Seattle Public Utilities
King County
Ship Canal Water Quality Project

Preliminary Engineering Report

BALLARD CONVEYANCE WORK PACKAGE

AUGUST 30, 2018

This Preliminary Engineering Report has been prepared under the direction of the following Registered Professional Engineer

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List of Abbreviations

AACE	Association for the Advancement of Cost Engineering
BTRR	Ballard Terminal Railroad
CSO	combined sewer overflow
CSS	combined sewer system
DNRP	Department of Natural Resources and Parks
HDPE	high density polyethylene
KC	King County
MH	maintenance hole
NAVD88	North American Vertical Datum of 1988
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
SCWQP	Ship Canal Water Quality Project
SDOT	Seattle Deaprtment of Transportation
SIP	Street Improvement Permit
SPU	Seattle Public Utilities
SSO	Sanitary Sewer Overflow
TEP	Tunnel Effluent Pump Station
WAC	Washintgon Administrative Code
WTD	Waste Treatment Division

Section 1. Executive Summary

The purpose of the Ship Canal Water Quality Project (SCWQP) is to provide offline storage for the combined sewer overflow (CSO) flows from five Seattle Public Utilities (SPU) and two King County Department of Natural Resources and Parks (DNRP) CSO basins to meet regulatory requirements, Section S.8 of SPU’s National Pollutant Discharge Elimination System (NPDES) permit (WA0031682), Section V.B.14 of the City of Seattle’s Consent Decree (Civil Action No. 2:13-cv-678; United States of America, 2013a), and Section V.B.15 of King County’s Consent Decree (Civil Action No. 2:13-cv-677; United States of America, 2013b). The SCWQP storage is a deep tunnel constructed under the Ballard, Fremont and Wallingford neighborhoods, on the north side of the Ship Canal. It will control the Ballard CSO Basins 150/151 and 152, Fremont Basin 174 and Wallingford Basin 147; and DNRP 3rd Avenue W Basin, and 11th Avenue NW Basin. The main components of the Ship Canal Water Quality Project are the 18-foot 10-inch diameter storage tunnel, drop shafts, appurtenances, conveyance facilities, and pump station.

One of the work packages of SCWQP is Ballard Conveyance which collects CSOs from SPU Ballard Basins 150/151 and 152 and routes it to the storage tunnel. The purpose of this project is to collect basin flows that would be released through Outfall 152 and Outfall 151 (Outfall 150 will be removed prior to the construction of Ballard conveyance project) and bring these CSO Basins into regulatory compliance by reducing the frequency of overflow to an average of one overflow per year per outfall on a rolling 20-year average.

1.1 Project Description

The scope of the Ballard Conveyance project includes the planning, design and construction of a conveyance system to capture flows from Ballard Basins and transport it to the storage tunnel. The main components of the project include diversion structures that divert flows from basins, conveyance pipes that transport flows to Tunnel Effluent Pump Station (TEPS) site, gate vaults that regulate flows going to the tunnel and maintenance holes used for accessing and maintaining conveyance pipes.

The SCWQP Facility Plan (SPU, March 2017) had identified three options to route flows from Ballard Basins to the storage tunnel. These options pertain to three alignments within the Ballard neighborhood: NW 56th Street, NW Market Street and NW 54th Street for placement of conveyance pipes for Basin 152 flows. These options were evaluated in combination with one alignment identified for routing Basin 150/151 flows. Options Analysis further developed and evaluated these three options to recommend an alignment to move forward into design and construction. The options evaluated were:

- Option 1: NW 56th Street and 24th Avenue NW alignment for Basin 152 conveyance with 2,230 feet of 60-inch diameter pipe, and 24th Avenue NW alignment for Basin 150/151 conveyance with 150 feet of 48-inch diameter pipes

- Option 2: NW Market Street and 24th Avenue NW alignment for Basin 152 conveyance with 2,050 feet of 60-inch diameter pipe, and 24th Avenue NW alignment for Basin 150/151 conveyance with 150 feet of 48-inch diameter pipes

- Option 3: NW 54th Street and 24th Avenue NW alignment for Basin 152 conveyance with 1,530 feet of 60-inch diameter pipe, and 24th Avenue NW alignment for Basin 150/151 conveyance with 150 feet of 48-inch diameter pipes

1.2 Hydraulic Modeling

Hydrologic and hydraulic modeling was conducted for Ballard Basins to support Option Analysis and help inform design parameters including diversion structure weir lengths; diameter of conveyance pipes; measures to control flow leaving the diversion structure; and potentials for sanitary sewer overflows (SSO) in the normal flow system. The Ballard hydraulic model was used to simulate hydraulic performance of wet weather events from 1978 through 2015 and conduct evaluations. The findings include:

- For Ballard 152 conveyance, initial long-term computer modeling simulations (1978 through 2015) adjusted for climate change factors showed that the project performance criteria outlined in Appendix A, can still be met by reducing the proposed 60-inch diameter conveyance to 48-inch diameter pipe. The reduction of pipe diameter adds two more CSO events while meeting the CSO frequency regulatory compliance requirement. During design, the project team will further analyze reducing pipe diameter to 48-inch.

- System surcharge evaluations on the normal flow path along NW Market Street, showed that a fixed orifice opening of 13.5 inches in diameter upstream of the combined sewer pipe along NW Market Street can mitigate possible surcharging to the surface (SSOs) during extreme wet weather events

- Diversion structure design dimension evaluations showed that weir crest lengths can be optimized between 10 to 20 feet with a combination of different weir elevations.

1.3 Preliminary Geotechnical Explorations

Preliminary geotechnical evaluations were conducted at four locations along NW 56th Street and NW Market Street with bore holes, and observation wells which were screened for contamination. One of the test locations along NW Market Street showed the soil to be lead contaminated between 5 and 15 feet below ground surface.

1.4 Triple Bottom Line Analysis

The impacts of the three proposed options were evaluated in five major areas:

1. Short Term Community Impact (during construction)
2. Long Term Community Impacts
3. Construction Risk
4. Construction Complexity
5. Ease of Maintenance

Triple Bottom Line analysis was conducted based on the above evaluation criteria. This process quantified the values of options based on several evaluation criteria and identified the tradeoffs between competing objectives from multiple stakeholders. The project team made up of representatives from the design team, operation, maintenance, asset management, communication, construction management, and instrumentation and control conducted the value modeling process which had the following steps:

1) Identification of evaluation criteria
2) Development of performance measure scales
3) Assignment of weights to the evaluation criteria
4) Scoring of evaluation criteria (based on 2 and 3)
5) Calculation of option's values
6) Pairing of option's values with life cycle costs

The results of the value modeling process showed the cumulative values of each of the options and compared it to the respective life-cycle costs as shown in ***Figure*** ES-1-1.

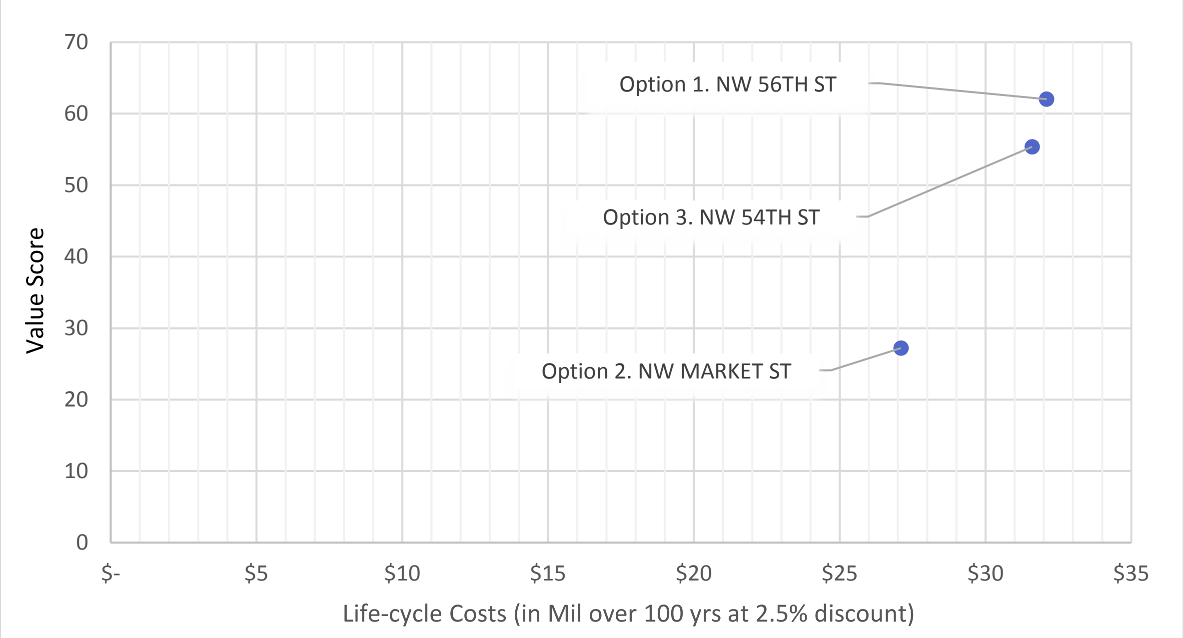

Figure ES-1-1. Total Life-Cycle Cost of Options vs Value

1.5 Recommended Option

The Tripe Bottom Line analysis and subsequent value modeling process showed that Option 1 and Option 3 have the highest and second highest values. Evaluation of the proposed alternatives shows that Option 1 along NW 56th Street and 24th Avenue NW offers the most economic value of all the options evaluated. This option was selected as the recommended alternative to construct the Ballard Conveyance system.

Option 3 was shown to have more risks in terms of impacts to truck traffic which is integral to businesses along NW 54th Street and carries a larger risk in terms of encountering contaminated material and contaminated groundwater during construction. The impacts to traffic and associated risks with environmental contamination results in higher risk to project schedule and budget.

The recommended alternative, Option 1 along NW 56th Street, was presented to the Asset Management Committee (AMC) on August 8, 2018 for Stage Gate 2 approval and was aaccepted.

Section 2. Existing System

2.1 Existing System Description

The Ballard CSO Area comprises approximately 1,170 acres in northwest Seattle bounded by 30th Avenue NW to the west, 15th Avenue NW to the east, NW 85th Street to the north, and Ship Canal to the south (***Figure 2-1***). The area is divided into Basins 150/151 (401 acres), and Basin 152 (769 acres) which drain from north to south toward Ship Canal and Salmon Bay. The wastewater generated in Ballard Basins flows by gravity through the SPU combined sewer system on Shilshole Avenue NW to DNRP's Ballard Regulator and into the Ballard Siphon for conveyance to the West Point Treatment Plant. Basins 152 and 150/151 contain permitted CSO outfalls, NPDES 150, NPDES 151, and NPDES 152, which discharge overflows to Salmon Bay during wet weather events when the capacity of the combined sewer system is exceeded.

The Ballard CSO Basins contain combined sewer system that conveys both sanitary and stormwater flow. The combined sewer system in Ballard have areas that are fully combined, and others partially separated. Fully combined systems are systems in which sanitary sewer and stormwater runoff flows are combined and conveyed in the same pipe. While partially separated systems are systems in which stormwater from roof and foundation drains combine with sanitary sewer and are conveyed in the same pipe; and stormwater from roadways is conveyed in a separate drainage pipe.

Within the Ballard basins, the area to the north of NW 65th Street (about two-thirds of the total area) is fully combined. The area south of NW 65th Street is partially separated. The combined sewer and drainage systems are shown in ***Figure 2-1***. The wastewater collection system in the Ballard CSO area is summarized in ***Table 2-1***.

Table 2-1. Summary of Sewer Pipe in the Ballard CSO Area

Infrastructure	Description
Length of pipe (feet)	186,000
Pipe diameter range (inches)	6 to 48
Number of connecting structures	750+
City pump stations	1 (PS84)

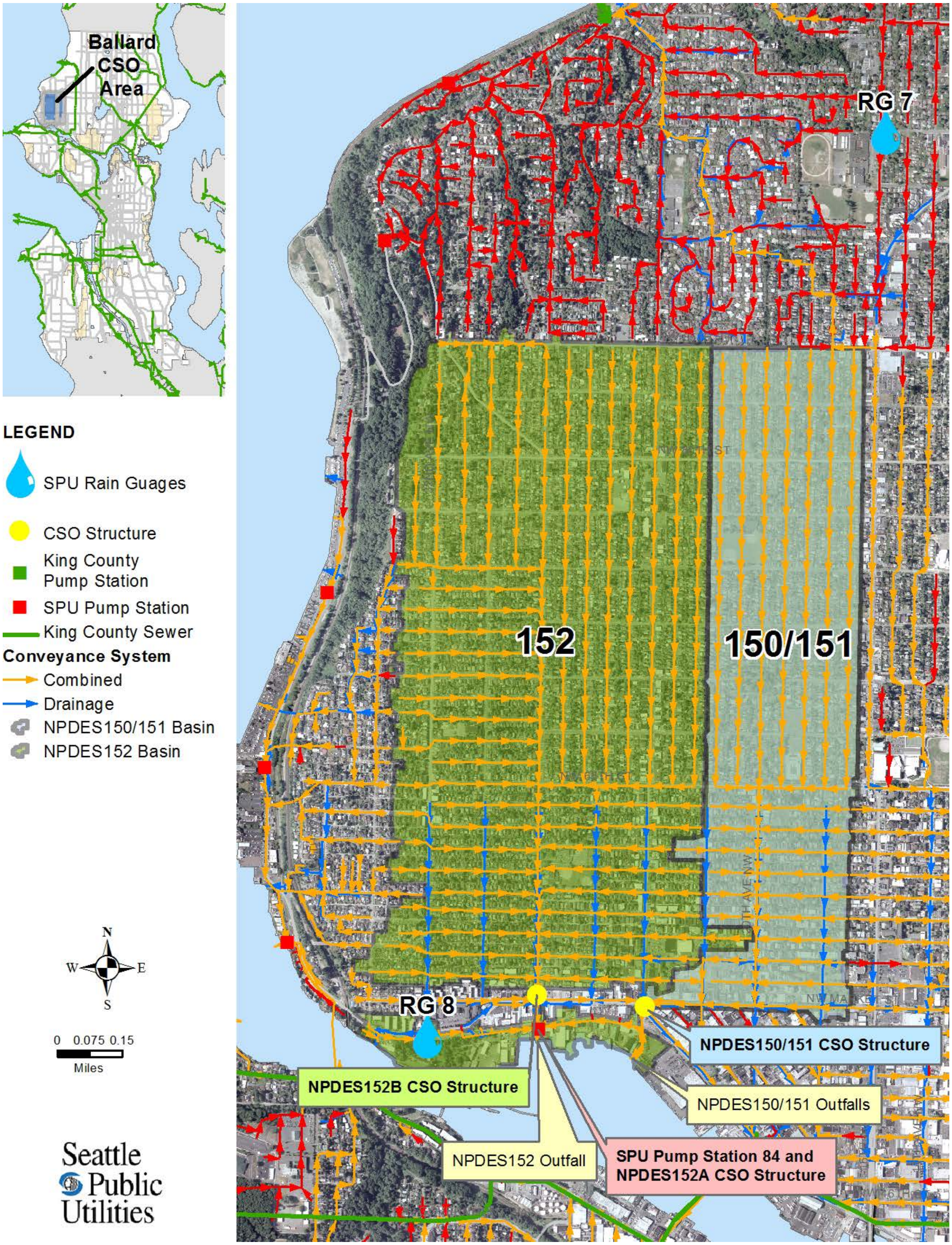

Figure 2-1. Ballard CSO Area Overview

2.1.1 Diversion Structures

Flows from Ballard Basin 150/151 are routed through overflow maintenance hole (MH) 011-184 which is located just south of the intersection of NW Market Street and 24th Avenue Northwest. During wet weather events, flow rises in MH 011-184 until it eventually crests over the overflow weir elevation of 38.31 feet North American Vertical Datum of 1988 (NAVD88) and is conveyed through a 30-inch combined sewer pipe to MH 011-236 that splits the flow to discharge to Salmon Bay through Outfalls 150 (30-inch diameter) and 151 (18-inch diameter). The existing flow diversion system for the basin is shown in ***Figure 2-2***.

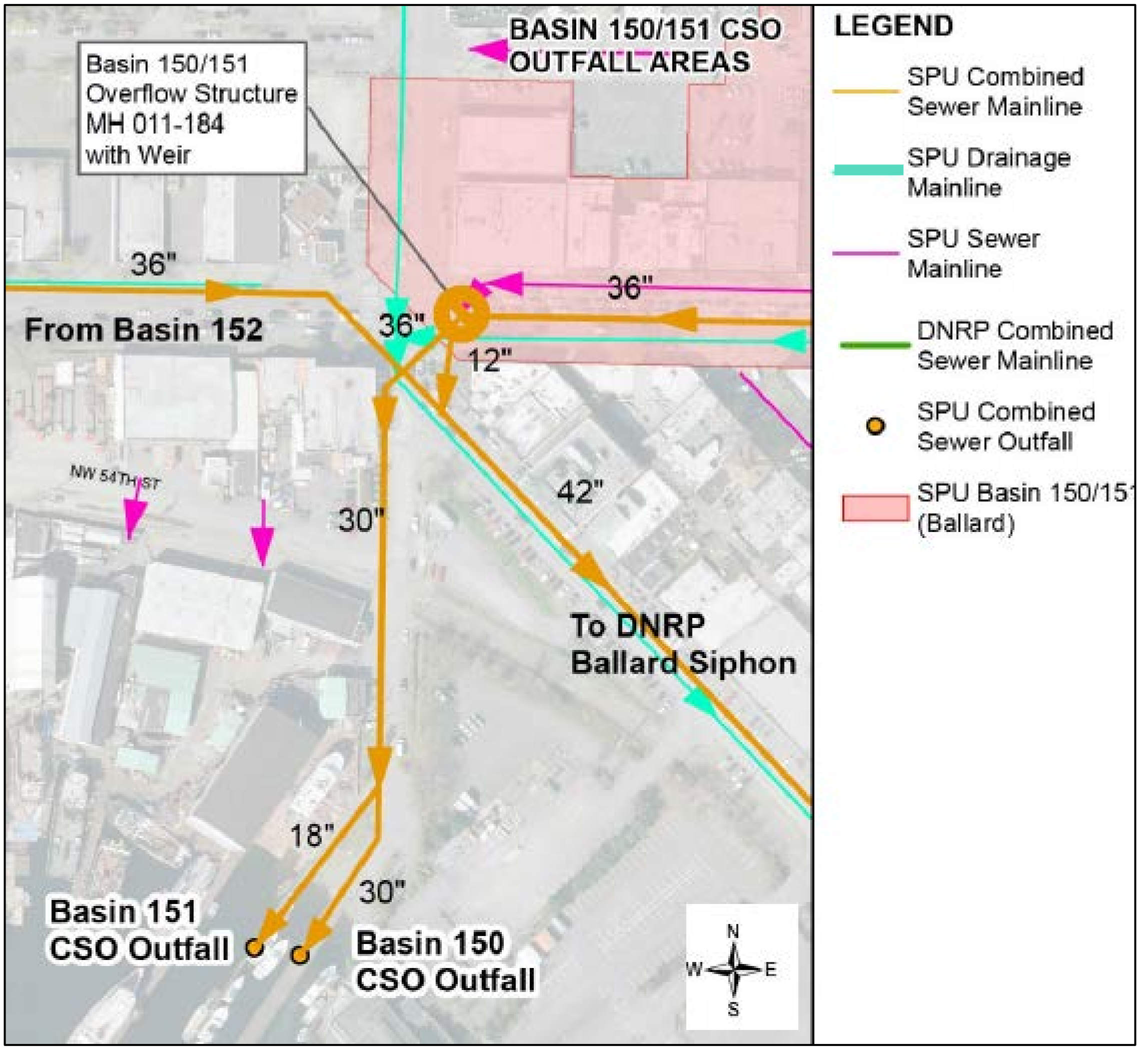

Figure 2-2. Basin 150/151 Flow Diversion Structures

Similarly, existing combined sewer flows for Basin 152 are routed through existing overflow MH 011-189 on 28th Avenue NW just north of NW Market Street. During wet weather events, flow rises in MH 011-189 until it eventually crests over the overflow weir elevation of 23.82 feet (NAVD88) and head downstream to discharge into Salmon Bay via NPDES 152 outfall (48-inch diameter). The existing flow diversion system for this basin is shown in ***Figure 2-3***.

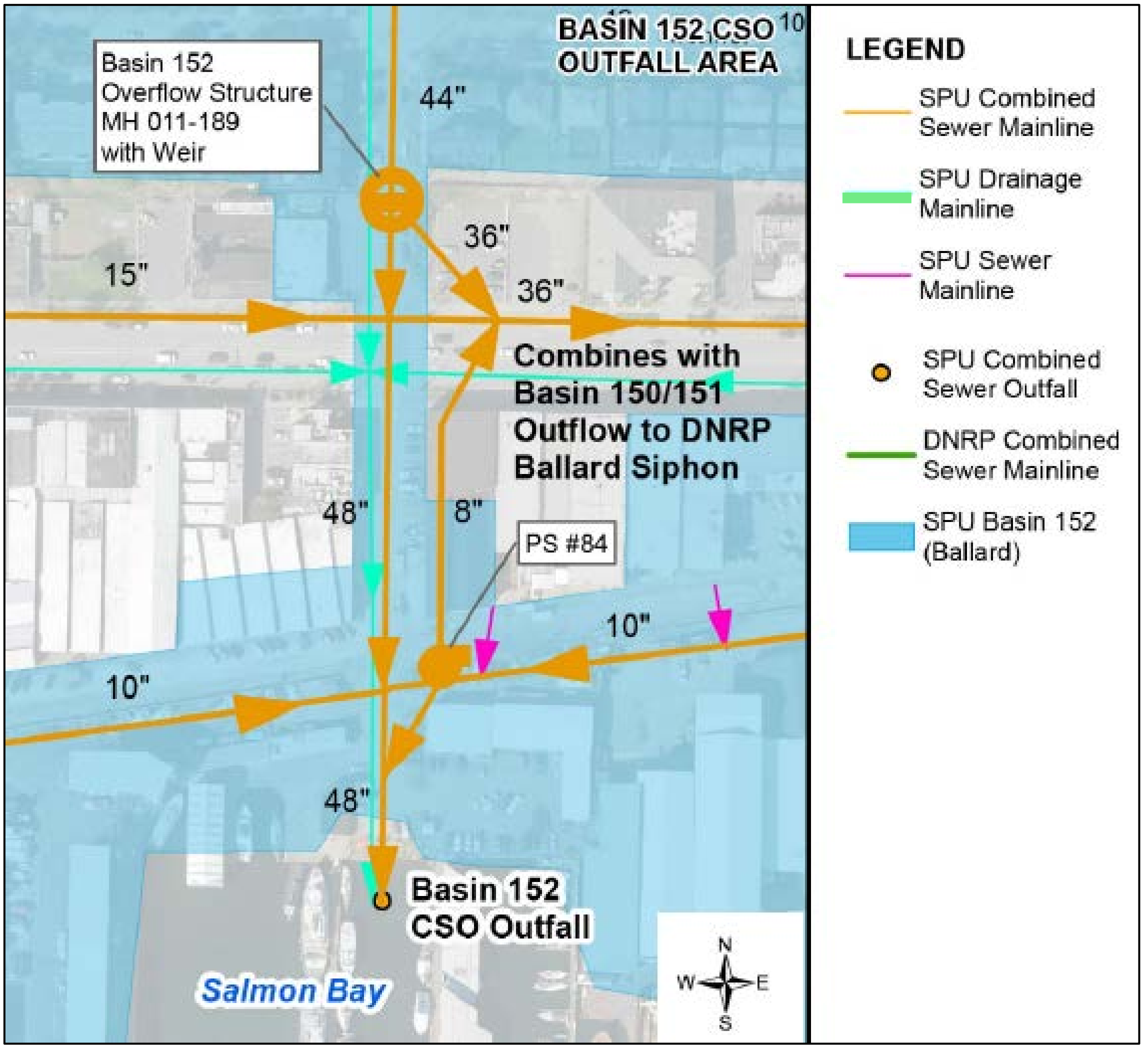

Figure 2-3. Basin 152 Flow Diversion Structures

2.1.2 Pump Station

Basin 152 contains a pump station, Pump Station 84, at the intersection of 28th Avenue NW and NW 54th Street. Pump Station 84 is a duplex pump station with constant-speed pumps and a maximum pumping capacity of 1.25 MGD. Pump Station 84 collects wastewater from a 38-acre area in the lower portion of Basin 152 and lifts flow towards the SPU combined sewer system along NW Market Street. When the maximum pumping capacity is reached and level within the wet well continues to rise, an overflow occurs at elevation 18.02 feet (NAVD88) via 10-inch diameter overflow pipe that discharges to Outfall 152 pipe.

2.1.3 Outfalls

CSO Basins 150/151 and 152 have permitted CSO outfalls that discharge overflows to Salmon Bay during wet weather events when the capacity of the combined sewer system is exceeded.

The overflow pipe downstream of Basin 150/151 splits into two separate outfalls, NPDES 150 and 151, at MH 011-236. Both outfalls are located south of the intersection of 24th Avenue NW and NW 54th Street. Outfall 151 is an 18-inch wood-stave pipe in poor condition while Outfall 150 is a new 30-inch high density polyethylene (HDPE) outfall installed along the west side of the existing pier on 24h Avenue NW. SPU plans to replace both the existing Outfall 150 and 151 with a single 48-inch diameter outfall with the SCWQP Ballard Early Works Package currently in construction with expected completion in 2019.

The Outfall for Basin 152 is located south of the NW 28th Avenue and 54th Street NW intersection. This pipe is a 48-inch wood-stave pipe that is in good condition. There are currently no plans to replace or repair this outfall.

2.2 Regulatory Requirement

Seattle is served by a combined sewer system (CSS) that handles both stormwater and wastewater generated by businesses and residents. Heavy rains can overwhelm combined sewer pipes and cause combined sewer overflows. These overflow discharge events can contribute pollutants to surrounding water bodies and impact their quality and uses.

The United States District Court Consent Decree number 2:13-cv-678 has mandated the City of Seattle to control sewer discharges to protect public health and the environment, in compliance with the Clean Water Act. The following laws and regulations require that the City and King County limit CSOs to a 20-year moving average of no more than one untreated discharge per year per permitted outfall:

Revised Code of Washington (RCW) 90.48.480—This law requires “the greatest reasonable reduction of combined sewer overflows.”

Washington Administrative Code (WAC) 173-245-020 (22)—"’The greatest reasonable reduction’ means control of each CSO in such a way that an average of one untreated discharge may occur per year.”

City of Seattle and King County’s National Pollutant Discharge Elimination System (NPDES) Permits and Consent Decrees—These direct that a moving 20-year period be used for long-term averaging of the overflow frequency (United States of America, 2013a and 2013b).

2.3 Existing Combined Sewer Overflow Performance

During wet weather events, the combined sewer system experiences overflows where combined sewage is released into the Ship Canal through NPDES 150,151, and 152 outfalls. SPU operates and maintains permanent monitoring equipment to track overflow frequency and estimate discharge volumes at each CSO outfall. ***Table 2-2*** lists the Ballard Basins CSO discharge volumes and frequencies recorded from 2013 through 2017.

Table 2-2. Ballard Basins CSO Frequency and Volumes

Outfall	Total Number of CSO Events	Average Number of CSO Events Per Year	Average Annual CSO Volume (MG)
150/151	136	27.2	2.9
152	244	48.8	37.7
TOTAL	**380**	**76.0**	**40.6**

Note: Data from Wastewater Collection System: 2017 Annual Report, March 2018

Section 3.Proposed Project

The Ballard Conveyance project proposes to construct a conveyance system that collects flows during wet weather events when capacity of existing combined sewer is reached. The overflows from existing Basins 150/151 and 152 will be routed to the storage tunnel at the Tunnel Effluent Pump Station (TEPS) site located at 24th Avenue NW and Shilshole Avenue NW. The main components of the project include diversion structures that divert flows from existing combined sewer system, conveyance pipes that transport flows from diversion structures to storage tunnel (TEPS site), gate valves that regulate flows to the tunnel and maintenance holes used for accessing and maintaining conveyance pipes.

The SCWQP Final Facility Plan (March 2017) identified three options for routing flows from Ballard Basins to the storage tunnel. The project team conducted options analysis to further develop these three options. To inform each option, the team developed project planning tools such as project requirements, project constraints, preliminary geotechnical assessment, hydraulic modeling, major utility conflicts, construction impacts, property acquisition, risk identification and project costs. For more information, refer to the following in the Appendix:

- Project Requirements: Guidelines to be used for further development of options, such as SPU design standards, permitting, health and safety, water quality requirements, hydraulic and operational performances, and maintenance; are documented in Appendix A: Ballard Conveyance Options Analysis Work Package: Project Requirement Memorandum (SPU, June 2018).
- Project Constraints: Summary of project constraints that the project options must meet are documented in Appendix B: Ballard Conveyance Options Analysis Work Package: Project Constraints Memorandum (SPU, June 2017).
- Construction Impacts: Construction related impacts and issues for each of the three proposed options are documented in Appendix C: Ballard Conveyance Options Analysis Work Package: Construction Impacts Memorandum (SPU, October 2017)
- Preliminary Plans and Profiles: Pipe layout, placement, and locations of hydraulic structures, maintenance holes and preliminary locations for pipe driving pits are shown in Appendix D
- Project Cost Estimate: Each option’s total project cost estimate are documented in Appendix E: Cost Estimate and Basis of Estimate.
- Hydraulic Modeling Report: Evaluation of hydraulic performance of option and associated hydraulic structures are documented in Appendix F and Section 3.4

- Preliminary Geotechnical Investigation Report: Investigations into subsurface conditions along the proposed conveyance pipe alignments are documented in Appendix G and Section 3.5
- Value Modeling Summary: Triple Bottom Line analysis steps and process of calculating the value of each option are summarized in Appendix H: Value Modeling Technical Memorandum.

Due to the close proximity to the TEPS site, only one alignment was developed for routing flows from existing combined sewer system of Basin 150/151 to the storage tunnel. The proposed conveyance system for the basin diverts flows from the existing 30-inch diameter overflow pipe 150 feet south of the intersection of 24th Avenue NW and NW 54th Street and then routed to TEPS site along 24th Avenue NW. Once storage tunnel is full, overflows are routed back to the existing 48-inch overflow pipe along 24th Avenue NW to discharge through Outfall 151. Ballard Early Work Package will construct 48-inch diameter pipe and Outfall 151 in 2018 and 2019.

The flows from Basin 152 flows can be routed along three different streets within the Ballard neighborhood based upon the geographical distance from where the flows are diverted to the TEPS site. The following three alignments were identified in the SCWQP Facility Plan (March 2017) for routing flows refer to ***Figure 3-1***:

Alignment 1: Basin 152 conveyance along NW 56th Street and 24th Avenue NW
Alignment 2: Basin 152 conveyance along NW Market Street and 24th Avenue NW
Alignment 3: Basin 152 conveyance along NW 54th Street and 24th Avenue NW

The conveyance pipes for Basin 150/151 and Basin 152 come together at a maintenance hole before connecting to the TEPS structure. This most downstream maintenance hole then connects to the TEPS structure with a 72-inch pipe that routes the flows from both basins.

