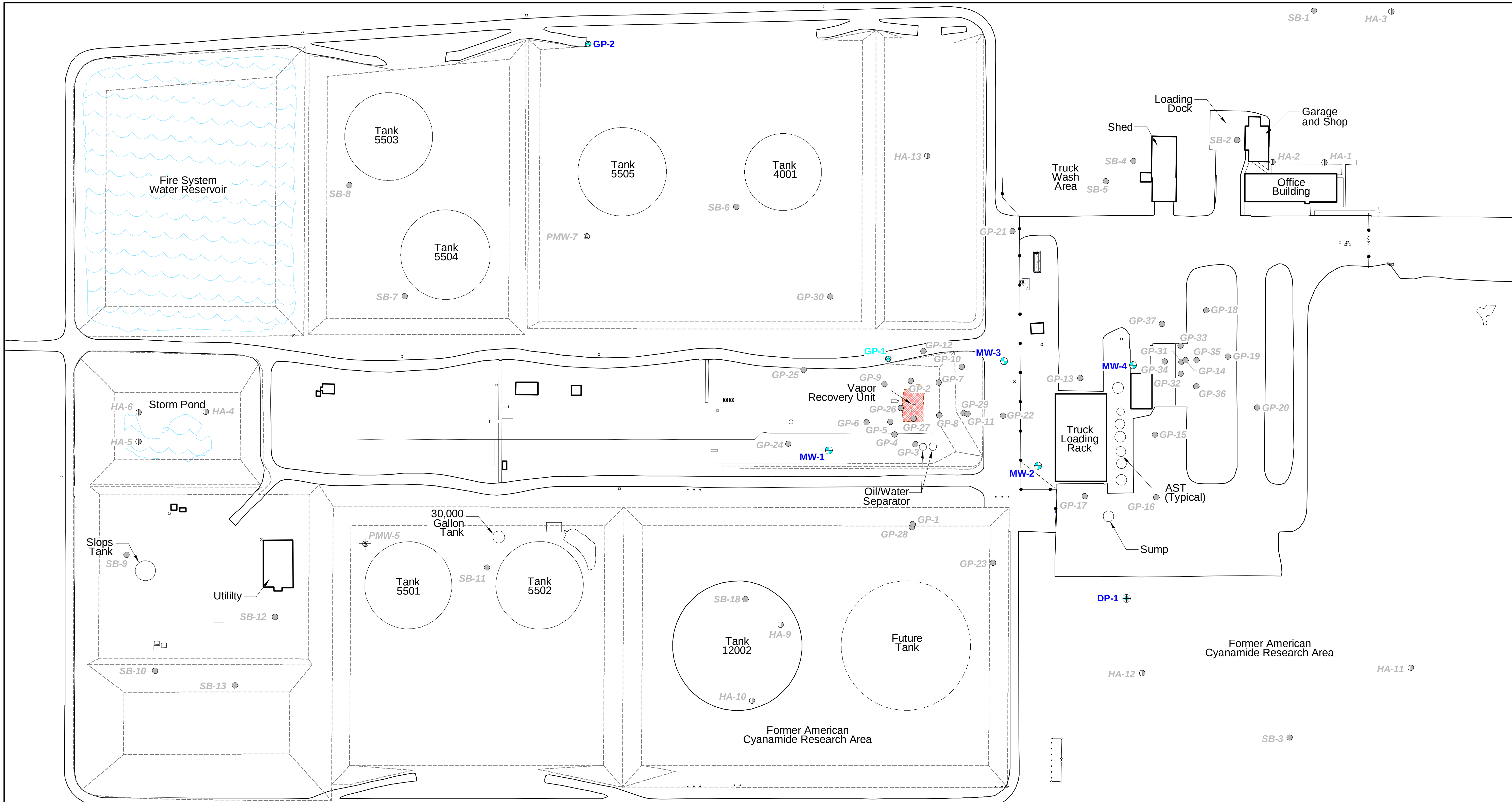
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Groundwater Elevations - December 2014

Groundwater Monitoring Results - December 2014
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1569-05	Figure
February 2015		3



Legend:

DP-1 Grab Groundwater Sample Location

MW-1 Groundwater Monitoring Well Location

GP-1 Deeper Direct-Push Geoprobe Location

GP-1 Historical Direct-Push Boring Location (Approximate)

PMW-5 Historical Temporary Well Location (Approximate)

HA-1 Historical Hand Auger Location (Approximate)

Excavation

N

0 100 200

Scale in Feet

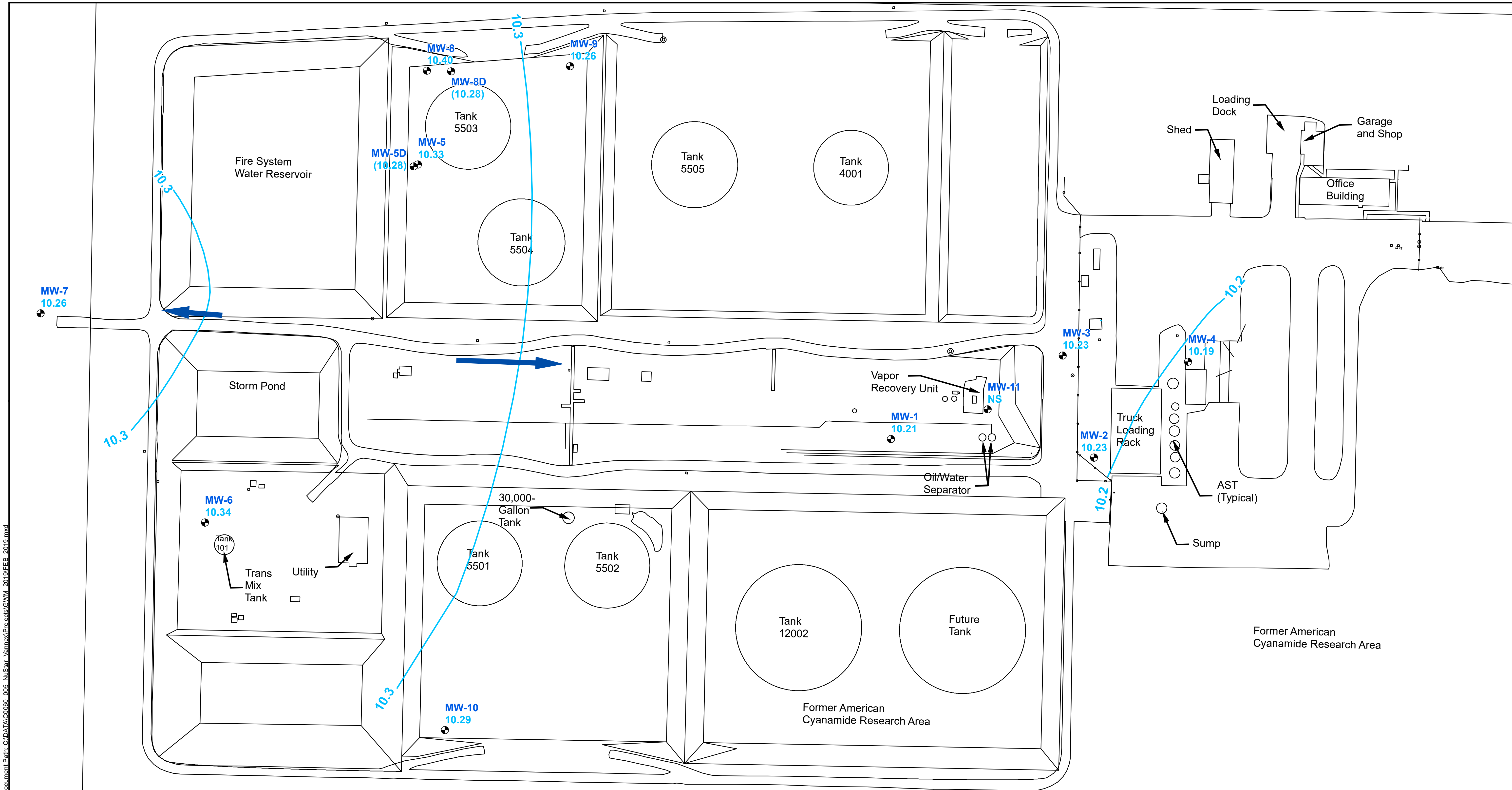
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Facility Site Plan

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1569-00	Figure
December 2010		2



Document Path: C:\DATA\C0060 005 NuStar Vannex\Projects\GWM 2019\FEB 2019.mxd

MW-1 Groundwater Monitoring Well Location

Groundwater Elevation Contour (Dashed Where Inferred)

10.28 Groundwater Elevation in Feet Above Mean Sea Limit (MSL)

(10.28) Deep Well Groundwater Elevation in Feet MSL (Not Used for Contouring)

NS Not Surveyed

Inferred Groundwater Flow Direction

Notes:

1. Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).

2. Locations of roads and containments are approximate.

3. Wells MW-1 through MW-11 are shallow wells screened across first encountered groundwater. Wells MW-5D and MW-8D are deeper monitoring well locations.

0 25 50 100 Feet

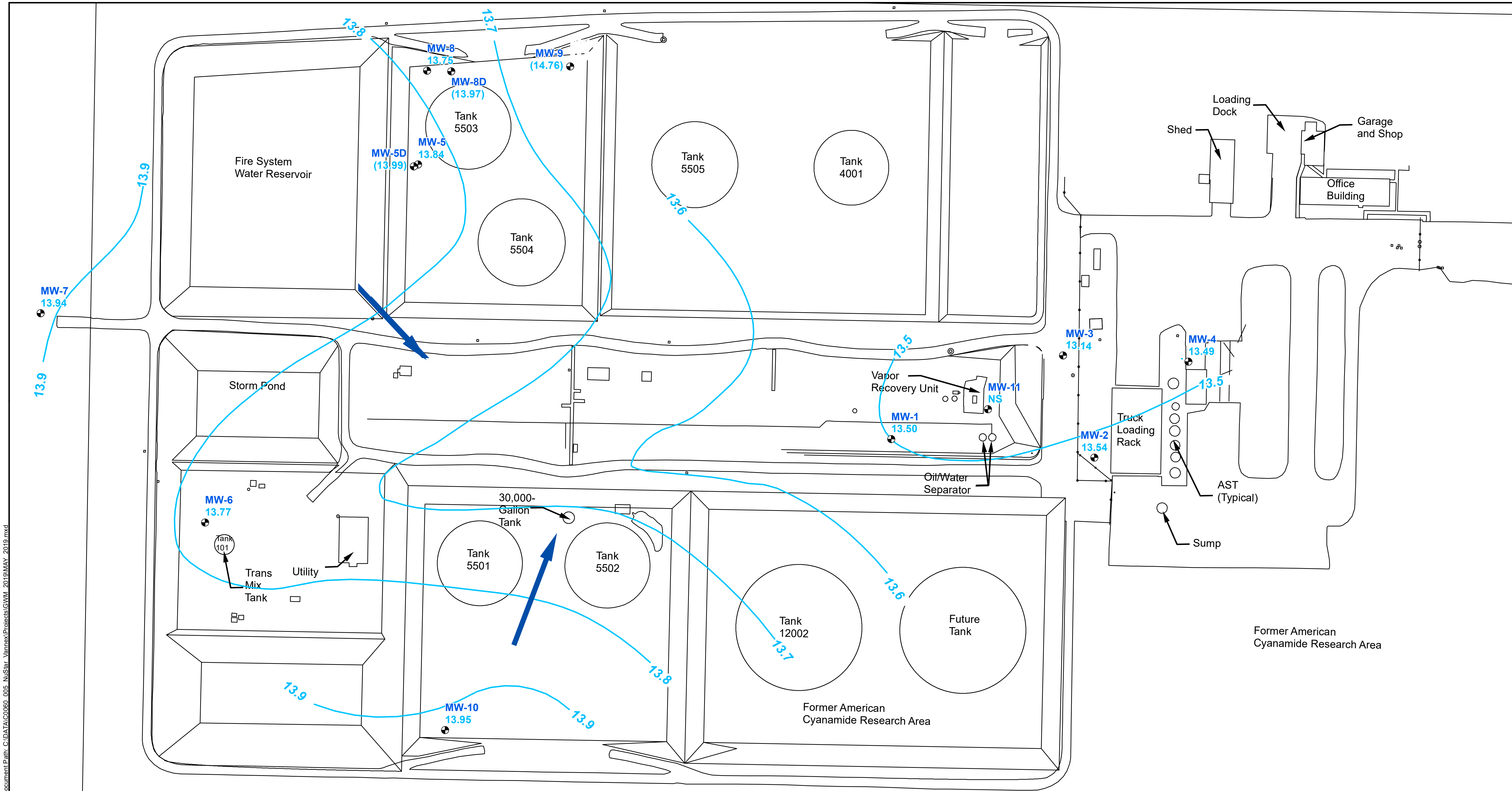
Groundwater Elevation Contour Map February 2019

2019 Groundwater Monitoring Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure 3

2/7/2020	Project No.: 0060-001-005	Drawn by: ES	Checked by: SS



MW-1	Groundwater Monitoring Well Location	10.28	Groundwater Elevation in Feet Above Mean Sea Limit (MSL)
	Groundwater Elevation Contour (Dashed Where Inferred)	(10.28)	Well Groundwater Elevation in Feet MSL (Not Used for Contouring)
		NS	Not Surveyed
			Inferred Groundwater Flow Direction

Notes:
1. Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).
2. Locations of roads and containments are approximate.
3. Wells MW-1 through MW-11 are shallow wells screened across first encountered groundwater. Wells MW-5D and MW-8D are deeper monitoring well locations.

0 25 50 100 Feet

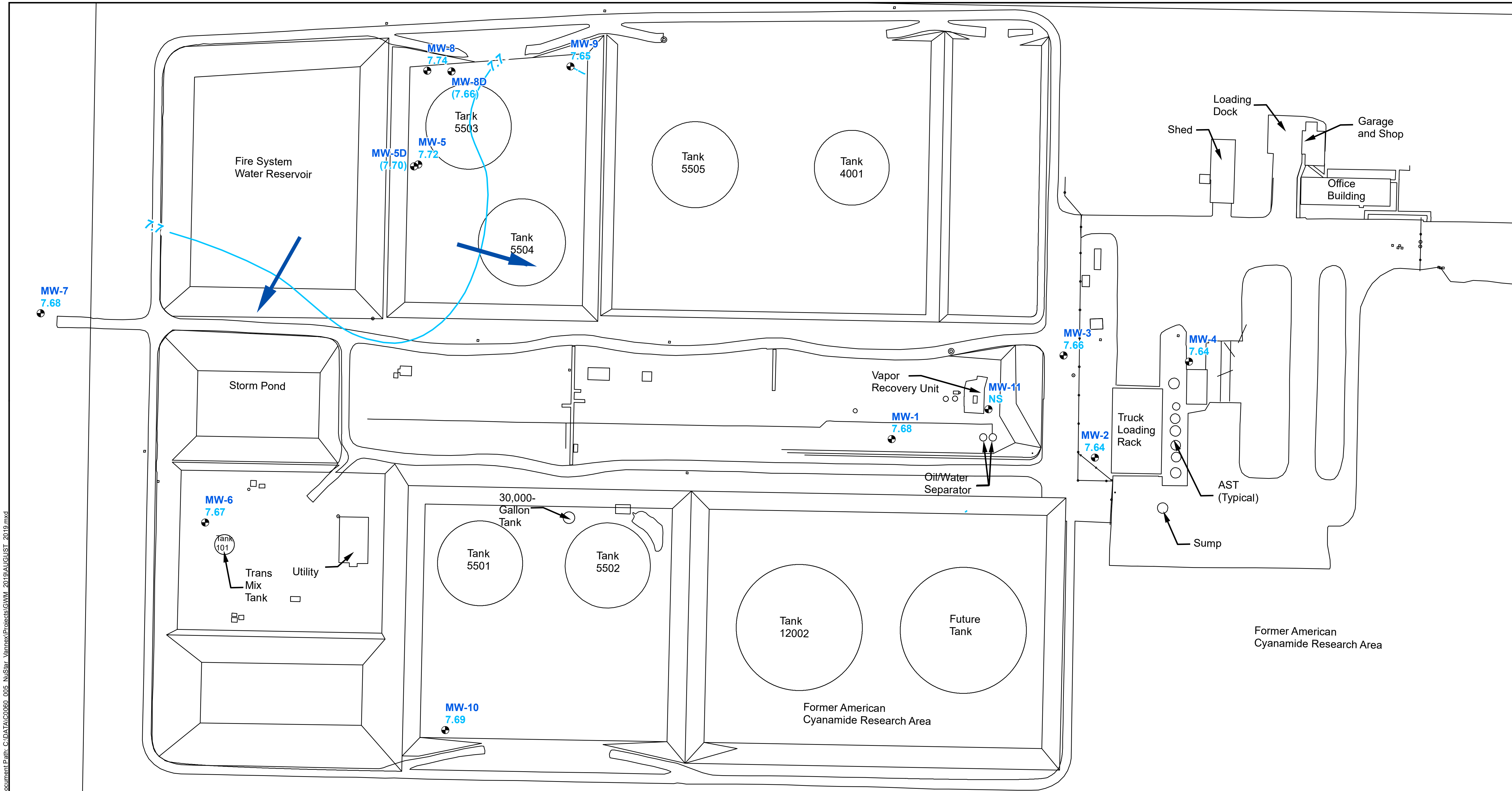
Groundwater Elevation Contour Map May 2019

2019 Groundwater Monitoring Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure 4

2/7/2020	Project No.: 0060-001-005	Drawn by: ES	Checked by: SS



MW-1 Groundwater Monitoring Well Location

Groundwater Elevation Contour (Dashed Where Inferred)

10.28 Groundwater Elevation in Feet Above Mean Sea Limit (MSL)

(10.28) Deep Well Groundwater Elevation in Feet MSL (Not Used for Contouring)

NS Not Surveyed

Inferred Groundwater Flow Direction

Notes:
1. Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).

2. Locations of roads and containments are approximate.

3. Wells MW-1 through MW-11 are shallow wells screened across first encountered groundwater. Wells MW-5D and MW-8D are deeper monitoring well locations.

0 25 50 100 Feet

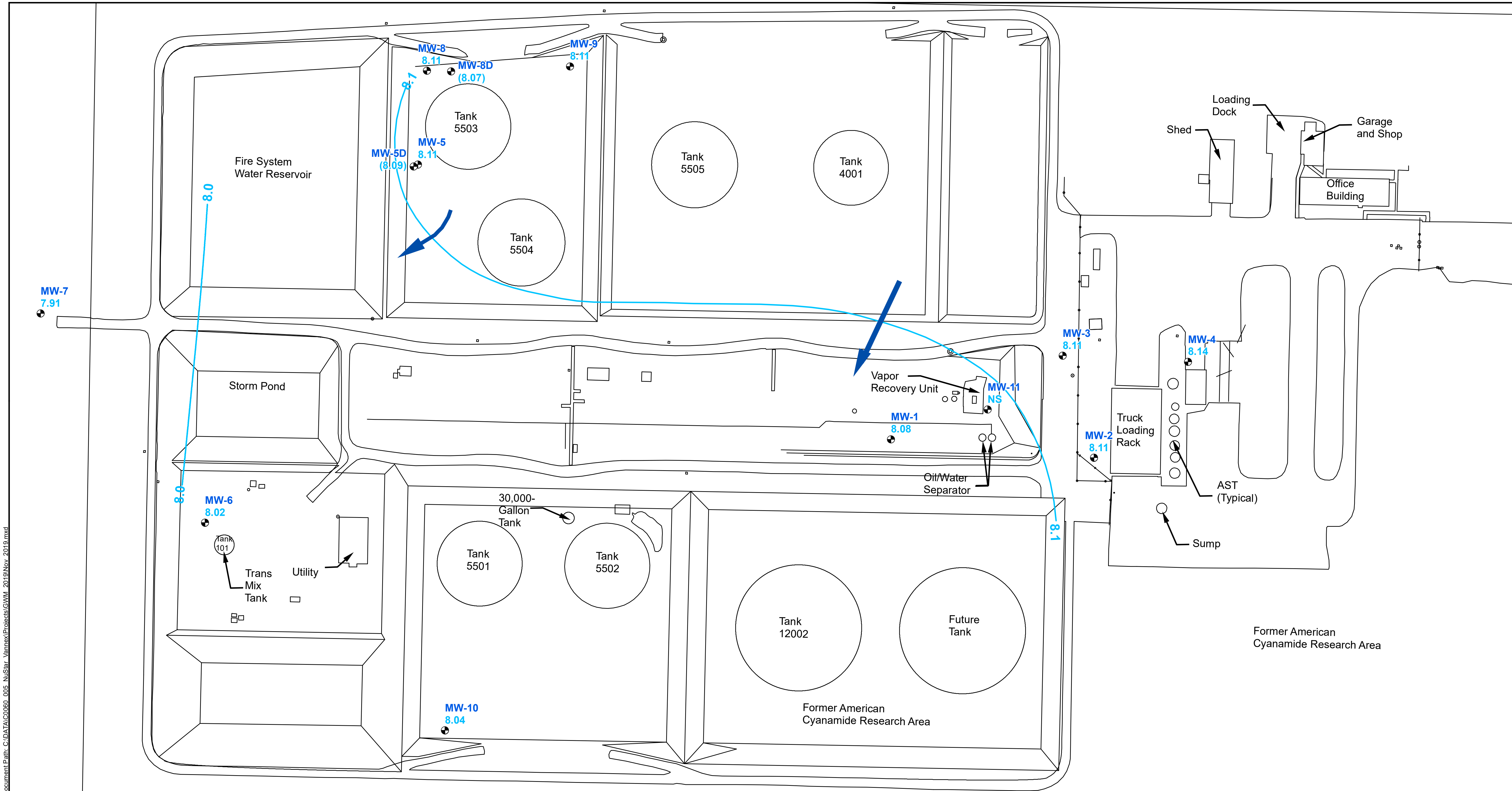
Groundwater Elevation Contour Map August 2019

2019 Groundwater Monitoring Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure 5

2/7/2020	Project No.: 0060-001-005	Drawn by: ES	Checked by: SS



MW-1 Groundwater Monitoring Well Location

Groundwater Elevation Contour (Dashed Where Inferred)

10.28 Groundwater Elevation in Feet Above Mean Sea Limit (MSL)

(10.28) Deep Well Groundwater Elevation in Feet MSL (Not Used for Contouring)

NS Not Surveyed

Inferred Groundwater Flow Direction

Notes:

1. Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007).

2. Locations of roads and containments are approximate.

3. Wells MW-1 through MW-11 are shallow wells screened across first encountered groundwater. Wells MW-5D and MW-8D are deeper monitoring well locations.

0 25 50 100 Feet

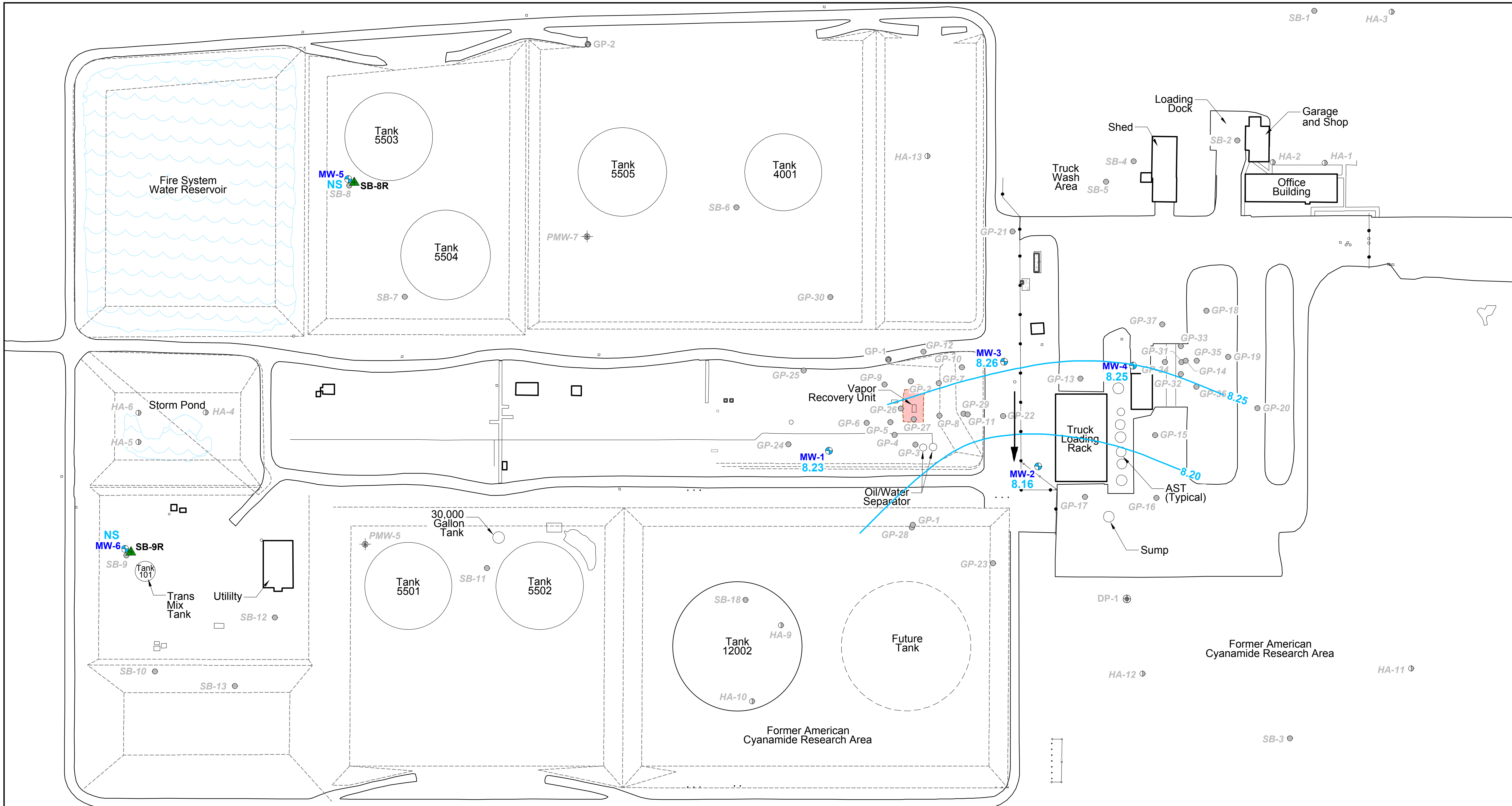
Groundwater Elevation Contour Map November 2019

2019 Groundwater Monitoring Report
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure 6

2/7/2020	Project No.: 0060-001-005	Drawn by: ES	Checked by: SS



Legend:

MW-1 8.23	Groundwater Monitoring Well Location and Groundwater Elevation in Feet Above Mean Sea Limit (MSL)
8.1	Groundwater Elevation Contour
NS	Not Surveyed
	Inferred Groundwater Flow Direction
SB-8R	Direct-Push Geoprobe Location
GP-1	Soil Boring Location (September 2014)
DP-1	Grab Groundwater Sample Location
GP-1	Historical Direct-Push Boring Location (Approximate)
PMW-5	Historical Temporary Well Location (Approximate)
HA-1	Historical Hand Auger Location (Approximate).
	Excavation

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Groundwater Elevations - June 2015

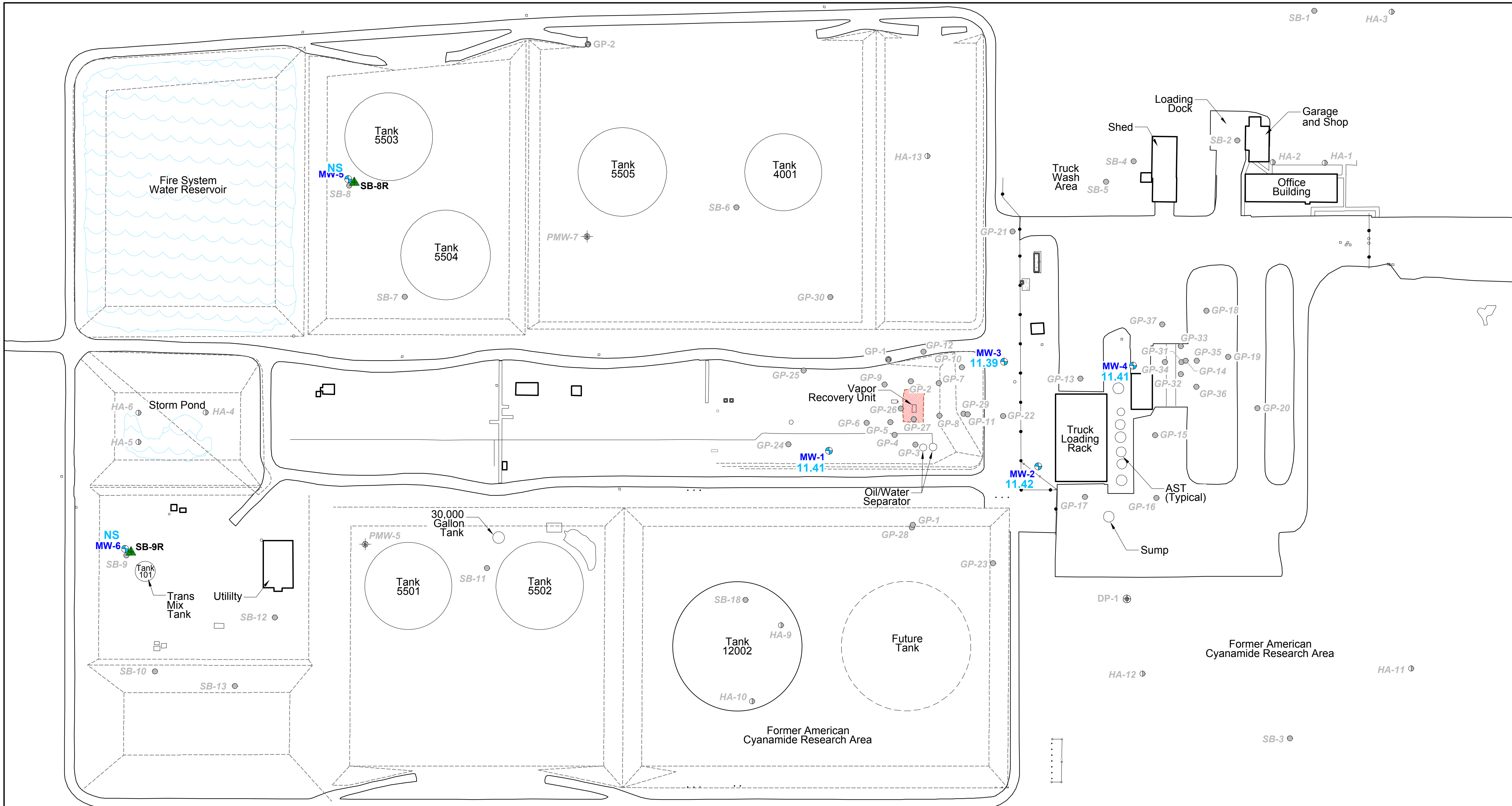
June 2015 Groundwater Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number 1569-05
August 2015

Figure 3



Legend:

MW-1 10.47 — Groundwater Monitoring Well Location and Groundwater Elevation in Feet Above Mean Sea Limit (MSL)

NS — Not Surveyed

SB-8R — Direct-Push Geoprobe Location

GP-1 — Soil Boring Location (September 2014)

DP-1 — Grab Groundwater Sample Location

GP-1 — Historical Direct-Push Boring Location (Approximate)

PMW-5 — Historical Temporary Well Location (Approximate)

HA-1 — Historical Hand Auger Location (Approximate).

Excavation

N

0 100 200

Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

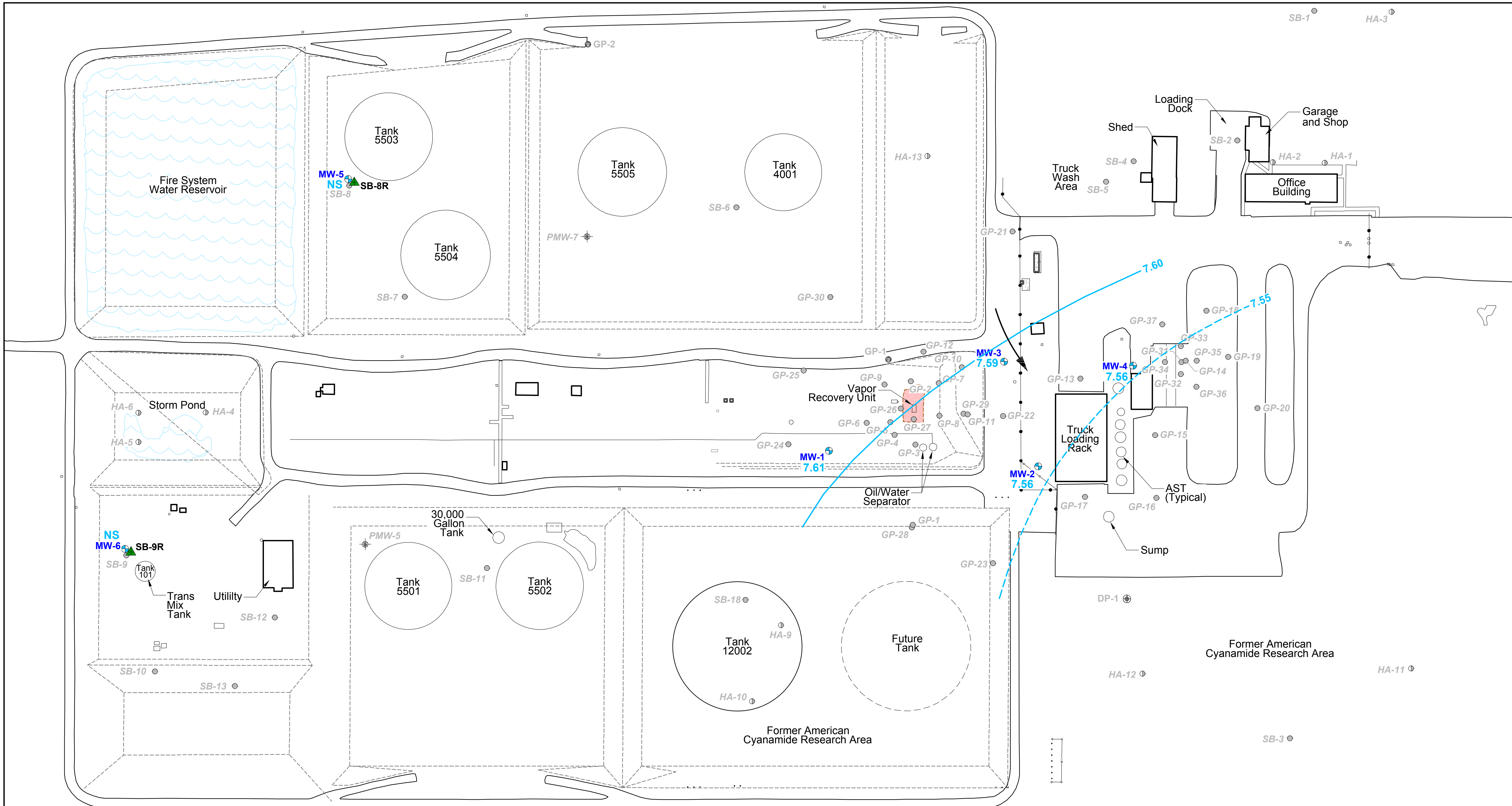
Groundwater Elevations - March 2015

Groundwater Results Report (March 2015) and Additional Groundwater Investigation Work Plan
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1569-05	Figure
May 2015		3



Legend:

MW-1 7.61	Groundwater Monitoring Well Location and Groundwater Elevation in Feet Above Mean Sea Limit (MSL)
7.55	Groundwater Elevation Contour (Dashed Where Inferred)
NS	Not Surveyed
	Inferred Groundwater Flow Direction
SB-8R	Direct-Push Geoprobe Location
GP-1	Soil Boring Location (September 2014)
DP-1	Grab Groundwater Sample Location
GP-1	Historical Direct-Push Boring Location (Approximate)
PMW-5	Historical Temporary Well Location (Approximate)
HA-1	Historical Hand Auger Location (Approximate).
	Excavation

N

0 100 200

Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Groundwater Elevations - September 2015

September 2015 Groundwater Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1569-05	Figure
October 2015		3

APPENDIX C

FIGURES FROM 2010 REMEDIAL INVESTIGATION REPORT

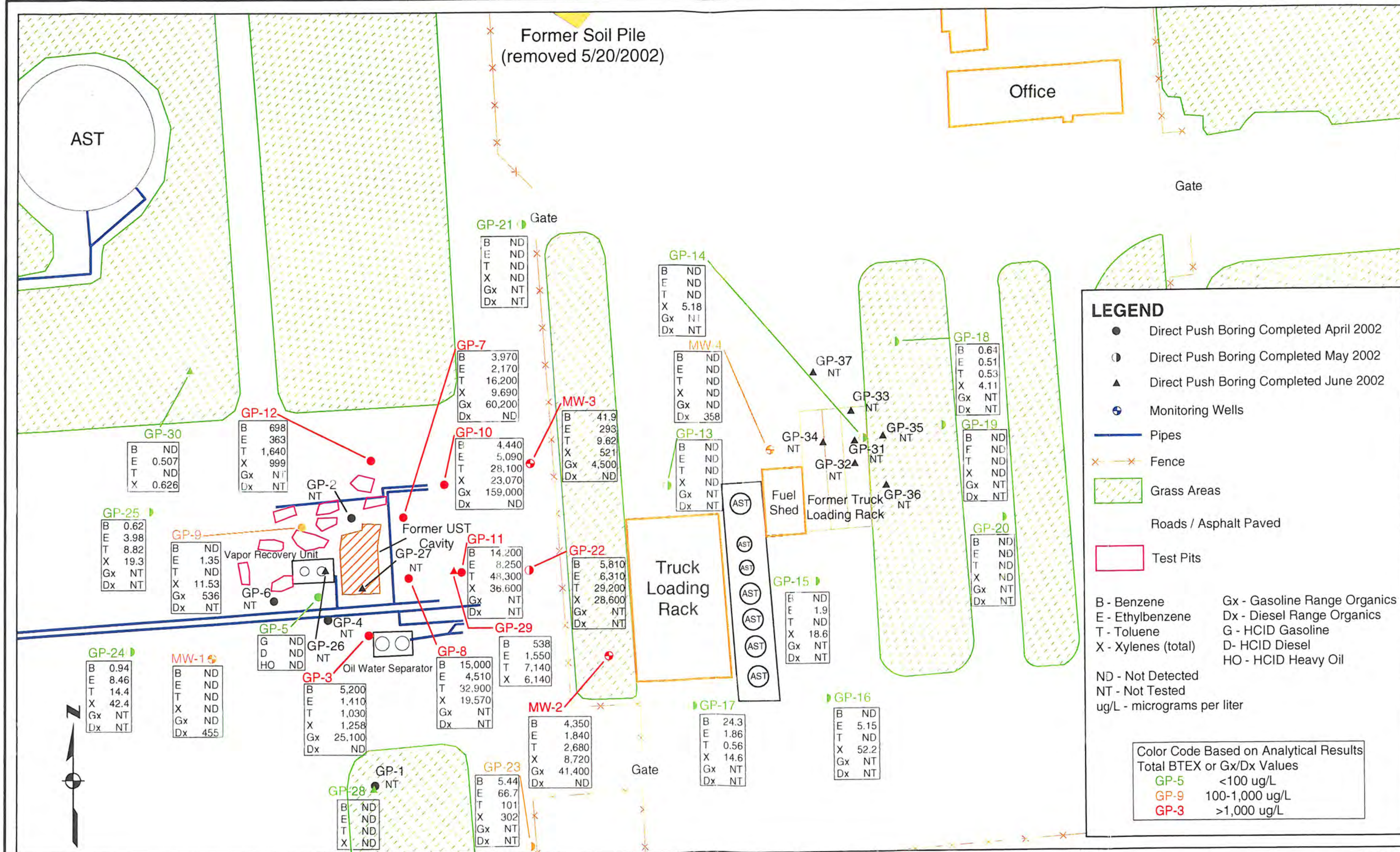


FIGURE 5

amec

7376 SW Durham Road
Portland, OR, U.S.A. 97224

W.O.	1-61M-11061-0 T2
DESIGN	BEL
DRAWN	BRJ
DATE	SEPTEMBER 2002

CENEX HARVEST STATES COOPERATIVES
5420 N.W. FRUIT VALLEY ROAD
VANCOUVER, WASHINGTON

BTEX, TPH-Gx, TPH-Dx, RESULTS FOR GROUNDWATER FROM DIRECT PUSH & MONITORING WELL BORINGS

K:\11000\11000\11061\dwg\arcview\Phase II RI\Figure 5 - Fuel Results - May & June 2002.mxd

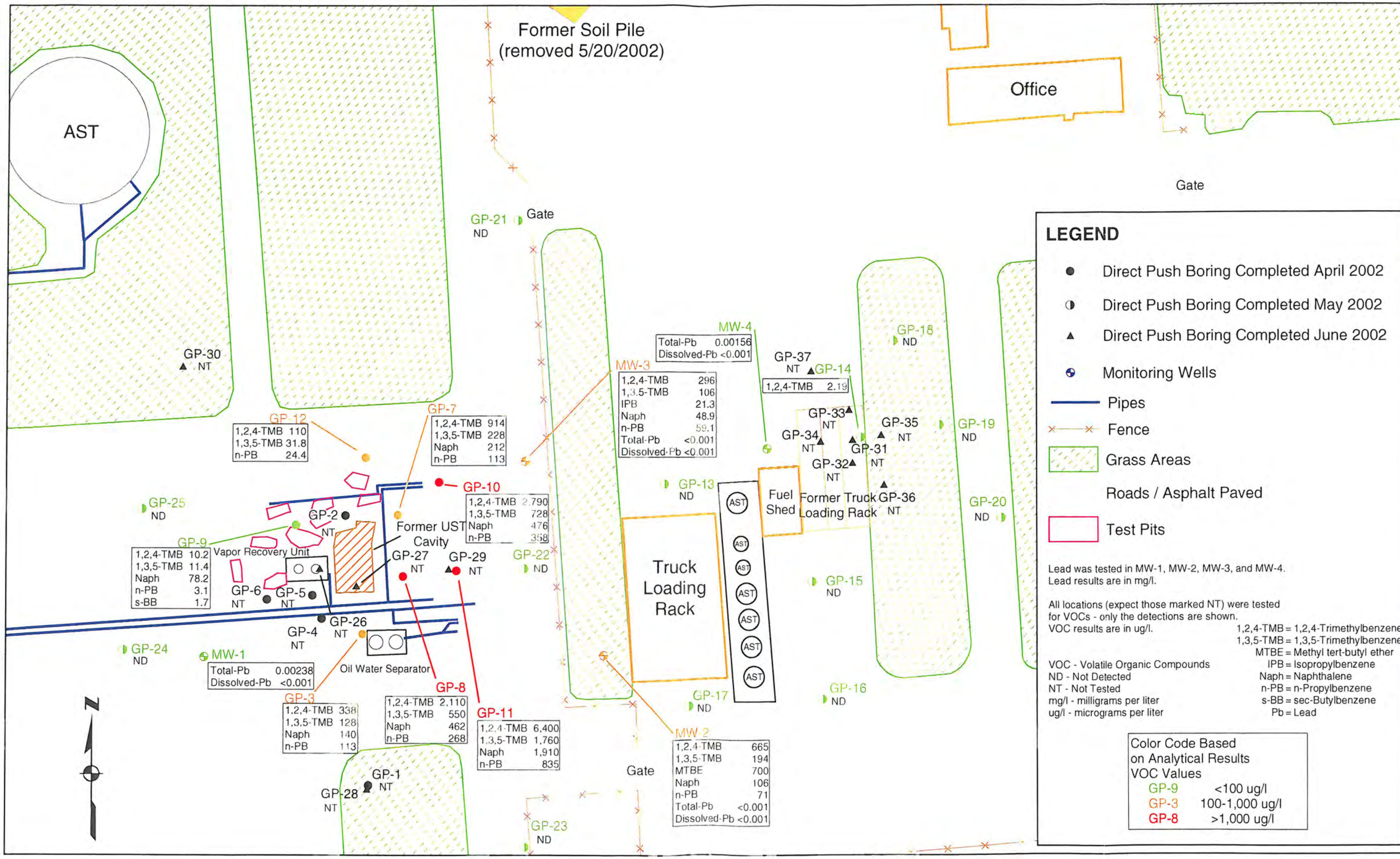


FIGURE 6

0 25 50 100 Feet

1 inch equals 50 feet

amec

7376 SW Durham Road
Portland, OR, U.S.A. 97224

W.O. 1-61M-11061-0 T2
DESIGN BEL
DRAWN BRJ
DATE SEPTEMBER 2002

CENEX HARVEST STATES COOPERATIVES
5420 N.W. FRUIT VALLEY ROAD
VANCOUVER, WASHINGTON

VOC and Pb RESULTS FOR GROUNDWATER FROM DIRECT PUSH & MONITORING WELL BORINGS

K:\11000\11000\11061\dwg\arcview\Phase II RI\Figure 6 - VOC and Pb Results - April & May & June 2002.mxd

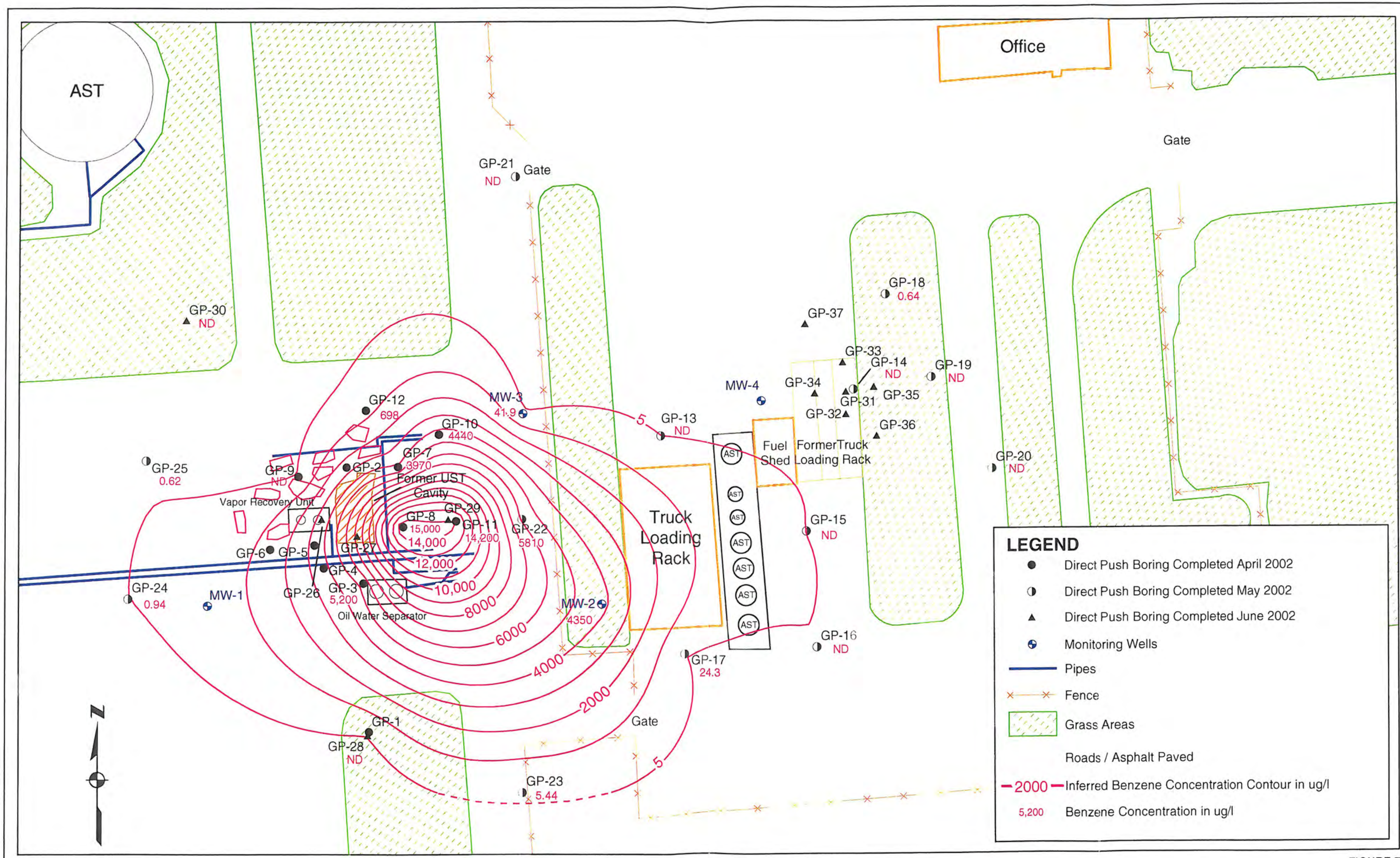


FIGURE 7

amec

7376 SW Durham Road
Portland, OR, U.S.A. 97224

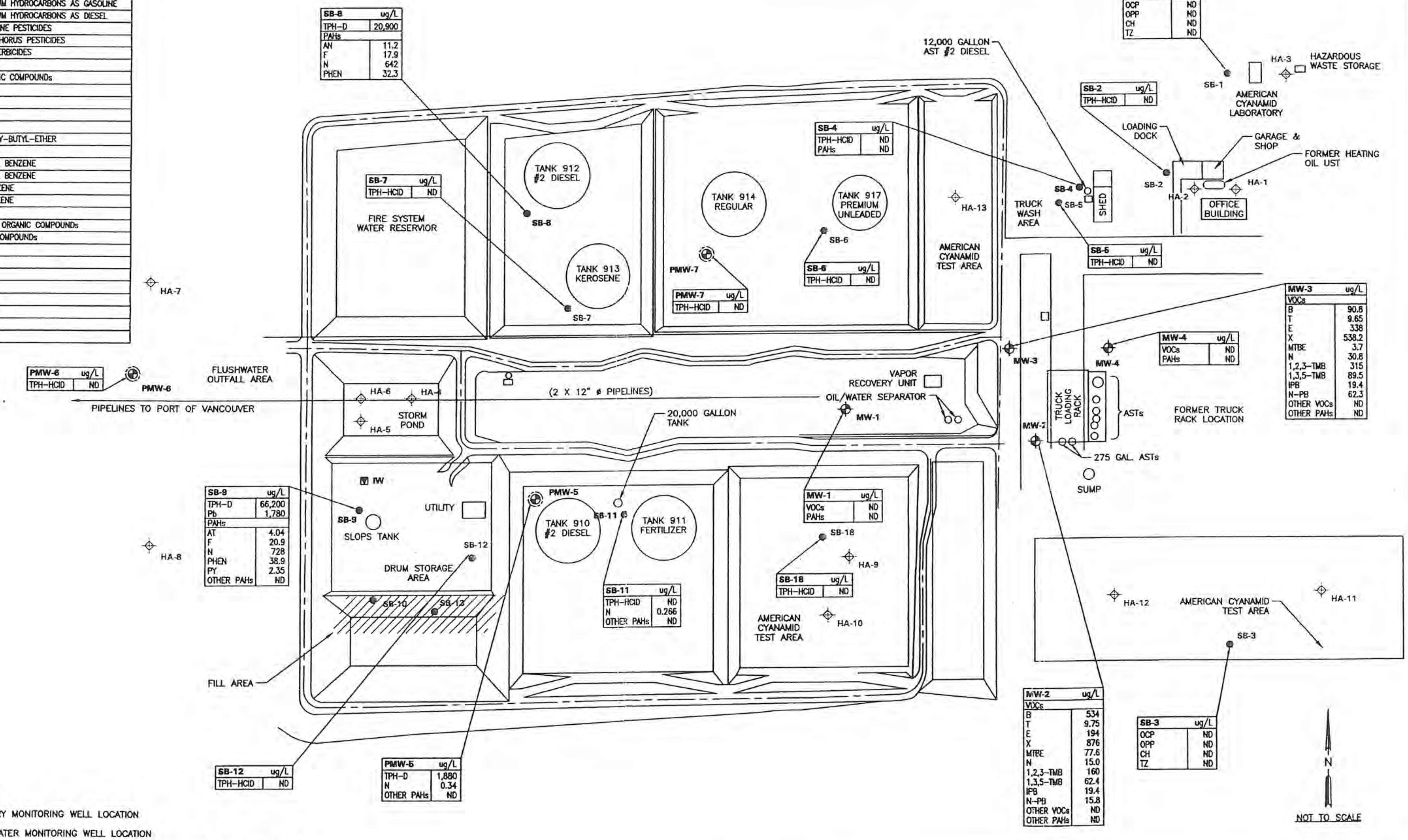
W.O. 1-61M-11061-0 T2
DESIGN BEL
DRAWN BRJ
DATE SEPTEMBER 2002

CENEX HARVEST STATES COOPERATIVES
5420 N.W. FRUIT VALLEY ROAD
VANCOUVER, WASHINGTON

BENZENE CONCENTRATIONS AND INFERRED CONTOUR FOR APRIL - JUNE 2002

K:\11000\11000\11061\dwg\arcview\Phase II RI\Figure 7 - Benzene Contour - April - May - June 2002.mxd

	ANALYTE
TPH-HCID	HYDROCARBON IDENTIFICATION
TPH-G	TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
TPH-D	TOTAL PETROLEUM HYDROCARBONS AS DIESEL
OCP	ORGANO-CHLORINE PESTICIDES
OPP	ORGANO-PHOSPHORUS PESTICIDES
CH	CHLORINATED HERBICIDES
TZ	TRIAZINES
VOCs	VOLATILE ORGANIC COMPOUNDs
B	BENZENE
T	TOLUENE
E	ETHYLBENZENE
X	XYLENES
MTBE	METHYL-TERTIARY-BUTYL-ETHER
N	NAPHTHALENE
1,2,3-TMB	1,2,4-TRIMETHYL BENZENE
1,3,5-TMB	1,3,5-TRIMETHYL BENZENE
IPB	ISOPROPYL BENZENE
N-PB	N-PROPYL BENZENE
CF	CHLOROFORM
OTHER VOCs	OTHER VOLATILE ORGANIC COMPOUNDs
PAHs	POLYAROMATIC COMPOUNDs
AN	ACENAPHTHENE
AT	ANTHRACENE
CHRYS	CHRYSENE
F	FLUORENE
N	NAPHTHALENE
PHEN	PHENANTHRENE
PY	PYRENE
Pb	TOTAL LEAD



LEGEND

- PMW-1 TEMPORARY MONITORING WELL LOCATION
- MW-5 GROUNDWATER MONITORING WELL LOCATION
- SB-1 AREA OF KNOWN RELEASES SOIL BORING/GROUNDWATER SAMPLE LOCATION
- SB-1 AREA OF CONCERN SOIL BORING/GROUNDWATER SAMPLE LOCATION
- HA-1 AREA OF KNOWN RELEASES HAND AUGER SAMPLE LOCATION
- HA-1 AREA OF CONCERN HAND AUGER SAMPLE LOCATION
- IW IRRIGATION WELL LOCATION

SECOR
International Incorporated
7730 SW MOHAWK STREET
TUALATIN, OREGON 97062
(503) 691-2030/692-7074 (FAX)

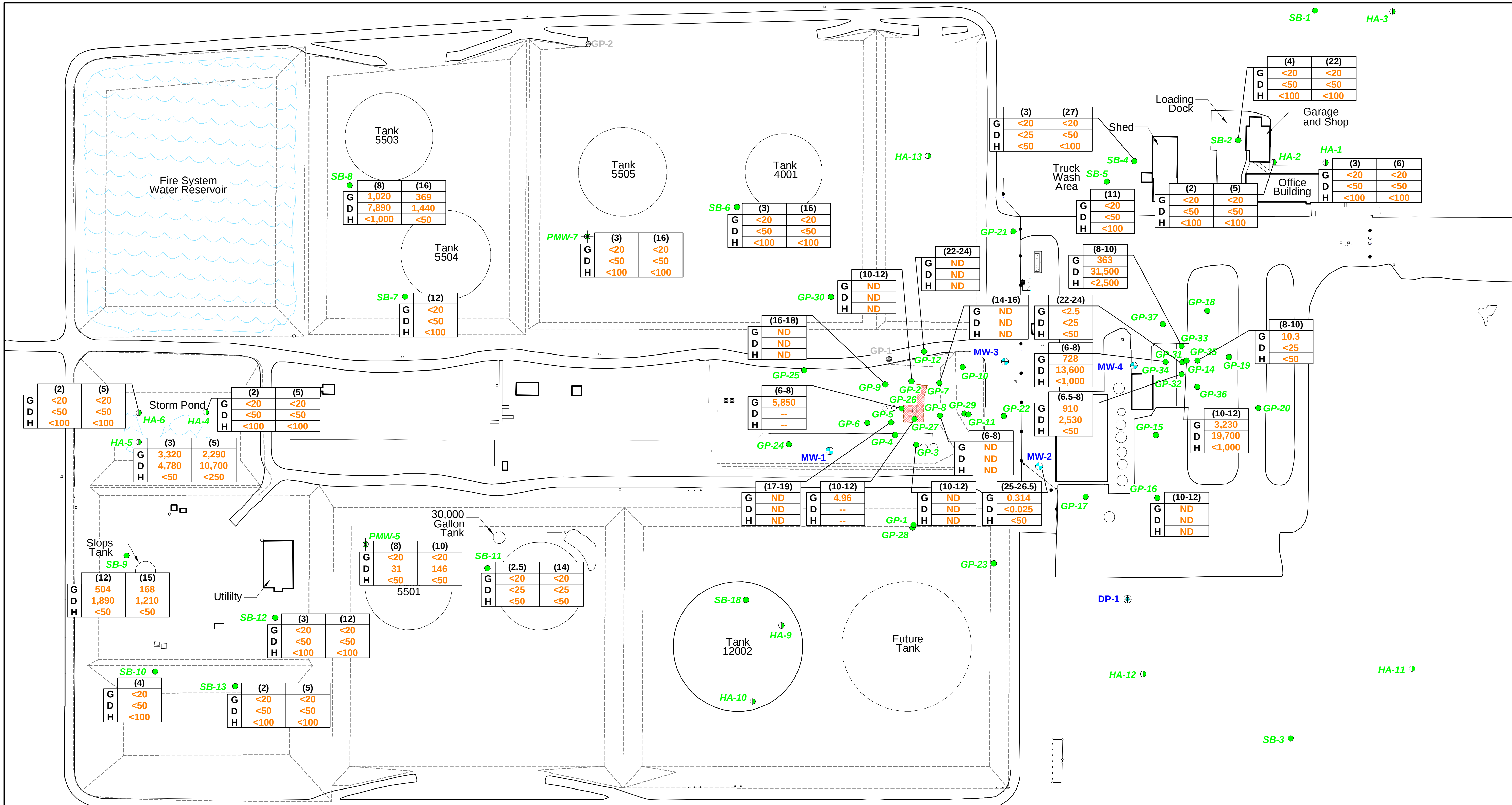
GROUNDWATER ANALYTICAL RESULTS MAP (APRIL 2003)
CENEX TERMINAL
5420 FRUIT VALLEY ROAD
VANCOUVER, WASHINGTON

FIGURE: **5**

JOB#: 150T.09413.00.0004 APPR: DWN: KPM DATE: 06/02/03

N:/CENEX

DWG: 150T-9413-45A-0403.dwg



Legend:

- DP-1 — Grab Groundwater Sample Location
- MW-1 — Groundwater Monitoring Well Location
- GP-1 — Deeper Direct-Push Geoprobe Location
- GP-1 — Historical Direct-Push Boring Location (Approximate; Sampled 2002-2003)
- PMW-5 — Historical Temporary Well Location (Approximate; Sampled April 2003)
- HA-1 — Historical Hand Auger Location (Approximate; Sampled April 2003)

	(6.5-8)
G	910
D	2,530
H	<50

(6.5-8) — Sample Depth in Feet
910 — Concentration in mg/kg
G / D / H — Analyte Sampled
G = Total Petroleum Hydrocarbons Gasoline-Range
D = Total Petroleum Hydrocarbons Diesel-Range
H = Total Petroleum Hydrocarbons Heavy Oil-Range
-- = Not Analyzed
ND = Not Detected Above Laboratory Method Reporting Limit

Excavation

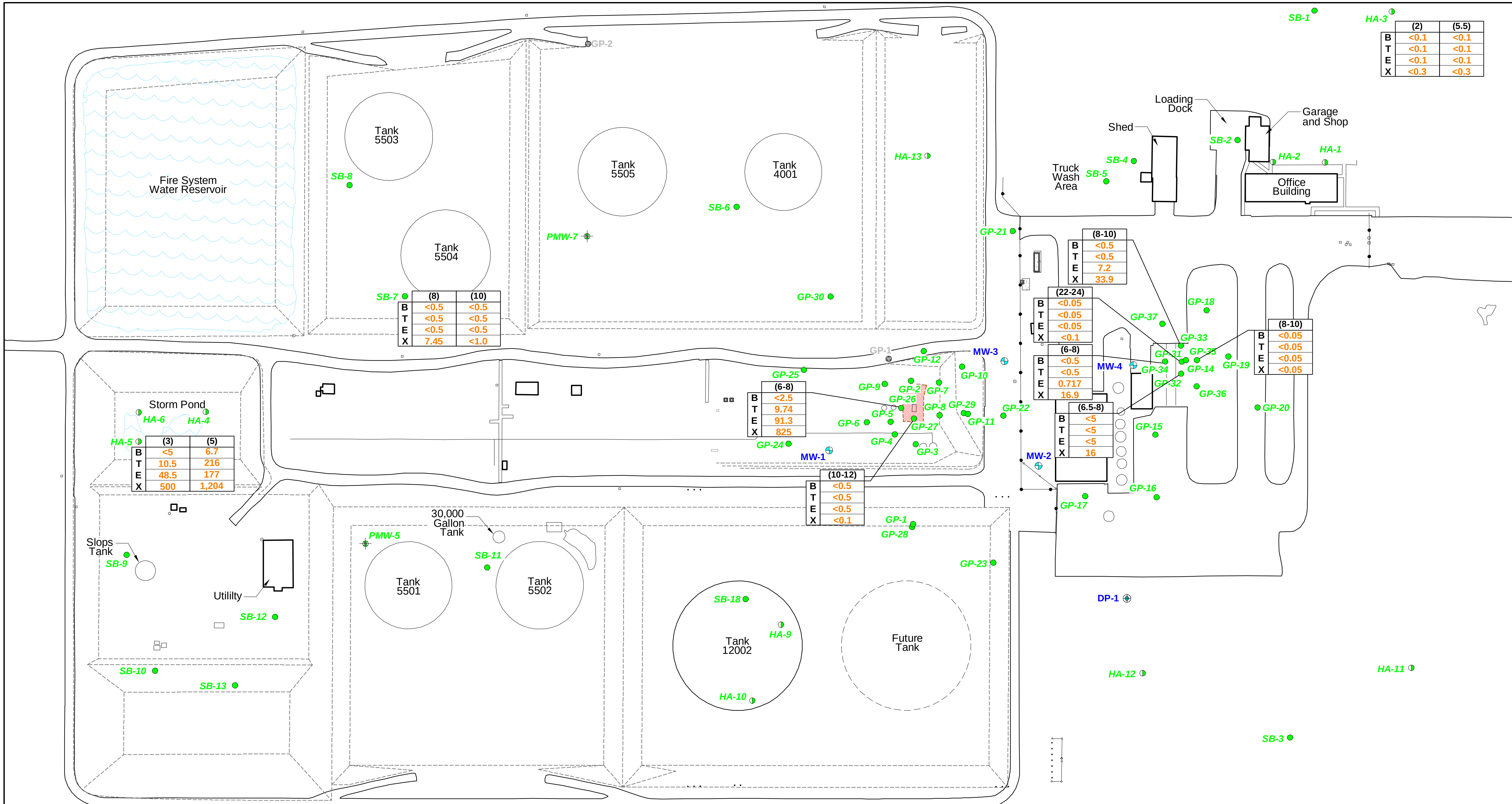
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2002/2003 TPH Concentrations in Soil

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number 1569-00
December 2010
Figure 4



Legend:

DP-1 Grab Groundwater Sample Location

MW-1 Groundwater Monitoring Well Location

GP-1 Deeper Direct-Push Geoprobe Location

GP-1 Historical Direct-Push Boring Location (Approximate; Sampled 2002-2003)

PMW-5 Historical Temporary Well Location (Approximate; Sampled April 2003)

HA-1 Historical Hand Auger Location (Approximate; Sampled April 2003)

(6.5-8)		Sample Depth in Feet
B	<5	Concentration in mg/kg
T	<5	
E	<5	
X	16	Analyte Sampled

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
-- = Not Analyzed
ND = Not Detected Above Laboratory Method Reporting Limit

Excavation

N

0 100 200
Scale in Feet

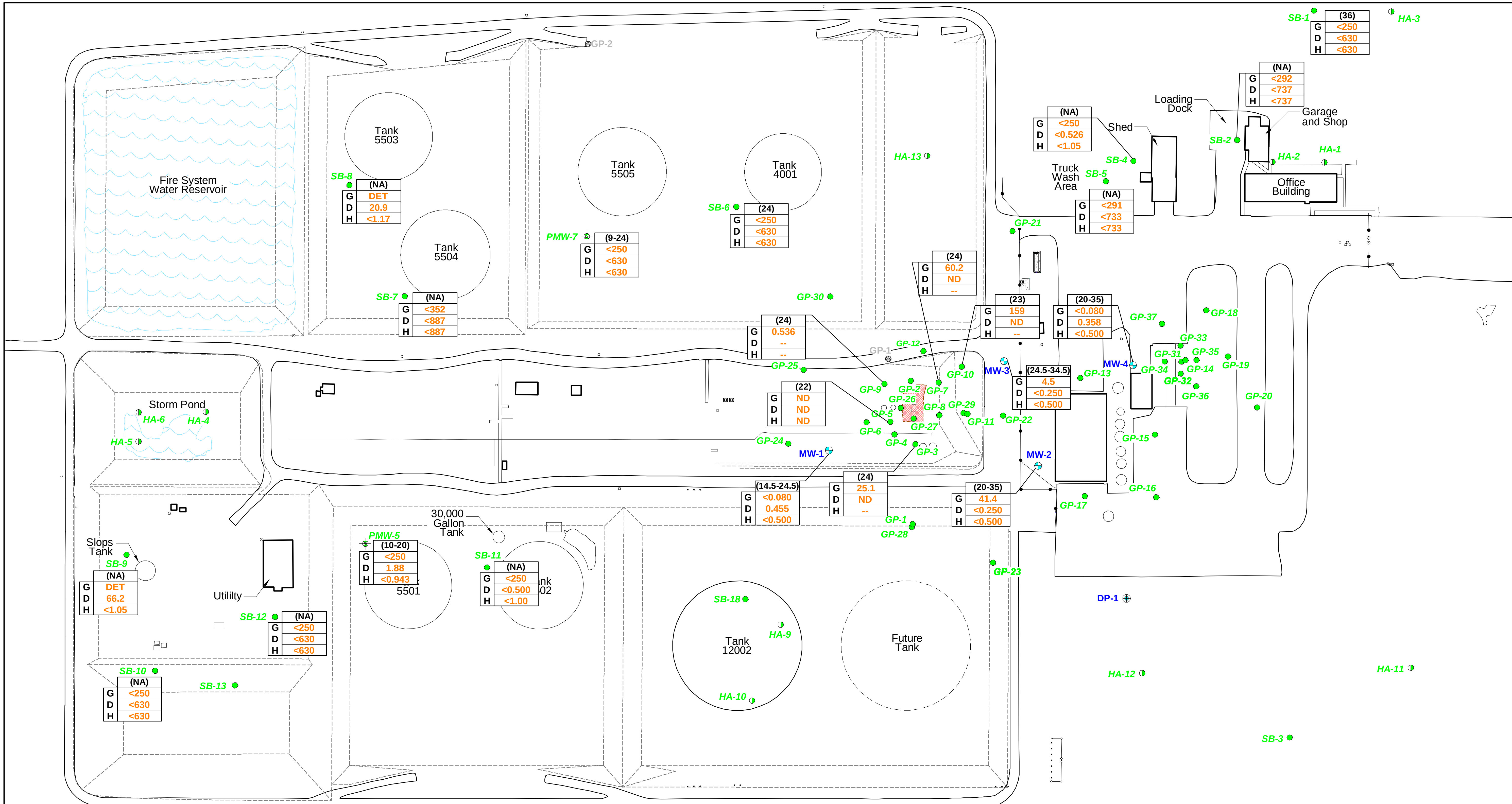
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2002/2003 BTEX Concentrations in Soil

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number 1569-00
December 2010
Figure 5



Legend:

DP-1 Grab Groundwater Sample Location

MW-1 Groundwater Monitoring Well Location (Sampled May 2002)

GP-1 Deeper Direct-Push Geoprobe Location

GP-1 Historical Direct-Push Boring Location (Approximate; Sampled 2002-2003)

PMW-5 Historical Temporary Well Location (Approximate; Sampled April 2003)

HA-1 Historical Hand Auger Location (Approximate; Sampled April 2003)

	(23)
G	910
D	2,530
H	<50

Sample Depth in Feet
NA = Depth Not Available

Concentration in mg/L

Analyte Sampled
G = Total Petroleum Hydrocarbons Gasoline-Range
D = Total Petroleum Hydrocarbons Diesel-Range
H = Total Petroleum Hydrocarbons Heavy Oil-Range
-- = Not Analyzed
ND = Not Detected Above Laboratory Method Reporting Limit
DET = Detection of TPHg, TPHd, or TPHho using NWTPH-HCID.

