Denny Way/Lake Union CSO Project
Phase II Environmental Site Assessment

Prepared for
King County Department of Natural Resources

Prepared by
Black & Veatch

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Phase II Environmental Site Assessment
Denny Way/Lake Union CSO Project

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1.0 Introduction

Black & Veatch was awarded a contract with King County Department of Natural Resources (DNR) to provide design services for the Denny Way/Lake Union Combined Sewer Overflow (CSO) Project. The CSO project includes three separate design contracts. Contract A includes the Mercer Street Tunnel, Elliott West CSO Control Facility, Elliott West Outfall, and modifications to the existing Denny Way Outfall. Contract B includes the Lake Union Tunnel Regulator Station, Lake Union Tunnel CSO Pipeline, South Lake Union CSO Pipeline, Central Trunk CSO Pipeline, and the Central Trunk Diversion Structure. Contract C includes the Elliott West CSO Pipeline, the Elliott West Effluent Pipeline, and the Denny Way Diversion Structure. Figure 1 (pocket) illustrates the project corridor and distinguishes between the three contract areas.

A Phase I Environmental Site Assessment (ESA) (Black & Veatch, 1997) was conducted for the three contract areas to identify potential areas of concern and contaminants likely to be encountered during the geotechnical investigation and subsequent construction activities. The Phase I ESA included a record search of historical aerial photographs and historical Sanborn fire insurance maps; a records review of federal, state, and local environmental agency databases; a search and review of Washington State Department of Ecology (Ecology) files; a site reconnaissance; and telephone interviews.

The Phase I ESA report for the Denny Way/Lake Union CSO Project identified properties along the project corridor with documented or suspected contamination. These properties were located to determine their proximity to the CSO project. This information was then used to identify areas and contaminants of concern that would be investigated during the geotechnical investigation. The geotechnical investigation was completed in two phases. The initial phase of the investigation was performed from May through November 1997. The final phase of the geotechnical investigation was performed from March through July 1998.

Soil and groundwater samples were collected from soil borings and monitoring wells installed during the geotechnical investigations. Soil samples were also collected from test pits excavated during the geotechnical investigations. Selected soil and groundwater samples were submitted for chemical analyses. Drilling locations were determined based on the requirements for the geotechnical design, and not specifically to fulfill Phase II ESA requirements. This Phase II ESA report describes sampling locations, soil and groundwater sampling methods used, analytical results for samples collected during both the initial and final phases of the investigation, and characteristics of contaminated material expected to be encountered during construction.

Three borings were drilled in Elliott Bay near the proposed alignment of the Elliott West Outfall during the initial investigation. The results of this investigation are presented in the Denny Way/Lake Union CSO Control Project, Sediment Characterization (Striplin Environmental Associates, 1998).

1.1 Purpose

The purpose of the Phase II ESA was to identify and confirm the presence or absence of contaminated soil and groundwater to the extent feasible along the Denny Way/Lake Union CSO project corridor, so that contamination likely to be encountered could be adequately addressed during the final design. Objectives for the Phase II ESA included the following:

- Verify the presence or absence of contaminated soil and groundwater along the CSO project corridor.
- Compare the concentrations of identified contaminants to regulatory cleanup levels.
- Characterize the contaminated materials expected to be encountered during construction.

1.2 Limitations of the Assessment

This report is a limited Phase II ESA and does not provide a complete site characterization of the Denny Way/Lake Union CSO Project corridor. Soil and groundwater sampling was limited to the soil borings and monitoring wells installed as part of the geotechnical investigations for each contract area. This Phase II ESA does not delineate the vertical or horizontal extents of soil or groundwater contamination. Characterization of site geology and hydrology was not part of the Phase II ESA, but was conducted as part of the geotechnical investigation. Detailed information about the geology and hydrogeology in the area are presented in the geotechnical investigation reports prepared by Shannon & Wilson, Inc. and HWA GeoSciences, Inc (HWA).

2.0 Site Background

The project corridor location and description, Phase I ESA findings, geology and hydrogeology, and the results of the geotechnical investigations are presented in this section.

2.1 Project Corridor Location and Description

The Denny Way/Lake Union CSO Control Project includes the design of a CSO tunnel for CSO detention storage; CSO control facilities; diversion structures; piping to connect the new tunnel to the existing City of Seattle interceptors in the east Lake Union area; outfalls; and affiliated CSO outfall piping. These project design components are shown on Figure 1.

During storm events, all flows from the Lake Union Tunnel currently flow to the Denny Way Regulator Station. From the Denny Way Regulator Station, lower flows are conveyed to the Elliott Bay Interceptor while higher flows are discharged to the existing Denny Way Outfall. When the capacity of the Elliott Bay Interceptor is exceeded, additional CSO is also conveyed to the existing Denny Way Outfall. The resulting CSO discharge events occur more than 50 times per year. The Lake Union Tunnel Regulator Station will be used to divert flow from the existing Lake Union Tunnel to the new Mercer Street Tunnel during storm events. The Lake Union Tunnel CSO Pipeline will convey flows from the Lake Union Tunnel Regulator Station to the East Tunnel Portal/Drop Structure and the Mercer Street Tunnel.

The East Tunnel Portal/Drop Structure will also receive CSO through the South Lake Union CSO Pipeline. This pipeline will provide a connection between the City of Seattle Phase 2 pipeline and the Mercer Street Tunnel.

The Central Trunk CSO Pipeline will also convey CSO to the Mercer Street Tunnel. The Central Trunk CSO Pipeline and associated Central Trunk Diversion Structure provide a connection between the existing Central Trunk sewer and the new Mercer Street Tunnel to prevent CSO discharge events into Lake Union.

The Mercer Street Tunnel will extend from the East Tunnel Portal/Drop Structure at 8th Avenue North and Roy Street, under Broad Street to Mercer Street, and then under Mercer Street to the West Tunnel Portal adjacent to the Elliott West CSO Control Facility. The Elliott West CSO Control Facility will provide the treatment portion of the Denny Way/Lake Union CSO Control Project including removal of floatable material and disinfection. The Elliott West Effluent Pipeline, to be located in Myrtle Edwards Park, will connect the Elliott West CSO Control Facility with the new Elliott West Outfall.

In addition to the Lake Union Tunnel Regulator Station, the Denny Way Diversion Structure will be constructed to connect the southwestern end of the Lake Union Tunnel to the Elliott West CSO Control Facility to convey CSO exceeding the Denny Way Regulator Station's capacity. Excess flow will be diverted in the Denny Way Diversion Structure and proceed north in the Elliott West CSO Pipeline. These excess flows will also be treated in the Elliott West CSO Control Facility and discharged through the Elliott West Outfall.

2.2 Phase I ESA Findings

The Phase I ESA identified several sites along both the tunnel's and pipeline's preliminary alignments with suspected soil and groundwater contamination. Historical records for many of the potentially contaminated sites that were identified indicated that contamination may extend beyond individual site boundaries. Numerous sites were identified where the vertical and horizontal extent of contamination had not been delineated for various reasons, most often because of limitations imposed by adjacent structures and property boundaries. The historical records review conducted for the Phase I ESA did not specifically confirm or deny the presence of contamination below the shallow aquifer. The Phase I ESA provided the following conclusions:

- Total Petroleum Hydrocarbons (TPH) in soil and groundwater was the most common suspected contaminant and was suspected to be present at all identified potential sites of concern. Other contaminants of concern suspected to be present included benzene, toluene, ethylbenzene, and total xylenes (BTEX), lead, and solvent compounds.

- Groundwater is relatively shallow in the project corridor, between 2 and 10 feet bgs. Many of the potential sites identified in the Phase I ESA were likely to have contaminated soil within the saturated zone and contaminated groundwater in the shallow aquifer.

- The majority of the documented releases were a result of leaking underground storage tanks (USTs), storing predominantly gasoline, fuel oil, or waste oil.

- Contaminated soil was left in place at many of the listed sites because of excavation limitations imposed by nearby buildings, roads, and utilities.

- The east end of the project corridor (Contract B) contains the largest number of suspected contaminated sites. This can be attributed to the historically dense industrial land uses in the area.

- Elliott Avenue West, along the Elliott Bay shoreline, has historically been an industrial area. Although few contaminated sites were documented in the Ecology files, review of aerial photographs suggested a strong potential for encountering contaminated soil and groundwater related to industrial activity. This conclusion was supported by the ongoing site investigation being conducted by the U.S. Environmental Protection Agency (EPA) at the Block 160 site.

On the basis of the information gathered for the Phase I ESA, it is likely that excavation activities above the shallow aquifer have a higher probability of encountering contaminated soils than the tunneling activities at greater depths. Areas at the east end of the project corridor near Lake Union and along Elliott Avenue West at the west end of the project corridor contain sites with suspected groundwater contamination that may extend beyond property boundaries. Most of the sites identified during the Phase I ESA are located within Contract A and B areas.

The Phase I ESA identified areas with potential soil and groundwater contamination which may impact construction of the Denny Way/Lake Union CSO project. Some of these areas were further investigated through sampling and analysis of soil and groundwater during the geotechnical investigation. Sampling activities are discussed in detail in Section 3.0.

2.3 Geology and Hydrogeology

The geology and hydrogeology of the region and project area are presented in the following sections.

2.3.1 Regional Geology

Seattle is located in the central portion of the Puget Sound Lowland, an elongated topographic and structural depression bordered by the Cascade Mountains on the east and the Olympic Mountains on the west. The Lowland is characterized by low-rolling relief with some deeply cut ravines. In general, the ground elevation is within 500 feet of sea level.

The Puget Sound Lowland was filled to significant depths by glacial and non-glacial sediments during the Pleistocene Epoch; however, bedrock outcrops are scattered throughout the area. Within the City of Seattle, bedrock outcrops are found south of an east-west line extending

from Bremerton to the middle of Mercer Island. This line of outcrops has been labeled the Seattle-Bremerton Fault, thought to be active within the last 1,000 years. Bedrock outcrops are present in only a few locations in the Seattle area: at Alki Point in West Seattle; the Duwamish Valley near Boeing Field; in the southern portion of Rainier Valley; and at Seward Park in southeastern Seattle. Elsewhere the rock is deeply buried by Pleistocene and Recent sediments. Based on results of borings and seismic profiling, the depth to bedrock in downtown Seattle is believed to be more than 3,000 feet.

Geologists generally agree that the Puget Sound area was subject to four major glaciations during the Pleistocene Epoch. Ice for these glacial events originated in the coastal mountains and the Vancouver Range of British Columbia. The maximum southward advance of the ice was about halfway between Olympia and Centralia. Ice thickness in the Seattle area may have exceeded one mile.

The Pleistocene stratigraphic record in the central portion of the Puget Lowland is a complex sequence of glacially derived and interglacial sediments. Erosion of certain deposits and local deposition of sediments further complicate the geologic setting.

2.3.2 Site Geology

Table 1, located at the end of this section, presents a stratigraphic outline for Seattle's late Pleistocene and recent geologic history, beginning with the most recent deposits (youngest at the top and oldest at the bottom).

The oldest geologic unit encountered in the exploration programs was Pre-Vashon glacial outwash and/or recessional soils deposited as the glacial ice retreated northward and eastward out of the Puget Sound Lowland.

Subsequently, as glacial ice moved back into the Puget Sound region, glaciolacustrine clays and silts were deposited in a lake formed by the blockage of the Strait of Juan de Fuca. In some locations, these clays and silts were rhythmically laminated, representative of annual seasonal variations in ice melting and depositional rates. In other locations, the clays are massively deposited. Isolated lenses and layers of fine sand are fairly common. Near the glacial terminus, the ice may have been floating and, as it melted, it dropped coarse debris such as gravel, cobbles, and boulders into the clays and silts on the lake bottom. Icebergs floating in the lake dropped their debris load, and streams flowing out from the glacier carried granular material into the lake basin. Subsequent glacial overriding consolidated these clays and silts into a hard, brittle material. Stress relief, associated with subsequent ice retreat and unloading, resulted in

fracturing and fissuring, which significantly reduces the mass strength of these otherwise hard materials.

As the ice continued to advance, the sediments became coarser. Sediments classified as glaciomarine drift were deposited by several processes including streams flowing out of the terminus of the glacier, dropping large quantities of iceberg-rafted sediments, and gravity flows at the outward edges of deltas into the lacustrine environment. Because of the multiple modes of deposition, this type of deposit is highly variable laterally as well as vertically. In general, the material is a mixture of coarser grained particles in a finer-grained matrix. In some areas, the glaciomarine drift resembles lodgment till. In the project area, these soils were subsequently overridden by glacial ice and may be virtually indistinguishable from lodgment till in both appearance and engineering properties.

Because of the waxing and waning of the glacial ice front and grounding and floating of the ice, glaciomarine drift and glaciolacustrine sediments are commonly interfingered. Both types of deposition occurred simultaneously in adjacent portions of the basin.

Advance of the ice closer to what is now Seattle resulted in the deposition of outwash sands and gravels in alluvial fan deposits and braided streambeds on the valley floor in front of the advancing grounded ice. The ice then retreated to the north and more glaciomarine and glaciolacustrine sediments were deposited.

The glacial ice retreated northward again, leaving a large lake in which a thick sequence of lacustrine silts and clays developed. Eventually the ice moved southward again for the last time.

In the 12,000 years since the last glacial episode, sediment has accumulated in low areas such as the Elliott Bay, the Lake Union area, and local lakes and swamps. In Elliott Bay, sands deposited by the Duwamish River and creeks from surrounding hills were interbedded with clays and silt during overbank floods. The clays were deposited in Elliott Bay and peat accumulated in swampy areas. The most recent sediments consist of fine sand, silt, and clay that were deposited in mudflats and near-shore environments, as evidenced by the numerous shell fragments they contain. Slope failures along the shoreline that is now Elliott Avenue left slope debris at the toe of the slope.

Within the last 100 years, extensive regrading has considerably altered the topography throughout the Seattle area. Substantial amounts of fill have been used to move the shoreline westward from the base of the bluff along the uphill side of Elliott Avenue. The railroad has moved westward on a series of timber trestles, remnants of which may still exist within the fill.