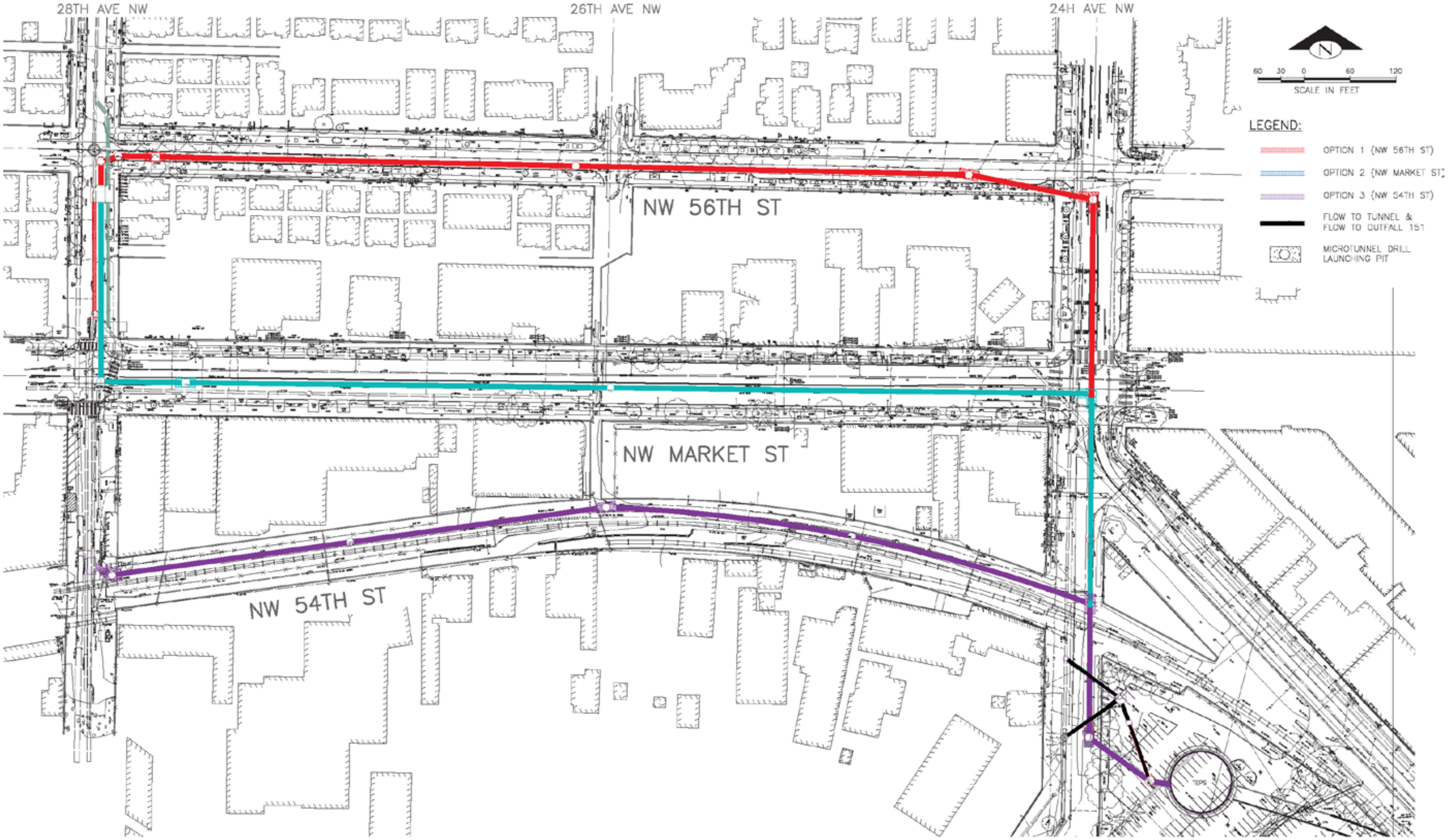

Figure 3-1. Basins 150/151 and 152 Conveyance Pipes Alignments Conceptual Layout

3.1 Option 1

3.1.1 Basin 150/151 Conveyance

A design flow rate of 60 million gallons per day (MGD) was used to size Basin 150/151 conveyance pipe to 48-inch diameter. These conveyance pipes were also designed to maintain a slope of 0.5% along the alignment with invert elevations ranging from 18.1 feet (NAVD 88) at proposed MH 2D to 17.5 feet (NAVD 88) invert at the maintenance hole upstream of the TEPS structure.

At the upstream end of the proposed conveyance system, overflows from Basin 150/151 will be diverted from the existing 30-inch combined sewer overflow flow pipe on 24th Avenue NW downstream of the basin's existing diversion structure at MH 011-233. The new 48-inch diameter conveyance pipe will then convey the basin's overflows from the existing 30-inch overflow pipe to the tunnel via a new diversion structure that will transfer flows to the tunnel first and then to the outfalls. The diversion structure will be housed within a new maintenance hole.

A gate valve vault will be placed 40 feet downstream of the new diversion structure to close off the flow routed to the tunnel when storage capacity is met within the tunnel. Flows will rise in new diversion structure MH 2D to the weir crest elevation of 23.06 feet (NAVD 88) and then overflow to the new Outfall 151 via a 48-inch pipe. Figure 3-2 shows the flow diversion and conveyance system for this basin.

The conveyance system for Basin 150/151 comes with three new maintenance holes; at the connection to the overflow line, at the proposed diversion structure, and at the connection to the outfall pipe. The conveyance system is located within the right of way adjacent to the TEPS site. The proposed construction method for installing these pipes is open trench construction. Power and backup power for the gate vault will be located within the TEPS facility. Refer to Appendix D for plan and profile.

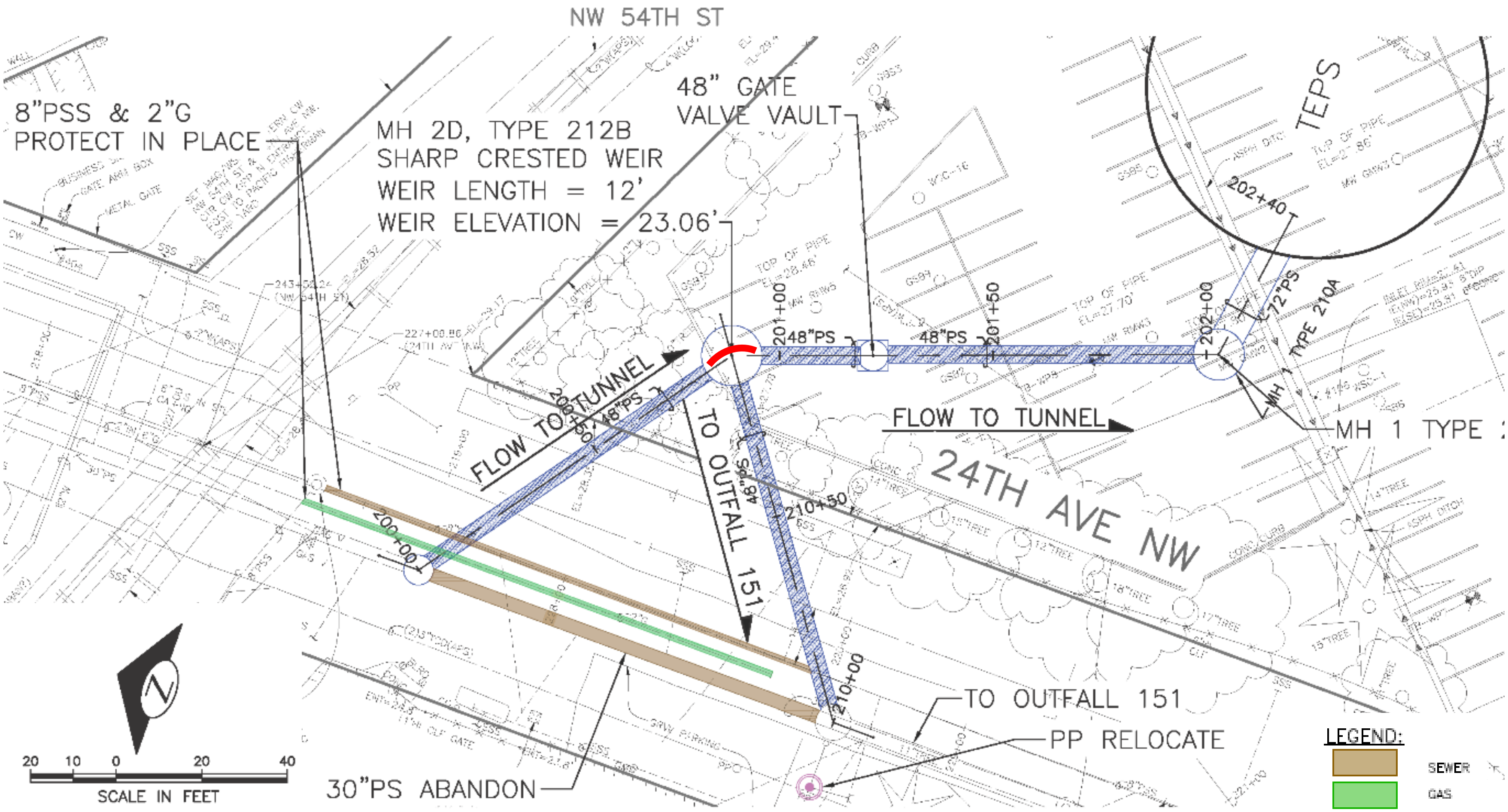

Figure 3-2. Basin 150/151 Conveyance System Layout

3.1.2 Basin 152 Conveyance – NW 56th Street

This option runs along NW 56th Street between 28th Avenue NW and 24th Avenue NW; and along 24th Avenue NW between NW 56th Street and NW 54th Street. NW 56th Street is two lane residential street with no public transit traffic.

A design flow rate of 125 million gallons per day (MGD) was used to size the Basin 152 conveyance pipe to 60-inch. The conveyance pipes maintain a slope of 0.5% along the alignment with invert elevations ranging from 18 feet (NAVD 88) at the diversion structure to 7.4 feet invert at the maintenance hole upstream of the TEPS structure.

This first option for conveyance pipe alignment will divert Basin 152 normal flows from the existing 42-inch brick combined sewer pipe via a new 48-inch pipe and route it to a new diversion structure south of the intersection of 28th Avenue NW and NW 56th Street. The diversion structure will be placed upstream of the existing diversion structure at the intersection of NW Market Street and 28th Avenue NW as shown in ***Figure 3-3***.

This structure will first route flows to the new 48-inch normal combined sewer path that runs south along 28th Avenue NW. During wet weather events, flow depth will rise in the diversion structure until it reaches the transfer weir elevation of 27.3 feet (NAVD88) and flows will then proceed to the tunnel through the proposed 60-inch conveyance pipe. Once the tunnel is full, the gate vault downstream of the diversion structure closes and the flow depth continues to rise until it reaches the overflow weir elevation of 29.33 feet NAVD88. Flows will then be diverted to the 48-inch pipe leading to Outfall 152. Refer to Appendix D for plan and profile.

The 60-inch diameter conveyance pipe will start from the diversion structure just south of the intersection of 28th Avenue NW and NW 56th Street, run north along 28th Avenue NW, turn east along NW 56th Street to 24th Avenue NW, south along 24th Ave NW and turn east at NW 54th Street into the West Portal TEPS site. To minimize direct conflicts with existing utilities, the pipes will be placed south of the centerline of NW 56th Street and east of the centerline on 24th Avenue NW. The conveyance pipe for this option has the longest length and the deepest pipe inverts.

Given the depth of the conveyance pipes, a combination of open trench excavation and trenchless installation is proposed for pipe installation. Open trench construction is proposed for the diversion structure as well as the 48-inch normal flow combined sewer connecting to the existing combined sewer system; the 48-inch overflow pipe connecting to NPDES 152; and the 60-inch conveyance pipes upstream of the gate valve vault.

Downstream of the gate valve vault, trenchless installation method is proposed for the conveyance pipe that spans about 1900 feet to the south end of 24th Avenue NW. As the conveyance pipes enter the TEPS site, about 100 feet of the 60-inch pipe will be installed with open trench excavation.

The trenchless construction method also comes with four pipe installation launch/retrieval pits which are used to house equipment for pipe driving and receiving the driven pipe. The launch pits are located at the gate valve vault on NW 56th Street (approximately 47 by 23 feet); at the east end of the NW 56th Street alignment (approximately 47 by 23 feet); at the intersection of 24th Avenue NW and NW 56th Street (L-shaped approximately 47 by 47 feet); and at the south end of 24th Avenue NW (approximately 47 by 23 feet). The locations and sizes for launch pits are preliminary and will be refined during design and construction.

This option includes seven maintenance holes along the conveyance pipe with depths below ground surface ranging from 18 feet downstream of the diversion structure, 40 feet at the intersection of 24th Avenue and NW 56th Street, to 15 feet at the TEPS site. Other hydraulic structures along the alignment include a gate valve vault, downstream of the diversion structure at about 50 feet east of the intersection of 24th Avenue NW and NW 56th Street.

The total project cost of Option 1 is $31,717,000 (Association for the Advancement of Cost Engineering [AACE] Class 4 estimate). This includes the cost of pipe; maintenance holes; pipe driving and installation pits; surface restoration; electrical equipment; utility relocations; and hydraulic structures and associated equipment. Other project costs include soft costs, and risk contingencies which were calculated from risk register analysis. For more information on costs, refer to the Basis of Estimate and breakdown of costs in Appendix E.

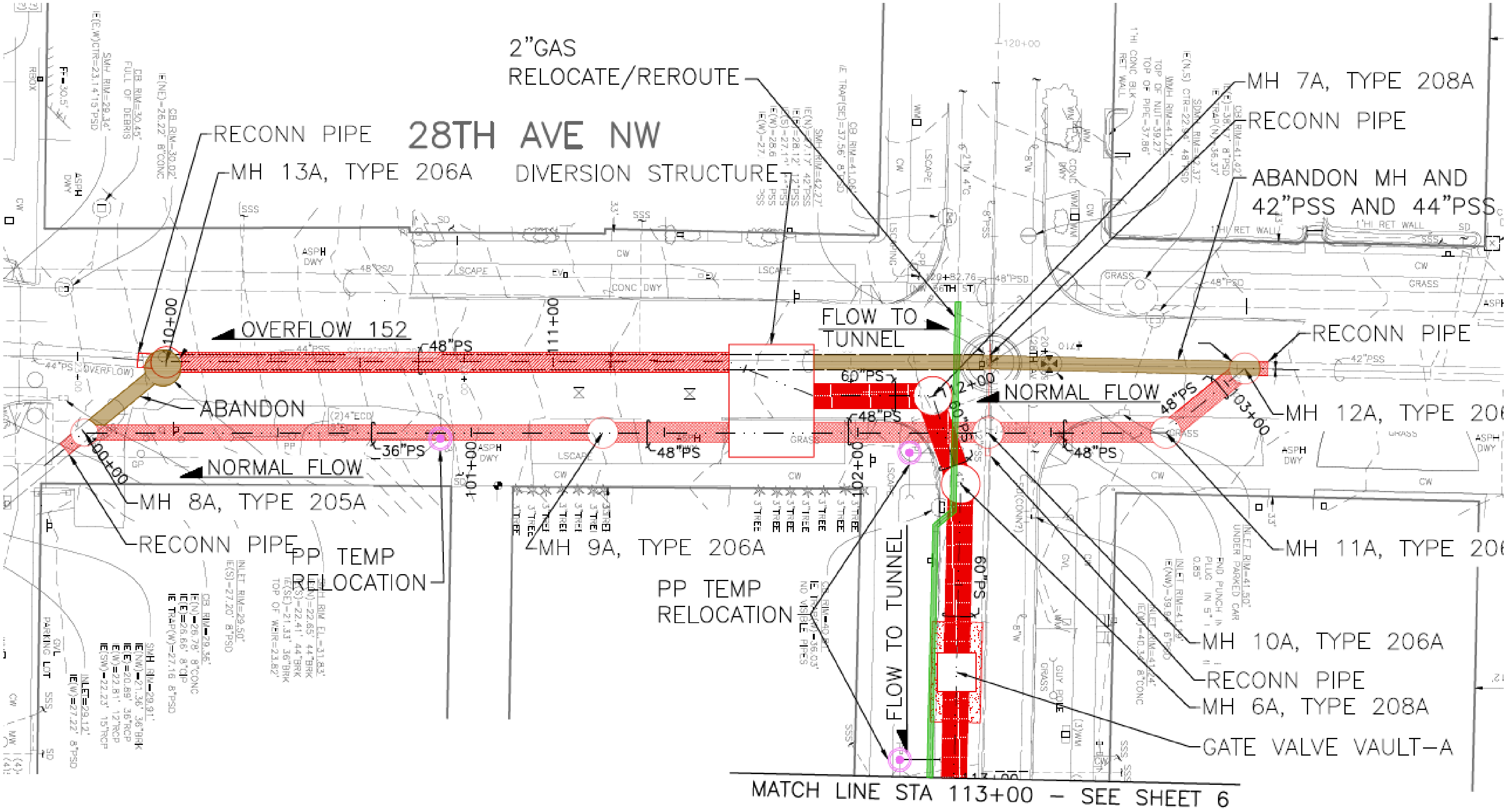

Figure 3-3. Pipes Connecting to Option 1 Diversion Structure

3.2 Option 2

3.2.1 Basin 150/151 Conveyance

A design flow rate of 60 million gallons per day (MGD) was used to size the Basin 150/151 conveyance pipe to 48-inch diameter. These conveyance pipes were also designed to maintain a slope of 0.5% along the alignment with invert elevations ranging from 18.1 feet (NAVD 88) at proposed MH 2D to 17.5 feet (NAVD 88) invert at the maintenance hole upstream of the TEPS structure.

At the upstream end of the proposed conveyance system, overflows from Basin 150/151 will be diverted from the existing 30-inch combined sewer overflow flow pipe on 24th Avenue NW downstream of the basin's existing diversion structure at MH 011-233. The new 48-inch diameter conveyance pipe will then convey the basin's overflows from the existing 30-inch overflow pipe to the tunnel via a new diversion structure that will transfer flows to the tunnel first and then to the outfalls. The diversion structure will be housed within a new maintenance hole.

A gate valve vault will be placed 40 feet downstream of the new diversion structure to close off the flow routed to the tunnel when storage capacity is met within the tunnel. Flows will rise in new diversion structure MH 2D to the weir crest elevation of 23.06 feet (NAVD 88) and then overflow to the new Outfall 151 via a 48-inch pipe. Figure 3-2 shows the flow diversion and conveyance system for this basin.

The conveyance system for Basin 150/151 comes with three new maintenance holes; at the connection to the overflow line, at the proposed diversion structure, and at the connection to the outfall pipe. The conveyance system is located within the right of way adjacent to the TEPS site. The proposed construction method for installing these pipes is open trench construction. Power and backup power for the gate vault will be located within the TEPS facility. Refer to Appendix D for plan and profile.

3.2.2 Basin 152 Conveyance – NW Market Street

This option runs along NW Market Street between 28th Avenue NW and 24th Avenue NW; and along 24th Avenue NW between NW Market Street and the NW 54th Street. NW Market Street is a 4 - lane arterial with commercial use. The street accommodates three public transit buses and is also the proposed route for the Burke Gilman Trail.

The second option for Basin 152 conveyance pipe alignment will also divert normal flows from the existing 42-inch brick combined sewer pipe via a new 48-inch pipe and route it to the proposed diversion structure south of the intersection of 28th Avenue NW and NW 56th Street. Within the diversion structure, the normal flow will be directed first to the normal combined sewer path and to the tunnel through the 60-inch conveyance line during wet weather flows (***Figure 3-4***). The diversion structure has transfer weir elevation of 27.5 feet

(NAVD88) and overflow weir elevation of 29.33 feet (NAVD88), same as the weir elevation in Option 1.

The 60-inch diameter conveyance pipe will start from the diversion structure just south of the intersection of 28th Avenue NW and NW 56th Street, run south along 28th Avenue NW, turn east on NW Market Street, south on 24th Avenue NW and then east to connect to TEPS (Appendix D). The conveyance pipes will be placed south of the centerline on NW Market Street and east of the centerline on 24th Avenue NW and 28th Avenue NW to minimize conflict with existing utilities.

This option comes with four maintenance holes along the conveyance line with depths below ground surface ranging from 10 feet near the diversion structure, 35 feet at the intersection of 24th Avenue and NW Market Street, to 15 feet at the TEPS site. Other hydraulic structures include a gate valve vault to be located 100 feet east of the intersection of 28th Avenue NW and NW Market Street, which closes when the tunnel is at capacity.

The proposed method of construction for this option is a combination of open trench and trenchless installation. Similar to Option 1, all the upstream facilities including the new diversion structure, connection to normal combined sewer and overflow pipe as well as the downstream end facilities in the TEPS site are proposed to be installed with open trench construction.

The conveyance pipe along NW Market Street and NW 24th Avenue which spans approximately 1600 feet will be installed with trenchless construction. This construction method also comes with three trenchless pipe installation launch/retrieval pits; one by the gate valve vault on NW Market Street (approximately 47 by 23 feet), another L-shaped pit in the intersection of 24th Avenue NW and NW Market Street (47 feet on the long side) and a third one at the south end of 24th Avenue NW (approximately 47 by 23 feet). The locations and sizes for launch pits are preliminary and will be refined during design.

The total project cost of Option 2 is $26,666,000 (AACE Class 4 estimate). This includes the cost of pipe; maintenance holes; pipe driving and installation pits; surface restoration; electrical equipment; utility relocations; and hydraulic structures and associated equipment. Other project costs include soft costs, and risk contingencies calculated as a percentage of construction costs. Associated project costs were calculated in a comparable manner to Option 1. For more information on costs, refer to the Basis of Estimate and breakdown of costs in Appendix E.

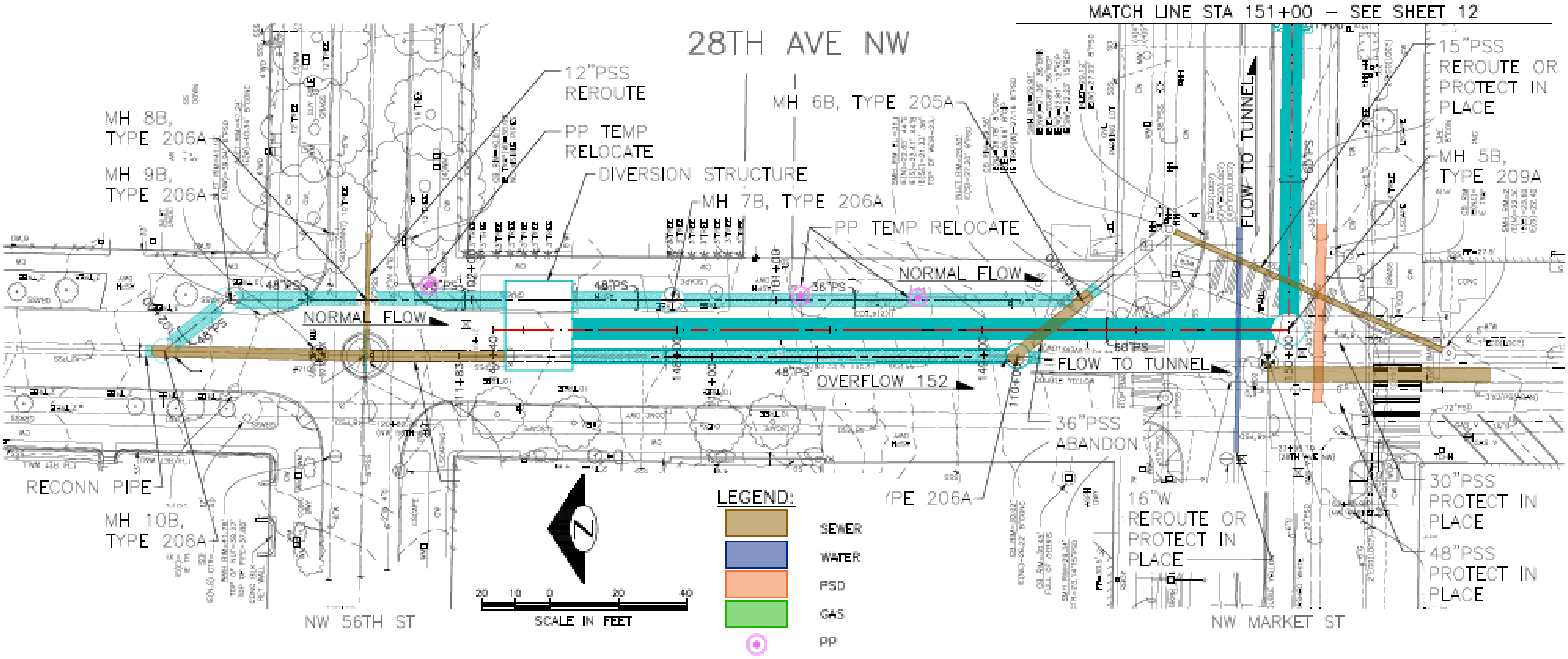

Figure 3-4. Pipes Connecting to Option 2 Diversion Structure

3.3 Option 3

3.3.1 Basin 150/151 Conveyance

A design flow rate of 60 million gallons per day (MGD) was used to size the Basin 150/151 conveyance pipe to 48-inch diameter. These conveyance pipes were also designed to maintain a slope of 0.5% along the alignment with invert elevations ranging from 18.1 feet (NAVD 88) at proposed MH 2D to 17.5 feet (NAVD 88) invert at the maintenance hole upstream of the TEPS structure.

At the upstream end of the proposed conveyance system, overflows from Basin 150/151 will be diverted from the existing 30-inch combined sewer overflow flow pipe on 24th Avenue NW downstream of the basin's existing diversion structure at MH 011-233. The new 48-inch diameter conveyance pipe will then convey the basin's overflows from the existing 30-inch overflow pipe to the tunnel via a new diversion structure that will transfer flows to the tunnel first and then to the outfalls. The diversion structure will be housed within a new maintenance hole.

A gate valve vault will be placed 40 feet downstream of the new diversion structure to close off the flow routed to the tunnel when storage capacity is met within the tunnel. Flows will rise in new diversion structure MH 2D to the weir crest elevation of 23.06 feet (NAVD 88) and then overflow to the new Outfall 151 via a 48-inch pipe. Figure 3-2 shows the flow diversion and conveyance system for this basin.

The conveyance system for Basin 150/151 comes with three new maintenance holes; at the connection to the overflow line, at the proposed diversion structure, and at the connection to the outfall pipe. The conveyance system is located within the right of way adjacent to the TEPS site. The proposed construction method for installing these pipes is open trench construction. Power and backup power for the gate vault will be located within the TEPS facility. Refer to Appendix D for plan and profile.

3.3.2 Basin 152 Conveyance – NW 54th Street

This option runs along NW 54th Street between 28th Avenue NW and 24th Avenue NW. NW 54th Street is an industrial 2 – lane local access street with no sidewalks or street parking. The street narrows to one lane west of 26th Avenue NW and turns into a spilt level road. This street also hosts the Ballard Terminal Railroad Line.

The stretch of NW 54th Street between 28th Avenue NW and 24th Avenue NW is not City of Seattle street right of way. One portion is owned by the Nordic Museum and the remainder is owned by Seattle Department of Transportation's (SDOT). This option requires the acquisition of a permanent easement from the Nordic Museum; and SDOT's permission for use of their fee-owned property. SDOT can grant permission either through their Street

Improvement Permit (SIP) process or through their Council Committee ordinance. Temporary construction easements will also be required.

The third option for conveyance pipe alignment will divert overflows from the existing 48-inch overflow line and route it to the proposed diversion structure near the intersection of NW 54th Street and 28th Avenue NW. The diversion structure will first transfer all flows to the tunnel conveyance line and secondly to the outfall pipe over an overflow weir elevation of 19.4 feet (NAVD88) when the tunnel capacity is met. This option is different from the other two options in that the basin flows are diverted from the overflow line instead of the normal flow line; and that the diversion structure is smaller because flows are diverted from the outfall pipe. This option also has the shallowest pipe depths and the shortest pipe length.

The route of the conveyance line is east along NW 54th Street, between 28th Avenue NW and 24th Avenue NW, south on 24th Avenue NW and east into the TEPS site. The pipes will be placed on the north side of the curved alignment along NW 54th Street. This alignment comes with five maintenance holes ranging in depth below ground surface from 6 feet near the diversion structure to 15 feet as the alignment turns south on 24th Avenue NW. This option also includes a gate valve vault about 20 feet downstream of the diversion structure. Refer to Appendix D for plan and profile.

The method of construction for this option is a combination of open trench installation for the upstream end, the diversion structure and conveyance pipe upstream of the gate valve vault; as well as the downstream end of the conveyance system within the TEPS site. The conveyance pipe running along NW 54th Street for about 1400 feet and south along 24th Avenue NW will be installed with a trenchless method. This installation method comes with four trenchless pipe construction launch/retrieval pits. These launch pits are located at the diversion structure, at the intersection of 26th Avenue NW and NW 54th Street, at the intersection between 24th Avenue NW and NW 54th Street and at the south end of 24th Avenue NW. The locations and sizes for launch pits are preliminary and will be refined during design.

The total project cost for Option 3 is $31,292,000 (AACE Class 4 estimate). This includes the cost of pipe; maintenance holes; pipe driving and installation pits; surface restoration; electrical equipment; utility relocations; and hydraulic structures and associated equipment. Other project costs include soft costs, property acquisition costs and risk contingencies which were calculated from risk register analysis. Associated project costs were calculated in a comparable manner to Option 1. For more information on costs, refer to the Basis of Estimate and breakdown of costs in Appendix E.

3.4 Hydraulic Modeling

Hydrologic and hydraulic models were developed for the Ballard Basins’ 150/151 and 152 Combined Sewer System (CSS). These models were calibrated by King County

Wastewater Treatment Division (WTD) in the municipal wastewater modeling software MIKE URBAN. The area modeled included three SPU combined sewer overflow (CSO) outfall points (NPDES 150, NPDES 151 and NPDES 152) that discharge into Salmon Bay, Ballard basins combined sewer tributary areas and the downstream connection to King County's Ballard Regulating Station. For the development of the Long-Term Control Plan (SPU, December 2010), flow meters were installed in the flow contributing areas, and gathered data from September 2008 to March 2010. These flow records were used to calibrate the hydrologic parameters for each sub-basin, a process automated using the calibration program PEST.

The Ballard hydraulic model was used to simulate hydraulic performance of wet weather events from 1978 through 2015 with climate change factors. Weir lengths and elevations for Basin 152 diversion structure, Basin 152 conveyance pipe sizes, and potential sanitary sewer overflows (SSO) associated with flow control structures were evaluated.

System surcharge in the normal flow path along NW Market Street was evaluated to ensure that no SSOs occur. Evaluations showed that installation of a fixed orifice in the combined sewer upstream of NW Market Street will mitigate surcharging of flows to surface during extreme wet weather events. An orifice size of 13.5-inches in diameter installed on the 48-inch combined sewer pipe normal flow path just south of the intersection of 28th Avenue NW and NW 56th Street was shown to prevent SSOs from occurring along NW Market Street.

For Basin 152, a smaller conveyance pipe diameter of 48-inch pipe was also simulated as an option to the proposed 60-inch pipe to determine if the regulatory overflow frequency can still be met with a smaller diameter pipe. Initial long-term modeling simulations showed that two additional CSOs will occur due to the reduced pipe diameter which is still well within regulatory compliance. Further analysis will be performed during design to potentially reduce the pipe diameter to 48-inches.

Other refinements, such as shortening the weir lengths that control flow to the SCWQP tunnel and the CSO outfall were explored and showed that a weir length of 20 feet would work in meeting overflow frequencies. Further modeling will be performed during design phase to optimize the weir length. The results of the modeling effort are documented in Appendix F: Ballard Conveyance Hydraulic Modeling Report.

3.5 Preliminary Geotechnical Explorations

Geotechnical explorations were conducted as part of Options Analysis to investigate the subsurface conditions along the proposed conveyance pipe alignments. A preliminary geotechnical evaluation was conducted by Shannon and Wilson with a scope to review existing geotechnical exploration logs and perform geotechnical borings in the project area. The findings of these evaluations are documented in Appendix G.

The geotechnical evaluations were conducted along NW 56th Street and NW Market Street (***Figure 3-5***). NW 54th Street was not included in the scope for preliminary evaluations as it was assumed to have some environmental contamination due to the findings of contamination within the TEPS site.

The four bore holes used for sampling were located at:

1. BCT - 1: 20 feet east from NW 56th Street and 28th Avenue NW intersection
2. BCT - 2: 20 feet west from NW 56th Street and 24th Avenue NW intersection
3. BCT - 3: 120 feet east from NW Market Street and 28th Avenue NW intersection
4. BCT - 4: 120 feet south from NW Market Street and 24th Avenue NW intersection

These borings were drilled and sampled to depths from 35 to 55 feet below ground surface to characterize the subsurface conditions. Observation wells were developed at these locations for additional evaluations. Soil samples from these boreholes were field screened for contamination using a combination of visual and olfactory observations, photoionization detector measurements, olfactory observations, and sheen tests. Environmental testing on a soil sample from boring BCT-4, along NW Market Street exhibited lead-contaminated between 5 and 15 feet below ground level.