Excavation

N

0 100 200
Scale in Feet

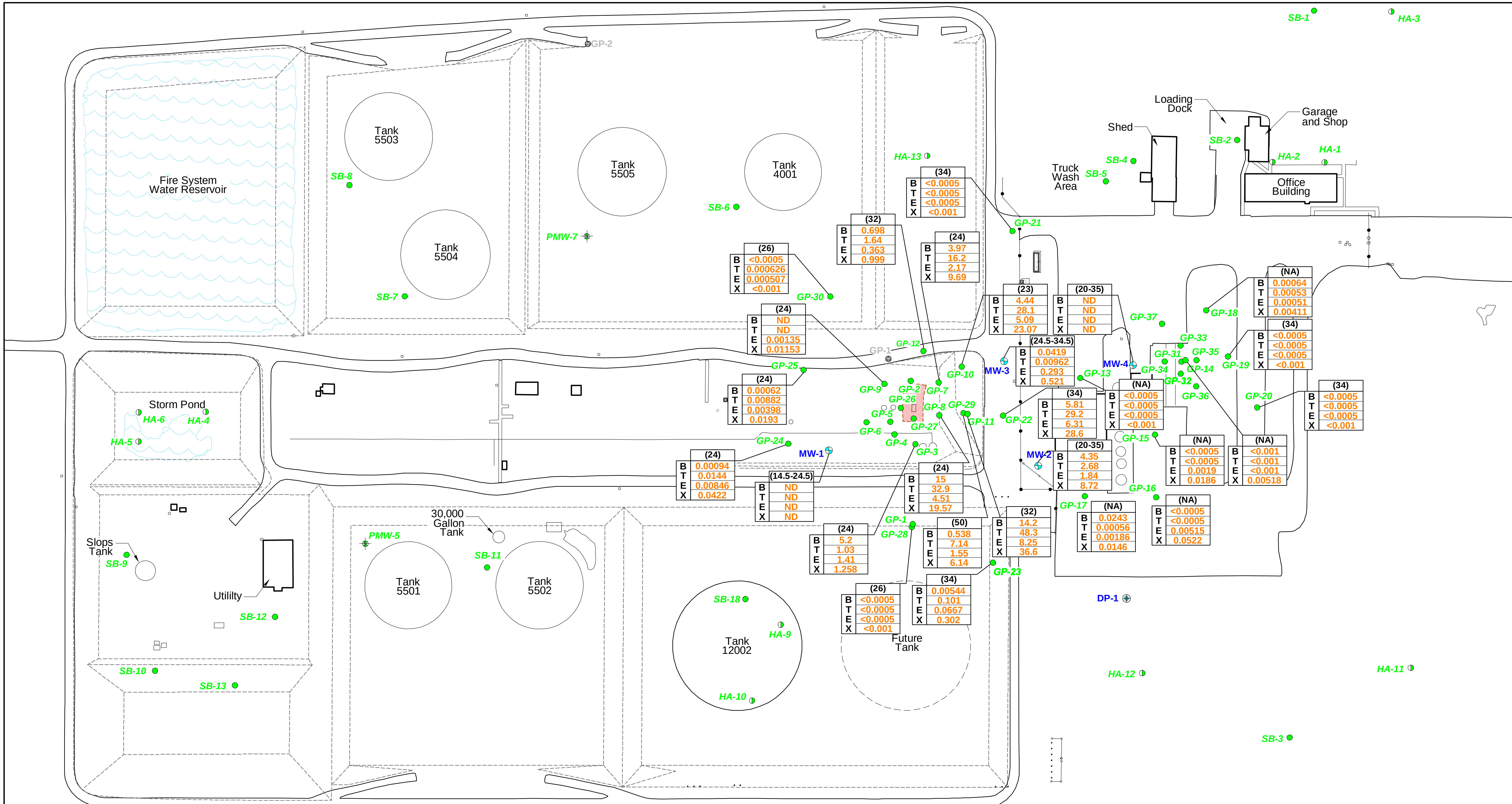
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2002/2003 TPH Concentrations in Groundwater

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1569-00	Figure
December 2010		6



Legend:

- DP-1 Grab Groundwater Sample Location
- MW-1 Groundwater Monitoring Well Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate; Sampled 2002-2003)
- PMW-5 Historical Temporary Well Location (Approximate; Sampled April 2003)
- HA-1 Historical Hand Auger Location (Approximate; Sampled April 2003)

(6.5-8)	
B	<5
T	<5
E	<5
X	16

Sample Depth in Feet
NA = Depth Not Available

Concentration in mg/L

Analyte Sampled
B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
-- = Not Analyzed
ND = Not Detected Above Laboratory Method Reporting Limit

Excavation

N

0 100 200
Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

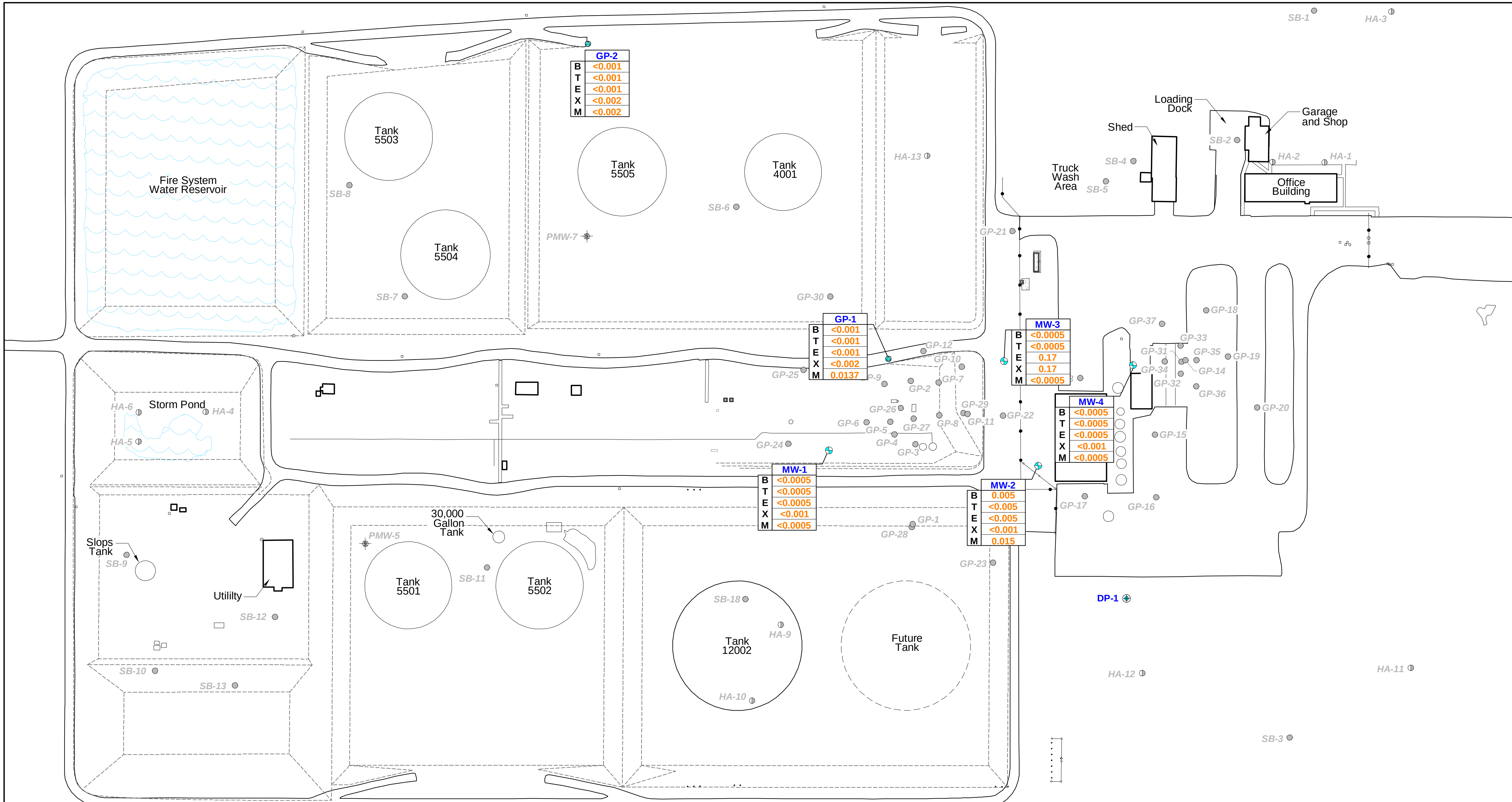
2002/2003 BTEX Concentrations in Groundwater

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number 1569-00
December 2010

Figure 7



Legend:

- DP-1 Grab Groundwater Sample Location
- MW-1 Groundwater Monitoring Well Location
- GP-1 Deeper Direct-Push Geoprobe Location (Sampled 6/11/07)
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)

	GP-2	
B	<0.001	Location Identification
T	<0.001	Concentration in mg/L
E	<0.001	
X	<0.002	Analyte Sampled
M	<0.002	

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
M = Methyl Tert-Butyl Ether
-- = Not Analyzed

0 100 200
Scale in Feet

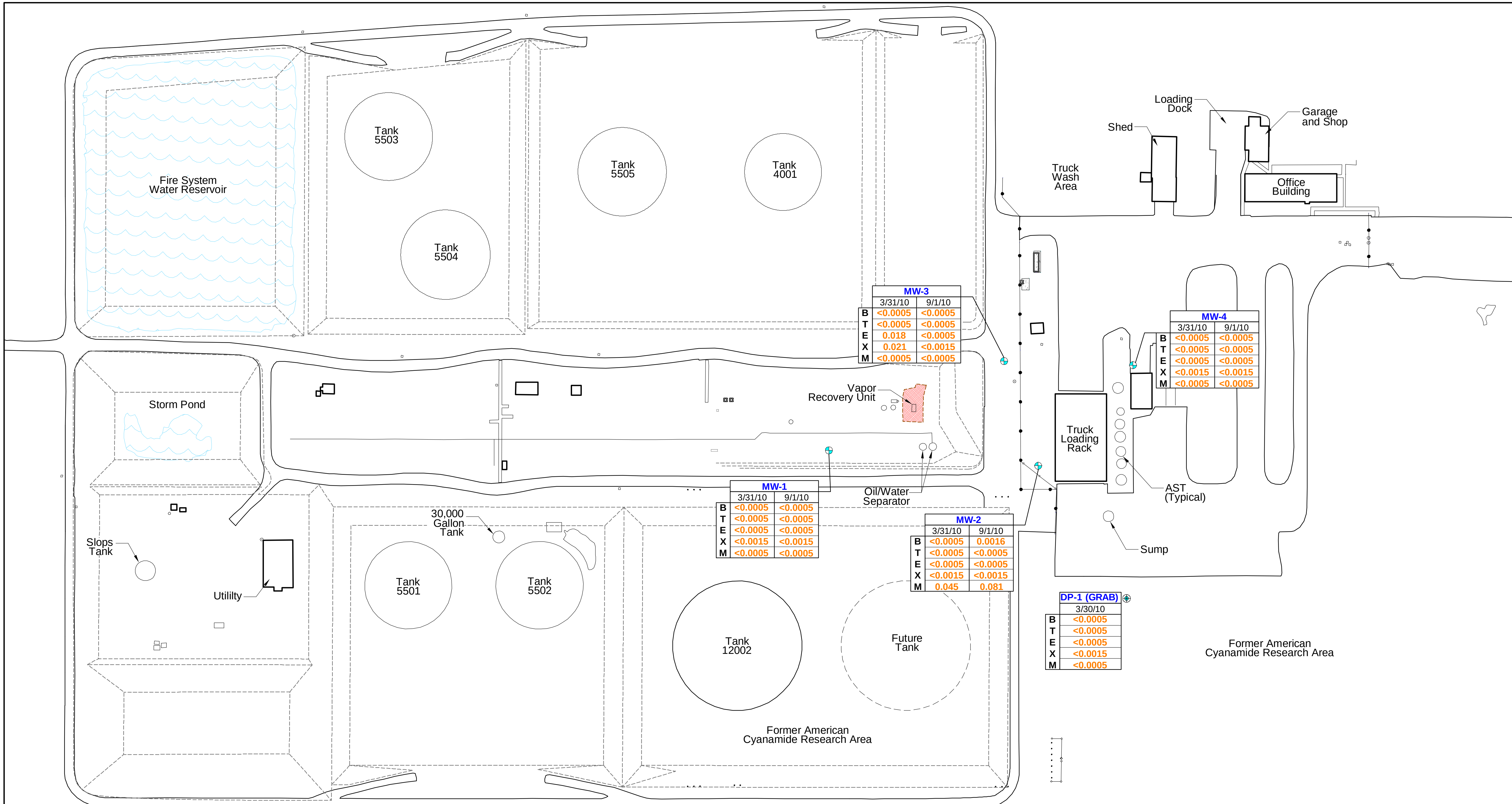
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2007/2008 BTEX and MTBE Concentrations in Groundwater

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1569-00	Figure
December 2010		8



MW-3

	3/31/10	9/1/10
B	<0.0005	<0.0005
T	<0.0005	<0.0005
E	0.018	<0.0005
X	0.021	<0.0015
M	<0.0005	<0.0005

MW-4

	3/31/10	9/1/10
B	<0.0005	<0.0005
T	<0.0005	<0.0005
E	<0.0005	<0.0005
X	<0.0015	<0.0015
M	<0.0005	<0.0005

MW-1

	3/31/10	9/1/10
B	<0.0005	<0.0005
T	<0.0005	<0.0005
E	<0.0005	<0.0005
X	<0.0015	<0.0015
M	<0.0005	<0.0005

MW-2

	3/31/10	9/1/10
B	<0.0005	0.0016
T	<0.0005	<0.0005
E	<0.0005	<0.0005
X	<0.0015	<0.0015
M	0.045	0.081

DP-1 (GRAB)

	3/30/10
B	<0.0005
T	<0.0005
E	<0.0005
X	<0.0015
M	<0.0005

Legend:

MW-1 Groundwater Monitoring Well Location

DP-1 Grab Intermediate Zone Groundwater Sample Location

Excavation

MW-1

	3/31/10	9/1/10
B	<0.0005	<0.0005
T	<0.0005	<0.0005
E	<0.0005	<0.0005
X	<0.0015	<0.0015
M	<0.0005	<0.0005

Sampling Date

Concentration in mg/L

Analyte Sampled
B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
M = Methyl Tert-Butyl Ether
-- = Not Analyzed

N

0 100 200

Scale in Feet

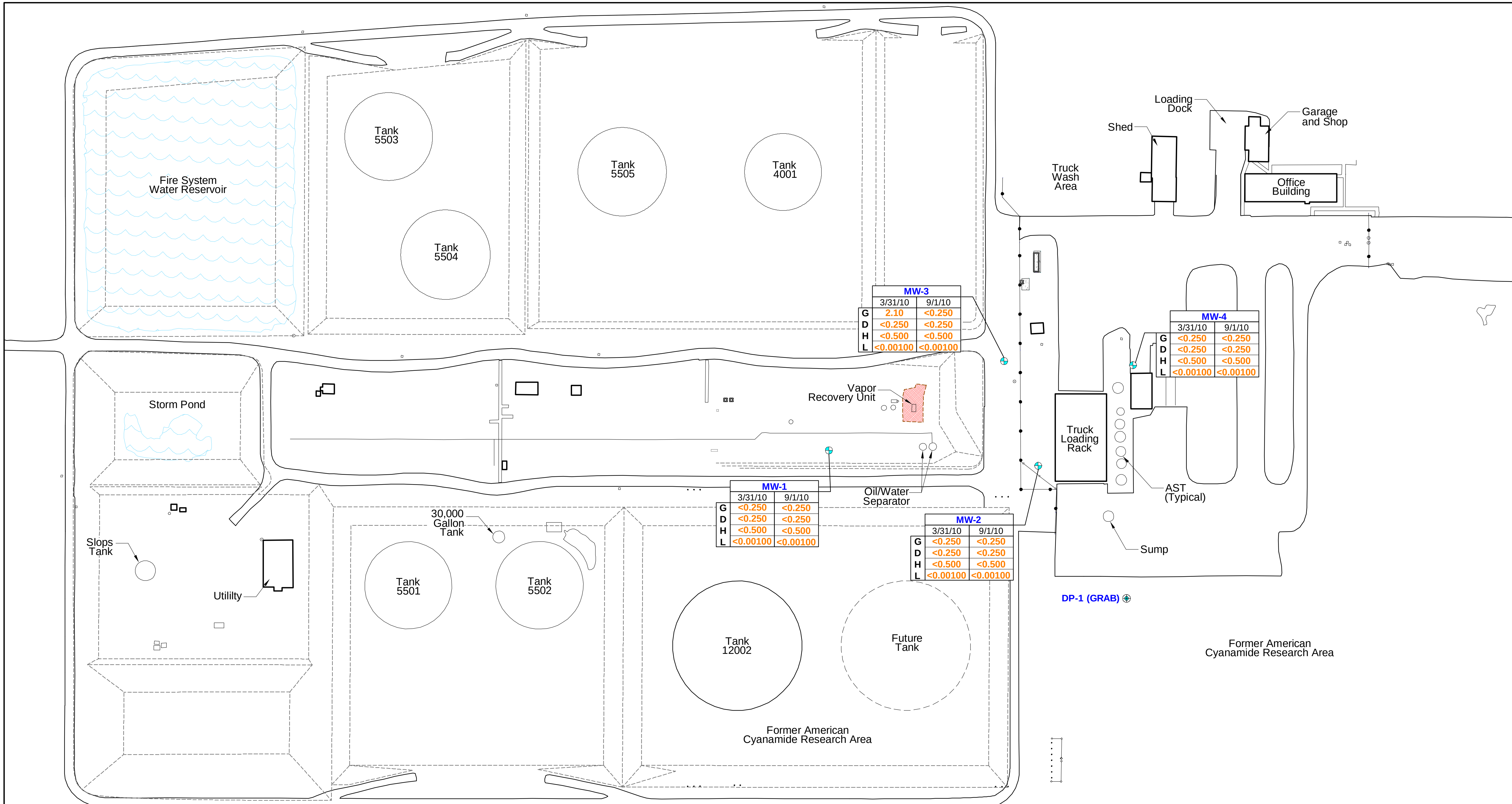
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2010 BTEX and MTBE Concentrations in Groundwater

Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1569-00	Figure
December 2010		9



Legend:

MW-1 Groundwater Monitoring Well Location

DP-1 Grab Intermediate Zone Groundwater Sample Location

Excavation

	MW-1	
	3/31/10	9/1/10
G	<0.250	<0.250
D	<0.250	<0.250
H	<0.500	<0.500
L	<0.00100	<0.00100

Sampling Date

Concentration in mg/L

Analyte Sampled

G = Total Petroleum Hydrocarbons Gasoline-Range
D = Total Petroleum Hydrocarbons Diesel-Range
H = Total Petroleum Hydrocarbons Heavy Oil-Range
L = Dissolved Lead
-- = Not Analyzed

N

0 100 200

Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

2010 TPH and Lead Concentrations in Groundwater

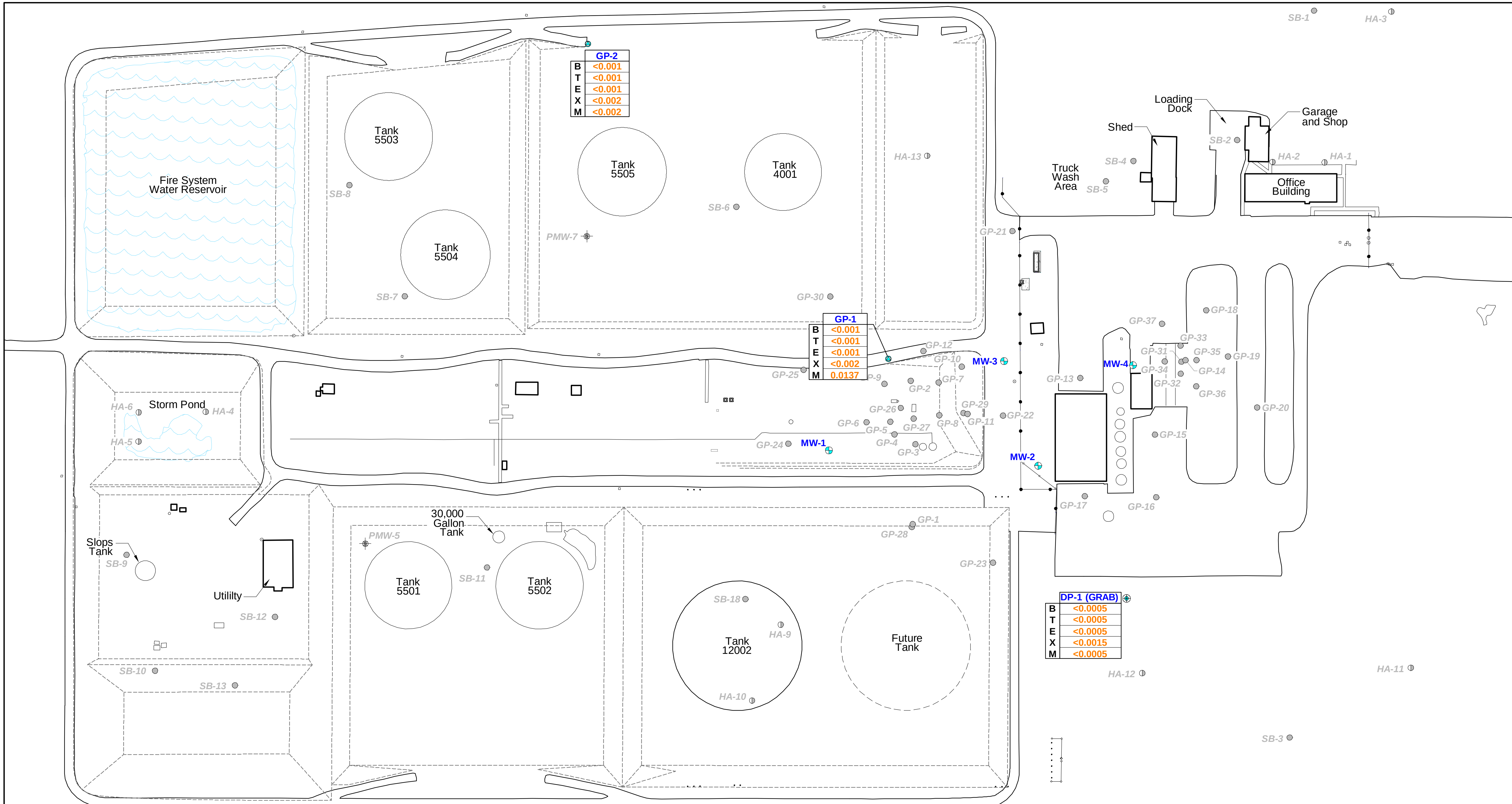
Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number 1569-00

December 2010

Figure 10



Legend:

- DP-1 Grab Groundwater Sample Location (Sampled 3/10/10)
- MW-1 Groundwater Monitoring Well Location
- GP-1 Deeper Direct-Push Geoprobe Location (Sampled 6/11/07)
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)

	GP-2-1
B	<0.001
T	<0.001
E	<0.001
X	<0.002
M	<0.002

Location Identification

Concentration in mg/L

Analyte Sampled
B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
M = Methyl Tert-Butyl Ether
-- = Not Analyzed

N

0 100 200
Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

Intermediate Zone Groundwater Results - BTEX and MTBE

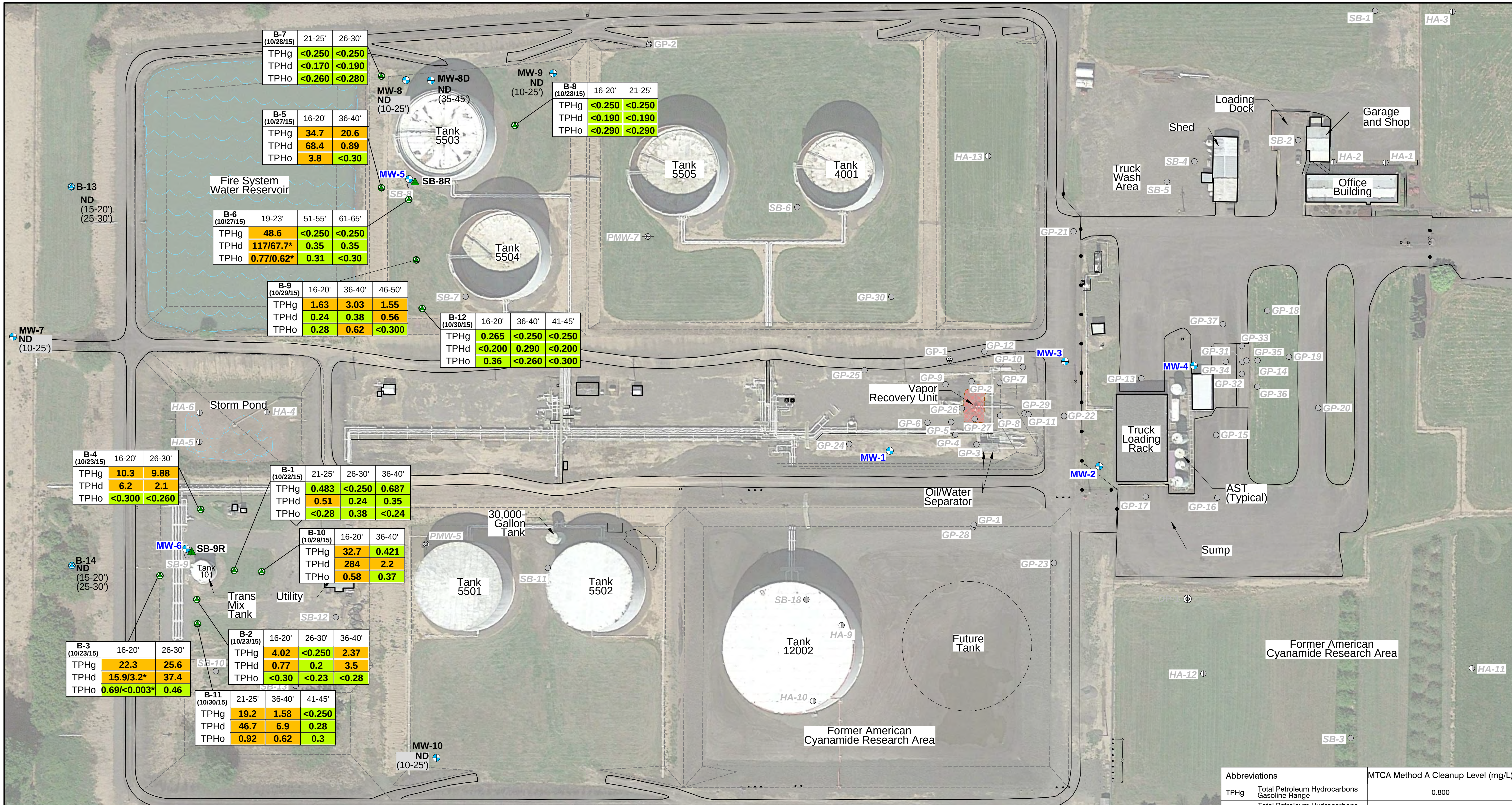
Remedial Investigation and Risk Assessment Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number 1569-00
December 2010
Figure 11

APPENDIX D

FIGURES FROM ADDITIONAL INVESTIGATIONS 2014 TO 2019



B-7 (10/28/15)	21-25'	26-30'
TPHg	<0.250	<0.250
TPHd	<0.170	<0.190
TPHo	<0.260	<0.280

B-8 (10/28/15)	16-20'	21-25'
TPHg	<0.250	<0.250
TPHd	<0.190	<0.190
TPHo	<0.290	<0.290

B-5 (10/27/15)	16-20'	36-40'
TPHg	34.7	20.6
TPHd	68.4	0.89
TPHo	3.8	<0.30

B-6 (10/27/15)	19-23'	51-55'	61-65'
TPHg	48.6	<0.250	<0.250
TPHd	117/67.7*	0.35	0.35
TPHo	0.77/0.62*	0.31	<0.30

B-9 (10/29/15)	16-20'	36-40'	46-50'
TPHg	1.63	3.03	1.55
TPHd	0.24	0.38	0.56
TPHo	0.28	0.62	<0.300

B-12 (10/30/15)	16-20'	36-40'	41-45'
TPHg	0.265	<0.250	<0.250
TPHd	<0.200	0.290	<0.200
TPHo	0.36	<0.260	<0.300

B-4 (10/23/15)	16-20'	26-30'
TPHg	10.3	9.88
TPHd	6.2	2.1
TPHo	<0.300	<0.260

B-1 (10/22/15)	21-25'	26-30'	36-40'
TPHg	0.483	<0.250	0.687
TPHd	0.51	0.24	0.35
TPHo	<0.28	0.38	<0.24

B-10 (10/29/15)	16-20'	36-40'
TPHg	32.7	0.421
TPHd	284	2.2
TPHo	0.58	0.37

B-3 (10/23/15)	16-20'	26-30'
TPHg	22.3	25.6
TPHd	15.9/3.2*	37.4
TPHo	0.69/<0.003*	0.46

B-2 (10/23/15)	16-20'	26-30'	36-40'
TPHg	4.02	<0.250	2.37
TPHd	0.77	0.2	3.5
TPHo	<0.30	<0.23	<0.28

B-11 (10/30/15)	21-25'	36-40'	41-45'
TPHg	19.2	1.58	<0.250
TPHd	46.7	6.9	0.28
TPHo	0.92	0.62	0.3

Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5
TPHo	Total Petroleum Hydrocarbons Heavy Oil-Range	0.5

Legend:

SB-8R Soil Boring Location (September 2014)

MW-1 Groundwater Monitoring Well Location (MW-8D is a Deep Monitoring Well Location)

DP-1 Grab Groundwater Sample Location

GP-1 Deeper Direct-Push Geoprobe Location

GP-1 Historical Direct-Push Boring Location (Approximate)

PMW-5 Historical Temporary Well Location (Approximate)

HA-1 Historical Hand Auger Location (Approximate)

B-1 Soil Boring Location (October 2015)

B-1 (10/22/15)	21-25'
TPHg	0.483
TPHd	0.51
TPHo	<0.28

Sample Identification (Date Sampled)
Depth of Sample
Concentration in mg/L
Analyte Sampled

Concentration is Below MTCA Method A Cleanup Level

Concentration is Above MTCA Method A Cleanup Level

* For TPHd and TPHo, the first value is the concentration with silica gel cleanup and the second without (i.e. 15.9/3.2). At the request of Ecology, select samples were analyzed with and without silica gel cleanup for comparison.

N

0 100 200
Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate. Aerial photograph from Google Earth Pro (4/2015).

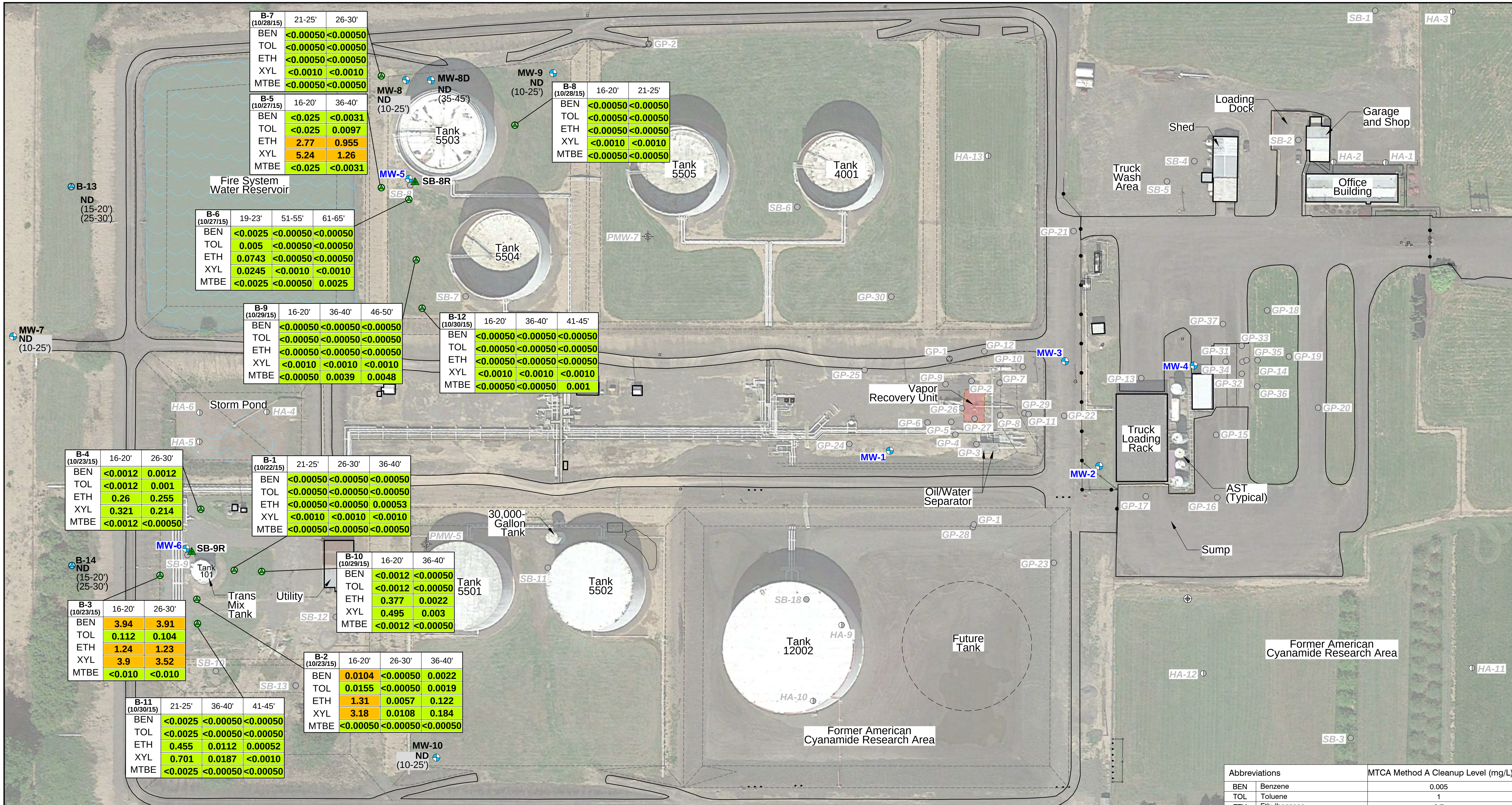
TPH Concentrations in Groundwater - October 2015

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number 1569-09
July 2017

Figure 4



B-7 (10/28/15)	21-25'	26-30'
BEN	<0.00050	<0.00050
TOL	<0.00050	<0.00050
ETH	<0.00050	<0.00050
XYL	<0.0010	<0.0010
MTBE	<0.00050	<0.00050

B-5 (10/27/15)	16-20'	36-40'
BEN	<0.025	<0.0031
TOL	<0.025	0.0097
ETH	2.77	0.955
XYL	5.24	1.26
MTBE	<0.025	<0.0031

B-8 (10/28/15)	16-20'	21-25'
BEN	<0.00050	<0.00050
TOL	<0.00050	<0.00050
ETH	<0.00050	<0.00050
XYL	<0.0010	<0.0010
MTBE	<0.00050	<0.00050

B-6 (10/27/15)	19-23'	51-55'	61-65'
BEN	<0.0025	<0.00050	<0.00050
TOL	0.005	<0.00050	<0.00050
ETH	0.0743	<0.00050	<0.00050
XYL	0.0245	<0.0010	<0.0010
MTBE	<0.0025	<0.00050	0.0025

B-9 (10/29/15)	16-20'	36-40'	46-50'
BEN	<0.00050	<0.00050	<0.00050
TOL	<0.00050	<0.00050	<0.00050
ETH	<0.00050	<0.00050	<0.00050
XYL	<0.0010	<0.0010	<0.0010
MTBE	<0.00050	0.0039	0.0048

B-12 (10/30/15)	16-20'	36-40'	41-45'
BEN	<0.00050	<0.00050	<0.00050
TOL	<0.00050	<0.00050	<0.00050
ETH	<0.00050	<0.00050	<0.00050
XYL	<0.0010	<0.0010	<0.0010
MTBE	<0.00050	<0.00050	0.001

B-4 (10/23/15)	16-20'	26-30'
BEN	<0.0012	0.0012
TOL	<0.0012	0.001
ETH	0.26	0.255
XYL	0.321	0.214
MTBE	<0.0012	<0.00050

B-1 (10/22/15)	21-25'	26-30'	36-40'
BEN	<0.00050	<0.00050	<0.00050
TOL	<0.00050	<0.00050	<0.00050
ETH	<0.00050	<0.00050	0.00053
XYL	<0.0010	<0.0010	<0.0010
MTBE	<0.00050	<0.00050	<0.00050

B-10 (10/29/15)	16-20'	36-40'
BEN	<0.0012	<0.00050
TOL	<0.0012	<0.00050
ETH	0.377	0.0022
XYL	0.495	0.003
MTBE	<0.0012	<0.00050

B-3 (10/23/15)	16-20'	26-30'
BEN	3.94	3.91
TOL	0.112	0.104
ETH	1.24	1.23
XYL	3.9	3.52
MTBE	<0.010	<0.010

B-2 (10/23/15)	16-20'	26-30'	36-40'
BEN	0.0104	<0.00050	0.0022
TOL	0.0155	<0.00050	0.0019
ETH	1.31	0.0057	0.122
XYL	3.18	0.0108	0.184
MTBE	<0.00050	<0.00050	<0.00050

B-11 (10/30/15)	21-25'	36-40'	41-45'
BEN	<0.0025	<0.00050	<0.00050
TOL	<0.0025	<0.00050	<0.00050
ETH	0.455	0.0112	0.00052
XYL	0.701	0.0187	<0.0010
MTBE	<0.0025	<0.00050	<0.00050

Abbreviations		MTCA Method A Cleanup Level (mg/L)
BEN	Benzene	0.005
TOL	Toluene	1
ETH	Ethylbenzene	0.7
XYL	Xylenes	1
MTBE	Methyl Tert-Butyl Ether	0.02

Legend:

- SB-8R Soil Boring Location (September 2014)
- B-1 Soil Boring Location (October 2015)
- MW-1 Groundwater Monitoring Well Location (MW-8D is a Deep Monitoring Well Location)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)

B-1 (10/22/15)	21-25'
BEN	<0.00050
TOL	<0.00050
ETH	<0.00050
XYL	<0.0010
MTBE	<0.00050

Sample Identification (Date Sampled)
Depth of Sample
Concentration in mg/L
Analyte Sampled

Concentration is Below MTCA Method A Cleanup Level

Concentration is Above TCA Method A Cleanup Level

N

0 100 200
Scale in Feet

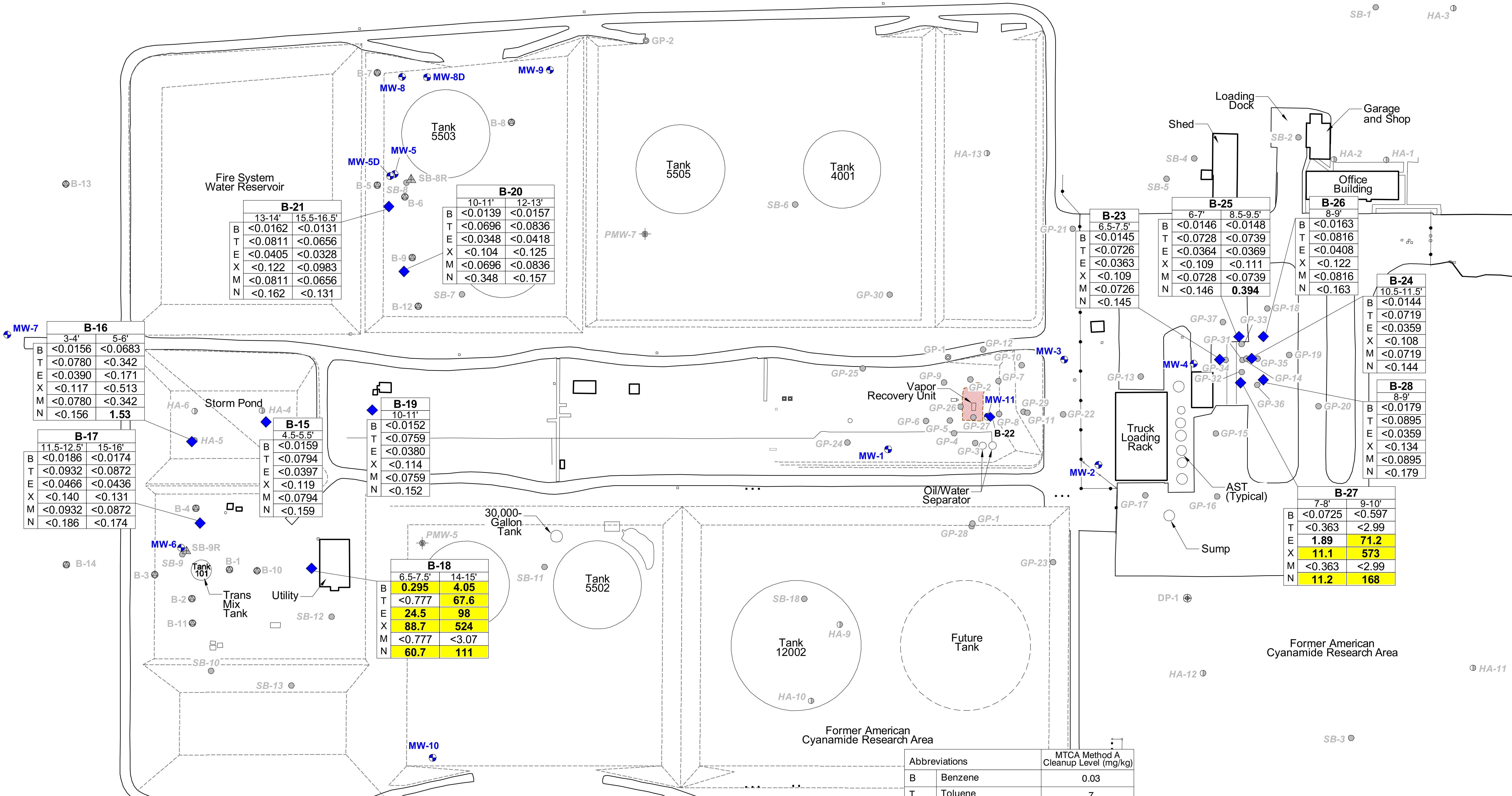
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate. Aerial photograph from Google Earth Pro (4/2015).

BTEX and MTBE Concentrations in Groundwater - October 2015

Additional Groundwater Investigation Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1569-09	Figure
July 2017		5



B-21

	13-14'	15.5-16.5'
B	<0.0162	<0.0131
T	<0.0811	<0.0656
E	<0.0405	<0.0328
X	<0.122	<0.0983
M	<0.0811	<0.0656
N	<0.162	<0.131

B-20

	10-11'	12-13'
B	<0.0139	<0.0157
T	<0.0696	<0.0836
E	<0.0348	<0.0418
X	<0.104	<0.125
M	<0.0696	<0.0836
N	<0.348	<0.157

B-16

	3-4'	5-6'
B	<0.0156	<0.0683
T	<0.0780	<0.342
E	<0.0390	<0.171
X	<0.117	<0.513
M	<0.0780	<0.342
N	<0.156	1.53

B-17

	11.5-12.5'	15-16'
B	<0.0186	<0.0174
T	<0.0932	<0.0872
E	<0.0466	<0.0436
X	<0.140	<0.131
M	<0.0932	<0.0872
N	<0.186	<0.174

B-15

	4.5-5.5'
B	<0.0159
T	<0.0794
E	<0.0397
X	<0.119
M	<0.0794
N	<0.159

B-19

	10-11'
B	<0.0152
T	<0.0759
E	<0.0380
X	<0.114
M	<0.0759
N	<0.152

B-18

	6.5-7.5'	14-15'
B	0.295	4.05
T	<0.777	67.6
E	24.5	98
X	88.7	524
M	<0.777	<3.07
N	60.7	111

B-23

	6.5-7.5'
B	<0.0145
T	<0.0726
E	<0.0363
X	<0.109
M	<0.0726
N	<0.145

B-25

	6-7'	8.5-9.5'
B	<0.0146	<0.0148
T	<0.0728	<0.0739
E	<0.0364	<0.0369
X	<0.109	<0.111
M	<0.0728	<0.0739
N	<0.146	0.394

B-26

	8-9'
B	<0.0163
T	<0.0816
E	<0.0408
X	<0.122
M	<0.0816
N	<0.163

B-24

	10.5-11.5'
B	<0.0144
T	<0.0719
E	<0.0359
X	<0.108
M	<0.0719
N	<0.144

B-28

	8-9'
B	<0.0179
T	<0.0895
E	<0.0359
X	<0.134
M	<0.0895
N	<0.179

B-27

	7-8'	9-10'
B	<0.0725	<0.597
T	<0.363	<2.99
E	1.89	71.2
X	11.1	573
M	<0.363	<2.99
N	11.2	168

Abbreviations		MTCA Method A Cleanup Level (mg/kg)
B	Benzene	0.03
T	Toluene	7
E	Ethylbenzene	6
X	Xylenes	9
M	Methyl Tert-Butyl Ether	*Not Available*
N	Naphthalene	5

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

B-28 — Location Sampled
8-9' — Depth of Sample in Feet BGS

B	<0.0179
T	<0.0895
E	<0.0359
X	<0.134
M	<0.0895
N	<0.163

Concentration in mg/kg
Highlighted Concentration Exceeds MTCA Method A Cleanup Level
Analyte Sampled

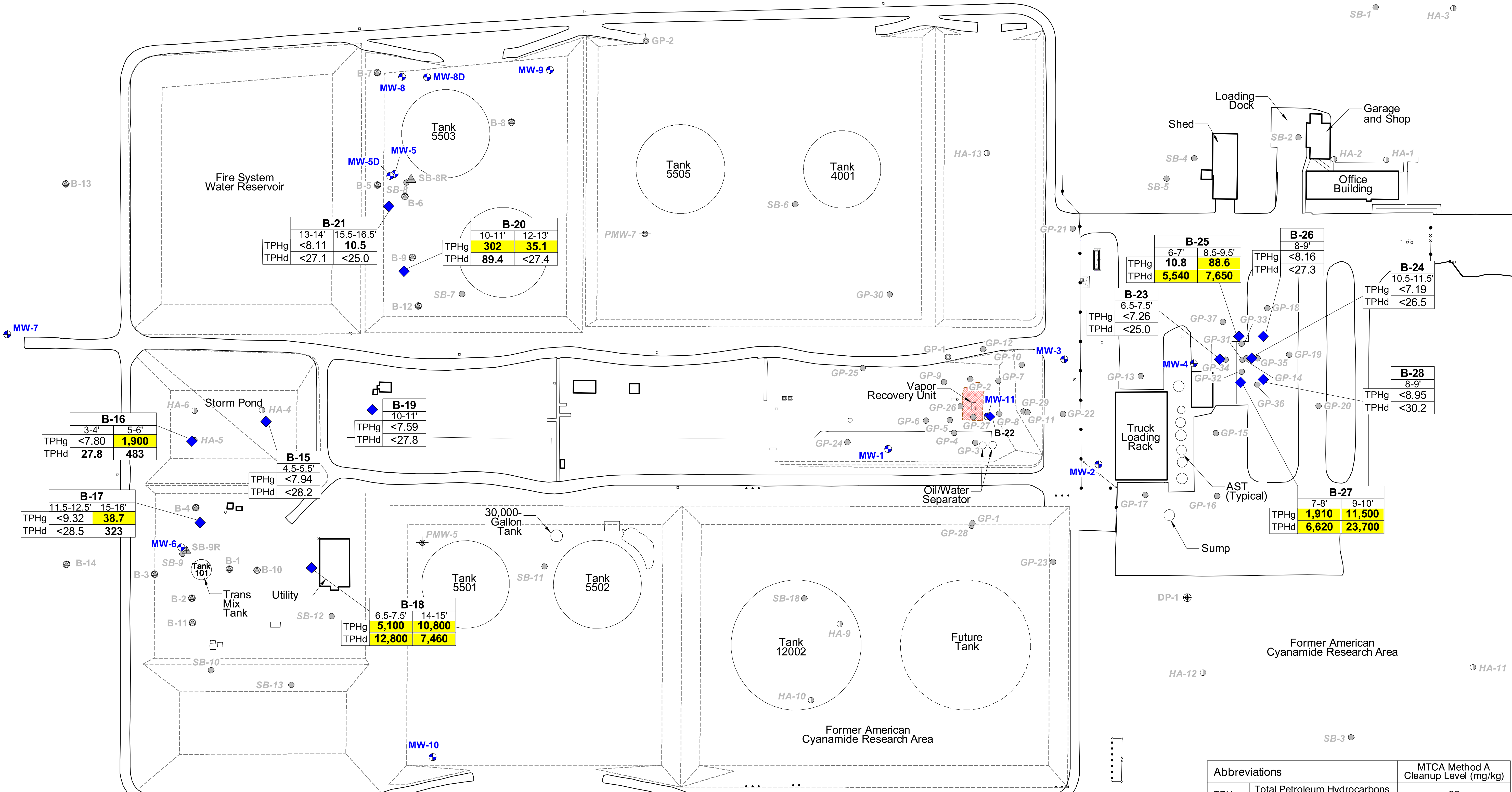
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX, MTBE, and Naphthalene Soil Sample Results - January/February 2019

Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-005	Figure
	May 2019	4



Abbreviations		MTCA Method A Cleanup Level (mg/kg)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	30
TPHd	Total Petroleum Hydrocarbons Diesel-Range	2,000

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

B-28		Location Sampled
	8-9'	Depth of Sample in Feet BGS
TPHg	<8.95	Concentration in mg/kg
TPHd	<30.2	

Highlighted Concentration Exceeds MTCA Method A Cleanup Level

Analyte Sampled

N

0 100 200

Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

TPHg and TPHd Soil Sample Results - January/February 2019

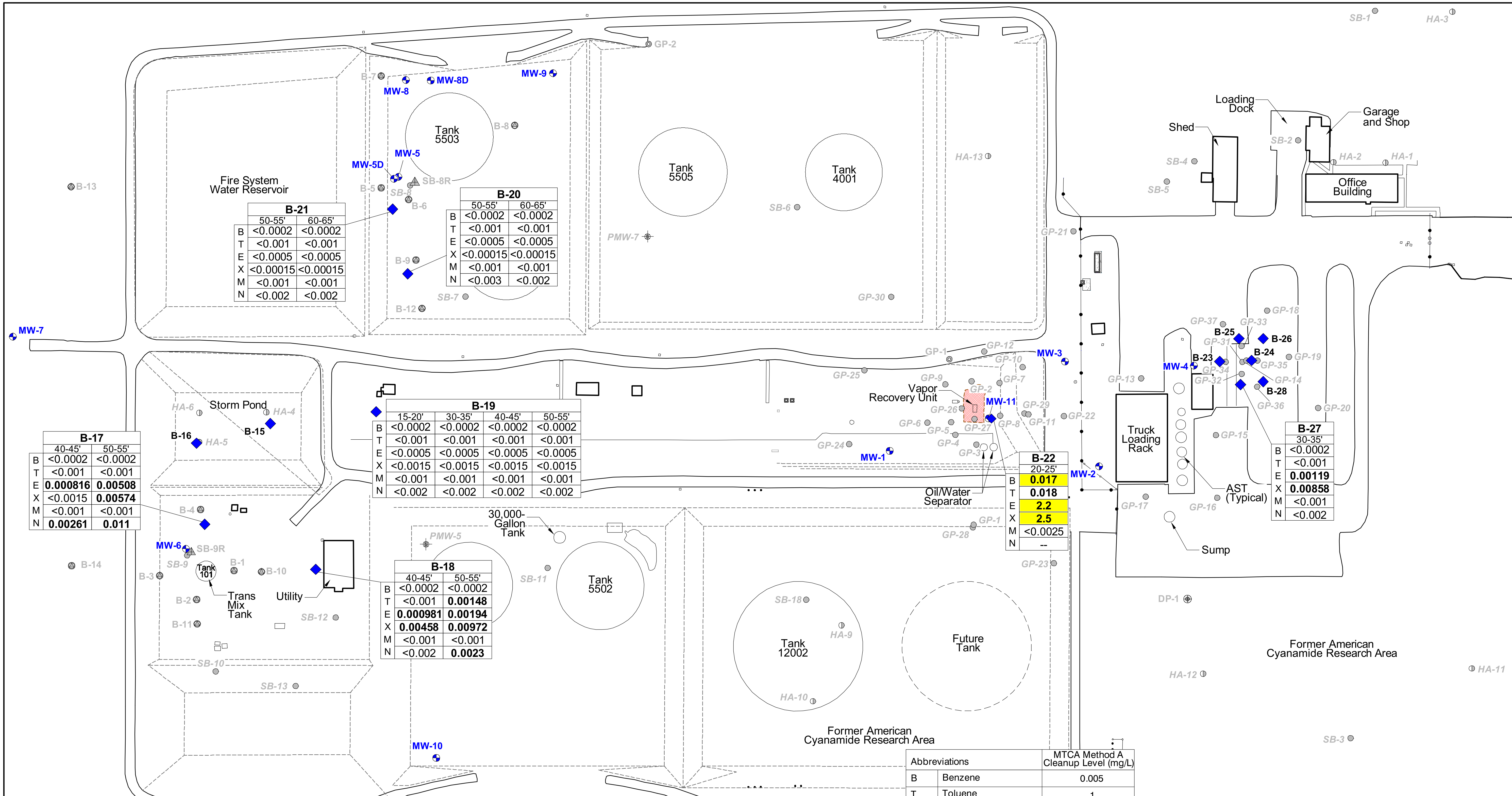
Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-005

May 2019

Figure 5



B-21

	50-55'	60-65'
B	<0.0002	<0.0002
T	<0.001	<0.001
E	<0.0005	<0.0005
X	<0.00015	<0.00015
M	<0.001	<0.001
N	<0.002	<0.002

B-20

	50-55'	60-65'
B	<0.0002	<0.0002
T	<0.001	<0.001
E	<0.0005	<0.0005
X	<0.00015	<0.00015
M	<0.001	<0.001
N	<0.003	<0.002

B-17

	40-45'	50-55'
B	<0.0002	<0.0002
T	<0.001	<0.001
E	**0.000816**	**0.00508**
X	<0.0015	**0.00574**
M	<0.001	<0.001
N	**0.00261**	**0.011**

B-19

	15-20'	30-35'	40-45'	50-55'
B	<0.0002	<0.0002	<0.0002	<0.0002
T	<0.001	<0.001	<0.001	<0.001
E	<0.0005	<0.0005	<0.0005	<0.0005
X	<0.0015	<0.0015	<0.0015	<0.0015
M	<0.001	<0.001	<0.001	<0.001
N	<0.002	<0.002	<0.002	<0.002

B-18

	40-45'	50-55'
B	<0.0002	<0.0002
T	<0.001	**0.00148**
E	**0.000981**	**0.00194**
X	**0.00458**	**0.00972**
M	<0.001	<0.001
N	<0.002	**0.0023**

B-22

	20-25'
B	**0.017**
T	**0.018**
E	**2.2**
X	**2.5**
M	<0.0025
N	--

B-27

	30-35'
B	<0.0002
T	<0.001
E	**0.00119**
X	**0.00858**
M	<0.001
N	<0.002

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

B-27		Location Sampled
	30-35'	Depth of Sample in Feet BGS
B	<0.0002	
T	<0.001	Concentration in mg/L
E	0.00119	
X	0.00858	Highlighted Concentration Exceeds MTCA Method A Cleanup Level
M	<0.001	
N	<0.002	Analyte Sampled

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1
M	Methyl Tert-Butyl Ether	0.02
N	Naphthalene	0.16

N

0 100 200

Scale in Feet

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX, MTBE, and Naphthalene Grab Groundwater Results - January/February 2019

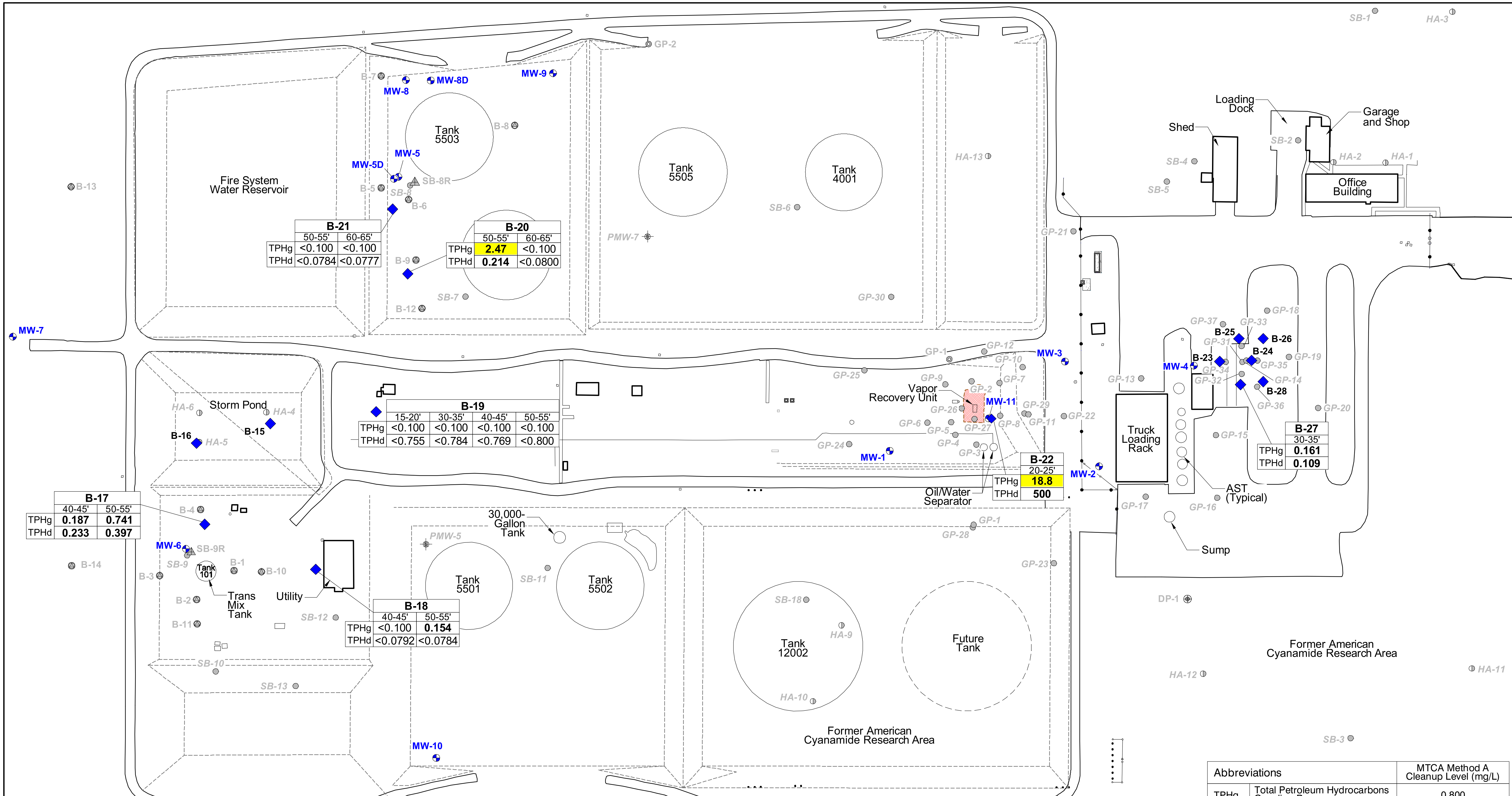
Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-005