2.3.3 Site Hydrogeology

Groundwater in the area is encountered between 2 feet and 10 feet below ground surface (bgs) depending on proximity to Elliott Bay or Lake Union. Seasonal fluctuations in groundwater elevation have been observed during previous investigations in the project area. Tidal influence appears to be minimal; an investigation of a site located between Elliott Avenue West and the Burlington Northern railroad tracks found little or no tidal influence in onsite monitoring wells. Groundwater in the western portion of the project area flows west towards Elliott Bay. Groundwater in the eastern portion of the project area flows east towards Lake Union (RZA 1994).

Lake Union and Elliott Bay are the only surface water bodies within the project corridor. The project corridor is densely developed with a majority of the land area covered by structures or paved surfaces; therefore, surface water infiltration is minimal. Surface water runoff is collected through the city storm sewer system.

A detailed description of the local geology and hydrogeology is provided in the geotechnical reports and memoranda prepared by Shannon & Wilson and HWA and briefly discussed in the following section.

2.4 Geotechnical Investigations

Separate geotechnical investigations were performed for the Contract A, B, and C areas. The scope and results of each investigation are discussed in the following subsections. Table 2 presents a list of the geotechnical reports prepared for each of the contract areas, the geotechnical subcontractor, and the date the report was prepared. The results of the geotechnical investigations that are relevant to this Phase II ESA are summarized in the following subsections.

2.4.1 Geotechnical Investigation – Contract A

The initial phase of the geotechnical investigation for the Contract A area was performed by Shannon & Wilson, Inc., under subcontract to Black & Veatch. The final phase of the geotechnical investigation was preformed by HWA. The scope of the geotechnical investigation for Contract A included field investigation and field and laboratory testing to determine subsurface conditions along the proposed Mercer Street Tunnel alignment, at the Elliott West CSO Control Facility, and the Elliott West Outfall. Soil borings were drilled, cone penetration tests were conducted, and monitoring wells were installed during the two investigation phases. In addition, three pumping wells and two observation wells were installed along the tunnel alignment. Boring and well construction logs are presented in Appendix A. A geotechnical

report and three memoranda were prepared to present geotechnical design recommendations and the results of the investigations and testing (Table 2). Detailed information regarding the geotechnical investigation activities, geology and hydrogeology is presented in these reports. A summary of the information from the geotechnical investigation report and memoranda, relevant to Phase II ESA activities, is presented in the following subsections.

2.4.1.1 Mercer Street Tunnel Alignment. Geotechnical investigation activities were performed along the Mercer Street Tunnel alignment to obtain subsurface information for the construction of the tunnel and its east and west portals. During the initial investigations, thirteen soil borings (TB-1 through TB-9, TB-11, TB-12, MB-1, and MB-2) were drilled along the proposed tunnel alignment (Figure 1). In October 1997, the decision was made to move the tunnel alignment east of 3rd Avenue North from Roy Street to Mercer Street. Therefore, soil borings TB-9 and TB-11 were not drilled along the current proposed tunnel alignment. During the final investigation, six additional soil borings (TB-13 through TB-18) were drilled along the current proposed tunnel alignment. Monitoring wells were installed in all nineteen borings drilled during the geotechnical investigation activities. In addition, two pumping wells and two observation wells were installed along the tunnel alignment and one pumping well was installed at the east portal. Boring and well construction logs are presented in Appendix A. Table 3 presents a summary of the soil borings drilled, and monitoring wells, pumping wells and observation wells installed during the initial and final geotechnical investigations.

Along the western portion of the tunnel alignment and at the West Tunnel Portal (TB-1, TB-2 and TB-13), fill material was observed underlain (in descending order) by beach deposits, lagoon/marsh deposits, landslide debris, and various glacial deposits. Fill material underlain by various glacial deposits was also identified along the eastern portion of the tunnel alignment and at the East Tunnel Portal/Drop Structure. The Mercer Street Tunnel will be constructed within deep water-bearing glacial deposits under confined conditions. The western portion of the tunnel will be constructed through silty and clayey glaciolacustine deposits. The central portion of the tunnel will be constructed through sand and gravel glaciomarine drift and glacial outwash deposits. The east end of the tunnel will be constructed through the dense sand and gravel glacial till.

Monitoring wells TB-4 through TB-9, TB-12 through TB-18, MB-1, and MB-2 were installed within the confined aquifer in glaciomarine drift and glacial outwash deposits. Monitoring wells TB-1 through TB-3, and TB-11 were installed in the shallower unconfined groundwater aquifers.

2.4.1.2 Elliott West CSO Control Facility. Geotechnical investigation activities at the proposed Elliott West CSO Control Facility were performed to obtain subsurface information for the construction of the control facility structures, effluent and drain pipes, and a retaining wall. Four soil borings were drilled (CB-1 through CB-4) and six cone penetration tests (CP-1 through CP-3, and CSP-1 through CSP-3) were performed in and around the proposed footprint of the control facility structures during the initial geotechnical investigation (Figure 1). Two additional borings (CB-5 and CB-7) were drilled and two additional cone penetrations tests (CP-4 and CP-5) were performed during the final geotechnical investigation. Monitoring wells were installed in the six borings drilled at the proposed control facility location. Two wells (upper and lower aquifers) were installed in boring CB-7. Boring and well construction logs are presented in Appendix A. Table 3 presents a summary of the soil borings drilled, cone penetration tests performed, and monitoring wells installed during both phases of the investigation.

Fill material underlain in descending order by lagoon/marsh deposits, beach deposits, and various glacial deposits was identified at the proposed control facility location. The Elliott West CSO Control Facility foundation will be constructed in the dense sand and gravel glaciomarine drift.

Monitoring wells CB-2, CB-3 and CB-7A are screened within the water table aquifer in fill and beach deposits which are present from approximately 0 to 25 feet below ground surface at the Elliott West CSO Control Facility location. Groundwater in the fill material, beach deposits, and deeper glacial units discharge to Elliott Bay. The confined aquifer is present in glaciomarine drift and glacial outwash deposits, which is approximately 50 feet below ground surface at the location of the proposed Elliott West CSO Control Facility. Wells CB-1, CB-4, CB-5 and CB-7B monitor groundwater within the confined aquifer. Groundwater elevations indicate an upward vertical gradient, and limited tidal influence in this aquifer.

2.4.1.3 Elliott West Outfall. Geotechnical investigation activities at the Elliott West Outfall location were performed to obtain subsurface information for the design of the outfall. Four soil borings, designated OB-1 through OB-4 were drilled and sampled during the preliminary investigation (Figure 1). One of these borings was drilled on land (OB-1) and three were drilled over water in Elliott Bay (OB-2 through OB-4) at the proposed outfall location. One monitoring well was installed at OB-1. Boring logs and well construction logs for OB-1 are presented in Appendix A. Borings OB-2, OB-3, and OB-4 were drilled in Elliott Bay, but no environmental samples were collected from these boreholes because a separate sediment characterization was

being performed to analyze the contamination that may be present in the sediment. The results of the Sediment Characterization are discussed in a separate report (Striplin Environmental Associates, 1998). No additional borings were drilled during the final geotechnical investigation. Table 3 presents a summary of the soil borings drilled and monitoring wells installed during the investigation.

Fill material, underlain in descending order by lagoon/marsh deposits, beach deposits, and various glacial deposits, was identified in borings OB-1 through OB-4, with the exception of OB-3, in which lagoon/marsh deposits were not identified. Groundwater discharges to Elliott Bay, with fluctuations in the water table less than five feet seasonally at the outfall location. The Outfall Transition Structure will be constructed within a pervious water table aquifer and above a confined aquifer with a shallow piezometric surface. The Outfall Transition Structure is located midway between borings OB-1 and OB-2. Well OB-1 is screened from 21 to 31 feet below ground surface (bgs), and monitors groundwater within the unconfined aquifer contained in fill and beach deposits. The water table was measured at approximately 8 feet bgs with a vibrating wire piezometer in this well. The fill and beach deposits are present from approximately 0 to 40 feet bgs for boring OB-1, from 0 to 30 feet bgs for OB-2 and OB-4, and from 0 to 16 feet bgs for boring OB-3. The confined aquifer is present in glaciomarine drift and glacial outwash deposits, which are below the fill and beach deposits. In OB-1, the top of the confined aquifer was found to be present at a depth of 70 feet bgs. In OB-2 through OB-4, the top of this aquifer was present at approximately 30 feet bgs. Water tables were not measured in borings OB-2 through OB-4, and no monitoring wells were installed in these borings.

2.4.2 Geotechnical Investigation – Contract B

The geotechnical investigation for the Contract B area was performed by HWA, under subcontract to Black & Veatch. The scope of the geotechnical investigation for Contract B included field investigation and field and laboratory testing to determine subsurface conditions along the Central Trunk CSO Pipeline, Lake Union Tunnel CSO Pipeline, and the South Lake Union CSO Pipeline; and at the East Tunnel Portal/Drop Structure, Central Trunk Diversion Structure, and the Lake Union Tunnel Regulator Station. Nine soil borings (BB-1 through BB-8 and BB-10) were drilled during the preliminary investigation. Five additional borings (BB-9 and B-11 through BB-14) were drilled during the final geotechnical investigation. Monitoring wells were installed in each boring during the investigation. In addition, one pumping well (PW-1) and one observation well (OW-1) were installed at the proposed Valley Street Connection Manhole during the final geotechnical investigation. Boring and well construction logs are

presented in Appendix A. Detailed information regarding the geotechnical investigation activities, geology and hydrogeology is presented in the Geotechnical Data Report (HWA GeoSciences, 1998a). A summary of the information from the geotechnical investigation report, relevant to Phase II activities, is presented in this subsection. Table 4 presents a summary of the soil borings drilled and monitoring wells installed during both phases of the geotechnical investigation.

The geology of the Contract B areas is variable. Fill material underlain by glacial outwash deposits and glaciomarine drift was identified along the South Lake Union CSO Pipeline alignment. The proposed South Lake Union CSO Pipeline construction method is to use an earth pressure balance tunnel boring machine. The pipeline will be installed through the glaciomarine drift in the eastern portion of the pipeline and at the East Tunnel Portal/Drop Structure, through outwash/alluvium deposits near the center of the pipeline, and through fill material in the western portion of the pipeline. The geology at the Lake Union Tunnel Regulator Station and along the southern portion of the Lake Union Tunnel CSO Pipeline alignment consists of a relatively thin fill material unit underlain, in descending order, by glaciomarine drift deposits, outwash/alluvium deposits, glaciolacustrine deposits, lacustrine deposits, and outwash deposits. The southern portion of the pipeline will be constructed through glaciolacustrine deposits, while the northern portion of the pipeline will be constructed through glaciomarine drift. The Lake Union Tunnel Regulator Station will be constructed through glaciomarine drift and glaciolacustrine deposits. At the Central Trunk Diversion Structure and along the Central Trunk CSO Pipeline alignment, the geology consists primarily of glaciomarine drift deposits, with fill material present along the eastern portion of the alignment and at the East Tunnel Portal/Drop Structure. The Central Trunk Diversion Structure and the Central Trunk CSO Pipeline will be constructed primarily within glaciomarine drift. Wells BB-1 and BB-11 monitor the aquifer within the glaciolacustrine and outwash/alluvium deposits. Wells BB-2, BB-4, BB-5, BB-8, BB-9 and BB-10 monitor the groundwater aquifer within the glaciomarine drift and outwash/alluvium deposits. Wells BB-3, BB-6, BB-7, BB-12 and BB-13 monitor the groundwater aquifer within the fill material and outwash/alluvium. The primary aquifer within the Contract B area is the outwash/alluvium deposit. The glaciolacustrine and glaciomarine drift deposits may act as aquitards in the area.

Excavation to approximately 50 feet below ground surface will be required during the construction of the East Tunnel Portal/Drop Structure. Minor dewatering of the upper aquifer may be required. Excavation will also be required to construct the Central Trunk Diversion Structure. The excavation will be less than 26 feet and possible dewatering may be required.

Excavation for the Lake Union Tunnel Regulator Station will extend to approximately 60 feet below ground surface. Dewatering will be required for construction of this structure.

A jacking and receiving pit will be constructed at Valley Street and Terry Avenue. The jacking pit will be constructed to 30 feet below ground surface and dewatering will be required for this structure.

An open-cut trench will be excavated for installation of the Central Trunk CSO Pipeline to a depth of 15 to 20 feet below ground surface. Dewatering would be required to minimize the locally high flow that may occur as a result of encountering the more permeable outwash/alluvium.

2.4.3 Geotechnical Investigation – Contract C

The geotechnical investigation for the Contract C area was performed by HWA, under subcontract to Black & Veatch. The scope of the geotechnical investigation for Contract C included field investigation, and field and laboratory testing to determine subsurface conditions along the proposed Elliott West CSO Pipeline and Elliott West Effluent Pipeline alignment, at the Denny Way Diversion Structure, and the Elliott Bay Interceptor (EBI) Control Structure. Test pits were excavated, soil borings were drilled, and monitoring and pumping wells were installed during the investigation. Test pit, boring, and well construction logs are presented in Appendix A. Detailed information regarding the geotechnical investigation activities, geology and hydrogeology is presented in the Geotechnical Data Report (HWA GeoSciences, 1998b). A summary of the information from the Contract C geotechnical investigation report, relevant to the Phase II ESA activities, is presented in this subsection.

Before selection of the final pipeline alignment, 15 test pits (TP-1 through TP-15) were excavated along the proposed pipeline routes. The final pipeline alignment was selected using information obtained from the test pits. Following selection of the pipeline alignment, 7 borings (CC-1 through CC-7) were drilled along the pipeline alignment during the preliminary geotechnical investigation. Six borings (CC-8 through CC-13) were drilled during the final investigation. Monitoring wells were installed in all 13 borings. Two monitoring wells, one in the upper aquifer and one in the lower aquifer, were installed in boring CC-3. One pumping well (PW-5) was installed during the final investigation. Boring and well construction logs are presented in Appendix A. Table 5 presents a summary of the soil borings drilled and the monitoring wells installed during both phases of the geotechnical investigation.