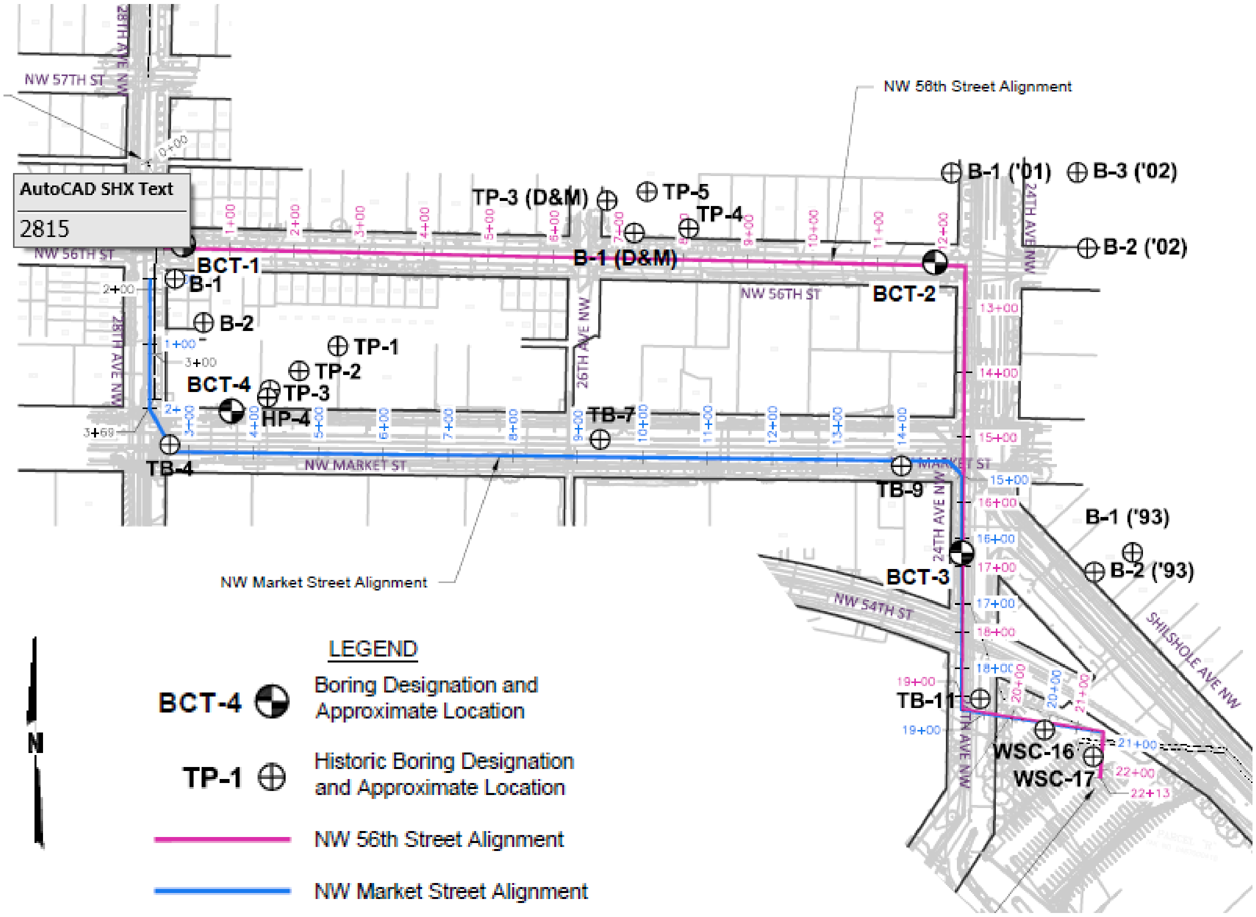

Figure 3-5. Borehole Testing Locations

3.6 Options Overview

The various parameters of the three options are summarized in ***Table 3-1***.

Table 3-1 . Summary of Options Parameters

Parameter		**Option 1- NW 56th St**	**Option 2 – NW Market St**	**Option 3 – NW 54th St**
Design Flow for Basin 150/151 Conveyance (MGD)		60	60	60
Design Flow for Basin 152 Conveyance (MGD)		125	125	125
Basin 150/151 Conveyance Pipe Diameter (inches)		48	48	48
Basin 152 Conveyance Pipe Diameter (inches)		60	60	60
Length of Pipe (Basin 150/151) (feet)		150	150	150
Length of Pipe (Basin 152) (feet)		2230	2050	1530
Length of Trenchless Installation (Basin 152) (feet)		1930	1630	1410
Depth of Lowest Pipe Invert below Ground Surface (feet)	Basin 152 Diversion Structure	22	23	10
	MH 3 on 24th Ave NW Crossing	40	35	15
	MH 1 on TEPS Site	16	16	16
Number of Maintenance Holes in Basin 150/151 Conveyance System		4	4	4
Number of Maintenance Holes in Basin 152 Conveyance System		8	5	6
Launch Pits		4	3	4
Outside Dimensions of Basin 152 Diversion Structure (feet)		22 X 30	22 X 30	10 X 10
Basin 152 Diversion Structure Tunnel Transfer Weir Crest Elevation (feet NAVD 88)		27.5	27.5	N/A
Basin 152 Diversion Structure Overflow Weir to Outfall Weir Crest Elevation (feet NAVD 88)		29.33	29.33	19.4
Basin 150/151 Diversion Structure Overflow Weir to Outfall Weir Crest Elevation (feet NAVD 88)		23.06	23.06	23.06
Length of Overflow Weir for Basin 152 Diversion Structure (feet)		20	20	10
Length of Transfer Weir for Basin 150/151 Diversion Structure (feet)		12	12	12
Diameter of orifice to control flows along NW Market Street (inches)		13.5	13.5	13.5
Contaminated Soil Disposal (ton)		52	787	4277
Easement Required		No	No	Yes
Total Project Costs ($)		$31,717,000	$26,666,000	$31,292,000

Section 4. Options Analysis

Options Analysis is the process in which the proposed Ballard Conveyance pipe alignments and associated infrastructure placements were evaluated; and the cost impacts and risks associated with each option were calculated. This process included the evaluation of short and long-term community impacts; consideration of operation and maintenance allowances and construction impacts review.

Evaluation of the three options focused on the Basin 152 conveyance, as there was only one alignment considered for Basin 150/151 conveyance pipes. The analysis took the following factors into consideration when evaluating alignments for the Basin 152 conveyance system and locations for hydraulic structures such as a diversion structure, gate valve vault and maintenance holes:

- Impacts to residential neighborhoods and businesses
- Avoidance of construction on private property
- Ease of construction
- Impacts on existing utilities
- Ease of access of maintenance

Preliminary plan and profile drawings were also prepared as part of Option Analysis. These drawings shown in Appendix D, identified the locations of the pipes in the ROW, the pipe inverts and the placement of hydraulic structures and maintenance holes. They capture current planning assumptions and were used to identify utility conflicts, find optimal locations for launch/retrieval pits for trenchless pipe installations and provide material quantities to calculate construction cost.

These drawings were also used for the basis of constructability review to evaluate construction related impacts for each of the three proposed options. A construction impacts review was conducted to identify the various impacts to property access, traffic and parking for the three alignments considered. Refer to Construction Impacts Memorandum (SPU, October 2017).

This project is in the economically diverse Ballard neighborhood that contains commercial, residential, and industrial areas in close proximity. Only one alignment was developed for conveying Basin 150/151 flows and will primarily be constructed at the TEPS site. On the other hand, three different alignments are under evaluation for conveying Basin 152 flows. The construction of the proposed project is expected to impact the three alignments differently while the impacts within TEPS site will be identical.

The following criteria were used to assess the magnitude of impact and identify the differential values of each of the alignments:

1. Short Term Community Impact (during construction)
2. Long Term Community Impacts
3. Construction Risk
4. Construction Complexity
5. Ease of Maintenance

4.1 Short Term Community Impact

This metric evaluates the community impacts during the construction phase of the project from the perspective of disruptions to traffic and public transportation; access to parking spaces, business or residences; and impacts to business activities. Possible transportation impacts include interference to public transit lines; traffic lane closures; and disruption to vehicular and non-vehicular transportation such as railroad use on NW 54th Street and bicycle traffic on the proposed Burke Gilman Trail on NW Market Street. Community impacts also extends to impact to business activities from street closures, impacts to pedestrians and construction noise.

4.1.1 Option 1 – Basin 152 - NW 56th Street

The first option along NW 56th Street is on a residential access street and a commercial street along 24th Avenue NW. The residents and commuters along NW 56th Street, 28th Avenue NW and 24th Avenue NW will experience impact during construction hours due to temporary removal of street parking spaces and partial street lane closures from construction staging; open cut trenching; installation of pipes; and launch/retrieval pit excavations.

The method of construction along this alignment is mostly trenchless resulting in less open cut area in the right of way. This option has the deepest pipes that will require deeper pipe driving launch/retrieval pits and a longer duration of construction activities at those pits. The placement of two launch/retrieval pits on the northwest and southeast side of the intersection of 24th Avenue NW and NW 56th Street will result in at least one lane closure on 24th Avenue NW and NW 56th Street, restricting traffic flow along both streets. The businesses and mass transit lines along 24th Avenue NW will be further impacted by construction activity and staging for the launch pit on the south west side of the intersection. Residents of 28th Avenue NW would also be impacted from the open cut construction of pipes and the diversion structure on that street. Deep excavation to install maintenance holes approximately every 500 feet also adds impacts along NW 56th Street and 24th Avenue NW.

4.1.2 Option 2 - Basin 152 - W Market Street

The second option along NW Market Street is on an arterial through a commercial zone in the Ballard Neighborhood. The construction phase of this option will result in impacts to the 28th Avenue NW, NW Market Street and 24th Avenue NW right of way in terms of disruption to traffic flow, road closure, obstruction to access to local businesses; and additional truck traffic to haul excavation material and bring in construction material. This alignment will also impact bicycle traffic along NW Market Street which is the proposed bike route for the Burke Gilman Trail extension.

The method of construction along NW Market Street is mostly trenchless installation resulting in less open cut area in right of way. This option also has the second deepest pipes and maintenance holes that will require deeper pipe driving launch/retrieval pits and a longer duration of construction activities at those pits. The placement of a launch/retrieval pit at the intersection of 24th Avenue NW and NW Market Street will result in at least one lane closure on 24th Avenue NW and NW Market Street, restricting traffic flow along the two arterials. The construction activity and staging for this launch pit will impact mass transit lines and traffic flow on the two arterials. In addition, open cut trenching for pipes and diversion structure along 28th Avenue NW will impact traffic along that street.

4.1.3 Option 3 – Basin 152 - NW 54th Street

The third option for conveyance system along NW 54th Street is in an industrial area. This alignment is along a street with a split-level section between 28th Avenue NW and 26th Avenue NW. This street accommodates business access, parking, truck traffic and Ballard Terminal Railroad (BTRR) tracks. The construction phase of this option will impact NW 54th Street truck traffic flow.

The method of construction along NW 54th Street is primarily trenchless installation, with three launch/retrieval pits along that street. The proposed placement of a launch/retrieval pit on the intersection of 28th Avenue NW and NW 54th Street and 26th Avenue NW and NW 54th Street will impact truck access to the industries from 28th Avenue NW and 26th Avenue NW. The excavation of these launch and retrieval pits may interfere with operations on the (BTRR) tracks and maritime businesses along the street.

4.2 Long Term Community Impact

Long term community impacts accounts for impacts from maintenance activities on elements of the conveyance system such as diversion structures, gate valve vaults and conveyance pipes. Maintenance activities include the following: annual inspection of diversion structures and possible cleaning; inspecting and exercising gate valves quarterly; and inspecting conveyance pipes every 10 years. These maintenance activities impact the neighborhood when maintenance crew trucks take up parking spaces in the right of way or close a lane for staging equipment. The maintenance crew indicated a preference for alignments with parking spaces along the right of way and streets with sufficient width for parking trucks.

4.2.1 Option 1 – Basin 152 - NW 56th Street

The alignment along NW 56th Street is primarily located in a multifamily residential area. Maintenance of the diversion structure near the intersection of 28th Avenue NW and NW 56th Street may block off a traffic lane on 28th Avenue NW, take up parking spaces in the right of way and affect traffic flow in the roundabout at the intersection. Maintenance of the gate vault on the east side of the intersection may block off a traffic lane and take up parking spaces in the NW 56th Street right of way. Due to the low volume of traffic along NW 56th Street, maintenance of gate valve vault may not have as high an impact as NW Market Street.

4.2.2 Option 2 - Basin 152 - NW Market Street

The alignment along NW Market Street is primarily located in a commercial area. Similarly, maintenance of the diversion structure near the intersection of 28th Avenue NW and NW 56th Street may block off a traffic lane on 28th Avenue NW, take up parking spaces in the right of way and affect traffic flow in the roundabout at the intersection. Maintenance of the gate vault on the NW Market Street right east of the intersection to 28th Avenue NW may also block off a traffic lane and take up parking spaces in the right of way. Given that NW Market Street is an arterial that accommodates a lot of traffic and businesses, maintenance activities on the gate valve vault will impact customers parking access and may cause traffic disruption.

4.2.3 Option 3 – Basin 152 - NW 54th Street

The alignment along NW 54th Street is primarily located in an industrial area. Maintenance of the diversion structure near the intersection of 28th Avenue NW and NW 54th Street and the gate valve vault nearby may block off a traffic lane on 28th Avenue NW or take up parking spaces along NW 54th Street and 28th Avenue NW. Maintenance activities in this location is not expected to cause traffic disruption due to the low volume of traffic at that intersection and the intersection has sufficient parking spaces for trucks and maintenance vehicles.

4.3 Construction Risk

The proposed method of construction is a combination of trenchless and open trench installation. For open cut excavations, construction risks stem from the existence of environmental contamination and the associated disposal of contaminated materials.

Construction risks for trenchless installation come from pipe driving encountering obstructions such as boulders and unknown obstructions; and tunnel drilling machine getting stuck. Additional geotechnical investigations will be carried out along the selected alignment to inform design and mitigate risks.

Construction risks also come from the process of acquiring easement for construction along an alignment that is not a street right of way.

4.3.1 Option 1 – Basin 152- NW 56th Street

This option poses a low construction risk since preliminary geotechnical investigations not finding any environmental contamination in samples taken along NW 56th Street. Additional findings also show that the dense nature of soil stratification poses less geotechnical risks.

On the other hand, there are two newly constructed large residential developments, including an assisted living center on the northwest corner of the intersection. Initial research has shown that the tiebacks from these buildings does not conflict with the conveyance pipes. But there is a possibility that there are some soil nails that can potentially impede excavation or trenchless pipe driving in this corridor.

4.3.2 Option 2 – Basin 152 - NW Market Street

This option poses a high construction risk since preliminary geotechnical evaluations had identified some environmental contamination along NW Market Street. This discovery adds risk of encountering contaminated soil and groundwater during pipe driving and excavation.

4.3.3 Option 3 – Basin 152 - NW 54th Street

The construction risks along for this option comes from high groundwater levels, environmental contamination, and type of underground material. Based on the nature of the industries that have historically operated along NW 54th Street, this alignment is assumed to be environmentally contaminated. Given the industrial nature of land use, there is a possibility of running into underground obstructions. This option is also the closest alignment to the Ship Canal waterway which would be associated with high groundwater levels. Any open cut excavation for launch/retrieval pit and pipe driving is assumed to encounter contaminated soil and high groundwater that will need to be disposed appropriately.

In addition, NW 54th Street is not a ROW and will require permanent easements and temporary construction easements to install conveyance pipes along the street. The process of acquiring easements can take up to 18 months. In addition, any temporarily closed businesses may need to be compensated for the loss of income. Construction on the private parcel also requires additional permitting. This alignment will also require coordination and agreement with BTRR for working near the railroad lines.

4.4 Construction Complexity

The three options come with several construction complexities. The factors that contribute to construction complexity include protection of existing utilities, limited work spaces, working near a railroad line, groundwater intrusion into excavation pits, depth of open cut trenches and launch/retrieval pits, soil conditions and high groundwater.

Trenchless installation method involves pipe driving over 500 feet stretches of pipe. The construction complexities associated with this method of construction come from recovering tunneling equipment and pipe driving.

4.4.1 Option 1 – Basin 152 - NW 56th Street

The construction complexities for this alignment come from the depth of excavations near the intersection of NW 56th Street and 24th Avenue NW. This option has the deepest conveyance pipes ranging from 16 to 40 feet below ground which come with deep maintenance holes. The installation of launch and retrieval pits as well as construction of maintenance holes at that depth comes with the added complexity of increased groundwater control and dewatering.

There are a few utility conflicts for this option which include a watermain along 24th Avenue NW, gas lines, water services, and power poles.

4.4.2 Option 2 - Basin 152 - NW Market Street

The construction complexity with this option come from handling contaminated soil and groundwater intrusion during excavation of the launch/retrieval pit at the corner of NW Market Street and 24th Avenue NW; and installation of deep maintenance holes. These conditions create some complexity in handling and disposing of materials from the deep pits as well as increased groundwater control and dewatering. The volume of traffic near this intersection, also requires extensive traffic control and working hour restrictions.

There are a few utility conflicts that will need to be relocated such as gas lines and power poles. There is a section of 30-inch combined sewer pipe that will need to be protected near the intersection of 28th Avenue NW and NW Market Street. This introduces some complexity to construction activities that can be managed.

4.4.3 Option 3 - Basin 152 - NW 54th Street

The construction complexities for this option stem from working near the BTRR railroad line, and the narrow nature of the street along 54th Avenue NW. The proposed placement of the launch pit on 26th Avenue NW and NW 54th Street will take up space on the intersection that will limit access of trucks and vehicles to the businesses along that street. The resulting limited space will introduce construction complexity in terms of construction equipment staging and traffic control and detouring around the street.

The section of NW 54th Street between 26th Avenue NW and 24th Avenue NW is curved. A launch pit is placed at the intersection of 26th Avenue NW to facilitate driving pipe. Two maintenance holes are also placed between 26th Avenue NW and 24th Avenue NW to address this. This factor will introduce some complexity in pipe and maintenance hole installation.

This alignment is also located closest to the Ship Canal shoreline and is expected to have higher groundwater level compared to the other two options, contaminated soil and possible subsurface obstructions. This results in additional construction complexity of disposing of contaminated materials, dewatering during excavation and encountering obstructions. Furthermore, there is an existing 12-inch watermain that will need to be relocated out of the way of the conveyance pipe.

4.5 Ease of Maintenance

This criterion evaluates the accessibility of hydraulic structures and maintenance holes in the conveyance system; and safety of crew for inspection and maintenance activities. Accessibility is dependent on the availability of parking spaces along the alignment, and the nature of land use along the streets. Safety of crew depends on the depth of maintenance holes and need for additional equipment to access these facilities.

4.5.1 Option 1 – Basin 152 - NW 56th Street

The alignment along NW 56th Street was not favorable for ease of maintenance due to the depth of the conveyance pipes along the alignment. The depth of the maintenance holes range from 20 to 44 feet below ground surface, may require additional equipment (that SPU currently does not own) for maintenance and inspection. The alignment also crosses several existing utilities for future repairs of the conveyance pipe may be exposed or in the way.

4.5.2 Option 2 - Basin 152 - NW Market Street

The alignment along NW Market Street was not favorable for ease of maintenance due to the depth of the conveyance pipes and the high traffic volume along the alignment. This option also has the second deepest pipe installations and maintenance hole depths ranging from 15 to 42 feet below ground surface, which may necessitate additional equipment for maintenance and inspection. The maintenance crew may need to block off a lane during deployment, which will impact access to businesses on the street.

4.5.3 Option 3 - Basin 152 - NW 54th Street

The alignment along NW 54th Street is the most favorable option for the maintenance crew mainly due to the shallow depth of conveyance pipes that range from 5 to 15 feet below ground surface. Potential future conveyance pipe replacement will be constrained due to the narrow width of the alignment.

Section 5.Triple Bottom Line Analysis

Triple Bottom Line analysis was conducted for the three options under consideration. This process quantified the values of options under review and provided input data for value modeling. Value Modeling is a tool that SPU uses to evaluate project options based on quantifiable and non-quantifiable project objectives. It is used to identify and communicate tradeoffs between competing objectives from multiple stakeholders. It is also used to document the process of choosing a recommended option. The Value Modeling conducted for evaluation of options is documented in Appendix H: Value Modeling Technical Memorandum.

The project team made up of representatives from design, operation, maintenance, asset management, communication, construction management, and instrumentation and control conducted the value modeling process which had the following steps:

1) Identification of evaluation criteria
2) Development of performance measure scales
3) Assignment of weights to the evaluation criteria
4) Scoring of evaluation criteria (based on 2 and 3)
5) Calculation of option’s values
6) Pairing of option’s values with life cycle costs

5.1 Identification of Evaluation Criteria

Evaluation criteria were developed to identify the important objectives the project needs to meet during the construction phase and long-term maintenance. A workshop was held to solicit input from project members and define the objectives of the different project stakeholders. The project team members developed the following evaluation criteria:

I. Short-term community impacts
    a. Access to residents, businesses, and industrial facilities
    b. Impact to transit traffic
    c. Impact on vehicular and truck traffic
    d. Impact to railroad use
    e. Impact on future Burke Gilman Trail Link
    f. Impact on business activities

II. Long-Term community impact from maintenance
III. Construction risk
IV. Construction complexity
V. Ease of maintenance

5.2 Development of Performance Measure Scales

Evaluation criteria performance metrics were developed to measure impacts to specific resources and quantify how the criteria addresses the project objective. The performance measure scales were quantitative (measurements) or qualitative (1 – 5 scale) based on the nature of evaluation criteria. The first criteria for short-term community impact was measured quantitatively while the remaining four criteria were measured qualitatively. The performance measure scale for the first evaluation criteria focused on short term community impacts measured the impact on community access and modes of transportation as shown in ***Table 5-1***.

The performance measure scales for the remaining four evaluation criteria focused on long term impacts, construction risks, ease of maintenance and construction complexity were qualitative. Qualitative performance scales were developed to establish the most and least favorable outcomes for an objective which were then scaled from 1 to 5, where 1 was the least-value while 5 was the highest-value.

Table 5-1. Qualitative Performance Measures

Evaluation Criteria	Performance Metric	Location
Access to Residences, Business and Industrial Facilities	Impacted or Obstructed Access to Residences/Businesses (number of days)	24th Avenue NW NW 56th Street NW Market Street NW 54th Street
Impact to Transit Riders	Number of Buses (count per week)	24th Avenue NW + NW Market Street
Impact to Vehicular and Truck Traffic	Number of Vehicles (count per week)	24th Avenue NW NW 56th Street NW Market Street NW 54th Street
Impact Railroad loss of use	Number of Trips (count per week)	NW 54th Street
Impact on Future Burke Gilman	Cyclists and Pedestrians (count per week)	Burke Gilman Trail (NW Market Street)
Impact on Business Activities	Number of businesses (count)	24th Avenue NW and NW Market Street NW 54th Street

5.3 Assignment of Weights to Evaluation Criteria

The next step in the analysis was to assign the relative importance of each evaluation criteria. Each project team member assigned weights to the evaluation criteria. These different individual weights provided were averaged to represent the relative importance of each criterion.

The workshop provided the following averaged weights:

I. Short-Term Community Impacts	30%
II. Long-Term Community Impacts	11%
III. Construction Risk	19%
IV. Construction Complexity	14%
V. Ease of Maintenance	26%
Total	100%

5.4 Scoring of Evaluation Criteria

For each option, the project team scored the evaluation criteria based on the qualitative or quantitative performance metric using information obtained during option analysis. The first evaluation criteria, short term community impact (***Table 5-2***), was scored based on magnitude of impact to access to residences and businesses as shown in ***Table 5-3***.

For the remaining criteria, performance measures were measured qualitatively on a performance scale of 1 to 5, where 1 was the lowest score, and 5 was the best possible score. The project team scores the evaluation criteria as shown in the legend in ***Figure 5-1***.

Table 5-2. Short-term Community Impact Scores

Criteria	**Option 1. NW 56th St**	**Option 2. NW Market St**	**Option 3. NW 54th St**
Access to Residences/Business (Impacted/Obstructed days)	58,320	72,000	48,900
Impact on Transit Riders (Bus trips / week)	1,110	1610	0
Impact on Vehicular and Truck Traffic (Vehicles/ week)	12,920	18,630	1,200
Impact on Railroad Use	0	0	1
Impact on Future Burke Gilman[1] (Cyclists/ week)	0	2,659	0
Impact on Business Activities (Number of Businesses)	7	24	10

[1] *Values are projected for trail opening in 2022*

Table 5-3. Qualitative Evaluation Criteria Scores

Evaluation Criteria		**Option 1 NW 56th St**	**Option 2 NW Market St**	**Option 3 NW 54th St**
Long-term Community Impact		3	2	4.5
Construction Risk	Environmental Contamination	5	1	1
	Property Acquisition	5	5	1
Construction Complexity		3	2	2
Ease of Maintenance	Ease of Future Replacement	3	2	4
	Accessibility	3	2	5

5.5 Calculation of Option’s Value

A Value Model spreadsheet was used to calculate the cumulative value of the objectives as shown in ***Figure 5-1***. To compare the qualitative and quantitative scores on the same gage, all performance measures were standardized to a scale of zero-to-one. For the quantitative performance measures of short-term community impact, the highest impact (lowest value) was pegged to 0 and the lowest impact (highest value) was pegged to 1. On the other hand, for the qualitative evaluation criteria, the lowest value (1) was pegged to 0 and the highest value (5) was pegged to 1. All the values in between were calculated as ratios between 0 and 1. The performance metric scores were then converted to values by multiplying the average weight of the criteria with the normalized scores.

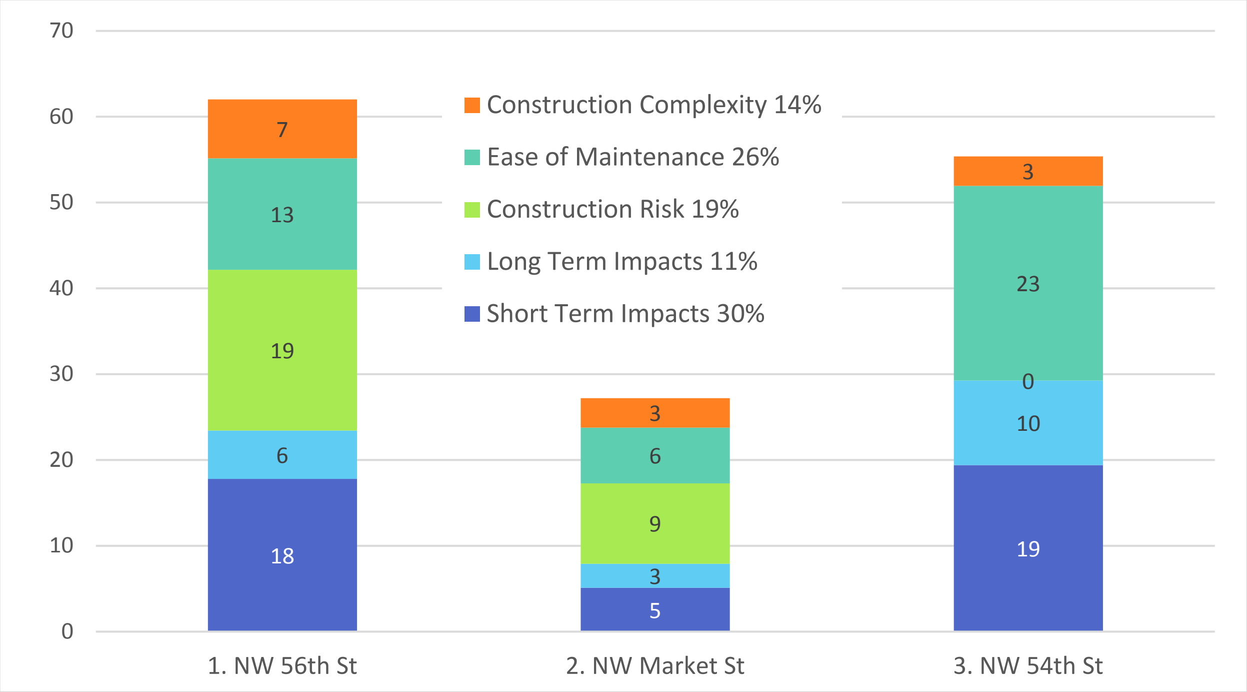

Figure 5-1. Cumulative Values of Options

5.6 Pairing of Option’s Value and Cost

The cost of the options was captured with life cycle costs that include capital costs and operational and maintenance costs over the 100-year design life of the project. The total capital costs include soft costs, and construction cost with project contingencies (Appendix E). The total life cycle costs are shown in ***Table 5-4***.

Table 5-4. Total Life-Cycle Cost of Options

Costs	**Option 1 – NW 56th St**	**Option 2 – NW Market St**	**Option 3 - NW 54th St**
Hard Cost	$16,605,000	$14,913,000	$13,190,000
Soft Cost	$8,137,000	$7,308,000	$6,464,000
Property Acquisition	-	-	$1,588,000
Reserves	$6,975,000	$4,444,200	$10,050,000
Maintenance[1]	$404,000	$398,000	$348,000
Total Life-Cycle Cost	$32,121,000	$27,063,200	$31,640,000

[1] *Maintenance Cost over 100 years at 2.5%*

Value Modeling is a tool used to pair the cumulative values and life-cycle cost of each option. The previous steps provided the input data for this exercise by identifying, scoring and quantifying the values and costs of the options. ***Figure*** 5-2 shows the comparison of the value modeling score with the estimated life-cycle project cost for each option.

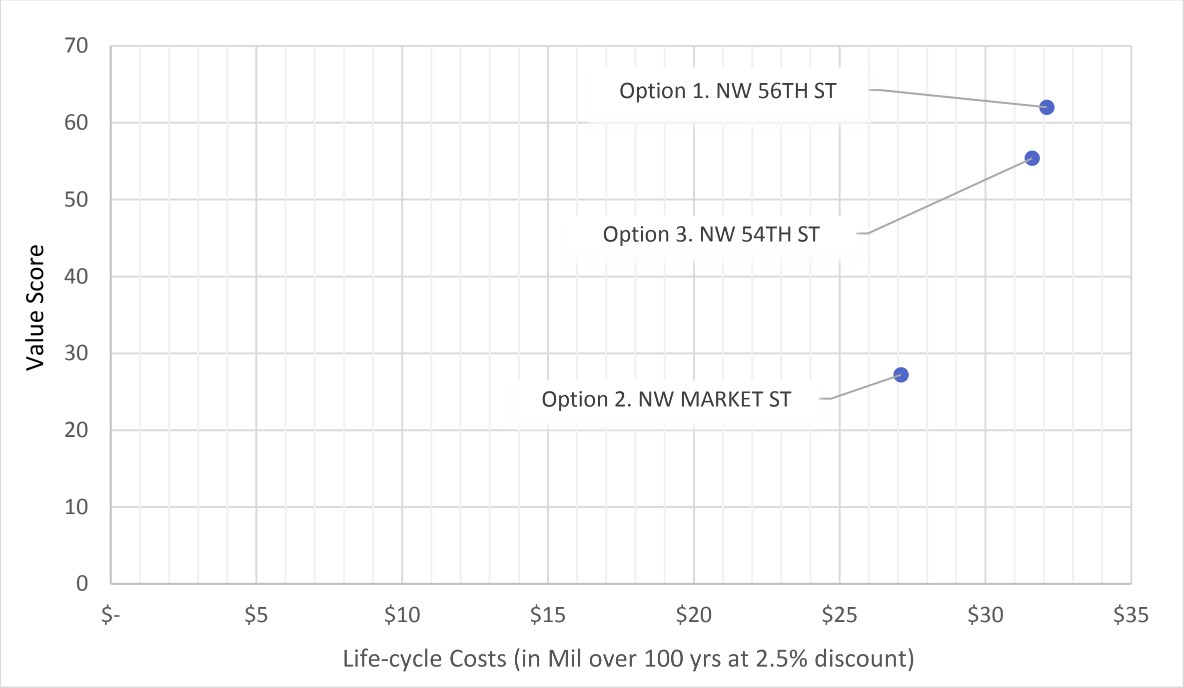

Figure 5-2. Value Cost Tradeoff

Overall, the value modeling process showed the following results

Option 1 – highest value and highest cost
Option 2 – lowest value and lowest cost
Option 3 – second highest value and second highest cost

Section 6.Recommended Option

The results of the Value Modeling analysis in Section 5 showed that Option 1 – NW 56th Avenue and Option 3 – NW 54th Street had the highest and second highest values with a cost difference of about $481,000. Given the similarity of prices of the two options, the selection of a recommended option mainly relied on the value offered by the two options. Evaluation of the proposed alternatives shows that Option 1 along NW 56th Street and 24th Avenue NW offers the most value of all the options evaluated. This option was selected as the recommended alternative to construct the Ballard Conveyance system.

Option 1 lies along NW 56th Street, a two-lane residential street and a commercial street along 24th Avenue NW. The conveyance system starts at the diversion structure at the intersection of NW 56th Street and 28th Avenue NW and is routed east along NW 56th Street, turn south on 24th Avenue NW and turn east south of NW 54th Street to enter the TEPS site. This option also comes with the deepest pipe elevations ranging from 16 to 40 feet between the diversion structure and TEPS.