May 2019

Figure 6



Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

B-27		Location Sampled
	30-35'	Depth of Sample in Feet BGS
TPHg	0.161	Concentration in mg/L
TPHd	0.109	

Highlighted Concentration Exceeds MTCA Method A Cleanup Level

Analyte Sampled

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

TPHg and TPHd Grab Groundwater Results - January/February 2019

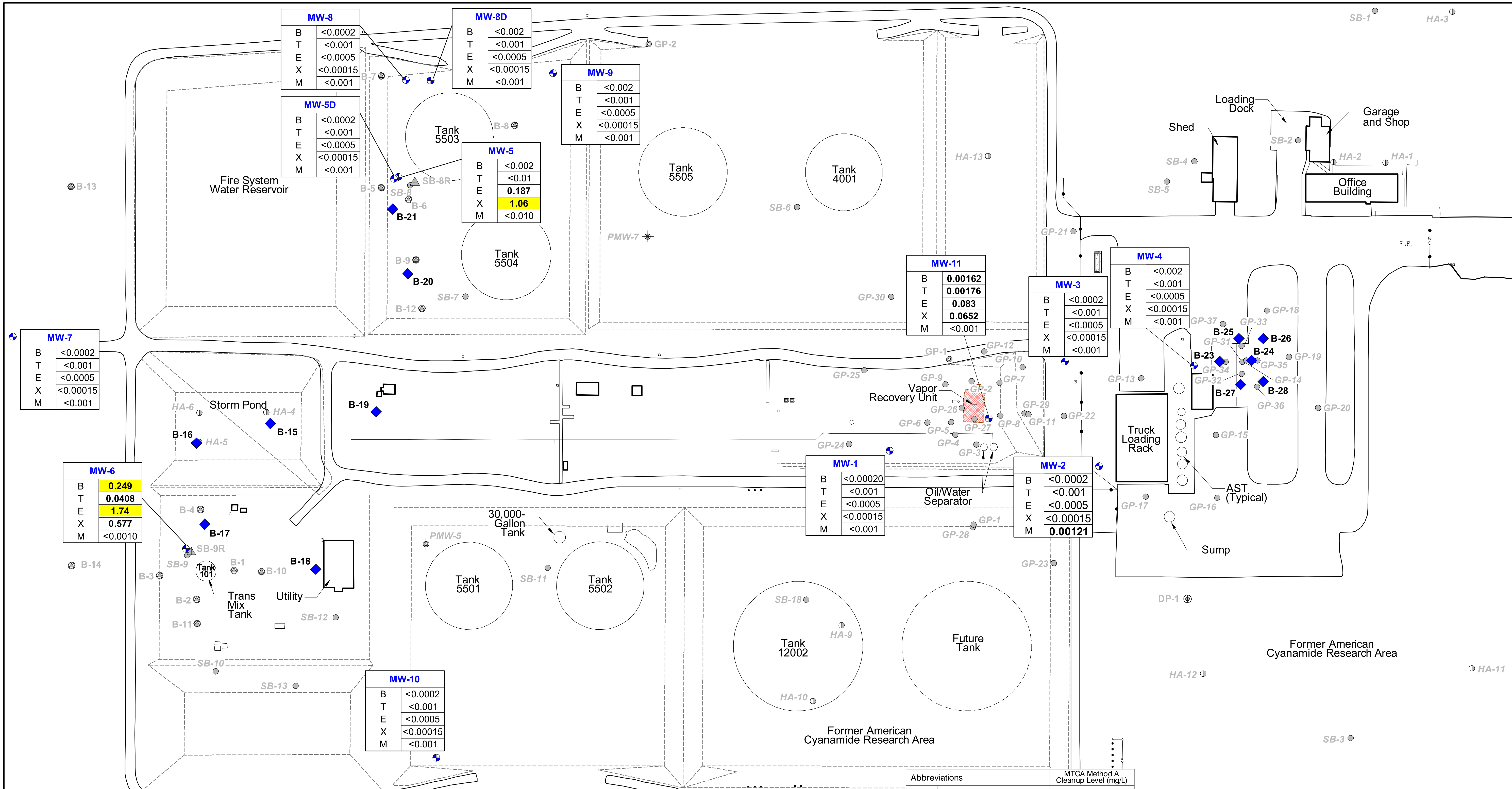
Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-005

May 2019

Figure 7



Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

MW-5		Location Sampled
B	<0.002	Concentration in mg/L
T	<0.01	
E	0.187	
X	1.06	Highlighted Concentration Exceeds MTCA Method A Cleanup Level
M	<0.010	Analyte Sampled

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1
M	Methyl Tert-Butyl Ether	0.02

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX and MTBE in Groundwater from Monitoring Wells - February 2019

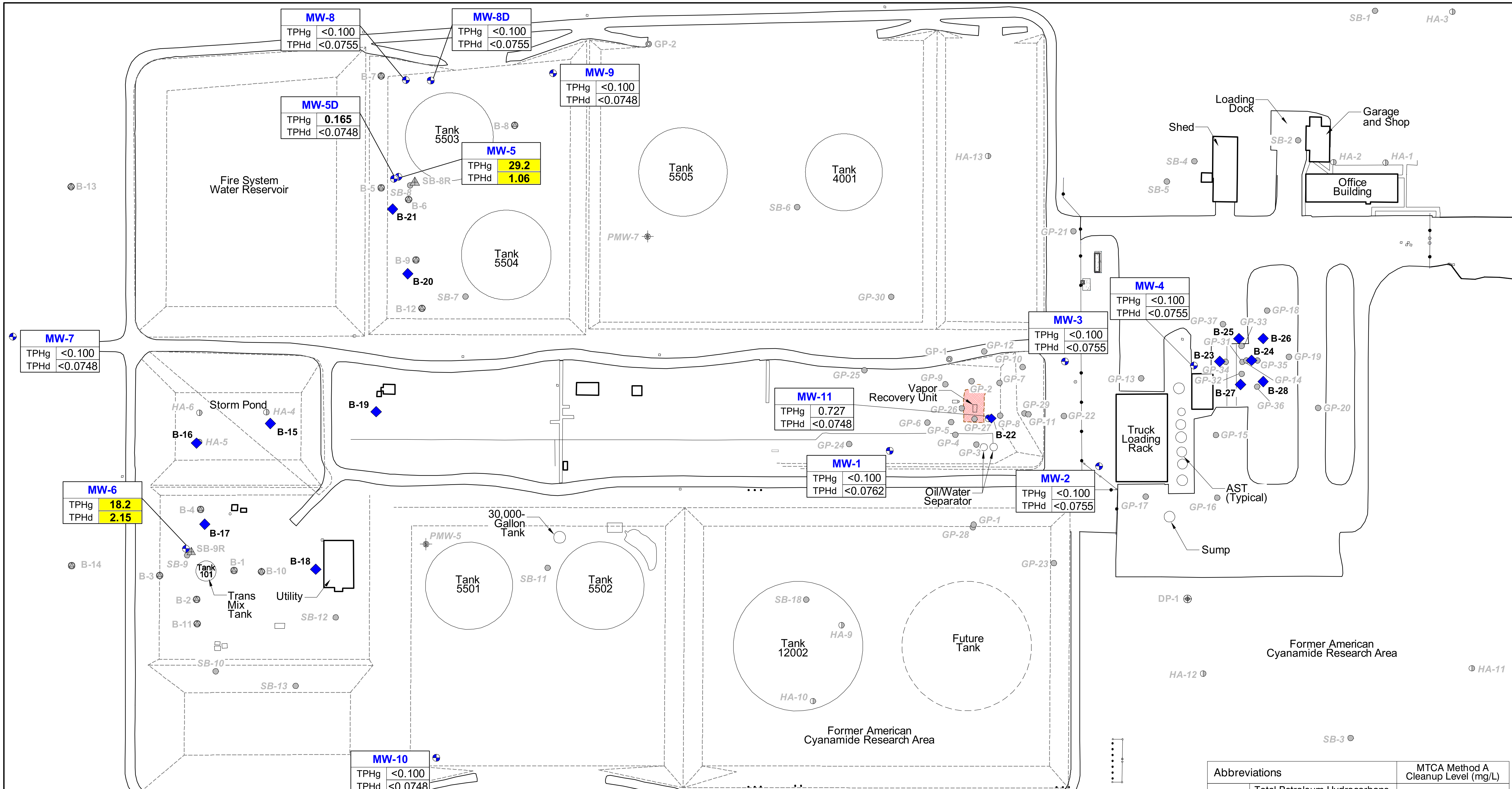
Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-005

May 2019

Figure 8



Legend:

- MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- SB-8R Soil Boring Location (September 2014)
- DP-1 Grab Groundwater Sample Location
- GP-1 Deeper Direct-Push Geoprobe Location
- GP-1 Historical Direct-Push Boring Location (Approximate)
- PMW-5 Historical Temporary Well Location (Approximate)
- HA-1 Historical Hand Auger Location (Approximate)
- B-1 Soil Boring Location (October 2015)
- B-1 Soil Boring Location (February 2019)

MW-6	
TPHg	18.2
TPHd	2.15

Location Sampled
Concentration in mg/L
Highlighted Concentration Exceeds MTCA Method A Cleanup Level
Analyte Sampled

Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

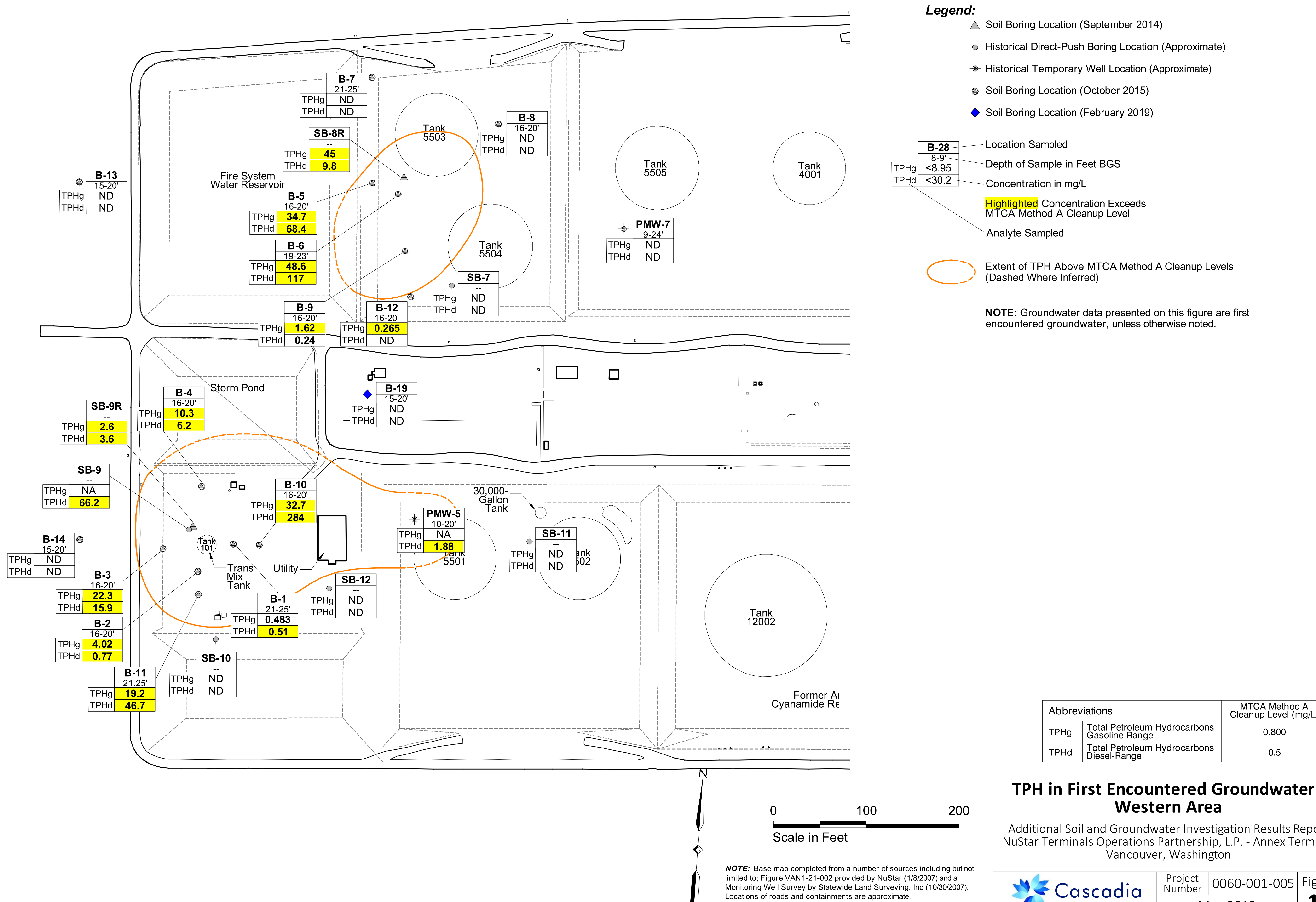
NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

TPHg and TPHd in Groundwater from Monitoring Wells - February 2019

Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-005	Figure
	May 2019	9



Abbreviations		MTCA Method A Cleanup Level (mg/L)
TPHg	Total Petroleum Hydrocarbons Gasoline-Range	0.800
TPHd	Total Petroleum Hydrocarbons Diesel-Range	0.5

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

TPH in First Encountered Groundwater - Western Area

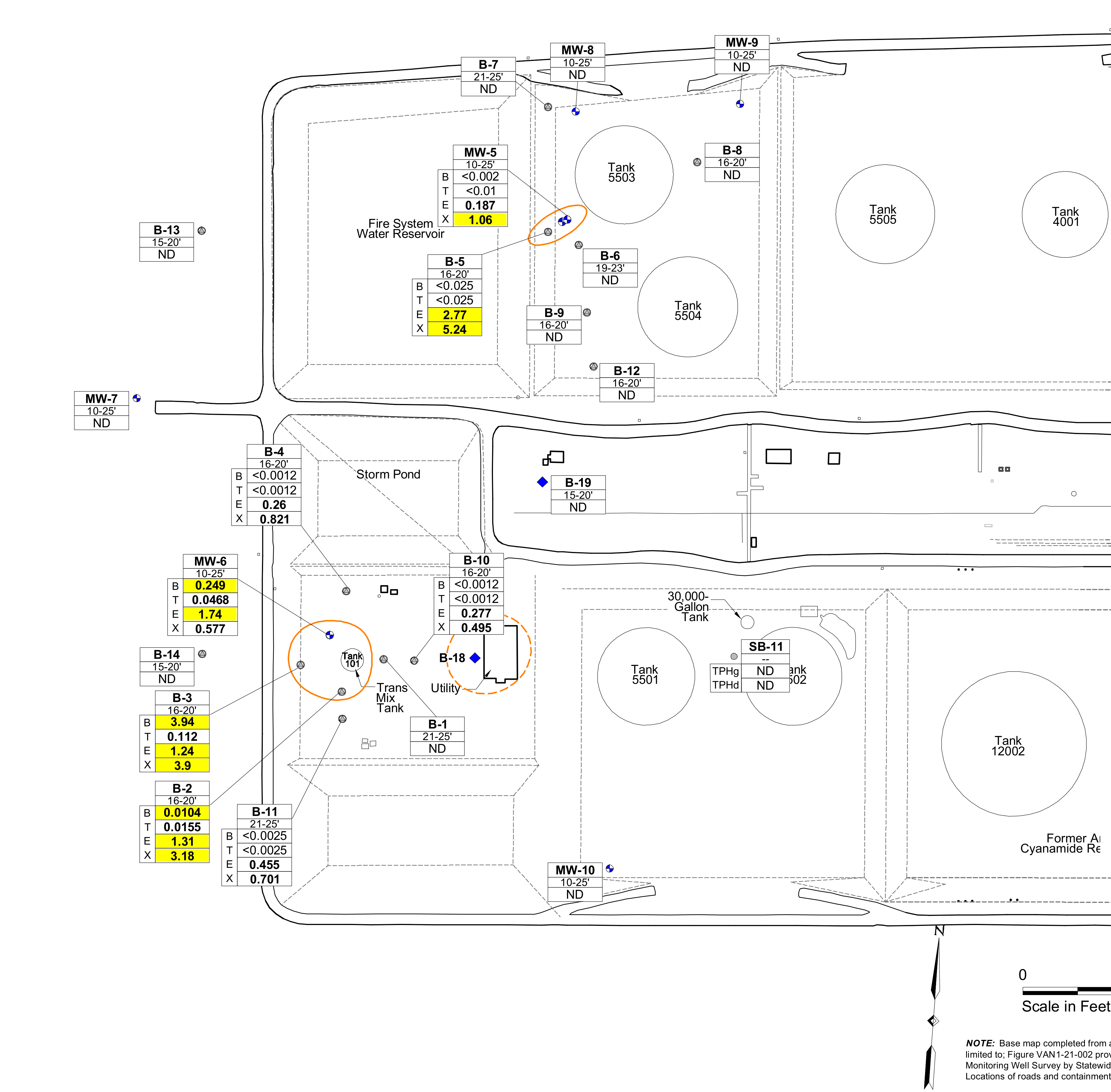
Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number 0060-001-005

May 2019

Figure 10



Legend:

- Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)
- Soil Boring Location (September 2014)
- Historical Direct-Push Boring Location (Approximate)
- Historical Temporary Well Location (Approximate)
- Soil Boring Location (October 2015)
- Soil Boring Location (February 2019)

MW-5	Location Sampled
10-25'	Depth of Sample in Feet BGS
B <0.002	
T <0.01	Concentration in mg/L
E 0.187	
X 1.06	Highlighted Concentration Exceeds MTCA Method A Cleanup Level - February 2019
	Analyte Sampled

Extent of TPH Above MTCA Method A Cleanup Levels (Dashed Where Uncertain)

NOTES: Groundwater data presented on this figure are first encountered groundwater, unless otherwise noted.

MTBE not detected in any samples, so data are not included on this figure.

If BTEX constituents are all below reporting limits, results are presented as 'ND' (Not Detected).

Abbreviations		MTCA Method A Cleanup Level (mg/L)
B	Benzene	0.005
T	Toluene	1
E	Ethylbenzene	0.7
X	Xylenes	1

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate.

BTEX in First Encountered Groundwater - Western Area

Additional Soil and Groundwater Investigation Results Report
NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-005	Figure
	May 2019	11

APPENDIX E

ANALYTICAL DATA SHEETS FROM 2020 INVESTIGATION

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Tuesday, March 3, 2020

Amanda Spencer
Cascadia Associates
5820 SW Kelly Ave Unit B
Portland, OR 97239

RE: A0B0557 - Nustar Vannex - 0060-001-005

Thank you for using Apex Laboratories. We greatly appreciate your business and strive to provide the highest quality services to the environmental industry.

Enclosed are the results of analyses for work order A0B0557, which was received by the laboratory on 2/20/2020 at 10:55:00AM.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: ldomenighini@apex-labs.com, or by phone at 503-718-2323.

Please note: All samples will be disposed of within 30 days of sample reciept, unless prior arrangements have been made.

Cooler Receipt Information

(See Cooler Receipt Form for details)

Cooler #1	5.6 degC	Cooler #2	4.4 degC

This Final Report is the official version of the data results for this sample submission, unless superseded by a subsequent, labeled amended report.
All other deliverables derived from this data, including Electronic Data Deliverables (EDDs), CLP-like forms, client requested summary sheets, and all other products are considered secondary to this report.

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Client Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
B-29(6.5)	A0B0557-01	Soil	02/18/20 09:15	02/20/20 10:55
B-29(11)	A0B0557-02	Soil	02/18/20 10:00	02/20/20 10:55
B-29(21)	A0B0557-03	Soil	02/18/20 10:15	02/20/20 10:55
B-30(4.5)	A0B0557-04	Soil	02/18/20 14:05	02/20/20 10:55
B-30(16)	A0B0557-05	Soil	02/19/20 08:30	02/20/20 10:55
B-30(21.5)	A0B0557-06	Soil	02/19/20 08:35	02/20/20 10:55
B-31(6.5)	A0B0557-07	Soil	02/18/20 11:20	02/20/20 10:55
B-31(14)	A0B0557-08	Soil	02/18/20 12:15	02/20/20 10:55
B-31(21.5)	A0B0557-09	Soil	02/18/20 12:40	02/20/20 10:55
B-32(9)	A0B0557-10	Soil	02/18/20 14:40	02/20/20 10:55
B-32(12)	A0B0557-11	Soil	02/18/20 14:45	02/20/20 10:55
B-32(21)	A0B0557-12	Soil	02/18/20 15:00	02/20/20 10:55
B-33(6.5)	A0B0557-13	Soil	02/19/20 09:15	02/20/20 10:55
B-33(18)	A0B0557-14	Soil	02/19/20 10:50	02/20/20 10:55
B-33(20)	A0B0557-15	Soil	02/19/20 11:00	02/20/20 10:55
B-34(6.5)	A0B0557-16	Soil	02/19/20 10:55	02/20/20 10:55
B-34(18)	A0B0557-17	Soil	02/19/20 13:15	02/20/20 10:55
B-34(20)	A0B0557-18	Soil	02/19/20 13:30	02/20/20 10:55
B-29 GW	A0B0557-19	Water	02/18/20 11:10	02/20/20 10:55
B-30 GW	A0B0557-20	Water	02/19/20 09:45	02/20/20 10:55
B-31 GW	A0B0557-21	Water	02/18/20 13:40	02/20/20 10:55
B-32 GW	A0B0557-22	Water	02/18/20 15:40	02/20/20 10:55
B-33 GW	A0B0557-23	Water	02/19/20 12:15	02/20/20 10:55
B-34 GW	A0B0557-24	Water	02/19/20 14:45	02/20/20 10:55
Trip Blank #2253	A0B0557-25	Water	02/18/20 00:00	02/20/20 10:55

Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29(6.5) (A0B0557-01)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	ND	---	25.6	mg/kg dry	1	02/25/20 21:35	NWTPH-Dx	
Oil	ND	---	51.3	mg/kg dry	1	02/25/20 21:35	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 79 %*		*Limits: 50-150 %*	*1*	*02/25/20 21:35*	*NWTPH-Dx*	
B-29(11) (A0B0557-02)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	ND	---	27.1	mg/kg dry	1	02/26/20 10:02	NWTPH-Dx	
Oil	ND	---	54.1	mg/kg dry	1	02/26/20 10:02	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 73 %*		*Limits: 50-150 %*	*1*	*02/26/20 10:02*	*NWTPH-Dx*	*Q-31*
B-29(21) (A0B0557-03)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	ND	---	26.3	mg/kg dry	1	02/25/20 23:29	NWTPH-Dx	
Oil	ND	---	52.5	mg/kg dry	1	02/25/20 23:29	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 91 %*		*Limits: 50-150 %*	*1*	*02/25/20 23:29*	*NWTPH-Dx*	
B-30(4.5) (A0B0557-04RE1)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	**14700**	---	503	mg/kg dry	20	02/26/20 10:42	NWTPH-Dx	
Oil	ND	---	1010	mg/kg dry	20	02/26/20 10:42	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: %*		*Limits: 50-150 %*	*20*	*02/26/20 10:42*	*NWTPH-Dx*	*S-01*
B-30(16) (A0B0557-05)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	**2630**	---	26.0	mg/kg dry	1	02/26/20 00:29	NWTPH-Dx	
Oil	ND	---	52.0	mg/kg dry	1	02/26/20 00:29	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 87 %*		*Limits: 50-150 %*	*1*	*02/26/20 00:29*	*NWTPH-Dx*	
B-30(21.5) (A0B0557-06)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	**208**	---	25.7	mg/kg dry	1	02/26/20 00:49	NWTPH-Dx	
Oil	ND	---	51.5	mg/kg dry	1	02/26/20 00:49	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 85 %*		*Limits: 50-150 %*	*1*	*02/26/20 00:49*	*NWTPH-Dx*	
B-31(6.5) (A0B0557-07)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	ND	---	25.8	mg/kg dry	1	02/26/20 01:08	NWTPH-Dx	
Oil	ND	---	51.6	mg/kg dry	1	02/26/20 01:08	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 82 %*		*Limits: 50-150 %*	*1*	*02/26/20 01:08*	*NWTPH-Dx*	
B-31(14) (A0B0557-08RE1)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	**6170**	---	261	mg/kg dry	10	02/26/20 10:22	NWTPH-Dx	

Apex Laboratories

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-31(14) (A0B0557-08RE1)				**Matrix: Soil**		**Batch: 0020749**		
Oil	ND	---	523	mg/kg dry	10	02/26/20 10:22	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 94 %*		*Limits: 50-150 %*	*10*	*02/26/20 10:22*	*NWTPH-Dx*	*S-05*
B-31(21.5) (A0B0557-09)				**Matrix: Soil**		**Batch: 0020749**		
Diesel	**54.1**	---	25.0	mg/kg dry	1	02/26/20 01:48	NWTPH-Dx	
Oil	ND	---	50.0	mg/kg dry	1	02/26/20 01:48	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 84 %*		*Limits: 50-150 %*	*1*	*02/26/20 01:48*	*NWTPH-Dx*	
B-32(9) (A0B0557-10)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	25.0	mg/kg dry	1	02/25/20 20:53	NWTPH-Dx	
Oil	ND	---	50.0	mg/kg dry	1	02/25/20 20:53	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 100 %*		*Limits: 50-150 %*	*1*	*02/25/20 20:53*	*NWTPH-Dx*	
B-32(12) (A0B0557-11)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	25.9	mg/kg dry	1	02/25/20 21:13	NWTPH-Dx	
Oil	ND	---	51.7	mg/kg dry	1	02/25/20 21:13	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 87 %*		*Limits: 50-150 %*	*1*	*02/25/20 21:13*	*NWTPH-Dx*	
B-32(21) (A0B0557-12)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	25.5	mg/kg dry	1	02/25/20 21:34	NWTPH-Dx	
Oil	ND	---	50.9	mg/kg dry	1	02/25/20 21:34	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 89 %*		*Limits: 50-150 %*	*1*	*02/25/20 21:34*	*NWTPH-Dx*	
B-33(6.5) (A0B0557-13)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	26.8	mg/kg dry	1	02/25/20 21:55	NWTPH-Dx	
Oil	ND	---	53.7	mg/kg dry	1	02/25/20 21:55	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 93 %*		*Limits: 50-150 %*	*1*	*02/25/20 21:55*	*NWTPH-Dx*	
B-33(18) (A0B0557-14)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	**261**	---	27.2	mg/kg dry	1	02/25/20 22:15	NWTPH-Dx	
Oil	ND	---	54.5	mg/kg dry	1	02/25/20 22:15	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 107 %*		*Limits: 50-150 %*	*1*	*02/25/20 22:15*	*NWTPH-Dx*	
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	26.1	mg/kg dry	1	02/25/20 22:35	NWTPH-Dx	
Oil	ND	---	52.2	mg/kg dry	1	02/25/20 22:35	NWTPH-Dx	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020758**		
Surrogate: o-Terphenyl (Surr)		*Recovery: 98 %*		*Limits: 50-150 %*	*1*	*02/25/20 22:35*	*NWTPH-Dx*	
B-34(6.5) (A0B0557-16)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	25.1	mg/kg dry	1	02/25/20 22:56	NWTPH-Dx	
Oil	ND	---	50.3	mg/kg dry	1	02/25/20 22:56	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 94 %*		*Limits: 50-150 %*	*1*	*02/25/20 22:56*	*NWTPH-Dx*	
B-34(18) (A0B0557-17)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	**47.8**	---	26.1	mg/kg dry	1	02/25/20 23:16	NWTPH-Dx	
Oil	ND	---	52.3	mg/kg dry	1	02/25/20 23:16	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 102 %*		*Limits: 50-150 %*	*1*	*02/25/20 23:16*	*NWTPH-Dx*	
B-34(20) (A0B0557-18)				**Matrix: Soil**		**Batch: 0020758**		
Diesel	ND	---	27.3	mg/kg dry	1	02/25/20 23:37	NWTPH-Dx	
Oil	ND	---	54.5	mg/kg dry	1	02/25/20 23:37	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 97 %*		*Limits: 50-150 %*	*1*	*02/25/20 23:37*	*NWTPH-Dx*	
B-29 GW (A0B0557-19)				**Matrix: Water**		**Batch: 0020661**		
Diesel	ND	---	0.0748	mg/L	1	02/24/20 07:58	NWTPH-Dx LL	
Oil	ND	---	0.150	mg/L	1	02/24/20 07:58	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 71 %*		*Limits: 50-150 %*	*1*	*02/24/20 07:58*	*NWTPH-Dx LL*	
B-30 GW (A0B0557-20)				**Matrix: Water**		**Batch: 0020661**		
Diesel	**2.81**	---	0.0748	mg/L	1	02/24/20 08:29	NWTPH-Dx LL	**F-20**
Oil	ND	---	0.150	mg/L	1	02/24/20 08:29	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 67 %*		*Limits: 50-150 %*	*1*	*02/24/20 08:29*	*NWTPH-Dx LL*	
B-31 GW (A0B0557-21)				**Matrix: Water**		**Batch: 0020661**		
Diesel	**10.3**	---	0.748	mg/L	10	02/24/20 08:49	NWTPH-Dx LL	**F-20**
Oil	ND	---	1.50	mg/L	10	02/24/20 08:49	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 55 %*		*Limits: 50-150 %*	*10*	*02/24/20 08:49*	*NWTPH-Dx LL*	*S-05*
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020661**		
Diesel	**0.110**	---	0.0792	mg/L	1	02/24/20 09:10	NWTPH-Dx LL	
Oil	ND	---	0.158	mg/L	1	02/24/20 09:10	NWTPH-Dx LL	

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Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020661**		
Surrogate: o-Terphenyl (Surr)		*Recovery: 77 %*		*Limits: 50-150 %*	*1*	*02/24/20 09:10*	*NWTPH-Dx LL*	
B-33 GW (A0B0557-23)				**Matrix: Water**		**Batch: 0020661**		
Diesel	**1.11**	---	0.0755	mg/L	1	02/24/20 09:30	NWTPH-Dx LL	**F-20**
Oil	ND	---	0.151	mg/L	1	02/24/20 09:30	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 62 %*		*Limits: 50-150 %*	*1*	*02/24/20 09:30*	*NWTPH-Dx LL*	
B-34 GW (A0B0557-24)				**Matrix: Water**		**Batch: 0020661**		
Diesel	**0.310**	---	0.0748	mg/L	1	02/24/20 09:51	NWTPH-Dx LL	
Oil	ND	---	0.150	mg/L	1	02/24/20 09:51	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 63 %*		*Limits: 50-150 %*	*1*	*02/24/20 09:51*	*NWTPH-Dx LL*	

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Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29 GW (A0B0557-19)				**Matrix: Water**		**Batch: 0020825**		
Diesel	ND	---	0.0748	mg/L	1	02/26/20 22:03	NWTPH-Dx/SGC	
Oil	ND	---	0.150	mg/L	1	02/26/20 22:03	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 69 %*		*Limits: 50-150 %*	*1*	*02/26/20 22:03*	*NWTPH-Dx/SGC*	
B-30 GW (A0B0557-20)				**Matrix: Water**		**Batch: 0020825**		
Diesel	**1.26**	---	0.0748	mg/L	1	02/26/20 22:26	NWTPH-Dx/SGC	**F-20**
Oil	ND	---	0.150	mg/L	1	02/26/20 22:26	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 50 %*		*Limits: 50-150 %*	*1*	*02/26/20 22:26*	*NWTPH-Dx/SGC*	
B-31 GW (A0B0557-21RE1)				**Matrix: Water**		**Batch: 0020825**		
Diesel	**9.02**	---	0.748	mg/L	10	02/27/20 08:40	NWTPH-Dx/SGC	**F-20**
Oil	ND	---	1.50	mg/L	10	02/27/20 08:40	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 45 %*		*Limits: 50-150 %*	*10*	*02/27/20 08:40*	*NWTPH-Dx/SGC*	*S-05*
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020825**		
Diesel	ND	---	0.0792	mg/L	1	02/26/20 23:12	NWTPH-Dx/SGC	
Oil	ND	---	0.158	mg/L	1	02/26/20 23:12	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 70 %*		*Limits: 50-150 %*	*1*	*02/26/20 23:12*	*NWTPH-Dx/SGC*	
B-33 GW (A0B0557-23)				**Matrix: Water**		**Batch: 0020825**		
Diesel	**1.09**	---	0.0755	mg/L	1	02/26/20 23:35	NWTPH-Dx/SGC	
Oil	ND	---	0.151	mg/L	1	02/26/20 23:35	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 56 %*		*Limits: 50-150 %*	*1*	*02/26/20 23:35*	*NWTPH-Dx/SGC*	
B-34 GW (A0B0557-24)				**Matrix: Water**		**Batch: 0020825**		
Diesel	**0.213**	---	0.0748	mg/L	1	02/26/20 23:58	NWTPH-Dx/SGC	
Oil	ND	---	0.150	mg/L	1	02/26/20 23:58	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 52 %*		*Limits: 50-150 %*	*1*	*02/26/20 23:58*	*NWTPH-Dx/SGC*	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0557 - 03 03 20 1223

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29(6.5) (A0B0557-01)				**Matrix: Soil**		**Batch: 0020607**		
Gasoline Range Organics	ND	---	6.89	mg/kg dry	50	02/20/20 20:18	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/20/20 20:18*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*94 %*	*50-150 %*	*1*	*02/20/20 20:18*	*NWTPH-Gx (MS)*	
B-29(11) (A0B0557-02)				**Matrix: Soil**		**Batch: 0020607**		
Gasoline Range Organics	ND	---	7.69	mg/kg dry	50	02/20/20 21:12	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*110 %*	*Limits: 50-150 %*	*1*	*02/20/20 21:12*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/20/20 21:12*	*NWTPH-Gx (MS)*	
B-29(21) (A0B0557-03)				**Matrix: Soil**		**Batch: 0020640**		
Gasoline Range Organics	ND	---	7.04	mg/kg dry	50	02/20/20 17:46	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/20/20 17:46*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/20/20 17:46*	*NWTPH-Gx (MS)*	
B-30(4.5) (A0B0557-04)				**Matrix: Soil**		**Batch: 0020607**		
Gasoline Range Organics	**6510**	---	123	mg/kg dry	1000	02/20/20 19:24	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*111 %*	*Limits: 50-150 %*	*1*	*02/20/20 19:24*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/20/20 19:24*	*NWTPH-Gx (MS)*	
B-30(16) (A0B0557-05)				**Matrix: Soil**		**Batch: 0020607**		
Gasoline Range Organics	**2930**	---	70.8	mg/kg dry	500	02/20/20 18:57	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/20/20 18:57*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/20/20 18:57*	*NWTPH-Gx (MS)*	
B-30(21.5) (A0B0557-06RE1)				**Matrix: Soil**		**Batch: 0020686**		
Gasoline Range Organics	**1660**	---	27.1	mg/kg dry	200	02/22/20 15:45	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/22/20 15:45*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/22/20 15:45*	*NWTPH-Gx (MS)*	
B-31(6.5) (A0B0557-07)				**Matrix: Soil**		**Batch: 0020657**		
Gasoline Range Organics	ND	---	7.31	mg/kg dry	50	02/21/20 18:59	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*110 %*	*Limits: 50-150 %*	*1*	*02/21/20 18:59*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/21/20 18:59*	*NWTPH-Gx (MS)*	
B-31(14) (A0B0557-08RE1)				**Matrix: Soil**		**Batch: 0020686**		
Gasoline Range Organics	**3940**	---	149	mg/kg dry	1000	02/22/20 15:18	NWTPH-Gx (MS)	

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Cascadia Associates	Project:	**Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number:	**0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager:	**Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-31(14) (A0B0557-08RE1)				**Matrix: Soil**		**Batch: 0020686**		
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*102 %*	*Limits: 50-150 %*	*1*	*02/22/20 15:18*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/22/20 15:18*	*NWTPH-Gx (MS)*	
B-31(21.5) (A0B0557-09)				**Matrix: Soil**		**Batch: 0020657**		
Gasoline Range Organics	**19.0**	---	7.07	mg/kg dry	50	02/21/20 18:05	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*114 %*	*Limits: 50-150 %*	*1*	*02/21/20 18:05*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*94 %*	*50-150 %*	*1*	*02/21/20 18:05*	*NWTPH-Gx (MS)*	
B-32(9) (A0B0557-10)				**Matrix: Soil**		**Batch: 0020657**		
Gasoline Range Organics	ND	---	7.23	mg/kg dry	50	02/21/20 18:32	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*109 %*	*Limits: 50-150 %*	*1*	*02/21/20 18:32*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*94 %*	*50-150 %*	*1*	*02/21/20 18:32*	*NWTPH-Gx (MS)*	
B-32(12) (A0B0557-11)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	7.90	mg/kg dry	50	02/23/20 19:43	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/23/20 19:43*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/23/20 19:43*	*NWTPH-Gx (MS)*	
B-32(21) (A0B0557-12)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	6.05	mg/kg dry	50	02/23/20 20:37	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*108 %*	*Limits: 50-150 %*	*1*	*02/23/20 20:37*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/23/20 20:37*	*NWTPH-Gx (MS)*	
B-33(6.5) (A0B0557-13)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	7.49	mg/kg dry	50	02/23/20 21:03	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/23/20 21:03*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/23/20 21:03*	*NWTPH-Gx (MS)*	
B-33(18) (A0B0557-14)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	**437**	---	7.71	mg/kg dry	50	02/23/20 21:30	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*111 %*	*Limits: 50-150 %*	*1*	*02/23/20 21:30*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/23/20 21:30*	*NWTPH-Gx (MS)*	
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	7.61	mg/kg dry	50	02/23/20 21:57	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*112 %*	*Limits: 50-150 %*	*1*	*02/23/20 21:57*	*NWTPH-Gx (MS)*	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020693**		
Surrogate: 1,4-Difluorobenzene (Sur)		*Recovery:*	*92 %*	*Limits: 50-150 %*	*1*	*02/23/20 21:57*	*NWTPH-Gx (MS)*	
B-34(6.5) (A0B0557-16)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	7.45	mg/kg dry	50	02/23/20 22:24	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*106 %*	*Limits: 50-150 %*	*1*	*02/23/20 22:24*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/23/20 22:24*	*NWTPH-Gx (MS)*	
B-34(18) (A0B0557-17)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	**28.7**	---	6.96	mg/kg dry	50	02/23/20 22:51	NWTPH-Gx (MS)	**F-13**
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*121 %*	*Limits: 50-150 %*	*1*	*02/23/20 22:51*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/23/20 22:51*	*NWTPH-Gx (MS)*	
B-34(20) (A0B0557-18)				**Matrix: Soil**		**Batch: 0020693**		
Gasoline Range Organics	ND	---	7.82	mg/kg dry	50	02/23/20 23:18	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*112 %*	*Limits: 50-150 %*	*1*	*02/23/20 23:18*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/23/20 23:18*	*NWTPH-Gx (MS)*	
B-29 GW (A0B0557-19)				**Matrix: Water**		**Batch: 0020602**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/20/20 20:02	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*101 %*	*Limits: 50-150 %*	*1*	*02/20/20 20:02*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*101 %*	*50-150 %*	*1*	*02/20/20 20:02*	*NWTPH-Gx (MS)*	
B-30 GW (A0B0557-20)				**Matrix: Water**		**Batch: 0020562**		
Gasoline Range Organics	**24.8**	---	5.00	mg/L	50	02/21/20 12:39	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*101 %*	*Limits: 50-150 %*	*1*	*02/21/20 12:39*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*103 %*	*50-150 %*	*1*	*02/21/20 12:39*	*NWTPH-Gx (MS)*	
B-31 GW (A0B0557-21)				**Matrix: Water**		**Batch: 0020602**		
Gasoline Range Organics	**47.0**	---	5.00	mg/L	50	02/20/20 22:44	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*102 %*	*Limits: 50-150 %*	*1*	*02/20/20 22:44*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*101 %*	*50-150 %*	*1*	*02/20/20 22:44*	*NWTPH-Gx (MS)*	
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020602**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/20/20 20:29	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*101 %*	*Limits: 50-150 %*	*1*	*02/20/20 20:29*	*NWTPH-Gx (MS)*	

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The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC

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EPA ID: OR01039

Cascadia Associates
5820 SW Kelly Ave Unit B
Portland, OR 97239

Project: **Nustar Vannex**
Project Number: **0060-001-005**
Project Manager: **Amanda Spencer**

Report ID:
A0B0557 - 03 03 20 1223

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020602**		
Surrogate: 1,4-Difluorobenzene (Sur)		*Recovery:*	*102 %*	*Limits: 50-150 %*	*1*	*02/20/20 20:29*	*NWTPH-Gx (MS)*	
B-33 GW (A0B0557-23RE1)				**Matrix: Water**		**Batch: 0020562**		
Gasoline Range Organics	**2.40**	---	0.100	mg/L	1	02/21/20 13:06	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*104 %*	*Limits: 50-150 %*	*1*	*02/21/20 13:06*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*106 %*	*50-150 %*	*1*	*02/21/20 13:06*	*NWTPH-Gx (MS)*	
B-34 GW (A0B0557-24)				**Matrix: Water**		**Batch: 0020562**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/21/20 17:37	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*106 %*	*Limits: 50-150 %*	*1*	*02/21/20 17:37*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*104 %*	*50-150 %*	*1*	*02/21/20 17:37*	*NWTPH-Gx (MS)*	

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Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29(6.5) (A0B0557-01)				**Matrix: Soil**		**Batch: 0020607**		
Benzene	ND	---	13.8	ug/kg dry	50	02/20/20 20:18	5035A/8260C	
Toluene	ND	---	68.9	ug/kg dry	50	02/20/20 20:18	5035A/8260C	
Ethylbenzene	ND	---	34.4	ug/kg dry	50	02/20/20 20:18	5035A/8260C	
Xylenes, total	ND	---	103	ug/kg dry	50	02/20/20 20:18	5035A/8260C	
Naphthalene	ND	---	138	ug/kg dry	50	02/20/20 20:18	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/20/20 20:18*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/20/20 20:18*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*106 %*	*80-120 %*	*1*	*02/20/20 20:18*	*5035A/8260C*	
B-29(11) (A0B0557-02)				**Matrix: Soil**		**Batch: 0020607**		
Benzene	ND	---	15.4	ug/kg dry	50	02/20/20 21:12	5035A/8260C	
Toluene	ND	---	76.9	ug/kg dry	50	02/20/20 21:12	5035A/8260C	
Ethylbenzene	ND	---	38.4	ug/kg dry	50	02/20/20 21:12	5035A/8260C	
Xylenes, total	ND	---	115	ug/kg dry	50	02/20/20 21:12	5035A/8260C	
Naphthalene	ND	---	154	ug/kg dry	50	02/20/20 21:12	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*110 %*	*Limits: 80-120 %*	*1*	*02/20/20 21:12*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/20/20 21:12*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*106 %*	*80-120 %*	*1*	*02/20/20 21:12*	*5035A/8260C*	
B-29(21) (A0B0557-03)				**Matrix: Soil**		**Batch: 0020640**		
Benzene	ND	---	14.1	ug/kg dry	50	02/20/20 17:46	5035A/8260C	
Toluene	ND	---	70.4	ug/kg dry	50	02/20/20 17:46	5035A/8260C	
Ethylbenzene	ND	---	35.2	ug/kg dry	50	02/20/20 17:46	5035A/8260C	
Xylenes, total	ND	---	106	ug/kg dry	50	02/20/20 17:46	5035A/8260C	
Naphthalene	ND	---	141	ug/kg dry	50	02/20/20 17:46	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/20/20 17:46*	*5035A/8260C*	
Toluene-d8 (Surr)			*95 %*	*80-120 %*	*1*	*02/20/20 17:46*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*103 %*	*80-120 %*	*1*	*02/20/20 17:46*	*5035A/8260C*	
B-30(4.5) (A0B0557-04)				**Matrix: Soil**		**Batch: 0020607**		
Benzene	ND	---	246	ug/kg dry	1000	02/20/20 19:24	5035A/8260C	
Toluene	ND	---	1230	ug/kg dry	1000	02/20/20 19:24	5035A/8260C	
Ethylbenzene	**23800**	---	616	ug/kg dry	1000	02/20/20 19:24	5035A/8260C	
Xylenes, total	**223000**	---	1850	ug/kg dry	1000	02/20/20 19:24	5035A/8260C	
Naphthalene	**82200**	---	2460	ug/kg dry	1000	02/20/20 19:24	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/20/20 19:24*	*5035A/8260C*	
Toluene-d8 (Surr)			*95 %*	*80-120 %*	*1*	*02/20/20 19:24*	*5035A/8260C*	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-30(4.5) (A0B0557-04)				**Matrix: Soil**		**Batch: 0020607**		
Surrogate: 4-Bromofluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/20/20 19:24*	*5035A/8260C*	
B-30(16) (A0B0557-05)				**Matrix: Soil**		**Batch: 0020607**		
Benzene	**148**	---	142	ug/kg dry	500	02/20/20 18:57	5035A/8260C	
Toluene	ND	---	708	ug/kg dry	500	02/20/20 18:57	5035A/8260C	
Ethylbenzene	**18600**	---	354	ug/kg dry	500	02/20/20 18:57	5035A/8260C	
Xylenes, total	**51900**	---	1060	ug/kg dry	500	02/20/20 18:57	5035A/8260C	
Naphthalene	**26300**	---	1420	ug/kg dry	500	02/20/20 18:57	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/20/20 18:57*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/20/20 18:57*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*110 %*	*80-120 %*	*1*	*02/20/20 18:57*	*5035A/8260C*	
B-30(21.5) (A0B0557-06RE1)				**Matrix: Soil**		**Batch: 0020686**		
Benzene	**147**	---	54.3	ug/kg dry	200	02/22/20 15:45	5035A/8260C	
Toluene	ND	---	271	ug/kg dry	200	02/22/20 15:45	5035A/8260C	
Ethylbenzene	**15400**	---	136	ug/kg dry	200	02/22/20 15:45	5035A/8260C	
Xylenes, total	**12900**	---	407	ug/kg dry	200	02/22/20 15:45	5035A/8260C	
Naphthalene	**14300**	---	543	ug/kg dry	200	02/22/20 15:45	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/22/20 15:45*	*5035A/8260C*	
Toluene-d8 (Surr)			*96 %*	*80-120 %*	*1*	*02/22/20 15:45*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*108 %*	*80-120 %*	*1*	*02/22/20 15:45*	*5035A/8260C*	
B-31(6.5) (A0B0557-07)				**Matrix: Soil**		**Batch: 0020657**		
Benzene	ND	---	14.6	ug/kg dry	50	02/21/20 18:59	5035A/8260C	
Toluene	ND	---	73.1	ug/kg dry	50	02/21/20 18:59	5035A/8260C	
Ethylbenzene	ND	---	36.6	ug/kg dry	50	02/21/20 18:59	5035A/8260C	
Xylenes, total	ND	---	110	ug/kg dry	50	02/21/20 18:59	5035A/8260C	
Naphthalene	ND	---	146	ug/kg dry	50	02/21/20 18:59	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/21/20 18:59*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/21/20 18:59*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*105 %*	*80-120 %*	*1*	*02/21/20 18:59*	*5035A/8260C*	
B-31(14) (A0B0557-08)				**Matrix: Soil**		**Batch: 0020657**		
Benzene	**199**	---	29.9	ug/kg dry	100	02/21/20 20:20	5035A/8260C	
Toluene	**154**	---	149	ug/kg dry	100	02/21/20 20:20	5035A/8260C	
Ethylbenzene	**16600**	---	74.6	ug/kg dry	100	02/21/20 20:20	5035A/8260C	
Xylenes, total	**30200**	---	224	ug/kg dry	100	02/21/20 20:20	5035A/8260C	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-31(14) (A0B0557-08)				**Matrix: Soil**		**Batch: 0020657**		
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*110 %*	*Limits: 80-120 %*	*1*	*02/21/20 20:20*	*5035A/8260C*	
Toluene-d8 (Surr)			*95 %*	*80-120 %*	*1*	*02/21/20 20:20*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/21/20 20:20*	*5035A/8260C*	
B-31(14) (A0B0557-08RE1)				**Matrix: Soil**		**Batch: 0020686**		
Naphthalene	**42200**	---	2990	ug/kg dry	1000	02/22/20 15:18	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*105 %*	*Limits: 80-120 %*	*1*	*02/22/20 15:18*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/22/20 15:18*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/22/20 15:18*	*5035A/8260C*	
B-31(21.5) (A0B0557-09)				**Matrix: Soil**		**Batch: 0020657**		
Benzene	ND	---	14.1	ug/kg dry	50	02/21/20 18:05	5035A/8260C	
Toluene	ND	---	70.7	ug/kg dry	50	02/21/20 18:05	5035A/8260C	
Ethylbenzene	**289**	---	35.4	ug/kg dry	50	02/21/20 18:05	5035A/8260C	
Xylenes, total	**645**	---	106	ug/kg dry	50	02/21/20 18:05	5035A/8260C	
Naphthalene	**354**	---	141	ug/kg dry	50	02/21/20 18:05	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/21/20 18:05*	*5035A/8260C*	
Toluene-d8 (Surr)			*92 %*	*80-120 %*	*1*	*02/21/20 18:05*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*104 %*	*80-120 %*	*1*	*02/21/20 18:05*	*5035A/8260C*	
B-32(9) (A0B0557-10)				**Matrix: Soil**		**Batch: 0020657**		
Benzene	ND	---	14.5	ug/kg dry	50	02/21/20 18:32	5035A/8260C	
Toluene	ND	---	72.3	ug/kg dry	50	02/21/20 18:32	5035A/8260C	
Ethylbenzene	ND	---	36.1	ug/kg dry	50	02/21/20 18:32	5035A/8260C	
Xylenes, total	ND	---	108	ug/kg dry	50	02/21/20 18:32	5035A/8260C	
Naphthalene	ND	---	145	ug/kg dry	50	02/21/20 18:32	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/21/20 18:32*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/21/20 18:32*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*106 %*	*80-120 %*	*1*	*02/21/20 18:32*	*5035A/8260C*	
B-32(12) (A0B0557-11)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	15.8	ug/kg dry	50	02/23/20 19:43	5035A/8260C	
Toluene	ND	---	79.0	ug/kg dry	50	02/23/20 19:43	5035A/8260C	
Ethylbenzene	ND	---	39.5	ug/kg dry	50	02/23/20 19:43	5035A/8260C	
Xylenes, total	ND	---	119	ug/kg dry	50	02/23/20 19:43	5035A/8260C	
Naphthalene	ND	---	158	ug/kg dry	50	02/23/20 19:43	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/23/20 19:43*	*5035A/8260C*	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-32(12) (A0B0557-11)				**Matrix: Soil**		**Batch: 0020693**		
Surrogate: Toluene-d8 (Surr)		*Recovery:*	*94 %*	*Limits: 80-120 %*	*1*	*02/23/20 19:43*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*104 %*	*80-120 %*	*1*	*02/23/20 19:43*	*5035A/8260C*	
B-32(21) (A0B0557-12)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	12.1	ug/kg dry	50	02/23/20 20:37	5035A/8260C	
Toluene	ND	---	60.5	ug/kg dry	50	02/23/20 20:37	5035A/8260C	
Ethylbenzene	ND	---	30.3	ug/kg dry	50	02/23/20 20:37	5035A/8260C	
Xylenes, total	ND	---	90.8	ug/kg dry	50	02/23/20 20:37	5035A/8260C	
Naphthalene	ND	---	121	ug/kg dry	50	02/23/20 20:37	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*105 %*	*Limits: 80-120 %*	*1*	*02/23/20 20:37*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/23/20 20:37*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*106 %*	*80-120 %*	*1*	*02/23/20 20:37*	*5035A/8260C*	
B-33(6.5) (A0B0557-13)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	15.0	ug/kg dry	50	02/23/20 21:03	5035A/8260C	
Toluene	ND	---	74.9	ug/kg dry	50	02/23/20 21:03	5035A/8260C	
Ethylbenzene	ND	---	37.5	ug/kg dry	50	02/23/20 21:03	5035A/8260C	
Xylenes, total	ND	---	112	ug/kg dry	50	02/23/20 21:03	5035A/8260C	
Naphthalene	ND	---	150	ug/kg dry	50	02/23/20 21:03	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/23/20 21:03*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/23/20 21:03*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*105 %*	*80-120 %*	*1*	*02/23/20 21:03*	*5035A/8260C*	
B-33(18) (A0B0557-14)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	15.4	ug/kg dry	50	02/23/20 21:30	5035A/8260C	
Toluene	ND	---	77.1	ug/kg dry	50	02/23/20 21:30	5035A/8260C	
Ethylbenzene	ND	---	38.6	ug/kg dry	50	02/23/20 21:30	5035A/8260C	
Xylenes, total	ND	---	116	ug/kg dry	50	02/23/20 21:30	5035A/8260C	
Naphthalene	**410**	---	154	ug/kg dry	50	02/23/20 21:30	5035A/8260C	**M-04**
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/23/20 21:30*	*5035A/8260C*	
Toluene-d8 (Surr)			*91 %*	*80-120 %*	*1*	*02/23/20 21:30*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*112 %*	*80-120 %*	*1*	*02/23/20 21:30*	*5035A/8260C*	
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	15.2	ug/kg dry	50	02/23/20 21:57	5035A/8260C	
Toluene	ND	---	76.1	ug/kg dry	50	02/23/20 21:57	5035A/8260C	
Ethylbenzene	ND	---	38.0	ug/kg dry	50	02/23/20 21:57	5035A/8260C	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020693**		
Xylenes, total	ND	---	114	ug/kg dry	50	02/23/20 21:57	5035A/8260C	
Naphthalene	ND	---	152	ug/kg dry	50	02/23/20 21:57	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/23/20 21:57*	*5035A/8260C*	
Toluene-d8 (Surr)			*92 %*	*80-120 %*	*1*	*02/23/20 21:57*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*104 %*	*80-120 %*	*1*	*02/23/20 21:57*	*5035A/8260C*	
B-34(6.5) (A0B0557-16)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	14.9	ug/kg dry	50	02/23/20 22:24	5035A/8260C	
Toluene	ND	---	74.5	ug/kg dry	50	02/23/20 22:24	5035A/8260C	
Ethylbenzene	ND	---	37.3	ug/kg dry	50	02/23/20 22:24	5035A/8260C	
Xylenes, total	ND	---	112	ug/kg dry	50	02/23/20 22:24	5035A/8260C	
Naphthalene	ND	---	149	ug/kg dry	50	02/23/20 22:24	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits: 80-120 %*	*1*	*02/23/20 22:24*	*5035A/8260C*	
Toluene-d8 (Surr)			*95 %*	*80-120 %*	*1*	*02/23/20 22:24*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/23/20 22:24*	*5035A/8260C*	
B-34(18) (A0B0557-17)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	13.9	ug/kg dry	50	02/23/20 22:51	5035A/8260C	
Toluene	ND	---	69.6	ug/kg dry	50	02/23/20 22:51	5035A/8260C	
Ethylbenzene	ND	---	34.8	ug/kg dry	50	02/23/20 22:51	5035A/8260C	
Xylenes, total	ND	---	104	ug/kg dry	50	02/23/20 22:51	5035A/8260C	
Naphthalene	ND	---	139	ug/kg dry	50	02/23/20 22:51	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/23/20 22:51*	*5035A/8260C*	
Toluene-d8 (Surr)			*88 %*	*80-120 %*	*1*	*02/23/20 22:51*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*110 %*	*80-120 %*	*1*	*02/23/20 22:51*	*5035A/8260C*	
B-34(20) (A0B0557-18)				**Matrix: Soil**		**Batch: 0020693**		
Benzene	ND	---	15.6	ug/kg dry	50	02/23/20 23:18	5035A/8260C	
Toluene	ND	---	78.2	ug/kg dry	50	02/23/20 23:18	5035A/8260C	
Ethylbenzene	ND	---	39.1	ug/kg dry	50	02/23/20 23:18	5035A/8260C	
Xylenes, total	ND	---	117	ug/kg dry	50	02/23/20 23:18	5035A/8260C	
Naphthalene	ND	---	156	ug/kg dry	50	02/23/20 23:18	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/23/20 23:18*	*5035A/8260C*	
Toluene-d8 (Surr)			*92 %*	*80-120 %*	*1*	*02/23/20 23:18*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/23/20 23:18*	*5035A/8260C*	
B-29 GW (A0B0557-19)				**Matrix: Water**		**Batch: 0020602**		

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0557 - 03 03 20 1223

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29 GW (A0B0557-19)				**Matrix: Water**		**Batch: 0020602**		
Benzene	ND	---	0.200	ug/L	1	02/20/20 20:02	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/20/20 20:02	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/20/20 20:02	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/20/20 20:02	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/20/20 20:02	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 106 %*		*Limits: 80-120 %*	*1*	*02/20/20 20:02*	*EPA 8260C*	
Toluene-d8 (Surr)		*102 %*		*80-120 %*	*1*	*02/20/20 20:02*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*96 %*		*80-120 %*	*1*	*02/20/20 20:02*	*EPA 8260C*	
B-30 GW (A0B0557-20)				**Matrix: Water**		**Batch: 0020562**		
Benzene	**37.8**	---	10.0	ug/L	50	02/21/20 12:39	EPA 8260C	
Toluene	ND	---	50.0	ug/L	50	02/21/20 12:39	EPA 8260C	
Ethylbenzene	**721**	---	25.0	ug/L	50	02/21/20 12:39	EPA 8260C	
Xylenes, total	**1630**	---	75.0	ug/L	50	02/21/20 12:39	EPA 8260C	
Naphthalene	**475**	---	100	ug/L	50	02/21/20 12:39	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 105 %*		*Limits: 80-120 %*	*1*	*02/21/20 12:39*	*EPA 8260C*	
Toluene-d8 (Surr)		*104 %*		*80-120 %*	*1*	*02/21/20 12:39*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*91 %*		*80-120 %*	*1*	*02/21/20 12:39*	*EPA 8260C*	
B-31 GW (A0B0557-21)				**Matrix: Water**		**Batch: 0020602**		
Benzene	**50.3**	---	10.0	ug/L	50	02/20/20 22:44	EPA 8260C	
Toluene	**57.8**	---	50.0	ug/L	50	02/20/20 22:44	EPA 8260C	
Ethylbenzene	**1020**	---	25.0	ug/L	50	02/20/20 22:44	EPA 8260C	
Xylenes, total	**2880**	---	75.0	ug/L	50	02/20/20 22:44	EPA 8260C	
Naphthalene	**1040**	---	100	ug/L	50	02/20/20 22:44	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 103 %*		*Limits: 80-120 %*	*1*	*02/20/20 22:44*	*EPA 8260C*	
Toluene-d8 (Surr)		*102 %*		*80-120 %*	*1*	*02/20/20 22:44*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*93 %*		*80-120 %*	*1*	*02/20/20 22:44*	*EPA 8260C*	
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020602**		
Benzene	ND	---	0.200	ug/L	1	02/20/20 20:29	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/20/20 20:29	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/20/20 20:29	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/20/20 20:29	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/20/20 20:29	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 105 %*		*Limits: 80-120 %*	*1*	*02/20/20 20:29*	*EPA 8260C*	
Toluene-d8 (Surr)		*102 %*		*80-120 %*	*1*	*02/20/20 20:29*	*EPA 8260C*	

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The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-32 GW (A0B0557-22)				**Matrix: Water**		**Batch: 0020602**		
Surrogate: 4-Bromofluorobenzene (Surr)		*Recovery: 96 %*		*Limits: 80-120 %*	*1*	*02/20/20 20:29*	*EPA 8260C*	
B-33 GW (A0B0557-23RE1)				**Matrix: Water**		**Batch: 0020562**		
Benzene	ND	---	0.200	ug/L	1	02/21/20 13:06	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/21/20 13:06	EPA 8260C	
Ethylbenzene	**1.67**	---	0.500	ug/L	1	02/21/20 13:06	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/21/20 13:06	EPA 8260C	
Naphthalene	**12.2**	---	2.00	ug/L	1	02/21/20 13:06	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 104 %*		*Limits: 80-120 %*	*1*	*02/21/20 13:06*	*EPA 8260C*	
Toluene-d8 (Surr)		*101 %*		*80-120 %*	*1*	*02/21/20 13:06*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*95 %*		*80-120 %*	*1*	*02/21/20 13:06*	*EPA 8260C*	
B-34 GW (A0B0557-24)				**Matrix: Water**		**Batch: 0020562**		
Benzene	ND	---	0.200	ug/L	1	02/21/20 17:37	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/21/20 17:37	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/21/20 17:37	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/21/20 17:37	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/21/20 17:37	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 105 %*		*Limits: 80-120 %*	*1*	*02/21/20 17:37*	*EPA 8260C*	
Toluene-d8 (Surr)		*101 %*		*80-120 %*	*1*	*02/21/20 17:37*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*92 %*		*80-120 %*	*1*	*02/21/20 17:37*	*EPA 8260C*	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-29(6.5) (A0B0557-01)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**76.8**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-29(11) (A0B0557-02)				**Matrix: Soil**		**Batch: 0020671**		
% Solids	**71.7**	---	1.00	%	1	02/21/20 15:00	EPA 8000C	
B-29(21) (A0B0557-03)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**74.6**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-30(4.5) (A0B0557-04)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**77.2**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-30(16) (A0B0557-05)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**72.7**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-30(21.5) (A0B0557-06)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**73.8**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-31(6.5) (A0B0557-07)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**72.9**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-31(14) (A0B0557-08)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**71.5**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-31(21.5) (A0B0557-09)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**73.6**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-32(9) (A0B0557-10)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**76.3**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-32(12) (A0B0557-11)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**72.9**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-32(21) (A0B0557-12)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**76.9**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-33(6.5) (A0B0557-13)				**Matrix: Soil**		**Batch: 0020666**		

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-33(6.5) (A0B0557-13)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**71.3**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-33(18) (A0B0557-14)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**71.3**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-33(20) (A0B0557-15)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**71.4**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-34(6.5) (A0B0557-16)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**73.0**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-34(18) (A0B0557-17)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**74.3**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	
B-34(20) (A0B0557-18)				**Matrix: Soil**		**Batch: 0020666**		
% Solids	**70.1**	---	1.00	%	1	02/24/20 08:36	EPA 8000C	

Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** A0B0557 - 03 03 20 1223

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020661 - EPA 3510C (Fuels/Acid Ext.)							**Water**					
Blank (0020661-BLK1)		Prepared: 02/21/20 11:12	Analyzed: 02/22/20 09:03									
NWTPH-Dx LL												
Diesel	ND	---	0.0727	mg/L	1	---	---	---	---	---	---	
Oil	ND	---	0.145	mg/L	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 80 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS (0020661-BS1)		Prepared: 02/21/20 11:12	Analyzed: 02/22/20 09:23									
NWTPH-Dx LL												
Diesel	0.395	---	0.0800	mg/L	1	0.500	---	79	58 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 85 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS Dup (0020661-BSD1)		Prepared: 02/21/20 11:12	Analyzed: 02/22/20 09:44									Q-19
NWTPH-Dx LL												
Diesel	0.393	---	0.0800	mg/L	1	0.500	---	79	58 - 115%	0.4	20%	
Surr: o-Terphenyl (Surr)		*Recovery: 83 %*	*Limits: 50-150 %*		*Dilution: 1x*							
Batch 0020749 - EPA 3546 (Fuels)							**Soil**					
Blank (0020749-BLK1)		Prepared: 02/25/20 07:30	Analyzed: 02/25/20 20:55									
NWTPH-Dx												
Diesel	ND	---	25.0	mg/kg wet	1	---	---	---	---	---	---	
Oil	ND	---	50.0	mg/kg wet	1	---	---	---	---	---	---	
Mineral Oil	ND	---	36.4	mg/kg wet	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 94 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS (0020749-BS1)		Prepared: 02/25/20 07:30	Analyzed: 02/25/20 21:15									
NWTPH-Dx												
Diesel	112	---	20.0	mg/kg wet	1	125	---	89	76 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 93 %*	*Limits: 50-150 %*		*Dilution: 1x*							
Duplicate (0020749-DUP1)		Prepared: 02/25/20 07:30	Analyzed: 02/25/20 21:55									
QC Source Sample: B-29(6.5) (A0B0557-01)												
NWTPH-Dx												
Diesel	ND	---	25.6	mg/kg dry	1	---	ND	---	---	---	30%	
Oil	ND	---	51.3	mg/kg dry	1	---	ND	---	---	---	30%	

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020749 - EPA 3546 (Fuels)							**Soil**					
Duplicate (0020749-DUP1)		Prepared: 02/25/20 07:30	Analyzed: 02/25/20 21:55									
QC Source Sample: B-29(6.5) (A0B0557-01)												
Mineral Oil	ND	---	51.3	mg/kg dry	1	---	ND	---	---	---	30%	
Surr: o-Terphenyl (Surr)		*Recovery: 76 %*		*Limits: 50-150 %*			*Dilution: 1x*					

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Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020758 - EPA 3546 (Fuels)							**Soil**					
Blank (0020758-BLK1)		Prepared: 02/25/20 10:03 Analyzed: 02/25/20 12:28										
NWTPH-Dx												
Diesel	ND	---	25.0	mg/kg wet	1	---	---	---	---	---	---	
Oil	ND	---	50.0	mg/kg wet	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 93 %*		*Limits: 50-150 %*		*Dilution: 1x*						
LCS (0020758-BS1)		Prepared: 02/25/20 10:03 Analyzed: 02/25/20 12:48										
NWTPH-Dx												
Diesel	108	---	20.0	mg/kg wet	1	125	---	87	76 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 95 %*		*Limits: 50-150 %*		*Dilution: 1x*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020825 - EPA 3510C (Fuels/Acid Ext.) w/Silica Gel							**Water**					
Blank (0020825-BLK1)		Prepared: 02/21/20 11:12	Analyzed: 02/26/20 20:54									
NWTPH-Dx/SGC												
Diesel	ND	---	0.0727	mg/L	1	---	---	---	---	---	---	
Oil	ND	---	0.145	mg/L	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 72 %*	*Limits: 50-150 %*			*Dilution: 1x*						
LCS (0020825-BS1)		Prepared: 02/21/20 11:12	Analyzed: 02/26/20 21:17									
NWTPH-Dx/SGC												
Diesel	0.328	---	0.0800	mg/L	1	0.500	---	66	58 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 76 %*	*Limits: 50-150 %*			*Dilution: 1x*						
LCS Dup (0020825-BSD1)		Prepared: 02/21/20 11:12	Analyzed: 02/26/20 21:40									**Q-19**
NWTPH-Dx/SGC												
Diesel	0.350	---	0.0800	mg/L	1	0.500	---	70	58 - 115%	6	20%	
Surr: o-Terphenyl (Surr)		*Recovery: 78 %*	*Limits: 50-150 %*			*Dilution: 1x*						

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Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020562 - EPA 5030B							Water					
Blank (0020562-BLK1)		Prepared: 02/21/20 10:00	Analyzed: 02/21/20 12:11									
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	0.100	mg/L	1	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 99 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*103 %*		*50-150 %*		*"*						
LCS (0020562-BS2)		Prepared: 02/21/20 10:00	Analyzed: 02/21/20 11:44									
NWTPH-Gx (MS)												
Gasoline Range Organics	0.505	---	0.100	mg/L	1	0.500	---	101	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 101 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*106 %*		*50-150 %*		*"*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020602 - EPA 5030B							Water					
Blank (0020602-BLK1)		Prepared: 02/20/20 10:00 Analyzed: 02/20/20 11:55										
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	0.100	mg/L	1	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 101 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*106 %*		*50-150 %*		*"*						
LCS (0020602-BS2)		Prepared: 02/20/20 10:00 Analyzed: 02/20/20 11:28										
NWTPH-Gx (MS)												
Gasoline Range Organics	0.506	---	0.100	mg/L	1	0.500	---	101	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 102 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*106 %*		*50-150 %*		*"*						
Duplicate (0020602-DUP2)		Prepared: 02/20/20 11:47 Analyzed: 02/20/20 23:11										**T-02**
QC Source Sample: B-31 GW (A0B0557-21)												
NWTPH-Gx (MS)												
Gasoline Range Organics	**47.4**	---	5.00	mg/L	50	---	47.0	---	---	0.7	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 102 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*102 %*		*50-150 %*		*"*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020607 - EPA 5035A							Soil					
Blank (0020607-BLK1)		Prepared: 02/20/20 09:00 Analyzed: 02/20/20 13:33										
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	0.0667	mg/kg wet	1	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 101 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*93 %*		*50-150 %*		*"*						
LCS (0020607-BS2)		Prepared: 02/20/20 09:00 Analyzed: 02/20/20 13:06										
NWTPH-Gx (MS)												
Gasoline Range Organics	21.8	---	5.00	mg/kg wet	50	25.0	---	87	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 101 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*92 %*		*50-150 %*		*"*						
Duplicate (0020607-DUP1)		Prepared: 02/18/20 09:15 Analyzed: 02/20/20 20:45										
QC Source Sample: B-29(6.5) (A0B0557-01)												
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	6.89	mg/kg dry	50	---	ND	---	---	---	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 111 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*95 %*		*50-150 %*		*"*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020640 - EPA 5035A							**Soil**					
Blank (0020640-BLK1)		Prepared: 02/20/20 09:00 Analyzed: 02/20/20 16:14										
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	3.33	mg/kg wet	50	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*100 %*	*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*		*"*						
LCS (0020640-BS2)		Prepared: 02/20/20 09:00 Analyzed: 02/20/20 15:46										
NWTPH-Gx (MS)												
Gasoline Range Organics	22.1	---	5.00	mg/kg wet	50	25.0	---	89	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*99 %*	*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*		*"*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020657 - EPA 5035A							Soil					
Blank (0020657-BLK1)		Prepared: 02/21/20 09:00	Analyzed: 02/21/20 12:15									
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	3.33	mg/kg wet	50	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*103 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*94 %*		*50-150 %*		*"*					
LCS (0020657-BS2)		Prepared: 02/21/20 09:00	Analyzed: 02/21/20 11:48									
NWTPH-Gx (MS)												
Gasoline Range Organics	20.4	---	5.00	mg/kg wet	50	25.0	---	81	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*97 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*90 %*		*50-150 %*		*"*					

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020686 - EPA 5035A							Soil					
Blank (0020686-BLK1)		Prepared: 02/22/20 09:00	Analyzed: 02/22/20 13:03									
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	3.33	mg/kg wet	50	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*99 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*91 %*		*50-150 %*		*"*					
LCS (0020686-BS2)		Prepared: 02/22/20 09:00	Analyzed: 02/22/20 12:36									
NWTPH-Gx (MS)												
Gasoline Range Organics	20.2	---	5.00	mg/kg wet	50	25.0	---	81	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*98 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*89 %*		*50-150 %*		*"*					

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QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020693 - EPA 5035A							Soil					
Blank (0020693-BLK1)		Prepared: 02/23/20 09:00	Analyzed: 02/23/20 13:53									
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	3.33	mg/kg wet	50	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*99 %*	*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)			*89 %*	*50-150 %*		*"*						
LCS (0020693-BS2)		Prepared: 02/23/20 09:00	Analyzed: 02/23/20 13:26									
NWTPH-Gx (MS)												
Gasoline Range Organics	21.7	---	5.00	mg/kg wet	50	25.0	---	87	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*117 %*	*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*		*"*						
Duplicate (0020693-DUP2)		Prepared: 02/18/20 14:45	Analyzed: 02/23/20 20:10									
QC Source Sample: B-32(12) (A0B0557-11)												
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	7.44	mg/kg dry	50	---	ND	---	---	---	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*		*"*						

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QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020562 - EPA 5030B							**Water**					
Blank (0020562-BLK1)		Prepared: 02/21/20 10:00	Analyzed: 02/21/20 12:11									
EPA 8260C												
Benzene	ND	---	0.200	ug/L	1	---	---	---	---	---	---	
Toluene	ND	---	1.00	ug/L	1	---	---	---	---	---	---	
Ethylbenzene	ND	---	0.500	ug/L	1	---	---	---	---	---	---	
Xylenes, total	ND	---	1.50	ug/L	1	---	---	---	---	---	---	
Naphthalene	ND	---	2.00	ug/L	1	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*105 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*104 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*95 %*		*80-120 %*		*"*					
LCS (0020562-BS1)		Prepared: 02/21/20 10:00	Analyzed: 02/21/20 11:17									
EPA 8260C												
Benzene	20.0	---	0.200	ug/L	1	20.0	---	100	80 - 120%	---	---	
Toluene	18.7	---	1.00	ug/L	1	20.0	---	93	80 - 120%	---	---	
Ethylbenzene	18.8	---	0.500	ug/L	1	20.0	---	94	80 - 120%	---	---	
Xylenes, total	54.6	---	1.50	ug/L	1	60.0	---	91	80 - 120%	---	---	
Naphthalene	18.6	---	2.00	ug/L	1	20.0	---	93	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*102 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*99 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*90 %*		*80-120 %*		*"*					

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QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020602 - EPA 5030B							**Water**					
Blank (0020602-BLK1)		Prepared: 02/20/20 10:00	Analyzed: 02/20/20 11:55									
EPA 8260C												
Benzene	ND	---	0.200	ug/L	1	---	---	---	---	---	---	
Toluene	ND	---	1.00	ug/L	1	---	---	---	---	---	---	
Ethylbenzene	ND	---	0.500	ug/L	1	---	---	---	---	---	---	
Xylenes, total	ND	---	1.50	ug/L	1	---	---	---	---	---	---	
Naphthalene	ND	---	2.00	ug/L	1	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits:*	*80-120 %*	*Dilution:*	*1x*					
Toluene-d8 (Surr)			*105 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*95 %*		*80-120 %*		*"*					
LCS (0020602-BS1)		Prepared: 02/20/20 10:00	Analyzed: 02/20/20 11:00									
EPA 8260C												
Benzene	21.6	---	0.200	ug/L	1	20.0	---	108	80 - 120%	---	---	
Toluene	20.0	---	1.00	ug/L	1	20.0	---	100	80 - 120%	---	---	
Ethylbenzene	20.0	---	0.500	ug/L	1	20.0	---	100	80 - 120%	---	---	
Xylenes, total	57.9	---	1.50	ug/L	1	60.0	---	97	80 - 120%	---	---	
Naphthalene	19.3	---	2.00	ug/L	1	20.0	---	96	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*103 %*	*Limits:*	*80-120 %*	*Dilution:*	*1x*					
Toluene-d8 (Surr)			*99 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*90 %*		*80-120 %*		*"*					
Duplicate (0020602-DUP2)		Prepared: 02/20/20 11:47	Analyzed: 02/20/20 23:11									**T-02**
QC Source Sample: B-31 GW (A0B0557-21)												
EPA 8260C												
Benzene	**51.0**	---	10.0	ug/L	50	---	50.3	---	---	1	30%	
Toluene	**54.9**	---	50.0	ug/L	50	---	57.8	---	---	5	30%	
Ethylbenzene	**1010**	---	25.0	ug/L	50	---	1020	---	---	0.5	30%	
Xylenes, total	**2850**	---	75.0	ug/L	50	---	2880	---	---	1	30%	
Naphthalene	**1040**	---	100	ug/L	50	---	1040	---	---	0.3	30%	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*104 %*	*Limits:*	*80-120 %*	*Dilution:*	*1x*					
Toluene-d8 (Surr)			*100 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*92 %*		*80-120 %*		*"*					

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QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Batch 0020607 - EPA 5035A — **Soil**

Blank (0020607-BLK1) Prepared: 02/20/20 09:00 Analyzed: 02/20/20 13:33

5035A/8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Benzene	ND	---	6.67	ug/kg wet	50	---	---	---	---	---	---	
Toluene	ND	---	33.3	ug/kg wet	50	---	---	---	---	---	---	
Ethylbenzene	ND	---	16.7	ug/kg wet	50	---	---	---	---	---	---	
Xylenes, total	ND	---	50.0	ug/kg wet	50	---	---	---	---	---	---	
Naphthalene	ND	---	66.7	ug/kg wet	50	---	---	---	---	---	---	

Surr: 1,4-Difluorobenzene (Surr) Recovery: 108 % Limits: 80-120 % Dilution: 1x
Toluene-d8 (Surr) 96 % 80-120 % "
4-Bromofluorobenzene (Surr) 104 % 80-120 % "

LCS (0020607-BS1) Prepared: 02/20/20 09:00 Analyzed: 02/20/20 11:18

5035A/8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Benzene	1050	---	10.0	ug/kg wet	50	1000	---	105	80 - 120%	---	---	
Toluene	1020	---	50.0	ug/kg wet	50	1000	---	102	80 - 120%	---	---	
Ethylbenzene	1000	---	25.0	ug/kg wet	50	1000	---	100	80 - 120%	---	---	
Xylenes, total	3210	---	75.0	ug/kg wet	50	3000	---	107	80 - 120%	---	---	
Naphthalene	877	---	100	ug/kg wet	50	1000	---	88	80 - 120%	---	---	

Surr: 1,4-Difluorobenzene (Surr) Recovery: 107 % Limits: 80-120 % Dilution: 1x
Toluene-d8 (Surr) 93 % 80-120 % "
4-Bromofluorobenzene (Surr) 104 % 80-120 % "

Duplicate (0020607-DUP1) Prepared: 02/18/20 09:15 Analyzed: 02/20/20 20:45

QC Source Sample: B-29(6.5) (A0B0557-01)

5035A/8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Benzene	ND	---	13.8	ug/kg dry	50	---	ND	---	---	---	30%	
Toluene	ND	---	68.9	ug/kg dry	50	---	ND	---	---	---	30%	
Ethylbenzene	ND	---	34.4	ug/kg dry	50	---	ND	---	---	---	30%	
Xylenes, total	ND	---	103	ug/kg dry	50	---	ND	---	---	---	30%	
Naphthalene	ND	---	138	ug/kg dry	50	---	ND	---	---	---	30%	

Surr: 1,4-Difluorobenzene (Surr) Recovery: 110 % Limits: 80-120 % Dilution: 1x
Toluene-d8 (Surr) 92 % 80-120 % "
4-Bromofluorobenzene (Surr) 107 % 80-120 % "

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0557 - 03 03 20 1223

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020607 - EPA 5035A							Soil					
Matrix Spike (0020607-MS1)		Prepared: 02/18/20 10:00	Analyzed: 02/20/20 21:39									
QC Source Sample: B-29(11) (A0B0557-02)												
5035A/8260C												
Benzene	1500	---	15.4	ug/kg dry	50	1540	ND	98	77 - 121%	---	---	
Toluene	1380	---	76.9	ug/kg dry	50	1540	ND	90	77 - 121%	---	---	
Ethylbenzene	1440	---	38.4	ug/kg dry	50	1540	ND	94	76 - 122%	---	---	
Xylenes, total	4600	---	115	ug/kg dry	50	4610	ND	100	78 - 124%	---	---	
Naphthalene	1280	---	154	ug/kg dry	50	1540	ND	84	62 - 129%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*91 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*107 %*		*80-120 %*		*"*					

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020640 - EPA 5035A							Soil					
Blank (0020640-BLK1)		Prepared: 02/20/20 09:00	Analyzed: 02/20/20 16:14									
5035A/8260C												
Benzene	ND	---	6.67	ug/kg wet	50	---	---	---	---	---	---	
Toluene	ND	---	33.3	ug/kg wet	50	---	---	---	---	---	---	
Ethylbenzene	ND	---	16.7	ug/kg wet	50	---	---	---	---	---	---	
Xylenes, total	ND	---	50.0	ug/kg wet	50	---	---	---	---	---	---	
Naphthalene	ND	---	66.7	ug/kg wet	50	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits:*	*80-120 %*	*Dilution:*	*1x*					
Toluene-d8 (Surr)			*97 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*103 %*		*80-120 %*		*"*					
LCS (0020640-BS1)		Prepared: 02/20/20 09:00	Analyzed: 02/20/20 15:19									
5035A/8260C												
Benzene	1020	---	10.0	ug/kg wet	50	1000	---	102	80 - 120%	---	---	
Toluene	960	---	50.0	ug/kg wet	50	1000	---	96	80 - 120%	---	---	
Ethylbenzene	1010	---	25.0	ug/kg wet	50	1000	---	101	80 - 120%	---	---	
Xylenes, total	3100	---	75.0	ug/kg wet	50	3000	---	103	80 - 120%	---	---	
Naphthalene	899	---	100	ug/kg wet	50	1000	---	90	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits:*	*80-120 %*	*Dilution:*	*1x*					
Toluene-d8 (Surr)			*96 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*104 %*		*80-120 %*		*"*					

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020657 - EPA 5035A							**Soil**					
Blank (0020657-BLK1)		Prepared: 02/21/20 09:00	Analyzed: 02/21/20 12:15									
5035A/8260C												
Benzene	ND	---	6.67	ug/kg wet	50	---	---	---	---	---	---	
Toluene	ND	---	33.3	ug/kg wet	50	---	---	---	---	---	---	
Ethylbenzene	ND	---	16.7	ug/kg wet	50	---	---	---	---	---	---	
Xylenes, total	ND	---	50.0	ug/kg wet	50	---	---	---	---	---	---	
Naphthalene	ND	---	66.7	ug/kg wet	50	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*94 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*106 %*		*80-120 %*		*"*					
LCS (0020657-BS1)		Prepared: 02/21/20 09:00	Analyzed: 02/21/20 11:21									
5035A/8260C												
Benzene	993	---	10.0	ug/kg wet	50	1000	---	99	80 - 120%	---	---	
Toluene	971	---	50.0	ug/kg wet	50	1000	---	97	80 - 120%	---	---	
Ethylbenzene	1020	---	25.0	ug/kg wet	50	1000	---	102	80 - 120%	---	---	
Xylenes, total	3200	---	75.0	ug/kg wet	50	3000	---	107	80 - 120%	---	---	
Naphthalene	850	---	100	ug/kg wet	50	1000	---	85	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*104 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*94 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*103 %*		*80-120 %*		*"*					
Matrix Spike (0020657-MS1)		Prepared: 02/18/20 11:20	Analyzed: 02/21/20 19:26									
QC Source Sample: B-31(6.5) (A0B0557-07)												
5035A/8260C												
Benzene	1450	---	14.6	ug/kg dry	50	1460	ND	99	77 - 121%	---	---	
Toluene	1340	---	73.1	ug/kg dry	50	1460	ND	92	77 - 121%	---	---	
Ethylbenzene	1390	---	36.6	ug/kg dry	50	1460	ND	95	76 - 122%	---	---	
Xylenes, total	4460	---	110	ug/kg dry	50	4380	ND	102	78 - 124%	---	---	
Naphthalene	1230	---	146	ug/kg dry	50	1460	ND	84	62 - 129%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*91 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*106 %*		*80-120 %*		*"*					

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5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020686 - EPA 5035A							**Soil**					
Blank (0020686-BLK1)		Prepared: 02/22/20 09:00	Analyzed: 02/22/20 13:03									
5035A/8260C												
Benzene	ND	---	6.67	ug/kg wet	50	---	---	---	---	---	---	
Toluene	ND	---	33.3	ug/kg wet	50	---	---	---	---	---	---	
Ethylbenzene	ND	---	16.7	ug/kg wet	50	---	---	---	---	---	---	
Xylenes, total	ND	---	50.0	ug/kg wet	50	---	---	---	---	---	---	
Naphthalene	ND	---	66.7	ug/kg wet	50	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*96 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*106 %*		*80-120 %*		*"*					
LCS (0020686-BS1)		Prepared: 02/22/20 09:00	Analyzed: 02/22/20 12:09									
5035A/8260C												
Benzene	1010	---	10.0	ug/kg wet	50	1000	---	101	80 - 120%	---	---	
Toluene	988	---	50.0	ug/kg wet	50	1000	---	99	80 - 120%	---	---	
Ethylbenzene	1010	---	25.0	ug/kg wet	50	1000	---	101	80 - 120%	---	---	
Xylenes, total	3220	---	75.0	ug/kg wet	50	3000	---	107	80 - 120%	---	---	
Naphthalene	920	---	100	ug/kg wet	50	1000	---	92	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*95 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*104 %*		*80-120 %*		*"*					

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Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0557 - 03 03 20 1223

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020693 - EPA 5035A							**Soil**					
Blank (0020693-BLK1)		Prepared: 02/23/20 09:00 Analyzed: 02/23/20 13:53										
5035A/8260C												
Benzene	ND	---	6.67	ug/kg wet	50	---	---	---	---	---	---	
Toluene	ND	---	33.3	ug/kg wet	50	---	---	---	---	---	---	
Ethylbenzene	ND	---	16.7	ug/kg wet	50	---	---	---	---	---	---	
Xylenes, total	ND	---	50.0	ug/kg wet	50	---	---	---	---	---	---	
Naphthalene	ND	---	66.7	ug/kg wet	50	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*96 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*109 %*		*80-120 %*		*"*					
LCS (0020693-BS1)		Prepared: 02/23/20 09:00 Analyzed: 02/23/20 13:00										
5035A/8260C												
Benzene	1010	---	10.0	ug/kg wet	50	1000	---	101	80 - 120%	---	---	
Toluene	959	---	50.0	ug/kg wet	50	1000	---	96	80 - 120%	---	---	
Ethylbenzene	986	---	25.0	ug/kg wet	50	1000	---	99	80 - 120%	---	---	
Xylenes, total	3130	---	75.0	ug/kg wet	50	3000	---	104	80 - 120%	---	---	
Naphthalene	905	---	100	ug/kg wet	50	1000	---	90	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*95 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*107 %*		*80-120 %*		*"*					
Duplicate (0020693-DUP2)		Prepared: 02/18/20 14:45 Analyzed: 02/23/20 20:10										
QC Source Sample: B-32(12) (A0B0557-11)												
5035A/8260C												
Benzene	ND	---	14.9	ug/kg dry	50	---	ND	---	---	---	30%	
Toluene	ND	---	74.4	ug/kg dry	50	---	ND	---	---	---	30%	
Ethylbenzene	ND	---	37.2	ug/kg dry	50	---	ND	---	---	---	30%	
Xylenes, total	ND	---	112	ug/kg dry	50	---	ND	---	---	---	30%	
Naphthalene	ND	---	149	ug/kg dry	50	---	ND	---	---	---	30%	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*93 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*105 %*		*80-120 %*		*"*					

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Lisa Domenighini, Client Services Manager

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020666 - Total Solids (Dry Weight)							**Soil**					
Duplicate (0020666-DUP2)		Prepared: 02/21/20 12:09 Analyzed: 02/24/20 08:36										
QC Source Sample: B-31(6.5) (A0B0557-07)												
EPA 8000C												
% Solids	**73.1**	---	1.00	%	1	---	72.9	---	---	0.3	10%	

No Client related Batch QC samples analyzed for this batch. See notes page for more information.

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020671 - Total Solids (Dry Weight)							**Soil**					
Duplicate (0020671-DUP1)		Prepared: 02/21/20 12:51 Analyzed: 02/21/20 15:00										
QC Source Sample: B-29(11) (A0B0557-02)												
EPA 8000C												
% Solids	**72.2**	---	1.00	%	1	---	71.7	---	---	0.7	10%	

No Client related Batch QC samples analyzed for this batch. See notes page for more information.

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5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

SAMPLE PREPARATION INFORMATION

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Prep: EPA 3510C (Fuels/Acid Ext.)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020661							
A0B0557-19	Water	NWTPH-Dx LL	02/18/20 11:10	02/21/20 11:12	1070mL/2mL	1000mL/2mL	0.94
A0B0557-20	Water	NWTPH-Dx LL	02/19/20 09:45	02/21/20 11:12	1070mL/2mL	1000mL/2mL	0.94
A0B0557-21	Water	NWTPH-Dx LL	02/18/20 13:40	02/21/20 11:12	1070mL/2mL	1000mL/2mL	0.94
A0B0557-22	Water	NWTPH-Dx LL	02/18/20 15:40	02/21/20 11:12	1010mL/2mL	1000mL/2mL	0.99
A0B0557-23	Water	NWTPH-Dx LL	02/19/20 12:15	02/21/20 11:12	1060mL/2mL	1000mL/2mL	0.94
A0B0557-24	Water	NWTPH-Dx LL	02/19/20 14:45	02/21/20 11:12	1070mL/2mL	1000mL/2mL	0.94

Prep: EPA 3546 (Fuels)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020749							
A0B0557-01	Soil	NWTPH-Dx	02/18/20 09:15	02/25/20 07:30	10.15g/5mL	10g/5mL	0.99
A0B0557-02	Soil	NWTPH-Dx	02/18/20 10:00	02/25/20 07:30	10.31g/5mL	10g/5mL	0.97
A0B0557-03	Soil	NWTPH-Dx	02/18/20 10:15	02/25/20 07:30	10.21g/5mL	10g/5mL	0.98
A0B0557-04RE1	Soil	NWTPH-Dx	02/18/20 14:05	02/25/20 07:30	10.31g/5mL	10g/5mL	0.97
A0B0557-05	Soil	NWTPH-Dx	02/19/20 08:30	02/25/20 07:30	10.58g/5mL	10g/5mL	0.95
A0B0557-06	Soil	NWTPH-Dx	02/19/20 08:35	02/25/20 07:30	10.52g/5mL	10g/5mL	0.95
A0B0557-07	Soil	NWTPH-Dx	02/18/20 11:20	02/25/20 07:30	10.63g/5mL	10g/5mL	0.94
A0B0557-08RE1	Soil	NWTPH-Dx	02/18/20 12:15	02/25/20 07:30	10.71g/5mL	10g/5mL	0.93
A0B0557-09	Soil	NWTPH-Dx	02/18/20 12:40	02/25/20 07:30	10.88g/5mL	10g/5mL	0.92
Batch: 0020758							
A0B0557-10	Soil	NWTPH-Dx	02/18/20 14:40	02/25/20 13:01	10.68g/5mL	10g/5mL	0.94
A0B0557-11	Soil	NWTPH-Dx	02/18/20 14:45	02/25/20 13:01	10.61g/5mL	10g/5mL	0.94
A0B0557-12	Soil	NWTPH-Dx	02/18/20 15:00	02/25/20 13:01	10.22g/5mL	10g/5mL	0.98
A0B0557-13	Soil	NWTPH-Dx	02/19/20 09:15	02/25/20 13:01	10.45g/5mL	10g/5mL	0.96
A0B0557-14	Soil	NWTPH-Dx	02/19/20 10:50	02/25/20 13:01	10.3g/5mL	10g/5mL	0.97
A0B0557-15	Soil	NWTPH-Dx	02/19/20 11:00	02/25/20 13:01	10.73g/5mL	10g/5mL	0.93
A0B0557-16	Soil	NWTPH-Dx	02/19/20 10:55	02/25/20 13:01	10.9g/5mL	10g/5mL	0.92
A0B0557-17	Soil	NWTPH-Dx	02/19/20 13:15	02/25/20 13:01	10.3g/5mL	10g/5mL	0.97
A0B0557-18	Soil	NWTPH-Dx	02/19/20 13:30	02/25/20 13:01	10.47g/5mL	10g/5mL	0.96

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Prep: EPA 3510C (Fuels/Acid Ext.) w/Silica Gel

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020825							

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

SAMPLE PREPARATION INFORMATION

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Prep: EPA 3510C (Fuels/Acid Ext.) w/Silica Gel

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0557-19	Water	NWTPH-Dx/SGC	02/18/20 11:10	02/21/20 11:12			0.94
A0B0557-20	Water	NWTPH-Dx/SGC	02/19/20 09:45	02/21/20 11:12			0.94
A0B0557-21RE1	Water	NWTPH-Dx/SGC	02/18/20 13:40	02/21/20 11:12			0.94
A0B0557-22	Water	NWTPH-Dx/SGC	02/18/20 15:40	02/21/20 11:12			0.99
A0B0557-23	Water	NWTPH-Dx/SGC	02/19/20 12:15	02/21/20 11:12			0.94
A0B0557-24	Water	NWTPH-Dx/SGC	02/19/20 14:45	02/21/20 11:12			0.94

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Prep: EPA 5030B

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020562							
A0B0557-20	Water	NWTPH-Gx (MS)	02/19/20 09:45	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
A0B0557-23RE1	Water	NWTPH-Gx (MS)	02/19/20 12:15	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
A0B0557-24	Water	NWTPH-Gx (MS)	02/19/20 14:45	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
Batch: 0020602							
A0B0557-19	Water	NWTPH-Gx (MS)	02/18/20 11:10	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00
A0B0557-21	Water	NWTPH-Gx (MS)	02/18/20 13:40	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00
A0B0557-22	Water	NWTPH-Gx (MS)	02/18/20 15:40	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020607							
A0B0557-01	Soil	NWTPH-Gx (MS)	02/18/20 09:15	02/18/20 09:15	6.05g/5mL	5g/5mL	0.83
A0B0557-02	Soil	NWTPH-Gx (MS)	02/18/20 10:00	02/18/20 10:00	6.1g/5mL	5g/5mL	0.82
A0B0557-04	Soil	NWTPH-Gx (MS)	02/18/20 14:05	02/18/20 14:05	6.92g/5mL	5g/5mL	0.72
A0B0557-05	Soil	NWTPH-Gx (MS)	02/19/20 08:30	02/19/20 08:30	6.61g/5mL	5g/5mL	0.76
Batch: 0020640							
A0B0557-03	Soil	NWTPH-Gx (MS)	02/18/20 10:15	02/18/20 10:15	6.27g/5mL	5g/5mL	0.80
Batch: 0020657							
A0B0557-07	Soil	NWTPH-Gx (MS)	02/18/20 11:20	02/18/20 11:20	6.29g/5mL	5g/5mL	0.80
A0B0557-09	Soil	NWTPH-Gx (MS)	02/18/20 12:40	02/18/20 12:40	6.43g/5mL	5g/5mL	0.78
A0B0557-10	Soil	NWTPH-Gx (MS)	02/18/20 14:40	02/18/20 14:40	5.77g/5mL	5g/5mL	0.87
Batch: 0020686							
A0B0557-06RE1	Soil	NWTPH-Gx (MS)	02/19/20 08:35	02/19/20 08:35	6.75g/5mL	5g/5mL	0.74

Apex Laboratories

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Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project:	**Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number:	0060-001-005	**Report ID:**
Portland, OR 97239	Project Manager:	Amanda Spencer	A0B0557 - 03 03 20 1223

SAMPLE PREPARATION INFORMATION

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0557-08RE1	Soil	NWTPH-Gx (MS)	02/18/20 12:15	02/18/20 12:15	6.4g/5mL	5g/5mL	0.78
Batch: 0020693							
A0B0557-11	Soil	NWTPH-Gx (MS)	02/18/20 14:45	02/18/20 14:45	5.68g/5mL	5g/5mL	0.88
A0B0557-12	Soil	NWTPH-Gx (MS)	02/18/20 15:00	02/18/20 15:00	7.15g/5mL	5g/5mL	0.70
A0B0557-13	Soil	NWTPH-Gx (MS)	02/19/20 09:15	02/19/20 09:15	6.4g/5mL	5g/5mL	0.78
A0B0557-14	Soil	NWTPH-Gx (MS)	02/19/20 10:50	02/19/20 10:50	6.16g/5mL	5g/5mL	0.81
A0B0557-15	Soil	NWTPH-Gx (MS)	02/19/20 11:00	02/19/20 11:00	6.24g/5mL	5g/5mL	0.80
A0B0557-16	Soil	NWTPH-Gx (MS)	02/19/20 10:55	02/19/20 10:55	6.11g/5mL	5g/5mL	0.82
A0B0557-17	Soil	NWTPH-Gx (MS)	02/19/20 13:15	02/19/20 13:15	6.43g/5mL	5g/5mL	0.78
A0B0557-18	Soil	NWTPH-Gx (MS)	02/19/20 13:30	02/19/20 13:30	6.28g/5mL	5g/5mL	0.80

BTEX+N Compounds by EPA 8260C

Prep: EPA 5030B

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020562							
A0B0557-20	Water	EPA 8260C	02/19/20 09:45	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
A0B0557-23RE1	Water	EPA 8260C	02/19/20 12:15	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
A0B0557-24	Water	EPA 8260C	02/19/20 14:45	02/21/20 11:46	5mL/5mL	5mL/5mL	1.00
Batch: 0020602							
A0B0557-19	Water	EPA 8260C	02/18/20 11:10	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00
A0B0557-21	Water	EPA 8260C	02/18/20 13:40	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00
A0B0557-22	Water	EPA 8260C	02/18/20 15:40	02/20/20 11:47	5mL/5mL	5mL/5mL	1.00

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020607							
A0B0557-01	Soil	5035A/8260C	02/18/20 09:15	02/18/20 09:15	6.05g/5mL	5g/5mL	0.83
A0B0557-02	Soil	5035A/8260C	02/18/20 10:00	02/18/20 10:00	6.1g/5mL	5g/5mL	0.82
A0B0557-04	Soil	5035A/8260C	02/18/20 14:05	02/18/20 14:05	6.92g/5mL	5g/5mL	0.72
A0B0557-05	Soil	5035A/8260C	02/19/20 08:30	02/19/20 08:30	6.61g/5mL	5g/5mL	0.76
Batch: 0020640							
A0B0557-03	Soil	5035A/8260C	02/18/20 10:15	02/18/20 10:15	6.27g/5mL	5g/5mL	0.80
Batch: 0020657							
A0B0557-07	Soil	5035A/8260C	02/18/20 11:20	02/18/20 11:20	6.29g/5mL	5g/5mL	0.80

Apex Laboratories

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Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

SAMPLE PREPARATION INFORMATION

BTEX+N Compounds by EPA 8260C

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0557-08	Soil	5035A/8260C	02/18/20 12:15	02/18/20 12:15	6.4g/5mL	5g/5mL	0.78
A0B0557-09	Soil	5035A/8260C	02/18/20 12:40	02/18/20 12:40	6.43g/5mL	5g/5mL	0.78
A0B0557-10	Soil	5035A/8260C	02/18/20 14:40	02/18/20 14:40	5.77g/5mL	5g/5mL	0.87
Batch: 0020686							
A0B0557-06RE1	Soil	5035A/8260C	02/19/20 08:35	02/19/20 08:35	6.75g/5mL	5g/5mL	0.74
A0B0557-08RE1	Soil	5035A/8260C	02/18/20 12:15	02/18/20 12:15	6.4g/5mL	5g/5mL	0.78
Batch: 0020693							
A0B0557-11	Soil	5035A/8260C	02/18/20 14:45	02/18/20 14:45	5.68g/5mL	5g/5mL	0.88
A0B0557-12	Soil	5035A/8260C	02/18/20 15:00	02/18/20 15:00	7.15g/5mL	5g/5mL	0.70
A0B0557-13	Soil	5035A/8260C	02/19/20 09:15	02/19/20 09:15	6.4g/5mL	5g/5mL	0.78
A0B0557-14	Soil	5035A/8260C	02/19/20 10:50	02/19/20 10:50	6.16g/5mL	5g/5mL	0.81
A0B0557-15	Soil	5035A/8260C	02/19/20 11:00	02/19/20 11:00	6.24g/5mL	5g/5mL	0.80
A0B0557-16	Soil	5035A/8260C	02/19/20 10:55	02/19/20 10:55	6.11g/5mL	5g/5mL	0.82
A0B0557-17	Soil	5035A/8260C	02/19/20 13:15	02/19/20 13:15	6.43g/5mL	5g/5mL	0.78
A0B0557-18	Soil	5035A/8260C	02/19/20 13:30	02/19/20 13:30	6.28g/5mL	5g/5mL	0.80

Percent Dry Weight

Prep: Total Solids (Dry Weight)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020666							
A0B0557-01	Soil	EPA 8000C	02/18/20 09:15	02/21/20 12:09			NA
A0B0557-03	Soil	EPA 8000C	02/18/20 10:15	02/21/20 12:09			NA
A0B0557-04	Soil	EPA 8000C	02/18/20 14:05	02/21/20 12:09			NA
A0B0557-05	Soil	EPA 8000C	02/19/20 08:30	02/21/20 12:09			NA
A0B0557-06	Soil	EPA 8000C	02/19/20 08:35	02/21/20 12:09			NA
A0B0557-07	Soil	EPA 8000C	02/18/20 11:20	02/21/20 12:09			NA
A0B0557-08	Soil	EPA 8000C	02/18/20 12:15	02/21/20 12:09			NA
A0B0557-09	Soil	EPA 8000C	02/18/20 12:40	02/21/20 12:09			NA
A0B0557-10	Soil	EPA 8000C	02/18/20 14:40	02/21/20 12:09			NA
A0B0557-11	Soil	EPA 8000C	02/18/20 14:45	02/21/20 12:09			NA
A0B0557-12	Soil	EPA 8000C	02/18/20 15:00	02/21/20 12:09			NA
A0B0557-13	Soil	EPA 8000C	02/19/20 09:15	02/21/20 12:09			NA
A0B0557-14	Soil	EPA 8000C	02/19/20 10:50	02/21/20 12:10			NA
A0B0557-15	Soil	EPA 8000C	02/19/20 11:00	02/21/20 12:10			NA
A0B0557-16	Soil	EPA 8000C	02/19/20 10:55	02/21/20 12:10			NA

Apex Laboratories

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Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

SAMPLE PREPARATION INFORMATION

Percent Dry Weight

Prep: Total Solids (Dry Weight)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0557-17	Soil	EPA 8000C	02/19/20 13:15	02/21/20 12:10			NA
A0B0557-18	Soil	EPA 8000C	02/19/20 13:30	02/21/20 12:10			NA
Batch: 0020671							
A0B0557-02	Soil	EPA 8000C	02/18/20 10:00	02/21/20 12:53			NA

QUALIFIER DEFINITIONS

Client Sample and Quality Control (QC) Sample Qualifier Definitions:

Apex Laboratories

F-13	The chromatographic pattern does not resemble the fuel standard used for quantitation
F-20	Result for Diesel is Estimated due to overlap from Gasoline Range Organics or other VOCs.
M-04	Due to matrix interference, this analyte cannot be accurately quantified. The reported result may contain a high bias.
Q-19	Blank Spike Duplicate (BSD) sample analyzed in place of Matrix Spike/Duplicate samples due to limited sample amount available for analysis.
Q-31	Estimated Results. Recovery of Continuing Calibration Verification sample below lower control limit for this analyte. Results are likely biased low.
S-01	Surrogate recovery for this sample is not available due to sample dilution required from high analyte concentration and/or matrix interference.
S-05	Surrogate recovery is estimated due to sample dilution required for high analyte concentration and/or matrix interference.
T-02	This Batch QC sample was analyzed outside of the method specified 12 hour tune window. Results are estimated.

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Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0557 - 03 03 20 1223**

REPORTING NOTES AND CONVENTIONS:

Abbreviations:

DET Analyte DETECTED at or above the detection or reporting limit.
ND Analyte NOT DETECTED at or above the detection or reporting limit.
NR Result Not Reported.
RPD Relative Percent Difference. RPDs for Matrix Spikes and Matrix Spike Duplicates are based on concentration, not recovery.

Detection Limits: Limit of Detection (LOD)

Limits of Detection (LODs) are normally set at a level of one half the validated Limit of Quantitation (LOQ).
If no value is listed ('-----'), then the data has not been evaluated below the Reporting Limit.

Reporting Limits: Limit of Quantitation (LOQ)

Validated Limits of Quantitation (LOQs) are reported as the Reporting Limits for all analyses where the LOQ, MRL, PQL or CRL are requested. The LOQ represents a level at or above the low point of the calibration curve, that has been validated according to Apex Laboratories' comprehensive LOQ policies and procedures.

Reporting Conventions:

Basis: Results for soil samples are generally reported on a 100% dry weight basis.
The Result Basis is listed following the units as " dry", " wet", or " " (blank) designation.

" dry" Sample results and Reporting Limits are reported on a dry weight basis. (i.e. "ug/kg dry")
See Percent Solids section for details of dry weight analysis.
" wet" Sample results and Reporting Limits for this analysis are normally dry weight corrected, but have not been modified in this case.
"   " Results without 'wet' or 'dry' designation are not normally dry weight corrected. These results are considered 'As Received'.

QC Source:

In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) may be analyzed to demonstrate accuracy and precision of the extraction batch.

Non-Client Batch QC Samples (Duplicates and Matrix Spike/Duplicates) are not included in this report. Please request a Full QC report if this data is required.

Miscellaneous Notes:

" --- " QC results are not applicable. For example, % Recoveries for Blanks and Duplicates, % RPD for Blanks, Blank Spikes and Matrix Spikes, etc.

" *** " Used to indicate a possible discrepancy with the Sample and Sample Duplicate results when the %RPD is not available. In this case, either the Sample or the Sample Duplicate has a reportable result for this analyte, while the other is Non Detect (ND).

Blanks:

Standard practice is to evaluate the results from Blank QC Samples down to a level equal to ½ the Reporting Limit (RL).
-For Blank hits falling between ½ the RL and the RL (J flagged hits), the associated sample and QC data will receive a 'B-02' qualifier.
-For Blank hits above the RL, the associated sample and QC data will receive a 'B' qualifier, per Apex Laboratories' Blank Policy.
For further details, please request a copy of this document.

Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0557 - 03 03 20 1223**

REPORTING NOTES AND CONVENTIONS (Cont.):

Blanks (Cont.):

Sample results flagged with a 'B' or 'B-02' qualifier are potentially biased high if the sample results are less than ten times the level found in the blank for inorganic analyses, or less than five times the level found in the blank for organic analyses.

‘B’ and ‘B-02’ qualifications are only applied to sample results detected above the Reporting Level.

Preparation Notes:

Mixed Matrix Samples:

Water Samples:

Water samples containing significant amounts of sediment are decanted or separated prior to extraction, and only the water portion analyzed, unless otherwise directed by the client.

Soil and Sediment Samples:

Soil and Sediment samples containing significant amounts of water are decanted prior to extraction, and only the solid portion analyzed, unless otherwise directed by the client.

Sampling and Preservation Notes:

Certain regulatory programs, such as National Pollutant Discharge Elimination System (NPDES), require that activities such as sample filtration (for dissolved metals, orthophosphate, hexavalent chromium, etc.) and testing of short hold analytes (pH, Dissolved Oxygen, etc.) be performed in the field (on-site) within a short time window. In addition, sample matrix spikes are required for some analyses, and sufficient volume must be provided, and billable site specific QC requested, if this is required. All regulatory permits should be reviewed to ensure that these requirements are being met.

Data users should be aware of which regulations pertain to the samples they submit for testing. If related sample collection activities are not approved for a particular regulatory program, results should be considered estimates. Apex Laboratories will qualify these analytes according to the most stringent requirements, however results for samples that are for non-regulatory purposes may be acceptable.

Samples that have been filtered and preserved at Apex Laboratories per client request are listed in the preparation section of the report with the date and time of filtration listed.

Apex Laboratories maintains detailed records on sample receipt, including client label verification, cooler temperature, sample preservation, hold time compliance and field filtration. Data is qualified as necessary, and the lack of qualification indicates compliance with required parameters.

Apex Laboratories, LLC

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

LABORATORY ACCREDITATION INFORMATION

TNI Certification ID: OR100062 (Primary Accreditation) - EPA ID: OR01039

All methods and analytes reported from work performed at Apex Laboratories are included on Apex Laboratories' ORELAP Scope of Certification, with the exception of any analyte(s) listed below:

Apex Laboratories

Matrix	Analysis	TNI_ID	Analyte	TNI_ID	Accreditation

All reported analytes are included in Apex Laboratories' current ORELAP scope.

Secondary Accreditations

Apex Laboratories also maintains reciprocal accreditation with non-TNI states (Washington DOE), as well as other state specific accreditations not listed here.

Subcontract Laboratory Accreditations

Subcontracted data falls outside of Apex Laboratories' Scope of Accreditation.
Please see the Subcontract Laboratory report for full details, or contact your Project Manager for more information.

Field Testing Parameters

Results for Field Tested data are provded by the client or sampler, and fall outside of Apex Laboratories' Scope of Accreditation.

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

APEX LABS
6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

CHAIN OF CUSTODY

Lab # A0B0557 COC 1 of 3

Company: Cascadia Associates | Project Mgr: Amanda Spencer | Project Name: Nustar - Vancouver Annex | Project #: 0060-001-005

Address: 5820 SW Kelly Ave., Suite B | Phone: 503.906.6577 | Email: aSpencer@CascadiaAssociates.com | PO #

Sampled by: Ian Maguire

Site Location: OR WA CA

AK ID ___

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	Naphthalene by EPA 8260							Archive
B-29 (6.5)		2/18/20	915	S	3		X	X	X												X							
B-29 (11)		2/18/20	1000	S	3		X	X	X												X							
B-29 (21)		2/18/20	1015	S	3		X	X	X												X							
B-30 (4.5)		2/18/20	1405	S	3		X	X	X												X							
B-30 (16)		2/19/20	830	S	3		X	X	X												X							
B-30 (21.5)		2/19/20	835	S	3		X	X	X												X							
B-31 (6.5)		2/18/20	1120	S	3		X	X	X												X							
B-31 (14)		2/18/20	1215	S	3		X	X	X												X							
B-31 (21.5)		2/18/20	1240	S	3		X	X	X												X							
B-32 (9)		2/18/20	1440	S	3		X	X	X												X							

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle): 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ______

SPECIAL INSTRUCTIONS:
No Silica gel Cleanup on TPH Dx analysis for Soil Samples

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature] Date: 2/20/20	Signature: [signature] Date: 2/20/20	Signature: Date:	Signature: Date:
Printed Name: Ian Maguire Time: 1055	Printed Name: Charles Hubbard Time: 1055	Printed Name: Time:	Printed Name: Time:
Company: Cascadia Associates	Company: Apex	Company:	Company:

Apex Laboratories, LLC

6700 S.W. Sandburg Street
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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

APEX LABS

6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

CHAIN OF CUSTODY

Lab # A0B0557 COC 2 of 3

Company: Cascadia Associates | Project Mgr: Amanda Spencer | Project Name: Nustar-Vancouver Annex | Project #: 0060-001-005

Address: 5820 SW Kelly Ave., Suite B | Phone: 503.906.6577 | Email: aspencer@cascadiaassociates.com | PO #

Sampled by: Ian Maguire

Site Location: OR (WA) CA

AK ID ___

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	Naphthalene by EPA 8260	Archive
B-32 (12)		2/18/20	1445	S	3		X	X	X												X	
B-32 (21)		2/18/20	1500	S	3		X	X	X												X	
B-33 (6.5)		2/19/20	915	S	3		X	X	X												X	
B-33 (18)		2/19/20	~~1045~~ 1050	S	3		X	X	X												X	
B-33 (20)		2/19/20	1100	S	3		X	X	X												X	
B-34 ~~1055~~ (6.5)		2/19/20	1055	S	3		X	X	X												X	
B-34 ~~1315~~ (18)		2/19/20	1315	S	3		X	X	X												X	
B-34 ~~1330~~ (20)		2/19/20	1330	S	3		X	X	X												X	

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle): 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ______

SPECIAL INSTRUCTIONS:
No Silica gel cleanup on TPH_{Dx} analysis for Soil Samples.

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature] Date: 2/20/20	Signature: [signature] Date: 2/20/20	Signature: Date:	Signature: Date:
Printed Name: Ian Maguire Time: 1055	Printed Name: Charles Hoffman Time: 1055	Printed Name: Time:	Printed Name: Time:
Company: Cascadia Associates	Company: Apex Labs	Company:	Company:

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0557 - 03 03 20 1223**

APEX LABS
6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

CHAIN OF CUSTODY

Lab # A0B0557 COC 3 of 3

Company: Cascadia Associates | Project Mgr: Amanda Spencer | Project Name: Nustar Vancouver Annex | Project #: 0060-001-005

Address: 5820 SW Kelly Ave, Suite B | Phone: 503.906.6577 | Email: aspencer@cascadiaassociates.com | PO #

Sampled by: Ian Maguine

Site Location: OR WA CA

AK ID ___

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	~~NWTPH-Dx~~	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	NWTPH-Dx w/ SG cleanup	NWTPH-Dx w/o SG cleanup	Naphthalene by EPA 8260					Archive
B-29 GW		2/18/20	1110	GW	5			X	X												X	X	X					
B-30 GW		2/19/20	945	GW	5			X	X												X	X	X					
B-31 GW		2/18/20	1340	GW	5			X	X												X	X	X					
B-32 GW		2/18/20	1540	GW	5			X	X												X	X	X					
B-33 GW		2/19/20	1215	GW	5			X	X												X	X	X					
B-34 GW		2/19/20	1445	GW	5			X	X												X	X	X					

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle): 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ______

SPECIAL INSTRUCTIONS:
Please run TPH$_{Dx}$ both with and without Silica gel cleanup on groundwater samples.

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature] Date: 2/20/20	Signature: [signature] Date: 2/20/20	Signature: Date:	Signature: Date:
Printed Name: Ian Maguine Time: 1055	Printed Name: Charles Nettleton Time: 1055	Printed Name: Time:	Printed Name: Time:
Company: Cascadia Associates	Company: Apex	Company:	Company:

APEX LABS COOLER RECEIPT FORM

Client: Cascadia Element WO#: A0 B0557

Project/Project #: Nustar - Vancouver Annex 0060-001-005

Delivery Info:

Date/time received: 2/20/20 @ 1035 By: CFH

Delivered by: Apex X Client___ESS___FedEx___UPS___Swift___Senvoy___SDS___Other___

Cooler Inspection Date/time inspected: 2/20/20 @ 1300 By: CFH

Chain of Custody included? Yes X No ___ Custody seals? Yes___ No X

Signed/dated by client? Yes X No ___

Signed/dated by Apex? Yes X No ___

	Cooler #1	Cooler #2	Cooler #3	Cooler #4	Cooler #5	Cooler #6	Cooler #7
Temperature (°C)	5.6	4.4					
Received on ice? (Y/N)	Y	Y					
Temp. blanks? (Y/N)	Y	Y					
Ice type: (Gel/Real/Other)	Real	Real					
Condition:	Good	Good					

Cooler out of temp? (Y/N) Possible reason why: ___

If some coolers are in temp and some out, were green dots applied to out of temperature samples? Yes/No/NA

Out of temperature samples form initiated? Yes/No/NA

Samples Inspection: Date/time inspected: 2/20/20 @ 1356 By: AKK

All samples intact? Yes X No ___ Comments: ___

Bottle labels/COCs agree? Yes ___ No X Comments: 2 Trip Blanks #2253 Provided, not on COC.

COC/container discrepancies form initiated? Yes ___ No X NA ___

Containers/volumes received appropriate for analysis? Yes X No ___ Comments: ___

Do VOA vials have visible headspace? Yes ___ No X NA ___

Comments 18/20 Sed. no Sed in TB's.

Water samples: pH checked: Yes X No___NA___ pH appropriate? Yes X No___NA___

Comments: ___

Additional information: ___

Labeled by: AKK Witness: b Cooler Inspected by: AKK See Project Contact Form: Y

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Monday, March 2, 2020

Amanda Spencer
Cascadia Associates
5820 SW Kelly Ave Unit B
Portland, OR 97239

RE: A0B0617 - Nustar Vannex - 0060-001-005

Thank you for using Apex Laboratories. We greatly appreciate your business and strive to provide the highest quality services to the environmental industry.

Enclosed are the results of analyses for work order A0B0617, which was received by the laboratory on 2/21/2020 at 5:50:00PM.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: ldomenighini@apex-labs.com, or by phone at 503-718-2323.

Please note: All samples will be disposed of within 30 days of sample reciept, unless prior arrangements have been made.

Cooler Receipt Information

(See Cooler Receipt Form for details)

Cooler #1	5.8 degC	Cooler #2	3.4 degC

This Final Report is the official version of the data results for this sample submission, unless superseded by a subsequent, labeled amended report.
All other deliverables derived from this data, including Electronic Data Deliverables (EDDs), CLP-like forms, client requested summary sheets, and all other products are considered secondary to this report.

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: 0060-001-005	**Report ID:**
Portland, OR 97239	Project Manager: Amanda Spencer	A0B0617 - 03 02 20 0958

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Client Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
B-35(6)	A0B0617-01	Soil	02/21/20 08:50	02/21/20 17:50
B-35(9)	A0B0617-02	Soil	02/21/20 08:55	02/21/20 17:50
B-35(19)	A0B0617-03	Soil	02/21/20 09:05	02/21/20 17:50
B-36(6)	A0B0617-04	Soil	02/21/20 09:20	02/21/20 17:50
B-36(14)	A0B0617-05	Soil	02/21/20 11:05	02/21/20 17:50
B-36(20)	A0B0617-06	Soil	02/21/20 11:40	02/21/20 17:50
B-37(6)	A0B0617-07	Soil	02/21/20 11:25	02/21/20 17:50
B-37(13)	A0B0617-08	Soil	02/21/20 12:20	02/21/20 17:50
B-37(21)	A0B0617-09	Soil	02/21/20 12:35	02/21/20 17:50
B-38(6)	A0B0617-10	Soil	02/21/20 11:55	02/21/20 17:50
B-38(13)	A0B0617-11	Soil	02/21/20 14:10	02/21/20 17:50
B-38(21.5)	A0B0617-12	Soil	02/21/20 14:25	02/21/20 17:50
B-39(6)	A0B0617-13	Soil	02/21/20 13:55	02/21/20 17:50
B-39(13.5)	A0B0617-14	Soil	02/21/20 14:55	02/21/20 17:50
B-39(21)	A0B0617-15	Soil	02/21/20 15:05	02/21/20 17:50
B-35 GW	A0B0617-16	Water	02/21/20 10:50	02/21/20 17:50
B-36 GW Shallow	A0B0617-17	Water	02/21/20 10:40	02/21/20 17:50
B-36 GW Deep	A0B0617-18	Water	02/21/20 12:40	02/21/20 17:50
B-37 GW	A0B0617-19	Water	02/21/20 13:35	02/21/20 17:50
B-38 GW	A0B0617-20	Water	02/21/20 15:15	02/21/20 17:50
Soil IDW	A0B0617-21	Soil	02/21/20 15:20	02/21/20 17:50

Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-35(6) (A0B0617-01)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	26.7	mg/kg dry	1	02/28/20 00:45	NWTPH-Dx	
Oil	ND	---	53.5	mg/kg dry	1	02/28/20 00:45	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 76 %*		*Limits: 50-150 %*	*1*	*02/28/20 00:45*	*NWTPH-Dx*	
B-35(9) (A0B0617-02)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	26.8	mg/kg dry	1	02/28/20 01:07	NWTPH-Dx	
Oil	ND	---	53.6	mg/kg dry	1	02/28/20 01:07	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 87 %*		*Limits: 50-150 %*	*1*	*02/28/20 01:07*	*NWTPH-Dx*	
B-35(19) (A0B0617-03)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	27.7	mg/kg dry	1	02/28/20 01:30	NWTPH-Dx	
Oil	ND	---	55.4	mg/kg dry	1	02/28/20 01:30	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 90 %*		*Limits: 50-150 %*	*1*	*02/28/20 01:30*	*NWTPH-Dx*	
B-36(6) (A0B0617-04)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	27.5	mg/kg dry	1	02/27/20 21:19	NWTPH-Dx	
Oil	ND	---	55.0	mg/kg dry	1	02/27/20 21:19	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 96 %*		*Limits: 50-150 %*	*1*	*02/27/20 21:19*	*NWTPH-Dx*	
B-36(14) (A0B0617-05)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	26.0	mg/kg dry	1	02/27/20 21:42	NWTPH-Dx	
Oil	ND	---	52.1	mg/kg dry	1	02/27/20 21:42	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 90 %*		*Limits: 50-150 %*	*1*	*02/27/20 21:42*	*NWTPH-Dx*	
B-36(20) (A0B0617-06)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	25.6	mg/kg dry	1	02/27/20 22:05	NWTPH-Dx	
Oil	ND	---	51.2	mg/kg dry	1	02/27/20 22:05	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 89 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:05*	*NWTPH-Dx*	
B-37(6) (A0B0617-07)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	27.1	mg/kg dry	1	02/27/20 22:28	NWTPH-Dx	
Oil	ND	---	54.2	mg/kg dry	1	02/27/20 22:28	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 76 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:28*	*NWTPH-Dx*	
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	**2300**	---	26.8	mg/kg dry	1	02/27/20 22:51	NWTPH-Dx	

Apex Laboratories

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020863**		
Oil	ND	---	53.7	mg/kg dry	1	02/27/20 22:51	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 93 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:51*	*NWTPH-Dx*	
B-37(21) (A0B0617-09)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	**98.8**	---	27.6	mg/kg dry	1	02/27/20 23:13	NWTPH-Dx	
Oil	ND	---	55.2	mg/kg dry	1	02/27/20 23:13	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 99 %*		*Limits: 50-150 %*	*1*	*02/27/20 23:13*	*NWTPH-Dx*	
B-38(6) (A0B0617-10)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	26.8	mg/kg dry	1	02/27/20 23:36	NWTPH-Dx	
Oil	ND	---	53.7	mg/kg dry	1	02/27/20 23:36	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 87 %*		*Limits: 50-150 %*	*1*	*02/27/20 23:36*	*NWTPH-Dx*	
B-38(13) (A0B0617-11RE1)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	**3900**	---	142	mg/kg dry	5	02/28/20 09:22	NWTPH-Dx	
Oil	ND	---	283	mg/kg dry	5	02/28/20 09:22	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 87 %*		*Limits: 50-150 %*	*5*	*02/28/20 09:22*	*NWTPH-Dx*	*S-05*
B-38(21.5) (A0B0617-12)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	**122**	---	25.6	mg/kg dry	1	02/28/20 00:22	NWTPH-Dx	
Oil	ND	---	51.2	mg/kg dry	1	02/28/20 00:22	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 98 %*		*Limits: 50-150 %*	*1*	*02/28/20 00:22*	*NWTPH-Dx*	
B-39(6) (A0B0617-13)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	27.2	mg/kg dry	1	02/28/20 00:45	NWTPH-Dx	
Oil	ND	---	54.4	mg/kg dry	1	02/28/20 00:45	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 97 %*		*Limits: 50-150 %*	*1*	*02/28/20 00:45*	*NWTPH-Dx*	
B-39(13.5) (A0B0617-14)				**Matrix: Soil**		**Batch: 0020863**		
Diesel	ND	---	26.5	mg/kg dry	1	02/28/20 01:07	NWTPH-Dx	
Oil	ND	---	53.1	mg/kg dry	1	02/28/20 01:07	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 95 %*		*Limits: 50-150 %*	*1*	*02/28/20 01:07*	*NWTPH-Dx*	
B-39(21) (A0B0617-15)				**Matrix: Soil**		**Batch: 0020864**		
Diesel	ND	---	26.2	mg/kg dry	1	02/27/20 22:04	NWTPH-Dx	
Oil	ND	---	52.3	mg/kg dry	1	02/27/20 22:04	NWTPH-Dx	

Apex Laboratories

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

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Apex Laboratories, LLC
6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-39(21) (A0B0617-15)				**Matrix: Soil**		**Batch: 0020864**		
Surrogate: o-Terphenyl (Surr)		*Recovery: 83 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:04*	*NWTPH-Dx*	
B-35 GW (A0B0617-16)				**Matrix: Water**		**Batch: 0020747**		
Diesel	ND	---	0.0825	mg/L	1	02/25/20 22:35	NWTPH-Dx LL	
Oil	ND	---	0.165	mg/L	1	02/25/20 22:35	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 80 %*		*Limits: 50-150 %*	*1*	*02/25/20 22:35*	*NWTPH-Dx LL*	
B-36 GW Shallow (A0B0617-17)				**Matrix: Water**		**Batch: 0020747**		
Diesel	**0.107**	---	0.0792	mg/L	1	02/25/20 22:56	NWTPH-Dx LL	**F-11**
Oil	ND	---	0.158	mg/L	1	02/25/20 22:56	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 73 %*		*Limits: 50-150 %*	*1*	*02/25/20 22:56*	*NWTPH-Dx LL*	
B-36 GW Deep (A0B0617-18)				**Matrix: Water**		**Batch: 0020747**		
Diesel	**0.0927**	---	0.0833	mg/L	1	02/25/20 23:16	NWTPH-Dx LL	**F-11**
Oil	ND	---	0.167	mg/L	1	02/25/20 23:16	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 77 %*		*Limits: 50-150 %*	*1*	*02/25/20 23:16*	*NWTPH-Dx LL*	
B-37 GW (A0B0617-19)				**Matrix: Water**		**Batch: 0020747**		
Diesel	**0.831**	---	0.0748	mg/L	1	02/25/20 23:37	NWTPH-Dx LL	**F-20**
Oil	ND	---	0.150	mg/L	1	02/25/20 23:37	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 70 %*		*Limits: 50-150 %*	*1*	*02/25/20 23:37*	*NWTPH-Dx LL*	
B-38 GW (A0B0617-20RE1)				**Matrix: Water**		**Batch: 0020747**		
Diesel	**8.65**	---	0.748	mg/L	10	02/26/20 09:42	NWTPH-Dx LL	**F-20**
Oil	ND	---	1.50	mg/L	10	02/26/20 09:42	NWTPH-Dx LL	
Surrogate: o-Terphenyl (Surr)		*Recovery: 61 %*		*Limits: 50-150 %*	*10*	*02/26/20 09:42*	*NWTPH-Dx LL*	*S-05*
Soil IDW (A0B0617-21)				**Matrix: Soil**		**Batch: 0020864**		
Diesel	**588**	---	27.0	mg/kg dry	1	02/27/20 22:44	NWTPH-Dx	
Oil	ND	---	54.0	mg/kg dry	1	02/27/20 22:44	NWTPH-Dx	
Surrogate: o-Terphenyl (Surr)		*Recovery: 93 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:44*	*NWTPH-Dx*	