Fill material underlain, in descending order, by beach deposits, lagoon/marsh deposits, and various glacial deposits was identified along the pipeline alignment, at the Denny Way

Diversion Structure, and at the EBI Control Structure. The pipelines will be constructed primarily within water-bearing fill material under unconfined conditions. Wells CC-1, CC-2, CC-4, and CC-5 monitor groundwater within the fill material and wells CC-3, CC-6, CC-10, CC-12 and CC-13 monitor groundwater in both the fill material and beach deposits. Well CC-7 monitors groundwater within the fill material, beach deposits, and the glaciolacustrine unit and well CC-9 monitors groundwater within the glaciolacustrine and outwash units. Wells CC-8 and CC-11 are screened in the groundwater aquifer within the glaciomarine drift deposits.

The Elliott West CSO Pipeline and the Elliott West Effluent Pipeline will be placed in one 20-foot wide, 20 to 30 foot deep trench. Overexcavation up to 4 feet may be required in some areas to remove unsuitable subgrade soils. Temporary construction dewatering will be required along the entire alignment.

Three pipelines will be installed under the railroad tracks near the Elliott West CSO Control Facility to connect the control structure to the Elliott West CSO Pipeline and Elliott West Effluent Pipeline.

The EBI Control Structure will have an approximate 20 by 40-foot footprint and will be constructed at a minimum depth of 33 feet. Dewatering will be required in this area.

Two drop structures will be constructed between the pipelines extending from the Elliott West CSO Control Facility and the Elliott West CSO and Effluent pipelines. Excavation and dewatering will be required during construction.

The Denny Way Diversion Structure is a 19 by 40-foot structure with a foundation 10 feet below grade. Dewatering will be required during construction of this structure.

Table 1
Geological History

Period	Event
Post - Vashon (interglacial)	• Fill • Recent beach, alluvially reworked, landslide debris, and lacustrine sediments
Vashon (glacial)	• Glaciomarine drift • Glaciomarine deposits • Advance and/or recessional outwash
Olympia (interglacial)	• Not identified in project area
Pre-Vashon (glacial)	• Advance and/or recessional outwash

Table 2
Geotechnical Investigation Reports

Title	Prepared By	Date
Contract A		
Geotechnical Data Report, Mercer Street Tunneland Elliott West CSO Facility, Denny Way/Lake Union CSO Project	Shannon & Wilson, Inc.	Expected October 1998
Geotechnical Data Report, Elliott West Outfall, Denny Way/Lake Union CSO Project	Shannon & Wilson, Inc.	Expected October 1998
Contract B		
Geotechnical Data Report, Denny Way/Lake Union CSO, Contract B	Hong West & Associates, Inc.	Expected October 1998
Contract C		
Geotechnical Data Report Denny Way/Lake Union CSO Contract C	Hong West & Associates, Inc.	Expected October 1998

Table 3

Geotechnical Investigation Summary for Contract Area A

Location	Purpose	Well Screen Interval (feet bgs)	Total Depth (feet bgs)
Mercer Street Tunnel Alignment			
TB-1	Tunnel Alignment	12-22	69.3
TB-2	Tunnel Alignment	40-50	96.5
TB-3	Tunnel Alignment	105-115	161.5
TB-4	Tunnel Alignment	133-143	170
TB-5	Tunnel Alignment	167-177	200.5
TB-6	Tunnel Alignment	153-163	189.5
TB-7	Tunnel Alignment	146-156	160.4
TB-8	Previous Tunnel Alignment	130-150	158.2
TB-9	Previous Tunnel Alignment	115-125	148.8
TB-11	Previous Tunnel Alignment	70-90	122.8
TB-12	Tunnel Alignment	110-120	120.8
TB-13	Tunnel Alignment	55-80	80.5
TB-14	Tunnel Alignment	150-200	200.5
TB-15	Tunnel Alignment	130-160	205.5
TB-16	Tunnel Alignment	85-165	171
TB-17	Tunnel Alignment	77-117	120.5
TB-18	Tunnel Alignment/East Portal	93-118	120.5
MB-1	Tunnel Alignment	115-135	160.5
MB-2	Tunnel Alignment	108-128	130.5
OW-2	Pump Test	153-224	241
OW-3	Pump Test	80-210	220
PW-2	Pump Test	155-219	219
PW-3	Pump Test	80-170	180
PW-4	Pump Test	45.5-50.5	56.5
Elliott West CSO Control Facility			
CB-1	Tunnel Alignment/CSO Control Facility	50-60	81
CB-2	CSO Control Facility	8-18	51.5
CB-3	CSO Control Facility	10-20	5.4
CB-4	CSO Control Facility	80-90	100.6
CB-5	CSO Control Facility	85-90	90.5
CB-7A	CSO Control Facility	24-44	90.5
CB-7B	CSO Control Facility	68-88	90.5

Table 3 (cont'd)

Geotechnical Investigation Summary for Contract Area A

Location	Purpose	Well Screen Interval (feet bgs)	Total Depth (feet bgs)
Elliott West CSO Control Facility (cont'd)			
CP-1 [1]	CSO Control Facility	not applicable	30
CP-2 [1]	CSO Control Facility	not applicable	48
CP-3 [1]	CSO Control Facility	not applicable	48
CP-4 [1]	CSO Control Facility	not applicable	40
CP-5 [1]	CSO Control Facility	not applicable	40
CSP-1 [1]	CSO Control Facility	not applicable	46.5
CSP-2 [1]	CSO Control Facility	not applicable	48.4
CSP-3 [1]	CSO Control Facility	not applicable	47.5
Elliott West Outfall			
OB-1	Outfall - onshore boring	21-31	80
OB-2 [2]	Outfall - overwater boring	not applicable	40
OB-3 [2]	Outfall - overwater boring	not applicable	41.8
OB-4 [2]	Outfall - overwater boring	not applicable	51.3

bgs - below ground surface

[1] Cone penetrometer borings. No soil samples were collected or monitoring wells installed.

[2] Overwater borings drilled during the initial phase are reported in a separate document (Shannon & Wilson 1998).

Table 4

Geotechnical Investigation Summary for Contract Area B

Location	Purpose	Well Screen Interval (feet bgs)	Total Depth (feet bgs)
BB-1	Lake Union Tunnel Regulator Station/Lake Union CSO Pipeline Alignment	52.5-62.5	66.5
BB-2	Lake Union CSO Pipeline Alignment	25-40	78
BB-3	Previous Lake Union CSO Pipeline Alignment	20-35	71
BB-4	Lake Union CSO Pipeline Alignment	30-40	78
BB-5	Lake Union CSO Pipeline Alignment	30-40	78
BB-6	South Lake Union CSO Pipeline Alignment	30-40	64
BB-7	South Lake Union CSO Pipeline Alignment	25-35	74
BB-8	South Lake Union CSO Pipeline Alignment/East Tunnel Portal/Drop Structure	30-40	78.5
BB-9	Lake Union Tunnel Regulator Station	56-80	80.5
BB-10	Central Trunk Diversion Structure	29-39	60.5
BB-11	Lake Union Tunnel Regulator Station	75-85	86
BB-12	South Lake Union CSO Pipeline Alignment	35-45	66.5
BB-13	South Lake Union CSO Pipeline Alignment	35-45	71.5
BB-14	South Lake Union CSO Pipeline Alignment	40-50	71.5
OW-1	South Lake Union CSO Pump Test	20-25	25
PW-1	South Lake Union CSO Pump Test	40-60	61.5
bgs – below ground surface			

Table 5
Geotechnical Investigation Summary for Contract Area C

Location	Purpose	Well Screen Interval (feet bgs)	Total Depth (feet bgs)
Monitoring Wells			
CC-1	Elliott West CSO Pipeline/Denny Way Diversion Structure	30 - 40	53
CC-2	Elliott West CSO Pipeline Alignment	20 - 30	31.5
CC-3A	Elliott West CSO Pipeline Alignment	15 - 20	53
CC-3B	Elliott West CSO Pipeline Alignment	40 - 50	53
CC-4	Elliott West CSO Pipeline Alignment	15 - 20	58.5
CC-5	Elliott West CSO Pipeline Alignment	20 - 30	53
CC-6	Elliott West CSO Pipeline Alignment	30 - 40	63
CC-7	Elliott West CSO Pipeline/Elliott Bay	25 - 35	64
CC-8	Elliott West CSO Pipeline Alignment	70 - 80	86.5
CC-9	Elliott West CSO Pipeline Alignment	50 - 60	80.5
CC-10	Elliott West CSO Pipeline Alignment	30 - 40	80
CC-11	Elliott West CSO Pipeline Alignment	60 - 70	81
CC-12	EBI Control Structure	32 - 42	61
CC-13	Elliott West CSO Pipeline Alignment	20 - 25	81
PW-5	Pump Test	22-39	42
Test Pits			
TP-1	Confirm GPR* findings/evaluate alternatives	not applicable	9
TP-2	Confirm GPR findings/evaluate alternatives	not applicable	11.5
TP-3	Confirm GPR findings/evaluate alternatives	not applicable	15
TP-4	Confirm GPR findings/evaluate alternatives	not applicable	11
TP-5	Confirm GPR findings/evaluate alternatives	not applicable	8
TP-6	Confirm GPR findings/evaluate alternatives	not applicable	9.5
TP-7	Confirm GPR findings/evaluate alternatives	not applicable	11
TP-8	Confirm GPR findings/evaluate alternatives	not applicable	9
TP-9	Confirm GPR findings/evaluate alternatives	not applicable	7
TP-10	Confirm GPR findings/evaluate alternatives	not applicable	10
TP-11	Confirm GPR findings/evaluate alternatives	not applicable	8.5

* Ground Penetrating Radar

Table 5 (cont'd)
Geotechnical Investigation Summary for Contract Area C

Location	Purpose	Well Screen Interval (feet bgs)	Total Depth (feet bgs)
Test Pits (cont'd)			
TP-12	Confirm GPR findings/evaluate alternatives	13.5	not applicable
TP-13	Confirm GPR findings/evaluate alternatives	15	not applicable
TP-14	Confirm GPR findings/evaluate alternatives	13.5	not applicable
TP-15	Confirm GPR findings/evaluate alternatives	12.5	not applicable
bgs - below ground surface			

3.0 Field Investigation

Field investigation activities for the Phase II ESA were performed from May through November 1997 (initial investigation) and from March through July 1998 (final investigation). All field activities reported in this Phase II ESA report were conducted in conjunction with the geotechnical investigations.

3.1 Investigation Locations

The locations of soil borings, monitoring wells, test pits, and other investigation activities performed during the Phase II ESA were selected based on the requirements of the geotechnical investigations. Monitoring wells, soil borings and test pits were located within the areas of proposed construction and tunneling activities (Figure 1).

The initial investigation for Contract A area consisted of drilling 13 soil borings along the Mercer Street Tunnel alignment, four borings at the Elliott West CSO Control Facility location, and four borings at the Elliott West Outfall location (Figure 1). Three of the borings drilled at the outfall were located offshore and one boring was drilled onshore in Myrtle Edwards Park. The final investigation for Contract A consisted of drilling six soil borings along the tunnel alignment and two borings at the Elliott West CSO Control Facility location. All of the borings were completed as monitoring wells, except for the offshore borings (OB-2, OB-3, and OB-4) associated with the Outfall. Two pumping wells and two observation wells were installed along the tunnel alignment and one pumping well was installed at the East Tunnel Portal/Drop Structure during the final phase of the geotechnical investigation.

The initial investigation for Contract B consisted of drilling nine soil borings along the Lake Union and South Lake Union CSO Pipelines and near the Lake Union Tunnel Regulator Station and Central Trunk Diversion Structure. Five additional borings were drilled during the final investigation. All borings were completed as monitoring wells. Also during the final phase of the geotechnical investigation, one pumping well and one observation well were installed at the Valley Street Connection Manhole (Figure 1).

Contract C initial investigation activities consisted of drilling seven soil borings and excavating 15 test pits along the Elliott Bay Interceptor and Elliott West CSO Pipeline alignment. Six additional soil borings were drilled during the final phase of the geotechnical investigation. All borings were completed as monitoring wells. One pumping well was also installed near the area of the microtunnel receiving pits in the Contract C area during the final geotechnical investigation.

Investigation locations were surveyed by White Shield, Inc. Coordinates and elevations were relative to either the Metro datum or the mean lowest low water (MLLW) datum.

3.2 Sample Collection

Drilling and well installation activities for Contract Areas A, B and C were conducted by Hokkaido Drilling & Developing Corp., Tacoma Pump and Drill, Pitcher Drilling Company, and Cherokee Drilling using both auger and mud rotary drilling methods. Test pit excavation activities were conducted by Northwest Excavation and Trucking. Shannon & Wilson supervised all investigation operations for the initial phase of Contract A and HWA provided oversight for Contracts B and C and for the final phase of Contract A.

A sampling and analysis plan (SAP) was prepared by Black & Veatch to coordinate Phase II ESA sampling requirements with the geotechnical investigation. The SAP described sample locations, sampling frequency, and chemical analyses required for soil and groundwater samples. Specific procedures for sample collection, equipment decontamination, sample packaging and shipment, and sampling documentation were not presented in the SAP. Instead, these procedures were the responsibility of the subconsultant conducting the geotechnical investigation who was required to use standard procedures conforming to Ecology and EPA criteria when collecting samples for chemical analysis. A well development form was completed for each well documenting the quantity of water removed and field parameter measurements during well development.

Monitoring wells were developed to remove sediment and drilling fluid from the casing and to improve the hydraulic connection between the well and the aquifer. Monitoring wells were developed a minimum of 24 hours after well construction and before groundwater samples were collected. Shannon & Wilson conducted the well development for monitoring wells installed in Contract Area A during the initial phase and HWA developed wells for Contract B and C as well as all contracts during the final investigation phase.