This option offers the most value for constructing the project due to its low construction complexity. Preliminary geotechnical evaluations have not uncovered any environmental contaminations that were present in borings along Option 2 along NW Market Street and assumed to exist along Option 3 on NW 54th Street. The soil stratification for this option is denser than the other two options s which reduces any additional construction complexity.

This option poses some difficulty in ease of maintenance due to the depth of pipes. This issue will be further investigated during design by raising depth of pipes where possible, providing self-cleaning flow velocities within pipes and working closely with SPU operations and maintenance crew to incorporate their needs. Other measures to be investigated include moving the gate vault to the TEPS site to avoid impacting the residential street along NW 56th Street; eliminating the grit removal structures from the conveyance system facilities; and reducing conveyance pipe for 152 from 60 to 48 inches in diameter. These issues will be further explored during design of the project.

The recommended option of Option 1 along NW 56th Street was presented to the AMC for Stage Gate 2 approval and was accepted.

References

SPU, 2010. Combined Sewer Overflow Program, Long-Term Control Plan, Volume 1 Flow Monitoring Summary Report 2008–2010, December 2010.

Seattle Public Utilities, 2017. Ship Canal Water Quality Project: Final Facility Plan, March 2017.

APPENDIX A:

BALLARD CONVEYANCE OPTIONS ANALYSIS WORK PACKAGE:
PROJECTS REQUIREMENTS MEMORANDUM, JUNE 1, 2018

SHIP CANAL WATER QUALITY PROJECT

Ballard Conveyance Options Analysis Work Package: Project Requirement Memorandum

PREPARED FOR:	Richard Fernandez, Ballard Conveyance Project Manager
COPY TO:	Eleanor Jackson, SCWQP Design Manager Alan Lord, SCWQP Program Manager Cynthia Blazina, SCWQP Construction Manager Alexander Mockos, CSO Program Manager
PREPARED BY:	Eset Alemu, Ballard Conveyance Project Engineer
DATE:	June 1, 2018

1. Introduction

The proposed Ship Canal Water Quality Project (Ship Canal Project) is designed to provide offline storage for the combined sewer overflow (CSO) flows from five Seattle Public Utilities (SPU) and two King County Department of Natural Resources and Parks, Wastewater Treatment Division (DNRP) CSO basins to meet regulatory standards. The Ship Canal Project storage is a deep tunnel to be constructed in the Ballard, Fremont and Wallingford neighborhoods, on the north side of the Ship Canal. The tunnel will control the Ballard CSO basins (Outfalls 150,151 and 152), Fremont (Outfall 174) and Wallingford (Outfall 147) CSO basins, DNRP 3rd Avenue W Overflow Structure (DSN008), and 11th Avenue NW Overflow Structure (DSN004).

The components of the Ship Canal Project include storage tunnel; appurtenances; conveyance facilities to transport SPU and DNRP CSO flows into the tunnel; and a pump station and force main to drain flows from the tunnel to King County's treatment facility. One of the elements of the Ship Canal Project is the Ballard Conveyance Project which collects combined sewer overflows from SPU basins 150, 151 and 152 and routes flows to the proposed Ship Canal storage tunnel. The purpose of this conveyance system is to bring the CSO Basins into regulatory compliance by reducing the frequency of overflows to an average of one overflow per year on a rolling 20-year average per outfall. The conveyance system spans from an upstream proposed diversion structure for Basin 150/151 and Basin 152 to the proposed West Portal located at the Old Yankee Diner property.

The Ballard Conveyance work package covers the conveyance pipes and infrastructure to the storage tunnel, including associated hydraulic structures. The design process is preceded by Options Analysis of conveyance alternatives which includes hydraulic modeling; identifying major utility conflicts, preliminary geotechnical assessment; permit identification, property acquisition identification, coordination and support for communications and outreach.

This technical memorandum documents the project requirements for the Options Analysis of the Ballard Conveyance work package. The project requirements provide guidelines for the evaluation of conveyance alternatives; and help to identify costs and risks associated with each of the alternatives. These requirements include consideration regarding design standards, health and safety, operation and maintenance, water quality, hydraulic and operational performances, and permitting.

2. Design Criterion and Standards

All alternatives identified during Option Analysis must conform to the following design standards, codes, and guidelines:

1. Seattle Public Utilities Design Standards and Guidelines (2016)
2. Seattle Building Code (2015)
3. City of Seattle Standard Plans for Municipal Construction (2017)
4. City of Seattle Standard Specifications for Road, Bridge and Municipal Construction (2017)
5. Washington State Department of Ecology Criteria for Sewage Works Design (2008)
6. Seattle Department of Transportation (SDOT) Right of Way Improvements Manual (2012)
7. Seattle Department of Transportation Right-of-Way Opening and Restoration Rule (ROWORR), (2017)
8. Washington Administrative Code Chapter 296-24, Department of Labor and Industries, General Safety and Health Standards

3. Regulatory Compliance Requirements

Regulatory compliance requirements pertain to adherence to relevant Federal, State and City Permits. The general environmental impacts of the Ballard Conveyance projects are covered under the program wide Supplemental Environmental Impact Statement (SEIS), which provides the Environmental Impacts Statement for the overall Ship Canal Water Quality program.

The permits required for the proposed alternatives are the following:

- SDOT Street Improvements Permit
- Shoreline Substantial Development Master Use Permit
- Grading Permit
- King County Industrial Waste Permit or National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit (depending on where discharge is for dewatering water, if needed)

4. Health and Safety Requirements

Health and safety requirements ensure that the alternatives evaluation process addresses health risks and safety concerns during construction and operation. Requirements mainly address two major aspects of the project; the first one being the depth of installation with the conveyance pipes to be laid at depths ranging from 15 to 50 feet below grade. The second aspect is the risk of encountering contaminated soil material during construction. Ballard neighborhood was a historically industrial area where a lot of shipping related activities took place. The discovery of any contaminated materials along the proposed alignments would help to inform alternatives analysis about the added cost of handling, testing, and disposal of material.

Health requirements include the safe disposition of any contaminated underground material. Safety requirements include adhering to Occupational Safety and Health Administration (OSHA) requirements for crew safety.

5. Water Quality Requirements

Water quality requirements for the Ballard Conveyance system alternative elevations fall under the City of Seattle Stormwater Code (SMC 22.800 - 808) which addresses runoff control and treatment during construction and operation; and also provides guidelines for selecting, designing, constructing, and maintaining stormwater flow control and water quality treatment best management practices (BMPs). Under the code, water quality requirements ensure that measures are in place to protect water quality, set guidelines to control surface water runoff from the project site, prevent erosion and sedimentation during construction, and manage activities and potential pollutant sources.

6. Hydraulic and Operational Performance Requirements

In addition to the operational performance goal of the Ballard Conveyance work package requirement of one combined overflow per year on a rolling 20-year average per CSO outfall, Drainage and Wastewater Line of Business identified the following hydraulic and operational performance requirements:

- flows within the conveyance system to be conveyed to the tunnel by gravity.
- flow conveyance into a vortex structure or level based control to have a Froude number of 0.5 or less.
- no sanitary sewer overflows (SSOs) in conveyance pipe to the tunnel or the normal flow system downstream of diversion to tunnel.
- not raising existing hydraulic grade line upstream of diversion to tunnel.
- elevations of the diversion weirs to either equal or exceed the elevation of the overflow weir at 3rd Avenue West and 11th Avenue Northwest conveyance diversion structures. These overflow weirs are the lowest relief points for the Ship Canal Water Quality tunnel.
- conveyance capacity to be based upon peak flows identified in the SCWQP Final Facility Plan dated March 2017 with peak flow of 60 MGD for Basin 150/151 and 80 MGD for Basin 152. Peak flows may change with the additional modeling for the SCWQP Integrated Model based upon SPU’s updated CSO sizing approach and climate change due out in October 2017.
- redundancy of automated gate for Basin 152 used for conveying flows to the tunnel. This requirement can be waived only if the diversion weir to CSO Outfall 152 is set at an elevation equivalent to the weir elevation of the 3rd Avenue West and 11th Avenue Northwest diversion structures. (Technical Memorandum: Draft Redundant Gate Evaluation, McMillen Jacobs and Associates, December 16, 2016)
- automated gate for Basin 150/151 conveying flow to tunnel does not require a redundant gate (Technical Memorandum: Draft Redundant Gate Evaluation, McMillen Jacobs and Associates, December 16, 2016)
- backup power to be provided for automated gates for both Basins 150/151 and 152 diversion structures.
- all monitoring instrumentation equipment to be redundant. Alternatives are required to identify monitoring locations and provide access to location of monitoring equipment.
- grit removal structure to be placed upstream of Basin 152 diversion to the tunnel. (Technical Memorandum: Ship Canal Tunnel: System-wide Grit/Debris Management Strategy, McMillen Jacobs and Associates, May 2016)

7. Maintenance Requirements

SPU maintenance requirements are meant to ensure adequate vertical and horizontal clearance inside infrastructure for crews to maintain and inspect. Some of operational requirements for the Ballard

Conveyance system will be coordinated with the Ship Canal Program under the Instrumentation and Control Program. Maintenance and operation requirements specific to the Ballard Conveyance package include:

- maximum spacing of maintenance holes of 500 feet to ensure that length of pipes is within the limits of cleaning equipment
- design accommodations for placements of ladders and platforms for inspection and maintenance activities
- minimum of 10 feet of vertical clearance inside vaults
- a fire hydrant along the same side of the street and within 20 feet of grit removal structure
- parking access for maintenance vehicles near diversion structures, grit removal structure, motor operated gates, and maintenance holes.

8. References

City of Seattle Stormwater Manual, Seattle Municipal Code Chapters 22.800 - 22.808- Volumes 1-5 and Appendices, Directors' Rules Seattle DCI 21-2015/SPU DWW 200, (http://www.seattle.gov/dpd/vault/cs/groups/pan/@pan/documents/web_informational/p2358283.pdf)

Seattle Department of Transportation (SDOT) Right of Way Improvements Manual (2012) http://www.seattle.gov/transportation/rowmanual/manual/

Seattle Department of Transportation Right-of-Way Opening and Restoration Rule (ROWORR), (2017) http://www.seattle.gov/transportation/docs/ROWORR_Manual.pdf

Ship Canal Water Quality Project Final Facility Plan, March 2017, CH2MHill

Technical Memorandum: Draft Redundant Gate Evaluation, McMillen Jacobs and Associates, December 16, 2016 (https://seattlegov.sharepoint.com/sites/SPU-T1/C314056/C314056SCWQP/20161216_Redundant%20Gate%20TM%20Draft.pdf)

Technical Memorandum: Ship Canal Tunnel System-Wide Grit/Debris Management Strategy, McMillen Jacobs and Associates, May 19, 2016, (https://seattlegov.sharepoint.com/sites/SPU-T1/C314056/C314056SCWQP/20160519%20ShipCanal-GritManagementStrategy_FinalTM.pdf)

APPENDIX B:

BALLARD CONVEYANCE OPTIONS ANALYSIS WORK PACKAGE: PROJECTS CONSTRAINTS MEMORANDUM, JUNE 12, 2017

Seattle Public Utilities

Memorandum

Date: June 12, 2017

To: Richard Fernandez, PE, Project Manager
Alex Mockos, PE, Drainage and Wastewater Line of Business Representative

From: Eset Alemu, PE, Project Engineer

Subject: Project Constraints

The purpose of this memo to provide a summary of the project constraints for the Ballard Conveyance Work Package that is part of the Ship Canal Water Quality (SCWQ) Project. All proposed alternatives must meet the project constraints identified as follows:

a. Schedule

The largest schedule constraints on the project include the consent decree milestones listed below. The design milestones for review and approval by the US Environmental Protection Agency and the Washington Department of Ecology is the nearest milestone the project needs to meet.

Submit Draft (90%) Plans and Specifications for review	3/31/2020
Submit Final Plans and Specifications for approval	12/31/2020
Construction Completion	12/31/2025
Achieve Controlled Status	12/31/2026

b. Community Activity Schedules

A schedule of events in the community is limiting factor in the number of working days and construction days. These events include street fairs, Sunday markets, festivals that are hosted seasonally or annually. These events may limit construction activities during certain periods of the week or year. These community activities will be further identified early in design to inform construction.

c. Non-exceedance of Normal Flow Rates to Downstream System

The Ballard Basins normal flows are directed to the King County system while combined flows during some wet weather events will be sent to the storage tunnel. Normal flow shall not increase downstream of the diversion structure due to proposed Ballard conveyance alternatives. This is a project constraint that shall be analyzed and met for each proposed alternative.

APPENDIX C:

BALLARD CONVEYANCE OPTIONS ANALYSIS WORK PACKAGE: CONSTRUCTION IMPACTS MEMORANDUM, OCTOBER 27, 2017

Ballard Conveyance Options Analysis Work Package: Construction Impacts Memorandum

PREPARED FOR:	Richard Fernandez, Ballard Conveyance Project Manager
COPY TO:	Eleanor Jackson, SCWQP Design Manager Eset Alemu, Ballard Conveyance Project Engineer
PREPARED BY:	Cynthia Blazina, SCWQP Construction Manager
DATE:	October 27, 2017

The purpose of this memo is to document the construction related impacts and issues for each of the three proposed alternatives for the Ballard Conveyance Work Package which is part of the Ship Canal Water Quality (SCWQ) Project. The three alignment options are depicted in Figures 1 through 3.
All proposed alternatives have some similarities; therefore, this memo focuses on the different impacts and issues for each of the alternatives.

The similarities include construction methods for the upstream end of the conveyance system where a set of normal flow pipes, Overflow 152 and conveyance pipes connecting at the Diversion Structure will be installed with open pit construction along 28th Avenue NW between NW 56 Street and NW Market St. This construction approach applies for both Alternative 1 and Alternative 2 (Figure 1 and Figure 2) and assumes the partial closure of 28th Avenue NW with construction activities extending from NW 56th Street to south into NW Market Street. Open cut construction also applies to installation of conveyance pipe from the Diversion Structure to the Gate Vault about 50 feet from the intersection of 28th Avenue NW and NW 56th St. The length of Conveyance pipes running east-west along the three chosen alignments are installed by trenchless methods (microtunnelling). This is applicable for all three alternatives. The trenchless installation of conveyance pipes is conducted through launch and retrieval pits that are about 15 x 30 feet.

For instance, all alternatives have nearly the same impacts for installation of vaults for mag meters & valves, diversion structure and grit removal structures, so those are not addressed in this memo. Similarly, the impacts for the work on 24th Avenue NW, south of NW 54th Street, to connect the conveyance to the Tunnel Effluent Pump Station (TEPS), are not discussed in this memo. The usual impacts of noise and dust would also be a factor for all three options. Below is an evaluation of each of the three alternatives with respect to impacts to property access, traffic and parking. A comparison summary follows the evaluations.

Alternative 1 (NW 56th Street): Alternative alignment is mainly composed of residential buildings including single family and multi-family residences along NW 56th Avenue and businesses and mixed development along 24th Avenue NW. The largest multi-family building is a retirement living facility on NW 56th Street and 24th Avenue NW.

- Property access impacts

  Vehicular and pedestrian access must be maintained at all times to the retirement facility at the corner of NW 56th Street and 24th Avenue NW. The microtunnel pits near, and within that intersection would likely prevent vehicular access to the building from 24th Avenue NW onto NW 56th Street, however traffic could access NW 56th Street via 26th Avenue NW.

  Microtunnelling method of pipe installation limits construction excavations to larger pits at the intersections of NW 56th Street and 28th Avenue NW and NW 56th Street and 24th Avenue NW, thereby allowing access to properties along NW 56th Street via 26th Avenue NW.

- Traffic impacts

  28th Avenue NW between NW Market Street and NW 56th Street would need to be closed for the duration of installation of pipes and structures on that street. 28th Avenue NW is a residential street; access to properties would be limited to other routes and a detour would be in place for several weeks.

  The pits at the intersections of NW 56th Street and 28th Avenue NW; and at NW 56th Street and 24th Avenue NW would be in place for the duration of microtunnelling in the area, and would prevent vehicular traffic from accessing NW 56th Street via 24th Avenue NW or 28th. Traffic would need to access 56th via 26th Avenue NW for several weeks.

  Bus routes along NW Market Street and 24th Avenue NW would also be impacted by the microtunnelling pit and supporting equipment in 24th Avenue NW at NW 56th St. Bus routes may not need to be rerouted; however, periodic delays are possible. Traffic lanes on 24th Avenue NW near NW 56th Street will be reduced and reconfigured for several weeks while the microtunnel pit and support equipment are in place.

- Parking Impacts

  Parking along NW 56th Street will be restricted to allow for staging of equipment. No parking will be allowed on 28th Avenue NW between Market and NW 56th Street for the duration of the closure, in addition to periodic parking restrictions for the duration of the project. Parking along 24th Avenue NW would be restricted near NW 56th St.

Alternative 2 (NW Market Street):

The land use along the alignment of the conveyance pipes, NW Market Street and 24th Avenue NW, is composed of commercial and business use. Both streets are minor arterials with high traffic volumes. In addition, NW Market Street is selected for the Burke Gilman Missing Link project alignment and SDOT proposes to add a bicycle lane.

- Property access impacts:

  The properties affected by Alternative 2 are mainly commercial businesses which rely on customer access to their facilities. Vehicular and pedestrian access on NW Market Street would be impacted during open cut construction on NW Market Street near 28th Avenue NW and installation of Maintenance Hole at the intersection of 26th Avenue NW and NW Market Street. The microtunnel pits near the intersection of NW Market Street and 28th Avenue NW; and within the intersection of NW Market St and 24th Avenue NW would greatly impact vehicular access to businesses in those areas.

- Traffic impacts:

  Similar to Alternative 1, 28th Avenue NW between NW Market Street and NW 56thtu Street would need to be closed for the duration of installation of pipe and structures in that area. 28th is a residential street; access to properties would be limited to other routes and a detour would be in place for several weeks. The open-cut excavations in Market at 28th Avenue NW would cause major re-routing of vehicle (and possible bicycle) lanes, and possibly periodic detours of traffic on Market.

  There are trolley bus routes on Market which would need to be re-routed and/or work requiring re-route of trolley buses would be restricted to weekends, thereby increasing the duration of the construction in that area. These same impacts apply to the microtunneling pits on Market, just East of 28th and at the intersection of 24th Avenue NW & Market. Further complicating the traffic control the intersection of Market & 24th is the fact that several bus routes use both streets. The pit would be large enough at that intersection to potentially require reroute of buses for several weeks while the microtunnel pits and support equipment are in place.

- Parking Impacts:

  Parking along NW Market Street would be severely restricted to allow for staging of equipment, and construction operations for the duration of construction (months). No parking will be allowed on 28th between Market and 56th for the duration of the closure of that block, in addition to periodic parking restrictions for the duration of the project.

Alternative 3 (NW 54th Street):

The Alternative 3 alignment along NW 54th Avenue is mainly industrial businesses. The existing “road” is extremely narrow, has a split-level section and is not a City right-of-way. This alignment also houses railroad tracks and a 12” watermain that would need to be replaced between 26th Avenue NW and 24th Avenue NW along NW 54th Street requiring extensive shoring adjacent to the existing railroad

- Property access impacts:

  The nature of the businesses along NW 54th Street rely on customer and truck & vehicle access to their facilities for material delivery & pick up. Vehicular and pedestrian access on NW 54th Street between 28th Avenue NW and 24th Avenue NW would be severely impacted during trenching to replace the watermain, as well as the presence of microtunnelling pits on NW 54th Street at 28th, 26th and 24th Avenue NW streets. The microtunnel pits would likely block vehicular access to the properties on the south side of 54th for the duration of trenchless construction. Thus, even if trenchless methods were used for the conveyance piping, the microtunnel launch & retrieval pits and the trenching for watermain replacement would still impact access to businesses along 54th.

- Traffic impacts:

This alternative would require detours of industrial truck traffic, and would prevent trucks from accessing industrial properties, loading docks, etc. There is no way to estimate the cost of impacting businesses; however, there would be a cost to impacting or blocking access.

- Parking Impacts (staging, construction foot print, etc.)
  Parking along NW 54th Street between 28th & 24th Avenues would be severely restricted to allow for construction operations and staging of equipment for the duration of construction (months).

SUMMARY / COMPARISON OF ALTERNATIVES

This section summarizes the above and includes relative durations of construction. Alternative 1 would mainly impact residential properties; however, access could be maintained. Alternative 2 would impact commercial businesses, including pedestrian and vehicular access to the businesses. It also would have the biggest impact on traffic in the area and bus routes (including trolleys). Alternative 3 would greatly impact the industrial businesses which have access needs along 54th Avenue NW. There is a possibility that access to several businesses on the south side of NW 54th Street would be cut off from vehicles & trucks for several weeks to a few months.

In general, it is anticipated construction duration would be the longest for Alternative 2 due to the traffic restrictions for work along Market Street. Alternatives 1 is the longest alignment, so it would likely have a longer duration than Alternative 3; however, Alternative 3 is more challenging and risky from a constructability standpoint. Also, Alternative 3 requires replacement of the existing 12” watermain and coordination with the Ballard Terminal Railroad for the entire alignment. Therefore, Alternative 3 is not likely to be much shorter duration than Alternative 1.

All three Alternatives would include some relocation and/or protection in place of existing utilities. The relocation & replacement of the existing 12” watermain along NW 54th Street required by Alternative 3 would be the most difficult due to the narrow road area and the proximity to the existing BTRR, as well as contaminated soil removal and dewatering treatment.

APPENDIX D:

PRELIMINARY PLANS AND PROFILES OF CONVEYANCE PIPES

LEGEND

- ▨ MICROTUNNEL LAUNCH/RETRIEVAL PIT
- ■ TUNNEL FLOW
- ▩ NORMAL FLOW
- ▧ FLOW TO OUTFALL
- ○ MAINTENANCE HOLE
- ⇨ FLOW DIRECTION
- – – – TRENCHING

NOT FOR CONSTRUCTION

OPTION 1 – NW 56TH ST, OVERVIEW

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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asuanj Apr-04-18 4:38pm

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DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
SEATTLE, WASHINGTON . . . . 20 . . .

BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

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REVISED AS BUILT

ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: 1" = 60'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 1 OF 19

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OPTION 2 – NW MARKET ST, OVERVIEW

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CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

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DESIGNED CHECKED	REVIEWED: DES. CONST. SDOT PROJ. MGR.
DRAWN CHECKED	RECEIVED REVISED AS BUILT

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City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: 1" = 60'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 2 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
			REVISIONS			

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LEGEND

▩	MICROTUNNEL LAUNCH/RETRIEVAL PIT
■	TUNNEL FLOW
▩	NORMAL FLOW
▨	FLOW TO OUTFALL
○	MAINTENANCE HOLE
⇨	FLOW DIRECTION
— — —	TRENCHING

NOT FOR CONSTRUCTION

OPTION 3 – NW 54TH ST, OVERVIEW

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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INITIALS AND DATE
REVIEWED:
DES. CONST.
SDOT PROJ. MGR.
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ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: 1" = 60'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
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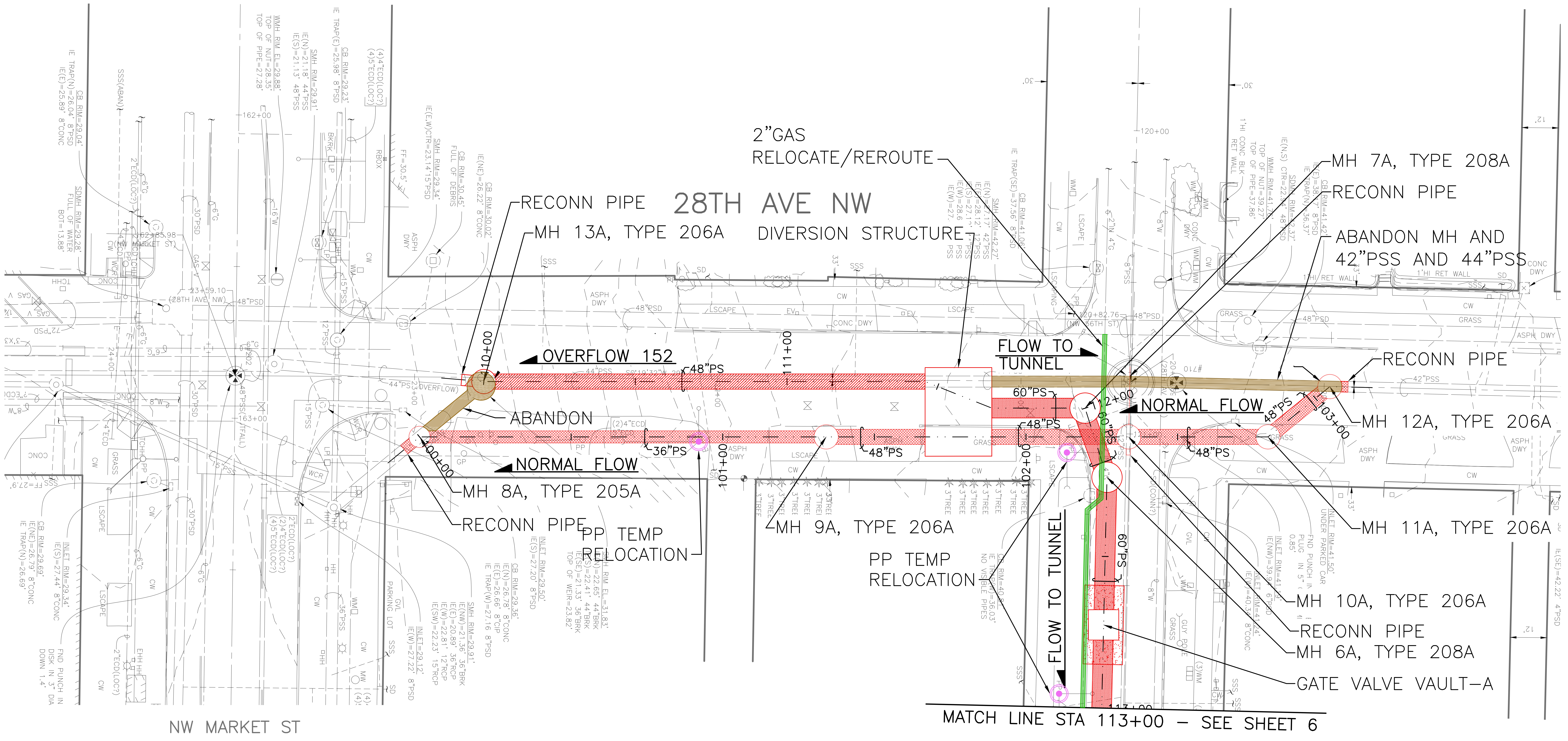
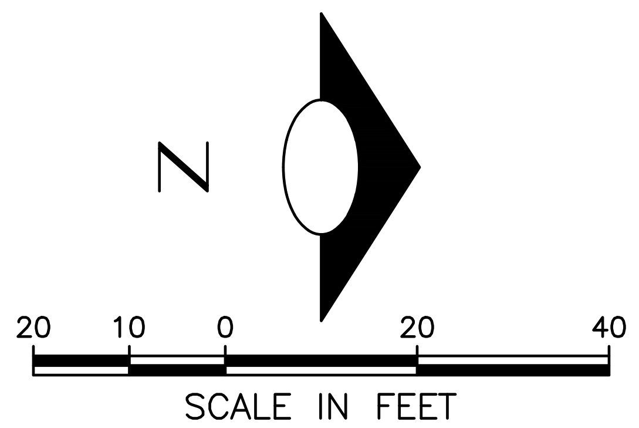
VAULT PLAN NO.
SHEET 3 OF 19





NOTES:

1. PROFILES FOR "NORMAL FLOW" & "OVERFLOW 152", SEE SHEET 5.
2. PROFILE & PLAN FOR "FLOW TO TUNNEL", SEE SHEET 6, 7, 8, & 9.

LEGEND:

🟫	SEWER
🟦	WATER
🟧	PSD
🟩	GAS
◎	PP
◯	MICROTUNNEL LAUNCH/RETRIEVAL PIT

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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NOT FOR CONSTRUCTION

OPTION 1 – NW 56TH ST, PLAN

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SEATTLE, WASHINGTON . . . . 20 . .

BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE	INITIALS AND DATE
DESIGNED	REVIEWED:
CHECKED	DES. CONST.
	SDOT PROJ. MGR.
DRAWN	RECEIVED
CHECKED	REVISED AS BUILT

ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

City of Seattle
Seattle Public Utilities
Mami Hara, Director

ORDINANCE NO. PW NO.
FUND:
SCALE: 1"=20'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO

VAULT PLAN NO.

SHEET 4 OF 19

OPTION 1 – NW 56TH ST, PROFILE

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

P:\Project\261-1067\05-DesignDrawings\0-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\XXX OPTION 1_Normal Flow.dwg
asuonj Apr-04-18 1:45pm

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APPROVED FOR ADVERTISING
NANCY LOCKE
DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
SEATTLE, WASHINGTON . . . . 20 . . .

BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE	INITIALS AND DATE
DESIGNED CHECKED	REVIEWED: DES. CONST. SDOT PROJ. MGR.
DRAWN CHECKED	RECEIVED REVISED AS BUILT

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ENGINEER'S NAME
STATE OF WASHINGTON
REGISTERED PROFESSIONAL ENGINEER
#

City of Seattle
Seattle Public Utilities
Mami Hara, Director

ORDINANCE NO. PW NO.
FUND:
SCALE: 1"=20'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO

VAULT PLAN NO.

SHEET 5 OF 19

NOT FOR CONSTRUCTION

OPTION 1 – NW 56TH ST, PLAN & PROFILE

APPROVED FOR ADVERTISING
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DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
SEATTLE, WASHINGTON . . . . 20 . . .

BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

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ENGINEER'S NAME

City of Seattle
Seattle Public Utilities
Mami Hara, Director

ORDINANCE NO. PW NO.
FUND:
SCALE: 1"=20'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO

VAULT PLAN NO.

SHEET 6 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
			REVISIONS			

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OPTION 1 – NW 56TH ST, PLAN & PROFILE

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City of Seattle
Seattle Public Utilities
Mami Hara, Director
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SCALE: 1"=20'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 7 OF 19

VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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asuonj Apr-04-18 1:45pm

OPTION 1 – NW 56TH ST, PLAN & PROFILE

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SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 8 OF 19

VAULT SERIAL NO.
NO. DATE MARK NATURE REVISIONS MADE CHK'D REV'D

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asuonj Apr-04-18 1:46pm

OPTION 1 – NW 56TH ST, PLAN & PROFILE

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DESIGNED
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INITIALS AND DATE
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SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 9 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
			REVISIONS			

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\XX5 OPTION 1_Normal Flow.dwg
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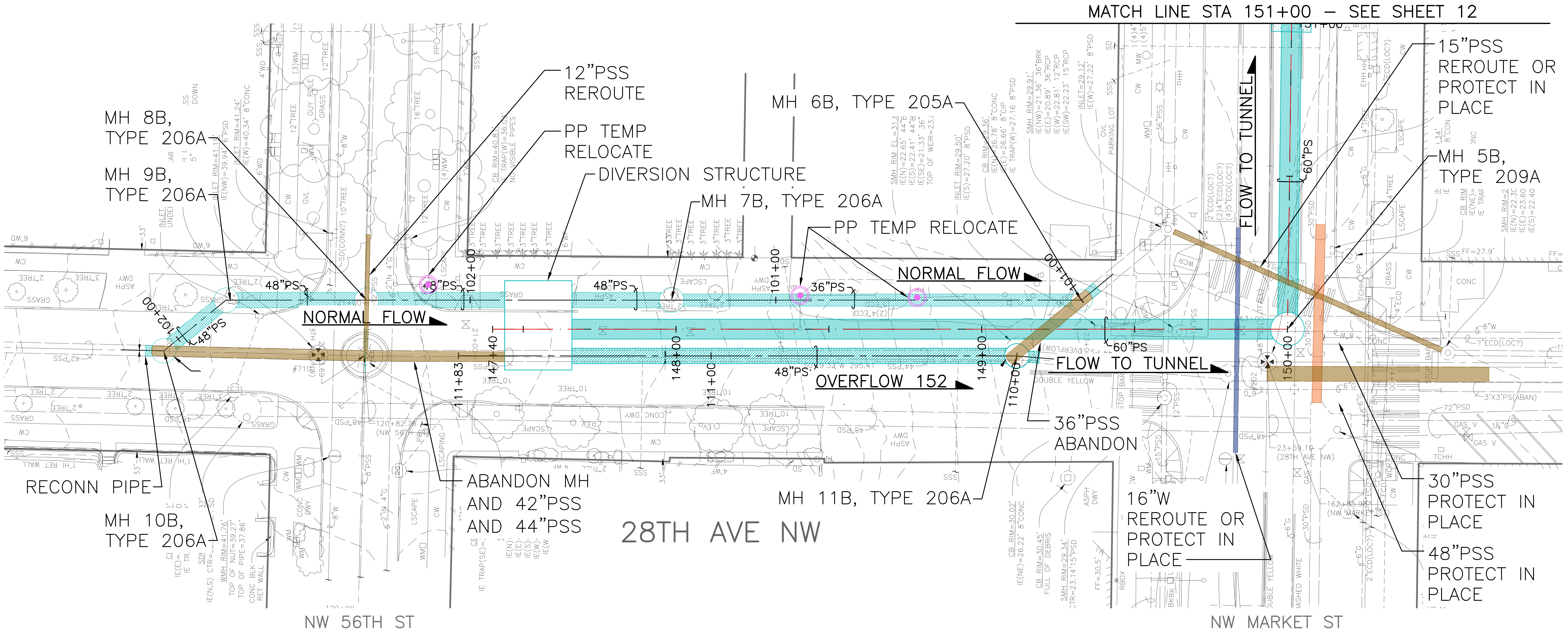

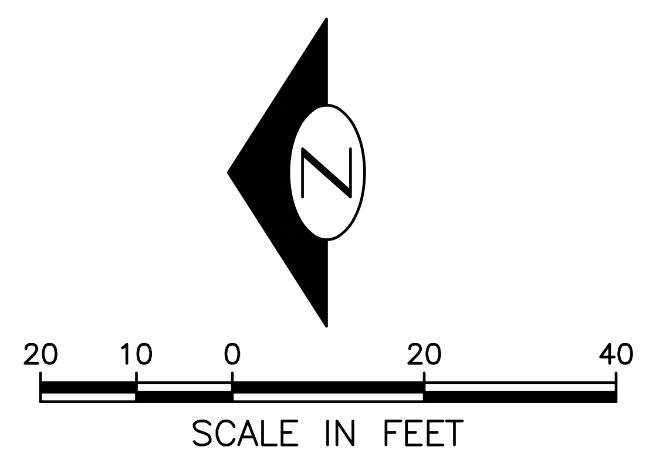

NOTES:

1. PROFILES FOR "NORMAL FLOW" & "OVERFLOW 152", SEE SHEET 11.
2. PROFILE & PLAN FOR "FLOW TO TUNNEL", SEE SHEET 12, 13, 14, & 15.