Apex Laboratories, LLC

6700 S.W. Sandburg Street
Tigard, OR 97223
503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-35 GW (A0B0617-16)				**Matrix: Water**		**Batch: 0020872**		
Diesel	ND	---	0.0825	mg/L	1	02/27/20 22:24	NWTPH-Dx/SGC	
Oil	ND	---	0.165	mg/L	1	02/27/20 22:24	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 77 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:24*	*NWTPH-Dx/SGC*	
B-36 GW Shallow (A0B0617-17)				**Matrix: Water**		**Batch: 0020872**		
Diesel	ND	---	0.0792	mg/L	1	02/27/20 22:46	NWTPH-Dx/SGC	
Oil	ND	---	0.158	mg/L	1	02/27/20 22:46	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 68 %*		*Limits: 50-150 %*	*1*	*02/27/20 22:46*	*NWTPH-Dx/SGC*	
B-36 GW Deep (A0B0617-18)				**Matrix: Water**		**Batch: 0020872**		
Diesel	ND	---	0.0833	mg/L	1	02/27/20 23:09	NWTPH-Dx/SGC	
Oil	ND	---	0.167	mg/L	1	02/27/20 23:09	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 69 %*		*Limits: 50-150 %*	*1*	*02/27/20 23:09*	*NWTPH-Dx/SGC*	
B-37 GW (A0B0617-19)				**Matrix: Water**		**Batch: 0020872**		
Diesel	**0.502**	---	0.0748	mg/L	1	02/27/20 23:32	NWTPH-Dx/SGC	**F-20**
Oil	ND	---	0.150	mg/L	1	02/27/20 23:32	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 57 %*		*Limits: 50-150 %*	*1*	*02/27/20 23:32*	*NWTPH-Dx/SGC*	
B-38 GW (A0B0617-20RE1)				**Matrix: Water**		**Batch: 0020872**		
Diesel	**6.57**	---	0.374	mg/L	5	02/28/20 08:22	NWTPH-Dx/SGC	**F-20**
Oil	ND	---	0.748	mg/L	5	02/28/20 08:22	NWTPH-Dx/SGC	
Surrogate: o-Terphenyl (Surr)		*Recovery: 51 %*		*Limits: 50-150 %*	*5*	*02/28/20 08:22*	*NWTPH-Dx/SGC*	*S-05*

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Lisa A Domenighini

Lisa Domenighini, Client Services Manager

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Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-35(6) (A0B0617-01)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	7.10	mg/kg dry	50	02/24/20 14:09	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*110 %*	*Limits: 50-150 %*	*1*	*02/24/20 14:09*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/24/20 14:09*	*NWTPH-Gx (MS)*	
B-35(9) (A0B0617-02)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	8.17	mg/kg dry	50	02/24/20 15:03	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*106 %*	*Limits: 50-150 %*	*1*	*02/24/20 15:03*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/24/20 15:03*	*NWTPH-Gx (MS)*	
B-35(19) (A0B0617-03)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	7.51	mg/kg dry	50	02/24/20 15:30	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/24/20 15:30*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/24/20 15:30*	*NWTPH-Gx (MS)*	
B-36(6) (A0B0617-04)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	8.52	mg/kg dry	50	02/24/20 15:57	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/24/20 15:57*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/24/20 15:57*	*NWTPH-Gx (MS)*	
B-36(14) (A0B0617-05)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	7.54	mg/kg dry	50	02/24/20 16:24	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*109 %*	*Limits: 50-150 %*	*1*	*02/24/20 16:24*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/24/20 16:24*	*NWTPH-Gx (MS)*	
B-36(20) (A0B0617-06)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	6.91	mg/kg dry	50	02/24/20 16:51	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/24/20 16:51*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/24/20 16:51*	*NWTPH-Gx (MS)*	
B-37(6) (A0B0617-07)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	ND	---	7.92	mg/kg dry	50	02/24/20 17:18	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/24/20 17:18*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/24/20 17:18*	*NWTPH-Gx (MS)*	
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	**2170**	---	81.7	mg/kg dry	500	02/24/20 17:45	NWTPH-Gx (MS)	

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Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** A0B0617 - 03 02 20 0958

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020710**		
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*107 %*	*Limits: 50-150 %*	*1*	*02/24/20 17:45*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*90 %*	*50-150 %*	*1*	*02/24/20 17:45*	*NWTPH-Gx (MS)*	
B-37(21) (A0B0617-09)				**Matrix: Soil**		**Batch: 0020710**		
Gasoline Range Organics	**454**	---	11.2	mg/kg dry	50	02/24/20 18:38	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*109 %*	*Limits: 50-150 %*	*1*	*02/24/20 18:38*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/24/20 18:38*	*NWTPH-Gx (MS)*	
B-38(6) (A0B0617-10)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	ND	---	8.46	mg/kg dry	50	02/26/20 20:11	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*104 %*	*Limits: 50-150 %*	*1*	*02/26/20 20:11*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*93 %*	*50-150 %*	*1*	*02/26/20 20:11*	*NWTPH-Gx (MS)*	
B-38(13) (A0B0617-11)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	**940**	---	35.1	mg/kg dry	200	02/26/20 21:05	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*111 %*	*Limits: 50-150 %*	*1*	*02/26/20 21:05*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*90 %*	*50-150 %*	*1*	*02/26/20 21:05*	*NWTPH-Gx (MS)*	
B-38(21.5) (A0B0617-12)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	**208**	---	8.13	mg/kg dry	50	02/26/20 20:38	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*110 %*	*Limits: 50-150 %*	*1*	*02/26/20 20:38*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*91 %*	*50-150 %*	*1*	*02/26/20 20:38*	*NWTPH-Gx (MS)*	
B-39(6) (A0B0617-13)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	ND	---	8.41	mg/kg dry	50	02/26/20 21:58	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits: 50-150 %*	*1*	*02/26/20 21:58*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/26/20 21:58*	*NWTPH-Gx (MS)*	
B-39(13.5) (A0B0617-14)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	ND	---	9.14	mg/kg dry	50	02/26/20 22:25	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*109 %*	*Limits: 50-150 %*	*1*	*02/26/20 22:25*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)			*92 %*	*50-150 %*	*1*	*02/26/20 22:25*	*NWTPH-Gx (MS)*	
B-39(21) (A0B0617-15)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	ND	---	8.00	mg/kg dry	50	02/26/20 22:52	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery:*	*108 %*	*Limits: 50-150 %*	*1*	*02/26/20 22:52*	*NWTPH-Gx (MS)*	

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Lisa Domenighini, Client Services Manager

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-39(21) (A0B0617-15)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Surrogate: 1,4-Difluorobenzene (Sur)		*Recovery: 92 %*		*Limits: 50-150 %*	*1*	*02/26/20 22:52*	*NWTPH-Gx (MS)*	
B-35 GW (A0B0617-16)				**Matrix: Water**		**Batch: 0020689**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/22/20 18:05	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 99 %*		*Limits: 50-150 %*	*1*	*02/22/20 18:05*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*116 %*		*50-150 %*	*1*	*02/22/20 18:05*	*NWTPH-Gx (MS)*	
B-36 GW Shallow (A0B0617-17)				**Matrix: Water**		**Batch: 0020689**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/22/20 17:11	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 100 %*		*Limits: 50-150 %*	*1*	*02/22/20 17:11*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*117 %*		*50-150 %*	*1*	*02/22/20 17:11*	*NWTPH-Gx (MS)*	
B-36 GW Deep (A0B0617-18)				**Matrix: Water**		**Batch: 0020689**		
Gasoline Range Organics	ND	---	0.100	mg/L	1	02/22/20 17:38	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 100 %*		*Limits: 50-150 %*	*1*	*02/22/20 17:38*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*114 %*		*50-150 %*	*1*	*02/22/20 17:38*	*NWTPH-Gx (MS)*	
B-37 GW (A0B0617-19)				**Matrix: Water**		**Batch: 0020689**		
Gasoline Range Organics	**4.96**	---	1.00	mg/L	10	02/22/20 19:26	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 99 %*		*Limits: 50-150 %*	*1*	*02/22/20 19:26*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*111 %*		*50-150 %*	*1*	*02/22/20 19:26*	*NWTPH-Gx (MS)*	
B-38 GW (A0B0617-20)				**Matrix: Water**		**Batch: 0020689**		
Gasoline Range Organics	**53.3**	---	1.00	mg/L	10	02/22/20 20:20	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 103 %*		*Limits: 50-150 %*	*1*	*02/22/20 20:20*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*108 %*		*50-150 %*	*1*	*02/22/20 20:20*	*NWTPH-Gx (MS)*	
Soil IDW (A0B0617-21)				**Matrix: Soil**		**Batch: 0020794**		**V-15**
Gasoline Range Organics	**731**	---	8.02	mg/kg dry	50	02/27/20 01:07	NWTPH-Gx (MS)	
Surrogate: 4-Bromofluorobenzene (Sur)		*Recovery: 112 %*		*Limits: 50-150 %*	*1*	*02/27/20 01:07*	*NWTPH-Gx (MS)*	
1,4-Difluorobenzene (Sur)		*91 %*		*50-150 %*	*1*	*02/27/20 01:07*	*NWTPH-Gx (MS)*	

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Lisa Domenighini, Client Services Manager

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-35(6) (A0B0617-01)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	14.2	ug/kg dry	50	02/24/20 14:09	5035A/8260C	
Toluene	ND	---	71.0	ug/kg dry	50	02/24/20 14:09	5035A/8260C	
Ethylbenzene	ND	---	35.5	ug/kg dry	50	02/24/20 14:09	5035A/8260C	
Xylenes, total	ND	---	106	ug/kg dry	50	02/24/20 14:09	5035A/8260C	
Naphthalene	ND	---	142	ug/kg dry	50	02/24/20 14:09	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/24/20 14:09*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/24/20 14:09*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*105 %*	*80-120 %*	*1*	*02/24/20 14:09*	*5035A/8260C*	
B-35(9) (A0B0617-02)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	16.3	ug/kg dry	50	02/24/20 15:03	5035A/8260C	
Toluene	ND	---	81.7	ug/kg dry	50	02/24/20 15:03	5035A/8260C	
Ethylbenzene	ND	---	40.9	ug/kg dry	50	02/24/20 15:03	5035A/8260C	
Xylenes, total	ND	---	123	ug/kg dry	50	02/24/20 15:03	5035A/8260C	
Naphthalene	ND	---	163	ug/kg dry	50	02/24/20 15:03	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*109 %*	*Limits: 80-120 %*	*1*	*02/24/20 15:03*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/24/20 15:03*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/24/20 15:03*	*5035A/8260C*	
B-35(19) (A0B0617-03)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	15.0	ug/kg dry	50	02/24/20 15:30	5035A/8260C	
Toluene	ND	---	75.1	ug/kg dry	50	02/24/20 15:30	5035A/8260C	
Ethylbenzene	ND	---	37.5	ug/kg dry	50	02/24/20 15:30	5035A/8260C	
Xylenes, total	ND	---	113	ug/kg dry	50	02/24/20 15:30	5035A/8260C	
Naphthalene	ND	---	150	ug/kg dry	50	02/24/20 15:30	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/24/20 15:30*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/24/20 15:30*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*108 %*	*80-120 %*	*1*	*02/24/20 15:30*	*5035A/8260C*	
B-36(6) (A0B0617-04)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	17.0	ug/kg dry	50	02/24/20 15:57	5035A/8260C	
Toluene	ND	---	85.2	ug/kg dry	50	02/24/20 15:57	5035A/8260C	
Ethylbenzene	ND	---	42.6	ug/kg dry	50	02/24/20 15:57	5035A/8260C	
Xylenes, total	ND	---	128	ug/kg dry	50	02/24/20 15:57	5035A/8260C	
Naphthalene	ND	---	170	ug/kg dry	50	02/24/20 15:57	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/24/20 15:57*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/24/20 15:57*	*5035A/8260C*	

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Lisa Domenighini, Client Services Manager

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-36(6) (A0B0617-04)				**Matrix: Soil**		**Batch: 0020710**		
Surrogate: 4-Bromofluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits: 80-120 %*	*1*	*02/24/20 15:57*	*5035A/8260C*	
B-36(14) (A0B0617-05)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	15.1	ug/kg dry	50	02/24/20 16:24	5035A/8260C	
Toluene	ND	---	75.4	ug/kg dry	50	02/24/20 16:24	5035A/8260C	
Ethylbenzene	ND	---	37.7	ug/kg dry	50	02/24/20 16:24	5035A/8260C	
Xylenes, total	ND	---	113	ug/kg dry	50	02/24/20 16:24	5035A/8260C	
Naphthalene	ND	---	151	ug/kg dry	50	02/24/20 16:24	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits: 80-120 %*	*1*	*02/24/20 16:24*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/24/20 16:24*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/24/20 16:24*	*5035A/8260C*	
B-36(20) (A0B0617-06)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	13.8	ug/kg dry	50	02/24/20 16:51	5035A/8260C	
Toluene	ND	---	69.1	ug/kg dry	50	02/24/20 16:51	5035A/8260C	
Ethylbenzene	ND	---	34.5	ug/kg dry	50	02/24/20 16:51	5035A/8260C	
Xylenes, total	ND	---	104	ug/kg dry	50	02/24/20 16:51	5035A/8260C	
Naphthalene	ND	---	138	ug/kg dry	50	02/24/20 16:51	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/24/20 16:51*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/24/20 16:51*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*108 %*	*80-120 %*	*1*	*02/24/20 16:51*	*5035A/8260C*	
B-37(6) (A0B0617-07)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	15.8	ug/kg dry	50	02/24/20 17:18	5035A/8260C	
Toluene	ND	---	79.2	ug/kg dry	50	02/24/20 17:18	5035A/8260C	
Ethylbenzene	ND	---	39.6	ug/kg dry	50	02/24/20 17:18	5035A/8260C	
Xylenes, total	ND	---	119	ug/kg dry	50	02/24/20 17:18	5035A/8260C	
Naphthalene	ND	---	158	ug/kg dry	50	02/24/20 17:18	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/24/20 17:18*	*5035A/8260C*	
Toluene-d8 (Surr)			*93 %*	*80-120 %*	*1*	*02/24/20 17:18*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/24/20 17:18*	*5035A/8260C*	
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	163	ug/kg dry	500	02/24/20 17:45	5035A/8260C	
Toluene	ND	---	817	ug/kg dry	500	02/24/20 17:45	5035A/8260C	
Ethylbenzene	**598**	---	409	ug/kg dry	500	02/24/20 17:45	5035A/8260C	
Xylenes, total	**2000**	---	1230	ug/kg dry	500	02/24/20 17:45	5035A/8260C	

Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020710**		
Naphthalene	**4300**	---	1630	ug/kg dry	500	02/24/20 17:45	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*105 %*	*Limits: 80-120 %*	*1*	*02/24/20 17:45*	*5035A/8260C*	
Toluene-d8 (Surr)			*94 %*	*80-120 %*	*1*	*02/24/20 17:45*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*107 %*	*80-120 %*	*1*	*02/24/20 17:45*	*5035A/8260C*	
B-37(21) (A0B0617-09)				**Matrix: Soil**		**Batch: 0020710**		
Benzene	ND	---	22.3	ug/kg dry	50	02/24/20 18:38	5035A/8260C	
Toluene	ND	---	112	ug/kg dry	50	02/24/20 18:38	5035A/8260C	
Ethylbenzene	**186**	---	55.8	ug/kg dry	50	02/24/20 18:38	5035A/8260C	
Xylenes, total	**491**	---	167	ug/kg dry	50	02/24/20 18:38	5035A/8260C	
Naphthalene	**778**	---	223	ug/kg dry	50	02/24/20 18:38	5035A/8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*106 %*	*Limits: 80-120 %*	*1*	*02/24/20 18:38*	*5035A/8260C*	
Toluene-d8 (Surr)			*91 %*	*80-120 %*	*1*	*02/24/20 18:38*	*5035A/8260C*	
4-Bromofluorobenzene (Surr)			*112 %*	*80-120 %*	*1*	*02/24/20 18:38*	*5035A/8260C*	
B-35 GW (A0B0617-16)				**Matrix: Water**		**Batch: 0020689**		
Benzene	ND	---	0.200	ug/L	1	02/22/20 18:05	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/22/20 18:05	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/22/20 18:05	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/22/20 18:05	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/22/20 18:05	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*96 %*	*Limits: 80-120 %*	*1*	*02/22/20 18:05*	*EPA 8260C*	
Toluene-d8 (Surr)			*102 %*	*80-120 %*	*1*	*02/22/20 18:05*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)			*96 %*	*80-120 %*	*1*	*02/22/20 18:05*	*EPA 8260C*	
B-36 GW Shallow (A0B0617-17)				**Matrix: Water**		**Batch: 0020689**		
Benzene	ND	---	0.200	ug/L	1	02/22/20 17:11	EPA 8260C	
Toluene	ND	---	1.00	ug/L	1	02/22/20 17:11	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/22/20 17:11	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/22/20 17:11	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/22/20 17:11	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery:*	*96 %*	*Limits: 80-120 %*	*1*	*02/22/20 17:11*	*EPA 8260C*	
Toluene-d8 (Surr)			*103 %*	*80-120 %*	*1*	*02/22/20 17:11*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)			*95 %*	*80-120 %*	*1*	*02/22/20 17:11*	*EPA 8260C*	
B-36 GW Deep (A0B0617-18)				**Matrix: Water**		**Batch: 0020689**		
Benzene	ND	---	0.200	ug/L	1	02/22/20 17:38	EPA 8260C	

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

ANALYTICAL SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-36 GW Deep (A0B0617-18)				**Matrix: Water**		**Batch: 0020689**		
Toluene	ND	---	1.00	ug/L	1	02/22/20 17:38	EPA 8260C	
Ethylbenzene	ND	---	0.500	ug/L	1	02/22/20 17:38	EPA 8260C	
Xylenes, total	ND	---	1.50	ug/L	1	02/22/20 17:38	EPA 8260C	
Naphthalene	ND	---	2.00	ug/L	1	02/22/20 17:38	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 96 %*		*Limits: 80-120 %*	*1*	*02/22/20 17:38*	*EPA 8260C*	
Toluene-d8 (Surr)		*102 %*		*80-120 %*	*1*	*02/22/20 17:38*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*98 %*		*80-120 %*	*1*	*02/22/20 17:38*	*EPA 8260C*	
B-37 GW (A0B0617-19)				**Matrix: Water**		**Batch: 0020689**		
Benzene	ND	---	2.00	ug/L	10	02/22/20 19:26	EPA 8260C	
Toluene	ND	---	10.0	ug/L	10	02/22/20 19:26	EPA 8260C	
Ethylbenzene	**13.3**	---	5.00	ug/L	10	02/22/20 19:26	EPA 8260C	
Xylenes, total	**38.4**	---	15.0	ug/L	10	02/22/20 19:26	EPA 8260C	
Naphthalene	**30.0**	---	20.0	ug/L	10	02/22/20 19:26	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 94 %*		*Limits: 80-120 %*	*1*	*02/22/20 19:26*	*EPA 8260C*	
Toluene-d8 (Surr)		*103 %*		*80-120 %*	*1*	*02/22/20 19:26*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*93 %*		*80-120 %*	*1*	*02/22/20 19:26*	*EPA 8260C*	
B-38 GW (A0B0617-20)				**Matrix: Water**		**Batch: 0020689**		
Benzene	ND	---	2.00	ug/L	10	02/22/20 20:20	EPA 8260C	
Toluene	**14.2**	---	10.0	ug/L	10	02/22/20 20:20	EPA 8260C	
Ethylbenzene	**1780**	---	5.00	ug/L	10	02/22/20 20:20	EPA 8260C	
Xylenes, total	**3260**	---	15.0	ug/L	10	02/22/20 20:20	EPA 8260C	
Naphthalene	**1220**	---	20.0	ug/L	10	02/22/20 20:20	EPA 8260C	
Surrogate: 1,4-Difluorobenzene (Surr)		*Recovery: 92 %*		*Limits: 80-120 %*	*1*	*02/22/20 20:20*	*EPA 8260C*	
Toluene-d8 (Surr)		*102 %*		*80-120 %*	*1*	*02/22/20 20:20*	*EPA 8260C*	
4-Bromofluorobenzene (Surr)		*92 %*		*80-120 %*	*1*	*02/22/20 20:20*	*EPA 8260C*	

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Lisa Domenighini, Client Services Manager

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0617 - 03 02 20 0958

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-35(6) (A0B0617-01)				**Matrix: Soil**		**Batch: 0020707**		
% Solids	**72.7**	---	1.00	%	1	02/25/20 09:41	EPA 8000C	
B-35(9) (A0B0617-02)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**69.4**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-35(19) (A0B0617-03)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.0**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-36(6) (A0B0617-04)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**67.5**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-36(14) (A0B0617-05)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.3**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-36(20) (A0B0617-06)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**75.0**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-37(6) (A0B0617-07)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.3**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-37(13) (A0B0617-08)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**69.0**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-37(21) (A0B0617-09)				**Matrix: Soil**		**Batch: 0020707**		
% Solids	**70.8**	---	1.00	%	1	02/25/20 09:41	EPA 8000C	
B-38(6) (A0B0617-10)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**73.1**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-38(13) (A0B0617-11)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**70.3**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-38(21.5) (A0B0617-12)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.8**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-39(6) (A0B0617-13)				**Matrix: Soil**		**Batch: 0020764**		

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Cascadia Associates	Project: **Nustar Vannex**	
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Portland, OR 97239	Project Manager: **Amanda Spencer**	A0B0617 - 03 02 20 0958

ANALYTICAL SAMPLE RESULTS

Percent Dry Weight

Analyte	Sample Result	Detection Limit	Reporting Limit	Units	Dilution	Date Analyzed	Method Ref.	Notes
B-39(6) (A0B0617-13)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.6**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-39(13.5) (A0B0617-14)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**69.0**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
B-39(21) (A0B0617-15)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**73.5**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	
Soil IDW (A0B0617-21)				**Matrix: Soil**		**Batch: 0020764**		
% Solids	**72.3**	---	1.00	%	1	02/26/20 08:27	EPA 8000C	

Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** A0B0617 - 03 02 20 0958

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020747 - EPA 3510C (Fuels/Acid Ext.)							**Water**					
Blank (0020747-BLK1)		Prepared: 02/25/20 07:13	Analyzed: 02/25/20 20:53									
NWTPH-Dx LL												
Diesel	ND	---	0.0727	mg/L	1	---	---	---	---	---	---	
Oil	ND	---	0.145	mg/L	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 80 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS (0020747-BS1)		Prepared: 02/25/20 07:13	Analyzed: 02/25/20 21:13									
NWTPH-Dx LL												
Diesel	0.403	---	0.0800	mg/L	1	0.500	---	81	58 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 84 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS Dup (0020747-BSD1)		Prepared: 02/25/20 07:13	Analyzed: 02/25/20 21:34									Q-19
NWTPH-Dx LL												
Diesel	0.408	---	0.0800	mg/L	1	0.500	---	82	58 - 115%	1	20%	
Surr: o-Terphenyl (Surr)		*Recovery: 83 %*	*Limits: 50-150 %*		*Dilution: 1x*							
Batch 0020863 - EPA 3546 (Fuels)							**Soil**					
Blank (0020863-BLK1)		Prepared: 02/27/20 12:51	Analyzed: 02/27/20 21:19									
NWTPH-Dx												
Diesel	ND	---	25.0	mg/kg wet	1	---	---	---	---	---	---	
Oil	ND	---	50.0	mg/kg wet	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 98 %*	*Limits: 50-150 %*		*Dilution: 1x*							
LCS (0020863-BS1)		Prepared: 02/27/20 12:51	Analyzed: 02/27/20 21:42									
NWTPH-Dx												
Diesel	119	---	25.0	mg/kg wet	1	125	---	96	76 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 103 %*	*Limits: 50-150 %*		*Dilution: 1x*							
Duplicate (0020863-DUP2)		Prepared: 02/27/20 12:51	Analyzed: 02/28/20 01:30									
QC Source Sample: B-39(13.5) (A0B0617-14)												
NWTPH-Dx												
Diesel	ND	---	26.8	mg/kg dry	1	---	ND	---	---	---	30%	
Oil	ND	---	53.7	mg/kg dry	1	---	ND	---	---	---	30%	

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Cascadia Associates	Project: **Nustar Vannex**	
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Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020863 - EPA 3546 (Fuels)							**Soil**					
Duplicate (0020863-DUP2)		Prepared: 02/27/20 12:51 Analyzed: 02/28/20 01:30										
QC Source Sample: B-39(13.5) (A0B0617-14)												
Surr: o-Terphenyl (Surr)		*Recovery: 91 %*		*Limits: 50-150 %*			*Dilution: 1x*					

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Lisa Domenighini, Client Services Manager

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Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020864 - EPA 3546 (Fuels)							**Soil**					
Blank (0020864-BLK1)		Prepared: 02/27/20 12:53	Analyzed: 02/27/20 21:24									
NWTPH-Dx												
Diesel	ND	---	25.0	mg/kg wet	1	---	---	---	---	---	---	
Oil	ND	---	50.0	mg/kg wet	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 95 %*	*Limits: 50-150 %*			*Dilution: 1x*						
LCS (0020864-BS1)		Prepared: 02/27/20 12:53	Analyzed: 02/27/20 21:44									
NWTPH-Dx												
Diesel	115	---	25.0	mg/kg wet	1	125	---	92	76 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 94 %*	*Limits: 50-150 %*			*Dilution: 1x*						
Duplicate (0020864-DUP1)		Prepared: 02/27/20 12:53	Analyzed: 02/27/20 22:24									
QC Source Sample: B-39(21) (A0B0617-15)												
NWTPH-Dx												
Diesel	ND	---	26.6	mg/kg dry	1	---	ND	---	---	---	30%	
Oil	ND	---	53.2	mg/kg dry	1	---	ND	---	---	---	30%	
Surr: o-Terphenyl (Surr)		*Recovery: 84 %*	*Limits: 50-150 %*			*Dilution: 1x*						

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Portland, OR 97239	Project Manager: Amanda Spencer	A0B0617 - 03 02 20 0958

QUALITY CONTROL (QC) SAMPLE RESULTS

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020872 - EPA 3510C (Fuels/Acid Ext.) w/Silica Gel							Water					
Blank (0020872-BLK1)		Prepared: 02/25/20 07:13	Analyzed: 02/27/20 21:16									
NWTPH-Dx/SGC												
Diesel	ND	---	0.0727	mg/L	1	---	---	---	---	---	---	
Oil	ND	---	0.145	mg/L	1	---	---	---	---	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 81 %*	*Limits: 50-150 %*			*Dilution: 1x*						
LCS (0020872-BS1)		Prepared: 02/25/20 07:13	Analyzed: 02/27/20 21:39									
NWTPH-Dx/SGC												
Diesel	0.382	---	0.0800	mg/L	1	0.500	---	76	58 - 115%	---	---	
Surr: o-Terphenyl (Surr)		*Recovery: 79 %*	*Limits: 50-150 %*			*Dilution: 1x*						
LCS Dup (0020872-BSD1)		Prepared: 02/25/20 07:13	Analyzed: 02/27/20 22:01									Q-19
NWTPH-Dx/SGC												
Diesel	0.380	---	0.0800	mg/L	1	0.500	---	76	58 - 115%	0.5	20%	
Surr: o-Terphenyl (Surr)		*Recovery: 76 %*	*Limits: 50-150 %*			*Dilution: 1x*						

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020689 - EPA 5030B							**Water**					
Blank (0020689-BLK1)		Prepared: 02/22/20 13:00 Analyzed: 02/22/20 14:55										
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	0.100	mg/L	1	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 100 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*115 %*		*50-150 %*		*"*						
LCS (0020689-BS2)		Prepared: 02/22/20 13:00 Analyzed: 02/22/20 14:28										
NWTPH-Gx (MS)												
Gasoline Range Organics	0.598	---	0.100	mg/L	1	0.500	---	120	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 100 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*110 %*		*50-150 %*		*"*						
Duplicate (0020689-DUP1)		Prepared: 02/22/20 15:15 Analyzed: 02/22/20 19:53										
QC Source Sample: B-37 GW (A0B0617-19)												
NWTPH-Gx (MS)												
Gasoline Range Organics	**4.95**	---	1.00	mg/L	10	---	4.96	---	---	0.2	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 98 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*109 %*		*50-150 %*		*"*						

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503-718-2323
EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020710 - EPA 5035A							Soil					
Blank (0020710-BLK1)		Prepared: 02/24/20 09:00	Analyzed: 02/24/20 12:48									
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	0.0667	mg/kg wet	1	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*102 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*92 %*		*50-150 %*		*"*					
LCS (0020710-BS2)		Prepared: 02/24/20 09:00	Analyzed: 02/24/20 12:21									
NWTPH-Gx (MS)												
Gasoline Range Organics	20.6	---	5.00	mg/kg wet	50	25.0	---	82	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*97 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*89 %*		*50-150 %*		*"*					
Duplicate (0020710-DUP1)		Prepared: 02/21/20 08:50	Analyzed: 02/24/20 14:36									
QC Source Sample: B-35(6) (A0B0617-01)												
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	7.87	mg/kg dry	50	---	ND	---	---	---	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*105 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*91 %*		*50-150 %*		*"*					
Duplicate (0020710-DUP2)		Prepared: 02/21/20 12:35	Analyzed: 02/24/20 19:05									
QC Source Sample: B-37(21) (A0B0617-09)												
NWTPH-Gx (MS)												
Gasoline Range Organics	**447**	---	9.04	mg/kg dry	50	---	454	---	---	2	30%	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery:*	*113 %*	*Limits:*	*50-150 %*		*Dilution: 1x*					
1,4-Difluorobenzene (Sur)			*92 %*		*50-150 %*		*"*					

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Lisa Domenighini, Client Services Manager

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020794 - EPA 5035A							**Soil**					
Blank (0020794-BLK1)		Prepared: 02/26/20 09:00 Analyzed: 02/26/20 15:14										
NWTPH-Gx (MS)												
Gasoline Range Organics	ND	---	3.33	mg/kg wet	50	---	---	---	---	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 103 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*94 %*		*50-150 %*		*"*						
LCS (0020794-BS2)		Prepared: 02/26/20 09:00 Analyzed: 02/26/20 14:47										
NWTPH-Gx (MS)												
Gasoline Range Organics	20.7	---	5.00	mg/kg wet	50	25.0	---	83	80 - 120%	---	---	
Surr: 4-Bromofluorobenzene (Sur)		*Recovery: 98 %*		*Limits: 50-150 %*		*Dilution: 1x*						
1,4-Difluorobenzene (Sur)		*91 %*		*50-150 %*		*"*						

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5820 SW Kelly Ave Unit B	Project Number:	**0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager:	**Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020689 - EPA 5030B							**Water**					
Blank (0020689-BLK1)		Prepared: 02/22/20 13:00 Analyzed: 02/22/20 14:55										
EPA 8260C												
Benzene	ND	---	0.200	ug/L	1	---	---	---	---	---	---	
Toluene	ND	---	1.00	ug/L	1	---	---	---	---	---	---	
Ethylbenzene	ND	---	0.500	ug/L	1	---	---	---	---	---	---	
Xylenes, total	ND	---	1.50	ug/L	1	---	---	---	---	---	---	
Naphthalene	ND	---	2.00	ug/L	1	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*95 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*103 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*97 %*		*80-120 %*		*"*					
LCS (0020689-BS1)		Prepared: 02/22/20 13:00 Analyzed: 02/22/20 14:01										
EPA 8260C												
Benzene	18.7	---	0.200	ug/L	1	20.0	---	93	80 - 120%	---	---	
Toluene	19.7	---	1.00	ug/L	1	20.0	---	99	80 - 120%	---	---	
Ethylbenzene	21.3	---	0.500	ug/L	1	20.0	---	107	80 - 120%	---	---	
Xylenes, total	62.3	---	1.50	ug/L	1	60.0	---	104	80 - 120%	---	---	
Naphthalene	18.5	---	2.00	ug/L	1	20.0	---	92	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*91 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*100 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*92 %*		*80-120 %*		*"*					
Duplicate (0020689-DUP1)		Prepared: 02/22/20 15:15 Analyzed: 02/22/20 19:53										
QC Source Sample: B-37 GW (A0B0617-19)												
EPA 8260C												
Benzene	ND	---	2.00	ug/L	10	---	ND	---	---	---	30%	
Toluene	ND	---	10.0	ug/L	10	---	ND	---	---	---	30%	
Ethylbenzene	**14.1**	---	5.00	ug/L	10	---	13.3	---	---	6	30%	
Xylenes, total	**38.3**	---	15.0	ug/L	10	---	38.4	---	---	0.3	30%	
Naphthalene	**29.8**	---	20.0	ug/L	10	---	30.0	---	---	0.7	30%	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*94 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*102 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*95 %*		*80-120 %*		*"*					

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020689 - EPA 5030B							**Water**					
Matrix Spike (0020689-MS1)		Prepared: 02/22/20 15:15 Analyzed: 02/22/20 18:32										
QC Source Sample: B-35 GW (A0B0617-16)												
EPA 8260C												
Benzene	19.6	---	0.200	ug/L	1	20.0	ND	98	79 - 120%	---	---	
Toluene	20.5	---	1.00	ug/L	1	20.0	ND	103	80 - 121%	---	---	
Ethylbenzene	22.1	---	0.500	ug/L	1	20.0	ND	110	79 - 121%	---	---	
Xylenes, total	65.1	---	1.50	ug/L	1	60.0	ND	108	79 - 121%	---	---	
Naphthalene	19.3	---	2.00	ug/L	1	20.0	ND	96	61 - 128%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery: 91 %*		*Limits: 80-120 %*			*Dilution: 1x*					
Toluene-d8 (Surr)		*100 %*		*80-120 %*			*"*					
4-Bromofluorobenzene (Surr)		*93 %*		*80-120 %*			*"*					

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Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020710 - EPA 5035A							**Soil**					
Blank (0020710-BLK1)	Prepared: 02/24/20 09:00 Analyzed: 02/24/20 12:48											
5035A/8260C												
Benzene	ND	---	0.133	ug/kg wet	1	---	---	---	---	---	---	
Toluene	ND	---	0.667	ug/kg wet	1	---	---	---	---	---	---	
Ethylbenzene	ND	---	0.333	ug/kg wet	1	---	---	---	---	---	---	
Xylenes, total	ND	---	1.00	ug/kg wet	1	---	---	---	---	---	---	
Naphthalene	ND	---	1.33	ug/kg wet	1	---	---	---	---	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*94 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*107 %*		*80-120 %*		*"*					
LCS (0020710-BS1)	Prepared: 02/24/20 09:00 Analyzed: 02/24/20 10:34											
5035A/8260C												
Benzene	987	---	10.0	ug/kg wet	50	1000	---	99	80 - 120%	---	---	
Toluene	939	---	50.0	ug/kg wet	50	1000	---	94	80 - 120%	---	---	
Ethylbenzene	975	---	25.0	ug/kg wet	50	1000	---	97	80 - 120%	---	---	
Xylenes, total	3110	---	75.0	ug/kg wet	50	3000	---	104	80 - 120%	---	---	
Naphthalene	880	---	100	ug/kg wet	50	1000	---	88	80 - 120%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*107 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*94 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*105 %*		*80-120 %*		*"*					
Duplicate (0020710-DUP1)	Prepared: 02/21/20 08:50 Analyzed: 02/24/20 14:36											
QC Source Sample: B-35(6) (A0B0617-01)												
5035A/8260C												
Benzene	ND	---	15.7	ug/kg dry	50	---	ND	---	---	---	30%	
Toluene	ND	---	78.7	ug/kg dry	50	---	ND	---	---	---	30%	
Ethylbenzene	ND	---	39.3	ug/kg dry	50	---	ND	---	---	---	30%	
Xylenes, total	ND	---	118	ug/kg dry	50	---	ND	---	---	---	30%	
Naphthalene	ND	---	157	ug/kg dry	50	---	ND	---	---	---	30%	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery:*	*108 %*	*Limits:*	*80-120 %*		*Dilution: 1x*					
Toluene-d8 (Surr)			*93 %*		*80-120 %*		*"*					
4-Bromofluorobenzene (Surr)			*107 %*		*80-120 %*		*"*					

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

BTEX+N Compounds by EPA 8260C

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020710 - EPA 5035A							**Soil**					
Duplicate (0020710-DUP2)		Prepared: 02/21/20 12:35 Analyzed: 02/24/20 19:05										
QC Source Sample: B-37(21) (A0B0617-09)												
5035A/8260C												
Benzene	ND	---	18.1	ug/kg dry	50	---	ND	---	---	---	30%	
Toluene	ND	---	90.4	ug/kg dry	50	---	ND	---	---	---	30%	
Ethylbenzene	**162**	---	45.2	ug/kg dry	50	---	186	---	---	14	30%	
Xylenes, total	**407**	---	136	ug/kg dry	50	---	491	---	---	19	30%	
Naphthalene	**691**	---	181	ug/kg dry	50	---	778	---	---	12	30%	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery: 109 %*		*Limits: 80-120 %*		*Dilution: 1x*						
Toluene-d8 (Surr)		*91 %*		*80-120 %*		*"*						
4-Bromofluorobenzene (Surr)		*111 %*		*80-120 %*		*"*						
Matrix Spike (0020710-MS1)		Prepared: 02/21/20 12:35 Analyzed: 02/24/20 19:32										
QC Source Sample: B-37(21) (A0B0617-09)												
5035A/8260C												
Benzene	2180	---	22.3	ug/kg dry	50	2230	ND	98	77 - 121%	---	---	
Toluene	2030	---	112	ug/kg dry	50	2230	ND	91	77 - 121%	---	---	
Ethylbenzene	2270	---	55.8	ug/kg dry	50	2230	186	93	76 - 122%	---	---	
Xylenes, total	7340	---	167	ug/kg dry	50	6700	491	102	78 - 124%	---	---	
Naphthalene	3100	---	223	ug/kg dry	50	2230	778	104	62 - 129%	---	---	
Surr: 1,4-Difluorobenzene (Surr)		*Recovery: 110 %*		*Limits: 80-120 %*		*Dilution: 1x*						
Toluene-d8 (Surr)		*96 %*		*80-120 %*		*"*						
4-Bromofluorobenzene (Surr)		*109 %*		*80-120 %*		*"*						

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020707 - Total Solids (Dry Weight)							**Soil**					

No Client related Batch QC samples analyzed for this batch. See notes page for more information.

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
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QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight

Analyte	Result	Detection Limit	Reporting Limit	Units	Dilution	Spike Amount	Source Result	% REC	% REC Limits	RPD	RPD Limit	Notes
Batch 0020764 - Total Solids (Dry Weight)							**Soil**					
Duplicate (0020764-DUP3)		Prepared: 02/25/20 16:07		Analyzed: 02/26/20 08:27								
QC Source Sample: B-37(13) (A0B0617-08)												
EPA 8000C												
% Solids	**67.5**	---	1.00	%	1	---	69.0	---	---	2	10%	

No Client related Batch QC samples analyzed for this batch. See notes page for more information.

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

SAMPLE PREPARATION INFORMATION

Diesel and/or Oil Hydrocarbons by NWTPH-Dx

Prep: EPA 3510C (Fuels/Acid Ext.)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020747							
A0B0617-16	Water	NWTPH-Dx LL	02/21/20 10:50	02/25/20 07:13	970mL/2mL	1000mL/2mL	1.03
A0B0617-17	Water	NWTPH-Dx LL	02/21/20 10:40	02/25/20 07:13	1010mL/2mL	1000mL/2mL	0.99
A0B0617-18	Water	NWTPH-Dx LL	02/21/20 12:40	02/25/20 07:13	960mL/2mL	1000mL/2mL	1.04
A0B0617-19	Water	NWTPH-Dx LL	02/21/20 13:35	02/25/20 07:13	1070mL/2mL	1000mL/2mL	0.94
A0B0617-20RE1	Water	NWTPH-Dx LL	02/21/20 15:15	02/25/20 07:13	1070mL/2mL	1000mL/2mL	0.94

Prep: EPA 3546 (Fuels)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020863							
A0B0617-01	Soil	NWTPH-Dx	02/21/20 08:50	02/27/20 12:51	10.29g/5mL	10g/5mL	0.97
A0B0617-02	Soil	NWTPH-Dx	02/21/20 08:55	02/27/20 12:51	10.74g/5mL	10g/5mL	0.93
A0B0617-03	Soil	NWTPH-Dx	02/21/20 09:05	02/27/20 12:51	10.03g/5mL	10g/5mL	1.00
A0B0617-04	Soil	NWTPH-Dx	02/21/20 09:20	02/27/20 12:51	10.77g/5mL	10g/5mL	0.93
A0B0617-05	Soil	NWTPH-Dx	02/21/20 11:05	02/27/20 12:51	10.62g/5mL	10g/5mL	0.94
A0B0617-06	Soil	NWTPH-Dx	02/21/20 11:40	02/27/20 12:51	10.42g/5mL	10g/5mL	0.96
A0B0617-07	Soil	NWTPH-Dx	02/21/20 11:25	02/27/20 12:51	10.21g/5mL	10g/5mL	0.98
A0B0617-08	Soil	NWTPH-Dx	02/21/20 12:20	02/27/20 12:51	10.81g/5mL	10g/5mL	0.93
A0B0617-09	Soil	NWTPH-Dx	02/21/20 12:35	02/27/20 12:51	10.23g/5mL	10g/5mL	0.98
A0B0617-10	Soil	NWTPH-Dx	02/21/20 11:55	02/27/20 12:51	10.2g/5mL	10g/5mL	0.98
A0B0617-11RE1	Soil	NWTPH-Dx	02/21/20 14:10	02/27/20 12:51	10.04g/5mL	10g/5mL	1.00
A0B0617-12	Soil	NWTPH-Dx	02/21/20 14:25	02/27/20 12:51	10.73g/5mL	10g/5mL	0.93
A0B0617-13	Soil	NWTPH-Dx	02/21/20 13:55	02/27/20 12:51	10.12g/5mL	10g/5mL	0.99
A0B0617-14	Soil	NWTPH-Dx	02/21/20 14:55	02/27/20 12:51	10.93g/5mL	10g/5mL	0.92
Batch: 0020864							
A0B0617-15	Soil	NWTPH-Dx	02/21/20 15:05	02/27/20 12:53	10.39g/5mL	10g/5mL	0.96
A0B0617-21	Soil	NWTPH-Dx	02/21/20 15:20	02/27/20 12:53	10.25g/5mL	10g/5mL	0.98

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Prep: EPA 3510C (Fuels/Acid Ext.) w/Silica Gel

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020872							
A0B0617-16	Water	NWTPH-Dx/SGC	02/21/20 10:50	02/25/20 07:13			1.03
A0B0617-17	Water	NWTPH-Dx/SGC	02/21/20 10:40	02/25/20 07:13			0.99
A0B0617-18	Water	NWTPH-Dx/SGC	02/21/20 12:40	02/25/20 07:13			1.04

Apex Laboratories, LLC
6700 S.W. Sandburg Street
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503-718-2323
EPA ID: OR01039

Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

SAMPLE PREPARATION INFORMATION

Diesel and/or Oil Hydrocarbons by NWTPH-Dx with Silica Gel Column Cleanup

Prep: EPA 3510C (Fuels/Acid Ext.) w/Silica Gel

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0617-19	Water	NWTPH-Dx/SGC	02/21/20 13:35	02/25/20 07:13			0.94
A0B0617-20RE1	Water	NWTPH-Dx/SGC	02/21/20 15:15	02/25/20 07:13			0.94

Gasoline Range Hydrocarbons (Benzene through Naphthalene) by NWTPH-Gx

Prep: EPA 5030B

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020689							
A0B0617-16	Water	NWTPH-Gx (MS)	02/21/20 10:50	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-17	Water	NWTPH-Gx (MS)	02/21/20 10:40	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-18	Water	NWTPH-Gx (MS)	02/21/20 12:40	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-19	Water	NWTPH-Gx (MS)	02/21/20 13:35	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-20	Water	NWTPH-Gx (MS)	02/21/20 15:15	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020710							
A0B0617-01	Soil	NWTPH-Gx (MS)	02/21/20 08:50	02/21/20 08:50	6.59g/5mL	5g/5mL	0.76
A0B0617-02	Soil	NWTPH-Gx (MS)	02/21/20 08:55	02/21/20 08:55	6.03g/5mL	5g/5mL	0.83
A0B0617-03	Soil	NWTPH-Gx (MS)	02/21/20 09:05	02/21/20 09:05	6.23g/5mL	5g/5mL	0.80
A0B0617-04	Soil	NWTPH-Gx (MS)	02/21/20 09:20	02/21/20 09:20	6.06g/5mL	5g/5mL	0.83
A0B0617-05	Soil	NWTPH-Gx (MS)	02/21/20 11:05	02/21/20 11:05	6.15g/5mL	5g/5mL	0.81
A0B0617-06	Soil	NWTPH-Gx (MS)	02/21/20 11:40	02/21/20 11:40	6.37g/5mL	5g/5mL	0.79
A0B0617-07	Soil	NWTPH-Gx (MS)	02/21/20 11:25	02/21/20 11:25	5.75g/5mL	5g/5mL	0.87
A0B0617-08	Soil	NWTPH-Gx (MS)	02/21/20 12:20	02/21/20 12:20	6.12g/5mL	5g/5mL	0.82
A0B0617-09	Soil	NWTPH-Gx (MS)	02/21/20 12:35	02/21/20 12:35	3.88g/5mL	5g/5mL	1.29
Batch: 0020794							
A0B0617-10	Soil	NWTPH-Gx (MS)	02/21/20 11:55	02/22/20 10:45	5.17g/5mL	5g/5mL	0.97
A0B0617-11	Soil	NWTPH-Gx (MS)	02/21/20 14:10	02/22/20 10:45	5.34g/5mL	5g/5mL	0.94
A0B0617-12	Soil	NWTPH-Gx (MS)	02/21/20 14:25	02/22/20 10:45	5.48g/5mL	5g/5mL	0.91
A0B0617-13	Soil	NWTPH-Gx (MS)	02/21/20 13:55	02/22/20 10:45	5.27g/5mL	5g/5mL	0.95
A0B0617-14	Soil	NWTPH-Gx (MS)	02/21/20 14:55	02/22/20 10:45	5.26g/5mL	5g/5mL	0.95
A0B0617-15	Soil	NWTPH-Gx (MS)	02/21/20 15:05	02/22/20 10:45	5.48g/5mL	5g/5mL	0.91
A0B0617-21	Soil	NWTPH-Gx (MS)	02/21/20 15:20	02/22/20 10:45	5.67g/5mL	5g/5mL	0.88

BTEX+N Compounds by EPA 8260C

Cascadia Associates 5820 SW Kelly Ave Unit B Portland, OR 97239	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

SAMPLE PREPARATION INFORMATION

BTEX+N Compounds by EPA 8260C

Prep: EPA 5030B

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020689							
A0B0617-16	Water	EPA 8260C	02/21/20 10:50	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-17	Water	EPA 8260C	02/21/20 10:40	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-18	Water	EPA 8260C	02/21/20 12:40	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-19	Water	EPA 8260C	02/21/20 13:35	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00
A0B0617-20	Water	EPA 8260C	02/21/20 15:15	02/22/20 15:15	5mL/5mL	5mL/5mL	1.00

Prep: EPA 5035A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020710							
A0B0617-01	Soil	5035A/8260C	02/21/20 08:50	02/21/20 08:50	6.59g/5mL	5g/5mL	0.76
A0B0617-02	Soil	5035A/8260C	02/21/20 08:55	02/21/20 08:55	6.03g/5mL	5g/5mL	0.83
A0B0617-03	Soil	5035A/8260C	02/21/20 09:05	02/21/20 09:05	6.23g/5mL	5g/5mL	0.80
A0B0617-04	Soil	5035A/8260C	02/21/20 09:20	02/21/20 09:20	6.06g/5mL	5g/5mL	0.83
A0B0617-05	Soil	5035A/8260C	02/21/20 11:05	02/21/20 11:05	6.15g/5mL	5g/5mL	0.81
A0B0617-06	Soil	5035A/8260C	02/21/20 11:40	02/21/20 11:40	6.37g/5mL	5g/5mL	0.79
A0B0617-07	Soil	5035A/8260C	02/21/20 11:25	02/21/20 11:25	5.75g/5mL	5g/5mL	0.87
A0B0617-08	Soil	5035A/8260C	02/21/20 12:20	02/21/20 12:20	6.12g/5mL	5g/5mL	0.82
A0B0617-09	Soil	5035A/8260C	02/21/20 12:35	02/21/20 12:35	3.88g/5mL	5g/5mL	1.29

Percent Dry Weight

Prep: Total Solids (Dry Weight)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 0020707							
A0B0617-01	Soil	EPA 8000C	02/21/20 08:50	02/24/20 16:39			NA
A0B0617-09	Soil	EPA 8000C	02/21/20 12:35	02/24/20 16:39			NA
Batch: 0020764							
A0B0617-02	Soil	EPA 8000C	02/21/20 08:55	02/25/20 16:07			NA
A0B0617-03	Soil	EPA 8000C	02/21/20 09:05	02/25/20 16:07			NA
A0B0617-04	Soil	EPA 8000C	02/21/20 09:20	02/25/20 16:07			NA
A0B0617-05	Soil	EPA 8000C	02/21/20 11:05	02/25/20 16:07			NA
A0B0617-06	Soil	EPA 8000C	02/21/20 11:40	02/25/20 16:07			NA
A0B0617-07	Soil	EPA 8000C	02/21/20 11:25	02/25/20 16:07			NA
A0B0617-08	Soil	EPA 8000C	02/21/20 12:20	02/25/20 16:07			NA
A0B0617-10	Soil	EPA 8000C	02/21/20 11:55	02/25/20 16:07			NA
A0B0617-11	Soil	EPA 8000C	02/21/20 14:10	02/25/20 16:07			NA

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

SAMPLE PREPARATION INFORMATION

Percent Dry Weight

Prep: Total Solids (Dry Weight)

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A0B0617-12	Soil	EPA 8000C	02/21/20 14:25	02/25/20 16:07			NA
A0B0617-13	Soil	EPA 8000C	02/21/20 13:55	02/25/20 16:07			NA
A0B0617-14	Soil	EPA 8000C	02/21/20 14:55	02/25/20 16:07			NA
A0B0617-15	Soil	EPA 8000C	02/21/20 15:05	02/25/20 16:07			NA
A0B0617-21	Soil	EPA 8000C	02/21/20 15:20	02/25/20 16:07			NA

Apex Laboratories

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

QUALIFIER DEFINITIONS

Client Sample and Quality Control (QC) Sample Qualifier Definitions:

Apex Laboratories

F-11 The hydrocarbon pattern indicates possible weathered diesel, mineral oil, or a contribution from a related component.

F-20 Result for Diesel is Estimated due to overlap from Gasoline Range Organics or other VOCs.

Q-19 Blank Spike Duplicate (BSD) sample analyzed in place of Matrix Spike/Duplicate samples due to limited sample amount available for analysis.

S-05 Surrogate recovery is estimated due to sample dilution required for high analyte concentration and/or matrix interference.

V-15 Sample aliquot was subsampled from the sample container. The subsampled aliquot was preserved in the laboratory within 48 hours of sampling.

Apex Laboratories, LLC

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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

REPORTING NOTES AND CONVENTIONS:

Abbreviations:

DET Analyte DETECTED at or above the detection or reporting limit.

ND Analyte NOT DETECTED at or above the detection or reporting limit.

NR Result Not Reported.

RPD Relative Percent Difference. RPDs for Matrix Spikes and Matrix Spike Duplicates are based on concentration, not recovery.

Detection Limits: Limit of Detection (LOD)

Limits of Detection (LODs) are normally set at a level of one half the validated Limit of Quantitation (LOQ).
If no value is listed ('-----'), then the data has not been evaluated below the Reporting Limit.

Reporting Limits: Limit of Quantitation (LOQ)

Validated Limits of Quantitation (LOQs) are reported as the Reporting Limits for all analyses where the LOQ, MRL, PQL or CRL are requested. The LOQ represents a level at or above the low point of the calibration curve, that has been validated according to Apex Laboratories' comprehensive LOQ policies and procedures.

Reporting Conventions:

Basis: Results for soil samples are generally reported on a 100% dry weight basis.
The Result Basis is listed following the units as " dry", " wet", or " " (blank) designation.

" dry" Sample results and Reporting Limits are reported on a dry weight basis. (i.e. "ug/kg dry")
See Percent Solids section for details of dry weight analysis.

" wet" Sample results and Reporting Limits for this analysis are normally dry weight corrected, but have not been modified in this case.

"   " Results without 'wet' or 'dry' designation are not normally dry weight corrected. These results are considered 'As Received'.

QC Source:

In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) may be analyzed to demonstrate accuracy and precision of the extraction batch.

Non-Client Batch QC Samples (Duplicates and Matrix Spike/Duplicates) are not included in this report. Please request a Full QC report if this data is required.

Miscellaneous Notes:

" --- " QC results are not applicable. For example, % Recoveries for Blanks and Duplicates, % RPD for Blanks, Blank Spikes and Matrix Spikes, etc.

" *** " Used to indicate a possible discrepancy with the Sample and Sample Duplicate results when the %RPD is not available. In this case, either the Sample or the Sample Duplicate has a reportable result for this analyte, while the other is Non Detect (ND).

Blanks:

Standard practice is to evaluate the results from Blank QC Samples down to a level equal to ½ the Reporting Limit (RL).
-For Blank hits falling between ½ the RL and the RL (J flagged hits), the associated sample and QC data will receive a ‘B-02’ qualifier.
-For Blank hits above the RL, the associated sample and QC data will receive a ‘B’ qualifier, per Apex Laboratories' Blank Policy.
For further details, please request a copy of this document.

Apex Laboratories

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Lisa A Domenighini

Lisa Domenighini, Client Services Manager

REPORTING NOTES AND CONVENTIONS (Cont.):

Blanks (Cont.):

Sample results flagged with a 'B' or 'B-02' qualifier are potentially biased high if the sample results are less than ten times the level found in the blank for inorganic analyses, or less than five times the level found in the blank for organic analyses.

'B' and 'B-02' qualifications are only applied to sample results detected above the Reporting Level.

Preparation Notes:

Mixed Matrix Samples:

Water Samples:

Water samples containing significant amounts of sediment are decanted or separated prior to extraction, and only the water portion analyzed, unless otherwise directed by the client.

Soil and Sediment Samples:

Soil and Sediment samples containing significant amounts of water are decanted prior to extraction, and only the solid portion analyzed, unless otherwise directed by the client.

Sampling and Preservation Notes:

Certain regulatory programs, such as National Pollutant Discharge Elimination System (NPDES), require that activities such as sample filtration (for dissolved metals, orthophosphate, hexavalent chromium, etc.) and testing of short hold analytes (pH, Dissolved Oxygen, etc.) be performed in the field (on-site) within a short time window. In addition, sample matrix spikes are required for some analyses, and sufficient volume must be provided, and billable site specific QC requested, if this is required. All regulatory permits should be reviewed to ensure that these requirements are being met.

Data users should be aware of which regulations pertain to the samples they submit for testing. If related sample collection activities are not approved for a particular regulatory program, results should be considered estimates. Apex Laboratories will qualify these analytes according to the most stringent requirements, however results for samples that are for non-regulatory purposes may be acceptable.

Samples that have been filtered and preserved at Apex Laboratories per client request are listed in the preparation section of the report with the date and time of filtration listed.

Apex Laboratories maintains detailed records on sample receipt, including client label verification, cooler temperature, sample preservation, hold time compliance and field filtration. Data is qualified as necessary, and the lack of qualification indicates compliance with required parameters.

Apex Laboratories, LLC
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Tigard, OR 97223
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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

LABORATORY ACCREDITATION INFORMATION

TNI Certification ID: OR100062 (Primary Accreditation) - EPA ID: OR01039

All methods and analytes reported from work performed at Apex Laboratories are included on Apex Laboratories' ORELAP Scope of Certification, with the exception of any analyte(s) listed below:

Apex Laboratories

Matrix	Analysis	TNI_ID	Analyte	TNI_ID	Accreditation

All reported analytes are included in Apex Laboratories' current ORELAP scope.

Secondary Accreditations

Apex Laboratories also maintains reciprocal accreditation with non-TNI states (Washington DOE), as well as other state specific accreditations not listed here.

Subcontract Laboratory Accreditations

Subcontracted data falls outside of Apex Laboratories' Scope of Accreditation.
Please see the Subcontract Laboratory report for full details, or contact your Project Manager for more information.

Field Testing Parameters

Results for Field Tested data are provded by the client or sampler, and fall outside of Apex Laboratories' Scope of Accreditation.

Apex Laboratories, LLC
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Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

APEX LABS

6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

CHAIN OF CUSTODY

Lab # A0B0617 COC 1 of 3

Company: Cascadia Associates | Project Mgr: Amanda Spencer | Project Name: Nustar Vancouver Annex | Project #: 0060-001-005

Address: 5820 SW Kelly Ave Suite B | Phone: 503.906.6577 | Email: aspencer@cascadiaassociates.com | PO #

Sampled by: Ian Maguire / Jon Weatherford

Site Location: OR WA CA AK ID ___

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	Naphthalene by EPA 8260						Archive
B-35 (6)		2/21/20	850	S	3		X	X	X												X						
B-35 (9)			855	S	3		X	X	X												X						
B-35 (19)			905	S	3		X	X	X												X						
B-36 (6)			920	S	3		X	X	X												X						
B-36 (14)			1105	S	3		X	X	X												X						
B-36 (20)			1140	S	3		X	X	X												X						
B-37 (6)			1125	S	3		X	X	X												X						
B-37 (13)			1220	S	3		X	X	X												X						
B-37 (21)			1235	S	3		X	X	X												X						
B-38 (6)			1155	S	1		X	X																			

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle): 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ______

SPECIAL INSTRUCTIONS:
No Silica gel Cleanup on TPHDx analysis for Soil Samples

SAMPLES ARE HELD FOR 30 DAYS

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2-21-20
Printed Name: Ian Maguire Time: 5:25	Printed Name: Kurt H. Time: 5:25	Printed Name: Kurt H. Time: 5:50	Printed Name: Tanna Goldy Time: 17:50
Company: Cascadia Associates	Company: Cascadia	Company: Cascadia	Company: Apex

Apex Laboratories, LLC

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EPA ID: OR01039

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

APEX LABS

6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

CHAIN OF CUSTODY

Lab # A0B0617 COC 2 of 3

Company: Cascadia Associates Project Mgr: Amanda Spencer Project Name: Nustar Vancouver Annex Project #: 0060-001-005

Address: 5820 SW Kelly Ave, Suite B Phone: 503.906.6577 Email: aspencer@cascadiaassociates.com PO #

Sampled by: Ian Maguire / Jon Weatherford

Site Location: OR WA CA (WA circled)

AK ID ____

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	NWTPH-Dx w/ SG Cleanup	NWTPH-Dx w/o SG Cleanup	Naphthalene by EPA 8260				Archive
B-38 (13)		2/21/20	1410	S	2		X	X																			
B-38 (21.5)			1425	S	2		X	X																			
B-39 (6)			1355	S	2		X	X																			
B-39 (13.5)			1455	S	2		X	X																			
B-39 (21)			1505	S	3		X	X																			
B-35 GW			1050	GW	5			X	X											X	X	X	X				
B-36 GW Shallow			1040	GW	5			X	X											X	X	X	X				
B-36 GW Deep			1240	GW	5			X	X											X	X	X	X				
B-37 GW			1335	GW	5			X	X											X	X	X	X				
B-38 GW			1515	GW	5			X	X											X	X	X	X				

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle) 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ________

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
No Silica gel Cleanup for TPH Dx analysis for Soil Samples
Please run TPH Dx both w/ & without silica gel Cleanup on Ground water samples

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: Jon Way Date: 2/21/20	Signature: Date: 2-21-20	Signature: Date: 2-21-20	Signature: Date: 2-21-20
Printed Name: Ian Maguire Time: 5:25	Printed Name: Kurt H. / ~~Tanna Godby~~ Time: 5:25 / ~~17:25~~	Printed Name: Kurt H. Time: 5:50	Printed Name: Tanna Godby Time: 17:50
Company: Cascadia Associates	Company: Cascadia	Company: Cascadia	Company: Apex

Cascadia Associates	Project: **Nustar Vannex**	
5820 SW Kelly Ave Unit B	Project Number: **0060-001-005**	**Report ID:**
Portland, OR 97239	Project Manager: **Amanda Spencer**	**A0B0617 - 03 02 20 0958**

APEX LABS — CHAIN OF CUSTODY

6700 SW Sandburg St., Tigard, OR 97223 Ph: 503-718-2323

Lab # A0B0617 COC 3 of 3

Company: Cascadia Associates | Project Mgr: Amanda Spencer | Project Name: Nustar - Vancouver Annex | Project #: 0060-001-005

Address: 5820 SW Kelly Ave, Suite B | Phone: 503.906.6577 | Email: | PO #

Sampled by: Ian Maguire / Tom Weatherford

Site Location: OR WA CA; AK ID ___

ANALYSIS REQUEST

SAMPLE ID	LAB ID #	DATE	TIME	MATRIX	# OF CONTAINERS	NWTPH-HCID	NWTPH-Dx	NWTPH-Gx	8260 BTEX	8260 RBDM VOCs	8260 Halo VOCs	8260 VOCs Full List	8270 SIM PAHs	8270 Semi-Vols Full List	8082 PCBs	8081 Pest	RCRA Metals (8)	Priority Metals (13)	Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Hg, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn TOTAL DISS. TCLP	TCLP Metals (8)	Archive
Soil IDW		2/21/20	1520	S	3		X	X													

Normal Turn Around Time (TAT) = 10 Business Days

TAT Requested (circle): 1 Day 2 Day 3 Day 4 DAY 5 DAY Other: ______

SAMPLES ARE HELD FOR 30 DAYS

SPECIAL INSTRUCTIONS:
No Silica gel cleanup ~~Dx~~ on TPHDx for Soil Samples

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2/21/20	Signature: [signature] Date: 2-21-20
Printed Name: Ian Maguire Time: 5:24	Printed Name: Kurt H. Time: 5:24	Printed Name: Kurt H. Time: 5:50	Printed Name: Tanna Godfry Time: 17:50
Company: Cascadia Associates	Company: Cascadia	Company: Cascadia	Company: Apex

Cascadia Associates **5820 SW Kelly Ave Unit B** **Portland, OR 97239**	Project: **Nustar Vannex** Project Number: **0060-001-005** Project Manager: **Amanda Spencer**	**Report ID:** **A0B0617 - 03 02 20 0958**

APEX LABS COOLER RECEIPT FORM

Client: Cascadia Associates Element WO#: A0 B0617

Project/Project #: Nustar Vancouver Annex / 0060-001-005

Delivery Info:

Date/time received: 2-21-20 @ 17:50 By: TAH

Delivered by: Apex____ Client X ESS____ FedEx____ UPS____ Swift___ Senvoy ___ SDS___ Other_____

Cooler Inspection Date/time inspected: 2-21-20 @ 17:50 By: TAH

Chain of Custody included? Yes X No ___ Custody seals? Yes______ No X

Signed/dated by client? Yes X No ___

Signed/dated by Apex? Yes X No ___

	Cooler #1	Cooler #2	Cooler #3	Cooler #4	Cooler #5	Cooler #6	Cooler #7
Temperature (°C)	5.8	3.4					
Received on ice? (Y/N)	Y	Y					
Temp. blanks? (Y/N)	Y	Y					
Ice type: (Gel/Real/Other)	Real	Real					
Condition:	good	good					

Cooler out of temp? (Y/N) Possible reason why:

If some coolers are in temp and some out, were green dots applied to out of temperature samples? Yes/No/NA

Out of temperature samples form initiated? Yes/No/NA

Samples Inspection: Date/time inspected: 2/22/20 @ 1000 By: AKK

All samples intact? Yes X No ___ Comments:

Bottle labels/COCs agree? Yes ___ No X Comments: B-38(6) T on Cont. reads 1215.