3.2.1 Soil Samples

Soil samples for chemical analyses were collected during test pit excavation or while drilling soil borings for the geotechnical investigation. The boring and test pit locations were selected based on the requirements for the geotechnical investigation. Before field investigation activities began, Black & Veatch personnel compared the proposed investigation locations to the sites identified during the Phase I ESA as potentially contaminated. Soil samples were collected at

boring or test pit locations where excavation or tunneling activities would most likely occur based on pre-design documents. A photo-ionization detector (PID) was used during drilling activities to screen drilling cuttings and geotechnical samples for the presence of volatile organic compounds (VOCs). Criteria for obtaining samples for chemical analysis were as follows:

- Collect a sample where contamination was suspected by PID readings above background.
- Collect a sample where contamination was suspected based on odor or visual observation.
- Collect a sample at or near the water table of the first aquifer encountered and at the top of any subsequent underlying aquifers.
- Collect at least one soil sample within the anticipated tunnel depth.
- Collect samples at 5-foot intervals in the first 30 feet at boring locations being used to evaluate structures.

Soil sampling depths at each soil boring or test pit were determined by the Shannon & Wilson or HWA geologist supervising drilling or excavation activities during the geotechnical investigation. A soil sampling checklist was completed by the geologist. Soil samples from borings were collected using a split-spoon-sampler, thin-walled sampler, or pitcher sampler. Samples from test pits were collected from either the test pit side wall or excavator bucket. Each soil sample was first screened with a PID for VOCs. Soil samples were then placed directly into sample containers. The sample containers were placed in a cooler with ice and shipped for delivery within 24 hours to OnSite Environmental, Inc. A copy of the chain-of-custody and the soil sampling checklist was faxed to Black & Veatch at the end of each work day. The laboratory was instructed to hold all soil samples until notified by Black & Veatch to proceed with analysis. Samples for chemical analysis were selected by Black & Veatch after a review of PID field screening results, the soil sampling checklist, and the field log identifying depth to water and geological units. Samples not initially selected for analyses were archived by the laboratory until further notice from Black & Veatch. Criteria for selecting a soil sample for chemical analysis included the following:

- At least one soil sample was submitted from each boring.
- A soil sample was submitted from the interval with the highest PID readings.
- A soil sample was submitted from immediately above the water table.
- A soil sample was submitted from within the Mercer Street Tunnel interval.

Soil samples selected for chemical analysis were analyzed for total petroleum hydrocarbons (TPH) using the Washington State Total Petroleum Hydrocarbon Identification (WTPH-HCID) method for screening purposes. Additional analyses were performed on selected samples based on findings from the Phase I ESA and results from the WTPH-HCID screening analysis. Additional analyses included methods: WTPH-D extended (WTPH-Dx) for diesel and heavy oil range TPH; WTPH-G for gasoline petroleum range; EPA SW-846 Method 8020 for benzene, toluene, ethylbenzene and xylenes (BTEX); EPA SW-846 Method 8270 for semivolatile organic compounds (SVOCs) and polycyclic aromatic hydrocarbons (PAHs); EPA SW-846 Method 8260 for VOCs; and EPA SW-846 Method 6010 for lead. Tables 6 through 10 lists soil samples submitted for analysis for Contracts A, B, and C. Analytical results are presented in Section 4.0.

Contract Area A A total of 30 soil samples from the tunnel alignment (Table 6), including the composite samples from wells OW-2, PW-3 and PW-4, six samples from the Elliott West CSO Control Facility site (Table 7), and three samples from the Elliott West Outfall area (Table 8) were collected and submitted for chemical analyses. Samples were not collected from wells OW-3 or PW-2 due to their proximity to PW-3 and OW-2, respectively. At least one sample was submitted from each boring. Selected sediment samples collected from OB-2 through OB-4 were analyzed for Puget Sound sediment parameters and the analytical results are reported separately (Striplin Environmental Associates, 1998).

Contract Area B A total of 24 soil samples were collected from the soil borings located in the Contract B area and submitted for analytical testing. At least one sample from each boring was selected for chemical analysis. In addition, one composite sample was collected from pumping well PW-1 and submitted for chemical analysis. Samples were not submitted for well OW-1 due to its proximity to PW-1.

Contract Area C Twenty-seven soil samples were collected from the soil borings located in the Contract C area and submitted for analytical testing. At least one sample from each soil boring was selected for chemical analysis. Eight samples were submitted for analytical testing from seven of the 15 test pits. Soil samples were not collected from some of the test pits because they were near other sampling locations. In addition, one composite sample was collected from pumping well PW-5 and submitted for chemical analysis.

3.2.2 Groundwater Samples

Groundwater samples were collected from monitoring wells, pumping wells and observation wells installed during the geotechnical investigation for the three contract areas. Table 11 provides a list of the monitoring wells sampled, rationale for sampling, and analyses performed for each contract area.

Seven of the 18 initial phase monitoring wells in Contract A, 4 along the Mercer Street Tunnel alignment, 2 at the Elliott West CSO Control Facility, and one at the Elliott West Outfall, were sampled during the initial phase. All 8 monitoring wells and two of the pumping wells installed during the final phase were sampled. In addition, TB-1, a monitoring well installed during the initial phase, was sampled during the final phase of the investigation. TB-6 and TB-8 were resampled during the final investigation to determine if contaminants continued to be present. The monitoring wells that were sampled in Contract Area A were selected based on information from the Phase I ESA, analytical results from soil samples, and distribution along the tunnel alignment.

All of the monitoring wells and pumping wells installed in Contract Areas B and C were sampled during the investigation. Observation well OW-1 was not sampled due to its proximity to pumping well PW-1. Monitoring wells BB-8 (Contract B) and CC-3A (Contract C) were resampled during the final phase of the investigation based upon review of results from the initial phase of groundwater sampling.

The Radix Ortega Group collected groundwater samples from selected wells for Contract Area A during the initial investigation. HWA sampled all of the wells for Contracts B and C, and during the final phase for Contract A. Before sampling, the water level in the well was measured and recorded in a field log. A groundwater sampling form was completed for each monitoring well and is included in Appendix B.

Groundwater samples were collected using dedicated polyethylene hand bailers. The samples were transferred directly from the bailer to the sample containers using a bottom emptying device. After collection, the containers were labeled and placed in a cooler with ice. Samples were transported to OnSite Environmental, Inc within 24 hours of sampling. All groundwater samples were analyzed for WTPH-HCID. Additional analyses were selected based on findings from the Phase I ESA and results of the groundwater TPH screening analysis. Analytical results are described in Section 4.0.

3.3 Investigation Derived Waste

Investigation derived waste (IDW) included soil cuttings, drilling mud, water generated from decontaminating drilling and sampling equipment, well development water, purge water from groundwater sampling, disposable sampling equipment, and personal protective equipment. IDW was placed into 55-gallon drums and stored on the lot which include the parcels proposed for the Elliott West CSO Control Facility and West Tunnel Portal until proper disposal methods were determined. IDW (including soil cuttings, drilling mud, decontamination water, well development water and purge water) determined to be clean from field observations, field screening, and analytical results from soil and groundwater sampling was disposed of on site. Contaminated IDW was transported off site and disposed of according to applicable Washington State requirements.

Table 6

Soil Samples Submitted for Analytical Testing

Contract A -- Mercer Street Tunnel

Boring	Depth (feet bgs)	Location	Analyses Performed
Initial Investigation			
TB-1	9-10	Tunnel Alignment	WTPH-HCID, Lead
TB-2	11-12	Tunnel Alignment	WTPH-HCID
TB-3	102-104	Tunnel Alignment	WTPH-HCID
TB-4	106-108	Tunnel Alignment	WTPH-HCID, BTEX
TB-5	127-128	Tunnel Alignment	WTPH-HCID, BTEX
TB-5	150-151	Tunnel Alignment	WTPH-HCID, BTEX
TB-6	132-134	Tunnel Alignment	WTPH-HCID
TB-7	107-109	Tunnel Alignment	WTPH-HCID
TB-8	80-81	Previous Tunnel Alignment	WTPH-HCID
TB-9	20-21	Previous Tunnel Alignment	WTPH-HCID
TB-11	102-103	Previous Tunnel Alignment	WTPH-HCID
TB-12	62-63	Tunnel Alignment	WTPH-HCID
MB-1	102-103	Tunnel Alignment	WTPH-HCID
MB-2	70-71	Tunnel Alignment	WTPH-HCID
Final Investigation			
TB-13	10-11.5	Tunnel Alignment	WTPH-HCID, Lead
TB-13	37.5-39	Tunnel Alignment	WTPH-HCID, Lead
TB-14	87.5-89	Tunnel Alignment	WTPH-HCID
TB-14	107-108.5	Tunnel Alignment	WTPH-HCID
TB-15	45-46.5	Tunnel Alignment	WTPH-HCID
TB-15	80-81.5	Tunnel Alignment	WTPH-HCID
TB-15	102.5-104	Tunnel Alignment	WTPH-HCID
TB-16	70-71.5	Tunnel Alignment	WTPH-HCID
TB-16	90-91.5	Tunnel Alignment	WTPH-HCID
TB-17	40-41.5	Tunnel Alignment	WTPH-HCID
TB-18	5-6.5	Tunnel Alignment/ East Tunnel Portal	WTPH-HCID, VOC
TB-18	20-21.5	Tunnel Alignment/ East Tunnel Portal	WTPH-HCID, VOC
TB-18	57.5-59	Tunnel Alignment/ East Tunnel Portal	WTPH-HCID, VOC

Table 6 (cont'd)
Soil Samples Submitted for Analytical Testing
Contract A -- Mercer Street Tunnel

Boring	Depth (feet bgs)	Location	Analyses Performed
OW-2	Composite	Tunnel Alignment	WTPH-HCID
PW-3	Composite	Tunnel Alignment	WTPH-HCID
PW-4	Composite	East Tunnel Portal	WTPH-HCID
WTPH-HCID – Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification BTEX – Benzene, Toluene, Ethylbenzene, Total Xylenes using SW-846 Method 8020 WTPH-D – Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended Lead – EPA SW-846 Method 6010 VOC – Volatile Organic Compound using EPA SW-846 method 8260.			

Table 7
Soil Samples Submitted for Analytical Testing
Contract A -- Elliott West CSO Control Facility

Boring	Depth (feet bgs)	Location	Analyses Performed
Initial Investigation			
CB-1	1-2	CSO Control Facility	WTPH-HCID
CB-2	15-16	CSO Control Facility	WTPH-HCID
CB-3	15-16	CSO Control Facility	WTPH-HCID, WTPH-Dx
CB-4	5-6	CSO Control Facility	WTPH-HCID
Final Investigation			
CB-5	5-6.5	CSO Control Facility	WTPH-HCID
CB-7	5-6.5	CSO Control Facility	WTPH-HCID
WTPH-HCID – Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification WTPH-Dx – Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended			

Table 8

Soil Samples Submitted for Analytical Testing

Contract A – Elliott West Outfall

Boring	Depth (feet bgs)	Location	Analyses Performed
Initial Investigation			
OB-1	5-6	Outfall	WTPH-HCID, WTPH-Dx
OB-1	10-12	Outfall	WTPH-HCID, WTPH-Dx
OB-1	15-16	Outfall	WTPH-HCID
WTPH-HCID – Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification WTPH-Dx – Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended			

Table 9

Soil Samples Submitted for Analytical Testing

Contract B

Boring	Depth (feet bgs)	Location	Analyses Performed
Initial Investigation			
BB-1	25-27	Previous Lake Union CSO Tunnel	WTPH-HCID
BB-1	60-62	Previous Lake Union CSO Tunnel	WTPH-HCID
BB-2	20-22	Central Trunk Diversion Structure	WTPH-HCID
BB-3	17-19	Previous Lake Union CSO Tunnel	WTPH-HCID
BB-4	5-7	Central Trunk Diversion Structure	WTPH-HCID
BB-5	15-17	Central Trunk Diversion Structure	WTPH-HCID, BTEX, SVOC
BB-5	25-27	Central Trunk Diversion Structure	WTPH-HCID
BB-6	7-9	East Tunnel Portal/Drop Structure	WTPH-HCID
BB-7	10-12	East Tunnel Portal/Drop Structure	WTPH-HCID
BB-8	20-22	Lake Union Tunnel CSO Pipeline	WTPH-HCID, VOC
BB-10	15-17	Central Trunk Diversion Structure	WTPH-HCID
Final Investigation			
BB-9	25-26.5	Lake Union Tunnel Regulator Station	WTPH-HCID
BB-9	50-51.5	Lake Union Tunnel Regulator Station	WTPH-HCID
BB-11	25-26.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID
BB-11	40-40.75	Lake Union Tunnel CSO Pipeline	WTPH-HCID
BB-12	15-16.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID, VOC
BB-12	45-46.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID, VOC
BB-13	25-26.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID, VOC
BB-13	40-41.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID, VOC
BB-14	5-6.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID
BB-14	12.5-14	Lake Union Tunnel CSO Pipeline	WTPH-HCID
BB-14	22.5-24	Lake Union Tunnel CSO Pipeline	WTPH-HCID
BB-14	30-31.5	Lake Union Tunnel CSO Pipeline	WTPH-HCID, WTPH-Dx
PW-1	Composite	Valley Street Connection Manhole	WTPH-HCID

WTPH-HCID: Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification

WTPH-Dx: Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended

BTEX: Benzene, Toluene, Ethylbenzene, Total Xylenes using EPA SW-846 Method 8020

SVOC: Semivolatile organic compound using EPA SW-846 Method 8270

VOC: Volatile organic compound using EPA SW-846 Method 8260

Table 10
Soil Samples Submitted for Analytical Testing
Contract C

Boring/ Test Pit	Depth (feet bgs)	Location	Analyses Performed
Initial Investigation - Soil Boring			
CC-1	10-12	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
CC-1	20-22	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx, PAH, SVOC
CC-1	27-29	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID
CC-2	5-7	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
CC-2	15-17	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID
CC-2	30-32	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx, PAH, SVOC
CC-3	7-9	Elliott West CSO/Effluent Pipeline - Middle	WTPH-HCID, WTPH-Dx
CC-4	2-4	Elliott West CSO/Effluent Pipeline - Middle	WTPH-HCID
CC-4	12-14	Elliott West CSO/Effluent Pipeline - Middle	WTPH-HCID
CC-5	7-9	Elliott West CSO/Effluent Pipeline - Middle	WTPH-HCID
CC-5	27-29	Elliott West CSO/Effluent Pipeline - Middle	WTPH-HCID
CC-6	2-4	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-6	20-22	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-7	2-4	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
Test Pits			
TP-1	7-8	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
TP-7	4-5	Elliott West CSO/Effluent Pipeline -Middle	WTPH-HCID, WTPH-Dx
TP-9	5-6	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
TP-11	7-8	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
TP-12	5-6	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
TP-13	3-4	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
TP-14	3-4	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx, SVOC, PAH
TP-14	9-10	Elliott West CSO/Effluent Pipeline -South End	WTPH-HCID, WTPH-Dx
Final Investigation - Soil Boring			
CC-8	7.5-9	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-8	45-46.5	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-9	7.5-9	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-9	45-46.5	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-10	7.5-9	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-10	45-46.5	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-11	7.5-9	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID

Table 10 (cont'd)
Soil Samples Submitted for Analytical Testing
Contract C

Boring/ Test Pit	Depth (feet bgs)	Location	Analyses Performed
CC-11	17.5-19	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID, WTPH-Dx, PAH, SVOC
CC-11	42.5-44	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID
CC-12	7.5-9	Elliott West CSO/Effluent Pipeline - South End	WTPH-HCID, WTPH-Dx, PAH, SVOC
CC-12	32.5-34	Elliott West CSO/Effluent Pipeline - South End	WTPH-HCID, WTPH-Dx, PAH, SVOC
CC-13	7.5-9	Elliott West CSO/Effluent Pipeline - North End	WTPH-HCID
CC-13	45-46.5	Elliott West CSO/Effluent Pipeline - North End	WTPH-HCID
PW-5	composite	Elliott West CSO/Effluent Pipeline -North End	WTPH-HCID

WTPH-HCID: Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification
WTPH-Dx: Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended
PAH: Polycyclic Aromatic Hydrocarbons using EPA SW-846 Method 8270
SVOC: Semivolatile organic compounds using EPA SW-846 Method 8270

Table 11

Groundwater Samples Submitted for Analytical Testing

Monitoring Well	Rationale for Sampling	Analyses Performed
Contract Area A – Mercer Street Tunnel		
TB-1	Along the tunnel alignment.	WTPH-G, BTEX
TB-2	Along the tunnel alignment.	WTPH-HCID, BTEX
TB-6	Along the tunnel alignment.	WTPH-HCID, WTPH-D, BTEX
TB-6[1]	Along the tunnel alignment.	WTPH-G, BTEX
TB-8	Along the tunnel alignment.	WTPH-HCID, BTEX
TB-8[1]	Along the tunnel alignment.	WTPH-G, BTEX
TB-11	Along the tunnel alignment.	WTPH-HCID, BTEX, SVOC
TB-13	Along the tunnel alignment.	WTPH-HCID
TB-14	Along the tunnel alignment.	WTPH-HCID
TB-15	Along the tunnel alignment.	WTPH-HCID
TB-16	Along the tunnel alignment.	WTPH-HCID
TB-17	Along the tunnel alignment.	WTPH-HCID
TB-18	Along the tunnel alignment.	WTPH-HCID, VOC
PW-3 8-hour	Along the tunnel alignment.	WTPH-HCID
Contract A - Elliott West CSO Control Facility		
CB-2	Downgradient from CB-3.	WTPH-HCID, BTEX
CB-3	TPH contamination in soil at 15-16 feet bgs.	WTPH-HCID, BTEX
CB-5	In excavation footprint.	WTPH-HCID
CB-7A	Near excavation footprint.	WTPH-HCID, WTPH-G, BTEX
Contract A – Elliott West Outfall		
OB-1	TPH contamination in soil at 5-11 feet bgs.	WTPH-HCID, BTEX
Contract B		
BB-1	Previous Lake Union CSO Tunnel alignment.	WTPH-HCID, WTPH-G, BTEX
BB-2	Near Central Trunk Diversion Structure.	WTPH-HCID, WTPH-G, BTEX
BB-3	Previous Lake Union CSO Tunnel alignment.	WTPH-HCID, BTEX
BB-4	Near Central Trunk Diversion Structure.	WTPH-HCID, WTPH-G, BTEX
BB-5	Near Central Trunk Diversion Structure.	WTPH-HCID, VOC
BB-6	Near East Tunnel Portal/Drop Structure	WTPH-HCID, WTPH-G, BTEX
BB-7	Near East Tunnel Portal/Drop Structure	WTPH-HCID, VOC
BB-8	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, VOC
BB-8[1]	Lake Union Tunnel CSO Pipeline alignment.	VOC
BB-9	Near Lake Union Tunnel Regulator Station.	WTPH-HCID, WTPH-G, BTEX
BB-10	Near Central Trunk Diversion Structure	WTPH-HCID, WTPH-G, VOC, BTEX

Table 11 (cont'd)

Groundwater Samples Submitted for Analytical Testing

Monitoring Well	Rationale for Sampling	Analyses Performed
Contract B (cont'd)		
BB-11	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
BB-12	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, VOC
BB-13	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, VOC
BB-14	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID
PW-1 8-hour	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, VOC
PW-1 Final	Lake Union Tunnel CSO Pipeline alignment.	WTPH-HCID, VOC
Contract C		
CC-1	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX, PAH
CC-2	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX, PAH
CC-3A	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX, PAH
CC-3A[1]	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX,
CC-3C	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
CC-4	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
CC-5	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
CC-6	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
CC-7	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
CC-8	Elliott West CSO Pipeline alignment.	WTPH-HCID
CC-9	Elliott West CSO Pipeline alignment.	WTPH-HCID
CC-10	Elliott West CSO Pipeline alignment.	WTPH-HCID
CC-11	Elliott West CSO Pipeline alignment.	WTPH-HCID
CC-12	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX, WTPH-D, PAH
CC-13	Elliott West CSO Pipeline alignment.	WTPH-HCID, WTPH-G, BTEX
PW-5 8-hour	Elliott West CSO Pipeline alignment.	WTPH-HCID
PW-5 Final	Elliott West CSO Pipeline alignment.	WTPH-HCID

WTPH-HCID: Washington State Total Petroleum Hydrocarbons - Hydrocarbon Identification

WTPD-D: Washington State Total Petroleum Hydrocarbons - Diesel and Heavy Oil Extended

WTPH-G: Washington State Total Petroleum Hydrocarbons - Gasoline

BTEX: Benzene, Toluene, Ethylbenzene, Total Xylenes using EPA SW-846 Method 8020

SVOC: Semivolatile organic compound using EPA SW-846 Method 8270

PAH: Polycyclic Aromatic Hydrocarbons using EPA SW-846 Method 8270

VOC: Volatile organic compound using EPA SW-846 Method 8260

[1] Resampled during the final phase of the investigation.

4.0 Analytical Results

This section presents analytical results obtained for soil and groundwater samples collected during Phase II ESA activities performed in conjunction with the geotechnical investigation of Contract Areas A, B, and C. Soil and groundwater samples were analyzed to determine the presence or absence of contamination in areas where CSO construction activities will be performed. Onsite Environmental, Inc., performed all chemical analyses for the Phase II ESA. Tables 6 through 11 in the previous section summarize samples submitted for chemical analysis. A summary of analytical results exceeding regulatory cleanup levels is presented in Section 5.0. Laboratory reports are included in Appendix C.

All soil and groundwater samples selected for chemical analysis were analyzed for TPH using WTPH-HCID. WTPH-HCID is a screening method that provides an indication of the presence of TPH in the gasoline, diesel and heavy oil ranges. Screening levels for soil are: gasoline above 20 mg/kg, diesel above 50 mg/kg, and heavy oil above 100 mg/kg. Screening levels may vary based on soil characteristics such as moisture content. Screening levels for water are: gasoline above 250 ug/L, diesel above 630 ug/L, and heavy oil above 630 ug/L. These screening levels are below the Model Toxics Control Act (MTCA) Method A cleanup levels. Additional TPH analysis was conducted when TPH concentrations exceeded the WTPH-HCID screening levels in either soil or groundwater samples. Method WTPH-Dx was used for TPH within the diesel and heavy oil ranges and method WTPH-G was used for TPH in the gasoline range. If gasoline was detected above screening levels, the sample was also analyzed for BTEX.

4.1 Contract A

4.1.1 Soil Sampling Results

Soil samples were collected from all of the borings installed in Contract A. These soil samples were analyzed to determine the presence or absence of soil contamination. Analytical results and sample depths are presented in Tables 12 through 15 and laboratory reports are included in Appendix C.

Mercer Street Tunnel Soil samples were collected from soil borings drilled along the Mercer Street Tunnel. All samples were analyzed for TPH using method WTPH-HCID for screening purposes. Soil samples analyzed are representative of soil which may be encountered during the

construction of the tunnel. TPH was not detected above screening levels in any of the samples collected along the tunnel alignment (Table 12).

Soil samples from borings TB-4 (106 to 108 bgs) and TB-5 (127 to 128 feet bgs and 150 to 151 feet bgs) were also analyzed for BTEX based on findings from the Phase I ESA. BTEX compounds were not detected above the laboratory detection limits in these samples.

The sample collected from TB-1 (9 to 10 feet bgs) was analyzed for lead and contained 31 mg/kg lead, which is below MTCA Method A cleanup level of 250 mg/kg. Samples collected from TB-13 (10 - 11.5 feet bgs and 37.5 - 39 feet bgs) were also analyzed for lead. Lead concentrations in these samples were less than the detection limit of 2.4 to 6.7 mg/kg. These samples were analyzed for lead because a property located northwest of these borings was identified as lead-contaminated during the Phase I ESA.

Selected samples from TB-18 (5 to 6.5 feet bgs, 20 to 21.5 feet bgs and 57.5 to 59 feet bgs) were analyzed for VOCs. The only compounds identified above detection limits was methylene chloride at 0.29 mg/kg in the sample from 57.7 to 59 feet bgs. The concentration is also below the MTCA Method A cleanup level of 0.5 mg/kg.

Elliott West CSO Control Facility Six soil borings were drilled in the footprint of the proposed Elliott West CSO Facility. One soil sample from each boring was analyzed for TPH using method WTPH-HCID for screening purposes. Samples from these borings did not contain detectable concentrations of TPH, with the exception of heavy oil in sample CB-3 (5 to 6 feet bgs) (Table 13). This sample was analyzed using WTPH-Dx. Diesel was detected at 41 mg/kg and heavy oil detected at 98 mg/kg. These concentrations are below MTCA Method A cleanup levels of 200 mg/kg.

Elliott West Outfall One soil boring was drilled onshore next to the Elliott West Outfall. Three soil samples were analyzed for TPH using method WTPH-HCID for screening purposes. Samples were collected from 5 to 6 feet, 10 to 12 feet and 15 to 16 feet bgs. Analytical results for samples collected from 5 to 6 feet and 10 to 12 feet detected concentrations of heavy oil above the screening level of 100 mg/kg. The sample collected from 15 to 16 feet contained no detectable concentrations of TPH above screening levels (Table 14). Follow-up TPH analysis was conducted for the two samples collected at 5 to 6 feet bgs and 10 to 12 feet bgs. Diesel was detected at 73 mg/kg and heavy oil at 280 mg/kg in the sample from 5 to 6 feet. Soil from 10 to 12 feet had 52 mg/kg diesel and 200 mg/kg heavy oil (Table 15). The heavy oil concentrations in both of these samples exceed MTCA Method A cleanup levels.

4.1.2 Groundwater Sampling Results

Groundwater samples were collected from seven of the 18 monitoring wells constructed in Contract Area A during initial Phase II ESA activities. All eight monitoring wells installed during the final phase, and pumping well PW-3 was sampled 8 hours into the pump test. TB-6 and TB-8 were resampled during the final investigation.

All groundwater samples were submitted for chemical analysis for TPH using WTPH-HCID. Selected samples underwent additional chemical analyses, including BTEX, WTPH-G, VOC and SVOC. Laboratory reports are included in Appendix C.

Mercer Street Tunnel Twelve wells were sampled along the Mercer Street Tunnel alignment and analyzed for TPH. TB-1 was sampled, but not screened for TPH. WTPH-HCID results indicated no detectable concentrations of TPH compounds above the screening levels from these monitoring wells, with the exception of TB-6 (initial phase). The groundwater sample collected from TB-6 during the initial investigation contained TPH in the heavy oil range at 630 ug/L (Table 16). Subsequent TPH analysis (WTPH-Dx) was performed on the sample from TB-6 (initial phase). TPH was not detected above detection limits for diesel or heavy oil using this method.

Groundwater samples TB-1, TB-2, TB-6 (initial phase and final phase), TB-8 (initial phase and final phase) and TB-11 were analyzed for BTEX. Toluene was detected in low concentrations in samples from wells TB-6 (2.0 ug/L) and TB-8 (1.1 ug/L) collected during the initial phase. These concentrations are below the MTCA Method A cleanup level for toluene (40 ug/L). No BTEX compounds were identified above detection limits in TB-1, TB-2, TB-6 (final phase), TB-8 (final phase) or TB-11. BTEX results are presented in Table 17.

Samples collected from TB-6 and TB-8 during the final investigation were analyzed using WTPH-G. TPH in the gasoline range was not identified above detection limits in these samples.

In addition to TPH and BTEX, the groundwater sample from monitoring well TB-11 was analyzed for SVOCs. This analysis was performed based on findings from the Phase I ESA indicating possible solvent and PAH contamination in groundwater near this boring. Two semivolatile organic compounds (dimethylphthalate (5.1 ug/L) and diethylphthalate (14 ug/L)) were detected in this groundwater sample. These compounds are common laboratory contaminants and are not considered contaminants of concern. However, no conclusions can be drawn from these results because the detection limits of carcinogenic PAHs for Method 8270 are greater than the MTCA Method A cleanup level of 0.1 ug/L of total carcinogenic PAHs

Based on findings from the Phase I ESA, groundwater from monitoring well TB-18 was also analyzed for VOCs. Toluene was detected at 1.2 ug/L, well below the MTCA Method A cleanup level of 40 ug/L. No other VOCs were identified above detection levels in this sample.