LEGEND:

🟫	SEWER
🟦	WATER
🟧	PSD
🟩	GAS
◉	PP
▨	MICROTUNNEL LAUNCH/RETRIEVAL PIT

NOT FOR CONSTRUCTION

OPTION 2 – NW MARKET ST, PLAN

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

P:\Project\261-1067\05-designdrawings\d-designfiles\261-1067_c315506_scwqp west ballard conveyance (150-152)\conflicts\15 OPTION 2_Flow-to-Tunnel-C.dwg
hwongc Apr-30-18 2:28pm

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BY: . . . .
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INITIALS AND DATE	INITIALS AND DATE
DESIGNED CHECKED	REVIEWED: DES. CONST. SDOT PROJ. MGR.
DRAWN CHECKED	RECEIVED REVISED AS BUILT

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REGISTERED PROFESSIONAL ENGINEER

City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: 1"=20'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 10 OF 19

OPTION 2 – NW MARKET ST, PROFILE

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D

REVISIONS

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\15 OPTION 2_Flow-To-Tunnel-C.dwg
asuanj Apr-04-18 1:48pm

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BY: . . . .
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DESIGNED
CHECKED
DRAWN
CHECKED

INITIALS AND DATE
REVIEWED:
DES. CONST.
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ENGINEER'S NAME
REGISTERED
PROFESSIONAL ENGINEER

City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 11 OF 19

NOT FOR CONSTRUCTION

OPTION 2 – NW MARKET ST, PLAN & PROFILE

APPROVED FOR ADVERTISING NANCY LOCKE DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES SEATTLE, WASHINGTON . . . . 20 . . BY: . . . . CITY PURCHASING & CONTRACTING SERVICES DIRECTOR	INITIALS AND DATE DESIGNED CHECKED DRAWN CHECKED	INITIALS AND DATE REVIEWED: DES. CONST. SDOT PROJ. MGR. RECEIVED REVISED AS BUILT	

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City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 12 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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OPTION 2 – NW MARKET ST, PLAN & PROFILE

VAULT SERIAL NO.	
DATE	
MARK	
NATURE REVISIONS	
MADE	
CHK'D	
REV'D	

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\15 OPTION 2_Flow To Tunnel-C.dwg
asuanj Apr-04-18 1:49pm

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DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
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DRAWN CHECKED	RECEIVED REVISED AS BUILT

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ENGINEER'S NAME
STATE OF WASHINGTON
REGISTERED PROFESSIONAL ENGINEER

City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD
CONVEYANCE – OPTION
ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 13 OF 19

NOT FOR CONSTRUCTION

OPTION 2 – NW MARKET ST, PLAN & PROFILE

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CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

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City of Seattle
Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 14 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
			REVISIONS			

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\15 OPTION 2_Flow-To-Tunnel-C.dwg
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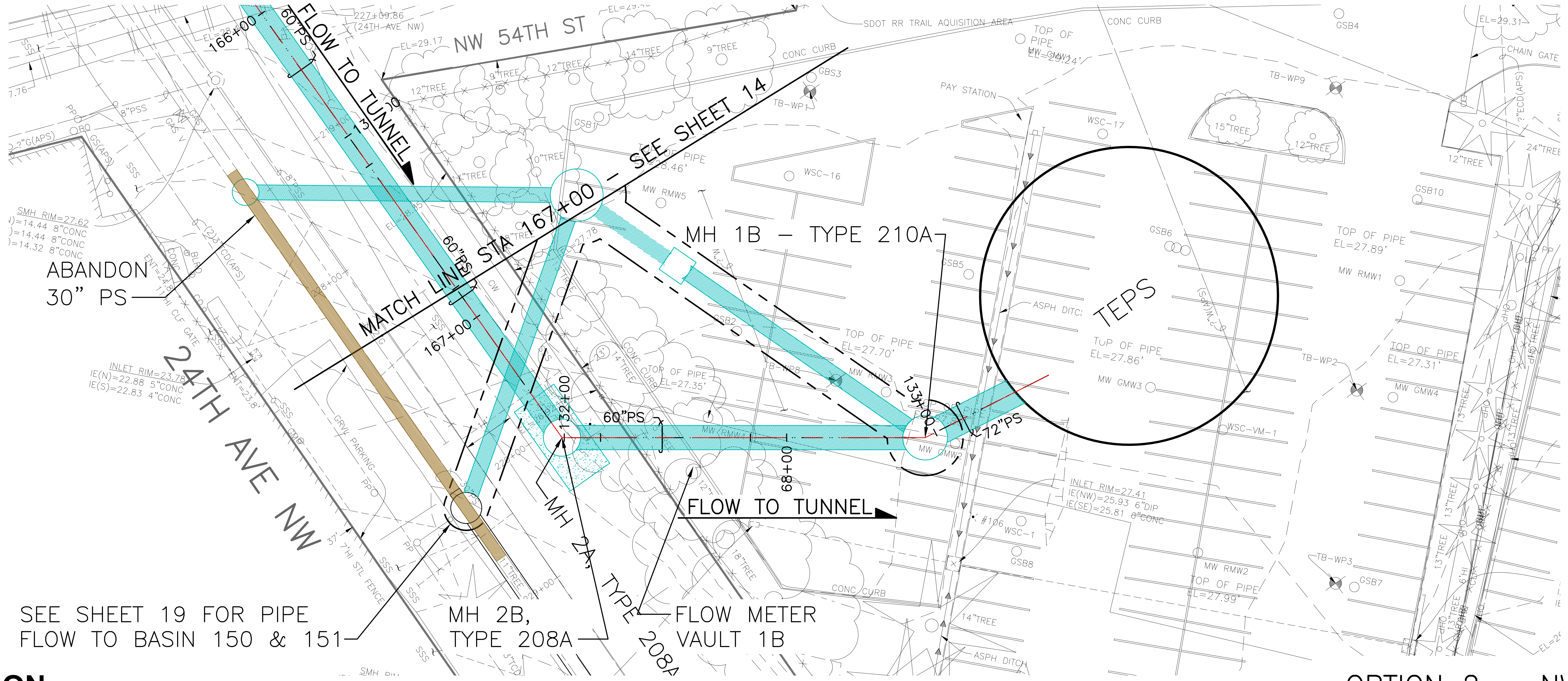

20 10 0 20 40
SCALE IN FEET

LEGEND:

🟫	SEWER
🟦	WATER
🟧	PSD
🟩	GAS
◉	PP
▨	MICROTUNNEL LAUNCH/RETRIEVAL PIT

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OPTION 2 – NW MARKET ST, PLAN & PROFILE

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DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
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BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

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Seattle Public Utilities
Mami Hara, Director
ORDINANCE NO. PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 15 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\15 OPTION 2_Flow To Tunnel-C.dwg
asuonj Apr-04-18 1:51pm

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OPTION 3 – NW 54TH ST, PLAN & PROFILE

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BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE
DESIGNED
CHECKED
DRAWN
CHECKED

INITIALS AND DATE
REVIEWED:
DES. CONST.
SDOT PROJ. MGR.
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City of Seattle
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FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 16 OF 19

VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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asuonj Apr-04-18 1:52pm

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OPTION 3 – NW 54TH ST, PLAN & PROFILE

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

P:\Project\261-1067\05-DesignDrawings\D-DesignFiles\261-1067_C315506_SCWQP West Ballard Conveyance (150-152)\CONFLICTS\18 OPTION 3_Flow-To-Tunnel-C.dwg
asuanj Apr-04-18 1:52pm

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FUND:
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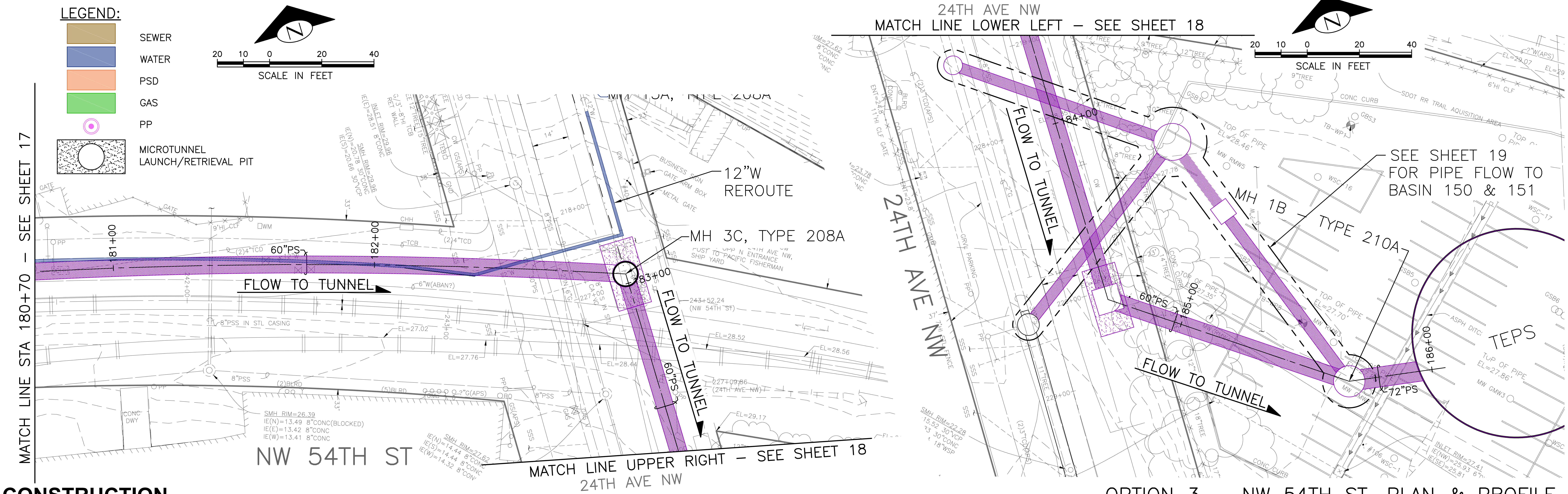
SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 17 OF 19



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SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO. PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 18 OF 19

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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asuonj Apr-04-18 1:53pm

BASIN 150 & 151 – FLOW TO TUNNEL & OUTFALL 151

VAULT SERIAL NO.
DATE
MARK
NATURE
REVISIONS
MADE
CHK'D
REV'D

P:\Project\261-1067\05-designdrawings\d-designfiles\261-1067_c315506_scwqp west ballard conveyance (150-152)\conflicts\19 BASIN 150 & 151_flow-to-tunnel-C.dwg
hwongc Apr-30-18 2:32pm

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BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE
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Mami Hara, Director
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PW NO.
FUND:
SCALE: H. 1"=20', V. 1"=10'

SCWQP WEST BALLARD CONVEYANCE – OPTION ANALYSIS – CONFLICTS

JOB NO.
PC C315506
R/W
CO
VAULT PLAN NO.
SHEET 19 OF 19

APPENDIX E:

COST ESTIMATE AND BASIS OF ESTIMATE

Construction Contract Amount Spreadsheet

Project Name: SCWQP: Ballard Conveyance- Options Analysis - NW 56th St
Project ID: C315506
Project Phase: Options Analysis
Cost Estimator(s): Eset Alemu
Est. Reviewer(s) Eleanor Jackson
Date: 1-Jun-18

Item	Bid Item	Bid Item Description	Quantity	Unit	Unit Price	Unit Price Extension
1	109005	MOBILIZATION-CSI(REF)	1	LS	$ 1,208,000	$ 1,208,000
2	107005	SAFETY AND HEALTH PROGRAM-CSI(REF)	12	Month	$ 1,725	$ 20,700
3	110005	MAINTENANCE & PROTECTION OF TRAFFIC CONTROL INC	240	Day	$ 895	$ 214,800
4	717985	TEMPORARY SEWER BYPASS	1	LS	$ 100,000	$ 100,000
5	801001	CONSTRUCTION STORMWATER EROSION CONTROL PLAN	1	LS	$ 100,000	$ 100,000
6	717990	TELEVISION INSPECTION { QTY >200FT 1 MOB}	2,876	LF	$ 5	$ 14,379
7	SPECIAL	VIBRATION AND SETTLEMENT MONITORING	1	LS	$ 500,000	$ 500,000
8	SPECIAL	Electrical Elements	1	LS	$ 123,500	$ 123,500
9	SPECIAL	Trenching and Backfill 2" Schedl 40 PVC Conduit Direct Burial, Saw Cutting, Pavement Removal, Excavation, Pavement Repair	1,850	LF	$ 250	$ 462,500
10	705010	MAINTENANCE HOLE, Type 205A{QTY<=5 EA}	1	EA	$ 10,250	$ 10,250
11	705012	MAINTENANCE HOLE, Type 206A{QTY>5 EA}	6	EA	$ 11,250	$ 67,500
12	705112	EXTRA Depth, Type 206A Maintenance Hole	6	VF	$ 310	$ 1,860
13	705016	MAINTENANCE HOLE, Type 208A{QTY<=5 EA}	8	EA	$ 15,500	$ 124,000
14	705116	EXTRA DEPTH, Type 208A Maintenance Hole	100	VF	$ 615	$ 61,500
15	705020	MAINTENANCE HOLE , Type 210A{QTY<=5 EA}	1	EA	$ 20,500	$ 20,500
16	705120	EXTRA Depth, Type 210A Maintenance Hole	5	VF	$ 920	$ 4,600
17	705024	MAINTENANCE HOLE, Type 212A{QTY<=5 EA}	1	EA	$ 30,750	$ 30,750
18	SPECIAL	Grit Removal Structure	1	LS	$ 489,600	$ 489,600
19	SPECIAL	Diversion Structure	1	LS	$ 393,400	$ 393,400
20	SPECIAL	60"Gate Valve Vault	1	LS	$ 159,700	$ 159,700
21	SPECIAL	48"Gate Valve Vault	1	LS	$ 112,800	$ 112,800
22	705300	RECHANNEL Maintenance Hole	2	EA	$ 1,250	$ 2,500
23	202850	ABANDON AND FILL PIPE {QTY >100}	236	LF	$ 36	$ 8,496
24	717236	PIPE, PS, Conc C76 CLIII, 36 IN { QTY>20FT}	134	LF	$ 155	$ 20,770
25	717036	BEDDING, CL B, 36 IN Pipe { QTY >50LF}	134	LF	$ 33	$ 4,422
26	SPECIAL	PIPE, PS, Conc C76 CLIII, 48 IN { QTY>20FT}	587	LF	$ 370	$ 217,042
27	717048	BEDDING, CL B, 48 IN Pipe { QTY >50LF}	587	LF	$ 32	$ 18,771
28	SPECIAL	PIPE, PS, Conc C76 CLIII, 60 IN	201	LF	$ 490	$ 98,490
29	717060	BEDDING, CL B, 60 IN Pipe { QTY >50LF}	201	LF	$ 62	$ 12,462
30	SPECIAL	PIPE, PS, Conc C76 CLIII, 72 IN	27	LF	$ 820	$ 22,304
31	717072	BEDDING, CL B,72 IN Pipe { QTY <=50LF}	27	LF	$ 77	$ 2,094
32	210110	Contaminated soils Disposal	52	TN	$ 135	$ 6,965
33	208013	Dewatering- Pumping Water(6" Pump) to Baker Tank Large Water Flow Capacity	180	DAY	$ 2,075	$ 373,500
34	SPECIAL	CONTAMINATED WATER TREATMENT	1,440	HR	$ 17	$ 24,480
35	SPECIAL	SURFACE RESTORATION	1	LS	$ 201,785	$ 201,785
36	SPECIAL	LANDSCAPING	1	LS	$ 20,038	$ 20,038
37	SPECIAL	UTILITY RELOCATIONS	1	LS	$ 321,500	$ 321,500
38	SPECIAL	MICROTUNNEL 60" PS DIP	1,927	LF	$ 4,000	$ 7,708,000
					Construction Line Item Pricing	**$ 13,283,959**
					Allowance for Indeterminates	25%
					Construction Bid Amount	**$ 16,604,949**
					Sales Tax %	0.0%
					Construction Contract Amount	**$ 16,604,949**

Construction Contract Amount Spreadsheet

Project Name: SCWQP: Ballard Conveyance- Options Analysis - NW Market St
Project ID: C315506
Project Phase: Options Analysis
Cost Estimator(s): Eset Alemu
Est. Reviewer(s) Eleanor Jackson
Date: 1-Jun-18

Item	Bid Item	Bid Item Description	Quantity	Unit	Unit Price	Jnit Price Extensior
1	109005	MOBILIZATION-CSI(REF)	1	LS	$ 1,085,000	$ 1,085,000
2	107005	SAFETY AND HEALTH PROGRAM-CSI(REF)	12	Month	$ 1,725	$ 20,700
3	110005	MAINTENANCE & PROTECTION OF TRAFFIC CONTROL INCLU	240	Day	$ 895	$ 214,800
4	717985	TEMPORARY SEWER BYPASS	1	LS	$ 100,000	$ 100,000
5	801001	CONSTRUCTION STORMWATER EROSION CONTROL PLAN	1	LS	$ 100,000	$ 100,000
6	SPECIAL	VIBRATION AND SETTLEMENT MONITORING	1	LS	$ 500,000	$ 500,000
7	717990	TELEVISION INSPECTION { QTY >200FT 1 MOB}	2,556	LF	$ 5	$ 12,778
8	SPECIAL	Electrical Elements	1	LS	$ 123,500	$ 123,500
9	SPECIAL	Trenching and Backfill 2" Schedl 40 PVC Conduit Direct Burial, Saw Cutting, Pavement Removal, Excavation, Pavement Repair	1,580	LF	$ 250	$ 395,000
10	705010	MAINTENANCE HOLE, Type 205A{QTY<=5 EA}	1	EA	$ 10,000	$ 10,000
11	705012	MAINTENANCE HOLE, Type 206A{QTY>5 EA}	6	EA	$ 8,175	$ 49,050
12	705112	EXTRA Depth, Type 206A Maintenance Hole	8	VF	$ 310	$ 2,480
13	705016	MAINTENANCE HOLE, Type 208A{QTY<=5 EA}	4	EA	$ 15,500	$ 62,000
14	705116	EXTRA DEPTH, Type 208A Maintenance Hole	33	VF	$ 615	$ 20,295
15	705018	MAINTENANCE HOLE, Type 209A{QTY<=5 EA}	1	EA	$ 18,500	$ 18,500
16	705020	MAINTENANCE HOLE , Type 210A{QTY<=5 EA}	1	EA	$ 20,500	$ 20,500
17	705120	EXTRA Depth, Type 210A Maintenance Hole	6	VF	$ 920	$ 5,520
18	705024	MAINTENANCE HOLE, Type 212A{QTY<=5 EA}	1	EA	$ 30,750	$ 30,750
19	SPECIAL	Grit Removal Structure	1	LS	$ 489,600	$ 489,600
20	SPECIAL	Diversion Structure	1	LS	$ 393,400	$ 393,400
21	SPECIAL	60"Gate Valve Vault	1	LS	$ 109,800	$ 109,800
22	SPECIAL	48"Gate Valve Vault	1	LS	$ 112,800	$ 112,800
23	705300	RECHANNEL Maintenance Hole	2	EA	$ 1,250	$ 2,500
24	202850	ABANDON AND FILL PIPE {QTY >100}	344	LF	$ 36	$ 12,384
25	717236	PIPE, PS, Conc C76 CLIII, 36 IN { QTY>20FT}	134	LF	$ 155	$ 20,770
26	717036	BEDDING, CL B, 36 IN Pipe { QTY >50LF}	134	LF	$ 33	$ 4,422
27	SPECIAL	PIPE, PS, Conc C76 CLIII, 48 IN { QTY>20FT}	296	LF	$ 370	$ 109,335
28	717048	BEDDING, CL B, 48 IN Pipe { QTY >50LF}	296	LF	$ 32	$ 9,456
29	SPECIAL	PIPE, PS, Conc C76 CLIII, 48 IN { QTY>20FT}	469	LF	$ 490	$ 229,859
30	717048	BEDDING, CL B, 48 IN Pipe { QTY >50LF}	469	LF	$ 62	$ 29,084
31	SPECIAL	PIPE, PS, Conc C76 CLIII, 60 IN	27	LF	$ 820	$ 22,140
32	717072	BEDDING, CL B,72 IN Pipe { QTY <=50LF}	27	LF	$ 77	$ 2,094
33	210110	Contaminated soils Disposal	787	TN	$ 135	$ 106,281
34	208013	Dewatering- Pumping Water(6" Pump) to Baker Tank Large Water Flow Capacity	180	DAY	$ 2,075	$ 373,500
35	SPECIAL	CONTAMINATED WATER TREATMENT	4,320	HR	$ 17	$ 73,440
36	SPECIAL	SURFACE RESTORATION	1	LS	$ 232,800	$ 232,800
37	SPECIAL	LANDSCAPING	1	LS	$ 41,600	$ 41,600
38	SPECIAL	UTILITY RELOCATIONS	1	LS	$ 264,000	$ 264,000
39	SPECIAL	MICROTUNNEL 60" PS DIP	1,630	LF	$ 4,000	$ 6,520,000
			Construction Line Item Pricing			**$ 11,930,138**
			Allowance for Indeterminates			25%
			Construction Bid Amount			**$ 14,912,673**
					Sales Tax %	0.0%
			Construction Contract Amount			**$ 14,912,673**

Construction Contract Amount Spreadsheet

Project Name: SCWQP: Ballard Conveyance- Options Analysis - NW 54th St
Project ID: C315506
Project Phase: Options Analysis
Cost Estimator(s): Eset Alemu
Est. Reviewer(s) Eleanor Jackson
Date: 1-Jun-18

Item	Bid Item	Bid Item Description	Quantity	Unit	Unit Price	Unit Price Extension
1	109005	MOBILIZATION-CSI(REF)	1	LS	$ 960,000	$ 960,000
2	107005	SAFETY AND HEALTH PROGRAM-CSI(REF)	12	Month	$ 1,725	$ 20,700
3	110005	MAINTENANCE & PROTECTION OF TRAFFIC CONTROL INC	240	Day	$ 895	$ 214,800
4	717985	TEMPORARY SEWER BYPASS	1	LS	$ 100,000	$ 100,000
5	801001	CONSTRUCTION STORMWATER EROSION CONTROL PLAN	1	LS	$ 100,000	$ 100,000
6	717990	TELEVISION INSPECTION { QTY >200FT 1 MOB}	1,754	LF	$ 5	$ 8,768
7	SPECIAL	VIBRATION AND SETTLEMENT MONITORING	1	LS	$ 500,000	$ 500,000
8	SPECIAL	Electrical Elements	1	LS	$ 123,500	$ 123,500
9	SPECIAL	Trenching and Backfill 2" Schedl 40 PVC Conduit Direct Burial, Saw Cutting, Pavement Removal, Excavation, Pavement Repair	1,440	LF	$ 250	$ 360,000
10	705012	MAINTENANCE HOLE, Type 206A{QTY>5 EA}	1	EA	$ 8,175	$ 8,175
11	705016	MAINTENANCE HOLE, Type 208A{QTY<=5 EA}	5	EA	$ 15,500	$ 77,500
12	705116	EXTRA DEPTH, Type 208A Maintenance Hole	8	VF	$ 615	$ 4,613
13	705020	MAINTENANCE HOLE , Type 210A{QTY<=5 EA}	1	EA	$ 20,500	$ 20,500
14	705120	EXTRA Depth, Type 210A Maintenance Hole	4	VF	$ 920	$ 3,680
15	705024	MAINTENANCE HOLE, Type 212A{QTY<=5 EA}	1	EA	$ 30,750	$ 30,750
16	SPECIAL	Grit Removal Structure	1	LS	$ 489,600	$ 489,600
17	SPECIAL	Diversion Structure	1	LS	$ 142,700	$ 142,700
18	SPECIAL	60"Gate Valve Vault	1	LS	$ 94,200	$ 94,200
19	SPECIAL	48"Gate Valve Vault	1	LS	$ 112,800	$ 112,800
20	705300	RECHANNEL Maintenance Hole	1	EA	$ 1,250	$ 1,250
21	202850	ABANDON AND FILL PIPE {QTY >100}	100	LF	$ 36	$ 3,600
22	SPECIAL	PIPE, PS, Conc C76 CLIII, 48 IN { QTY>20FT}	292	LF	$ 370	$ 108,077
23	717048	BEDDING, CL B, 48 IN Pipe { QTY >50LF}	292	LF	$ 32	$ 9,347
24	SPECIAL	PIPE, PS, DI CL 52, 60 IN	24	LF	$ 615	$ 14,883
25	717060	BEDDING, CL B, 60 IN Pipe { QTY >50LF}	24	LF	$ 62	$ 1,500
26	SPECIAL	PIPE, PS, Conc C76 CLIII, 72 IN	27	LF	$ 820	$ 22,304
27	717072	BEDDING, CL B,72 IN Pipe { QTY <=50LF}	27	LF	$ 77	$ 2,094
28	210110	Contaminated soils Disposal	4,277	TN	$ 135	$ 577,462
29	208013	Dewatering- Pumping Water(6" Pump) to Baker Tank Large Water Flow Capacity	180	DAY	$ 2,075	$ 373,500
30	SPECIAL	CONTAMINATED WATER TREATMENT	4,320	HR	$ 17	$ 73,440
31	SPECIAL	SURFACE RESTORATION	1	LS	$ 114,200	$ 114,200
32	SPECIAL	LANDSCAPING	1	LS	$ 20,000	$ 20,000
33	SPECIAL	UTILITY RELOCATIONS	1	LS	$ 217,370	$ 217,370
34	SPECIAL	MICROTUNNEL 60" PS DIP	1,410	LF	$ 4,000	$ 5,640,000
					Construction Line Item Pricing	**$ 10,551,313**
					Allowance for Indeterminates	25%
					Construction Bid Amount	**$ 13,189,142**
					Sales Tax %	0.0%
					Construction Contract Amount	**$ 13,189,142**

	Option 1	Option 2	Option 3	
	Estimated Cost	**Estimated Cost**	**Estimated Cost**	
	$ 16,604,949	$ 14,912,673	$ 13,189,142	
Construction Bid Amount	**$ 16,605,000**	**$ 14,913,000**	**$ 13,190,000**	
Sales Tax %	0.00%	0.00%	0.00%	See Appendix B
Construction Contract Amount	**$ 16,605,000**	**$ 14,913,000**	**$ 13,190,000**	
Crew Construction Costs	$ -	$ -	$ -	
Miscellaneous Hard Costs	$ -	$ -	$ -	See Appendix A
Construction Cost Total	**$ 16,605,000**	**$ 14,913,000**	**$ 13,190,000**	
Soft Cost %	49%	49%	49%	See Section 3.4.1
Soft Cost	$ 8,137,000	$ 7,308,000	$ 6,464,000	
Property Acquisition Costs	$ -	$ -	$ 1,588,000	Do not include Labor
Base Cost Total	**$ 24,742,000**	**$ 22,221,000**	**$ 21,242,000**	
Contingency Reserve %		20%		See Section 4.2
Contingency Reserve	$ 6,975,000	$ 4,445,000.00	$ 10,050,000	**Based on Risk Register Analysis for Option 1 and 3**
Management Reserve %	20%	20%	20%	See Section 4.1
Management Reserve				**Reserve managed at the Program level**
Project Reserves	**$ 6,975,000**	**$ 4,445,000**	**$ 10,050,000**	
Total Cost	**$ 31,717,000**	**$ 26,666,000**	**$ 31,292,000**	
Inflation Cost Projection				**To be calculated for the recommended option**
Escalation Adjustment Cost Projection				**To be calculated for the recommended option**
Total Cost Projection				*Sumation of Total Cost, Inflation & Escalation Adjustment = Total Cost Projection*
-20%	**$ 25,373,600**	**$ 21,332,800**	**$ 25,033,600**	**Class IV Cost Estimate Range**
30%	**$ 41,232,100**	**$ 34,665,800**	**$ 40,679,600**	

Basis of Estimate-Before or at Stage Gate 2

**Note this BOE is for estimating the Total Cost Projection

Title	**SCWQP: Ballard Conveyance- Options Analysis - Calss IV - 06/01/2018**	
1. Project Information:	* Activity Name/Number * LOB Representative and Project Manager * Cost estimator * Estimate Reviewer(s)	C315506 Alex Mockos / Richard Fernandez Eset Alemu Eleanor Jackson
2. Project Objectives	The purpose of the Ballard Conveyance System is to bring the Ballard CSO Basins 150, 151 and 152 into regulatory compliance by reducing the frequency of overflows to an average of one overflow per year on a rolling 20-year average per outfall.	
3. Project Scope	The Ballard Conveyance System includes conveyance pipes, and infrastructure to the storage tunnel, including associated hydraulic structures. The Options Analysis phase of this project evaluates alternatives to route flows from Ballard Basins 150, 151 and 152 to the Storage Tunnel. This work package includes hydraulic modeling; identifying major utility conflicts; preliminary geotechnical assessment; permit identification; property acquisition identification; and coordination and support for communications and outreach.	
4. Location	The project is in the Ballard neighborhood which is an economically diverse and developing neighborhood featuring commercial, residential, and industrial areas in close proximity. The conveyance pipe is a 60-inch-diameter gravity pipe starting at a proposed diversion structure near 28th Ave NW and terminating at the West Portal site on 24th Ave NW and Shilshole Ave NW. The three alignments considered for the conveyance system are: 1. Alignment south along 28th Ave NW, east on NW 56th St and south on 24th Ave NW 2. Alignment south along 28th Ave NW, east on NW Market St and south on 24th Ave NW 3. Alignment south along 28th Ave NW, east on NW 54th St to 24th Ave NW	
5. Schedule	See attached schedule	
6. Labor Resourcing Strategy	SPU will perform Options Analysis to select the preferred alignment for the Ballard Conveyance project. The design of the preferred alternative will be defined at a later date.	
7. Construction Contracting Strategy	SPU currently plans to employ design bid build contracting approach.	
8. Conceptual Design	* Design Assumptions * Conceptual drawing/sketch * Specifications (if applicable)	Refer to Item 20 See attached conceptual drawings City of Seattle Standard Specifications for 2017
9. Basis of Quantity:	* Take-off by LOB * Take-off by Engineering * Take-off by SPU Consultant	☐ ☑ ☐ *Please explain if more than 2 boxes checked
10. Basis of Labor, Materials & Equipment Pricing (aka Unit Price)	* Historical unit costs (aka Cost Model) * Similar completed project * Engineering Judgment * Semi-detailed unit costs	SCWQP Fremont Conveyance Project 60% CH2M Hill Facility Plan -Cost Estimates - August 2015 • SPU APWA 2017 and CSI 2017
11. Allowance For Indeterminates:	An Allowance for Indeterminates of 25 percent was used based on professional judgment.	
12. Sales Tax	* Sales Tax Applicable * Sales Tax Not Applicable	10.10%
13. SPU Field Crew Costs/Misc Hard Costs	SPU crews are assumed to be used for the connection to existing watermains which is incorporated in the cost estimate.	
14. Soft Cost	* From SPU CEG * Not from SPU CEG	49% of project construction cost was used per SCWQP options analysis guidelines
15. Property Acquisition Cost	Property acquisition costs were calculated by Real Properties for Alternative 3 alignment along NW 54th St alignment between 28th Ave NW and 24th Ave NW	
16. Contingency Reserve	* From SPU CEG Recommended Range * Not from SPU CEG	Option 1 and Option 3 -Risk Register Analysis was used to calculate contingency reserve. Option 2 Contingency reserve was 20% s Base Cost
17. Management Reserve	* From SPU CEG * Not from SPU CEG	Managament Reserve will be held and managed at the Program level.