COC/container discrepancies form initiated? Yes ___ No X NA ____

Containers/volumes received appropriate for analysis? Yes X No ___ Comments:

Do VOA vials have visible headspace? Yes ___ No X NA ____

Comments 15/15 seed

Water samples: pH checked: Yes X No___NA___ pH appropriate? Yes X No___NA____

Comments:

Additional information:

Labeled by: AKK Witness: MH Cooler Inspected by: CB See Project Contact Form: Y

APPENDIX F

SIMPLIFIED TERRESTRIAL ECOLOGICAL EVALUATION

Cascadia Associates, LLC

Memorandum

To:	Andrew Smith, P.E., LHG; Department of Ecology	**Project:**	0060-001-006
From:	Amanda Spencer, PE, RG; Cascadia Associates, LLC	**CC:**	Renee Robinson, NuStar Energy, L.P.
Date:	September 21, 2020		
Subject:	NuStar Annex Terminal – Simplified Terrestrial Ecological Evaluation		

A Supplemental Remedial Investigation (SRI) and revised Feasibility Study (FS) was completed for the NuStar Terminals Operations Partnership L.P. (NuStar) Annex Terminal located at 5420 NW Fruit Valley Road, Vancouver, Washington (the Facility). The SRI/FS was conducted in accordance with the protocols in the Model Toxics Control Act (MTCA) as defined in Washington Administrative Code (WAC) 173-340 and pursuant to Agreed Order No. 09-TC-S DE5250 (Agreed Order) between the Washington State Department of Ecology (Ecology) and NuStar. The SRI/FS concluded that the Facility would be excluded from performance of a Terrestrial Ecological Evaluation (TEE) because it is a highly industrialized property with little to no terrestrial habitat (Cascadia, 2020). Based on Ecology's comments on the SRI/FS, we understand that Ecology believes that this exclusion does not apply and a TEE is needed. The first step in performing a TEE is to determine whether a Simplified or Site-specific TEE is needed. Therefore, this memorandum:

- Evaluates whether the Facility would qualify for a Simplified TEE;
- Documents the conclusion that the Facility does qualify for the Simplified TEE; and
- Presents the results of the Simplified TEE.

Figure 1 provides a Facility Location Map and Figure 2 provides an aerial photograph that shows the Facility boundary and neighboring properties.

SITE BACKGROUND

The "site" is defined consistent with MTCA and the Agreed Order to include the area where a hazardous substance from a release at the Facility has "come to be located." The boundary of the site as defined in the Agreed Order is shown on Figure 2.

Location. The Facility address is 5420 NW Fruit Valley Road, Vancouver, Washington 98660 (Latitude: 45.6617ºN, Longitude: 122.6932ºW) (Section 16, Range 1E, Township 2N), as shown on Figure 1. The Facility is located on Clark County Tax Lot No. 147360.

Physical Features. The Facility is approximately 31 acres and is roughly rectangular, with dimensions of approximately 800 by 1,800 feet. The Facility is located in a mixed industrial-agricultural area and currently includes a tank farm consisting of seven large aboveground storage tanks (ASTs) contained in four containment areas; a covered truck loading rack; smaller ASTs containing fuel additives; a 42,000-gallon transmix AST; and several buildings used for equipment storage and offices. The large ASTs are used to store jet fuel and range in capacity size from 1,680,000 to 4,599,378 gallons. A former underground storage tank (UST) associated with a vapor recovery system was also located on the Facility and was removed in 2001. The current vapor recovery unit and adjacent oil/water separator (OWS) are located within a pipeline area between the south and north tank farm containments. The Facility is connected to the municipal sanitary sewer and water supply systems. In accordance with a State Waste Discharge Permit, stormwater is monitored and generally discharged to ground for infiltration. Stormwater from one of the AST containment areas which is lined is directed to a lined Fire System Water Reservoir in the northwestern portion of the Facility. An unlined overflow Storm Pond is located immediately south of the Fire System Water Reservoir and is used for stormwater storage and infiltration during heavy rain events.

Property History. Support Terminals Operating Partnership, L.P. (STOP) purchased the Facility from Cenex Harvest States Cooperative (Cenex) in 2003. In March 2008, STOP changed its name to NuStar.

The property was developed in 1957 as a truck loading terminal. Records are unclear as to whether the Facility was developed by Cenex. Historically, chemicals and other products stored at the Facility included liquid fertilizers and refined petroleum products such as gasoline, diesel and kerosene, de-natured alcohol, and petroleum product additives.

RATIONALE FOR SIMPLIFIED TEE

According to the Ecology February 2017 *Technical Document: Terrestrial Ecological Evaluation under the Model Toxics Control Act* ("TEE Guidance") and WAC 173-340-7492, there are four criteria that are to be used to determine whether a Simplified TEE can be performed. If any of the below criteria apply at the site, then a Simplified TEE cannot be performed, and a site-specific terrestrial ecological evaluation is necessary. These criteria are:

- Natural areas;
- Vulnerable species;
- Extensive habitat; or
- Risk to significant wildlife populations.

The subsections below evaluate each of these criteria relative to the requirements of the TEE guidance and the conditions at the site to identify a conclusion. As detailed below, none of the four criteria apply to the site.

Natural Areas

TEE Guidance. "If the site is located on, or directly adjacent to an area where management or land use plans will maintain or restore native or semi-native vegetation, then a site-specific terrestrial ecological evaluation is necessary. Examples of these areas include:

- Green-belts.
- Protected wetlands.
- Forestlands.
- Riparian areas.
- Locally designated environmentally sensitive areas.

- Open space areas managed for wildlife, and;
- Some parks and outdoor recreation areas".

Rationale Supporting that this Criteria Does Not Apply to the Site. The site is not one of the above listed areas nor is it "directly adjacent to" any of these areas. As shown on Figure 2, the land directly south and east of the site is under industrial use. Land directly to the north has been developed and is used for agricultural purposes—it is a blueberry farm. Land to the west and southwest is open space and according to Clark County zoning maps[1], is zoned for "Greenway/open space (GW) and Agriculture/Wildlife (AG/WL)"—see a copy of the zoning map for this area contained in Attachment A. However, as shown on Figure 2, the land to the southwest is clearly developed for agricultural use and the land to the west shows signs of active grading and therefore is clearly not being maintained as an "open space managed for wildlife". Additionally, the grading activity on the land to the west illustrates that it is not a protected wetland nor is it being used to "maintain or restore native or semi-native vegetation".

Conclusion. There are no natural areas consistent with TEE Guidance directly adjacent to the site; therefore, this criterion does not apply.

Vulnerable Species

TEE Guidance. "If the site is used by vulnerable species, a site-specific terrestrial ecological evaluation is necessary. Examples of listed vulnerable species are:

- A threatened or endangered species protected under the Federal Endangered Species Act.
- A wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or "species of concern" under Title 77 RCW, and;
- A plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW."

Rationale Supporting that this Criteria Does Not Apply to the Site. The following evaluates each of the above lists of vulnerable species relative to site conditions to support the rationale that this criterion would not apply to the site.

Federal Endangered Species Act. The threatened or endangered species that are found in Clark County that are protected under the Federal Endangered Species Act are:

Birds:	Northern spotted owl
Fish:	Bull Trout; Steelhead Trout; Coho Salmon; Chinook Salmon; Chum Salmon
Flowering plants:	Bradshaw's desert parsley; Water howelia
Mammals:	North American wolverine; Brush Prairie pocket gopher

[1] https://gis.clark.wa.gov/gishome/property/?pid=FindSN&account=147403000

As detailed below, none of these species would be present at the site:

- Northern spotted owls live in forests characterized by dense canopy closure of mature and old-growth trees, abundant logs, standing snags, and live trees with broken tops. The site would not provide suitable habitat for the Northern spotted owl.
- The identified threatened or endangered fish are migratory. The only surface water at the site is the fire pond. Therefore, these migratory fish would not be found in a fire pond nor would it be suitable habitat for these fish.
- Bradshaw's desert parsley and Water howelia are wetland species. According to the US Fish and Wildlife website, Bradshaw's desert parsley "occur on seasonally saturated or flooded prairies, adjacent to creeks and small rivers where soils are dense, heavy clays" and Water howelia "predominantly occur in ephemeral wetlands". There are no wetlands at the site.
- No wolverines have been identified at the site; these wolverines are typically found in tundra and forested areas. Brush Prairie pocket gophers live in well-drained, easily-crumbled soil; the majority of the Facility is covered in pavement or packed gravel, which would not be conducive habitat for these pocket gophers.

State Priority Species or Species of Concern. Attachment B lists the wildlife species classified by the Washington State Department of Fish and Wildlife as a "priority species" or "species of concern" under Title 77 RCW. With the exception of birds, amphibians, and small mammals, no wildlife—threatened or otherwise—have been identified at the site by onsite personnel or Cascadia staff because the industrial nature of the facility makes it unsuitable habitat. The Facility is gated, fenced, and operated 24/7, with significant large tanker truck traffic entering and exiting the site.

Birds observed at the site are typically transient, as there are no trees for roosting and the site structures (e.g., buildings, aboveground tanks, truck loading facility) do not provide suitable habitat. Further, as detailed in the FS, the contamination is found below 2 feet and the proposed remedy will be removing this material from the vadose zone (i.e., above a depth of 8 to 10 feet), eliminating the potential exposure to birds or the foods upon which they feed. The proposed remedy will also eliminate exposure to any small mammals or amphibians at the site.

Plant species classified by the Washington State Department of Natural Resources Natural Heritage Program. Attachment C contains the list of vascular plant species classified by the Washington State Department of Natural Resources Natural Heritage Program as "endangered," "threatened," or "sensitive" under Title 79 RCW. Consulting the list identifies that none of the threatened, endangered, or candidate plant species are found in the vicinity of the site. Further, the site is predominantly covered by compacted gravel or pavement. In the few areas where plants are present, the plants consist of weeds or non-native ornamental grasses.

Conclusion. There is no evidence that the site is used by vulnerable species; therefore, this criterion does not apply.

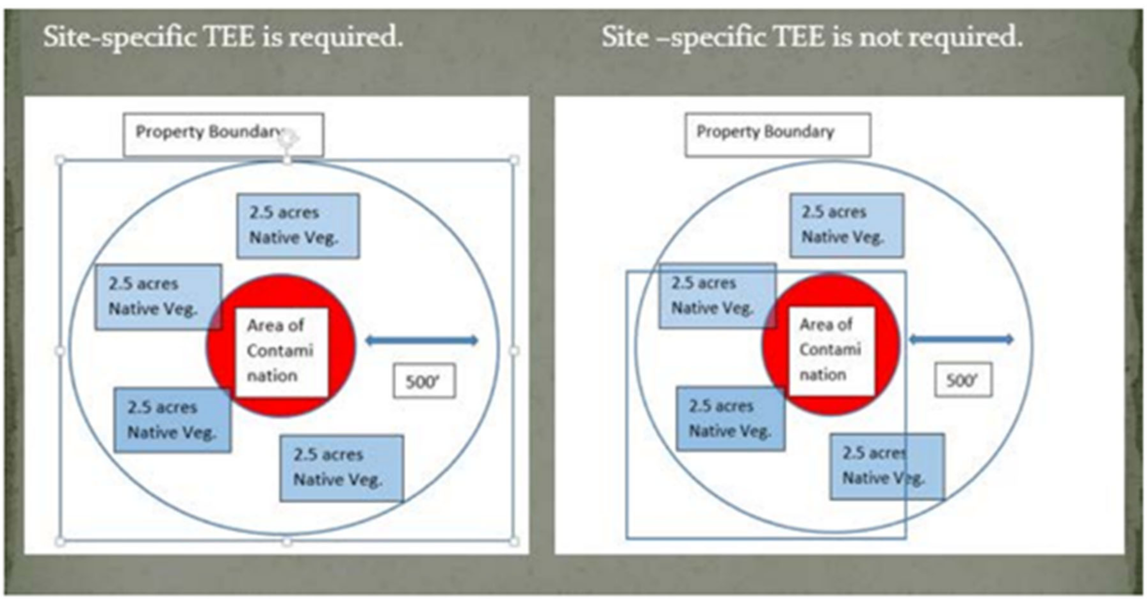
Extensive Habitat

TEE Guidance. "If the site is located on a property that contains at least 10 acres of native vegetation within 500 feet of the site, not including vegetation beyond the property boundaries, a site-specific TEE is necessary."

Rationale Supporting that this Criteria Does Not Apply to the Site. As shown on Figure 1, a vegetated area is present on the Facility to the west of the site. However, the dimensions of this vegetated area are approximately 800 feet by 400 feet, equating to approximately 8 acres, which is less than the criteria specification of 10 acres. Furthermore, this area is a former orchard area where many of the former pear trees that encompassed the orchard are still present. Therefore, this 8-acre area is not vegetated by native vegetation.

As also shown on Figure 1, the area to the west of the 8 vegetated acres on the property is also vegetated. However, the TEE Guidance shows that habitat that is not on the property, even if within 500 feet of the site, does not count towards the 10 acres. This is illustrated on Figure 3.1 of the TEE Guidance, which has been included below for reference.

Figure 3.1 of the TEE Guidance: Extensive Habitat Scenarios for Determination if a Site-Specific TEE is Necessary



The picture on the left, above, shows the site as the red circle and the property boundary as a square that includes 10 acres of native vegetation, which would then require a site-specific TEE. The picture on the right, above, shows less than 10 acres of native vegetated area within the square property boundary and does not require a site-specific TEE, illustrating that native vegetation acreage that is outside of the property boundary is not being counted towards the 10 acres, even if it is within 500 feet of the site.

Additionally, as noted previously above, the area west of the property is graded and does not appear to maintain native vegetation.

Conclusion. The site is not located on property that includes extensive habitat.

Risk to Significant Wildlife Populations

TEE Guidance. "If the department determines the contamination may present a risk to significant wildlife populations, a site-specific terrestrial ecological evaluation is necessary."

Rationale Supporting that this Criteria Does Not Apply to the Site. As detailed above, there is limited wildlife at the property, and the wildlife that is present consists of: birds that occasionally land on the firewater pond or other structures at the Facility; non-native, stocked fish in the pond; and rodents such as mice. Further, the contamination is generally found 2 or more feet below the ground surface, and the ground surface is predominantly heavily graveled. Therefore, significant wildlife populations are not present at the site and the contamination does not present an unacceptable risk to the limited wildlife that is present.

Conclusion. The site will not present a risk to significant wildlife populations.

SIMPLIFIED TEE

As detailed above, none of the criteria for a site-specific TEE apply to the site and, therefore, a Simplified TEE can be performed. According to WAC 173-340-7492 and the TEE Guidance, the Simplified TEE can be ended and a determination can be made that the site does not pose a significant risk to the environment if <u>any</u> of the following three criteria are met:

- Exposure analysis shows there is not significant exposure as defined in WAC 173-340-7492;
- Pathways analysis indicates that exposure pathways are not complete; or
- Toxicity analysis supports that toxicants are safe for ecological receptors.

The following subsections examines each of these criteria.

Exposure Analysis

According to the TEE Guidance, the Exposure Analysis process, as represented on Figure 4.2 of the TEE Guidance, is designed to determine the potential for significant exposure to ecological receptors that either use or inhabit sites. The TEE may be ended at a site where:

- The total area of soil contamination is not more than 350 square feet; or
- Land use at the site and surrounding area make substantial wildlife exposure unlikely.

As detailed in the SRI/FS, the total area of soil contamination is greater than 350 square feet. However, the site is located on a property which is an active bulk terminal, and the contamination is entirely within the confines of the property. Consistent with the TEE Guidance, Table 4.2 of the guidance was used to make the determination whether land use and wildlife exposure is likely. A copy of the table and the responses relevant to the property are included below.

The Total Score of 11 on Table 4.2 is one point below line 1; therefore, the Simplified TEE continues to the pathway analysis.

Cascadia Associates, LLC

Table 4.2 of TEE Guidance: Simplified Terrestrial Ecological Evaluation – Exposure Analysis Procedures

Estimate the area of contiguous (connected) undeveloped land on or within 500 feet of any area of the contaminated soil to the nearest 0.5 acre (0.25 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildfire from feeding on plants, earthworms, insects or other food in or on the soil.		**Rationale for Numeric Response**
(1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right.		
Area (acres) Points 0.25 or less = 4 0.5 = 5 1.0 = 6 1.5 = 7 2.0 = 8 2.5 = 9 3.0 = 10 3.5 = 11 4.0 or more = 12	12	There is approximately 8 acres of undeveloped land on the Property and adjacent to the site.
(2) Is this an industrial or commercial property? See the definition in WAC 173-340-200. If yes, enter a score of 3 in the box to the right. If no, enter a score of 1.	3	The site is an industrial property.
(3) Enter a score in the box to the right for the habitat quality of the contaminated soil and surrounding area, using the rating system shown below. (High = 1, Intermediate = 2, Low = 3)	3	The contaminated soil and surround area is within the bulk terminal, which is covered by paved or heavily graveled surfaces, buildings, or above ground storage tanks.
(4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2c.	1	The undeveloped land that is adjacent to the site is former orchard, disturbed by anthropogenic operations, and is not vegetated with non-native vegetation but could attract wildlife.
5) Are there any of the following soil hazardous substances present: Chlorinated dioxins/furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4.	4	No.
Add the numbers in the boxes on lines 2 through 5 and enter this number to the right. If this number is larger than the number in the box on line 1, the simplified TEE may be ended under WAC 173-340-7292(2) (a) (ii).	**11**	Total score of 11 is one point below line 1; therefore, the Simplified TEE continues to the pathway analysis.

Footnotes to Table .2 of the TEE Guidance:

a It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

b Habitat rating system. Rate the quality of the habitat as high, intermediate, or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:

- **Low:** Early successional vegetative stands; vegetation predominantly noxious, non-native, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.
- **High:** Area is ecologically significant for one or more of the following reasons: Late successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington Department of Fish and Wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.
- **Intermediate:** Area does not rate as either high or low.

c Indicate "yes" if the area attracts wildlife or is likely to do so. Examples:

- Birds frequently visit the area to feed
- Evidence of high use by mammals (tracks, scat, etc…)
- Habitat "island" in an industrial area
- Unusual features of an area that make it important for feeding animals
- Heavy use during seasonal migrations
- Areas adjacent to wildlife corridors (i.e., greenbelts and waterways)

Pathway and Toxicity Analyses

According to the TEE Guidance, only potential exposure pathways to wildlife (e.g., small mammals, birds) need be considered for commercial or industrial properties. Additionally, only exposure pathways for priority chemicals of ecological concern listed in Table 4.1 of the TEE Guidance (MTCA Table 749-2) where the chemicals are present at or above the concentrations provided in the table must be considered. Because the latter is both a pathway analysis and a toxicity analysis, the guidance recommends that the pathway and toxicity analyses be conducted concurrently. A copy of Table 4.1 is included in Attachment D for reference.

The chemicals of concern (COCs) identified in the SRI/FS for soil and/or groundwater are total petroleum hydrocarbons (TPH) in the gasoline carbon range (TPHg), TPH in the diesel carbon range (TPHd), benzene, toluene, ethylbenzene, and xylenes. Comparing the constituents on Table 4.1 to the COCs for the site identifies TPHd and TPHg as the priority contaminants of ecological concern that might be present at the site. The levels of potential ecological concern are 12,000 milligrams per kilogram (mg/kg) and 15,000 mg/kg for TPHg and TPHd, respectively, for an industrial or commercial property. Table 1 lists the concentrations of TPHg and TPHd detected at the site and identifies the concentrations above the ecological levels of concern. As shown in Table 1, TPHg concentrations are all below the ecological levels of concern and TPHd exceeds at just three locations. Boring locations are shown on Figure 3.

All three locations are in the truck loading rack area in soil that is more than 8 feet below ground surface. This area is paved, eliminating access by wildlife, including small mammals, to subsurface soil. Additionally, the truck rack is operated on a 24/7 basis to load fuel transport trucks and could not sustain habitat for birds or small mammals. Finally, the mitigation measure proposed for soil in this area in the FS is an institutional control and soil media management plan that will identify the presence of the fuel hydrocarbons and document a plan for handling soil if it is accessed in the future. The plan would mitigate the potential that the subsurface in this area could be excavated and placed at ground surface. Therefore, the pathway for ecological exposure is currently incomplete, and the subsurface soil will be appropriately managed under the proposed remedy so future exposure is mitigated.

CONCLUSIONS

Site conditions at the Facility were evaluated consistent with WAC 173-340-7492, with the following conclusions:

- The four criteria, natural areas, vulnerable species, extensive habitat, and risk to significant wildlife populations, do not apply to the site and therefore, a Simplified TEE is applicable.
- A Simplified TEE was performed and identified three subsurface soil locations with TPHd concentrations above ecological levels of concern listed in Table 4.1 of the TEE Guidance. However, all three locations are below 8 feet in depth, are beneath a paved area that is operated on a continuous basis as a truck loading rack precluding any habitat for birds or small mammals, and will be managed by an institutional control and soil management plan to eliminate the potential for future ecological exposure.
- The Simplified TEE supports that the presence of TPH at the site will not present an unacceptable ecological health risk.

ATTACHMENTS

Table 1 Comparison of TPH Concentrations to Ecological Concern Levels

Figure 1 Facility Location Map
Figure 2 Aerial View of Site and Site Vicinity
Figure 3 Site Plan

Attachment A Zoning Map for Site Vicinity
Attachment B State Listed Candidate Species
Attachment C Federal Listed Endangered Species Found in Clark County
Attachment D Table 4.1 of TEE Guidance

REFERENCES

Cascadia Associates, Inc., 2020. *Supplemental Remedial Investigation and Feasibility Study Report, NuStar Vancouver Annex Terminal*. June 1, 2020.

Washington Department of Ecology, 2017. *Technical Document: Terrestrial Ecological Evaluation under the Model Toxics Control Act.* February 2017.

TABLE

Table 1
Comparison of TPH Concentrations to Ecological Concern Levels
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth	TPHg	TPHd
			Concentrations in mg/kg (ppm)	
Soil Borings				
GP-2	04/10-04/11/2002	10-12	ND	ND
GP-3	04/10-04/11/2002	10-12	ND	ND
GP-5	04/10-04/11/2002	17-19	ND	ND
GP-7	04/10-04/11/2002	14-16	ND	ND
GP-8	04/10-04/11/2002	6-8	ND	ND
GP-9	04/10-04/11/2002	16-18	ND	ND
GP-12	04/10-04/11/2002	22-24	ND	ND
GP14	05/09/2002	10-12	3,230	19,700
GP16	05/09/2002	10-12	ND	ND
MW2	05/09/2002	25-26.5	314	<25
GP26	06/26/2002	6-8	5,850	--
GP27	06/26/2002	10-12	4.96	--
GP31	06/26/2002	22-24	<2.5	<25
GP32	06/26/2002	6.5-8	910	2,530
GP33	06/26/2002	8-10	363	31,500
GP34	06/26/2002	6-8	728	13,600
GP35	06/26/2002	8-10	10.3	<25
SB-2	04/17/2003	4	--	--
SB-2	04/17/2003	22	--	--
SB-4	04/17/2003	3	--	<25
SB-4	04/17/2003	27	--	<25
SB-5	04/17/2003	11	--	--
SB-6	04/16/2003	3	--	--
SB-6	04/16/2003	16	--	--
SB-7	04/17/2003	12	--	--
SB-8	04/17/2003	8	1,020	7,890
SB-8	04/17/2003	16	369	1,440
SB-8R	09/30/2014	12	<5.0	<5.0
SB-9	04/18/2003	12	504	1,890
SB-9	04/18/2003	15	168	1,210
SB-9R	09/30/2014	12	1,000	4,000
SB-9R	09/30/2014	13.5	--	3,400
SB-11	04/16/2003	2.5	--	<25
SB-11	04/16/2003	14	--	<25
SB-12	04/22/2003	3	--	--
SB-12	04/18/2003	12	--	--
SB-13	04/22/2003	2	--	--
SB-13	04/22/2003	5	--	--
Washington DOE MTCA Ecological Concern Level			12,000	15,000

Please refer to notes at end of table.

Table 1
Comparison of TPH Concentrations to Ecological Concern Levels
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth	TPHg	TPHd
			Concentrations in mg/kg (ppm)	
Soil Borings (continued)				
B-15	01/31/2019	4.5 - 5.5	<7.94	<28.2
B-16-1	01/30/2019	3 - 4	<7.80	27.8 F-11
B-16-2	01/30/2019	5 - 6	1,900	483 F-20
B-17-1	01/31/2019	11.5 - 12.5	<9.32	<28.5
B-17-2	01/31/2019	15 - 16	38.7	323 F-13
B-18-1	01/30/2019	6.5 - 7.5	5,100	12,800
B-18-2	01/30/2019	**14 - 15**	10,800	7,460
B-19	01/29/2019	10 - 11	<7.59	<27.8
B-20-1	02/04/2019	10 - 11	302	89.4
B-20-2	02/04/2019	12 - 13	35.1	<27.4
B-21-1	02/01/2019	13 - 14	<8.11	<27.1
B-21-2	02/01/2019	15.5 - 16.5	10.5	<25.0
B-23	01/29/2019	6.5 - 7.5	<7.26	<25.0
B-24	01/28/2019	10.5 - 11.5	<7.19	<26.5
B-25-1	01/28/2019	6 - 7	10.8	5,540
B-25-2	01/28/2019	8.5 - 9.5	88.6	7,650
B-26	01/28/2019	8 - 9	<8.16	<27.3
B-27	01/28/2019	7 - 8	1,910	6,620
B-27-2	01/28/2019	9 - 10	11,500	23,700
B-28	01/28/2019	8 - 9	<8.95	<30.2
B-29(6.5)	02/18/2020	6.5	<6.89	<25.6
B-29(11)	02/18/2020	11	<7.69	<27.1
B-29(21)	02/18/2020	21	<7.04	<26.3
B-30(4.5)	02/18/2020	4.5	6,510	14,700
B-30(16)	02/19/2020	16	2,930	2,630
B-30(21.5)	02/19/2020	21.5	1,660	208
B-31(6.5)	02/18/2020	6.5	<7.31	<25.8
B-31(14)	02/18/2020	14	3,940	6,170
B-31(21.5)	02/18/2020	21.5	19.0	54.1
B-32(9)	02/18/2020	9	<7.23	<25
B-32(12)	02/18/2020	12	<7.9	<25.9
B-32(21)	02/18/2020	21	<6.05	<25.5
B-33(6.5)	02/18/2020	6.5	<7.49	<26.8
B-33(18)	02/19/2020	18	437	261
B-33(20)	02/19/2020	20	<7.61	<26.1
B-34(6.5)	02/19/2020	6.5	<7.45	<25.1
B-34(18)	02/19/2020	18	28.7	47.8
B-34(20)	02/19/2020	20	<7.82	<27.3
B-35(6)	02/21/2020	6	<7.1	<26.7
B-35(9)	02/21/2020	9	<8.17	<26.8
B-35(19)	02/21/2020	19	<7.51	<27.7
B-36(6)	02/21/2020	6	<8.52	<27.5
B-36(14)	02/21/2020	14	<7.54	<26
B-36(20)	02/21/2020	20	<6.91	<25.6
B-37(6)	02/21/2020	6	<7.92	<27.1
B-37(13)	02/21/2020	13	2,170	2,300
B-37(21)	02/21/2020	21	454	98.8
B-38(6)	02/21/2020	6	<8.46	<26.8
B-38(13)	02/21/2020	13	940	3,900
B-38(21.5)	02/21/2020	21.5	208	122
B-39(6)	02/21/2020	6	<8.41	<27.2
B-39(13.5)	02/21/2020	13.5	<9.14	<26.5
B-39(21)	02/21/2020	21	<8	<26.2
Washington DOE MTCA Ecological Concern Level			12,000	15,000

Please refer to notes at end of table.

Cascadia Associates, LLC

Table 1
Comparison of TPH Concentrations to Ecological Concern Levels
NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Sample Location	Sample Date	Depth	TPHg	TPHd
			Concentrations in mg/kg (ppm)	
Hand Augers				
HA-1	04/17/2003	3	--	--
HA-1	04/17/2003	6	--	--
HA-2	04/18/2003	2	--	--
HA-2	04/18/2003	5	--	--
HA-3	04/17/2003	2	--	--
HA-3	04/17/2003	5.5	--	--
HA-4	04/18/2003	2	--	--
HA-4	04/18/2003	5	--	--
HA-5	04/18/2003	3	3,320	4,780
HA-5	04/18/2003	5	2,290	10,700
HA-6	04/18/2003	2	--	--
HA-6	04/18/2003	5	--	--
HA-7	04/14/2003	6	--	--
HA-8	04/14/2003	6	--	--
Soil Sample from Advancement of Temporary Monitoring Wells				
PMW-5	04/16/2003	8		31
PMW-5	04/16/2003	10	--	146
PMW-6	04/16/2003	3	--	--
PMW-6	04/16/2003	12	--	--
PMW-7	04/16/2003	3	--	--
PMW-7	04/16/2003	16	--	--
Soil Samples from Excavation Confirmation				
N. Wall	05/20/2002	10	--	--
N. Wall	05/20/2002	3	--	--
E. Wall	05/21/2002	10	--	--
E. Wall	05/21/2002	3	--	--
Washington DOE MTCA Ecological Concern Level			12,000	15,000

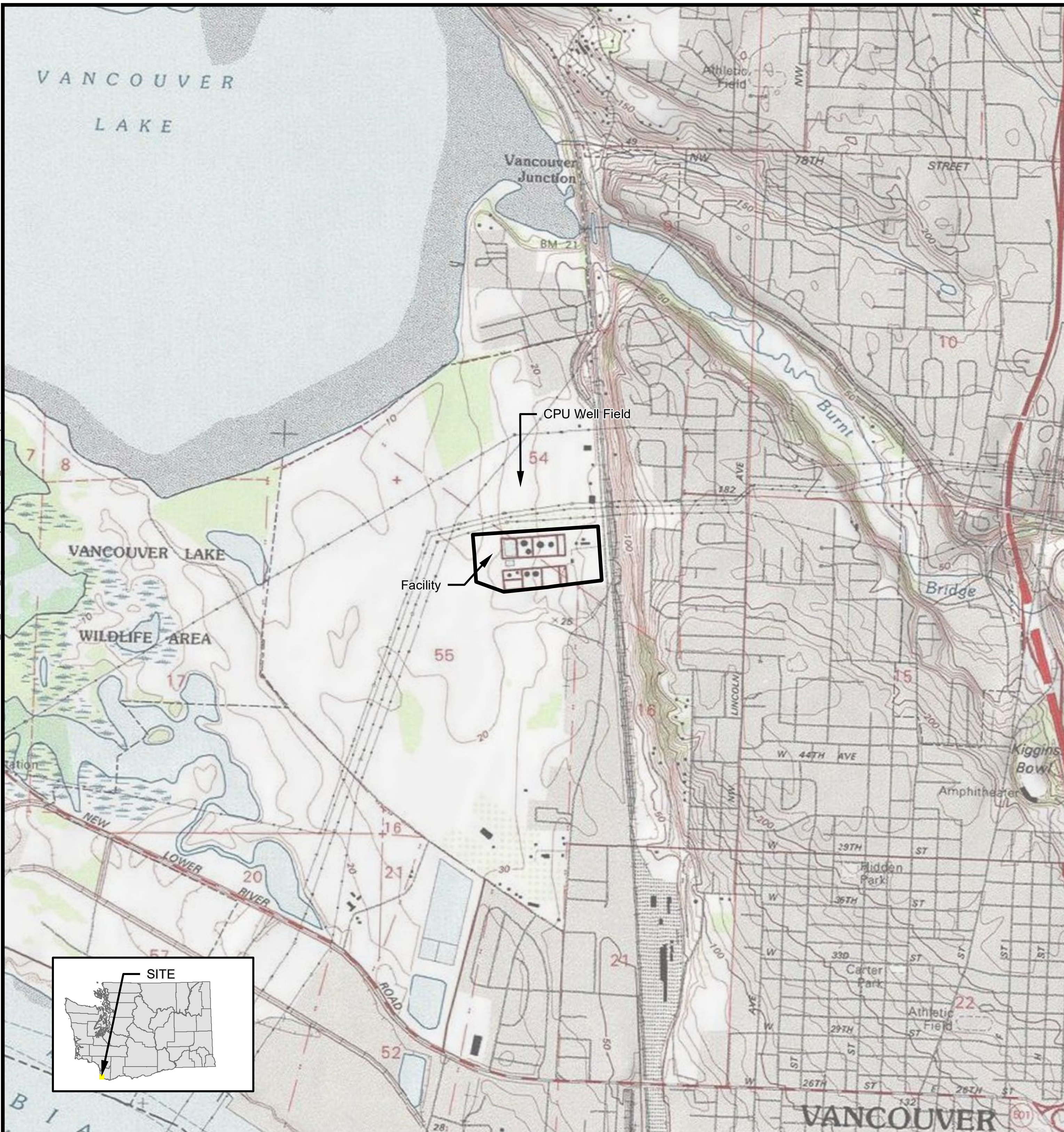
Notes:
1. TPHg = Total petroleum hydrocarbons in the gasoline carbon range by NW-TPH-Gx method.
2. TPHd = Total petroleum hydrocarbons in the diesel carbon range by NW-TPH-Dx method with silica gel cleanup.

Note: Flags in the lab reports indicate that TPHg and TPHd results do not fall under the (respective) standard gasoline or diesel ranges, but typically represent an overlap of diesel and gasoline ranges. Specific notes for individual samples can be found in the attached laboratory anlaytical reports.

3. mg/kg (ppm) = Milligrams per kilogram (parts per mil
4. -- = Not analyzed or not available.
5. < = Not detected at or above the specified laboratory method reporting limit (MRL).
6. ND = Not detected; MRL not available.
7. **Yellow highlighted** values represent concentration that exceeds MTCA Ecological Concern level.
8. Washington DOE MTCA = Washington Department of Ecology Model Toxics Control Act.

Cascadia Associates, LLC

FIGURES



Source: USGS Map obtained from Esri ArcGIS Online	Facility Boundary

0 1,000 2,000
Feet

Facility Location Map

NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Figure

1

Path: C:\DATA\C0060_005_NuStar_Vannex\Projects\Updated_FS\VicinityMap.mxd

Print Date: 4/27/2020

Approved By:

Produced By: ErikStrandhagen

Project:

Document Path: Y:\C0060_005_NuStar_Vannex\Projects\SWPP\Aerial_View_Site_Vicinity.mxd

Source:
Aerial from Mapbox.

Facility Boundary

Site Boundary as Defined in the Agreed Order

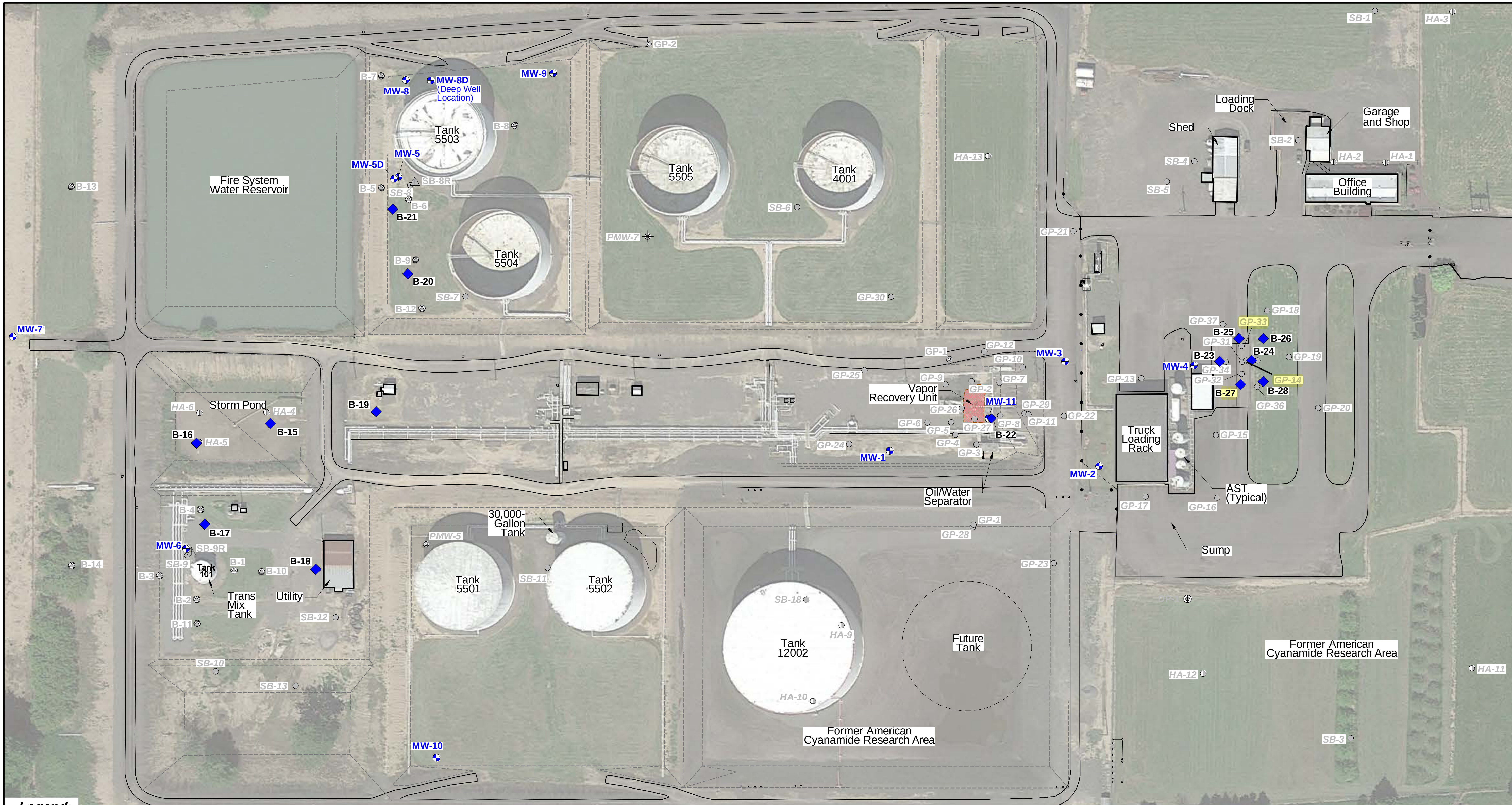
0 100 200
Feet

Aerial View of
Site and Site Vicinity

NuStar Terminals Operations Partnership L.P. - Annex Terminal
Vancouver, Washington

Cascadia Associates, LLC

Project Number	0060-001-006	Figure
	September 2020	2



Legend:

MW-1 Groundwater Monitoring Well Location (MW-5D and MW-8D are Deep Monitoring Well Locations)

SB-8R Soil Boring Location (September 2014)

DP-1 Grab Groundwater Sample Location

GP-1 Deeper Direct-Push Geoprobe Location

GP-1 Historical Direct-Push Boring Location (Approximate)

PMW-5 Historical Temporary Well Location (Approximate)

HA-1 Historical Hand Auger Location (Approximate)

B-1 Soil Boring Location (October 2015)

B-1 Soil Boring Location (February 2019)

Yellow higlighted locations indicate concentration exceeds Ecological concern level of TPHd

NOTE: Base map completed from a number of sources including but not limited to; Figure VAN1-21-002 provided by NuStar (1/8/2007) and a Monitoring Well Survey by Statewide Land Surveying, Inc (10/30/2007). Locations of roads and containments are approximate. Aerial photograph from Google Earth Pro (4/2015).

Site Plan

NuStar Terminals Operations Partnership, L.P. - Annex Terminal
Vancouver, Washington

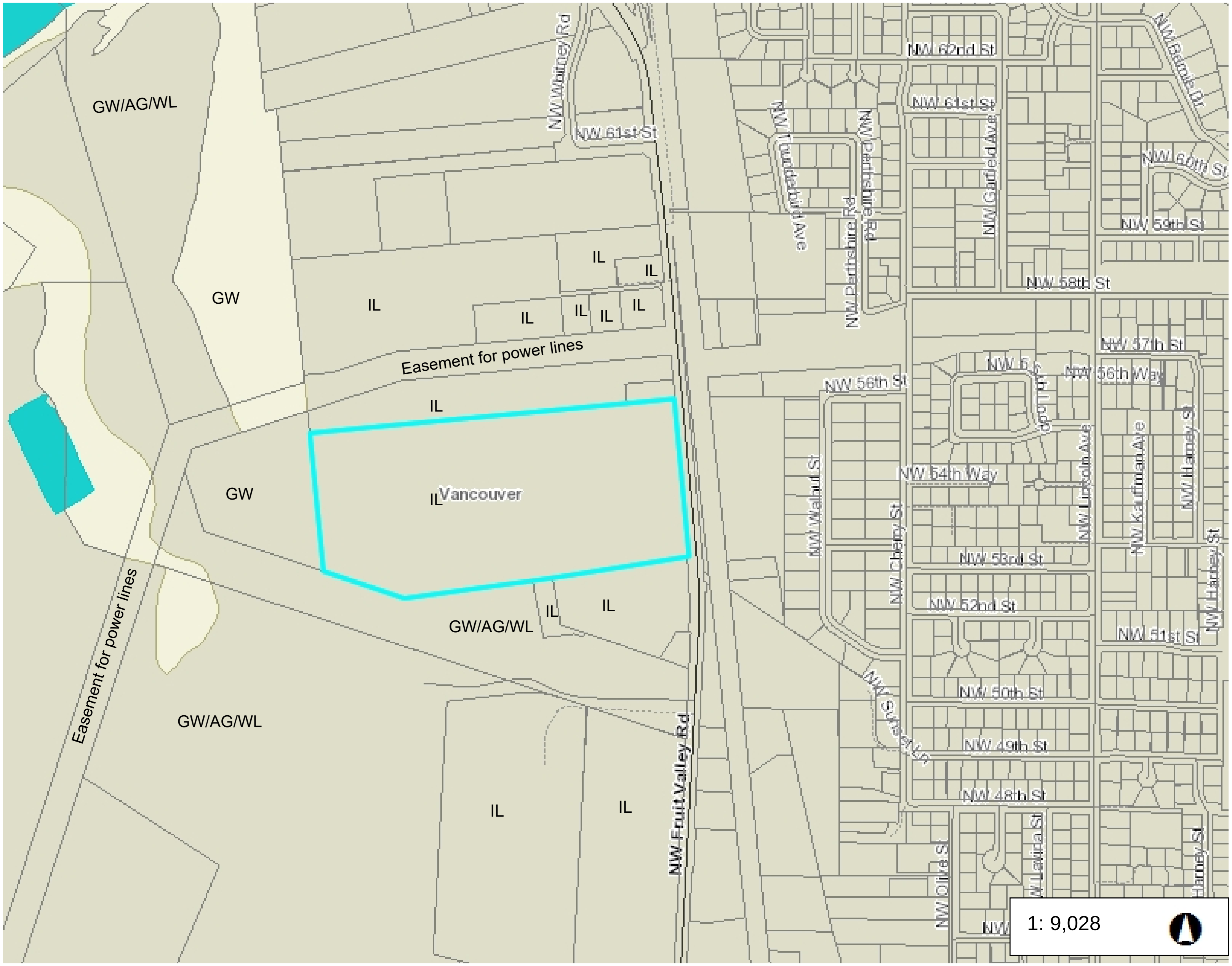
Cascadia Associates, LLC

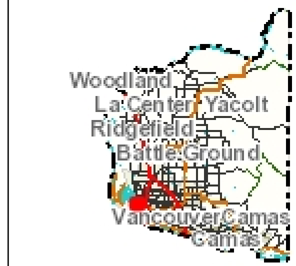
Project Number	0060-001-005	Figure
	May 2019	3

ATTACHMENT A

ZONING MAP FOR SITE VICINITY

ZONING MAP





Legend

- Taxlots
- Cities Boundaries
- Urban Growth Boundaries

GW- Greenway/Open Space

IL - Light Industrial

AG/WL - Agriculture/Wildlife

Notes: Area outlined in blue is the Facility taxlot boundary

1,504.7 0 752.33 1,504.7 Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere
Clark County, WA. GIS - http://gis.clark.wa.gov

ATTACHMENT B

STATE LISTED CANDIDATE SPECIES

STATE LISTED SPECIES

Revised February 2020

The Washington Fish and Wildlife Commission has classified the following 45 species as Endangered, Threatened, or Sensitive. The federal status of species under the Endangered Species Act differs in some cases from state status; federal status is indicated by: Federal Endangered (FE), Threatened (FT), or Candidate (FC).

STATE ENDANGERED

A species native to the State of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state.

The 32 State Endangered species are designated in Washington Administrative Code 220-610-010

MAMMALS (14)

Pygmy Rabbit	FE
Fin Whale	FE
Sei Whale	FE
Blue Whale	FE
Humpback Whale	FT/FE#
#Mexico DPS=T; Central America DPS=E	
North Pacific Right Whale	FE
Sperm Whale	FE
Killer Whale	FE#
#Southern Residents only	
Gray Wolf	FE#
#Federally listed west of north-south line following Highways 97, 17, and 395.	
Grizzly Bear	FT
Lynx	FT
Fisher	FC
Columbian White-tailed Deer	FT
Woodland Caribou	FE

BIRDS (9)

Sandhill Crane	-
Snowy Plover	FT
Upland Sandpiper	-
Marbled Murrelet	FT
Tufted Puffin	-
Columbian Sharp-tailed Grouse	-
Northern Spotted Owl	FT
Yellow-billed Cuckoo	FT
Streaked Horned Lark	FT

REPTILES (3)

Western Pond Turtle	-
Leatherback Sea Turtle	FE
Loggerhead Sea Turtle	FE

AMPHIBIANS (2)

Oregon Spotted Frog	FT
Northern Leopard Frog	-

INVERTEBRATES (4)

Oregon Silverspot Butterfly	FT
Taylor's Checkerspot	FE
Mardon Skipper	-
Pinto Abalone	-

STATE THREATENED

A species native to the state of Washington that is likely to become endangered within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.

The 7 State Threatened species are designated in Washington Administrative Code 220-200-100

MAMMALS (3)

Sea Otter	-
Western Gray Squirrel	-
Mazama Pocket Gopher	
subsp. *glacialis, pugetensis, tumuli, yelmensis*	FT
…subsp. *couchi, louiei, melanops*	-

BIRDS (3)

American White Pelican	-
Greater Sage-Grouse	-
Ferruginous Hawk	-

REPTILES (1)

Green Sea Turtle	FT

For more information, check our website:
https://wdfw.wa.gov/species-habitats

Or contact us at:
Wildlife Program (360) 902-2515
Fish Program (360) 902-2700

For more information on federal status, check the US Fish and Wildlife Service or the National Marine Fisheries Service

STATE SENSITIVE

A species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats.

The 6 State Sensitive species are designated in Washington Administrative Code 220-200-100

MAMMALS (1)

Gray Whale	FE#
#Western North Pacific Stock	

BIRDS (1)

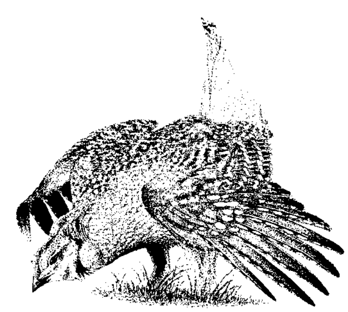
Common Loon	-

FISH (3)

Pygmy Whitefish	-
Margined Sculpin	-
Olympic Mudminnow	-

AMPHIBIAN (1)

Larch Mountain Salamander	-



STATE CANDIDATE SPECIES

Revised February 2020

The Washington Department of Fish and Wildlife has designated the following 102 species as Candidates for listing in Washington as State Endangered, Threatened, or Sensitive. The Department reviews species for listing following procedures in Washington Administrative Code 220-610-110. The federal status of species under the Endangered Species Act differs in some cases from state status; federal status is indicated by: Federal Endangered (FE), Threatened (FT), or Candidate (FC).

MAMMALS (10)

Townsend's Big-eared Bat	-
Keen's Myotis Bat	-
White-tailed Jackrabbit	-
Black-tailed Jackrabbit	-
Washington Ground Squirrel	-
Townsend's Ground Squirrel South of the Yakima River	-
Olympic Marmot	-
Cascade Red Fox	-
Wolverine	FC
Pacific Harbor Porpoise	-

BIRDS (17)

Western Grebe	-
Clark's Grebe	-
Short-tailed Albatross	FE
Northern Goshawk	-
Golden Eagle	-
Cassin's Auklet	-
Flammulated Owl	-
Burrowing Owl	-
Vaux's Swift	-
White-headed Woodpecker	-
Black-backed Woodpecker	-
Pileated Woodpecker	-
Loggerhead Shrike	-
Slender-billed White-breasted Nuthatch	-
Sage Thrasher	-
Oregon Vesper Sparrow	-
Sagebrush Sparrow	-

REPTILES and AMPHIBIANS (10)

Sagebrush Lizard	-
Common Sharp-tailed Snake	-
California Mountain Kingsnake	-
Striped Whipsnake	-
Dunn's Salamander	-
Van Dyke's Salamander	-
Cascade Torrent Salamander	-
Western Toad	-
Columbia Spotted Frog	-
Rocky Mountain Tailed Frog	-

FISH (37)

Mountain Sucker	-
Lake Chub	-
Leopard Dace	-
Umatilla Dace	-
River Lamprey	-
Pacific Herring	-
Eulachon –Southern DPS	FT
Pacific Cod	
South and Central Puget Sound	-
Walleye Pollock	
South Puget Sound	-
Pacific Hake (Whiting) Georgia Basin	-
Black Rockfish#	-
Brown Rockfish#	-
Copper Rockfish#	-
Quillback Rockfish#	-
Tiger Rockfish#	-
Bocaccio Rockfish#	FE
Canary Rockfish	-
Yelloweye Rockfish#	FT
Yellowtail Rockfish#	-
Greenstriped Rockfish#	-
Widow Rockfish#	-
Redstripe Rockfish#	-
China Rockfish#	-

#Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca east of the Sekiu R.

Chinook Salmon	
Snake River Fall	FT
Snake River Spring/Summer	FT
Puget Sound	FT
Upper Columbia Spring	FE
Lower Columbia	FT
Chum Salmon	
Hood Canal Summer (includes Strait of Juan de Fuca, not Puget Sound)	FT
Columbia River	FT
Sockeye Salmon	
Snake River	FE
Ozette Lake	FT
Steelhead	
Snake River	FT
Upper Columbia	FT
Middle Columbia	FT
Lower Columbia	FT
Bull Trout	FT

NOT STATE CANDIDATES

Fish stocks that have been the subjects of federal register notices, but have not yet been added to the state candidate list.

Coho Salmon	
Puget Sound/Strait of Georgia	-
Lower Columbia	FT
Steelhead, Puget Sound DPS	FT
Green Sturgeon	FT

MOLLUSKS (9)

Shortface Lanx	-
Ashy (Columbia) Pebblesnail	-
California Floater	-
Olympia Oyster	-
Columbia Oregonian (snail)	-
Poplar Oregonian (snail)	-
Dalles Sideband (snail)	-
Blue-gray Taildropper (slug)	-

INSECTS (18)

Beller's Ground Beetle	-
Mann's Mollusk-eating Ground Beetle	-
Columbia River Tiger Beetle	-
Hatch's Click Beetle	-
Columbia Clubtail (dragonfly)	-
Pacific Clubtail	-
Sand-verbena Moth	-
Yuma Skipper	-
Shepard's Parnassian	-
Makah Copper	-
Chinquapin Hairstreak	-
Johnson's Hairstreak	-
Juniper Hairstreak	-
Puget Blue	-
Valley Silverspot	-
Silver-bordered Fritillary	-
Great Arctic	-
Island Marble	FC

OTHER INVERTEBRATES (2)

Giant Palouse Earthworm	-
Leschi's Millipede	-

Many species of uncertain conservation need are listed in our State Wildlife Action Plan:
https://wdfw.wa.gov/species-habitats/at-risk/swap

For more information, check our website:
https://wdfw.wa.gov/species-habitats

Or contact us:

Wildlife Program (360) 902-2515
Fish Program (360) 902-2700

ATTACHMENT C

FEDERAL LISTED ENDANGERED SPECIES
FOUND IN CLARK COUNTY

WASHINGTON NATURAL HERITAGE PROGRAM

2019 Washington Vascular Plant Species of Special Concern

Washington Natural Heritage Progam

July 15, 2019

Natural Heritage
Report 2019-04

WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES

2019 Washington Vascular Plant Species of Special Concern

Washington Natural Heritage Program Report Number: 2019-04

July 15, 2019

Washington Natural Heritage Program
Washington Department of Natural Resources
Olympia, Washington 98504-7014

.

ON THE COVER: Broad-fruit mariposa lily (*Calochortus nitidus*) from Whitman Co., Washington

Photograph by: Walter Fertig, WNHP

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Introduction

For more than 40 years the Washington Natural Heritage Program (WNHP) has maintained a list of Washington plant species of conservation concern. Each of these species is ranked at the global and state scale following the standardized protocol of the NatureServe network. Although WNHP is not a regulatory agency, the program's list and rankings help inform conservation decisions relating to rare plants on federal, state, private, and tribal lands (WDNR 2018).

The WNHP list is periodically updated as new information becomes available on the status and distribution of rare plants in Washington. The following is an update of the June 2018 list (WNHP 2018). No species have been dropped from the previous list, but 13 have been added. New species are indicated by a * preceding the species name (status changes are underlined or crossed ~~through~~). Additional information is provided on distribution pattern within Washington (local endemic, peripheral, disjunct, etc.) and by county, ecoregion, and major managed area (such as national forest, national park, or state lands).

Each of the main headings in the species list and their codes are briefly described below:

Species/Common Name: Species are organized alphabetically by their scientific name. Nomenclature mostly follows Hitchcock and Cronquist (2018). Pertinent synonyms are included in parentheses. Common names follow the USDA Plants database (http://plants.usda.gov) or NatureServe (http://explorer.natureserve.org).

Heritage Rank: WNHP uses the ranking system developed by NatureServe to assess global and state conservation status of each plant species, subspecies, and variety. Taxa are ranked on a scale of 1 to 5 (from highest to lowest conservation concern).

G = Global Rank: rangewide status of a full species
T = Trinomial Rank: rangewide status of a subspecies or variety
S = State Rank: status of a species, subspecies, or variety within the state of Washington

1 = Critically Imperiled – at very high risk of extirpation due to very restricted range, very few occurrences, very steep declines, very severe threats, or other factors
2 = Imperiled – at high risk of extirpation due to restricted range, few occurrences, steep declines, severe threats, or other factors
3 = Vulnerable – at moderate risk of extirpation due to a fairly restricted range, relatively few occurrences, recent and widespread declines, threats, or other factors
4 = Apparently secure – at fairly low risk of extirpation due to an extensive range or many occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors
5 = Secure – at very low risk of extirpation due to a very extensive range, abundant occurrences, and little to no concern from decline or threats
H = Historical– known from only historical occurrences (prior to 1978) but still with some hope of rediscovery
X = Presumed Extirpated – not relocated since 1978 despite intensive searches and virtually no likelihood of rediscovery

U = Unrankable – lack of information or substantially conflicting information about status
NR = Not Ranked – rank not assessed yet
Q = Questionable - questions exist about the taxonomic validity of a species, subspecies, or variety
? = Questionable – questions exist about the assigned G, T, or S rank of a taxon

State Status: Washington state status is assigned by WNHP. Factors considered include abundance, distribution patterns, number of extant occurrences, vulnerability, threats, existing protection, and taxonomic distinctness. Categories include:

Endang = Endangered, in danger of becoming extinct or extirpated from Washington
Threat = Threatened, likely to become Endangered in Washington
Sens = Sensitive, vulnerable or declining and could become Threatened or Endangered in Washington
Extirp = possibly extinct or extirpated in Washington (includes state historical species)

Federal Status: Under the US Endangered Species Act (ESA), the US Fish and Wildlife Service recognizes four categories:

Endang = Endangered. A species, subspecies, or variety in danger of extinction throughout all or a significant portion of its range.
Threat = Threatened. A species, subspecies, or variety likely to become Endangered in the foreseeable future
Prop = Proposed. A species, subspecies, or variety formally proposed for listing as Endangered or Threatened (a proposal has been published in the Federal Register, but not a final rule)
Cand = Candidate. A species, subspecies, or variety being evaluated by USFWS for potential listing as Threatened or Endangered under the ESA, but no formal proposal has been published yet.

The Interagency Special Status and Sensitive Species Program (ISSSSP) of the US Forest Service (USFS) and Bureau of Land Management (BLM) in Washington and Oregon recognize two categories of species of concern (ISSSSP 2019). Strategic species, defined as sensitive species that might potentially occur on BLM or USFS-managed lands, are no longer being recognized in the 2019 ISSSSP list.

B-Sens = BLM Sensitive; all USFWS candidate and delisted species and WNHP species of concern ranked S1, S1S2, S1S3, S2, or S2S3 found on at least one BLM managed area in Washington.
F-Sens = Forest Service Sensitive: all USFWS candidate and delisted species and WNHP species of concern ranked S1, S1S2, S1S3, S2, or S2S3 found on at least one USFS managed area in Washington.

Distribution (Dist.) Pattern: Species rarity is often correlated with geographic distribution patterns. The following patterns can be recognized in Washington:

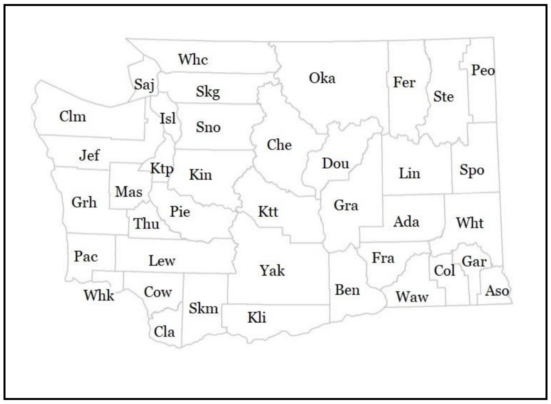
LocEnd = Local Endemic; global range of taxon is less than 16,500 km^2 or about 1 degree of latitude x 2 degrees of longitude (about the size of an average county)
RegEnd = Regional Endemic; global range of taxon is between 16,500 to 250,000 km^2 (or an area about the size of the state of Washington)
Disjunct = Disjunct; globally widespread but state population is isolated from the main contiguous range by a gap or more than 500 km
Periph = Peripheral; globally widespread but Washington population is at the margin of the main contiguous range of the taxon
Sparse = Sparse; widely distributed across the state but with relatively few populations (less than 20)
Widesp = Widespread; widely distributed globally and in Washington, with more than 20 populations in the state.

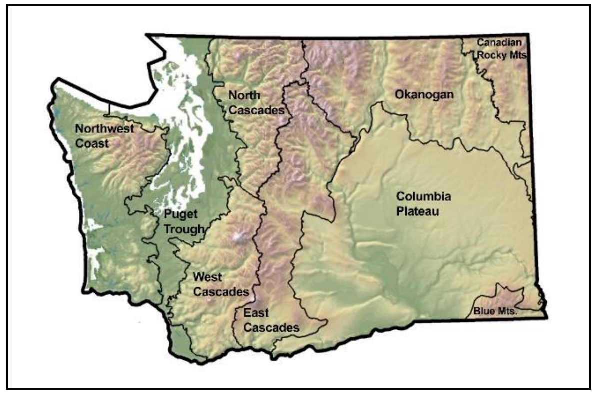
County: Three-letter codes are used to document the distribution of plant species by county. Vague or unsubstantiated reports are indicated by ?.

Ada = Adams	Grh = Grays Harbor	Pie = Pierce
Aso = Asotin	Isl = Island	Saj = San Juan
Ben = Benton	Jef = Jefferson	Skg = Skagit
Che = Chelan	Kin = King	Skm = Skamania
Clm = Clallam	Ktp = Kitsap	Sno = Snohomish
Clk = Clark	Ktt = Kittitas	Spo = Spokane
Col = Columbia	Kli = Klickitat	Ste = Stevens
Cow = Cowlitz	Lew = Lewis	Thu = Thurston
Dou = Douglas	Lin = Lincoln	Whk = Wahkiakum
Fer = Ferry	Mas = Mason	Waw = Walla Walla
Fra = Franklin	Oka = Okanogan	Whc = Whatcom
Gar = Garfield	Pac = Pacific	Wht = Whitman
Gra = Grant	Peo = Pend Oreille	Yak = Yakima

Ecoregion: Ecoregions are biologically-defined geographic areas with similar environmental, physiographic, or vegetation patterns. We follow the classification of Camp and Gamon (2011). Two-letter codes are used for ecoregion names. Vague or unsubstantiated reports are indicated by ?.