Additionally, the sample from the 8-hour pump test of PW-3 (PW-3 8-hour) was tested for iron and manganese for groundwater quality requirements using EPA test method 6010B. Iron was detected at 130 ug/L and manganese at 210 ug/L. Water quality parameters were tested in this sample to provide data for obtaining a discharge permit for dewatering during construction.

Elliott West CSO Control Facility Four of the six monitoring wells installed at the Elliott West CSO Facility were sampled. All samples were screened for TPH using WTPH-HCID. TPH compounds were not detected above screening levels in any of the monitoring wells, with the exception of gasoline greater than 250 ug/L in CB-7A (Table 16). The groundwater sample from CB-7A was further analyzed for WTPH-G and BTEX. Neither gasoline-range TPH nor BTEX were identified above detection limits. Monitoring wells CB-2 and CB-3 were also analyzed for BTEX. BTEX was not detected in samples collected from these wells (Table 17).

Elliott West Outfall One monitoring well was installed near the Elliott West Outfall and analyzed for TPH and BTEX compounds (Tables 16 and 17). WTPH-HCID results indicated no detectable TPH compounds above screening levels. BTEX analytical results also had no detectable concentrations.

4.2 Contract B

4.2.1 Soil Sampling Results

Soil samples were collected from all of the soil borings drilled during the Phase II ESA activities. All samples submitted for chemical analysis were screened using WTPH-HCID. Results are presented in Table 18. One sample, BB-14 from 30 to 31.5 feet bgs, contained heavy oil-range TPH above screening levels. No other samples had TPH concentrations above WTPH-HCID screening levels. BB-14 (30 to 31.5 feet bgs) was further analyzed using WTPH-Dx for diesel and heavy oil-range TPH. Diesel was detected at 54 mg/kg and heavy oil at 120 mg/kg. Both results were below the MTCA Method A cleanup level of 200 mg/kg.

Soil sample BB-5 (15 to 17) feet bgs was also analyzed for BTEX, WTPH-G and SVOCs. Additional chemical analyses were requested based on findings from the Phase I ESA. None of these compounds were detected above detection limits.

Possible chlorinated solvent contamination was identified during the Phase I ESA near soil borings BB-8, BB-12 and BB-13. Therefore, selected samples from these borings were analyzed for VOCs. No detectable concentrations of volatile compounds were found in the samples BB-8 (20 to 22 feet bgs), BB-12 (15 to 16.5 feet bgs and 45 to 46.5 feet bgs), and BB-13 (40 to 41.5 feet bgs). Methylene Chloride was detected in sample BB-13 (25-27.5 feet bgs) at 0.10 mg/kg, below the MTCA Method A cleanup level of 0.5 mg/kg.

4.2.2 Groundwater Sampling Results

Groundwater samples were collected from all monitoring wells constructed in Contract Area B. Monitoring well BB-8 was also resampled during the final phase of the investigation, and PW-1 was sampled during the pumping test at 8-hours (PW-1 8-hour) and at the end (PW-1 final). All groundwater samples, with the exception of BB-8 (final phase) were analyzed for TPH using WTPH-HCID. TPH screening results indicated groundwater samples from monitoring wells BB-1, BB-8 (initial phase) and BB-9 contained TPH in the gasoline range exceeding the TPH screening level (Table 19). None of the groundwater samples contained detectable concentrations of TPH in the diesel or oil ranges.

Groundwater samples from monitoring wells BB-1 through BB-4, BB-6 and BB-8 (initial phase) through BB-11 were analyzed for BTEX compounds. These samples, with the exception of BB-3 and BB-8 were also analyzed for WTPH-G. TPH in the gasoline-range and BTEX compounds were not detected in any of the groundwater samples (Table 20), with the exception of BB-8. Benzene and toluene were detected in BB-8 as discussed below.

Groundwater samples from monitoring wells BB-5, BB-7, BB-8 (initial), BB-10, BB-12, BB-13 and DWP-1 were analyzed for VOCs. Monitoring well BB-8 was resampled during the final investigation and was reanalyzed for VOCs. Benzene and toluene were detected in groundwater sampled in BB-8 in levels below MTCA Method A cleanup levels. These results are listed in Table 20, and were quantified during the VOC analysis. Table 21 presents concentrations of detected VOCs and the MTCA Method A cleanup level for each detected compound. No compounds were detected in groundwater samples from BB-7 and BB-10. Groundwater samples collected from BB-8, BB-12 and BB-13 all contained VOCs exceeding MTCA Method A cleanup levels. BB-8 contained levels of vinyl chloride, (cis) 1, 2-dichloroethene, (trans) 1,2-dichloroethene, trichloroethene, and tetrachloroethene exceeding MTCA Method A cleanup levels. BB-12 contained vinyl chloride and (cis) 1, 2-dichloroethene in excess of MTCA Method A cleanup levels, and BB-13 contained vinyl chloride in levels exceeding MTCA Method A cleanup

with a detectable level of (cis) 1, 2-dichloroethene. Concentrations in BB-8 were higher than in the other two wells.

4.3 Contract C

4.3.1 Soil Sampling Results

Soil samples were collected from 14 soil borings and seven test pits along the Elliott West Effluent and CSO Pipelines. Soil samples selected for chemical analysis were analyzed using WTPH-HCID. TPH in the diesel and/or heavy oil-range was detected in samples collected from borings CC-1, CC-2, CC-3, CC-11, CC-12 and all test pits except TP-1 and TP-9. TPH in the gasoline range was detected above screening levels in sample CC-11 (17.5 to 19 feet bgs). TPH concentrations were not above screening levels in samples collected from the other borings or from TP-1 and TP-9. TPH screening results are presented in Table 22.

All samples with TPH above screening levels were further tested using WTPH-Dx for heavy oil and diesel (Table 23). Samples CC-1 (20 to 22 feet bgs), CC-2 (30 to 32 feet bgs) and CC-11 (17.5 to 19 feet bgs) contained TPH in the diesel range above MTCA Method A cleanup levels. Samples collected from CC-1, CC-2, TP-12, TP-13, and TP-14 contained TPH in the heavy oil range above MTCA Method A cleanup levels.

Gasoline was detected above WTPH-HCID screening levels in boring CC-11 (17.5 to 19). This sample was not further analyzed for BTEX or WTPH-G because of insufficient sample volume.

Soil samples which contained elevated TPH concentrations and were collected from borings or tests pits near the EPA site identified in the Phase I ESA were also analyzed for SVOCs/PAHs. SVOCs/PAH analysis was performed on samples collected from CC-1 (20 to 22 feet bgs), CC-2 (30 to 32 feet bgs), CC-11 (17.5 to 19 feet bgs), CC-12 (7.5 to 9 feet bgs), CC-12 (32.5 to 34 feet bgs), and TP-14 (3 to 4 feet bgs). Results are presented in Table 24. Total carcinogenic PAHs were detected above MTCA Method A cleanup levels in samples collected from CC-2, CC-11, CC-12, and TB-14. CC-11 (17.5 to 19 feet bgs) had the highest levels of PAHs.

No soil samples were selected for chemical analysis from test pits TP-2 through TP6, TP-8, and TP-15.

4.3.2 Groundwater Sampling Results

Groundwater samples were collected from all monitoring wells constructed for Contract C. Well CC-3A was resampled during the final investigation, and PW-5 was sampled during the

pumping test at 8-hours (PW-5 8-hour) and at the end (PW-5 final). All samples were screened for TPH using WTPH-HCID. Screening results are presented in Table 25. Gasoline was detected in CC-12 and CC-13. Diesel was also detected in the groundwater sample collected from CC-12. TPH compounds were not detected above screening levels in any other groundwater samples.

Groundwater samples from CC-1, CC-2, CC-3A, CC-3C, CC-4, CC-5, CC-6, CC-7, CC-12 and CC-13 were further analyzed for WTPH-G and BTEX. TPH in the gasoline range and BTEX compounds were detected in the samples from CC-12 and CC-13 (Table 26). CC-13 results were not above cleanup levels. However, CC-12 was further analyzed using WTPH-Dx. Results from the WTPH-G (gasoline at 1200 ug/L) and the WTPH-Dx (diesel at 830 ug/L) bring the contaminant levels in CC-12 above MTCA Method A cleanup levels for TPH in groundwater. BTEX was detected in CC-12, but results were below MTCA Method A cleanup levels. The sample taken from CC-3A during the initial investigation indicated detectable levels of gasoline and benzene, but the sample taken from CC-3A during the final investigation did not contain detectable levels of either product.

CC-12 was also analyzed for PAHs using EPA 8270C. The results of this test are listed below, and indicate the presence of some PAHs in the sample. No conclusions can be drawn from these results because the detection limits of carcinogenic PAHs for Method 8270 are greater than the MTCA Method A cleanup level of 0.1 ug/L of total carcinogenic PAHs.

CC-12 PAH Results by EPA 8270C

Compound	Results (ug/L)
Naphthalene	170
2-Methylnaphthalene	22
Acenaphthylene	< 1.0
Acenaphthene	21
Fluorene	13
Phenanthrene	17
Anthracene	3.8
Fluoranthene	1.7
Pyrene	1.1
Benzo[a]anthracene	< 1.0
Chrysene	< 1.0
Benzo[b]fluoranthene	< 1.0
Benzo[k]fluoranthene	< 1.0
Benzo[a]pyrene	< 1.0
Indeno[1,2,3-cd]pyrene	< 1.0
Dibenz[a,h]anthracene	< 1.0
Benzo[g,h,i]perylene	< 1.0

Groundwater samples collected from monitoring wells CC-1 through CC-7 and CC-3A (final phase) were also analyzed for WTPH-G and BTEX. No compounds were detected above MTCA Method A cleanup levels in any of these samples (Table 26).

Groundwater samples from monitoring wells CC-1, CC-2, and CC-3A (initial phase) were also analyzed for PAHs using EPA-SW-846 Method 8270. Acenaphthane was detected in samples CC-2 at 1.4 ug/L and CC-3A at 25 ug/L. There were no other PAH compounds detected in samples from CC-1, CC-2, or CC-3A. Again, no conclusions can be drawn from these results because the detection limits of carcinogenic PAHs for Method 8270 are greater than the MTCA Method A cleanup level of 0.1 ug/L of total carcinogenic PAHs.

Additionally, two samples from PW-5 were tested for iron and manganese using test method EPA 6010B in order to determine whether groundwater pumped from this region would be acceptable for discharge into a municipal combined sewer. An initial sample was taken after 8 hours of pumping, and a final sample was taken at the end of the pump test. Iron was detected in the samples at 200 ug/L and 1100 ug/L, and manganese at 360 ug/L and 390 ug/L, respectively.

4.4 Data Quality

Overall, the analytical data generated during the Phase II ESA are usable for evaluating the presence of the contaminants of potential concern identified in the Phase I ESA. The laboratory reported that all samples met standard method quality assurance and quality control limits. The data evaluated in this data quality assessment did not require validation.

Data evaluation was performed by Black & Veatch using best professional judgment. Data users may review and re-interpret data quality for specific uses. All sample analytical data for this investigation are included in Appendix C.

Table 12
Soil Results for WTPH-HCID Screening
Contract Area A - Mercer Street Tunnel

Soil Boring	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		100	200	200
TB-1	9-10	< 20	< 50	< 100
TB-2	11-12	< 20	< 50	< 100
TB-3	102-104	< 20	< 50	< 100
TB-4	106-108	< 20	< 50	< 100
TB-5	127-128	< 20	< 50	< 100
TB-5	150-151	< 20	< 50	< 100
TB-6	132-134	< 20	< 50	< 100
TB-7	107-109	< 20	< 50	< 100
TB-8	80-81	< 20	< 50	< 100
TB-9	20-21	< 20	< 50	< 100
TB-11	102-103	< 20	< 50	< 100
TB-12	62-63	< 24	<60	< 119
TB-13	10-11.5	<27	<54	<110
TB-13	37.5-39	<33	<67	<130
TB-14	87.5-89	<28	<56	<110
TB-14	107-108.5	<33	<66	<130
TB-15	45-46.5	<26	<51	<100
TB-15	80-81.5	<26	<52	<100
TB-15	102.5-104	<25	<51	<100
TB-16	70-71.5	<29	<58	<120
TB-16	90-91.5	<29	<57	<110
TB-17	40-41.5	<30	<60	<120
TB-18	5-6.5	<27	<55	<110
TB-18	20-21.5	<28	<56	<110
TB-18	57.5-59	<28	<56	<110
OW-2	composite	<30	<60	<120
PW-4	composite	<27	<53	<110
PW-3	composite	<30	<61	<120
MB-1	102-103	< 22	< 56	< 111
MB-2	70-71	< 23	< 57	< 115

Table 13
Soil Results for WTPH-HCID Screening
Contract Area A - Elliott West CSO Control Facility

Soil Boring	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		100	200	200
CB-1	1-2	< 20	< 50	< 100
CB-2	15-16	< 20	< 50	< 100
CB-3	15-16	< 20	< 50	**> 100***
CB-4	5-6	< 26	< 66	< 132
CB-5	5-6.5	<30	<60	<120
CB-7	5-6.5	<29	<58	<120

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.
* Extended screening results discussed in text

Table 14
Soil Results for WTPH-HCID Screening
Contract Area A - Elliott West Outfall

Soil Boring	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		100	200	200
OB-1	5-6	< 23	< 58	**> 116**
OB-1	10-12	< 20	< 50	**> 100**
OB-1	15-16	< 24	< 60	< 119

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.