18. Inflation	* Yes * No	Inflation costs wil be calcuated for the recommended alternative based on construction timeline.
19. Escalation Adjustment	* Yes * No	Escalation costs wil be calcuated for the recommended alternative based on construction timeline.
20. Other Assumptions:	Additional assumptions that may affect the cost estimate include: • The subsurface material along NW Market St alignment, NW 54th St alignment, 24th Ave NW and TEPS site are assumed to be contaminated based on the results of the geotechnical investigation conducted in the Options Analysis phase. The cost estimate assumed presence of contaminated spoils for the following alternatives: • Alternative 1: Excavation 150/151 Basin conveyance pipes along 24th Ave NW and in the TEPS site • Alternative 2: Excavation for the installation of the diversion structure and gate vault, and 150/151 Basin conveyance pipes along 24th Ave NW and in the TEPS site • Alternative 3: Excavation for the installation of the diversion structure and gate vault, and 150/151 Basin conveyance pipes along 24th Ave NW and in the TEPS site • Alternative 3: Due to location near the shoreline, includes monitoring wells for dewatering potentially contaminated groundwater and cost of treating contaminated water. These costs were taken from the Fremont 60% design. • The volume of contaminated soil for Alternative 3 also includes material removed during microtunneling; excavation of launch and retrieval pits; and maintenance holes. • Microtunneling unit cost is based on 3rd Ave W microtunneling costs for a 94” pipe and includes assembly and disassembly of jacking station, and installation of electrical conduits, cost of pipes & backfill of launch and retrieval pits • Disposal of soil material for launch and retrieval pits are included in the unit cost of microtunneling • Unit prices for 48” normal and overflow pipes were based on 54” PS pipes • Unit prices for 72” tunnel conveyance pipes were based on a 72” Detention pipes • The conveyance pipes for Basin 150/151 pipes and combined 72” pipe connecting to TEPS structure will be installed to meet minimum pipe cover requirements • Costs for hydraulic structures such as Diversion Structures, and Gate Vaults include cost of construction material, excavation, shoring and hauling of material • Electrical equipment such as backup generator can be installed at the site. • The cost of utility conflict relocations was considered for all alternatives. This included electric poles, gas lines, sewer lines, water mains and railroad. The alignment of Alternative 3 is parallel with a 12” Ductile Iron water main that may need to be relocated due to proximity to the tunnel conveyance pipes. • Since Alternative 3 alignment falls mainly along private property, property acquisition cost was incorporated in the construction cost. This line item was not included in the mobilization cost. • Due to the open cut nature of construction along 28th Ave NW, Alternative 1 and Alternativ2 both consider the restoration of the whole width of the street. • Surface restoration for basin 150/151 conveyance pipes and connecting pipe to TEPS are assumed to be included in the TEPS package and not in Ballard Conveyance. • The cost of grit removal structure was sources from the Ballard Conveyance Facility Plan cost estimate completed in August 2015. The estimate was adjusted for escalation and inflation and adjusted for 2017 dollars. • The cost of compliance to City of Seattle Stormwater Code is not included. • Risk register analysis was used to calculate the management reserve costs for Alternative 1 and Alternative 3, while Alternative 2 used 20% of the base cost * The Washington State Department of Revenue issued a letter stating that SCWQP conveyance projects will be tax exempt.	
21. Exceptions:	There are no variances to SPU’s cost estimating practices or any significant deviations from the deliverables normally required for the current project phase.	
22. Risks	The “Key Risks & Issues” section of the Stage Gate 2 is not available. Excavation, shoring, and dewatering are not well defined and comprise a large part of the project and, therefore, there is significant risk associated with those items in terms of both cost and schedule.	
23. Basis of Estimate Reviews and Bechmarking	* How/Why Estimate Has Changed * Benchmarking * Attachments	Mag Meter costs were taken out Last Update was 06-01-2018 Ballard Conveyance Alternatives Class IV Cost Estimate_20180828.xlsx

APPENDIX F:

BALLARD CONVEYANCE HYDRAULIC MODELING REPORT

McMILLEN
JACOBS
ASSOCIATES

Technical Memorandum

To:	Dylan Menes (SPU) Eleanor Jackson (SPU) Eset Alemu (SPU)	Project:	Ship Canal Water Quality Project, Ballard Conveyance Modeling
From:	Dr. Steve Merrill (BC) Andrew Henson (Aqualyze)	cc:	Jeremy Johnson (MJA) Pat Tangora (BC) Richard Fernandez (SPU)
Date:	March 20, 2018	Job No.:	5426.0
Subject:	Ballard Conveyance Modeling for Ship Canal Water Quality Project		

1.0 Introduction and Purpose

Seattle Public Utilities (SPU) is designing facilities that will convey combined sewage from the SPU Ballard Basin 152 to the proposed Ship Canal Water Quality project (SCWQP) tunnel. These facilities will consist of a new diversion structure as well as a piped conveyance system connecting the diversion structure to the SCWQP storage tunnel. The new diversion structure will replace the existing National Pollutant Discharge Elimination System (NPDES) 152 CSO structure that is currently located near the intersection of 28th Avenue NW and NW Market Street. The new diversion structure will perform the following actions:

- Control flows to the combined sewer line along NW Market Street to reduce the risk of a sanitary sewer overflow (SSO) in that line.
- Direct high flows to the SCWQP tunnel through a new conveyance pipe.
- Direct excess flows to the NPDES 152 combined sewer overflow (CSO) outfall during large events when the tunnel full set point is reached.

To support the analysis of options and inform final design, a task “Additional Ballard Basins Modeling” was added to Consultant Contract 14-213-S in Amendment 3. The goal of this task was to identify and examine solutions to potential Sanitary Sewer Overflows (SSO) projected in previous modeling studies (McMillen Jacobs Associates [MJA] 2016). This work included refinement of the existing Mike Urban model developed and calibrated for the Ballard basins by King County, and integration of that model with a model including the SCWQP tunnel (SPU 2018).

The hydraulic modeling effort supports option~~s~~ analysis and helps inform design parameters including the weir lengths at the diversion structure, diameter of conveyance pipe; measures to control flow leaving the diversion structure; and investigates other conditions that may contribute to SSOs. This technical memorandum presents the process, methodology, and results of using the model to support the Ballard 152 Conveyance Option Analysis.

2.0 Hydrologic/Hydraulic (H/H) Modeling

The following sections provide details regarding the modeling platform, and model development.

2.1 Modeling Platform

All modeling for this work was conducted using the 2016 version of DHI's MOdel for Urban SEwers (MOUSE) H/H engine running under the MIKE URBAN interface software platform (DHI 2016). This is consistent with all other H/H modeling analysis conducted for the SCWQP.

2.2 Model Development

An Integrated Model was created in MIKE URBAN (SPU 2018) that included the following:

- Hydraulics and hydrology for the Ballard CSO Basins 150/151 and 152 were created by King County modeling staff and calibrated against flow monitoring data. Inflows were used to represent upper basin flows from NPDES 152 and NPDES 150/151, which were generated in separate model runs using calibrated models with desired rainfall inputs.
- The proposed SCWQP tunnel hydraulics and all additional tributary areas (in the form of inflow timeseries). This version of the model relied on tunnel level only to dictate CSO diversion gate operation.
- King County North Interceptor (KCNI) hydraulics.
- SPU's Pump Station 84 (PS84) and associated hydraulic structures.
- Rainfall input representative of the perturbed climate for the year 2035, including rainfall scaling factors to represent model uncertainty for the 95th confidence interval.
- Inflow time series from the following basins applied upstream of the facilities included in the model:
    - SPU Ballard 150/151
    - SPU Ballard 152
    - King County Interbay Pump Station
    - King County Carkeek Pump Station
    - King County Central Trunk
    - King County Green Lake and Laurelhurst Trunks
    - King County Southwest Lake Washington Trunk
    - King County Matthews Park Pump Station
    - SPU basins along the King County North Interceptor and areas tributary to the King County 11th Ave NW overflow and Ballard Regulator Station

This model provided the appropriate flows and downstream conditions to properly evaluate the proposed Ballard conveyance concept under a variety of storm events. Figure 2-1 shows the overall model components.

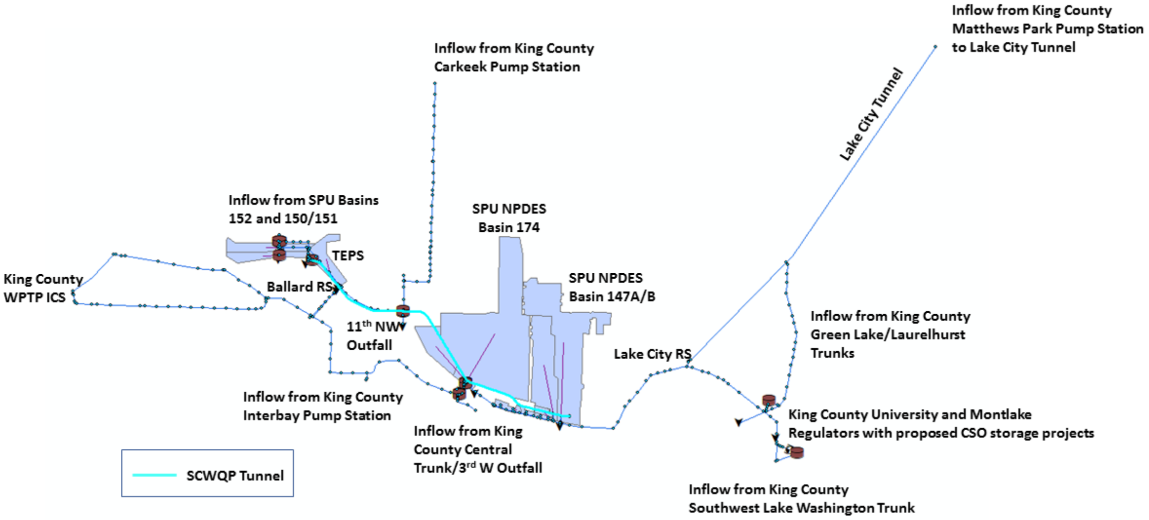


Figure 2-1. SCWQP tunnel model components

The model was modified to represent Ballard Basin 152 alignment along NW 56th Street with the various components of the proposed Ballard conveyance configuration. The SPU Ballard Option Analysis is considering 3 options for conveyance of flow to the tunnel. For this H/H analysis, SPU chose to model an alignment along NW 56th Street which will also provide information to inform the remaining options. The NW 56th Street option includes a new diversion structure near the intersection of 28th Avenue NW and NW 56th Street that would replace the existing CSO diversion structure. The proposed structure has three flow paths:

- Normal low flow is directed along 28th Avenue NW to the mainline in NW Market Street in a new pipe paralleling the existing line.
- If the capacity of the normal flow path is exceeded, high flows are first directed to the east where a nearly 2,200-foot-long conduit conveys flows to the Tunnel Effluent Pump Station (TEPS). Flows in this direction must first crest a weir then travel through a gate, which is opened or closed depending on the water level in the SCWQP tunnel.
- If the flows are too excessive for the normal and TEPS flow paths, a CSO weir will allow flow to spill into the CSO outfall pipe and drain into the Ship Canal.

Figure 2-2 shows the location of the Ballard conveyance hydraulics and related structures leading to the TEPS and the Ballard Regulator Station (RS). Figure 2-3 shows the layout of the diversion structure adopted for modeling, and Figure 2-4 shows the model layout of the diversion structure.

Figure 2-2. Ballard conveyance site map

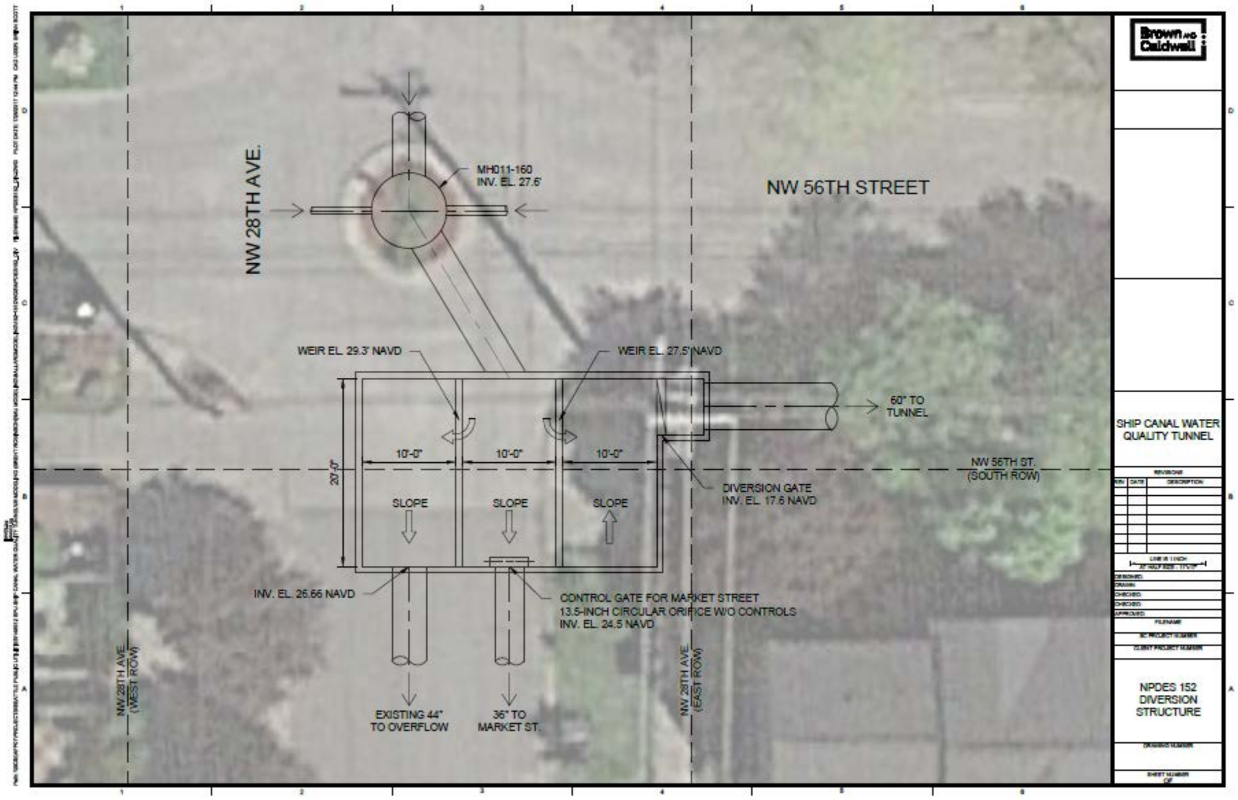


Figure 2-3. Diversion structure layout adopted for modeling

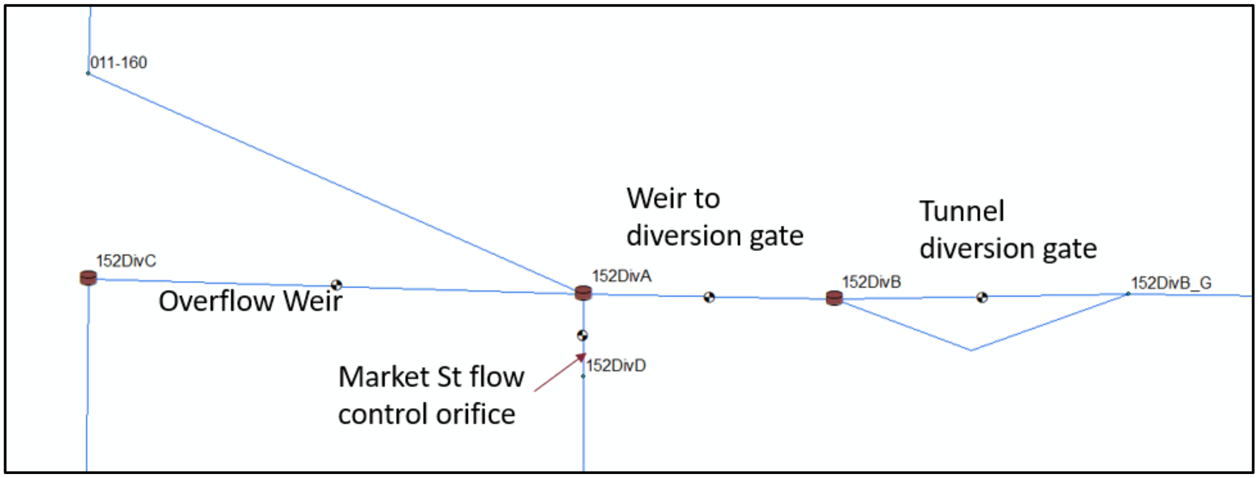


Figure 2-4. Model layout of diversion structure

The initial concept was modified to represent refinements to improve system performance. The configurations considered are discussed in Section 3.

3.0 Alternatives Considered

The original concept for the diversion settings and dimensions were developed as part of the SPU Long-Term-Control Plan (LTCP) alternatives modeling (SPU 2015a). These initial concepts were modified in development of the SCWQP Facility Plan (SPU 2015b) and were further modified in the initial SCWQP design contract modeling (MJA 2016). Alternative configurations for the Ballard conveyance considered in this work are presented in Table 3-1 and discussed below. The performance of each alternative was evaluated for hydraulic grade line (HGL) impacts at key locations, as well as CSO frequency.

Table 3 1. Ballard Conveyance Alternatives

Alternative Description	Remarks
Revise outlet control to NW Market Street	A revised concept for the diversion in the preliminary SCWQP design modeling included a modulated control gate to prevent excessive surcharge in the mainline sewer in NW Market Street at MH011-188 [a]. This would have required a level sensor in the MH as well as a proportional-integral-derivative controller for the gate. At the request of SPU, this concept was removed from consideration in favor of a fixed orifice to control the low flows to NW Market Street.
Replace the 60-inch-diameter diversion conveyance pipe with a 48-inch-diameter pipe	The original concept includes a nearly 2,200-foot-long, 60-inch-diameter pipe to divert flows from Outfall 152 to the TEPS. The alternative of downsizing this pipe to 48 inches diameter was analyzed.
Shorten overflow weir lengths in new diversion structure	The proposed diversion structure contains a weir for discharge to CSO outfall 152, and a weir for diversion of flow to the tunnel. The length of these weirs was analyzed.

[a] MJA 2016

3.1 Fixed Orifice for Control of Flow to NW Market Street

The SCWQP *Draft Facilities Plan* did not include any mechanism at the Outfall 152 diversion to control the maximum water surface elevation that might be reached at the intersection of NW Market Street and 28th Avenue NW at maintenance hole (MH) 011-188. Subsequent design work moved the diversion structure north to NW 56th Street, placing the overflow weir near the rim elevation of MH011-188, which could force more flow into the NW Market Street sewer than the existing overflow structure can produce. The existing overflow structure also limits the maximum HGL than can occur in the NW Market Street sewer. Further, MH011-195 is upstream on NW Market Street with a rim that is 1-foot lower than MH011-188 per the SPU geographic information system (GIS). Figure 3-1 shows the location of MH011-188 and MH011-195.

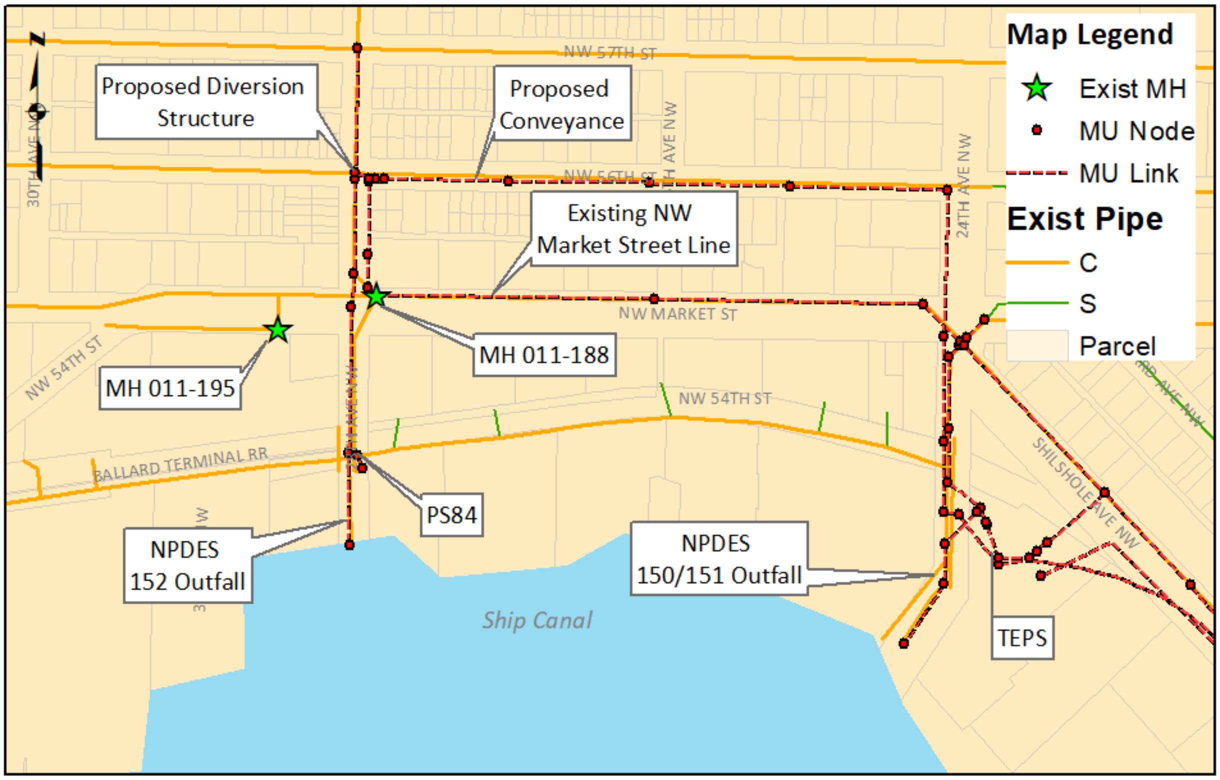


Figure 3-1. Location map showing MH011-188 and MH011-195 in relation to analyzed facilities

With the higher overflow weir elevation and head loss terms in the King County model in the mainline sewer in NW Market Street, there is concern that flooding might arise at MH011-188 or MH011-195 during extreme storm events. The HGL at these MHs is a function of the flow rate from the diversion structure and the head loss in the mainline sewer. As a result, a preliminary model constructed for design analysis in the U.S. Environmental Protection Agency’s (EPA) Storm Water Management Model 5 (SWMM5) platform included a modulating gate at the diversion structure for normal flow with opening controlled by the measured head at MH011-188 (MJA 2016). This would introduce significant complexity as well as capital and operations and maintenance cost for the facility. As a result, SPU requested examination of an alternative to use a fixed orifice in place of the modulating gate.

A series of model simulations were conducted with various sizes of fixed orifice plates on the normal flow line running from the diversion structure to NW Market Street at MH011-188. The results of these simulations are shown in Figure 3-2 and Figure 3-3.

Figure 3-2 presents the maximum HGL elevation at MH011-188 and the flow through the control orifice plotted as functions of the assumed orifice diameter for two cases: (1) when there is no overflow to the CSO 152 outfall from the diversion structure, and (2) when there is overflow to the CSO 152 outfall. The overflow weir in the model is set at an elevation about 1.8 feet higher than the weir diverting flow to the tunnel, thus increasing the orifice flow when overflows are occurring by increasing the HGL. The model includes a 13.5-inch-diameter orifice controlling flow to MH011-188. As Figure 3-2 shows, increasing the orifice to the 36-inch-diameter size of pipe leading to MH011-188 increases flow from about 7 million gallons per day (mgd) to about 11 mgd, and increases the HGL elevation at MH011-188 by about 3.5 feet. Orifice diameters greater than 18 to 21 inches increase the HGL at MH011-188 to about the elevation of the weir in the diversion structure that is sending flow to the tunnel.

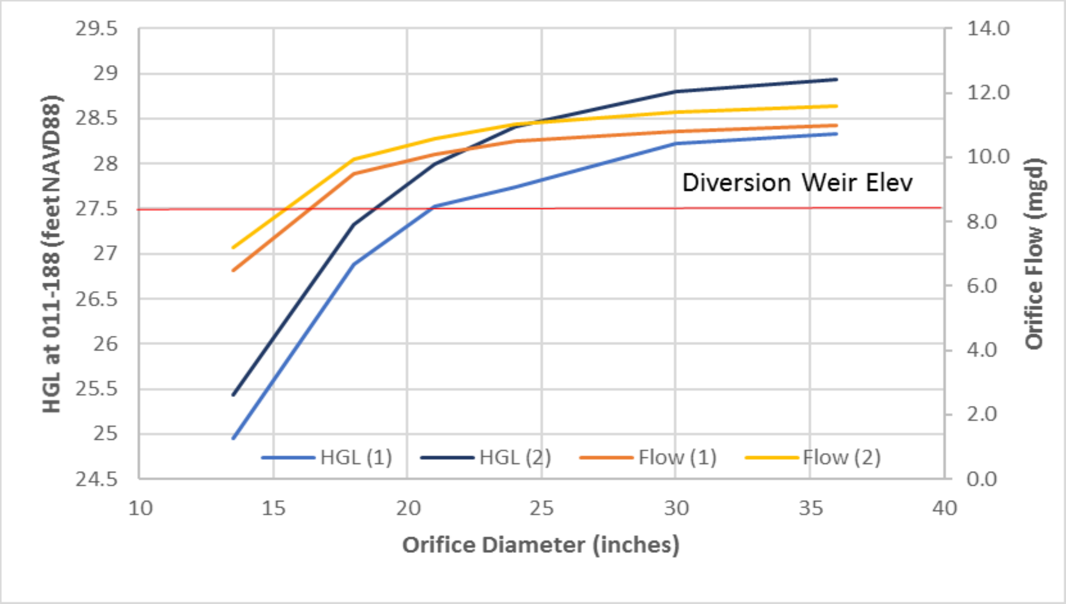


Figure 3-2. HGL elevation at MH011-188 and control orifice flow vs. orifice diameter; Case 1 no overflow to CSO 152 outfall, Case 2 overflow to CSO 152 outfall

Figure 3-3 presents the surcharge (i.e., distance the HGL is above the crown of the pipe) at MH011-188 and the freeboard (i.e., distance the HGL is below the rim) at MH011-195 as functions of orifice diameter. The rim elevation at MH011-188 is 31-feet NAVD and is one foot lower at MH011-195. As indicated, an orifice diameter of 13.5 inches provides a minimum freeboard of 4.5 to 5.0 feet below the rim at MH011-195, and a surcharge at MH011-188 less than 1.5 feet. The freeboard diminishes rapidly, and surcharge increases with increasing orifice diameter.

Simulations with the Integrated Model have been performed with an orifice diameter of 13.5 inches as a conservative approach to limit the HGL on NW Market Street. The modeled profile of the pipe between MH011-160 immediately upstream of the diversion structure and MH011-188 on NW Market Street, together with the maximum HGL reached in the model simulations, are shown in Figure 3-4. A larger orifice diameter is expected to decrease diversion flow volume to the tunnel, and overflow volumes to some small extent. Larger diameters are not expected to decrease the frequency of overflow, however.

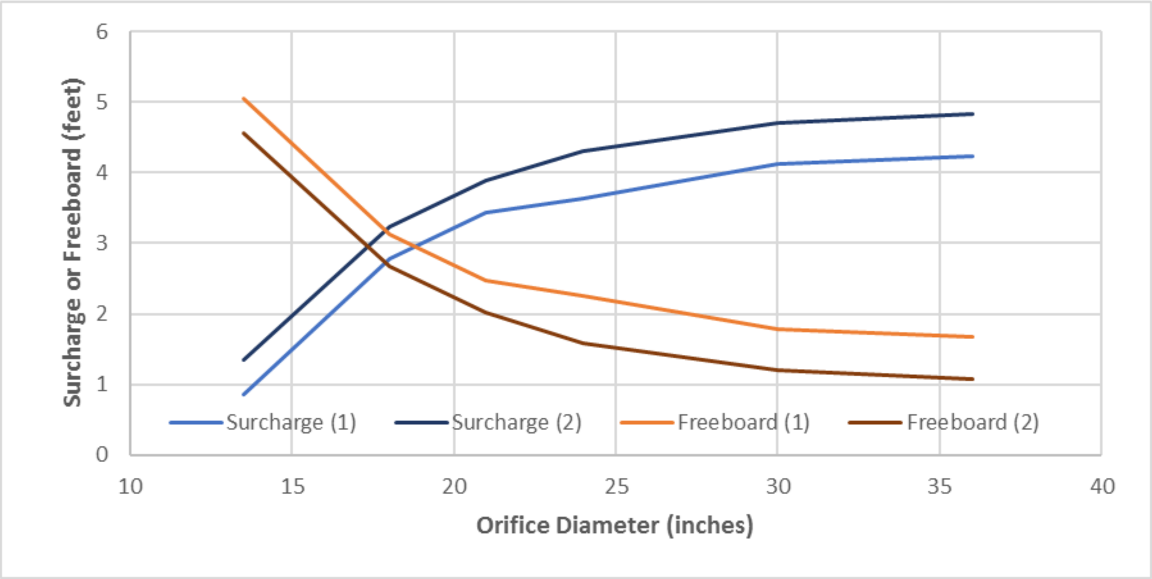
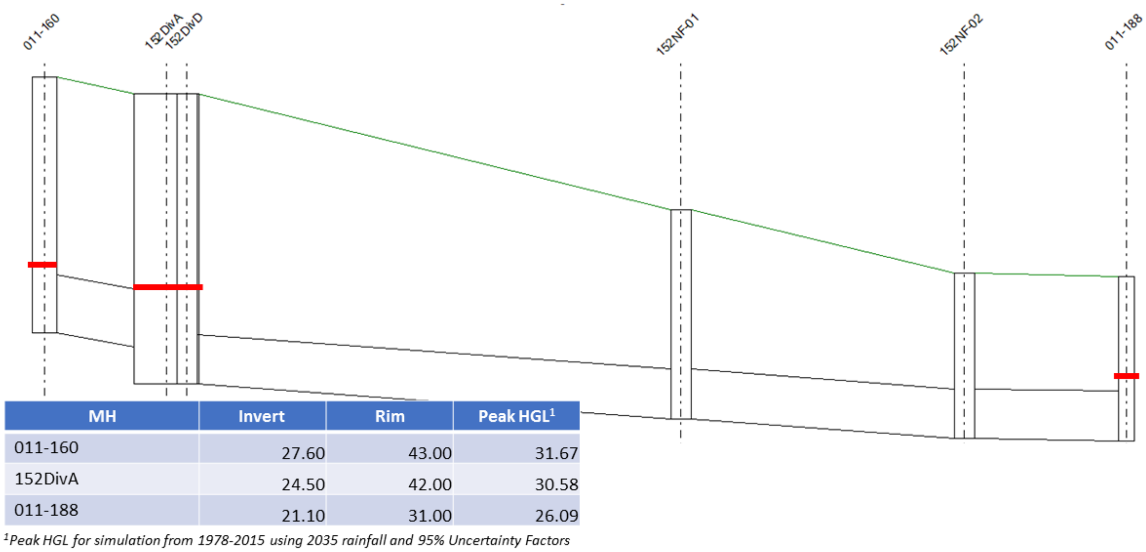


Figure 3-3. Surcharge at MH011-188 and freeboard at MH011-195 vs. control orifice diameter; Case 1 no overflow to CSO 152 outfall, Case 2 overflow to CSO 152 outfall



MH	Invert	Rim	Peak HGL[1]
011-160	27.60	43.00	31.67
152DivA	24.50	42.00	30.58
011-188	21.10	31.00	26.09

[1] *Peak HGL for simulation from 1978-2015 using 2035 rainfall and 95% Uncertainty Factors*

Figure 3-4. Pipe profile and maximum simulated HGL between MH-11-160 and MH011-188

The surcharge that occurs at MH011-188 is a function of losses (Manning's friction factor of 0.04) in the conduit (011-188_011-187) immediately downstream in the NW Market Street mainline sewer. These were introduced by King County in the MIKE URBAN model calibration to help match reported overflows at the existing overflow structure. Post-construction monitoring may find that this loss is excessive, which would permit installing a somewhat larger control orifice at the diversion structure. The diversion structure design should thus allow for changing the orifice plate to modify the diameter.