BM = Blue Mountains	EC = East Cascades	PC = Pacific Northwest Coast
CP = Columbia Plateau	NC = North Cascades	PT = Puget Trough
CR = Canadian Rockies	OK = Okanogan	WC = West Cascades





Washington Counties

Washington Ecoregions

<u>Managed Area</u>: Major Washington state, federal, or tribal land management areas are included when known. Blank listings indicate that a species is only known from private lands or state trust lands. "? "indicates that presence within a management area is not confirmed. Complete managed area information, or data specific to individual plant occurrences, can be obtained from WNHP (www.dnr.wa.gov/natural-heritage-program). The following abbreviations are used:

AFB = Air Force Base (Dept. of Defense)
BLM = Bureau of Land Management
CF = Community Forest
ERP = Environmental Research Park (nuclear reservation)
JB = Joint Base (Dept. of Defense)
NAP = Natural Area Preserve (Washington Dept of Natural Resources)
NF = National Forest
NHP = National Historical Park
NM = National Monument
NP = National Park
NRCA = Natural Resources Conservation Area (Washington Dept of Natural Resources)
NRA = National Recreation Area
NSA = National Scenic Area
NVM = National Volcanic Monument
NWR = National Wildlife Refuge
PUD = Public Utility District
SP = State Park
SWA = State Wildlife Area (Washington Dept of Fish & Wildlife)
TC = Training Center (Dept of Defense)
WA = Wilderness Area

Name Changes: The following species names have been changed to follow the revised taxonomy of Hitchcock and Cronquist (2018):

2018 List	2019 List
Astragalus multiflorus	*Astragalus tenellus*
Cheilanthes feei	*Myriopteris gracilis*
Chylismia scapoidea ssp. *scapoidea*	*Chylismia scapoidea* ssp. *brachycarpa*
Coeloglossum viride var. *virescens*	*Dactylorhiza viridis*
Collinsia sparsiflora var. *bruceae*	*Collinsia sparsiflora* var. *sparsiflora*
Lycopodium dendroideum	*Dendrolycopodium dendroideum*
Minuartia nuttallii var. *fragilis*	*Sabulina nuttallii* var. *fragilis*
Minuartia pusilla	*Sabulina pusilla*
Monolepis spathulata	*Blitum spathulatum*
Myosurus clavicaulis	*Myosurus alopecuroides*
Orobanche californica ssp. *grayana*	*Aphyllon californicum*
Ranunculus cooleyae	*Arcteranthis cooleyae*
Tauschia hooveri	*Lomatium lithosolamans*
Tauschia tenuissima	*Lomatium tenuissimum*
Trillium parviflorum	*Trillium albidum* ssp. *parviflorum*

Washington Species of Special Concern

Washington Species of Special Concern List							
Species Common Name	**Heritage Rank**	**State Status**	**Federal Status**	**Dist. Pattern**	**County**	**Eco-region**	**Managed Area**
Abronia umbellata var. *acutalata* (*A. u.* ssp. *breviflora*) pink sand-verbena	G4G5 TUQ/S1	Endang		RegEnd	Clm, ~~Isl~~, Ktp, Pac	PC, PT	Willapa NWR
Achnatherum richardsonii Richardson's needlegrass	G5/S1	Sens	F-Sens	Periph	Oka, Ste	OK	Little Pend Oreille NWR Okanogan-Wenatchee NF
Actaea elata var. *elata* (*Cimicifuga elata*) tall bugbane	G4T4/S3	Sens		RegEnd	Clk, Clm, Cow, Grh, Kin, Lew, Pie, Skm, Thu, Whc	EC, PC, PT, WC	Battle Ground SP Beacon Rock SP Columbia Falls NAP Columbia River Gorge NSA Flaming Geyser SP Gifford Pinchot NF Lewis & Clark SP Olympic NP Paradise Point SP Penrose Point SP
**Actaea laciniata* (*Cimicifuga laciniata*) Mt. Hood bugbane	G4/S2	Sens		RegEnd	Clk, Lew, Skm	WC	Gifford Pinchot NF Mt. St. Helens NVM Yacolt Burn SF
Agoseris aurantiaca var. *carnea* (*A. lackschewitzii*) pink agoseris	G5T4Q/ S2	Sens	F-Sens	Sparse	Ktt, Oka	EC, OK	Okanogan-Wenatchee NF
Agoseris elata (*A.* × *elata*) tall agoseris	G4/S3?	Sens		RegEnd	Che, Clm, Cow, Isl, Kli, Ktt, Oka, Pie, Sno, Thu, Whc, Yak	EC, NC, OK, PC, PT, WC	Camas Meadows NAP Conboy Lake NWR Mt. Baker-Snoqualmie NF Mt. Rainier NP Okanogan-Wenatchee NF Pasayten WA
Agrostis mertensii (*A. borealis*) northern bentgrass	G5/S1S2	Sens	B-Sens F-Sens	Periph	Che, Oka, Skg	NC, OK	Chopaka Mountain NAP Okanogan-Wenatchee NF
Aliciella leptomeria (*Gilia leptomeria*) Great Basin gilia	G5/S1	Threat		Periph	Ben, Fra, Gra	CP	Hanford ERP Saddle Mountain NWR South Columbia SWA
Allium bisecptrum twincrest onion	G4G5/S1	Threat		Periph	Fra	CP	Palouse Falls SP
Allium campanulatum Sierra onion	G4/S1	Threat	B-Sens F-Sens	Periph	Col, Yak	BM, EC	Okanogan-Wenatchee NF Umatilla NF
Allium constrictum constricted onion	G2G3/ S2S3	Sens	B-Sens	LocEnd	Dou, Gra	CP	Spokane BLM Steamboat Rock SP
Allium dictuon Blue Mountain onion	G2/S2	Threat	F-Sens	LocEnd	Col, Gar	BM	Umatilla NF Wenaha-Tucannon WA
Ammannia robusta grand redstem	G5/S1	Threat	B-Sens F-Sens	Sparse	Aso, Fra, Gra, Kli, Spo, Wht	CP, EC	Columbia River Gorge NSA Hanford ERP Hanford NWR South Columbia SWA Turnbull NWR
Anemone patens var. *multifida* pasqueflower	G5T5/S1	Threat	B-Sens F-Sens	Periph	Che	EC	Colockum SWA Okanogan-Wenatchee NF
Antennaria corymbosa meadow pussytoes	G5/S1	Threat	B-Sens F-Sens	Periph	Col, Oka, Peo	BM, CR OK	Colville NF Okanogan-Wenatchee NF Umatilla NF Wenaha-Tucanon WA

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Aphyllon californicum var. *grayanum* (*Orobanche californica* ssp. *grayana*) Gray's broomrape	G4T3T4/ S1	Endang		Periph	Clk, Kli, Yak	CP, EC, PT	Columbia River Gorge NSA Conboy Lake NWR? Fort Vancouver NHS Klickitat Canyon NRCA
Arabis crucisetosa cross-haired rockcress	G4G5/S1	Threat	B-Sens F-Sens	RegEnd	Aso	BM	Vale BLM
Arabis olympica (*A. furcata* var. *olympica*) Olympic rockcress	G2/S2	Sens	F-Sens	RegEnd	Clm, Jef	PC	Buckhorn WA Olympic NF Olympic NP The Brothers WA
Arcteranthis cooleyae (*Ranunculus cooleyae*) Cooley's buttercup	G5/S1	Threat	B-Sens F-Sens	Periph	Grh, Sno	NC, PC	Colonel Bob WA Henry M. Jackson WA Morning Star NRCA Mt. Baker-Snoqualmie NF Olympic NF
Arenaria paludicola swamp sandwort	G1/SX	Extirp	Endang	Disjunct	Grh?, Kin?, Pie	NC?, PC?, PT	Carlisle Bog NAP?
Artemisia campestris var. *wormskioldii* Wormskiold's northern wormwood	G5T1/S1	Endang	B-Sens F-Sens	RegEnd	Ben, Fra, Gra, Kli	CP, EC	Columbia River Gorge NSA Gifford Pinchot NF McNary NWR
Asclepias cryptoceras (*A. cryptoceras* ssp. *davisii*) pallid milkweed	G4/S1	Threat		Periph	Aso	BM	Chief Joseph SWA
Astragalus arrectus Palouse milkvetch	G2G4/S2	Threat	B-Sens F-Sens	RegEnd	Che, Kli, Ktt, Lin, Wht	CP, EC	Colockum SWA Okanogan-Wenatchee NF Roosevelt Lake NRA
Astragalus arthurii Arthur's milkvetch	G4/S2	Sens	B-Sens F-Sens	RegEnd	Aso	BM, CP	Chief Joesph SWA Nez Perce NHP Umatilla NF Vale BLM
Astragalus asotinensis Asotin milkvetch	G2/S1	Endang	B-Sens	LocEnd	Aso	BM	Vale BLM
Astragalus australis var. *cottonii* Cotton's milkvetch	G5T2Q/ S2	Threat	B-Sens F-Sens	LocEnd	Clm	PC	Olympic NF Olympic NP
Astragalus columbianus Columbia milkvetch	G2G3/ S2S3	Sens	B-Sens	LocEnd	Ben, Ktt, Waw, Yak	CP	Gingko Petrified Forest SP Hanford ERP Spokane BLM Yakima TC
Astragalus cusickii var. *cusickii* (*A. eremeticus* var. *malheurensis*) Cusick's milkvetch	G5T4/S2	Sens	B-Sens F-Sens	RegEnd	Aso, Fra, Gar, Lin	BM, CP	4-O Ranch SWA Chief Joseph SWA Umatilla NF Vale BLM
Astragalus diaphanus transparent milkvetch	G4/SX	Extirp		RegEnd	Kli	EC	Columbia River Gorge NSA
Astragalus geyeri var. *geyeri* Geyer's milkvetch	G4T4/ S1S2	Threat	B-Sens	Disjunct	Gra	CP	Columbia NWR Crab Creek SWA Hanford ERP Saddle Mountain NWR
Astragalus kentrophyta var. *douglasii* thistle milkvetch	G5TX/ SX	Extirp		LocEnd	Waw	CP	

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Astragalus microcystis least bladdery milkvetch	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Jef, Lin, Peo, Ste	CP, CR, OK, PC	Buckhorn WA Colville NF Little Pend Oreille SWA Olympic NF Roosevelt Lake NRA Spokane BLM
Astragalus misellus var. *pauper* pauper milkvetch	G3T3/S2	Sens	B-Sens	RegEnd	Ben, Dou, Fra, Kli, Ktt, Yak	CP	Colockum SWA LT Murray SWA Quilomene SWA Spokane BLM Yakima TC
Astragalus pulsiferae var. *suksdorfii* Ames' milkvetch	G4T2/S1	Endang		Disjunct	Kli	EC	Conboy Lake NWR
Astragalus riparius Piper's milkvetch	G2/S2	Threat	B-Sens	RegEnd	Aso, Gar, Wht	CP	Vale BLM
Astragalus sinuatus Whited's milkvetch	G1/S1	Endang	B-Sens	LocEnd	Che	CP	Colockum SWA Spokane BLM Upper Dry Gulch NAP
Astragalus tenellus *(A. multiflorus)* loose-flower milkvetch	G5/S1	Threat		Disjunct	Dou	CP	
Baccharis pilularis ssp. *consanguinea* coyotebush	G5TNR/ S1	Threat		Periph	Pac	PC	Cape Disappointment SP
Bergia texana Texas bergia	G5/SX	Extirp		Periph	Gar, Kli, Wht?	CP, EC	Columbia River Gorge NSA
Blitum spathulatum (*Monolepis spathulata*) prostrate povertyweed	G5/S1	Threat	B-Sens F-Sens	Periph	Oka	OK	Pearrygin Lake SP
Boechera cascadensis (*Arabis microphylla* var. *thompsonii*) littleleaf rockcress	G1Q/SH	Extirp		RegEnd	Ktt	EC	Okanogan-Wenatchee NF
Bolandra oregana Oregon bolandra	G3/S2	Threat	B-Sens F-Sens	RegEnd	Aso, Clk, Col, Gar, Kli, Skm	BM, EC, WC	Beacon Rock SP Chief Joseph SWA Columbia Falls NAP Columbia River Gorge NSA Gifford Pinchot NF Umatilla NF Vale BLM Wenaha-Tucannon WA
Botrychium ascendens triangular-lobed moonwort	G3/S2	Sens	B-Sens F-Sens	Sparse	Fer, Kin, Mas, Oka, Peo, Pie, Ste, Whc	CR, NC, OK, PC, WC	Colville NF Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF Olympic NF Olympic NP Pasayten WA
Botrychium hesperium western moonwort	G4/S2	Sens	B-Sens F-Sens	Sparse	Che, Fer, Kin, Peo, Sno, Ste	CR, EC, NC, OK	Colville NF North Cascades NP Mt. Baker-Snoqualmie NF
Botrychium lineare skinny moonwort	G2G3/S1	Endang	B-Sens F-Sens	Periph	Fer	OK	Colville NF
**Botrychium michiganense* Michigan moonwort	G3/S1	Threat		Periph	Ste	CR	Colville NF

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Botrychium paradoxum two-spiked moonwort	G3G4/S2	Threat	B-Sens F-Sens	Sparse	Che, Fer, Oka, Peo, Ste	CR, EC, OK	Chopaka Mountain NAP Colville NF Kanisku NF Loomis NRCA Okanogan-Wenatchee NF
Botrychium pedunculosum stalked moonwort	G3/S2	Sens	B-Sens F-Sens	Sparse	Fer, Kin, Peo, Sno, Ste, Whc	CR, NC, OK	Colville NF Mt. Baker-Snoqualmie NF Ross Lake NRA
Brodiaea rosea var. *rosea* (*B. coronaria* ssp. *rosea*) harvest brodiaea	G4G5T4 /SH	Extirp		Disjunct	Pie, Saj	PT	San Juan Islands NWR
Calochortus longebarbatus var. *longebarbatus* long-bearded mariposa lily	G4T3/S3	Sens		RegEnd	Kli, Wht, Yak	CP, EC	Brooks Memorial SP Conboy Lake NWR Klickitat SWA Klickitat Canyon NRCA
Calochortus macrocarpus var. *maculosus* sagebrush mariposa lily	G5T2/ S2?	Sens	B-Sens F-Sens	RegEnd	Aso, Gar, Wht	BM, CP	Chief Joseph SWA Spokane BLM Umatilla NF Vale BLM Wenaha-Tucannon WA
Calochortus nitidus broad-fruit mariposa lily	G3/S1	Endang		RegEnd	Aso, Gar, Wht	BM, CP	Umatilla NF
Calyptridium roseum rosy pussypaws	G5/S1	Threat	B-Sens F-Sens	Periph	Ben	CP	Hanford ERP
**Camassia cusickii* Cusick's camas	G4/S1	Sens		RegEnd	Kli	EC	
Campanula lasiocarpa Alaska harebell	G5/S2	Sens	B-Sens F-Sens	Periph	Kin, Sno	NC	Alpine Lakes WA Glacier Peak WA Morning Star NRCA Mt. Baker-Snoqualmie NF
Carex anthoxanthea yellow-flowered sedge	G5/S1	Threat	B-Sens F-Sens	Periph	Grh	PC	Olympic NF
Carex capillaris hair-like sedge	G5/S1	Threat	B-Sens F-Sens	Periph	Che?, Oka, Peo	CR, OK	Colville NF Okanogan-Wenatchee NF Spokane BLM
Carex capitata capitate sedge	G5/S1	Threat		Periph	Oka, Whc	NC, OK	Chopaka Mountain NAP Mt. Baker WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF Pasayten WA Spokane BLM
Carex chordorrhiza cordroot sedge	G5/S1	Threat	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Carex circinata coiled sedge	G4/S1	Threat	B-Sens F-Sens	Periph	Grh, Jef	PC	Colonel Bob WA Olympic NF Olympic NP
Carex cordillerana cordilleran sedge	G3G4/S1	Sens	F-Sens	Sparse	Fer, Oka, Peo, Spo, Ste	CP, OK	Colville NF Okanogan-Wenatchee NF Pasayten WA Sinlahekin SWA
Carex davyi Davy's sedge	G2/SX	Extirp		Periph	Yak	EC	
Carex densa dense sedge	G5/S2	Sens	B-Sens F-Sens	Periph	Clk, Lew, Thu, Yak	EC, PC, PT	Gifford Pinchot NF Lacamas Prairie NAP Mt. Adams WA
Carex eburnea bristleleaf sedge	G5/S1	Threat	B-Sens F-Sens	Periph	Peo	CR	Colville NF Spokane BLM

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Carex gynocrates yellow bog sedge	G5/S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Carex heteroneura (*C. heterneura* var. *epapillosa*) smooth-fruited sedge	G5/S2S3	Sens	F-Sens	Sparse	Oka, Whc, Yak	EC, NC, OK	Loomis NRCA Okanogan-Wenatchee NF Pasayten WA
Carex macrochaeta longawn sedge	G5/S1	Threat	B-Sens F-Sens	Sparse	Grh?, Pac, Pie?, Skm, Whc, Yak?	EC?, NC, PC, WC	Columbia Falls NAP Columbia River Gorge NSA Gifford Pinchot NF? Mt. Rainier NP? North Cascades NP
Carex media intermediate sedge	G5/S2	Sens	B-Sens F-Sens	Sparse	Oka	OK	Chopaka Mountain NAP Loomis NRCA Okanogan-Wenatchee NF Pasayten WA
Carex obtusata blunt sedge	G5/S2	Sens	B-Sens F-Sens	Periph	Clm, Jef, Mas	PC	Buckhorn WA Olympic NF Olympic NP
Carex pauciflora few-flowered sedge	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Jef, Kin, Ktt, Mas, Saj, Skg, Sno, Whc	EC, NC, PC, PT	Kings Lake Bog NAP Moran SP Morning Star NRCA Mt. Baker-Snoqualmie NF Olympic NF Snoqualmie Bog NAP
Carex pluriflora several-flowered sedge	G5/S2	Sens		Sparse	Clm, Sno, Whc	NC, PC, PT	Dailey Prairie NAP Morning Star NRCA Olympic NP
Carex proposita Smoky Mountain sedge	G4/S2	Sens	B-Sens F-Sens	Sparse	Che, Fer, Oka, Pie, Skm, Sno, Ste	CR, EC, NC, OK, WC	Alpine Lakes WA Colville NF Gifford Pinchot NF Glacier Peak WA Henry M. Jackson WA Mt. Rainier NP Mt. St. Helens NVM Okanogan-Wenatchee NF
Carex rostrata (*sensu stricto*) beaked sedge	G5/S2	Sens	B-Sens F-Sens	Sparse	Fer, Peo	CR, OK	Colville NF
Carex scirpoidea ssp. *scirpoidea* Canadian single-spike sedge	G5T5/S2	Sens	B-Sens F-Sens	Periph	Jef, Ktt, Mas, Oka, Whc	EC, NC, OK, PC	Chopaka Mountain NAP Mt. Baker WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF Olympic NP Pasayten WA
Carex stylosa long-styled sedge	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Jef, Kin, Skg, Sno, Whc	NC, PC	Morning Star NRCA Mt. Baker-Snoqualmie NF Olympic NP
Carex sychnocephala many-headed sedge	G4/S2	Sens	B-Sens F-Sens	Sparse	Fer, Lin, Oka, Peo	CP, CR, OK	Alta Lake SP Okanogan-Wenatchee NF Sinlahekin SWA Spokane BLM
Carex tenera var. *tenera* quill sedge	G5TNR/S2	Sens	B-Sens F-Sens	Sparse	Oka, Peo	CR, OK	Colville NF Sinlahekin SWA Spokane BLM
Carex tenuiflora sparse-flowered sedge	G5/S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Carex vallicola valley sedge	G5/S2	Sens	B-Sens F-Sens	Periph	Gra, Oka	CP, OK	Okanogan-Wenatchee NF Sinlahekin SWA Steamboat Rock SP

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Cassiope lycopodioides clubmoss cassiope	G4/S1	Threat		Periph	Kin, Sno	NC	Mount Si NRCA Mt. Baker Snoqualmie NF
Castilleja chambersii Chambers paintbrush	G1/S1	Sens		LocEnd	Pac	PC	
Castilleja cryptantha obscure paintbrush	G2G3/ S2S3	Sens	B-Sens F-Sens	LocEnd	Pie, Yak	EC, WC	Mt. Rainier NP Okanogan-Wenatchee NF William O. Douglas WA
Castilleja levisecta golden paintbrush	G2/S2	Threat	Threat	RegEnd	Clk, Isl, Jef, Ktp, Kin, Pie, Saj, Skg, Thu	PT	Admiralty Inlet NAP Deception Pass SP Ft. Casey SP Mima Mounds NAP Rocky Prairie NAP
Castilleja victoriae Victoria's paintbrush	G1/S1	Endang		LocEnd	Saj	PT	Iceberg Island SP
Chaenactis thompsonii Thompson's chaenactis	G3/S3	Sens	B-Sens F-Sens	LocEnd	Che, Ktt, Pie	EC, WC	Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Chrysolepis chrysophylla var. *chrysophylla* golden chinquapin	G5T5/S2	Sens	B-Sens F-Sens	Periph	Mas, Skm	EC, PC, PT, WC	Columbia River Gorge NSA Gifford Pinchot NF Olympic NF Trapper Creek WA
Chrysosplenium tetrandrum northern golden-carpet	G5/S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Chylismia scapoidea ssp. *brachycarpa* (*Camissonia scapoidea*) short-fruited bee-blossom	G5T4T5/ S1	Threat	B-Sens	Periph	Ktt, Lin	CP	Iron Horse Pioneer Trail SP Yakima TC
Cicuta bulbifera bulb-bearing water-hemlock	G5/S2S3	Sens	B-Sens F-Sens	Sparse	Che, Isl, Peo, Ste, Thu, Whc	CR, EC, PT	Colville NF Elbow Lake SP Lake Terrell SWA Little Pend Oreille River NAP Okanogan-Wenatchee NF Pend Oreille NWR
Cirsium remotifolium var. *remotifolium* weak thistle	G5TNR/ S1	Sens	F-Sens	Periph	Clk, Clm, Grh, Kin, Kli, Pie, Skm, Thu	EC, PC, PT, WC	Columbia River Gorge NSA Conboy Lake NWR Gifford Pinchot NF JB Lewis McChord Klickitat SWA Lake Sylvia SP Olympic NF Soda Springs SWA Spokane BLM? Trout Lake NAP? White Salmon NRCA?
Claytonia multiscapa ssp. *pacifica* Pacific lanceleaved springbeauty	G5T3T4/ S1	Endang	F-Sens	RegEnd	Clm, Grh, Jef, Mas	PC	Colonel Bob WA Mount Skokomish WA Olympic NF Olympic NP
Cochlearia groenlandica scurvygrass	G4?/ S1S2	Threat		Periph	Clm, Grh, Jef, Mas	PC, PT	Olympic NP Washington Islands NWR
Collinsia sparsiflora var. *sparsiflora* (*C. s.* var. *bruceae*) few-flowered collinsia	G4T4/S1	Threat	B-Sens F-Sens	Periph	Clk, Kli, Skm	CP, EC, PT, WC	Columbia River Gorge NSA Gifford Pinchot NF Ridgefield NWR Spokane BLM
Collomia macrocalyx bristle-flowered collomia	G3G4/S2	Threat		RegEnd	Ktt, Yak	CP	Spokane BLM? Yakima TC
Comastoma tenellum (*Gentianella tenella*) slender gentian	G4G5/S1	Threat	B-Sens F-Sens	Disjunct	Oka	OK	Chopaka Mountain NAP Okanogan-Wenatchee NF Pasayten WA

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Coptis aspleniifolia spleenwort-leaved goldthread	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Kin, Sno	PC, WC	Mt. Baker-Snoqualmie NF Olympic NP
Coptis trifolia threeleaf goldthread	G5/S1	Threat	B-Sens F-Sens	Periph	Clm, Peo	CR, PC	Olympic NP
Corispermum pallidum pale bugseed	GH/SH	Extirp		RegEnd	Gra	CP	South Columbia Basin SWA
Corispermum villosum hairy bugseed	G4?/S2	Sens		Sparse	Gra, Kli	CP, EC	<u>Spokane BLM</u>
Corydalis aquae-gelidae Clackamas corydalis	G3/S2	Threat	B-Sens F-Sens	RegEnd	Clk, Cow, Skm	WC	Gifford Pinchot NF Mt. St. Helens NVM
Crassula connata erect pygmyweed	G5/S1	Threat		Disjunct	Saj	PT	Lime Kiln Point SP San Juan Island NHP
Crataegus phippsii Phipps' hawthorn	G2G3/S1	Sens		RegEnd	Oka	OK	
Crepis bakeri ssp. *idahoensis* Idaho hawksbeard	G4T2/S1	Endang		RegEnd	Aso	BM	Asotin Creek SWA Chief Joesph SWA
Cryptantha gracilis narrow-stem cryptantha	G5/S2	Sens	B-Sens	Sparse	<u>Aso</u>, Dou, Gra, Ktt, Yak	<u>BM</u>, CP	<u>Chief Joseph SWA</u> Spokane BLM Sun Lakes SP Yakima TC
Cryptantha leucophaea gray cryptantha	G2G3/S2	Threat	B-Sens	RegEnd	Ben, Dou, Fra, Gra, Ktt, Waw, Yak	CP, <u>EC</u>	Colockum SWA Columbia NWR Crab Creek SWA Gingko Petrified Forest SP Hanford ERP Juniper Dunes WA North Columbia Basin SWA Saddle Mountain NWR South Columbia Basin SWA Spokane BLM Yakima TC
Cryptantha rostellata beaked cryptantha	G4/S2	Threat	B-Sens F-Sens	RegEnd	Aso, Kli, Ktt, Waw, Wht, Yak	BM, CP, EC	Badger Gap NAP Chief Joseph SWA Columbia River Gorge NSA Spokane BLM Yakima TC
Cryptantha scoparia desert cryptantha	G4?/S2	Sens		Sparse	Ben, <u>Dou</u>, Gra, Ktt, Yak	CP	Hanford ERP Sun Lakes SP Yakima TC
Cryptantha spiculifera Snake River cryptantha	G4?/ S2S3	Sens	B-Sens	Sparse	Ada, Ben, Che, Fra, Gra, Kli, Lin, Oka, Yak	CP, EC, OK	Entiat Slopes NAP <u>Hanford ERP</u> Riverside Breaks NAP South Columbia Basin SWA Spokane BLM
Cryptogramma stelleri Steller's rockbrake	G5/S2	Sens	B-Sens F-Sens	Periph	Che, Oka, Peo, Ste	CR, EC, OK	Chelan-Sawtooth WA Colville NF Glacier Peak WA Okanogan-Wenatchee NF Trombetta Canyon NAP
Cuscuta denticulata desert dodder	G4G5/S1	Threat		Periph	Ben, Fra	CP	Hanford ERP South Columbia SWA
Cusickiella douglasii Douglas' draba	G4G5/S1	Threat	B-Sens F-Sens	Periph	Kli	CP, EC	Columbia Hills NAP Columbia River Gorge NSA

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Cypripedium parviflorum (includes vars. *makasin* & *pubescens*) yellow lady's slipper	G5/S2	Sens	B-Sens F-Sens	Sparse	Fer, Oka, Spo, Ste	CP, CR, OK	Colville NF Sinlahekin SWA Spokane BLM Turnbull NWR
<u>*Dactylorhiza viridis*</u> (<u>*Coeloglossum viride* var. *virescens*</u>) long-bract frog orchid	G5/S1	Threat	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Damasonium californicum fringed water-plantain	G4/S1	Threat	F-Sens	Periph	Kli	CP	Columbia Hills SP Columbia River Gorge NSA Gifford Pinchot NF
Delphinium leucophaeum pale larkspur	<u>G2</u>/S1	Endang		RegEnd	Lew	PT	
Delphinium viridescens Wenatchee larkspur	G2/S2	Threat	B-Sens F-Sens	LocEnd	Che, Dou, Ktt	CP, EC	Camas Meadows NAP Okanogan-Wenatchee NF
<u>*Dendrolycopodium dendroideum*</u> (<u>*Lycopodium dendroideum*</u>) treelike clubmoss	G5/S2	Sens	B-Sens F-Sens	Sparse	Kin, Peo, Sno, Whc	CR, NC	Colville NF Kaniksu NF Mt. Baker-Snoqualmie NF North Cascades NP Ross Lake NRA
Diplacus cusickioides (D. cusickii misapplied, *Mimulus cusickii)* Cusick's monkeyflower	<u>G4G5</u>/S1	Threat	B-Sens F-Sens	Periph	Aso, Che, Kli	BM, CP, EC	Chief Jospeh SWA Columbia River Gorge NSA Okanogan-Wenatchee NF
Dodecatheon austrofrigidum frigid shootingstar	G2/S1	Endang	B-Sens F-Sens	RegEnd	Grh, Pac	PC	Colonel Bob WA Olympic NF
Draba aurea golden draba	G5/S1	Sens	B-Sens F-Sens	Periph	Oka, Whc	NC, OK	Chopaka Mountain NAP Okanogan-Wenatchee NF Pasayten WA
Draba cana lance-leaved draba	G5/S1	Sens	B-Sens F-Sens	Periph	Clm, Oka	OK, PC	Buckhorn WA Okanogan-Wenatchee NF Olympic NF Pasayten WA
Draba taylori Taylor's draba	<u>G1G2</u>/<u>S1</u>	<u>Endang</u>	<u>F-Sens</u>	LocEnd	Oka	OK	Okanogan-Wenatchee NF
Dryas drummondii var. *drummondii* yellow mountain-avens	G5T5/S2	Sens	B-Sens F-Sens	Periph	Jef. Peo, Sno, Ste	CR, NC, PC	Colville NF Glacier Peak WA Mt. Baker-Snoqualmie NF Olympic NF Olympic NP Trombetta Canyon NAP
Dryopteris cristata crested shield-fern	G5/S2	Sens	B-Sens F-Sens	Periph	Peo, Ste	CR, OK	Colville NF Kaniksu NF Little Pend Oreille NAP
Eatonella nivea white eatonella	G4G5/S2	Threat		Periph	Gra, Ktt	CP	Hanford ERP North Columbia Basin SWA Saddle Mountain NWR Yakima TC
Eleocharis atropurpurea purple spike-rush	G4G5/ SX	Extirp		Disjunct	Che	EC	Okanogan-Wenatchee NF?
Eleocharis coloradoensis dwarf spike-rush	GNR/<u>S1</u>	<u>Sens</u>		Sparse	<u>Ben</u>, <u>Gra</u>, Wht	CP	Columbia Park (DOD)
Eleocharis mamillata ssp. *mamillata* soft-stemmed spikerush	G4?T4?/ S1	Sens		Periph	Skg	NC	

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Eleocharis rostellata beaked spike-rush	G5/S2	Sens		Sparse	Gra, Oka, Peo, Yak	CP, OK	Colville NF Sinlahekin SWA Sun Lakes SP Yakima TC
Epilobium mirabile (*E. glandulosum* var. *macounii*) Olympic Mountain willowherb	G4Q/S1	Sens		RegEnd	Clm, Whc	NC, PC	Mt. Baker WA Mt. Baker-Snoqualmie NF Olympic NP
Eremogone franklinii var. *thompsonii* (*Arenaria f.* var. *t.*) Thompson's sandwort	G4T2Q/ S2	Sens		RegEnd	Ben, Gra	CP	Hanford ERP South Columbia Basin SWA
Eremothera minor (*Camissonia minor*) small-flower evening-primrose	G4/S2	Sens		Sparse	Ben, Gra, Kli, Ktt, Yak	CP, EC	Hanford ERP Saddle Mountain NWR
Eremothera pygmaea (Camissonia pygmaea) dwarf evening-primrose	G3/S3	Sens	B-Sens F-Sens	RegEnd	Ben, Dou, Fra, Gra, Ktt, Yak	CP	Hanford ERP North Columbia Basin SWA Saddle Mountain NWR South Columbia Basin SWA Spokane BLM Steamboat Rock SP Sun Lakes SP Yakima TC
Erigeron aliceae Alice's fleabane	G4/S2	Sens	B-Sens	RegEnd	Clm, Grh, Lew, Pac	PC	Colonel Bob WA Olympic NF Olympic NP Willapa Divide NAP
Erigeron basalticus basalt daisy	G2/S2	Threat	B-Sens	LocEnd	Ktt, Yak	CP	LT Murray SWA Selah Cliffs NAP Spokane BLM Yakima TC
Erigeron davisii (*E. engelmannii* var. *davisii*) Davis' fleabane	G3/S1	Sens	B-Sens F-Sens	RegEnd	Aso, Gar	BM	Vale BLM William T. Wooten SWA
Erigeron disparipilus Snake River daisy	G5/S2	Sens		RegEnd	Aso, Col, Gar	BM, CP	Fields Spring SP Umatilla NF William T Wooten SWA
Erigeron howellii Howell's daisy	G2/S2	Threat	B-Sens F-Sens	LocEnd	Ska	WC	Columbia Falls NAP Columbia River Gorge NSA Table Mt/Greenleaf Pk NRCA
Erigeron oreganus gorge daisy	G3/S2	Threat	B-Sens F-Sens	RegEnd	Ska, Whk	PC, WC	Beacon Rock SP Columbia Falls NAP Columbia River Gorge NSA Gifford Pinchot NF
Erigeron peregrinus var. *thompsonii* Thompson's wandering daisy	G5T3/S2	Threat	B-Sens F-Sens	LocEnd	Grh, Jef	PC	Olympic NF Olympic NP
Erigeron salishii Salish fleabane	G3/S2	Sens	B-Sens F-Sens	RegEnd	Che, Sno	EC, NC	Alpine Lakes WA Chelan-Sawtooth WA Glacier Peak WA Lake Chelan NRA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Eriogonum codium Umtanum desert buckwheat	G1/S1	Endang	Threat	LocEnd	Ben	CP	Hanford Reach NM

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Eriogonum maculatum spotted buckwheat	G5/SX	Extirp		Periph	Yak	CP	
Eriophorum viridicarinatum green keeled cottongrass	G5/S2	Sens	B-Sens F-Sens	Periph	Fer, Oka, Peo, Ska, ~~Spo~~	~~CP~~, CR, OK, WC	Colville NF Gifford Pinchot NF Kaniksu NF Mt. St. Helens NVM Okanogan-Wenatchee NF Pasayten WA Salmo Priest WA ~~Spokane BLM~~
Eritrichium argenteum (*E. nanum* var. *elongatum*) pale alpine fotget-me-not	G4/S1	Sens	B-Sens F-Sens	Periph	Che, Oka	EC, OK	Chelan-Sawtooth WA Okanogan-Wenatchee NF
Eryngium articulatum jointed coyote-thistle	G5/SH	Extirp		Periph	Spo, Wht	CP	
Eryngium petiolatum Oregon coyote-thistle	G4/S2	Threat	B-Sens F-Sens	RegEnd	Clk, Kli, Lew	EC, PT	Columbia River Gorge NSA Conboy Lake NWR Klickitat SWA Lacamas Prairie NAP
**Erythranthe ampliata* Nez Perce monkeyflower	G3/SH	Threat		RegEnd	Aso	BM	Vale BLM?
Erythranthe jungermannioides (*Mimulus j.*) liverwort monkeyflower	G3/SH	Extirp		RegEnd	Kli	EC	Columbia River Gorge NSA
Erythranthe patula (*Mimulus patulus*) stalk-leaved monkeyflower	G3?/S2?	Threat	B-Sens F-Sens	Periph	Aso, Oka	BM, CP, OK	Asotin Creek SWA Okanogan-Wenatchee NF Vale BLM
Erythranthe pulsiferae (*Mimulus pulsiferae*) Pulsifer's monkeyflower	G4?/S2	Sens	B-Sens F-Sens	Sparse	Kli, Oka, Skm, Waw, Wht, Yak	CP, EC, OK, WC	Columbia River Gorge NSA Conboy Lake NWR Gifford Pinchot NF Klickitat Canyon NRCA Okanogan-Wenatchee NF Trout Lake NAP
Erythranthe suksdorfii *(Mimulus suksdorfii)* Suksdorf's monkeyflower	G4/S2S3	Sens	B-Sens F-Sens	Sparse	Ben, Che, Dou, Gra, Kli, Ktt, Oka, Yak	CP, EC, OK	Columbia River Gorge NSA Crab Creek SWA Hanford ERP <u>Marcellus Shrub Steppe NAP</u> Mt. Adams WA North Columbia Basin SWA Okanogan-Wenatchee NF Steamboat Rock SP Sun Lakes SP Yakima TC
Erythranthe washingtonensis (*Mimulus w.*) Washington monkeyflower	G4/<u>SH</u>	Extirp		RegEnd	Ada?, Col?, Kli, Oka?, Skm	BM?, CP?, EC, OK?, WC	Columbia River Gorge NSA Conboy Lake NWR Okanogan-Wenatchee NF? Umatilla NF? Wenaha-Tucannon WA?
Erythronium quinaultense Quinault fawn-lily	G1G2/ S1S2	Threat	F-Sens	LocEnd	Clm, Grh, Jef	PC	Olympic NF
Erythronium revolutum pink fawn-lily	G4G5/S3	Sens		Sparse	Clm, Cow, Grh, Jef, Lew, Pac, Skg, Thu, Whk	PC, PT	Deception Pass SP Olympic NF

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Euonymus occidentalis var. *occidentalis* western wahoo	G5TNR/ S2	Sens		Periph	Clk, Cow, Lew, Pac, Thu	PC, PT, WC	Lewis & Clark SP Mt. St. Helens SWA
Eurybia merita (*Aster meritus*) subalpine aster	G5/S2	Threat	F-Sens	Periph	Oka, Saj, Sno?, Ste, Whc	CR, NC, OK, PT	Colville NF Glacier Peak WA Moran SP Mt. Baker WA Mt. Baker-Snoqualmie NF
Eutrochium maculatum var. *bruneri* (*Eupatorium maculatus*) spotted Joe-Pye weed	G5T5/ SH	Extirp		Periph	Whc	PT	
Filipendula occidentalis queen-of-the-forest	G2G3/ S2S3	Sens		RegEnd	Pac	PC	
Fritillaria camschatcensis black lily	G5/S2	Threat	B-Sens F-Sens	Periph	Isl, Kin, Skg, Skm, Sno	NC, PT, WC	Alpine Lakes WA Boulder River WA Columbia River Gorge NSA Deception Pass SP Morning Star NRCA Mt. Baker-Snoqualmie NF
Gaultheria hispidula creeping snowberry	G5/S2	Sens	B-Sens F-Sens	Periph	Peo	CR	Colville NF Kaniksu NF Salmo Priest WA
Gentiana douglasiana swamp gentian	G5/S2	Sens	B-Sens F-Sens	Periph	Clm, Kin, Ktt	EC, PC, WC	Okanogan-Wenatchee NF Olympic NP
Gentiana glauca glaucous gentian	G4G5/S2	Sens	B-Sens F-Sens	Periph	Oka, Whc	NC, OK	Chopaka Mountain NAP Mt. Baker WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF Pasayten WA
Geranium oreganum Oregon crane's-bill	G4G5/ SX	Extirp		Periph	Clk	PT	
Geum rivale water avens	G5/S2S3	Sens	B-Sens F-Sens	Periph	Fer, Oka, Peo, Ste	CR, OK	Colville NF Okanogan-Wenatchee NF Pasayten WA
Geum rossii var. *depressum* Ross' avens	G5T1/S1	Endang	F-Sens	LocEnd	Che	EC	Alpine Lakes WA Okanogan-Wenatchee NF
Githopsis specularioides common bluecup	G5/S2S3	Sens	B-Sens F-Sens	Sparse	Che, Kli, Lew, Mas, Pie, Skm, Thu, Wht	CP, EC, PC, PT, WC	Bald Hill NAP Chelan-Sawtooth WA Columbia River Gorge NSA Gifford Pinchot NF Hamma Hamma Balds NAP Klickitat SWA Lake Chelan NRA Okanogan-Wenatchee NF Spokane BLM
Hackelia cinerea gray stickseed	G4?/S1	Threat	B-Sens F-Sens	Periph	Che?, Dou?, Lin, Spo, Ste	CP, EC?. OK	Riverside SP
Hackelia diffusa var. *diffusa* diffuse stickseed	G4T3/S2	Threat	B-Sens F-Sens	RegEnd	Col, Kli, Yak	BM, EC	Columbia River Gorge NSA Klickitat SWA Klickitat Canyon NRCA Umatilla NF
Hackelia hispda var. *disjuncta* sagebrush stickseed	G4T3/S3	Sens	B-Sens F-Sens	LocEnd	Che, Dou, Gra, Ktt	CP, EC	Okanogan-Wenatchee NF Spokane BLM Sun Lakes SP

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Hackelia hispida var. *hispida* rough stickseed	G4T4/S1	Threat	B-Sens F-Sens	RegEnd	Aso	BM	Vale BLM
Hackelia taylorii Taylor's stickseed	G2/S2	Threat	F-Sens	LocEnd	Che	EC	Alpine Lakes WA Okanogan-Wenatchee NF
Hackelia venusta showy stickseed	G1/S1	Endang	Endang	LocEnd	Che	EC	Okanogan-Wenatchee NF
Hedysarum occidentale western hedysarum	G5/S2	Sens	F-Sens	Sparse	Clm, Jef, Mas, Skm	PC, WC	Gifford Pinchot NF Mt. Skokomish WA Mt. St. Helens NVM Olympic NF Olympic NP
Heterotheca oregona Oregon goldenaster	G4/S2	Sens	B-Sens F-Sens	Sparse	Kin, Ktt, Lew, Mas, Pie, Thu, Yak	CP, EC, PC, PT, WC	Federation Forest SP JB Lewis McChord Oak Creek SWA Okanogan-Wenatchee NF Olympic NF
Howellia aquatilis water howellia	G3/S2	Threat	Threat	Sparse	Clk, Mas, Pie, Spo, Thu	CP, PT	Dishman Hills NRCA JB Lewis McChord Ridgefield NWR Scatter Creek SWA Spokane BLM Turnbull NWR
Hymenophyllum wrightii Wright's filmy fern	G4?/S1	Sens		Periph	Clm, Jef	PC	Olympic NP
Hypericum majus Canadian St. John's-wort	G5/S2	Sens		Sparse	Ben, Fra, Kin, Ktp, Peo, Skg, Spo, Thu, Whc	CP, CR, NC, PT	Colville NF Hanford ERP South Columbia Basin SWA Square Lake SP?
Impatiens noli-tangere western jewel-weed	G4G5/S1	Threat	B-Sens F-Sens	Sparse	Skg, Spo, Whc	NC, OK, PT	Mt. Baker-Snoqualmie NF
Isöetes minima midget quillwort	G1G2/S1	Sens	B-Sens F-Sens	RegEnd	Ktt, Oka, Spo	CP, EC, OK	Okanogan-Wenatchee NF
Isöetes nuttallii Nuttall's quillwort	G4?/S2	Sens	B-Sens F-Sens	Sparse	Clk, Cow, Kli, Lew, Pie, Saj, Thu	EC, PT	Bald Hill NAP Cattle Point NRCA Columbia Hills Historical SP Columbia River Gorge NSA Conboy Lake NWR JB Lewis McChord
Juncus hemiendytus var. *hemiendytus* dwarf rush	G5T5/S1	Threat		Periph	Kli, Spo, Yak	CP, EC	Conboy Lake NWR Klickitat Canyon NRCA Turnbull NWR
Juncus howellii Howell's rush	G4/S1	Threat	B-Sens F-Sens	Sparse	Ktt, Skm	EC	Gifford Pinchot NF Okanogan-Wenatchee NF
Juncus kelloggii Kellogg's rush	G3?/S1	Endang	B-Sens F-Sens	Periph	Kli, Yak	EC	Columbia River Gorge NSA Conboy Lake NWR Klickitat Canyon NRCA
**Juncus patens* spreading rush	G5/S1	Sens		Periph	Cla	PT	Lacamas Prairie NAP
Juncus tiehmii Tiehm's rush	G4/S1	Threat	B-Sens	Disjunct	Dou	CP	Spokane BLM
Juncus uncialis inch-high rush	G3G4/S2	Threat	B-Sens	Sparse	Ada, Dou, Gra, Kli, Lin, Spo	CP	Columbia Hills Historical SP Columbia River Gorge NSA Fairchild AFB Marcellus Shrub Steppe NAP North Columbia Basin SWA Swanson Lakes SWA

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Kalmia procumbens (*Loiseluria procumbens*) alpine azalea	G5/S1	Threat	B-Sens F-Sens	Periph	Che, Skg,	EC, NC	Glacier Peak WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Lasthenia glaberrima smooth goldfields	G5/S1	Threat	B-Sens F-Sens	Periph	Clk, Kli	CP, PT	Columbia Hills Historical SP Columbia River Gorge NSA
Lathrocasis tenerrima (*Gilia tenerrima*) delicate gilia	G5/S1	Threat	B-Sens F-Sens	Sparse	Che, Dou, Oka	CP, EC, OK	Okanogan-Wenatchee NF Spokane BLM
Lathyrus holochlorus thin-leaved peavine	G2?/S1	Endang		RegEnd	Lew	PT	
Lathyrus torreyi Torrey's peavine	G5/S1	Threat		Sparse	Clk, Lew, Pie	PT, WC	JB Lewis McChord
Lathyrus vestitus var. *ochropetalus* Pacific pea	G5TNR/ S1	Endang		RegEnd	Kin, Lew, Thu	PT	Lewis & Clark SP
Lepidium oxycarpum sharpfruited peppergrass	G4/S1	Endang		Disjunct	Saj	PT	Cattle Point NRCA
Leptosiphon bolanderi Baker's linanthus	G4G5/S2	Sens	B-Sens F-Sens	Periph	Kli	EC	Columbia River Gorge NSA Klickitat SWA Spokane BLM
**Leptosiphon minimus* (*Linanthus bicolor* var. *m.*) true babystars	GNR/ S1S2	Sens		RegEnd	Isl, Saj, Skg, Thu	PT	Anacortes CF Deception Pass SP Moran SP Scatter Creek SWA Spokane BLM
Leymus flavescens (*Elymus flavescens*) yellow wildrye	G4/S1	Sens	B-Sens	RegEnd	Ada, Ben, Fra, Gar, Gra, Kli, Ktt, Skm, Waw, Wht	EC, CP	Columbia River Gorge NSA Hanford Reach NM Juniper Dunes WA Spokane BLM
Liparis loeselii bog twayblade	G5/S1	Endang		Disjunct	Kli, Saj	EC, PT	Conboy Lake NWR Killebrew Lake NAP
Lipocarpha aristulata awned halfchaff sedge	G5?/ S1S2	Threat	B-Sens F-Sens	Disjunct	Aso, Ben, Gar, Gra, Kli, Spo, Wht, Yak	CP, EC	Columbia River Gorge NSA Crab Creek SWA Hanford NWR Hanford Reach NM
Lobelia dortmanna water lobelia	G4G5/S3	Sens		Sparse	Clm, Kin, Mas, Saj, Skg, Sno, Whc	NC, PC, PT	Moran SP Olympic NP
Lobelia kalmii Kalm's lobelia	G5/S1	Endang		Disjunct	Yak	CP	Yakima TC
Loeflingia squarrosa spreading pygmyleaf	G5/S1	Threat		Disjunct	Ben	CP	Hanford ERP
Lomatium bradshawii Bradshaw's desert-parsley	G2/S1	Endang	Endang	RegEnd	Clk	PT	Lacamas Prairie NAP
Lomatium knokei Knoke's desert-parsley	G1/S1	Threat	B-Sens F-Sens	LocEnd	Ktt	EC	Okanogan-Wenatchee NF
Lomatium laevigatum smooth desert-parsley	G3/S2S3	Threat	B-Sens F-Sens	LocEnd	Kli	CP	Columbia Hills Historical SP Columbia River Gorge NSA Gifford Pinchot NF
Lomatium lithosolamans (*Tauschia hooveri*) Hoover's tauschia	G2G3/ S2S3	Sens	B-Sens	LocEnd	Ktt, Yak	CP, EC	Fort Simcoe SP LT Murray SWA Spokane BLM
Lomatium rollinsii Rollins' desert-parsley	G3/S2	Threat	B-Sens F-Sens	RegEnd	Aso	BM, CP	Chief Joseph SWA Fields Spring SP Umatilla NF Vale BLM

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**Lomatium roneorum* Leavenworth desert-parsley	G1/S1	Endang		LocEnd	Che	EC	Okanogan-Wenatchee NF
Lomatium sandbergii Sandberg's desert-parsley	G4/SH	Extirp		RegEnd	Oka, Peo	CR, OK	Kaniksu NF Okanogan-Wenatchee NF Salmo Priest WA
Lomatium serpentinum Snake Canyon desert-parsley	G4/S2	Sens	B-Sens	RegEnd	Aso, Col, Gar, Gra, Waw, Wht	BM, CP	Chief Joseph SWA McNary SWA Vale BLM
Lomatium suksdorfii Suksdorf's desert-parsley	G3/S3	Sens	B-Sens F-Sens	LocEnd	Kli	EC	Columbia River Gorge NSA Gifford Pinchot NF Klickitat SWA Spokane BLM White Salmon Oak NRCA
Lomatium tamanitchii (*L. packardiae* var. *t.*) ribseed biscuitroot	G3?/S2	Sens	F-Sens	LocEnd	Kli	CP	Cleveland Shrub Steppe NAP? Columbia River Gorge NSA
Lomatium tenuissimum (*Tauschia tenuissima*) Leiberg's tauschia	G3/SX	Extirp		RegEnd	Spo	CP	
Lomatium tuberosum Hoover's desert-parsley	G2G3/ S2S3	Sens	B-Sens	RegEnd	Ben, Gra, Ktt, Yak	CP, EC	Columbia NWR Crab Creek SWA Hanford ERP Oak Creek SWA Spokane BLM Yakima TC
Lupinus oreganus var. *kincaidii* Kincaid's sulphur lupine	G4T2/ S1	Endang	Threat	RegEnd	Lew	PT	Lozier Prairie Preserve
**Lupinus pachylobus* Bigpod lupine	G4/S1	Sens		Disjunct	Saj	PT	Sentinel Island TNC Preserve
Lupinus sabinianus Sabin's lupine	G3/S1	Endang		LocEnd	Aso, Waw	BM, CP	
Luzula arcuata ssp. *unalaschcensis* curved woodrush	G5T3T5/ S1	Threat	F-Sens	Sparse	Oka, Pie, Skg, Yak	EC, NC, OK, WC	Gifford Pinchot NF Mt. Adams WA Mt. Rainier NP Okanogan-Wenatchee NF Pasayten WA
Lycopodiella inundata bog clubmoss	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Kin, Ktp, Pac, Pie, Skm, Thu, Whc	NC, PC, PT, WC	Columbia River Gorge NSA JB Lewis McChord North Cascades NP Olympic NP Ross Lake NRA Skating Lake SP
Lycopodium lagopus one-cone clubmoss	G5/S1	Sens		Disjunct	Che, Kin, Whc	EC, NC	Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Malaxis monophyllos var. *brachypoda* (*M. brachypoda*) white adder's-mouth orchid	G4G5 T4T5Q/ S1	Sens	F-Sens	Periph	Whc	NC	Mt. Baker-Snoqualmie NF
Meconella oregana white meconella	G2G3/S1	Endang	B-Sens F-Sens	RegEnd	Isl, Kin, Kli, Pie, Saj	EC, PT	Columbia River Gorge NSA Deception Pass SP Gifford Pinchot NF
Micranthes tischii (*Saxifraga tischii*) Tisch's saxifrage	G1G2/ S1?	Sens	F-Sens	RegEnd	Clm, Jef	PC	Buckhorn WA Olympic NF Olympic NP
Micromonolepis pusilla red poverty-weed	G5/S1	Threat	B-Sens F-Sens	Disjunct	Dou, Gra, Yak	CP	Hanford ERP

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Microseris bigelovii coast microseris	G4/SX	Extirp		Periph	Saj	PT	
Microseris borealis northern microseris	G5/S2	Sens	B-Sens F-Sens	Sparse	Clm, Pie, Skm	EC, PC, WC	Gifford Pinchot NF Mt. Adams WA Mt. Rainier NP Mt. St. Helens NVM Olympic NP
Mimetanthe pilosa false monkeyflower	G5/S1	Sens		Sparse	Ben, Dou, Gra, Kli, Skm, Waw, Wht, Yak	CP, EC	Gifford Pinchot NF
Montia diffusa branching montia	G4/S1S2	Sens	B-Sens F-Sens	RegEnd	Clm, Clk, Grh, Jef, Kin, Kli, Lew, Pie, Skg, Skm, Sno	EC, NC, PC, PT, WC	Columbia River Gorge NSA Gifford Pinchot NF Mt. St. Helens NVM Olympic NP
Muhlenbergia glomerata marsh muhly	G5/S2	Sens	B-Sens F-Sens	Periph	Oka, Peo, Spo	CP, CR, OK	Colville NF Kaniksu NF
Myosurus alopecuroides (*M. clavicaulis*) foxtail mousetail	G3?/S2	Threat	B-Sens	Sparse	Ada, Ben, Kli, Lin, Spo	CP	Columbia Hills Historical SP Columbia River Gorge NSA Fairchild AFB Hanford ERP Klickitat SWA Marcellus Shrub Steppe NAP Spokane BLM Turnbull NWR
Myosurus sessilis Vernal pool mousetail	G2/S1	Endang		Periph	Kli	CP	WA DNR?
Myriopteris gracilis (*Cheilanthes feei*) Fee's lip-fern	G5/S1	Threat	B-Sens	Periph	Aso, Wht	BM, CP	Vale BLM
Navarretia leucocephala ssp. *diffusa* least pincushion-plant	G4T1/ S1	Threat		LocEnd	Lin, Spo	CP	Spokane BLM Swanson Lakes SWA
Navarretia tagetina marigold navarretia	G5/S1	Threat	B-Sens F-Sens	Periph	Kli	EC	Columbia River Gorge NSA Gifford Pinchot NF
Nicotiana attenuata coyote tobacco	G4/S2	Sens	B-Sens F-Sens	Sparse	Ben, Che, Dou, Fra, Gra, Kli, Ktt, Wht, Yak	CP, EC	Colockum SWA Columbia River Gorge NSA Gingko Petrified Forest SP Hanford ERP Oak Creek SWA Okanogan-Wenatchee NF Spokane BLM Two Steppe NAP Yakima TC
Nuttallanthus texanus (*Linaria canadensis* var. *texana*) Texas toadflax	G4G5/S1	Threat		Sparse	Isl, Kin, Pie, Skg, Thu	PT	Deception Pass SP Glacial Heritage Preserve JB Lewis McChord Scatter Creek SWA
Nymphaea tetragona pygmy water-lily	G5/SH	Extirp		Periph	Whc	PT	
Oenothera cespitosa ssp. *cespitosa* caespitose evening-primrose	G5T5/S2	Sens	B-Sens	Periph	Ben, Gra, Kli, Ktt, Yak	CP	Columbia NWR Hanford ERP Saddle Mountain NWR Spokane BLM Yakima TC

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Oenothera cespitosa ssp. *marginata* tufted evening-primrose	G5T3T5/ S1	Threat	B-Sens F-Sens	Periph	Aso, Kli, Wht	BM, CP, EC	Asotin Creek SWA Chief Joseph SWA Vale BLM
Oenothera flava ssp. *flava* long-tubed evening-primrose	G5T3T5/ SH	Extirp		Periph	Yak	CP	
Ophioglossum pusillum adder's-tongue	G5/S2	Sens	B-Sens F-Sens	Sparse	Che, Dou, Kli, Ktt, Mas, Oka, Peo, Saj, Ste	CP, CR, EC, OK, PC, PT	Colville NF Conboy Lake NWR Killebrew Lake NAP Little Pend Oreille NWR Spokane BLM
Orthocarpus bracteosus rosy owl's-clover	G3?/S2	Threat	B-Sens F-Sens	RegEnd	Kli, Saj, Skm, Whc, Yak	EC, PT	Conboy Lake NWR Gifford Pinchot NF Trout Lake NAP
Oxalis suksdorfii western yellow oxalis	G4/SH	Extirp		RegEnd	Clm, Clk, Kli, Ktp	EC, PC, PT	Columbia River Gorge NSA
Oxytropis borealis var. *viscida* sticky crazyweed	G5T4?/ S1S2	Sens		Periph	Clm	PC	Olympic NP
Oxytropis campestris var. *columbiana* Columbia crazyweed	G5T2/S1	Endang		RegEnd	Fer, Oka, Ste	CR, OK	Roosevelt Lake NRA Spokane BLM
Oxytropis campestris var. *gracilis* (*O. monticola*) slender crazyweed	G5T5/ S2	Sens	B-Sens F-Sens	Sparse	Clm, Jef, Ktt, Oka, Pie, Saj, Whc	EC, NC, OK, PC, PT, WC	Buckhorn WA Mt. Baker WA Mt. Baker-Snoqualmie NF Mt. Rainier NP Okanogan-Wenatchee NF Olympic NF Olympic NP Pasayten WA San Juan Islands NWR
Oxytropis campestris var. *wanapum* Wanapum crazyweed	G5T1/S1	Endang	B-Sens	LocEnd	Gra	CP	Spokane BLM
Packera bolanderi var. *harfordii* *(Senecio bolanderi* var. *h.)* Harford's ragwort	G4TUQ/ S1	Sens	F-Sens	RegEnd	~~Che~~, ~~Oka~~, Skm, Whk	EC, ~~OK~~, PC, ~~WC~~	Beacon Rock SP Columbia River Gorge NSA Gifford Pinchot NF
Packera macounii (*Senecio macounii*) Siskiyou Mountain ragwort	G5/S1	Threat		RegEnd	Saj, Skg	PT	Burrows Island SP Moran SP
Packera porteri (*Senecio porteri*) Porter's butterweed	G4/S1	Endang	F-Sens	Disjunct	Oka	OK	Chelan-Sawtooth WA North Cascades NP Okanogan-Wenatchee NF
Parnassia cirrata var. *intermedia* (*P. fimbriata* var. *hoodiana*) Cascade grass-of-Parnassus	G5T3/S1	Threat		Periph	Skm	WC	
Parnassia kotzebuei Kotzebue's grass-of-Parnassus	G5/S1	Threat	B-Sens F-Sens	Periph	Che, Oka	OK	Chelan-Sawtooth WA Okanogan-Wenatchee NF
Parnassia palustris (*P. p.* var. *neogaea*, var. *tenuis*) northern grass-of-Parnassus	G5/S2	Sens	B-Sens F-Sens	Periph	Grh, Jef, Mas, Pac	PC	Olympic NF Olympic NP
Pedicularis pulchella mountain lousewort	G3/S1	Sens	F-Sens	Disjunct	Che	EC	Alpine Lakes WA Okanogan-Wenatchee NF

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Pedicularis rainierensis Mt. Rainier lousewort	G2G3/ S2S3	Sens	F-Sens	LocEnd	Lew, Pie, Yak	EC, WC	Clearwater WA Mt. Baker-Snoqualmie NF Mt. Rainier NP Okanogan-Wenatchee NF
Pediocactus nigrispinus snowball cactus	G4/S2	Sens	B-Sens	RegEnd	Dou, Gra, Ktt, Yak	EC, CP	Colockum SWA Gingko Petrified Forest SP LT Murray SWA North Columbia Basin SWA Quilomene SWA Spokane BLM Yakima TC
Pellaea brachyptera Sierra cliffbrake	G4G5/S2	Sens	B-Sens F-Sens	Disjunct	Che	EC	Chelan-Sawtooth WA Okanogan-Wenatchee NF
Pellaea breweri Brewer's cliffbrake	G5/S2	Sens	F-Sens	Sparse	Che, Jef, Kin, Ktt, Mas, Ste	CR, EC, PC	Buckhorn WA Glacier Peak WA Mt Baker Snoqualmie NF Okanogan-Wenatchee NF Olympic NF Olympic NP Spokane BLM
**Pellaea gastonyi* Gastony's cliffbrake	G2G3/S1	Threat		Periph	Ste	OK	Trombetta Canyon NAP
Penstemon barrettiae Barrett's beardtongue	G2/S2	Threat	B-Sens F-Sens	LocEnd	Kli, Skm	EC	Columbia River Gorge NSA Gifford Pinchot NF Klickitat SWA Spokane BLM
Penstemon deustus var. *variabilis* hot-rock penstemon	G5T1T2/ S1	Threat	B-Sens F-Sens	RegEnd	Kli	CP	Columbia Hills NAP Columbia River Gorge NSA
Penstemon eriantherus var. *whitedii* Whited's fuzzytongue penstemon	G4T2/S2	Threat	B-Sens F-Sens	RegEnd	Che, Dou, Fra, Gra, Kli, Ktt, Lin, Spo	CP, EC	Colockum SWA Entiat Slopes NAP Hanford ERP Okanogan-Wenatchee NF Peshastin Pinnacles SP Riverside SP Saddle Mountain NWR South Columbia Basin SWA Spokane BLM
Penstemon hesperius tall beardtongue (*P. rydbergii*, misapplied)	G1/S1	Endang		RegEnd	Clk	PT	Lacamas Prairie NAP
Penstemon pennellianus Blue Mountain penstemon	G3/S2	Threat	F-Sens	RegEnd	Aso, Col, Gar	BM	Chief Joseph SWA Fields Spring SP Umatilla NF Wenaha Tucannon WA
Penstemon wilcoxii Wilcox's beardtongue	G4/S1	Threat	B-Sens F-Sens	RegEnd	Col, Gra, Oka, Skm, Spo, Wht	BM, CP, OK, WC	Columbia River Gorge NSA Gifford Pinchot NF North Columbia Basin SWA Okanogan-Wenatchee NF Trapper Creek WA Umatilla NF
Perideridia oregana Oregon yampah	G4G5/ SH	Extirp		Periph	Skm	WC	Columbia River Gorge NSA
Petrophytum caespitosum ssp. *caespitosum* Rocky Mountain rockmat	G5T3T5/ S1	Endang	B-Sens	Periph	Aso	BM	Vale BLM

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Petrophytum cinerascens Chelan rockmat	G1G2/ S1S2	Endang	B-Sens F-Sens	LocEnd	Che, Dou	CP, EC	Colockum SWA Okanogan-Wenatchee NF Spokane BLM
Phacelia lenta sticky phacelia	G2?/S2?	Threat	B-Sens	LocEnd	Dou	CP	Spokane BLM
Phacelia minutissima least phacelia	G3/S1	Endang	B-Sens F-Sens	Disjunct	Ktt	EC	Okanogan-Wenatchee NF
Phacelia tetramera dwarf phacelia	G4/S1	Threat	B-Sens F-Sens	Sparse	Dou, Gra	CP	Spokane BLM? Sun Lakes SP
Phlox solivaga yeti phlox	G1/S1	Endang	F-Sens	LocEnd	Col, Gar, Waw?	BM	Spokane BLM? Umatilla NF
Physaria didymocarpa ssp. *disymocarpa* common twinpod	G5T4/ SH	Extirp		Periph	Ste	OK	
Physaria douglasii ssp. *tuplashensis* (*Lesquerella tuplashensis*) White Bluffs bladderpod	G4?T1/ S1	Endang	Threat	LocEnd	Fra	CP	Hanford ERP South Columbia Basin SWA
Pilularia americana American pillwort	G5/S2	Threat	B-Sens F-Sens	Disjunct	Ada, Lin, Spo	CP	Fairchild AFB Marcellus Shrub Steppe NAP Spokane BLM Swanson Lakes SWA Turnbull NWR
Pityopus californicus pine-foot	G4G5/S1	Threat		Disjunct	Pie, ~~Sno~~, Thu	~~NC~~, PT, WC	JB Lewis McChord Mt. Rainier NP
Plantago macrocarpa Alaska plantain	G4/S2	Sens		Periph	Clm, Grh, Jef	PC	Clearwater Bogs NAP Olympic NP
Platanthera chorisiana Choris' bog-orchid	G3G4/S2	Threat	B-Sens F-Sens	Periph	Kin, Sno	NC	Boulder River WA Henry M. Jackson WA Morning Star NRCA Mt. Baker-Snoqualmie NF
**Plectritis brachystemon* short-spurred plectritis	G5?/S1	Sens		Sparse	Clm. Grh, Isl, Kli, Mas, Skg, Skm	EC, PC, PT	Anacortes CF Columbia River Gorge NSA Conboy Lake NWR Deception Pass SP Elwha SWA Fort Casey SP Gifford Pinchot NF Olympic NF Olympic NP Trout Lake NAP?
Poa laxiflora loose-flowered bluegrass	G3G4/ S2S3	Sens		Sparse	Clm, Cow, Jef, Lew, Pac, Whk	PC, PT	Olympic NP
Poa unilateralis ssp. *pachypholis* ocean-bluff bluegrass	G4TNR/ S1	Threat		RegEnd	Pac	PC	Cape Disappointment SP
Polemonium carneum great polemonium	G4/S2	Threat	B-Sens F-Sens	RegEnd	Clm, Clk, Grh, Lew, Pac, Skm, Thu	PC, PT, WC	Columbia River Gorge NSA Olympic NP
Polemonium pectinatum Washington polemonium	G2/S2	Threat	B-Sens	RegEnd	Ada, Lin, Spo, Wht	CP	Spokane BLM
Polemonium viscosum skunk polemonium	G5/S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Chelan-Sawtooth WA Okanogan-Wenatchee NF Pasayten WA
Polyctenium fremontii Fremont's combleaf	G4/S1	Threat	B-Sens	Disjunct	Gra	CP	Spokane BLM

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Polygonum austiniae Austin's knotweed	G4/S1	Threat		Sparse	Col, Gra, Spo	BM, CP	Sun Lakes SP Umatilla NF
Polygonum parryi Parry's knotweed	G4/S1	Threat		Periph	Kli	EC	Conboy Lake NWR Trout Lake NAP
Polystichum californicum California swordfern	G4/S1	Threat	B-Sens F-Sens	Sparse	Pie, Skm, Thu	WC	Bald Hill NAP Gifford Pinchot NF Mt St. Helens NVM
Potamogeton obtusifolius blunt-leaf pondweed	G5/S2	Sens		Sparse	Jef, Mas, Oka, Saj, Skg, Thu	NC, OK, PT	Sinlahekin SWA
Potentilla breweri (*P. drummondii* ssp. *b.*) Brewer's cinquefoil	G5/S1	Threat	B-Sens F-Sens	Sparse	Clm, Ktt, Lew, Yak	EC, PC, WC	Gifford Pinchot NF Goat Rocks WA Okanogan-Wenatchee NF Olympic NP
Potentilla glaucophylla var. *perdissecta* (*P. diversifolia* var. *p.*) diverse-leaved cinquefoil	G5T4/S1	Sens	B-Sens F-Sens	Disjunct	Che, Oka	EC, OK	Alpine Lakes WA Chopaka Mountain NAP Loomis NRCA Okanogan-Wenatchee NF
Potentilla newberryi Newberry's cinquefoil	G3G4/ SH	Extirp		Periph	Kli	EC	Columbia River Gorge NSA
Potentilla nivea snow cinquefoil	G5/S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Chelan-Swatooth WA Chopaka Mountain NAP Okanogan-Wenatchee NF Pasayten WA
Pyrrocoma hirta var. *sonchifolia* sticky goldenweed	G4G5T3 /S2	Threat	B-Sens F-Sens	RegEnd	Ktt	EC	Okanogan-Wenatchee NF
Pyrrocoma liatriformis smallhead goldenweed	G2/S2	Threat		RegEnd	Spo, Wht	CP	Steptoe Butte SP
Pyrrocoma scaberula Palouse goldenweed	G2/S1	Endang	B-Sens F-Sens	RegEnd	Aso	BM, CP	Chief Joseph SWA Fields Spring SP Umatilla NF Vale BLM
Ranunculus californicus California buttercup	G5/S1	Threat	B-Sens	Periph	Saj, ~~Skg~~	PT	Iceberg Island SP
Ranunculus hebecarpus downy buttercup	G5/S1	Threat		Periph	Ada, Gar?, Kli, Wht	CP, EC	Columbia River Gorge NSA Spokane BLM
Ranunculus populago mountain buttercup	G4/S2	Sens	B-Sens F-Sens	Sparse	Col, Gar, Pie	BM, NC	Gifford Pinchot NF Glacier View WA Umatilla NF Wenaha-Tucannon WA
Ranunculus triternatus (*R. reconditus*) obscure buttercup	G2/S1S2	Endang	B-Sens F-Sens	LocEnd	Kli	CP, EC	Columbia Hills Historical SP Columbia Hills NAP Columbia River Gorge NSA Klickitat SWA Spokane BLM
Ribes cereum var. *colubrinum* squaw currant	G5T3/S1	Endang	B-Sens F-Sens	RegEnd	Aso	BM, CP	Asotin SWA Vale BLM
Ribes oxyacanthoides var. *irriguum* Idaho gooseberry	G5T4/S2	Threat	B-Sens F-Sens	RegEnd	Aso, Clk, ~~Fer~~, Spo, ~~Ste~~, Wht	BM, CP, ~~OK~~, PT	Chief Joseph SWA Fields Spring SP Umatilla NF
Ribes wolfii Wolf's currant	G4/S2	Sens	F-Sens	Periph	Aso, Gar	BM	Umatilla NF