Table 15
Soil Results for WTPH-Dx Analysis
Contract Area A – Elliott West Outfall

Soil Boring	Sampling Depth (feet bgs)	WTPH-D extended (mg/kg)	
		Diesel	Heavy Oil
MTCA Method A Cleanup Levels		200	200
OB-1	5-6	73	**280**
OB-1	10-12	52	**200**

Bold indicates concentration exceeds MTCA Method A Cleanup

Table 16
Groundwater Results for WTPH-HCID Screening
Contract Area A

Monitoring Well	Well Screen Depth (feet bgs)	WTPH-HCID Screening Analysis (ug/L)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		Sum < 1000		
Mercer Street Tunnel				
TB-2	40-50	< 250	< 630	< 630
TB-6	153-163	< 250	< 630	**> 630**
TB-8	130-150	< 250	< 630	< 630
TB-11[a]	70-90	< 250	< 630	< 630
TB-13	55-80	< 250	< 630	< 630
TB-14	150-200	< 250	< 630	< 630
TB-15	130-160	< 250	< 630	< 630
TB-16	85-165	< 250	< 630	< 630
TB-17	77-117	< 250	< 630	< 630
TB-18[b]	93-118	< 250	< 630	< 630
PW-3 8-hour	80-170	<400	<630	<630
Elliott West CSO Control Facility				
CB-2	8-18	< 250	< 630	< 630
CB-3	10-20	< 250	< 630	< 630
CB-5	85-90	< 250	< 630	< 630
CB-7A	24-44	**> 250**	< 630	< 630
Elliott West Outfall				
OB-1	21-31	< 250	< 630	< 630

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.

[a] SVOC results for TB-11 discussed in text

[b] VOC results for TB-18 discussed in text

Table 17

Groundwater Results for BTEX Analysis

Contract Area A

Monitoring Well	Screen Interval (feet)	EPA SW-846 Method 8020 (ug/L)			
		Benzene	Ethylbenzene	Toluene	Xylene (total)
MTCA Method A Cleanup Levels		5	30	40	20
Mercer Street Tunnel					
TB-1	12-22	<1.0	<1.0	<1.0	<1.0
TB-2	40-50	< 1.0	< 1.0	< 1.0	< 1.0
TB-6	153-163	< 1.0	< 1.0	2.0	< 1.0
TB-6[1]	153-163	< 1.0	< 1.0	< 1.0	< 1.0
TB-8	130-150	< 1.0	< 1.0	1.1	< 1.0
TB-8[1]	130-150	< 1.0	< 1.0	< 1.0	< 1.0
TB-11	70-90	< 1.0	< 1.0	< 1.0	< 1.0
Elliott West CSO Control Facility					
CB-2	8-18	< 1.0	< 1.0	< 1.0	< 1.0
CB-3	10-20	< 1.0	< 1.0	< 1.0	< 1.0
CB-7A	24-44	< 1.0	< 1.0	< 1.0	< 1.0
Elliott West Outfall					
OB-1	21-31	< 1.0	< 1.0	< 1.0	< 1.0

[1] Resampled during Final Investigation

Table 18
Soil Results for WTPH-HCID Screening
Contract Area B

Soil Boring	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		100	200	200
BB-1	25-27	< 27	< 68	< 137
BB-1	60-62	< 24	< 59	< 118
BB-2	20-22	< 22	< 56	< 111
BB-3	17-19	< 20	< 50	< 100
BB-4	5-7	< 25	< 62	< 123
BB-5[b]	15-17	< 22	< 54	< 108
BB-5	25-27	< 22	< 56	< 112
BB-6	7-9	< 24	< 61	<122
BB-7	10-12	< 26	< 66	< 132
BB-8	20-22	< 20	< 50	< 100
BB-9	25-26.5	<32	< 64	< 130
BB-9	50-51.5	< 28	< 57	< 110
BB-10	15-17	< 22	< 54	< 109
BB-11	25-26.5	< 27	< 55	< 110
BB-11	40-40.75	< 29	< 57	< 110
BB-12	15-16.5	< 29	< 58	< 120
BB-12	45-46.5	<29	<59	<120
BB-13	25-26.5	< 34	< 68	< 140
BB-13	40-41.5	< 30	< 61	< 120
BB-14	5-6.5	< 32	< 64	< 130
BB-14	12.5-14	< 31	< 62	< 120
BB-14	22.5-24	< 31	< 62	< 120
BB-14[b]	30-31.5	< 27	< 54	**>110**
PW-1	Composite	< 31	< 63	< 130

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.

[a] SVOC results discussed in text

[b] Results of extended analysis discussed in text

Table 19
Groundwater Results for WTPH-HCID Screening
Contract Area B

Monitoring Well	Well Screen Depth (feet bgs)	WTPH-HCID Screening Analysis (ug/L)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Level		Sum < 1000		
BB-1	52.5-62.5	**> 250**	< 630	< 630
BB-2	25-40	< 250	< 630	< 630
BB-3*	20-35	< 200	< 500	< 1000
BB-4	30-40	< 250	< 630	< 630
BB-5	30-40	< 250	< 630	< 630
BB-6	30-40	< 250	< 630	< 630
BB-7	25-35	< 250	< 630	< 630
BB-8*	30-40	**> 200**	< 500	< 1000
BB-9	56-80	**> 250**	< 630	< 630
BB-10	29-39	< 250	< 630	< 630
BB-11	75-85	< 250	< 630	< 630
BB-12	35-45	< 250	< 630	< 630
BB-13	35-45	< 250	< 630	< 630
BB-14	40-50	< 300	< 630	< 630
PW-1 8-hour	40-60	<250	< 630	< 630
PW-1 Final	40-60	<250	< 630	< 630

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.
* Detection limits higher due to analytical method.

Table 20
Groundwater Results for WTPH-G and BTEX Analysis
Contract Area B

Monitoring Well	EPA SW-846 Method 8020/WTPH-G (ug/L)				
	Gasoline	**Benzene**	**Ethylbenzene**	**Toluene**	**Xylene (total)**
MTCA Method A Cleanup Levels	TPH sum < 1000	5	30	40	20
BB-1	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-2	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-3	NA	< 1.0	< 1.0	< 1.0	< 1.0
BB-4	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-6	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-8[1]	NA	1.8	<1.0	1.3	<1.0
BB-9	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-10	< 100	< 1.0	< 1.0	< 1.0	< 1.0
BB-11	< 100	< 1.0	< 1.0	< 1.0	< 1.0

NA - not analyzed
[1] BTEX compounds were quantified during the VOC analysis (EPA SW-846 Method 8260).

Table 21

Volatile Compounds Detected in Groundwater

Contract Area B

Monitoring Well	Contaminant	Concentration (ug/L)	MTCA Method A Cleanup Level (ug/L)
BB-5	1,1,1-Trichlorethene	3.3	200
	1,2-Dichloroethene	1.1	5.0
BB-8	Vinyl Chloride	**180**	0.2
	(cis) 1,2-Dichloroethene	**3,100**	5.0
	Trichloroethene	**1,100**	5.0
	Tetrachloroethene	**8,400**	5.0
BB-8[1]	Vinyl Chloride	**280**	0.2
	(trans) 1,2- Dichloroethene	**14**	5.0
	(cis) 1,2- Dichloroethene	**4,200**	5.0
	Benzene	1.8	5.0
	Trichloroethene	**1,500**	5.0
	Toluene	1.3	40
	Tetrachloroethene	**11,000**	5.0
BB-12	Vinyl Chloride	**380**	0.2
	(cis) 1,2-Dichloroethene	**540**	5.0
BB-13	Vinyl Chloride	**1.1**	0.2
	(cis) 1,2-Dichloroethene	2.6	5.0
PW-1 8-hour	Tetrachloroethene	1.0	5.0

Bold indicates compound exceeds MTCA Method A Cleanup Levels for groundwater.

BB-8[1] was re-sampled during the final phase of the investigation

Table 22
Soil Results for WTPH-HCID Screening
Contract Area C

Soil Borings/ Test Pits	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		100	200	200
Soil Borings				
CC-1	10-12	< 24	< 60	**> 119**
CC-1	20-22	< 25	**> 62**	**> 123**
CC-1	27-29	< 24	< 59	< 118
CC-2	5-7	< 24	< 61	**>122**
CC-2	15-17	< 25	< 62	<123
CC-2	30-32	< 30	< 76	**> 152**
CC-3	7-9	< 26	< 64	**> 128**
CC-4	2-4	< 22	< 54	< 108
CC-4	12-14	< 23	< 57	< 115
CC-5	7-9	< 21	< 52	< 103
CC-5	27-29	< 22	< 56	< 111
CC-6	2-4	< 21	< 52	< 104
CC-6	20-22	< 24	< 59	< 118
CC-7	2-4	< 23	< 57	< 114
CC-8	7.5-9	<33	<66	<130
CC-8	45-46.5	<37	<75	<150
CC-9	7.5-9	<28	<56	<110
CC-9	45-46.5	<33	<66	<130
CC-10	7.5-9	<28	<56	<110
CC-10	45-46.5	<33	<67	<130
CC-11	7.5-9	<30	<60	<120
CC-11	17.5-19	**>33**	**>67**	**>130**
CC-11	42.5-44	<34	<68	<140
CC-12	7.5-9	<29	<59	**>120**
CC-12	32.5-34	<30	**>60**	<120
CC-13	7.5-9	<25	<51	<100
CC-13	45-46.5	<31	<62	<120
PW-5	composite	<36	<71	<140

Table 22 (cont'd)
Soil Results for WTPH-HCID Screening
Contract Area C

Soil Borings/ Test Pits	Sampling Depth (feet bgs)	WTPH-HCID Screening Analysis (mg/kg)		
		Gasoline	Diesel	Heavy Oil
Test Pits				
TP-1	7-8	< 20	< 50	< 100
TP-7	4-5	<20	< 50	> 100
TP-9	5-6	< 20	< 50	< 100
TP-11	7-8	<20	< 50	> 100
TP-12	5-6	< 23	< 58	> 116
TP-13	3-4	< 26	< 64	>128
TP-14	3-4	< 26	< 65	> 130
TP-14	9-10	< 24	< 60	> 120
Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.				

Table 23
Soil Results for WTPH-Dx Analysis
Contract Area C

Soil Borings/Test Pits	Sampling Depth (feet bgs)	WTPH-D extended (mg/kg)	
		Diesel	Heavy Oil
MTCA Method A Cleanup Levels		200	200
Soil Borings			
CC-1	10-12	140	**530**
CC-1	20-22	**260**	**420**
CC-2	5-7	160	**920**
CC-2	30-32	**740**	**2,300**
CC-3	7-9	< 32	71
CC-11	17.5-19	**680**[1]	180
CC-12	7.5-9	80[2]	190
CC-12	32.5-34	180	< 60
Test Pits			
TP-7	4-5	62	120
TP-11	7-8	< 31	< 62
TP-12	5-6	130	**310**
TP-13	3-4	56	**240**
TP-14	3-4	84	**220**
TP-14	9-10	60	**580**

Bold indicates concentration exceeds MTCA Method A Cleanup Level of 200.

[1] Chromatogram atypical of diesel pattern.

[2] Diesel results elevated by hydrocarbons in the heavy oil range.

Table 24
Soil Results for PAH Analysis
Contract Area C

Compound	Sample Locations and Concentrations (mg/kg)					
	CC-1 (20-22)	CC-2 (30-32)	TP-14 (3-4)	CC-11 (17.5-19)	CC-12 (7.5-9)	CC-12 (32.5-34)
Naphthalene	0.048	0.34	0.086	98	0.13	0.27
2-Methylnaphthalene	0.058	0.20	0.052	200	.011	0.19
Acenaphthylene	< 0.033	0.13	< 0.04	12	0.14	< 0.040
Acenaphthene	< 0.033	1.6	0.069	130	0.42	1.9
Dibenzofuran	< 0.033	< 0.051	< 0.04	9.1	0.087	1.8
Fluorene	< 0.033	2.6	0.076	74	0.2	2.3
Phenanthrene	< 0.033	12	0.41	190	0.54	7.2
Anthracene	< 0.033	3.5	0.11	59	0.26	1.0
Carbazole	< 0.033	< 0.051	< 0.04	1.6	0.045	0.070
Fluoranthene	0.053	11	0.37	58	0.66	2.4
Pyrene	0.059	7.9	0.47	68	0.63	1.7
Benzo(a)anthracene *	< 0.033	2.0	0.22	30	0.21	0.33
Chrysene *	< 0.033	2.0	0.27	30	0.28	0.31
Benzo(b)fluoranthene *	< 0.033	1.0	0.19	14	0.17	0.10
Benzo(k)fluoranthene *	< 0.033	0.99	0.19	19	0.17	0.13
Benzo(a)pyrene *	< 0.033	1.3	0.25	21	0.20	0.15
Indeno(1,2,3-cd)pyrene *	< 0.033	<0.051	0.077	1.3	< 0.040	< 0.040
Dibenz(a,h)anthracene*	< 0.033	0.18	0.044	>0.88	< 0.040	< 0.040
Benzo(g,h,i)perylene	< 0.033	0.38	0.078	>0.88	< 0.040	< 0.040
Total Carcinogenic PAHs	< 0.033	**7.47**	**1.24**	**241**	**1.03**	**1.02**

* Carcinogenic PAH
Bold indicates concentration exceed MTCA Method A Cleanup Level for Total Carcinogenic PAH of 1.0 mg/kg in soil.

Table 25
Groundwater Results for WTPH-HCID Screening
Contract Area C

Monitoring Well	Well Screen Depth (feet bgs)	WTPH-HCID Screening Analysis (ug/L)		
		Gasoline	Diesel	Heavy Oil
MTCA Method A Cleanup Levels		Sum < 1000		
CC-1[a]	30-40	< 250	< 630	< 630
CC-2[a]	20-30	< 250	< 630	< 630
CC-3A[a]	15-20	< 250	< 630	< 630
CC-3A[1]	15-20	< 250	< 630	< 630
CC-3C	40-50	< 250	< 630	< 630
CC-4	15-20	< 250	< 630	< 630
CC-5	20-30	< 250	< 630	< 630
CC-6	30-40	< 250	< 630	< 630
CC-7	25-35	< 250	< 630	< 630
CC-8	70-80	< 250	< 630	< 700
CC-9	50-60	< 250	< 630	< 700
CC-10	30-40	<250	<630	<630
CC-11	60-70	< 250	< 630	< 630
CC-12[b]	32-42	**> 250**	**> 630**	< 630
CC-13	20-25	**> 250**	< 630	< 630
PW-5 8-hour	22-39	<250	<630	<630
PW-5 Final	22-39	<250	<630	<630

Bold indicates concentration exceeds WTPH-HCID screening level. Additional TPH analysis required to quantify.