3.2 Alternative Sizing of Conveyance to the Tunnel

The *Final Facility Plan* included 2,200 feet of 60-inch-diameter conveyance pipe leading from the Outfall 152 diversion structure to the TEPS (SPU 2017). The cost of the conveyance pipe can be significantly reduced if the diameter is reduced. A 48-inch-diameter pipe can transport approximately 80 mgd of flow while the 60-inch-diameter pipe can transport approximately 125 mgd.

Integrated Model runs were conducted with alternative diameters of 60 and 48 inches. The 38-year simulation, using the SPU 2035 perturbed rainfall (CH2M 2017) and a 95 percent uncertainty scaling factor with a 48-inch-diameter conveyance, resulted in two additional overflows compared to that with the 60-inch-diameter conveyance (12 versus 10). Both occurred in the first 20 years of the simulation. Total overflow volumes were also slightly increased. The total of the overflow volumes simulated with the 48-inch-diameter conveyance were about 2 percent higher than the 38-year simulation compared to the 60-inch-diameter conveyance. One of the additional overflows occurred before the tunnel was filled due to the restriction of the 48-inch-diameter conveyance pipe. Table 3-2 compares the alternative simulation results. Overflows occur in events when peak inflow rates are less than the transfer capacity of the conveyance pipe because the tunnel has filled and the control gate has closed.

Table 3 2. Overflow Results for 60- and 48-inch-diameter Ballard Conveyance Simulation

Event Date	Maximum Inflow to 152 Diversion (mgd)	48-inch Overflow (MG)	60-inch Overflow (MG)
11/3/1978	98.7	0.15	No Overflow
12/18/1979	39.9	3.08	2.89
10/6/1981	74.8	4.58	4.55
12/4/1982	40.3	< 0.01	No Overflow
1/18/1986	41.5	7.51	7.36
9/23/1992	140.2	0.37	< 0.01
12/29/1996	40.1	11.64	11.54
3/19/1997	33.4	0.78	0.65
10/20/2003	40.0	4.23	4.21
12/3/2007	60.4	19.16	19.13
12/12/2010	42.4	9.59	9.59
11/19/2012	51.8	9.29	9.28

MG = million gallons, mgd = million gallons per day

Examination of the relative results indicates that downsizing the Ballard conveyance from 60 to 48 inches diameter has a minor impact on overflow frequency and volume for the 2035 condition.

The HGL differences along the proposed conveyance between the 60- and 48-inch-diameter conveyance lines were also analyzed using the Integrated Model for surcharge over the 38-year simulation. The 60-inch-diameter pipe surcharges once during the simulation, while the 48-inch-diameter pipe surcharges six times. Table 3-3 shows the surcharge events for the 48-inch-diameter conveyance options with the corresponding depths simulated in the 60-inch-diameter option. These results are sampled at model node 152DivB_G, which is sealed and just downstream of the diversion gate controlling flow to the SCWQP tunnel (see Figure 2-4). The actual ground surface elevation at node 152DivB_G is approximately 42-feet and the MH has a depth of approximately 24-feet from invert to rim.

Table 3-1. Surcharge Events

Event Date	Maximum Inflow to 152 Diversion (mgd)	48-inch-diameter Depth (feet)	60-inch-diameter Depth (feet)
9/23/1992	140.2	11.19	7.89
11/3/1978	98.7	10.72	3.64
9/5/2015	88.2	7.74	3.16
9/4/1995	87.5	6.62	3.08
8/17/1980	83.0	6.12	3.14
10/15/1996	74.7	4.67	2.91

Similarly, the recurrence interval of the peak annual flow that each conveyance option would convey was compiled. Figure 3-5 presents the expected recurrence frequency of peak flows in both conduit diameters.

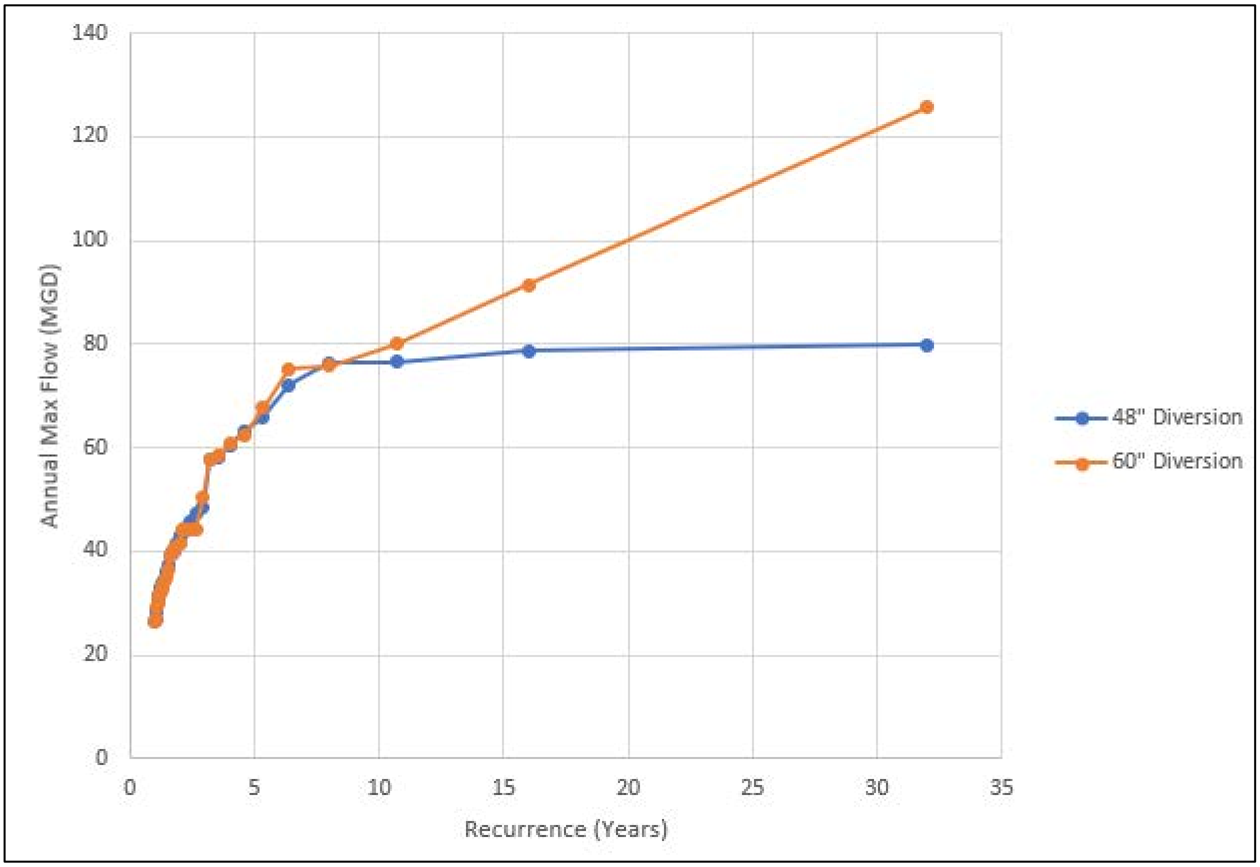
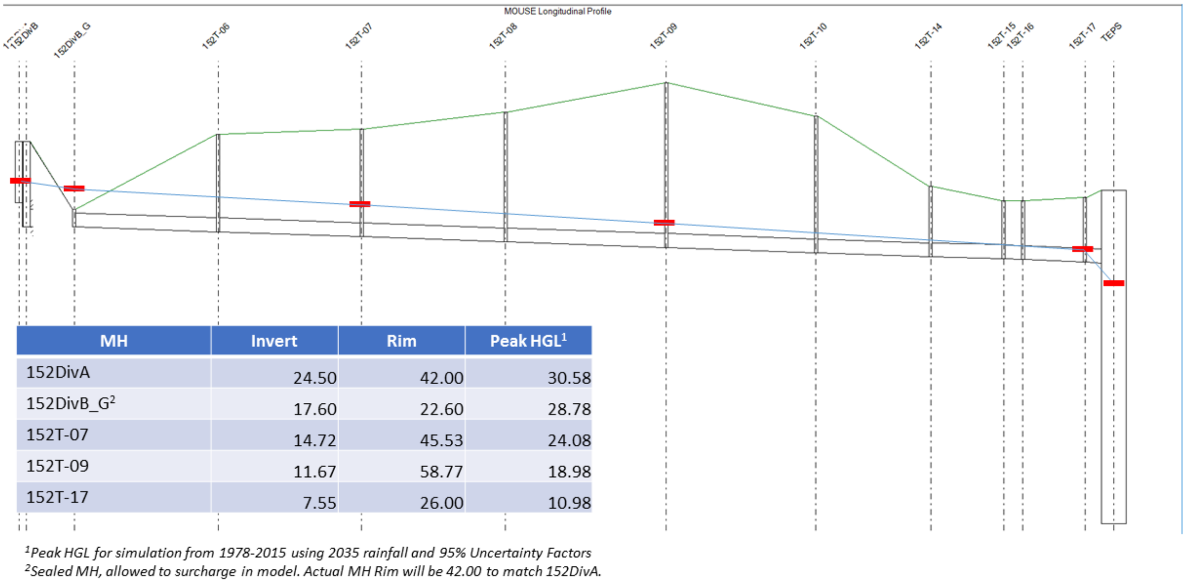


Figure 3-5. Peak annual flow recurrence intervals

Figure 3-6 shows the peak HGL along the conveyance alignment for the 38-year Integrated Model simulation for the 48-inch conveyance pipe. The peak for the conveyance pipe occurs during the September 23, 1992, storm event when the inflow to the diversion structure was about 140 mgd. The peak elevation at node 152DivA occurred during the October 6, 1981, event, which is 0.3 foot higher than the September 23, 1992, event. The tunnel was not full and the diversion gate was open during the September 23, 1992, event, whereas the gate was closed in the October 1981 event and an overflow to CSO outfall 152 was occurring.



MH	Invert	Rim	Peak HGL[1]
152DivA	24.50	42.00	30.58
152DivB_G[2]	17.60	22.60	28.78
152T-07	14.72	45.53	24.08
152T-09	11.67	58.77	18.98
152T-17	7.55	26.00	10.98

[1] *Peak HGL for simulation from 1978-2015 using 2035 rainfall and 95% Uncertainty Factors*
[2] *Sealed MH, allowed to surcharge in model. Actual MH Rim will be 42.00 to match 152DivA.*

Figure 3-6. Peak HGL along conveyance line for the 48-inch-diameter alternative (elevations in NAVD88)

3.3 Weir Length in Diversion Structure

The current Integrated Model includes Ballard Conveyance system diversion structure weirs diverting flow to the tunnel and to the outfall that each have a total length of 20 feet. The weir crest elevations are set at 27.50 feet North American Vertical Datum of 1988 (NAVD88) for the weir diverting flow to the tunnel (i.e., crown of the pipe leading to MH011-188), and 29.33 feet NAVD88 for the overflow weir (i.e., crown of the overflow pipe).

A simulation was made assuming that the weir crest lengths were reduced to 10 feet long with the same crest elevations, a 13.5-inch-diameter control orifice as discussed above, and a 60.0-inch-diameter conveyance to the tunnel. The simulation revealed that the shortened weir length in combination with the weir crest elevations and control orifice diameter resulted in overflows in some events that did not occur with the 20-foot-long weir lengths.

There may be an opportunity to optimize weir crest lengths in combination with the crest elevations, the control orifice diameter, and the diameter of the conveyance conduit diverting flow to the tunnel. This optimization should be preceded by a decision regarding the diameter of the conveyance conduit, as discussed above. The weir crest elevations should be adjustable over a range of ±1 foot to accommodate adjustment based on future observations.

3.4 SPU Pump Station 84

Models used during development of the LTCP for this area were uncalibrated. Basin parameters from other Ballard areas were used because flow data from the local PS84 area were considered of low quality (SPU 2010). The LTCP model and subsequent models derived therefrom predicted a single overflow from PS84, and a potential overflow from the sewer system east of the pump station where rim elevations are lower, during the rain event that occurred on December 3, 2007. That event is unprecedented in the record. The prediction of an overflow in that event is subject to question because the hydrological parameters used in the LTCP model were not directly correlated with the actual basin. Additional study of this area is discussed below.

The recent King County model development and calibration for PS84 was reviewed as a part of this effort. The King County calibration for this portion of the Ballard 152 model used flow data collected during the long-term control plan monitoring effort at MH011-218 immediately upstream of the wet well. The calibration was relatively good, but for the final model, rainfall-derived infiltration parameters taken from another basin were substituted. The basin boundaries used in the King County model were reviewed and found to adequately represent the area for the purposes of assigning hydrologic parameters (see Figure 3-7).

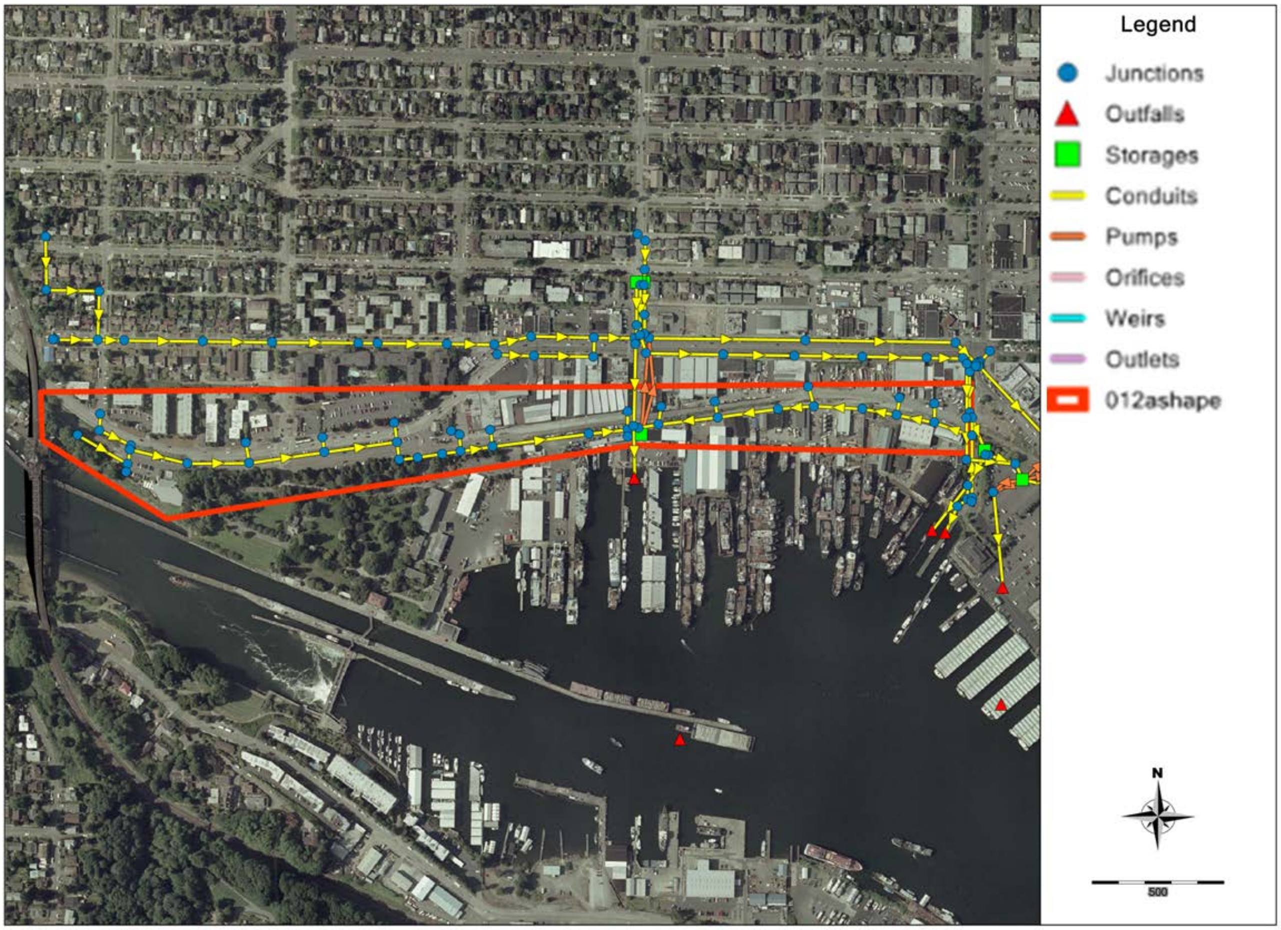


Figure 3-7. PS84 area

For confirmation of the model, supervisory control and data acquisition (SCADA) data were obtained from SPU's data historian for November 2012, March 2014, and January 2016 through February 2017. These data allow estimates of inflow to the pump station and pump output using the time and wet well depth in the same manner as adopted for estimating pump capacity in 2009 (ADS 2010). Review of these data as well as previous estimates yielded the following observations:

1. The drawdown tests conducted in December 2009 reported individual pump capacities of 0.76 and 0.79 mgd, and a combined capacity with both pumps running of 1.25 mgd.
2. The SPU *Facility Operations Plan* (FOP) for this station indicates an individual pump capacity of 0.47 mgd each (SPU unknown date).
3. PumpTech, Inc. reported individual pump capacities of 0.41 and 0.55 mgd (RH2 Engineering 2004).
4. Review of the SCADA data indicates that the station capacity is variable, but generally reports an average individual pump capacity of 0.65 mgd (range of 0.59 to 0.69) and a combined capacity of about 1.08 mgd.

5. There is indication that the pumps may become clogged at certain times, particularly in larger rain events. For example:
    a. On May 17, 2016, in the absence of rain, SCADA indicated both pumps running for a period of about 10 hours at low wet well depths as shown in Figure 3-8. It is possible that this is a SCADA error, but the wet well depth never quite reached the pump shutdown level during this period. Similar behavior was exhibited in the days immediately preceding and following this period.
    b. On November 19, 2012, (the largest recent storm), the wet well rose to more than 7 feet while both pumps were running, roughly double the depth at which both pumps will turn on. Various estimates of the potential inflow in this period suggest that it should not have exceeded the capacity of a single pump, and certainly not both pumps assuming the capacities given in item 4. Further discussion of this event is given below.

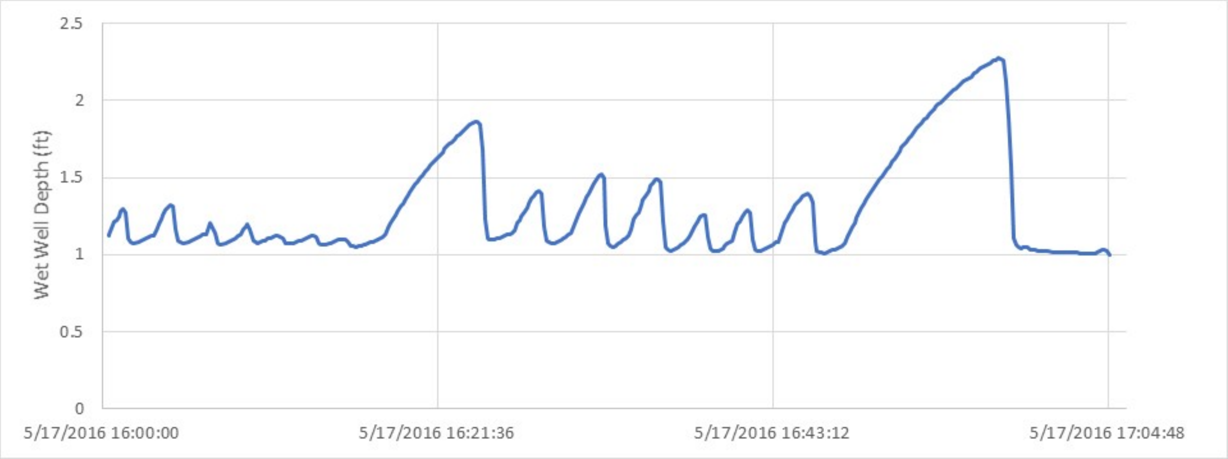


Figure 3-8. Plot of PS84 wet well depth during May 17, 2016, period with 2 pumps running

The November 19, 2012, event resulted in 2.39 inches of rainfall between 5:00 a.m. and 3:00 p.m. About 0.64 inch of rain was reported at SPU RG08 in the first 3 hours of the event. The wet well depth rose rapidly beginning about 8:08 a.m. rising to 7 feet at about 8:16 a.m., with two pumps running. The wet well level was subsequently reduced to the pump shutoff level by about 8:30 a.m. Leading up to the rise at about 8:00 a.m., the flow was handled by a single pump. Inflows were estimated from SCADA readings to be less than 0.6 mgd during this period. Review of the model behavior and the rainfall hyetograph (RG08) suggest that the peak inflow to the station should have occurred around Noon when two pumps were capably handling the flow.

In the subsequent 3 hours (8:00–11:00 AM), about 0.82 inch of rain fell with peak intensities similar to those during the first 3 hours. In the next 3 hours (11:00 a.m. to 2:00 p.m.) about 0.88 inch of rain fell with the highest peak 5-minute intensity for the event (0.6 inch per hour). Two pumps were sufficient to handle flows during these subsequent periods. A hydrologic model roughly calibrated to SCADA estimated flows in February 2017, and verified by comparison to the sum of flows from the long-term control plan meters at MH012-218 and MH012-222, suggests peak inflows to the station of about 0.7 to 0.8 mgd between 11:00 a.m. and 1:00 p.m. that would require two pumps but not exceed the estimated combined capacity. It is concluded that the high wet well observed in this event was due to a temporary restriction in pump capacity.

These observations show that the pumps likely have less consistent capacity than indicated in the 2009 drawdown tests, but more than indicated in the FOP or PumpTech, Inc. findings. Further, the pumps may be subject to short-term fouling. Further review of the station may be warranted.

PS84 does not have a history of overflows. Using the pump capacities estimated from the SCADA data, neither the King County model nor the revised model show overflows at PS84 in the 38-year model simulations with existing or 2035 rainfall.

4.0 Conclusions

H/H modeling has been used to assess the performance of the proposed Ballard conveyance concept. Models were used to simulate hydraulic performance for large storm events and for a long period of record to determine if the facility will meet project goals. Through this work, several alternatives that may improve facility performance and lower project cost were shown to be viable.

System surcharge downstream of the proposed diversion structure in the normal flow path along NW Market Street was evaluated to ensure that no unintended SSOs occur with the design. A fixed orifice opening of 13.5 inches in diameter will restrict flows to the downstream system enough to avoid excessive surcharging in that line. We recommend that the orifice opening be adjustable so that it can be refined during commissioning due to some model uncertainty with hydraulic conditions near MH011-188.

The conveyance line that conveys flow from the diversion structure to the tunnel was specified as 60 inches diameter in the original concept. The project objectives can still be met if this line is reduced to 48 inches diameter. The 48-inch-diameter pipe surcharges six times during model simulations, but this line is sufficiently deep and there will be no side connections—so some surcharging is likely acceptable. The smaller-diameter pipe results in two more CSO events in the 1978-2015 simulation period, and the modeling still shows the CSO frequency to be well within CSO regulatory compliance.

Other refinements, such as shortening the weirs that control flow to the SCWQP tunnel and the CSO outfall, can be explored during design. This will likely result in a need to optimize the normal flow orifice in conjunction with shortening the weirs.

Table 4-1 summarizes the findings for the design elements of the CSO 152 diversion structure investigated.

Table 4-1 Summary of findings for CSO 152 Diversion Structure

Design Element	Based Upon Modeling Results	Comment
Orifice Plate to limit flow to existing combined sewer along NW Market Street to avoid future SSOs	13.5 inches diameter Range 12 to 24 inches	Make orifice plate adjustable and refine size during design
Diversion weir to tunnel - elevation and length	27.50 feet (NAVD88) Length 10 to 20 feet Elevation +/- one-foot	Refine elevation and weir length during design
Diversion weir to CSO 152 outfall and length	29.33 feet (NAVD88) Length 10 to 20 feet Elevation +/- one-foot	Refine elevation and weir length during design
Conveyance pipe diameter from diversion structure to TEPS	48-inch diameter	Refine weir elevations and weir lengths based upon 48-inch diameter pipe

Examination of SCADA data for PS84 suggested that the actual capacity of the pumps may be less than found during the 2009 drawdown test, but is larger than indicated in the SPU FOP or previous PumpTech, Inc. tests. It was also noted that the station is periodically subject to temporary instances of fouling, which reduces capacity. Overflows at PS84 are not expected, but better flow data and further review of the station may be warranted.

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APPENDIX G:

BALLARD CONVEYANCE PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

Preliminary Geotechnical Report
Ship Canal Water Quality Project
Ballard Conveyance
Seattle, Washington

July 19, 2017

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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SHIP CANAL WATER QUALITY PROJECT
BALLARD CONVEYANCE
SEATTLE, WASHINGTON

1.0 INTRODUCTION

The Ship Canal Water Quality Project has been broken out into a number of work packages, one of which is the Ballard Conveyance work. This report summarizes our geotechnical studies for the Ballard Conveyance project (Project) in the Ballard neighborhood of Seattle, Washington (Figure 1). The purpose of our geotechnical studies was to evaluate the subsurface conditions related to the geotechnical feasibility and geotechnical risk associated with constructing the conveyance pipeline using trenchless methods. This geotechnical report was prepared for the exclusive use of HDR Engineering, Inc. and Seattle Public Utilities (SPU) for planning-level purposes. Our conclusions are based on limited explorations and testing and a literature search and should not be used for final design of the Project. Additional explorations, testing, and analyses are required to develop final design recommendations for this Project.

2.0 PROJECT AND SITE DESCRIPTION

The purpose of the Project is to collect flows from Basin 152 and convey them to the Tunnel Effluent Pump Station (TEPS) to be located near the intersection of Shilshole Avenue NW and 24th Avenue NW. This report covers two alignments that are currently being considered for the proposed 60-inch-diameter conveyance pipeline. Both proposed alignments start near the intersection of NW 56th Street and 28th Avenue NW. The NW 56th Street alignment follows NW 56th Street east to 24th Avenue NW where it turns south and follows 24th Avenue NW to the TEPS site. The alternative NW Market Street alignment follows 28th Avenue NW south to NW Market Street where it turns east and follows NW Market Street to 24th Avenue NW. At 24th Avenue NW, it turns south and extends to the TEPS site. The approximate locations of these two alignments are shown in Figure 2.

The site is in an urban neighborhood that includes residential, commercial, and industrial land use. The proposed alignments are primarily located within public right-of-way and under paved roads. The site topography generally slopes from north to south, with the surface elevation varying from about 42 feet to 28 feet, respectively.

3.0 PURPOSE AND SCOPE

We understand this geotechnical report will be used for planning-level purposes only. This report should not be used for other purposes without Shannon & Wilson, Inc.'s (Shannon & Wilson's) review. Our geotechnical scope of services included:

- Collecting and reviewing existing geotechnical exploration logs.
- Developing a geotechnical exploration plan.
- Performing geotechnical explorations at four locations.
- Performing geotechnical laboratory testing on selected samples obtained from the explorations.
- Evaluating the feasibility of trenchless construction for two alignments.
- Preparing this preliminary geotechnical report.

If a service is not specifically indicated in this report, do not assume that it was performed.

4.0 BASIS OF REPORT

Our conclusions and considerations presented in this report are based on:

- The limitations of our approved scope, schedule, and budget described in the executed Amendment 01 to Task Order 0005 for the Project.
- Our understanding of the Project and information provided by SPU during the development of our scope of services included in the aforementioned amended task order and our February 3, 2017, kick-off meeting with SPU and HDR Engineering, Inc.
- Subsurface conditions we observed in the borings as they existed during drilling between April 3 and 6, 2017.
- The results of testing performed in the borings and on samples we collected from the borings.

5.0 SUBSURFACE EXPLORATION PROGRAM

Our subsurface exploration program consisted of collecting and reviewing existing geotechnical exploration logs along the proposed alignments, preparing a site exploration plan (Shannon & Wilson, 2017), and performing four geotechnical borings in accordance with the approved site exploration plan.

We performed a search of the Department of Natural Resources database (Washington State Division of Geology and Earth Resources [DGER], 2012) and our project files to identify and collect existing geotechnical exploration logs along the proposed alignments. The approximate locations of the explorations are presented in Figure 2 and the exploration logs are included in Appendix B, Existing Exploration Data.

In addition to collecting existing geotechnical exploration logs, our scope of services included drilling and sampling four borings, designated BCT-1 through BCT-4. These borings were drilled and sampled to depths of 35 to 55 feet to characterize the subsurface conditions. The site and exploration plan (Figure 2) shows the approximate boring locations. Observation wells were installed in all four borings. Descriptions of the methodologies and procedures used for drilling and sampling the borings and constructing the observation wells are included in Appendix A, Project Subsurface Explorations. The boring logs are presented in Appendix A as Figures A-2 through A-5 and a soil description and log key is included as Figure A-1.

6.0 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed on selected samples retrieved from the borings. The geotechnical laboratory testing was performed in the Shannon & Wilson laboratory in Seattle, Washington, and included visual classification, water content determinations, grain size analyses, and hydrometer analyses. A description of the methodology and testing procedures is discussed in Appendix C, Geotechnical Laboratory Testing.

7.0 GEOLOGY AND SUBSURFACE CONDITIONS

The geology and subsurface conditions along the proposed alignments were evaluated based on:

- Conditions encountered in the subsurface explorations performed for this study,
- A review of borings previously completed at the site, and
- The Geologic Map of Northwest Seattle (Booth and others, 2005).

The geotechnical explorations were performed to evaluate the subsurface soil and groundwater conditions along the proposed alignments. Our observations are specific to the locations and depths noted on the boring logs and may not be applicable to all areas of the alignments. No number of explorations or testing can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. Potential variations include, but are not limited to:

- The conditions between and below explorations and testing may be different;
- The passage of time or intervening causes (natural and manmade) may result in changes to site and subsurface conditions;
- Groundwater levels and flow directions may fluctuate due to seasonal variations;

- Groundwater flow between different aquifers can occur. No soil layer should be assumed to be continuous and/or watertight;
- Standard penetration test results in gravelly soils may be unrealistic. Actual soil density may be lower than estimated if the test was performed on a gravel or cobble; and
- Obstructions such as boulders, fill debris (rubble), and wood may be present in the subsurface.

The following sections present a description of the site geology and the subsurface conditions encountered in our borings.

7.1 Site Geology

The Project is in the central portion of the Puget Lowland, an elongated topographic and structural depression filled with a complex sequence of glacial and nonglacial sediments that overlie bedrock. The area has been glaciated six or more times in the past 2 million years. The distribution of the sediments is complex, because each glacial advance deposited new sediments and partially eroded previous sediments. Between glacial episodes, the complete or partial erosion or the reworking of deposits, as well as the local deposition of other sediments, took place. During the Vashon Stade of the Fraser Glaciation, about 15,000 to 13,000 years before present, the lobe of the Cordilleran Ice Sheet that covered the Puget Lowland was locally over 3,000 feet thick. When the glacial ice sheet receded from the area about 13,500 years ago, it left behind topography characterized by low-rolling relief about 500 feet above sea level with some deeply cut ravines and broad valleys. Since then, present-day geologic processes, such as erosion and deposition by streams and landsliding, as well as human activity, have modified the ground surface and further complicated the geology.

7.2 Site Subsurface Conditions

The subsurface conditions along the NW 56th Street and NW Market Street alignments are presented in Figures 3 and 4, respectively. The subsurface profiles are interpreted from materials observed in the explorations and existing geotechnical exploration logs. Variations between the interpretations shown and actual conditions will exist.

Along the NW 56th Street alignment between 28th Avenue NW and 26th Avenue NW, the subsurface conditions consist of fill over recessional deposits. The fill is about 12 feet thick consisting of loose, silty sand. The recessional deposits are not glacially overridden and consist primarily of medium dense to dense, silty sand. Groundwater was measured at 9 feet below ground surface (bgs) at BCT-1.