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Rorippa columbiae Columbia yellowcress	G3/S1S2	Threat	B-Sens F-Sens	RegEnd	Ben, Fra, Kli, Skm	CP, EC, WC	Beacon Rock SP Columbia River Gorge NSA Hanford Reach NM McNary NWR Saddle Mountain NWR South Columbia Basin SWA
Rotala ramosior lowland toothcup	G5/S2	Sens	B-Sens F-Sens	Sparse	Ben, Che, Fra, Gar, Kli, Spo, ~~Whc~~, Wht	CP, EC, ~~PT~~	Columbia River Gorge NSA Conboy Lake NWR Hanford ERP Hanford Reach NWR ~~Lake Terrell SWA~~ Okanogan-Wenatchee NF Saddle Mountain NWR Spokane BLM Turnbull NWR
Rubus arcticus ssp. *acaulis* nagoonberry	G5T5/S1	Threat	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Rubus nigerrimus northwest raspberry	G2/S2	Threat		LocEnd	Aso, Gar, Wht	BM, CP	Vale BLM
Sabulina nuttallii var. *fragilis* (*Minuartia nuttallii* var. *f.*) Nuttall's sandwort	G5T4/S1	Threat	B-Sens	Periph	Ben, Gra, Ktt	CP	Columbia NWR Spokane BLM Yakima TC
Sabulina pusilla (*Minuartia pusilla*) annual sandwort	G5/S1	Threat		Sparse	Col?, Gra, Kli, Spo, Waw, Wht	CP, EC	Columbia River Gorge NSA
Sabulina sororia Twin Sisters sandwort	G1/S1	Endang		LocEnd	Whc	NC	Mt. Baker WA Mt. Baker-Snoqualmie NF
Salix candida hoary willow	G5/S1	Threat	B-Sens F-Sens	Periph	Peo, Ste	CR	Colville NF
Salix glauca var. *villosa* glaucous willow	G5T5?/ S1S2	Sens	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF Pasayten WA
Salix maccalliana MacCalla's willow	G5/S1	Threat	B-Sens F-Sens	Periph	Oka, Peo, Ste	CR, OK	Colville NF Sinlahekin SWA
Salix pseudomonticola false mountain willow	G5/S1	Sens	B-Sens F-Sens	Periph	Che, Peo	CR, EC	Alpine Lakes WA Colville NF Okanogan-Wenatchee NF
Salix sessilifolia soft-leaved willow	G4/S2	Sens	B-Sens F-Sens	RegEnd	Clk, Cow, Kli, Skg, Whc, Whk	EC, PC, PT	Columbia River Gorge NSA Ridgefield NWR
Salix vestita rock willow	G5/SH	Extirp		Periph	Che, Whc	EC, NC	Mt. Baker WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Samolus parviflorus (*S. valerandi* ssp. *p.*) water pimpernel	G5/S1	Threat		Disjunct	Whk	PC	
Sandbergia perplexa puzzling rockcress	G4/S1	Endang		Disjunct	Dou	CP	
Sanguisorba menziesii Menzies' burnet	G3G4/S2	Threat		Periph	Clm, Grh	PC	Carlilsle Bog NAP Olympic NP
Sanicula arctopoides bear's-foot sanicle	G5/S1	Endang	B-Sens	Sparse	Grh, Pac, Saj	PC, PT	San Juan Islands NM San Juan Islands NWR Spokane BLM Turn Island SP
Saxifraga cernua nodding saxifrage	G5/S1	Sens	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF Pasayten WA

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Saxifraga hyperborea pygmy saxifrage	G5/S3	Sens		Sparse	Che, Clm, Jef, Oka, Pie, Skg, Sno, Whc	EC, NC, OK, PC, WC	Buckhorn WA Chelan-Sawtooth WA Chopaka Mountain NAP Glacier Peak WA Lake Chelan NRA Mt. Baker WA Mt. Baker-Snoqualmie NF Mt. Rainier NP North Cascades NP Okanogan-Wenatchee NF Olympic NF Olympic NP Pasayten WA
Saxifragopsis fragarioides strawberry saxifrage	G3?/S2	Threat	B-Sens F-Sens	Disjunct	Che	EC	Alpine Lakes WA Okanogan-Wenatchee NF
Schizachyrium scoparium var. *scoparium* little bluestem	G5T5/S1	Threat	B-Sens	Disjunct	Che, Dou, Ste	CP, CR, EC	Spokane BLM
Schoenoplectus saximontanus Rocky Mountain bulrush	G5/S1	Threat		Sparse	Spo	CP	Turnbull NWR
Sclerolinon digynum northwestern yellowflax	G5/S2	Sens		Periph	Spo, Wht	CP	Fairchild AFB Turnbull NWR
Scribneria bolanderi Scribner's grass	G4/S1	Threat	B-Sens F-Sens	Periph	Kli, Pie, Skm	EC, WC	Columbia River Gorge NSA Gifford Pinchot NF Mt. Baker-Snoqualmie NF Norse Creek WA
Sericocarpus oregonensis ssp. *oregonensis* (*Aster oreganus*) Oregon white-top aster	G5TNR/ S1	Threat	B-Sens F-Sens	RegEnd	Skm	EC, WC	Columbia River Gorge NSA
Sericocarpus rigidus (*Aster curtus*) white-top aster	G3/S3	Sens	B-Sens F-Sens	RegEnd	Grh, Isl, Kin, Pie, Saj, Skm, Thu	EC, PC, PT	Columbia River Gorge NSA Glacial Heritage Preserve JB Lewis McChord Mima Mounds NAP Rocky Prairie NAP Scatter Creek SWA Spokane BLM
Sidalcea hirtipes bristly-stemmed checkermallow	G2/S2	Threat	B-Sens F-Sens	RegEnd	Clk, Lew, Whk	PC, PT, WC	Gifford Pinchot NF
Sidalcea nelsoniana Nelson's checkermallow	G2G3/S1	Endang	Threat	RegEnd	Cow, Lew	PT	
Sidalcea oregana var. *calva* Wenatchee Mountain checkermallow	G5T1/ S1?	Endang	Endang	RegEnd	Che, Ktt?	EC	Camas Meadows NAP Colockum SWA? Okanogan-Wenatchee NF
Sidalcea virgata (*S. malviflora* ssp. *virgata*) rose checkermallow	G5/S1	Threat		RegEnd	Thu	PT	Scatter Creek SWA
Silene scouleri ssp. *scouleri* Scouler's catchfly	G5T3T5/ S1	Sens	B-Sens F-Sens	Sparse	Che, Clm, Fer, Isl, Pie, Spo, Ste, Thu, Wht, Yak	CP, CR, EC, OK, PT	Colville NF JB Lewis McChord Okanogan-Wenatchee NF Steptoe Butte SP William O. Douglas WA
Silene seelyi Seely's catchfly	G3/S3	Sens	B-Sens F-Sens	LocEnd	Che, Ktt	EC	Alpine Lakes WA Lake Chelan NRA North Cascades NP Okanogan-Wenatchee NF

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Silene spaldingii Spalding's catchfly	G2/S2	Threat	Threat	RegEnd	Ada, Aso, Gar, Lin, Spo, Wht	BM, CP, CR	Asotin Creek SWA Fairchild AFB Nez Perce NHP Spokane BLM Steptoe Butte SP Swanson Lakes SWA Turnbull NWR Umatilla NF
Sisyrinchium montanum var. *montanum* strict blue-eyed grass	G5T5/S1	Threat	B-Sens F-Sens	Periph	Dou, Peo	CP, CR	Colville NF Kaniksu NF? Spokane BLM
Sisyrinchium sarmentosum pale blue-eyed grass	G2/S2	Threat	B-Sens F-Sens	LocEnd	Kli, Skm	EC, WC	Columbia River Gorge NSA Conboy Lake NWR? Gifford Pinchot NF Trout Lake NAP
Sisyrinchium septentrionale northern blue-eyed grass	G3G4/S3	Sens		Periph	Fer, Oka, Peo, Ste	CR, OK	Colville NF Little Pend Oreille NWR Okanogan-Wenatchee NF Spokane BLM
Sparganium fluctuans water bur-reed	G5/S1	Threat		Periph	Clm	PC	Olympic NP
Spartina pectinata prairie cordgrass	G5/S2	Sens	B-Sens F-Sens	Sparse	Aso, Dou, Fra, Gar, Gra, Peo, Spo, Wht	BM, CP, CR, OK	Chief Joseph SWA Colville NF Little Pend Oreille SWA Palouse Falls SP Riverside SP Vale BLM Wells SWA
Spiranthes diluvialis Ute ladies'-tresses	G2G3/S1	Endang	Threat	Sparse	Che, Dou, Gra, Oka	CP, EC, OK	Chelan County PUD Colockum SWA Grant County PUD Spokane BLM
Spiranthes porrifolia western ladies'-tresses	G4/S2	Sens	B-Sens F-Sens	Sparse	Che, Clk, Kli, Ktt, Lin, Oka, Skm	CP, EC, OK, PT, WC	Chelan-Sawtooth WA Columbia Hills Historical SP Columbia River Gorge NSA Klickitat SWA Okanogan-Wenatchee NF Pasayten WA
Sporobolus compositus var. *compositus* composite dropseed	G5T5/S1	Sens	B-Sens	Sparse	Che, Fra, Ktt	CP	Hanford ERP Spokane BLM
Sullivantia oregana Oregon sullivantia	G2/S1	Endang	B-Sens F-Sens	LocEnd	Skm	WC	Beacon Rock SP Columbia Falls NAP Columbia River Gorge NSA
Swertia perennis swertia	G5/S1	Threat	B-Sens F-Sens	Periph	Che, Sno	EC, WC	Glacier Peak WA Henry M. Jackson WA Mt. Baker-Snoqualmie NF Okanogan-Wenatchee NF
Symphyotrichum boreale (*Aster borealis*) rush aster	G5/S1	Threat		Periph	Peo, Pie, ~~Saj~~, Ste	CR, ~~PT~~	Colville NF Killebrew Lake NAP
Symphyotrichum hallii (*Aster hallii*) Hall's aster	G4/S2	Threat		RegEnd	Clk, Thu	PT	JB Lewis McChord Scatter Creek SWA
Symphyotrichum jessicae (*Aster jessicae*) Jessica's aster	G2/S1S2	Endang		RegEnd	Spo, Wht	CP	Turnbull NWR

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Synthyris lanuginosa (*S.pinnatifida* var. *lanuginosa* cut-leaf synthyris	G3/S3?	Sens	B-Sens F-Sens	RegEnd	Clm, Jef	PC	Buckhorn WA Olympic NF Olympic NP
**Synthyris schizantha* fringed synthyris	G4/S1	Sens		RegEnd	Grh, Lew	PC, WC	Colonel Bob WA Gifford Pinchot NF Mt Baker Snoqualmie NF Olympic NF Olympic NP?
Thelypodium howellii ssp. *howellii* Howell's thelypody	G1T1/ SH	Extirp		RegEnd	Yak	CP	
Thelypodium sagittatum ssp. *sagittatum* arrow thelypody	G4T4/S1	Threat	B-Sens	Disjunct	Dou, Gra, Lin	CP	Spokane BLM
Trifolium douglasii Douglas' clover	G2/S1	Endang	B-Sens F-Sens	RegEnd	Aso, Gar, Wht	BM, CP	Umatilla NF
Trifolium plumosum var. *plumosum* plumed clover	G4T4/S1	Threat		RegEnd	Waw	BM	
Trifolium thompsonii Thompson's clover	G3/S3	Threat	B-Sens F-Sens	LocEnd	Che, Dou	CP, EC	Colockum SWA Entiat Slopes NAP Spokane BLM Okanogan-Wenatchee NF
Triglochin palustris marsh arrowgrass	G5/S1	Sens	F-Sens	Periph	Oka, Peo, Ste	CR, OK	Colville NF Okanogan-Wenatchee NF
Trillium albidum ssp. *parviflorum* (*T. parviflorum*) small-flowered trillium	G2G3/ S2S3	Sens	B-Sens F-Sens	RegEnd	Clk, Lew, Pie, Thu	PC, PT, WC	Bald Hill NAP Columbia River Gorge NSA Glacial Heritage Preserve JB Lewis McChord Lacamas Prairie NAP Ridgefield NWR Scatter Creek SWA West Rocky Prairie SWA Willapa Hills SP
Utricularia intermedia flat-leaved bladderwort	G5/S2S3	Sens	B-Sens F-Sens	Sparse	Clm, Kin, Kli, Peo, Skm, Sno	CR, EC, NC, PC, PT, WC	Conboy Lake NWR Gifford Pinchot NF Olympic NP Snoqualmie Bog NAP
Vaccinium myrtilloides velvetleaf blueberry	G5/S1	Threat	B-Sens F-Sens	Periph	Oka	OK	Okanogan-Wenatchee NF
Veratrum insolitum Siskiyou false hellebore	G3/S1	Endang		RegEnd	Kli	EC	Columbia River Gorge NSA
Whipplea modesta yerba de selva	G4/S1	Threat		Periph	Clm, Thu	PC, PT	Olympic NP
Woodwardia fimbriata giant chainfern	G5/S2	Sens		Sparse	Jef, Ktp, Mas, Pie, Thu	PC, PT	Blake Island SP Hamma Hamma Balds NAP Olympic NF
Wyethia angustifolia California compassplant	G4/S1	Sens		Periph	Clk, Kli, Lew, Thu	EC, PT	Columbia River Gorge NSA Lacamas Prairie NAP Scatter Creek SWA
Zeltnera muehlenbergii (*Centaurium muehlenbergii*) Monterey centaury	G5?/S1	Threat		Sparse	Kli	EC	Conboy Lake NWR?

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Acknowledgments

Thanks to the following individuals for contributing new data and recommendations on species ranks: Ed Alverson, Joe Arnett, Katy Beck, Molly Boyter, Karen Brimacombe, Paula Brooks, Keyna Bugner, Tara Callaway, Pam Camp, Florence Caplow, Kenton Chambers, Mark Darrach, Tatiana Dreisbach, Peter Dunwiddie, Richard Easterly, John Gamon, Rod Gilbert, Wendy Gibble, David Giblin, Regina Johnson, Susan Kephart, Judy Lantor, Helen Lau, Ben Legler, Larry Loftis, Lauri Malmquist, Kelli Van Norman, Emily Orling, Tynan Ramm-Granberg, Karen Reagan, James Riser, Joe Rocchio, Debra Salstrom, Mark Skinner, Rylan Sprague, Ted Thomas, David Thomsen, Andrea Thorpe, Lisa Weigel, Barry Wendling, Dave Wilderman, and Peter Zika. Jasa Holt, database specialist with the WA Natural Heritage Program assisted with data entry and quality control. Distribution pattern, county, ecoregion, and managed area data compiled by Walter Fertig, rare species botanist, WA Natural Heritage Program.

ATTACHMENT D

TABLE 4.1 OF TEE GUIDANCE

Table 4.1: Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified TEE[a]

Priority Contaminant	Unrestricted Land Use[b]	Industrial or Commercial Property	Priority Contaminant	Unrestricted Land Use[b]	Industrial or Commercial Property
Metals:[c]			Chlorpyrifos/chlorpyrifosmethyl (total)	See note d	See note d
Antimony	See note d	See note d	DDT/DDD/DDE (total)	1 mg/kg	1 mg/kg
Arsenic III	20 mg/kg	20 mg/kg	Dieldrin	0.17 mg/kg	0.17 mg/kg
Arsenic V	95 mg/kg	260 mg/kg	Endosulfan	See note d	See note d
Barium	1,250 mg/kg	1,320 mg/kg	Endrin	0.4 mg/kg	0.4 mg/kg
Beryllium	25 mg/kg	See note d	Heptachlor/heptachlor epoxide (total)	0.6 mg/kg	0.6 mg/kg
Cadmium	25 mg/kg	36 mg/kg	Hexachlorobenzene	31 mg/kg	31 mg/kg
Chromium (total)	42 mg/kg	135 mg/kg	Parathion/methyl parathion (total)	See note d	See note d
Cobalt	See note d	See note d	Pentachlorophenol	11 mg/kg	11 mg/kg
Copper	100 mg/kg	550 mg/kg	Toxaphene	See note d	See note d
Lead	220 mg/kg	220 mg/kg	Chlorinated dibenzofurans (total)[e]	3E-06 mg/kg	3E-06 mg/kg
Magnesium	See note d	See note d	Chlorinated dibenzo-p-dioxins (total)[e]	5E-06 mg/kg	5E-06 mg/kg
Manganese	See note d	23,500 mg/kg	Hexachlorophene	See note d	See note d
Mercury, inorganic	9 mg/kg	9 mg/kg	PCB mixtures (total)	2 mg/kg	2 mg/kg
Mercury, organic	0.7 mg/kg	0.7 mg/kg	Pentachlorobenzene	168 mg/kg	See note d
Molybdenum	See note d	See note d	**Other Non-Chlorinated Organics:**		
Nickel	100 mg/kg	1,850 mg/kg	Acenaphthene	See note d	See note d
Selenium	0.8 mg/kg	0.8 mg/kg	Benzo(a)pyrene	30 mg/kg	300 mg/kg
Silver	See note d	See note d	Bis (2-ethylhexyl) phthalate	See note d	See note d
Tin	275 mg/kg	See note d	Di-n-butyl phthalate	200 mg/kg	See note d
Vanadium	26 mg/kg	See note d	**Petroleum:**		
Zinc	270 mg/kg	570 mg/kg	Gasoline Range Organics	200 mg/kg	12,000 mg/kg[g]
Pesticides:			Diesel Range Organics[f]	460 mg/kg	15,000 mg/kg[g]
Aldicarb/aldicarb sulfone (total)	See note d	See note d			
Aldrin	0.17 mg/kg	0.17 mg/kg			
Benzene hexachloride (including lindane)	10 mg/kg	10/mg/kg			
Carbofuran	See note d	See note d			
Chlordane	1 mg/kg	7 mg/kg			

Footnotes:

[a] Caution on misusing these values. They have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. The table is not intended for purposes such as evaluating sludges or wastes. This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

[b] Applies to any site that does not meet the definition of industrial or commercial property under WAC 173-340-200.

[c] For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated, anaerobic and unsaturated aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

[d] Safe concentration has not yet been established. See WAC 173-340-7492(2) (c) for procedures for establishing values for these substances.

[e] These values represent a total toxic equivalent concentration of all furan or dioxin congeners. Use the toxicity equivalency factors in Table 749-6 to convert congener mixtures to a total toxic equivalent concentration.

[f] Diesel range organics includes the sum of diesel fuels and heavy oils measured using method the NWTPH-Dx method. Mineral oils are essentially non-toxic to plants and animals and do not need to comply with these values (see Compendium – Section V).

[g] Except that the concentration shall not exceed residual saturation.

APPENDIX G

PRELIMINARY COST ESTIMATES

Alternatives 2-6
Remedial Option
Cost Summary

Alternative[1]	Description[2]	Unknowns[3]	Cost								
			Design and Construction ($)	O&M Years 1-5 ($)	O&M Years 6-10 ($)	O&M Years 11-15 ($)	O&M Years 16-20 ($)	O&M Years 21-25 ($)	O&M Years 26-30 ($)	Total	Present Worth
Alternative 1 No Action											
Alternative 2 Monitored Natural Attenuation	This alternative consists of institutional controls (IC) and long-term groundwater quality monitoring. The application of IC provide notification regarding the presence of contaminated materials, regulate the disturbance/management of these materials, and prohibit the creation of preferential pathways for contaminant migration. The principal assumption of Alternative 2 is that reductions of COCs within the shallow water bearing zone (silt unit) will occur through natural processes such as biodegradation, diffusion, dispersion, hydrolysis, and sorption.	Future distribution of contaminants in soil and groundwater. Mobility of dissolved phase COCs in shallow groundwater. Risks posed by residual contamination (e.g., future contact by earth workers, migration to CPU wellfield). Site conditions (e.g., soil permeability, degree of heterogeneity, preferential pathways) affecting contaminant mobility, plume expansion, and rate of natural attenuation. Cleanup levels and regulatory enforcement action(s).	$0	$447,000	$223,000	$223,000	$112,000	$112,000	$112,000	$1,229,000	$882,600
Alternative 3 Hydraulic Containment	In addition to the implementation of IC and MNA, this alternative is designed to hydraulically control and contain contaminated groundwater detected beneath the Site. Gradient control would be accomplished through the installation of nineteen 35-foot-deep extraction wells throughout the defined extent of TPH in shallow groundwater in beneath the MW-5, MW-6, and MW-11 Areas. The estimate of 19 extraction wells is based on an assumed radius of influence of 25 feet while pumping from a 4-inch-diameter well at 1 gpm. Using submersible pumps, extracted groundwater would be routed to a common treatment system consisting of a coalescing plate oil-water-separator followed by GAC treatment prior to discharge to the POTW. At a total system pumping rate of 19 gpm, the system would treat and discharge up to 10,000,000 gallons of water annually. Its is assumed that cleanup goals would be met in 30 years.	Pumping tests would be needed to verify drawdown, radius of influence, flow rate, well depth, well locations, and the number of extraction wells needed to provide full hydraulic containment within each area of interest. During the pump test, an aboveground treatment system would be pilot tested to verify the treat train necessary to meet discharge criteria and to establish a maintenance schedule. During full-scale implementation, the following unknowns could have a significant impact on cleanup costs: (a) the amount and degree of maintenance required to keep the full-scale pump & treat system operational; (b) the need for deeper hydraulic containment; (c) the need for significant changes to the ex situ treatment processes and the discharge of treated water (e.g., on-site infiltration); (d) the restoration time frame; (e) changes to cleanup levels; and (f) regulatory enforcement action(s).	$926,000	$2,129,000	$1,906,000	$1,906,000	$1,794,000	$1,794,000	$1,255,000	$11,710,000	$7,966,000
Alternative 4 Plume Stabilization, Enhanced Bioremediation	In addition to the implementation of IC and MNA, this alternative includes the direct injection of micron-scale activated carbon (plume stabilization) and biostimulants (enhanced bioremediation) throughout contaminated smear zones beneath the MW-5, MW-6, and VRU Areas. This alternative assumes 10 years of MNA.	Remedial design investigations would be needed to verify: (a) the lateral and vertical extent of PCM in select areas; and (b) the effectiveness of PetroFix injections on groundwater quality and enhanced bioremediation. Other unknowns include the remedy's impact on terminal operations and regulatory UIC approval of biostimulant injections (e.g., nitrate and sulfate electron acceptors).	$1,911,000	$447,000	$447,000	$0	$0	$0	$0	$2,805,000	$2,595,000

Please refer to footnotes at end of table.

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Alternatives 2-6
Remedial Option
Cost Summary

Alternative[1]	Description[2]	Unknowns[3]	Cost								
			Design and Construction ($)	O&M Years 1-5 ($)	O&M Years 6-10 ($)	O&M Years 11-15 ($)	O&M Years 16-20 ($)	O&M Years 21-25 ($)	O&M Years 26-30 ($)	Total	Present Worth
Alternative 5 Removal of Readily Accessible PCS, Hydraulic Containment, Enhanced Bioremediation (Active)	In addition to the implementation of IC, MNA, the removal of readily accessible PCS (i.e., 12-foot removal actions near B-6 and B-30), and the hydraulic containment beneath the MW-5 and MW-6 Areas, this alternative includes the on-site recirculation of treated/amended water. Gradient control would be accomplished through the installation of eighteen 35-foot-deep extraction wells throughout the defined extent of TPH in shallow groundwater. The estimate of 18 extraction wells is based on an assumed radius of influence of 25 feet while pumping from a 4-inch-diameter well at 1 gpm. Using submersible pumps, extracted groundwater would be routed to a common treatment system consisting of a coalescing plate oil-water-separator followed by GAC treatment to remove COCs. Following the removal of COCs, the extracted groundwater would be amended with biostimulants and discharged into the backfilled excavations for infiltration. The continuous recirculation of oxygen/nutrient-rich water through the COC-containing silt zones is designed to actively enhance the biodegradation of residual COCs in soil and groundwater. This alternative includes the direct injection of liquid micron-scale adsorbents and biostimulants (PetroFix) throughout the impacted silt zone surrounding MW-11 within the VRU Area. This alternative assumes 5 years of groundwater recirculation and 2 years of MNA.	Remedial design investigations would be needed to verify: (a) the lateral and vertical extent of PCM in select area; (b) temporary shoring requirements associated with 12-foot-deep excavations; (c) the radius of influence of extraction wells; (d) treatability of extracted groundwater; (e) the ability to infiltrate treated/amended water within the backfilled excavations; (f) the ability to stimulate biodegradation between water injection and groundwater extraction points; and (g) the ability to control plume migration. Other unknowns include the remedy's impact on terminal operations and regulatory approval of groundwater recirculation. As mentioned, pilot testing within both source areas would be needed to develop the final design of the recirculation system. During full-scale implementation, the following unknowns could have a significant impact on cleanup costs: (a) the amount and degree of maintenance required to keep recirculation system operational; (b) the potential mobilization of undetected free product; (c) the ability to maintain hydraulic containment; (d) the restoration time frame; and (e) the effectiveness of direct injections of adsorbents and biostimulants beneath the VRU Area to achieve cleanup levels.	$1,590,000	$2,329,000	$179,000	$0	$0	$0	$0	$4,098,000	$3,757,000
Alternative 6 Removal of All Accessible PCS, Enhanced Bioremediation (Active)	In addition to the implementation of IC and MNA, this alternative includes the removal of accessible PCM beneath the MW-5 Area and MW-6/B-18 Areas (i.e., 22 feet bgs) and backfill with hydrocarbon degradation stimulating amendments (e.g., ORC). The soil removal actions would require excavation shoring and dewatering. Following excavation, this alternative includes the direct injection of liquid micron-scale adsorbents and biostimulants throughout the contaminated smear zone surrounding MW-11 within the VRU Area. This alternative assumes MNA for a total of 5 years.	(a) The amount of accessible PCM; (b) the quantity and quality of excavation water; (c) excavation wall stability and degree of shoring required to limit settlement and damage to surrounding structures; (d) type of excavation equipment required; (e) permit requirements; (f) the effectiveness of placing ORC at the limits of the excavation to stimulate biodegradation; and (g) restoration time frame.	$3,968,000	$447,000	$0	$0	$0	$0	$0	$4,415,000	$4,250,000

FOOTNOTES

[1] Alternative: Remedial technology deemed potentially applicable to Source Control Strategy objective.
[2] Description: Typical mode of action of technology.
[3] Unknowns: Factors that may heavily influence remedy design and cost.

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Alternative 2 - Monitored Natural Attenuation
GWM (Quarterly for 5 yrs, Semi-Annual for 10 yrs, Annual for 15 yrs)

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	30	$220.00	$6,600.00
Sr. Associate	Labor	90	$187.00	$16,830.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	0	$154.00	$0.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	15	$123.00	$1,845.00
Staff	Labor	140	$108.00	$15,120.00
GIS/CAD	Labor	8	$150.00	$1,200.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	12	$68.00	$816.00
Subtotal Labor		**303**		**$43,003.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Freight/Shipping	Each	4	$250.00	$1,000.00
Field Equipment	Estimate	1	$4,480.00	$4,480.00
Subtotal Cascadia Expenses				**$5,480.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Quarterly	4	$5,340.00	$21,360.00
IDW Disposal	Each	4	$1,300.00	$5,200.00
10% markup	Misc			$2,656.00
Subtotal Outside Expenses				**$29,216.00**
Contingency (15%)				**$11,654.85**
Annual Costs				**$89,353.85**

GWM (Assumptions)

Assumes four quarters of groundwater quality monitoring utilizing existing 11 monitoring wells for the first 5 years; semi-annual monitoring for the next 10 years, and annual monitoring for the last 15 years. Assumes two days per event.

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Alternative 2 - Monitored Natural Attenuation
Estimated Cash Flow and Future Costs

Interest Rate= 3%

Year	Capital	Routine O&M	Total	Frequency
-	$0	$0	$0	
1	$0	$89,354	$89,354	Quarterly Monitoring
2	$0	$89,354	$89,354	Quarterly Monitoring
3	$0	$89,354	$89,354	Quarterly Monitoring
4	$0	$89,354	$89,354	Quarterly Monitoring
5	$0	$89,354	$89,354	Quarterly Monitoring
6	$0	$44,677	$44,677	Semiannual Monitoring
7	$0	$44,677	$44,677	Semiannual Monitoring
8	$0	$44,677	$44,677	Semiannual Monitoring
9	$0	$44,677	$44,677	Semiannual Monitoring
10	$0	$44,677	$44,677	Semiannual Monitoring
11	$0	$44,677	$44,677	Semiannual Monitoring
12	$0	$44,677	$44,677	Semiannual Monitoring
13	$0	$44,677	$44,677	Semiannual Monitoring
14	$0	$44,677	$44,677	Semiannual Monitoring
15	$0	$44,677	$44,677	Semiannual Monitoring
16	$0	$22,338	$22,338	Annual Monitoring
17	$0	$22,338	$22,338	Annual Monitoring
18	$0	$22,338	$22,338	Annual Monitoring
19	$0	$22,338	$22,338	Annual Monitoring
20	$0	$22,338	$22,338	Annual Monitoring
21	$0	$22,338	$22,338	Annual Monitoring
22	$0	$22,338	$22,338	Annual Monitoring
23	$0	$22,338	$22,338	Annual Monitoring
24	$0	$22,338	$22,338	Annual Monitoring
25	$0	$22,338	$22,338	Annual Monitoring
26	$0	$22,338	$22,338	Annual Monitoring
27	$0	$22,338	$22,338	Annual Monitoring
28	$0	$22,338	$22,338	Annual Monitoring
29	$0	$22,338	$22,338	Annual Monitoring
30	$0	$22,338	$22,338	Annual Monitoring
Present Worth	**$0**	**$882,600**	**$882,600**	
Future Costs	$0	$1,228,600	$1,228,600	
Target		$89,400		

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Alternative 3 - Hydraulic Containment

Pump and Treatment System Installation

Direct Labor	**Units**	**Hours**	**Rate**	**Total $US**
Principal	Labor	60	$220.00	$13,200.00
Sr. Associate	Labor	0	$187.00	$0.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	60	$154.00	$9,240.00
Project	Labor	40	$142.00	$5,680.00
Sr. Staff	Labor	120	$123.00	$14,760.00
Staff	Labor	200	$108.00	$21,600.00
GIS/CAD	Labor	40	$150.00	$6,000.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	40	$68.00	$2,720.00
Subtotal Labor		**568**		**$73,792.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Pressure Transducers	Each	19	$850.00	$16,150.00
Postage/UPS/Courier	Cost Plus	5	$50.00	$250.00
Field Equipment	Estimate	1	$7,300.00	$7,300.00
Subtotal Cascadia Expenses				**$23,700.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Extraction Well Installation, Pumping and Treatment (P&T) System Installation				
Drilling	Day	21	$6,500.00	$136,500.00
Start Cards	Each	19	$150.00	$2,850.00
Blank PVC Casing	Each	285	$4.50	$1,282.50
Well Screens	Per Ft.	380	$10.00	$3,800.00
Vaults	Each	19	$450.00	$8,550.00
Drop Box Delivery, Pickup, Cleaning	Month	1	$2,800.00	$2,800.00
P&T System Install Subcontractor	Each	2	$25,000.00	$50,000.00
System Equipment/Materials	Per Job	1	$211,267.50	$211,267.50
Waste Disposal for Well Installation	Per Job	1	$1,545.98	$1,545.98
Trenching and Piping to Treatment Equip and to Sewer at Fruit Valley Road	Per LF	600	$18.00	$10,800.00
Oil-water-separator	Each	1	$15,000.00	$15,000.00
Carbon Units	Each	4	$20,000.00	$80,000.00
Carbon to fill the Units	Per Pound	16,000	$2.85	$45,600.00
Construction Permits	Per Job	1	$500.00	$500.00
City of Vancouver Sewer Connection	Each	1	$2,000.00	$2,000.00
Survey	Per Job	1	$3,500.00	$3,500.00
Analytical	Per Job	1	$17,415.00	$17,415.00
Taxes on Outside Expenses	Per Job	1	8.4%	$49,846.52
10% Markup on Subcontracted Services	Misc			$64,325.75
Subtotal Outside Expenses				**$707,583.25**
Contingency (15%)				**$120,761.29**
TASK TOTAL				**$925,836.54**

Shallow P&T Installation and Operation (Assumptions)

Assumes the installation of 19 pumping wells (7 pumping wells in the Well MW-5 Area, 11 pumping wells in the B-18/MW-6 Area, and 1 well in the Vapor Recovery Unit [VRU] Area) to 35 feet below ground surface (bgs), each pumping at 1 gallon per minute (gpm), 25 feet radius of influence (ROI) with water being treated by oil/water separator (OWS) and granular activated carbon (GAC) on-site prior to discharge to sanitary sewer system. Assumes pilot-scale pump test, and full-scale pumping well/treatment system installation oversight by engineer/geologist.

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Alternative 3 - Hydraulic Containment
P&T System Operations and Maintenance

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	40	$220.00	$8,800.00
Sr. Associate	Labor	0	$187.00	$0.00
Sr. Project	Labor	50	$154.00	$7,700.00
Project	Labor	20	$142.00	$2,840.00
Sr. Staff	Labor	80	$123.00	$9,840.00
Staff	Labor	180	$108.00	$19,440.00
GIS/CAD	Labor	0	$150.00	$0.00
Admin	Labor	10	$68.00	$680.00
6% labor markup				$2,958.00
Subtotal Labor		**380**		**$52,258.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Pressure Transducer	Each	1	$800.00	$800.00
Postage/UPS/Courier	Cost Plus	10	$10.00	$100.00
Field Equipment	Per Year	1	$3,670.00	$3,670.00
Subtotal Cascadia Expenses				**$4,570.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Annual	1	$26,640.00	$26,640.00
Monthly P&T System O&M Subcontractor	Monthly	12	$2,500.00	$30,000.00
Waste Disposal	Per Ton	10.4	$215.00	$2,239.92
Waste Transport	Each	1	$900.00	$900.00
Sanitary Sewer Discharge	Per CCF	13,351	$7.02	$93,722.63
Electricity	Per Year	1	$15,422.86	$15,422.86
GAC Media	Per Year	1	$30,212.83	$30,212.83
Taxes on Outside Expenses	Per Job	1	8.4%	$16,727.61
10% Markup	Misc			$19,913.82
Subtotal Outside Expenses				**$235,779.67**
Contingency (15%)				**$43,891.15**
Annual Costs (Yrs 1 through 28)				**$336,498.82**

O&M (Assumptions)

Assumes routine site visits to check system operation, backwash adsorbers, download pressure transducer data, and permit sampling. The system operations and maintenance assumes that all extracted groundwater would pumped to a common treatment equipment enclosure (OWS and GAC) prior to discharge to the publicly owned treatment works (POTW). Two GAC media changeouts per year.

Alternative 3 - Hydraulic Containment
Groundwater Monitoring

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	30	$220.00	$6,600.00
Sr. Associate	Labor	90	$187.00	$16,830.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	0	$154.00	$0.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	15	$123.00	$1,845.00
Staff	Labor	140	$108.00	$15,120.00
GIS/CAD	Labor	8	$150.00	$1,200.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	12	$68.00	$816.00
Subtotal Labor		**303**		**$43,003.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Freight/Shipping	Each	4	$250.00	$1,000.00
Field Equipment	Estimate	1	$4,480.00	$4,480.00
Subtotal Cascadia Expenses				**$5,480.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Quarterly	4	$5,340.00	$21,360.00
IDW Disposal	Each	4	$1,300.00	$5,200.00
10% markup	Misc			$2,656.00
Subtotal Outside Expenses				**$29,216.00**
Contingency (15%)				**$11,654.85**
Annual Costs				**$89,353.85**

GWM (Assumptions)
Assumes four quarters of groundwater quality monitoring utilizing existing 11 monitoring wells for the first 5 years, semi-annual monitoring for the next 10 years, and annual monitoring for the next 13 years, and quarterly for the final 2 years.

Alternative 3 - Hydraulic Containment
Estimated Cash Flow and Future Costs

Interest Rate= 3%

Year	Capital	Routine O&M/GWM	Total
-	$925,837	$0	$925,837
1	$0	$425,853	$425,853
2	$0	$425,853	$425,853
3	$0	$425,853	$425,853
4	$0	$425,853	$425,853
5	$0	$425,853	$425,853
6	$0	$381,176	$381,176
7	$0	$381,176	$381,176
8	$0	$381,176	$381,176
9	$0	$381,176	$381,176
10	$0	$381,176	$381,176
11	$0	$381,176	$381,176
12	$0	$381,176	$381,176
13	$0	$381,176	$381,176
14	$0	$381,176	$381,176
15	$0	$381,176	$381,176
16	$0	$358,837	$358,837
17	$0	$358,837	$358,837
18	$0	$358,837	$358,837
19	$0	$358,837	$358,837
20	$0	$358,837	$358,837
21	$0	$358,837	$358,837
22	$0	$358,837	$358,837
23	$0	$358,837	$358,837
24	$0	$358,837	$358,837
25	$0	$358,837	$358,837
26	$0	$358,837	$358,837
27	$0	$358,837	$358,837
28	$0	$358,837	$358,837
29	$0	$89,354	$89,354
30	$0	$89,354	$89,354
Present Worth	**$898,870**	**$7,067,256**	**$7,966,126**
Future Costs	$925,837	$10,784,613	$11,710,450

Cascadia
Associates, LLC

Alternative 4 - Plume Stabilization and Enhanced Bioremediation
Injection of PetroFix

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	80	$220.00	$17,600.00
Sr. Associate	Labor	100	$187.00	$18,700.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	100	$154.00	$15,400.00
Project	Labor	100	$142.00	$14,200.00
Sr. Staff	Labor	647	$123.00	$79,565.63
Staff	Labor	647	$108.00	$69,862.50
GIS/CAD	Labor	5	$150.00	$750.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	0	$74.00	$0.00
Admin Assist	Labor	20	$68.00	$1,360.00
Subtotal Labor		**1699**		**$217,438.13**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Regenesis Freight	Estimate	1	12.0%	$48,767.02
Field Equipment	Estimate	1	$16,520.00	$16,520.00
Subtotal Cascadia Expenses				**$65,287.02**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Initial Round of PetroFix direct injections in B-5, B-18, and VRU areas throughout the extent of TPH in GW (Points spaced approximately 5 feet apart).				
Drilling Mob/Demob	Day	65	$500.00	$32,343.75
Drilling Injection Rig/Equipment	Day	65	$8,500.00	$549,843.75
WA Required NOI/Decon Logs by Driller	Each	939	$95.00	$89,205.00
Hand Clearing Injection Locations	Estimate	1	$20,000.00	$20,000.00
Backfill Injection Points				
VRU Area Direct Injections	Each	19	$15.00	$285.00
B-6 Area Direct Injections	Each	280	$15.00	$4,200.00
B-18 Area Direct Injections	Each	640	$15.00	$9,600.00
Drums	Each	47	$75.00	$3,521.25
IDW Disposal	Estimate	1	$36,000.00	$36,000.00
Biostimulant Material (Initial Injections)				
VRU Area Direct Injections	Per Pound	3,591	$3.35	$12,029.85
B-6 Area Direct Injections	Per Pound	42,840	$3.35	$143,514.00
B-18 Area Direct Injections	Per Pound	74,880	$3.35	$250,848.00
Analytical	Per Job	1	$5,000.00	$5,000.00
Taxes on Outside Expenses	Per Job	1	8.4%	$97,136.81
10% Markup on Subcontracted Services	Misc			$125,352.74
Subtotal Outside Expenses				**$1,378,880.15**
Contingency (15%)				**$249,240.79**
TASK TOTAL				**$1,910,846.09**

Direct Injections

Direct injections of plume stabilizer and biostimulant (PetroFix) via direct-push drilling techniques with boring spaced approximately 6 feet apart. Injections will be completed between 15 and 25 feet bgs. Assume that water for mixing reagents will be provided by the Terminal.

Cascadia Associates, LLC

Alternative 4 - Plume Stabilization and Enhanced Bioremediation
Groundwater Monitoring

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	30	$220.00	$6,600.00
Sr. Associate	Labor	90	$187.00	$16,830.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	0	$154.00	$0.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	15	$123.00	$1,845.00
Staff	Labor	140	$108.00	$15,120.00
GIS/CAD	Labor	8	$150.00	$1,200.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	12	$68.00	$816.00
Subtotal Labor		**303**		**$43,003.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Freight/Shipping	Each	4	$250.00	$1,000.00
Field Equipment	Estimate	1	$4,480.00	$4,480.00
Subtotal Cascadia Expenses				**$5,480.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Quarterly	4	$5,340.00	$21,360.00
IDW Disposal	Each	4	$1,300.00	$5,200.00
10% markup	Misc			$2,656.00
Subtotal Outside Expenses				**$29,216.00**
Contingency (15%)				**$11,654.85**
Annual Costs				**$89,353.85**

GWM (Assumptions)

Assumes four quarters of groundwater quality monitoring utilizing existing 11 monitoring wells for 10 years.

Cascadia Associates, LLC

Alternative 4 - Plume Stabilization and Enhanced Bioremediation
Estimated Cash Flow and Future Costs

Interest Rate= 3%

Year	Capital	Routine GWM	Total
-	$1,910,846	$0	$1,910,846
1	$0	$89,354	$89,354
2	$0	$89,354	$89,354
3	$0	$89,354	$89,354
4	$0	$89,354	$89,354
5	$0	$89,354	$89,354
6	$0	$89,354	$89,354
7	$0	$89,354	$89,354
8	$0	$89,354	$89,354
9	$0	$89,354	$89,354
10	$0	$89,354	$89,354
11	$0	$0	$0
12	$0	$0	$0
13	$0	$0	$0
14	$0	$0	$0
15	$0	$0	$0
16	$0	$0	$0
17	$0	$0	$0
18	$0	$0	$0
19	$0	$0	$0
20	$0	$0	$0
21	$0	$0	$0
22	$0	$0	$0
23	$0	$0	$0
24	$0	$0	$0
25	$0	$0	$0
26	$0	$0	$0
27	$0	$0	$0
28	$0	$0	$0
29	$0	$0	$0
30	$0	$0	$0
Present Worth	**$1,855,190**	**$740,006**	**$2,595,197**
Future Costs	$1,910,846	$893,539	$2,804,385

Cascadia Associates, LLC

Alternative 5 - Groundwater Recirculation
Removal of Readily Accessible PCS

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	80	$220.00	$17,600.00
Sr. Associate	Labor	80	$187.00	$14,960.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	80	$154.00	$12,320.00
Project	Labor	30	$142.00	$4,260.00
Sr. Staff	Labor	200	$123.00	$24,600.00
Staff	Labor	30	$108.00	$3,240.00
GIS/CAD	Labor	20	$150.00	$3,000.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	10	$68.00	$680.00
Subtotal Labor		**538**		**$81,252.00**
Cascadia Equipment	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Field Vehicle	Week	3	$480.00	$1,440.00
Mileage (30 Miles Round Trip)	Per Mile	60	$0.60	$36.00
Hand Auger	Week	3	$100.00	$300.00
PID	Week	3	$300.00	$900.00
GPS Unit	Day	3	$150.00	$450.00
4-gas Meter	Week	3	$300.00	$900.00
Subtotal Cascadia Expenses				**$4,026.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Remedial Excavation Contractor				
Mob/Demob	Per Job	1	$8,000.00	$8,000.00
Building demo and move transmix tank	Per Job	1	$15,000.00	$15,000.00
Utility/Locates - Air knife to expose piping	Per Job	1	$5,000.00	$5,000.00
Erosion and sediment control	Per Job	1	$2,500.00	$2,500.00
Excavation and direct load into trucks	CY	3,100	$13.00	$40,300.00
Biostimulant amendment during backfill	Per Pound	0	$4.25	$0.00
Freight and Taxes for PetroFix	Estimate	0	$8,000.00	$0.00
Infiltration Gallery for Recirculation System	Per LF	150	$25.00	$3,750.00
Import, placement, and compaction of fill	CY	3,100	$35.00	$108,500.00
Offsite Transport and Disposal	Ton	4,700	$75.00	$352,500.00
Analytical Testing				
NWTPH-Gx	Sample	25	$55.00	$1,375.00
NWTPH-Dx	Sample	25	$70.00	$1,750.00
VOCs by EPA 8260B	Sample	10	$160.00	$1,600.00
PAH by EPA 8270 SIM	Sample	10	$160.00	$1,600.00
Taxes on Outside Expenses	Per Job	1	8.4%	$43,585.50
10% markup on Subcontracted Services	Misc			$54,187.50
Subtotal Outside Expenses				**$639,648.00**
Contingency (15%)				**$108,738.90**
TASK TOTAL				**$833,664.90**

Remedial Excavation Assumptions

Assumes the remedial excavation of approximately 2,100 tons of petroleum contaminated soil (PCS) within the MW-5 Area and 2,600 tons of PCS within the MW-6 Area. Assumes remedial excavation and backfill oversight by engineer/geologist, 3-week field duration. PSC disposal at Hillsboro Landfill. No permits, shoring or dewatering required.

Cascadia Associates, LLC

Alternative 5 - Groundwater Recirculation
Recirculation Pump and Treatment System Installation
(with Active Bioremediation)

Direct Labor	**Units**	**Hours**	**Rate**	**Total $US**
Principal	Labor	60	$220.00	$13,200.00
Sr. Associate	Labor	0	$187.00	$0.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	60	$154.00	$9,240.00
Project	Labor	40	$142.00	$5,680.00
Sr. Staff	Labor	120	$123.00	$14,760.00
Staff	Labor	200	$108.00	$21,600.00
GIS/CAD	Labor	40	$150.00	$6,000.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	40	$68.00	$2,720.00
Subtotal Labor		**568**		**$73,792.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Pressure Transducers	Each	19	$850.00	$16,150.00
Postage/UPS/Courier	Cost Plus	5	$50.00	$250.00
Field Equipment	Estimate	1	$7,300.00	$7,300.00
Subtotal Cascadia Expenses				**$23,700.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Extraction and Monitoring Well Installation, Pumping and Treatment (P&T) System Installation				
Drilling	Day	20	$6,500.00	$130,000.00
Start Cards	Each	18	$150.00	$2,700.00
Blank PVC Casing	Each	270	$4.50	$1,215.00
Well Screens	Per Ft.	360	$10.00	$3,600.00
Vaults	Each	18	$450.00	$8,100.00
Drop Box Delivery, Pickup, Cleaning	Month	1	$2,800.00	$2,800.00
Drilling and P&T System Install Mob/Demob	Each	2	$5,000.00	$10,000.00
System Equipment/Materials	Per Job	0	$198,790.00	$0.00
Waste Disposal for Well Installation	Per Job	1	$1,464.61	$1,464.61
Trenching and Piping to Treatment Equip	Per LF	600	$18.00	$10,800.00
Oil-water-separator	Each	1	$15,000.00	$15,000.00
Carbon Units	Each	4	$20,000.00	$80,000.00
Carbon to fill the Units	Per Pound	16,000	$2.85	$45,600.00
ETEC Systems				
MOB/DEMOB	Each	2	$2,084.00	$4,168.00
Treatment Unit (2 Units)	Each	2	$4,000.00	$8,000.00
Setup/Training	Each	2	$12,000.00	$24,000.00
PetroBac Amendment	Each	2	$12,000.00	$24,000.00
System Pan and Pump Rental	Each	2	$500.00	$1,000.00
UIC Permit	Each	1	$1,200.00	$1,200.00
Construction Permits	Per Job	2	$2,000.00	$4,000.00
Survey	Per Job	1	$3,500.00	$3,500.00
Analytical	Per Job	1	$17,010.00	$17,010.00
Taxes	Per Job	1	8.4%	$33,445.24
10% Markup on Subcontracted Services	Misc			$39,815.76
Subtotal Outside Expenses				**$471,418.61**
Contingency (15%)				**$85,336.59**
TASK TOTAL				**$654,247.20**

Shallow P&T Installation and Operation (Assumptions)

Assumes the installation of 19 pumping wells (7 pumping wells in the Well MW-5 Area and 11 pumping wells in the B-18/MW-6 Area) to 35 feet below ground surface (bgs), each pumping at 1.0 gallon per minute (gpm),
25 feet radius of influence (ROI) with water being treated by oil/water separator (OWS) and granular activated carbon (GAC) on-site prior to discharge to sanitary sewer system. Assumes pilot-scale pump test, and full-scale pumping well/treatment system installation oversight by engineer/geologist.

Cascadia Associates, LLC

Alternative 5 - Groundwater Recirculation
VRU Area Plume Stabilization

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	40	$220.00	$8,800.00
Sr. Associate	Labor	40	$187.00	$7,480.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	40	$154.00	$6,160.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	100	$123.00	$12,300.00
Staff	Labor	0	$108.00	$0.00
GIS/CAD	Labor	5	$150.00	$750.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	0	$74.00	$0.00
Admin Assist	Labor	5	$68.00	$340.00
Subtotal Labor		**230**		**$35,830.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Regenesis Freight + Sales Tax	Estimate	1	$4,100.00	$4,100.00
Field Equipment	Estimate	1	$2,100.00	$2,100.00
Subtotal Cascadia Expenses				**$6,200.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Biostimulant direct injections in VRU area (20 points spaced approximately 6 feet apart).				
Drilling Mob/Demob	Day	4	$250.00	$1,000.00
Drilling Injection Rig/Equipment	Day	4	$4,250.00	$17,000.00
WA Required NOI/Decon Logs by Driller	Each	20	$95.00	$1,900.00
Hand Clearing Injection Locations	Estimate	1	$4,000.00	$4,000.00
Backfill Injection Points	Each	20	$15.00	$300.00
Drums	Each	2	$75.00	$150.00
IDW Disposal	Estimate	1	$2,000.00	$2,000.00
Biostimulant Material	Per Pound	3,780	$4.25	$16,065.00
Analytical	Per Job			$0.00
10% Markup on Subcontracted Services	Misc			$4,141.50
Subtotal Outside Expenses				**$46,556.50**
Contingency (15%)				**$13,287.98**
TASK TOTAL				**$101,874.48**

VRU Direct Injections

Direct injections of biostimulant (PetroFix) at 20 locations spaced approximately 6 feet apart. Injections will be completed between 15 and 25 feet bgs. Assume that water for mixing biostimulant will be provided by the Terminal.

Alternative 5 - Groundwater Recirculation
P&T System Operations and Maintenance

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	40	$220.00	$8,800.00
Sr. Associate	Labor	0	$187.00	$0.00
Sr. Project	Labor	50	$154.00	$7,700.00
Project	Labor	20	$142.00	$2,840.00
Sr. Staff	Labor	80	$123.00	$9,840.00
Staff	Labor	220	$108.00	$23,760.00
GIS/CAD	Labor	0	$150.00	$0.00
Admin	Labor	10	$68.00	$680.00
6% labor markup				$3,217.20
Subtotal Labor		**420**		**$56,837.20**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Pressure Transducer	Each	1	$800.00	$800.00
Postage/UPS/Courier	Cost Plus	10	$10.00	$100.00
Field Equipment	Per Year	1	$3,670.00	$3,670.00
Subtotal Cascadia Expenses				**$4,570.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Annual	1	$26,640.00	$26,640.00
Monthly P&T System O&M Subcontractor	Monthly	0	$2,500.00	$0.00
ETEC Systems				
Treatment Unit Rental (2 Units)	Monthly	12	$8,000.00	$96,000.00
PetroBac Amendment	Monthly	12	$5,000.00	$60,000.00
System Panel and Pump Rental	Monthly	12	$1,000.00	$12,000.00
Waste Disposal	Per Ton	10	$215.00	$2,122.03
Waste Transport	Each	1	$900.00	$900.00
Electricity	Per Year	1	$15,422.86	$15,422.86
GAC Media	Per Year	1	$28,622.68	$28,622.68
10% Markup	Misc			$24,170.76
Subtotal Outside Expenses				**$265,878.32**
Contingency (15%)				**$49,092.83**
Annual Costs (Yrs 1 through 5)				**$376,378.35**

O&M (Assumptions)

Assumes monthly site visits to check system operation, backwash adsorbers, download pressure transducer data, and maintenance of two ETEC systems. Assumes that there will be two separate systems with a common treatment train (OWS and GAC) prior to discharge to separate infiltration galleries. Assumes two GAC media changeouts per year.

Cascadia Associates, LLC

Alternative 5 - Groundwater Recirculation
Groundwater Monitoring

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	30	$220.00	$6,600.00
Sr. Associate	Labor	90	$187.00	$16,830.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	0	$154.00	$0.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	15	$123.00	$1,845.00
Staff	Labor	140	$108.00	$15,120.00
GIS/CAD	Labor	8	$150.00	$1,200.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	12	$68.00	$816.00
Subtotal Labor		**303**		**$43,003.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Freight/Shipping	Each	4	$250.00	$1,000.00
Field Equipment	Estimate	1	$4,480.00	$4,480.00
Subtotal Cascadia Expenses				**$5,480.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Quarterly	4	$5,340.00	$21,360.00
IDW Disposal	Each	4	$1,300.00	$5,200.00
10% markup	Misc			$2,656.00
Subtotal Outside Expenses				**$29,216.00**
Contingency (15%)				**$11,654.85**
Annual Costs				**$89,353.85**

GWM (Assumptions)
Assumes four quarters of groundwater quality monitoring utilizing existing 11 monitoring wells for 7 years.

Cascadia Associates, LLC

Alternative 5 - Groundwater Recirculation
Estimated Cash Flow and Future Costs

Interest Rate= 3%

Year	Capital	Routine O&M	Total
-	$1,589,787	$0	$1,589,787
1	$0	$465,732	$465,732
2	$0	$465,732	$465,732
3	$0	$465,732	$465,732
4	$0	$465,732	$465,732
5	$0	$465,732	$465,732
6	$0	$89,354	$89,354
7	$0	$89,354	$89,354
8	$0	$0	$0
9	$0	$0	$0
10	$0	$0	$0
11	$0	$0	$0
12	$0	$0	$0
13	$0	$0	$0
14	$0	$0	$0
15	$0	$0	$0
16	$0	$0	$0
17	$0	$0	$0
18	$0	$0	$0
19	$0	$0	$0
20	$0	$0	$0
21	$0	$0	$0
22	$0	$0	$0
23	$0	$0	$0
24	$0	$0	$0
25	$0	$0	$0
26	$0	$0	$0
27	$0	$0	$0
28	$0	$0	$0
29	$0	$0	$0
30	$0	$0	$0
Present Worth	**$1,543,482**	**$2,213,983**	**$3,757,465**
Future Costs	$1,589,787	$2,507,369	$4,097,155

Alternative 6 - Removal of All Accessible Soil; Enhanced Bioremediation (Active)
Remedial Excavation

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	80	$220.00	$17,600.00
Sr. Associate	Labor	80	$187.00	$14,960.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	80	$154.00	$12,320.00
Project	Labor	30	$142.00	$4,260.00
Sr. Staff	Labor	300	$123.00	$36,900.00
Staff	Labor	60	$108.00	$6,480.00
GIS/CAD	Labor	30	$150.00	$4,500.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	10	$68.00	$680.00
Subtotal Labor		**678**		**$98,292.00**
Cascadia Equipment	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Field Vehicle	Week	5	$480.00	$2,400.00
Mileage (30 Miles Round Trip)	Per Mile	100	$0.60	$60.00
Hand Auger	Week	4	$100.00	$400.00
PID	Week	3	$300.00	$900.00
GPS Unit	Day	3	$150.00	$450.00
4-gas Meter	Week	3	$300.00	$900.00
Subtotal Cascadia Expenses				**$5,110.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Remedial Excavation Contractor				
Mob/Demob	Per Job	1	$8,000.00	$8,000.00
Shed Demolition	Per Job	1	$15,000.00	$15,000.00
Utility/Locates - Air knife to expose piping	Per Job	1	$5,000.00	$5,000.00
Erosion and sediment control	Per Job	1	$2,500.00	$2,500.00
Sheetpile Shoring for Deep Excavation	Per LF	1,120	$22.00	$24,640.00
Excavation Dewatering and Treatment	Per Job	1	$63,547.70	$63,547.70
Excavation and direct load into trucks	CY	16,700	$13.00	$217,100.00
Biostimulant amendment during backfill	Per Pound	12,000	$3.75	$45,000.00
Freight and Taxes for PetroFix	Estimate	1	$8,000.00	$8,000.00
Import, placement, and compaction of fill	CY	16,700	$25.00	$417,500.00
Offsite Transport and Disposal of soil	Ton	25,100	$75.00	$1,882,500.00
Analytical Testing				
NWTPH-Gx	Sample	25	$55.00	$1,375.00
NWTPH-Dx	Sample	25	$70.00	$1,750.00
VOCs by EPA 8260B	Sample	10	$160.00	$1,600.00
PAH by EPA 8270 SIM	Sample	10	$160.00	$1,600.00
Taxes on Outside Expenses	Per Job	1	8.4%	$226,389.47
10% markup on Subcontracted Services	Misc			$292,150.22
Subtotal Outside Expenses				**$3,213,652.38**
Contingency (15%)				**$497,558.16**
TASK TOTAL				**$3,814,612.54**

Remedial Excavation Assumptions

Assumes the remedial excavation of approximately 9,800 tons of petroleum contaminated soil (PCS) within the MW-5 Area and 15,300 tons of PCS within the MW-6/B-18 Areas. Assumes excavation in both containment areas will extend to 22 feet bgs. Assumes remedial excavation and backfill oversight by engineer/geologist, 5-week field duration. PSC disposal at Hillsboro Landfill. Shoring and dewatering required. No permit required.

Cascadia Associates, LLC

Alternative 6 - Removal of All Accessible Soil; Enhanced Bioremediation (Active)
VRU Area Plume Stabilization

Direct Labor	Units	Hours	Rate	Total $US
Principal	Labor	40	$220.00	$8,800.00
Sr. Associate	Labor	40	$187.00	$7,480.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	40	$154.00	$6,160.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	100	$123.00	$12,300.00
Staff	Labor	0	$108.00	$0.00
GIS/CAD	Labor	5	$150.00	$750.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	0	$74.00	$0.00
Admin Assist	Labor	5	$68.00	$340.00
Subtotal Labor		**230**		**$35,830.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Regenesis Freight	Estimate	1	$4,100.00	$4,100.00
Field Equipment	Estimate	1	$2,100.00	$2,100.00
Subtotal Cascadia Expenses				**$6,200.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Biostimulant direct injections in VRU area (36 points spaced approximately 5 feet apart).				
Drilling Mob/Demob	Day	7	$250.00	$1,800.00
Drilling Injection Rig/Equipment	Day	7	$4,250.00	$30,600.00
WA Required NOI/Decon Logs by Driller	Each	36	$95.00	$3,420.00
Hand Clearing Injection Locations	Estimate	1	$7,000.00	$7,000.00
Backfill Injection Points				
VRU Area Direct Injections	Each	36	$15.00	$540.00
B-6 Area Direct Injections	Each	0	$15.00	$0.00
B-18 Area Direct Injections	Each	0	$15.00	$0.00
Drums	Each	6	$75.00	$450.00
IDW Disposal	Estimate	1	$4,000.00	$4,000.00
Biostimulant Material (Initial Injections)				
VRU Area Direct Injections	Per Pound	6,800	$4.25	$28,900.00
B-6 Area Direct Injections	Per Pound	0	$3.75	$0.00
B-18 Area Direct Injections	Per Pound	0	$3.75	$0.00
Analytical	Per Job			$0.00
Taxes on Outside Expenses	Per Job	1	8.4%	$6,443.64
10% Markup on Subcontracted Services	Misc			$8,135.36
Subtotal Outside Expenses				**$91,289.00**
Contingency (15%)				**$19,997.85**
TASK TOTAL				**$153,316.85**

VRU Direct Injections

Direct injections of biostimulant (PetroFix) at 36 locations spaced approximately 5 feet apart. Injections will be completed between 15 and 25 feet bgs. Assume that water for mixing biostimulant will be provided by the Terminal.

Cascadia Associates, LLC

Alternative 6 - Removal of All Accessible Soil; Enhanced Bioremediation (Active)
Groundwater Monitoring

Direct Labor	**Units**	**Hours**	**Rate**	**Total $US**
Principal	Labor	30	$220.00	$6,600.00
Sr. Associate	Labor	90	$187.00	$16,830.00
Associate	Labor	0	$170.00	$0.00
Sr. Project	Labor	0	$154.00	$0.00
Project	Labor	0	$142.00	$0.00
Sr. Staff	Labor	15	$123.00	$1,845.00
Staff	Labor	140	$108.00	$15,120.00
GIS/CAD	Labor	8	$150.00	$1,200.00
Tech	Labor	0	$79.00	$0.00
Drafter	Labor	0	$82.00	$0.00
Tech Editor	Labor	8	$74.00	$592.00
Admin Assist	Labor	12	$68.00	$816.00
Subtotal Labor		**303**		**$43,003.00**
Cascadia Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Freight/Shipping	Each	4	$250.00	$1,000.00
Field Equipment	Estimate	1	$4,480.00	$4,480.00
Subtotal Cascadia Expenses				**$5,480.00**
Outside Expenses	**Units**	**Quan.**	**Unit Cost**	**Total $US**
Analytical	Quarterly	4	$5,340.00	$21,360.00
IDW Disposal	Each	4	$1,300.00	$5,200.00
10% markup	Misc			$2,656.00
Subtotal Outside Expenses				**$29,216.00**
Contingency (15%)				**$11,654.85**
Annual Costs				**$89,353.85**

GWM (Assumptions)
Assumes four quarters of groundwater quality monitoring of the existing 11 monitoring wells for 5 years.

Cascadia Associates, LLC

Alternative 6 - Removal of All Accessible Soil; Enhanced Bioremediation (Active)
Estimated Cash Flow and Future Costs

Interest Rate= 3%

Year	Capital	Routine GWM	Total
-	$3,967,929	$0	$3,967,929
1	$0	$89,354	$89,354
2	$0	$89,354	$89,354
3	$0	$89,354	$89,354
4	$0	$89,354	$89,354
5	$0	$89,354	$89,354
6	$0	$0	$0
7	$0	$0	$0
8	$0	$0	$0
9	$0	$0	$0
10	$0	$0	$0
11	$0	$0	$0
12	$0	$0	$0
13	$0	$0	$0
14	$0	$0	$0
15	$0	$0	$0
16	$0	$0	$0
17	$0	$0	$0
18	$0	$0	$0
19	$0	$0	$0
20	$0	$0	$0
21	$0	$0	$0
22	$0	$0	$0
23	$0	$0	$0
24	$0	$0	$0
25	$0	$0	$0
26	$0	$0	$0
27	$0	$0	$0
28	$0	$0	$0
29	$0	$0	$0
30	$0	$0	$0
Present Worth	**$3,852,359**	**$397,296**	**$4,249,654**
Future Costs	$3,967,929	$446,769	$4,414,699

Cascadia
Associates, LLC