[1] Resampled during final investigation.

[a] Results of PAH analysis discussed in text

[b] WTPH-Dx and PAH analysis results discussed in text

Table 26

Groundwater Results for BTEX and WTPH-G Analysis

Contract Area C

Monitoring Well	WTPH-G (ug/L)	EPA SW-846 Method 8020 (ug/L)			
		Benzene	Ethylbenzene	Toluene	Xylene (total)
MTCA Method A Cleanup Levels	TPH < 1000	5	30	40	20
CC-1	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-2	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-3A	480	1.0	< 1.0	< 1.0	< 1.0
CC-3A[1]	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-3C	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-4	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-5	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-6	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-7	< 100	< 1.0	< 1.0	< 1.0	< 1.0
CC-12	**1,200**	4.8	3.7	1.5	8.3
CC-13	120	< 1.0	1.4	< 1.0	3.5

[1] Resampled during final investigation.

5.0 Conclusions

This report is a limited Phase II ESA and does not provide a complete site characterization. Soil and groundwater sampling was limited to the soil borings and monitoring wells installed as part of the geotechnical investigation of the Contract Areas A, B, and C. The Phase II activities were intended to identify potential contaminants of concern and to determine general locations where contamination may be encountered during construction. The Phase II ESA was not intended to delineate the vertical or horizontal extent of soil or groundwater contamination identified. Conclusions regarding the location of identified contamination and the magnitude of the contamination are provided in this section. Potential contaminants of concern were compared with State of Washington standards (Model Toxics Control Act (MTCA) Method A Cleanup Levels). Table 27 provides a summary of detections above cleanup standards.

Overall, soil contamination above MTCA Method A cleanup levels, primarily from diesel and heavy oil, was identified in soil samples analyzed near the proposed locations for the Elliott West Outfall and Denny Way Diversion Structure and along the southeastern portion of the Elliott West CSO and Effluent Pipeline alignments. On the basis of the soil samples analyzed during Phase II ESA, heavy oil and diesel were identified in soil samples collected between 0 and 34 feet below ground surface in these areas. A groundwater sample collected from this area also contained TPH above MTCA Method A cleanup levels. In addition, carcinogenic PAHs were detected above the MTCA Method A cleanup level in two borings and a test pit along the southeastern portion of the Elliott West CSO and Effluent Pipeline alignments. PAHs and diesel were detected above cleanup levels in a sample collected from the northern portion of the Elliott West CSO and Effluent Pipeline alignment, near the Elliott West CSO Control Facility.

Concentrations of tetrachlorothene, trichloroethene, 1,2-dichloroethene, and/or vinyl chloride above the MTCA Method A cleanup levels were detected in the groundwater sample submitted for analysis from monitoring wells BB-8, BB-12 and BB-13 near the East Tunnel Portal/Drop Structure and along the South Lake Union CSO Pipeline alignment. No other groundwater samples submitted for chemical analysis contained concentrations of analyzed contaminants above the MTCA Method A cleanup levels. The following sections discuss the results of the investigation by area.

5.1 Contract A

5.1.1 Mercer Street Tunnel Alignment

No potential contaminants of concern were detected above MTCA Method A cleanup levels in soil and groundwater samples obtained along the Mercer Street Tunnel alignment at its proposed depth. There were no soil samples collected during the Phase II ESA that contained detectable concentrations of TPH. Lead was detected in a soil sample collected from TB-1 at 9 to 10 feet bgs. This lead result was below the MTCA Method A cleanup levels.

Groundwater samples from monitoring wells TB-6 and TB-8 contained detectable concentrations of toluene. These concentrations were significantly below MTCA Method A cleanup levels; however, several sites with potentially contaminated groundwater were identified nearby during the Phase I ESA. Well BB-8, located near the East Tunnel Portal Drop Structure contained VOCs above cleanup levels in groundwater samples collected from the upper aquifer.

5.1.2 Elliott West CSO Control Facility

TPH at concentrations below the MTCA Method A cleanup levels was detected in the soil sample from soil boring CB-3 at the Elliott West CSO Control Facility. Diesel (41 mg/kg) and heavy oil (98 mg/kg) were detected in the soil sample from 5 to 6 feet bgs at concentrations below the MTCA Method A cleanup level of 200 mg/kg. Groundwater samples contained no detectable concentrations of TPH or BTEX compounds.

The Elliott West CSO Control Facility is located on a property where the Phase I ESA reported five USTs were removed in 1991. TPH contaminated soil was removed from the site; however, some contaminated soils were reported to be left in place because of excavation limitations resulting from the nearby railroad tracks. Soil boring CB-3 is located on the west side of the property closest to the railroad tracks (Figure 1). In addition, boring CC-11, located just west of the Elliott West CSO Control Facility footprint, contained diesel and PAHs above cleanup levels.

5.1.3 Elliott West Outfall

Soil boring OB-1 was drilled near the proposed Elliott West Outfall located in Myrtle Edwards Park northeast of the CSO Outfall Transition Structure. TPH was identified in soil samples collected from OB-1. Heavy oil was detected at 280 mg/kg between 5 and 6 feet bgs and at 200 mg/kg between 10 and 12 feet bgs, which exceeds the MTCA Method A cleanup level of

200 mg/kg. The soil sample analyzed from 15 to 16 feet bgs in OB-1 did not contain detectable concentrations of TPH. Soil samples from boring CC-1 and test pit TP-12 located near the proposed Denny Way Diversion Structure, approximately 120 feet east of soil boring OB-1, also contained concentrations of diesel and heavy oil above MTCA Method A cleanup levels. TPH and BTEX contamination was not detected in the groundwater sample collected from monitoring well OB-1.

5.2 Contract B

5.2.1 South Lake Union CSO Pipeline and East Tunnel/Portal Drop Structure

Analytical results for soil samples from soil borings BB-6 through BB-8 and BB-12 through BB-14 indicate there are no potential contaminants of concern identified in soil along the South Lake Union CSO Pipeline and at the East Tunnel Portal Drop Structure. No soil samples collected during the Phase II ESA contained concentrations of TPH exceeding MTCA Method A cleanup levels.

Analytical results for groundwater samples indicate that potential contaminants of concern above MTCA Method A cleanup levels were detected in the groundwater sample submitted for analysis from monitoring wells BB-8, BB-12 and BB-13. These monitoring wells were installed near the East Tunnel Portal/Drop Structure and along the South Lake Union CSO Pipeline alignment 30 to 45 feet bgs in the glacial drift. These groundwater samples contained detectable concentrations of tetrachloroethene; trichloroethene; (cis) and (trans) 1,2-dichloroethene; and/or vinyl chloride which exceeded the MTCA Method A cleanup levels.

5.2.2 Central Trunk CSO Pipeline and Central Trunk Diversion Structure

Analytical results for soil and groundwater samples from monitoring well BB-10 indicate there are no potential contaminants of concern identified in soil along the Central Trunk CSO Pipeline and at the Central Trunk Diversion Structure. No soil samples analyzed during the Phase II ESA contained concentrations of TPH exceeding the WTPH-HCID screening levels. No soil samples from the area were analyzed further on the basis of the screening results. No compounds above MTCA Method A cleanup levels were detected in the groundwater sample from monitoring well BB-10.

5.2.3 Lake Union Tunnel CSO Pipeline and Lake Union Tunnel Regulator Station

Analytical results for soil samples from BB-1 through BB-5, BB-9 and BB-11 indicate there are no contaminants of concern identified along the Lake Union Tunnel CSO Pipeline alignment, or near the proposed Lake Union Tunnel Regulator Station location. No soil samples analyzed during the Phase II ESA contained concentrations of TPH exceeding the WTPH-HCID screening levels. BTEX and SVOCs were not detected in the soil sample analyzed from 15 to 17 feet bgs in soil boring BB-5.

Analytical results for groundwater samples indicate that potential contaminants of concern were only detected in the sample submitted for analysis from monitoring well BB-5. Monitoring well BB-5 was installed in the northern portion of the Lake Union Tunnel CSO Pipeline and monitors groundwater 30 to 40 feet bgs in the glacial drift. The groundwater sample from monitoring well BB-5 contained concentrations of 1,1,1-trichloroethene and 1,2-dichloroethene at 3.3 and 1.1 ug/L, respectively. These concentrations are below the MTCA Method A cleanup levels of 200 and 5 ug/L, respectively.

5.3 Contract C

5.3.1 Denny Way Diversion Structure

Diesel and heavy oil were detected in two soil samples submitted for analysis from soil boring CC-1 near the Denny Way Diversion Structure. Heavy oil (530 mg/kg) was detected above the MTCA Method A cleanup level of 200 mg/kg in the soil sample submitted from 10 to 12 feet bgs. Both diesel (260 mg/kg) and heavy oil (420 mg/kg) were detected above the MTCA Method A cleanup level of 200 mg/kg in the soil sample submitted from 20 to 22 feet below ground surface (Table 27). However, this soil sample was collected from below the anticipated depth of excavation during construction. Concentrations of total carcinogenic PAHs detected in the soil sample from CC-1 at 20 to 22 feet bgs did not exceed the MTCA Method A cleanup level.

Soil samples were also submitted from test pit TP-12, excavated near OB-1. Heavy oil (310 mg/kg) above the 200 mg/kg MTCA Method A cleanup level was detected in the soil sample submitted from 5 to 6 feet below ground surface in this test pit.

No detectable concentrations of TPH or BTEX were identified in the groundwater sample submitted from monitoring well CC-1. Monitoring well CC-1 monitors groundwater from 30 to 40 feet below ground surface, below the depth of identified soil contamination at this location.

5.3.2 Elliott West CSO Pipeline and Effluent Pipeline Alignment

Analytical results for soil samples from borings and test pits indicate that high concentrations of heavy oil ranging from 71 to 2,300 mg/kg and diesel ranging from 56 to 720 mg/kg were detected from 5 to 32 feet below ground surface along the pipeline alignment. TPH contamination detected above MTCA Method A cleanup levels in soil samples appears to be limited to approximately the southeastern 600 feet along the Elliott West CSO Pipeline and Effluent Pipeline alignments. Soil samples collected between 5 and 32 feet below ground surface from borings CC-1, CC-2 and CC-12; and test pits TP-12, TP-13, and TP-14 contained concentrations of heavy oil above the MTCA Method A cleanup levels (Table 27). CC-2 and CC-12 between 30 and 34 feet bgs also contain PAHs above MTCA Method A cleanup levels. Samples collected between 5 and 12 feet bgs represent the proposed depths within the pipeline alignment and above the alignment where soil excavation will be performed during construction activities. Soil samples collected from 20 to 22 feet below ground surface in boring CC-1 and 30 to 34 feet below ground surface in borings CC-2 and CC-12 were collected from below the anticipated depth of the pipelines.

Analytical results for groundwater samples indicate that potential contaminants of concern were detected in the groundwater sample submitted for analysis from monitoring well CC-3 located along the proposed Elliott West CSO Pipeline and Effluent Pipeline alignments (Figure 1). The groundwater sample from monitoring well CC-3 contained 480 ug/L of TPH as gasoline and 1 ug/L benzene. These concentrations are below the MTCA Method A cleanup levels of 1,000 ug/L for TPH and 5 ug/L for benzene.

Groundwater collected from monitoring well CC-12, near the proposed location of the EBI Control Structure, contained TPH above MTCA Method A cleanup levels. PAHs were detected in groundwater from CC-12, but concentrations of total carcinogenic PAHs did not exceed the MTCA Method A cleanup levels. This well monitors water below the planned depth of the Elliott West CSO and Effluent Pipelines and below the depth of identified soil contamination, but it may be representative of groundwater collected during dewatering activities.

Table 27
Detection Above MTCA Method A Cleanup Levels

Location	Sample	Depth (feet bgs)	Compound	Concentration[1]	MTCA Method A[1]
Soil					
Contract A- Elliott West Outfall	OB-1	5 - 6	Heavy Oil	280	200
	OB-1	10 - 12	Heavy Oil	200	200
Contract C - Denny Way Diversion Structure	CC-1	10 - 12	Heavy Oil	530	200
	CC-1	20 - 22	Diesel	260	200
	CC-1	20 - 22	Heavy Oil	530	200
Contract C - Elliott West CSO/Effluent Pipelines - South End	CC-2	5 - 7	Heavy Oil	920	200
	CC-2	30 - 32	Diesel	740	200
	CC-2	30 - 32	Heavy Oil	2,300	200
	CC-2	30 - 32	PAHs	7.47	1.0
	CC-12	7.5 - 9	PAHs	1.03	1.0
	CC-12	32.5 - 34	PAHs	1.02	1.0
	TP-12	5 - 6	Heavy Oil	310	200
	TP-13	3 - 4	Heavy Oil	240	200
	TP-14	3 - 4	Heavy Oil	220	200
	TP-14	3 - 4	PAHs	1.24	1.0
	TP-14	9 - 10	Heavy Oil	580	200
Contract C - Elliott West CSO/Effluent Pipelines - North End & CSO Control Structure	CC-11	17.5 - 19	Diesel	680	200
	CC-11	17.5 - 19	PAHs	241	1.0
Groundwater					
Contract B - South Lake Union Pipeline East Tunnel Portal/ Drop Structure (BB-8)	BB-8[2]	30 - 40	Vinyl Chloride	280	0.2
	BB-8[2]	30 - 40	(trans) 1,2-Dichloroethene	14	5.0
	BB-8[2]	30 - 40	(cis) 1,2-Dichloroethene	4,200	5.0
	BB-8[2]	30 - 40	Trichloroethene	1,500	5.0
	BB-8[2]	30 - 40	Tetrachloroethene	11,000	5.0
	BB-12	35 - 45	Vinyl Chloride	380	0.2
	BB-12	35 - 45	(cis) 1,2-Dichloroethene	540	5.0
	BB-13	35 - 45	Vinyl Chloride	1.1	0.2
Contract C - Elliott West CSO/Effluent Pipelines - South End	CC-12	32 - 42	TPH	2,030	1000

[1] Soil concentrations are in mg/kg. Water concentrations are in ug/L.
[2] Results are from the sample collected during the final phase of the investigation.

6.0 References

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