Between 26th Avenue NW and 24th Avenue NW, the subsurface conditions consist of shallow fill over glacial till and till-like deposits. The depth to glacial till is about 14 feet bgs at existing boring B-1 (Station [Sta.] 7+24) and becomes shallower to the east along the alignment, about 5 feet bgs in boring BCT-2 (Sta. 11+90). The till and till-like deposits are glacially overridden and consist of very dense, silty sand and silty sand with gravel. Cobbles and boulders may be present within the glacial till and till-like deposits. Groundwater was measured at 22 feet bgs at BCT-2.

From NW 56th Street to 24th Avenue NW along the NW Market Street alignment, the subsurface conditions consist of fill over recessional deposits and glacial till and till-like deposits. The thickness of the fill ranges between 10 and 20 feet and consists of very loose to medium dense, silty sand, and sand with silt and gravel. Along the NW Market Street portion of this alignment, the glacial till and till-like deposits were observed about 15 to 25 feet bgs and consist of very dense, silty sand. Groundwater was measured at 7 feet bgs at BCT-4.

Along 24th Avenue NW between NW 56th Street and NW 54th Street, the subsurface conditions consist of fill over recessional deposits and glacial till and till-like deposits. Near NW 54th Street, the recessional deposits become thicker. Till-like deposits are also observed near NW 54th Street; however, they do not display the typical density characteristics of glacially overconsolidated till and may be weathered, disturbed, or an ablation till deposit.

Groundwater is encountered at an elevation of about 35 feet along NW 56th Street and about 25 feet along NW Market Street. The elevation will vary by season and rainfall quantities.

7.3 Environmental Findings

Field screening of soil samples were performed for worker protection and to assist with the proper disposal of investigation-derived waste. Soil samples were field screened by the field representative for contamination using a combination of: (a) visual observations, (b) photoionization detector measurements, (c) olfactory observations, and/or (d) sheen tests.

One soil sample was collected for environmental testing from boring BCT-4 based on the field screening. The results of the environmental testing show the soil to be lead-contaminated between 5 and 15 feet bgs. The test results are presented in Appendix D.

7.4 Seismic Hazards

The Project is located in a region where numerous small to moderate earthquakes and occasional strong shocks have occurred in recorded history. Much of this seismicity is the result of ongoing relative movement and collision between the tectonic plates that underlie North America and the Pacific Ocean. These tectonic plates include the Juan de Fuca Plate and the North American Plate, and the intersection of these two plates is called the Cascadia Subduction Zone (CSZ). As these two plates collide, the Juan de Fuca Plate is being driven northeast (subducted), beneath the North American Plate.

Within the present understanding of the regional tectonic framework and historical seismicity, three broad earthquake source zones are identified. These include a shallow crustal source zone, a deep source zone within the portion of the Juan de Fuca Plate subducted beneath the North American Plate (deep subcrustal zone), and an interplate zone where the Juan de Fuca and North American Plates are in contact in the CSZ. The anticipated earthquakes related to these sources are summarized below:

- Shallow Crustal Zone: Geophysical lineaments in Western Washington are believed to be capable of producing earthquakes with magnitudes up to 7.5. The closest of these geophysical lineaments to the site is the Seattle Fault (or Seattle Fault Zone). Geologic studies suggest that this is an active fault with an estimated magnitude 7.0 event occurring approximately 1,100 years ago. Historical shallow crustal seismicity has also been observed between a depth of 1 and 10 miles. Based on the U.S. Geological Survey (USGS) Interactive Fault Map (USGS, 2017), the Project alignment is located about 5 miles north of the nearest mapped fault splay of the Seattle Fault.
- Deep Subcrustal Zone: The largest historical earthquakes (magnitudes up to 7.1) to affect the site were in the subducted Juan de Fuca Plate (deep subcrustal zone) at depths of 32 miles or greater. The depth of this zone is estimated at about 34 miles below the Project alignment.
- Interplate Zone (CSZ): The CSZ has produced, and remains capable of producing, strong earthquakes. Work to date suggests that earthquake magnitudes may range from 8.0 to 9.0 and may occur at time intervals ranging from about 400 to 1,000 years. The Project alignment is located about 60 miles east of this zone. Based on work by Goldfinger and others (2012), the last earthquake produced by the CSZ was about 315 years ago.

Based on our review, the site is located north of the generally accepted limits of the Seattle Fault Zone. Consistent with accepted local engineering practice, we did not consider conjectural lineaments.

We note that risk of fault rupture, liquefaction, and lateral spreading is all low along the two currently identified trenchless alignments. We also note that the hazards are the same for either open-cut or trenchless construction.

8.0 ENGINEERING STUDIES AND RECOMMENDATIONS

Based on the subsurface conditions encountered in field explorations and our current understanding of the proposed Project, we performed engineering studies to develop conclusions and recommendations regarding our opinion of soil engineering parameters and recommendations related to the proposed pipeline. Our conclusions and recommendations are presented in the following sections.

For purposes of our analyses, recommendations, and conclusions, it was necessary for us to assume that the results of the explorations, testing, and monitoring are representative of conditions throughout the Project site. However, as stated in Section 7.2, subsurface conditions should be expected to vary. We may need to revise our recommendations during future design phases if different conditions are encountered.

8.1 Trenchless Methods

All the trenchless methods discussed in this preliminary geotechnical report are suitable for the likely depths required to provide gravity conveyance from the Ballard 152 Conveyance Structure to the TEPS site. The methods have different degrees of inherent risks, but are generally suitable for the construction of 60-inch-diameter, gravity conveyance pipeline.

All the trenchless methods discussed require the construction of shafts. The entry shaft for each method is typically 20 feet wide by 40 feet long. The receiving or exit shaft for each method is typically about 15 feet wide by 15 feet long. The location of the shafts will depend on the trenchless method selected since the length that can be excavated between shafts varies by method. Section 8.3 discusses the potential shaft locations and spacing in more detail.

8.1.1 Pipe Ramming

Pipe ramming utilizes a double-acting pneumatic hammer to drive an open-ended steel casing between two shafts. Pipe ramming is typically limited to lengths of about 300 feet. For line- and grade-sensitive utilities, lengths of 100 to 200 feet are more common. Some or all of the soil can be left in the pipe during driving to limit ground loss and control groundwater. When possible, the soil is removed from the pipe after the drive is completed, but more commonly, at least some soil is removed during drilling to reduce the weight of the pipe and decrease drag. Pipe ramming is a non-steerable method, which is a source of risk on a gravity pipeline project. Although some preliminary methods have been established to analyze pipe ramming feasibility, the prediction of constructability is more commonly based on previous experience in similar ground than on engineering analyses or design.

A stiffening ring is typically welded to the leading edge of the casing to help prevent deformation of the pipe and provide some overcut to reduce the friction on the outside of the pipe. Bullet teeth bits can also be welded to the leading edge to assist with pipe ramming in denser soil and where cobbles and boulders are present.

Bentonite slurry can also be injected through regularly spaced ports around the circumference of the pipe to fill the overcut annular space. The injected bentonite slurry around the pipe helps reduce settlement and friction between the soil and the pipe.

As discussed, pipe ramming lengths are typically limited to about 300 feet. Longer alignments can be facilitated by telescoping the casing. This process involves ramming a larger diameter casing, clearing out the soil, and then ramming a smaller diameter casing within the larger casing.

Pipe ramming below the groundwater table requires special considerations, including mechanical seals in both shafts and a stable soil plug within the pipe to reduce potential groundwater inflow into the pipe and entry shaft. Removal of soil from within the casing or telescoping the casing is more difficult when ramming below the groundwater table. Removing the soil can result in loss of ground support in the pipe and water and soil flowing into the pipe and entry shaft. Also, because pipe ramming is a non-steerable method, deviations in the alignment and profile can make it difficult to anticipate where the pipe will breach the receiving shaft. This complicates the construction of the receiving shaft and could require modifications to the receiving shaft geometry or the groundwater control methods prior to the pipe entering the receiving shaft.

Vibrations generated at the cutting shoe during ramming can damage adjacent structures and utilities. Additional analysis of potential vibration impacts would be required during final design.

For gravity pipelines, oversizing the casing to facilitate adjustment to the carrier pipe grade using shims or spacers can be used to mitigate some of the steerability risk.

Pipe ramming can accommodate some obstructions. Large wood debris and buried logs can be difficult to pipe ram through. The wood tends to absorb energy and reduce the ability of the pipe to cut through the ground. However, pipe ramming is commonly selected for use on projects with gravels, cobbles, and boulders, since these potential obstructions can commonly be ingested by the open-ended pipe.

For purposes of this Project, pipe ramming is only considered to be marginally applicable in the ground conditions anticipated along the alignments. In our opinion, given the lack of steerability and construction vibrations, pipe ramming does not provide a significant advantage over the other methods described in this report.

8.1.2 Auger Boring

Auger boring uses an auger slightly smaller than the shoe or shield diameter to perform the excavation. Auger boring is typically limited to lengths of about 300 to 400 feet. As the pipe is jacked into the ground, the auger excavates the soil and transports it back to the driving shaft for removal. An oversized cutting shoe or shield is normally attached to the leading edge of the pipe string to stiffen the end of the pipe and to provide some steerability. The auger can be positioned in advance of the cutting shoe, flush with the cutting shoe, or within the casing to facilitate construction and manage overexcavation. To avoid overexcavation, such as can occur with the auger in advance of the cutting shoe, the auger can be withdrawn approximately one diameter inside the casing so that a soil plug forms at the entrance of the casing pipe. The soil plug helps maintain a stable heading and reduces the likelihood of ground loss. Flowing or running ground, if encountered, could result in excessive ground loss and could cause settlement or sink holes to develop at the ground surface.

The cutting shoe or leading edge of the shield is typically larger in diameter than the pipe, creating an annular space between the pipe and the surrounding ground. This annular space in combination with the injection of bentonite slurry reduces the friction and jacking forces along the pipe. The injection of the bentonite slurry into the annular space reduces the potential for ground loss and associated settlement and allows some steering and adjustments to the pipe alignment.

Auger boring is generally not suitable in granular soils below the water table unless the alignment is dewatered or the ground is modified by grouting or freezing. Flowing or running ground, if encountered, could result in excessive ground loss and settlement or sink holes at the ground surface.

Auger boring can accommodate some obstructions. Based on a 60-inch-diameter pipe, the auger bore can handle gravels, cobbles, and boulders up to one-third of the pipe diameter (20-inch-diameter boulder). For boulders larger than one-third of the pipe diameter, and where groundwater is not present or it is controlled, the auger can be removed and the boulder mechanically broken and removed from within the pipe.

For purposes of this Project, auger boring is considered to be marginally applicable in ground conditions anticipated along the alignments. In our opinion, given the limited bore lengths of 300 to 400 feet and the need for more shafts and dewatering, auger boring does not provide a significant advantage over microtunneling, as discussed below.

8.1.3 Pipe Jacking

Pipe jacking consists of installing a continuous string of pipes by hydraulic jacking from a driving shaft located at one side of the crossing to a receiving shaft located at the opposite end. Pipe jacking is typically limited to lengths of about 600 to 700 feet. For trenchless construction in the Pacific Northwest, a rotating cutter face is commonly located at the leading edge of the shield. Openings on the cutter face (wheel) can be partially closed to allow for some control of running or flowing ground. The shield may be articulated to provide limited steering corrections in the vertical and horizontal direction. In unsaturated or dewatered soils, sand decks or doors can be used to limit the amount of material excavated as the pipe is jacked into place. Soils are typically excavated by hand or excavator and removed from within the pipe by auger, conveyor, muck bucket, or similar manner.

The cutting shoe or leading edge of the tunneling shield is typically only about 1½ to 2 inches larger in diameter than the jacking pipe itself. During pipe jacking, bentonite slurry can be pumped through regularly spaced ports around the circumference of the pipe to fill this annular space, which reduces the friction and jacking forces along the pipe. The injection of the bentonite slurry into the overcut annulus also reduces the potential for ground loss and associated settlement and allows some steering and adjustments to the pipe alignment.

Pipe jacking is generally not suited for alignments in granular soils below the groundwater table unless the alignment is dewatered or the ground is modified by grouting and freezing. Flowing or running ground, if encountered, could result in excessive ground loss, settlement at the ground surface, and could endanger personnel working within the shield, casing, or jacking shaft.

For purposes of this Project, pipe jacking is considered to be marginally applicable in the ground conditions anticipated along the alignments. In our opinion, given the limited bore lengths and the need for more shafts and dewatering, pipe jacking does not provide a significant advantage over microtunneling, as discussed below.

8.1.4 Microtunneling

Microtunneling consists of installing a continuous string of pipes by hydraulic jacking from a driving shaft located at one side of the crossing to a receiving shaft located at the opposite end. Microtunneling is typically limited to lengths of about 1,250 to 1,500 feet in length. A tunneling shield attached to the leading edge of the pipe string is used to cut through the ground, support the face of the excavation, and control the amount of material excavated as the pipe is jacked into place. The shield is articulated to provide limited steering corrections in the vertical and horizontal direction. Typically, microtunneling utilizes a closed-face slurry shield, which is designed to maintain pressure on the excavated soil face and prevent soil and water from flowing into the shield, pipe string, and driving shaft.

The leading edge of the tunneling shield is typically only about 1½ to 2 inches larger in diameter than the jacking pipe itself. This small annulus reduces the potential for ground loss and associated surface settlement while allowing some steering and alignment control. During microtunneling, bentonite slurry is commonly pumped through regularly spaced ports around the circumference of the pipe to fill this annular space, which reduces settlement and the friction between the soil and the pipe.

A closed-face microtunneling machine does not require personnel working within the machine and is usually used for tunneling below the groundwater level to mitigate the risk of the groundwater and flowing ground. The flowing ground would create a hazard for personnel working within an open-face and could lead to significant loss of ground, sinkholes, and flooding of the shafts. Microtunneling below the groundwater table requires special considerations, including mechanical seals in the shafts and grouting or other ground improvement outside the entrance and exit location of the shafts to reduce groundwater and soil inflow into the shaft.

The microtunneling machine circulates slurry through the mixing chamber located behind the rotating cutter head. The slurry mixed with the soil cuttings is pumped to the ground surface where it is then processed in a slurry separation plant to remove the soil cuttings from the slurry. A slurry balanced tunneling machine can control groundwater and prevent flowing ground from entering the tunnel excavation.

For purposes of this Project, microtunneling is considered to be the most applicable method for the ground conditions anticipated along the alignments. Microtunnel reduces the number of required shafts and the groundwater control requirements. While it does not mitigate the risk of encountering an obstruction to the degree of the other methods discussed in this report, microtunneling has been successfully used in similar soils such as the recently completed King County Fremont Siphon project.

8.2 Direction of Trenchless Excavation

We anticipate that the direction of the trenchless pipeline excavation for either alignment would generally be from south to north and east to west. The reason for this is two-fold; first, based on the anticipated soils and second based on the proposed grade of pipeline.

Where contacts between relatively loose and very dense materials are encountered, it is advantageous for trenchless systems to excavate in a direction that approaches the looser soils. Trenchless systems tend to follow the path of least resistance. So, if the direction of excavation were reversed, it would increase the risk of alignment and grade deviation, since the advancing pipe could deflect upward along the very dense till and follow the contact between the loose and very dense deposits. Therefore, based on the expected subsurface conditions, we anticipate that both the NW Market Street and NW 56th Street alignments would be excavated from east to west between 24th Avenue NW and 28th Avenue NW.

For the north-south portions of both the NW Market Street and NW 56th Street alignments, the anticipated soils are relatively consistent, so the decision on which direction to excavate is not expected to be made based on subsurface conditions. Instead, the general preference to excavate upgrade to allow any groundwater, process water or slurry in the pipe to drain by gravity will likely result in the excavation being performed from south to north.

8.3 Shaft Locations

The discussion in this section assumes that microtunneling is the preferred method to construct the conveyance pipelines. Methods other than microtunneling would require additional shafts to those discussed below. Pipe jacking would require shafts about every 600 to 700 feet, while auger boring would require shafts about every 300 to 400 feet. Pipe ramming drive lengths are generally limited to about 300 feet in length or less. Note that the 300-foot spacing for pipe ramming would carry some additional risk regarding line and grade control.

The trenchless methods discussed in this report require shafts at the beginning and ends of the drive and at any bends in the alignment. For the NW 56th Street alignment, the microtunneling alternative would require a minimum of three shafts. These shafts would be located at the start and end of the alignment and at the bend in the alignment at the NW 56th Street/24th Avenue NW intersection. In our opinion, a combination of two driving shafts and a single receiving would likely be used. One driving shaft would be located at the southern end of the alignment, a combination driving/receiving shaft would be located at the bend in the alignment and a receiving shaft would be located at the western end of the alignment. Alternatively, consideration could be given to a single larger driving shaft located at the bend in the alignment with receiving shafts at the western and southern ends of the Project. This arrangement would have a longer duration of surface impact at a single location and a larger driving shaft footprint.

For the NW Market Street alignment, the microtunneling alternative would require a minimum of four shafts. One shaft at each end and shafts at the turn points in the alignment at the intersections of 28th Avenue NW/NW Market Street and 24th Avenue NW/NW Market Street. The driving operation would need to be performed from three shafts, most likely the southern shaft near the TEPS site and at the two intersections discussed above. Consideration could be given for larger driving shafts at the bends in the alignment at 28th Avenue NW/NW Market Street and 24th Avenue NW/NW Market Street with receiving shafts at the northern and southern ends of the Project. This would reduce the number of driving shafts from three to two. However, this arrangement would have a longer duration of surface impact at a two locations and larger driving shaft footprints.

8.4 Groundwater Control

Groundwater levels are between 10 and 25 feet above the invert of the pipe. Dewatering along the alignment would be required for pipe jacking and auger boring methods to reduce risks associate with excavating below the groundwater table. Without dewatering, there is a risk that saturated sand layers could result in localized flowing ground conditions, ground loss, and resulting surface settlement. Pipe ramming might require dewatering if excavation of the soil plug is required or a sufficient soil plug is not formed. Microtunneling is best suited for excavating below the groundwater table as it can provide face stabilization by applying a pressurized slurry at the face, as discussed in Section 8.1.4. This ability would reduce the risk of ground loss associated with the other methods.

Dewatering or some sort of watertight shoring will likely be required at the shaft locations. Where dewatering and associated drawdown occurs solely within glacially overconsolidated soil, the potential for groundwater-drawdown induced settlement is low. Where overlying recessional and fill soils are actively dewatered or where a hydraulic connection exists between the soil being dewatering and these looser and soft soils, there is an increased risk for inducing settlement. While additional testing and analysis will be required during final design, for planning purposes, we recommend assuming that wells are required to control the groundwater. If the additional testing and analysis indicates an unacceptable risk for settlement, then watertight shoring for the pits, tremied base seals, and microtunneling could be selected to reduce the risk.

8.5 Obstructions

There is a moderate risk of encountering obstructions or ground conditions that could impact the trenchless feasibility. These areas of moderate risk include:

- The presence of glacial till at shallow depths at multiple points along both alignments increases the likelihood of encountering cobbles and boulders that could obstruct the advancement or impede the steerability of some trenchless methods.
- Buried erosional contacts (e.g., where the recessional outwash overlies the glacial till) are also areas where there is an increased likelihood of encountering cobbles and boulders.
- Wood debris is commonly encountered in non-engineered fill deposits. Like cobbles and boulders, depending on the size, concentration, and location, the presence of wood debris can be an obstruction for some trenchless methods.

Abundant cobbles and scattered boulders should be anticipated in all of the soils along the alignments. Boulders encountered in glacial soils generally range from 1 to 10 feet in diameter, with the most common size being between about 1 and 3 feet. Concentrations of cobbles and boulders are often found near contacts between geologic units.

While it is difficult to determine if a boulder is encountered during microtunneling, boulders can be measured and counted if pipe jacking, pipe ramming, or auger boring is used. During final design, an estimated boulder quantity should be developed to assist with characterizing the risks and associated design and contractual mitigation.

Pipe jacking provides the easiest access to the excavation face for removal of obstructions. For pipe ramming and auger boring methods, the removal of obstructions will require the removal of the soil plug or removal of the auger, respectively. Microtunneling machines typically do not provide any access to the excavation face for removal of obstructions. If a boulder is encountered that is large enough to impede the progress of the microtunneling machine, a rescue shaft will be required.

8.6 Preliminary Preferred Alignment

Based on the completed explorations and available geotechnical data reviewed, for the two alignments included in the scope of this geotechnical study, the NW 56th Street alignment, in our opinion, has less geotechnical and environmental risk. The NW Market Street alignment requires one more pit than the NW 56th Street alignment. This increases the project risk for claims associated with groundwater control and associated dewatering impacts. In addition, the contamination encountered in BCT-4, combined with the more permeable soils encountered in

BCT-4 compared to the other borings, also suggests additional project risk and cost with the NW Market Street alignment.

8.7 Geotechnical Instrumentation

Prior to the start of construction, we recommend that a preconstruction survey be conducted to document the existing condition of nearby structures and utilities. In addition, geotechnical instrumentation should be installed to monitor the response of the ground and adjacent structures, utilities, and pavement to the construction activities.

In general, preconstruction surveys should be conducted on existing surface structures located within a horizontal distance equal to 1.5 times the open-cut and trenchless excavation depth. In addition, preconstruction surveys should also be conducted on existing gravity pipelines located within a horizontal distance equal to the open-cut and trenchless excavation depth. For structures, the preconstruction survey should include diagrams, sketches, and photographs. These records should include, but not be limited to, the number, locations, and length and width of existing cracks, etc. The surveys should be conducted by a Professional Engineer registered in the state of Washington and should be completed with the owner, Contractor, and resident engineer present. A formal report should then be developed and signed by each member of the group. For accessible gravity pipelines, they should be scanned with video equipment. If damage claims are made, then follow-up surveys should be made to compare the original documented condition to the current condition.

Geotechnical instrumentation should be installed to monitor the response of the ground and adjacent structures, utilities, and pavement to the construction of the pipeline, manholes, and appurtenant structures. Data collected from the monitoring program would be used to assess:

- The validity of any claims.
- Effectiveness of remedial measures.
- Performance of the shoring.
- Performance of the dewatering system.

The construction of the Project will require relatively deep shored excavations, dewatering, and trenchless construction. Each of these construction activities could result in deformations or ground losses that may lead to vertical settlements adjacent to excavations, which may affect adjacent structures, utilities, and pavements. Each of these and other related elements should be monitored prior to construction and during construction, as required. For preliminary design, we recommend assuming the following geotechnical instrumentation systems:

- Surface settlement points for monitoring curbs, sidewalks, and roadways that will remain after construction that are within a distance equal to 1.5 times the excavation depth or within an area that could be influenced by construction vibrations.
- Utility settlement points should be established on settlement-sensitive utilities such as sewers and water mains that cross above and/or parallel to the pipe excavations and are within a distance equal to 1.5 times the excavation depth or within an area that could be influenced by construction vibrations.
- Structure settlement points should be established on all residences where preconstruction surveys were conducted, structures within 100 feet of pipe ramming operations, and structures within a distance equal to 1.5 times the excavation depth.
- Vibration monitors for measuring vibration levels at adjacent structures and utilities within 100 feet of where pipe ramming is conducted.
- Groundwater monitoring wells located at property boundaries adjacent to dewatering activities.

The design and related specifications and drawings for the geotechnical instrumentation should be developed as part of final design.

Assuming microtunneling is the selected trenchless alternative, in our opinion and for planning-level costing purposes only, we recommend assuming that the cost of monitoring ground movements, vibrations, and groundwater for either alignment will be $70,000.

8.8 Other Risks

Methane has been identified by exploration programs and encountered during tunneling on several projects in the Seattle area, including the Lake City Trunk Sewer, Mercer Street Tunnel, Alki CSO Tunnel, and West Point Sewer Tunnel. Hydrogen sulfide associated with bacterial anaerobic decay can also be encountered in glacial soil. However, testing in this area performed as part of the Ship Canal Water Quality Project suggests methane and hydrogen sulfide are unlikely to be encountered in concentrations that would require changes to typical construction means and methods. Therefore, for planning purposes, it is our opinion that the risk of encountering methane or hydrogen sulfide at levels that would require special consideration during excavation is low.

The current NW Market Street alignment is within the zone of lead contamination encountered in BCT-4. There is a moderate to high risk that this highly contaminated soil will also be encountered in excavations through this area. The presence of lead contamination does not necessarily preclude the selection of a trenchless method, but rather any contaminated soils encountered would require special handling and disposal, which would increase the project costs and could risk the safety of workers in the excavation.

9.0 CLOSURE

We have prepared the document “Important Information About Your Geotechnical Report/Environmental Report” (Appendix E) to assist you and others in understanding the use and limitations of this report. Please read this document to learn how you can lower your risks for this Project.

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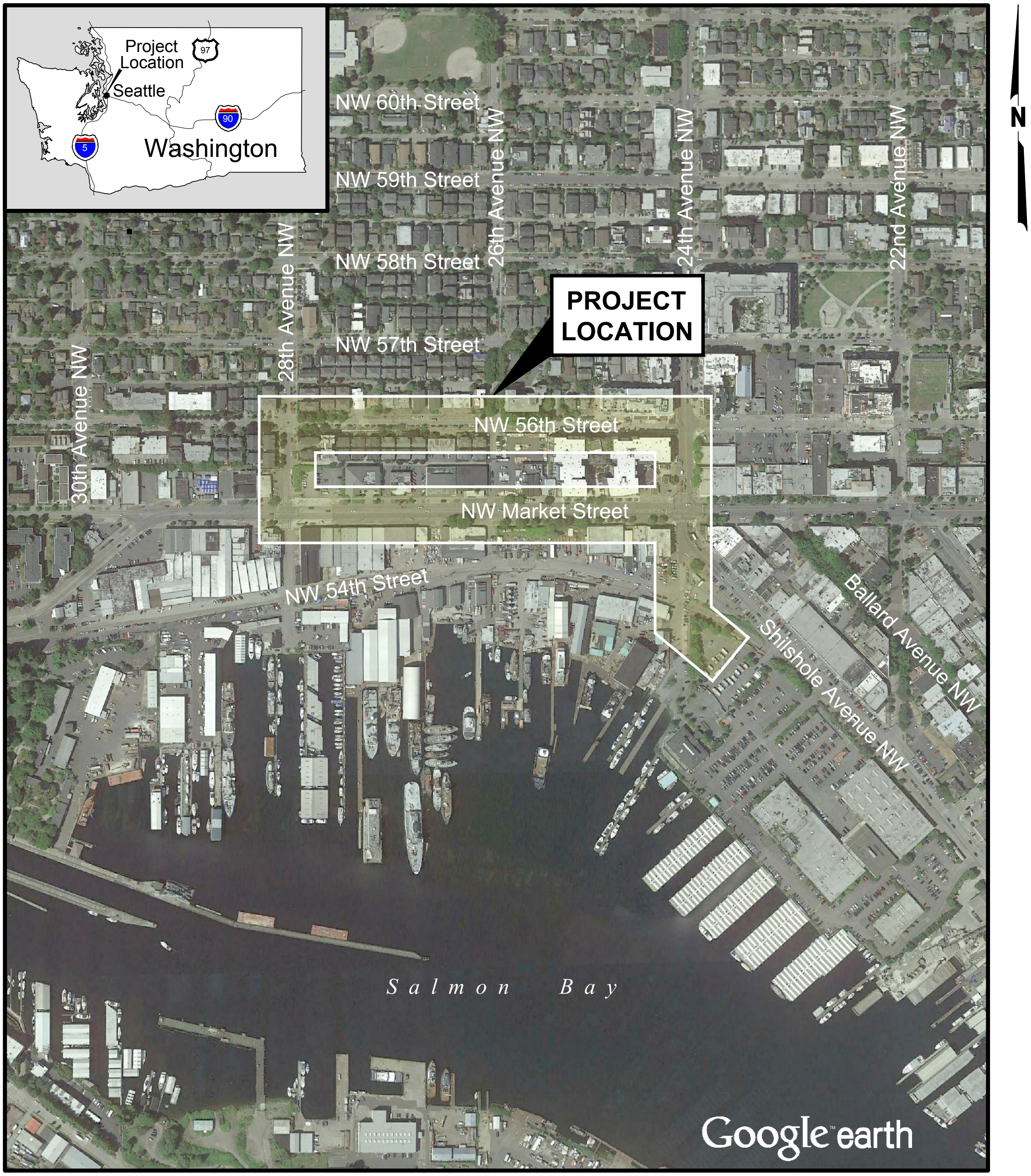
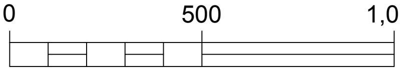




Approximate Scale in Feet

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

Ballard Conveyance
Seattle, Washington

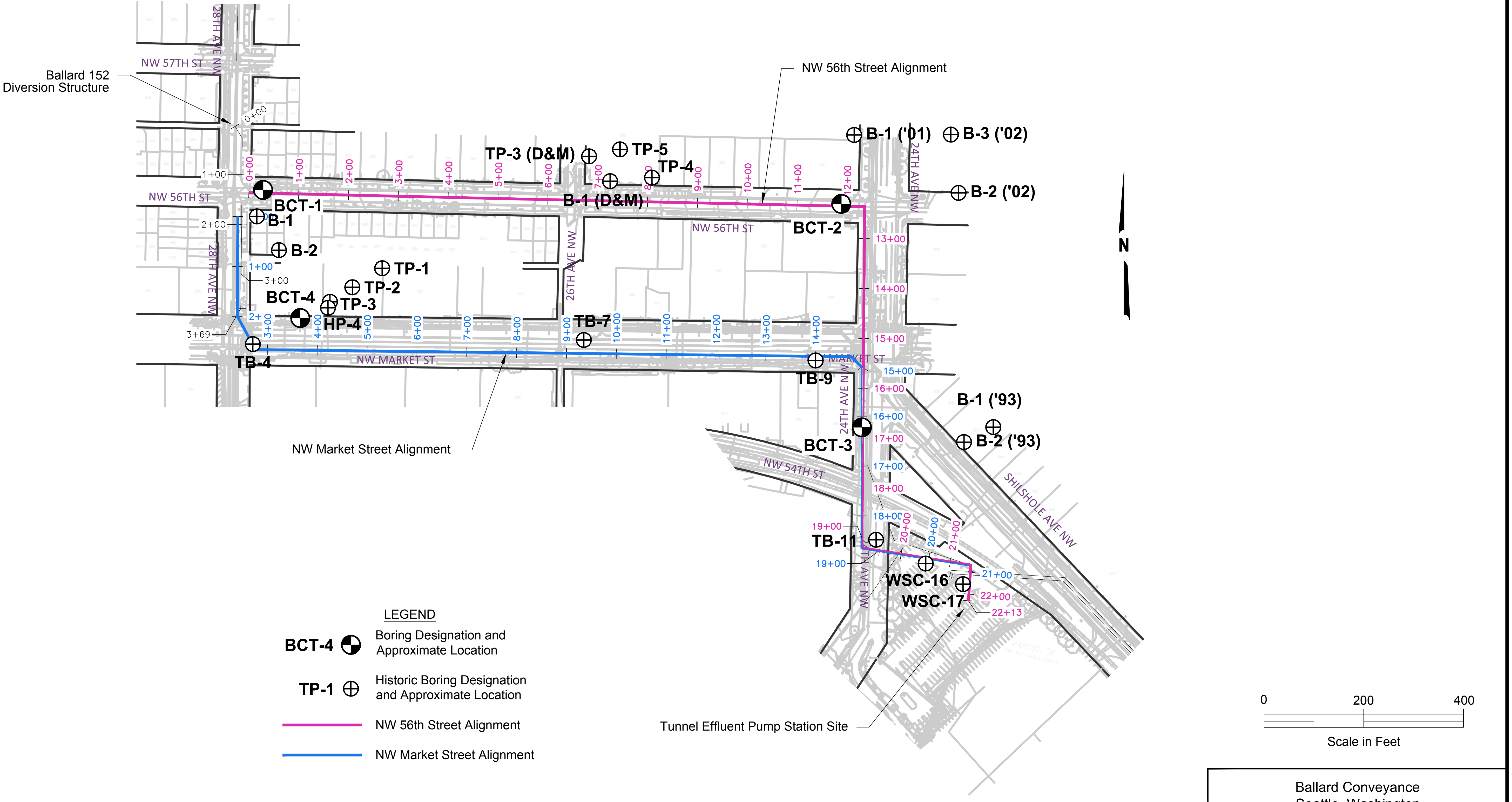
VICINITY MAP

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

Filename: J:\211\22329\004\21-1-22329-004 Fig 1.dwg Date: 07-19-2017 Login: jrs



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SITE AND EXPLORATION PLAN

July 2017 21-1-22329-004

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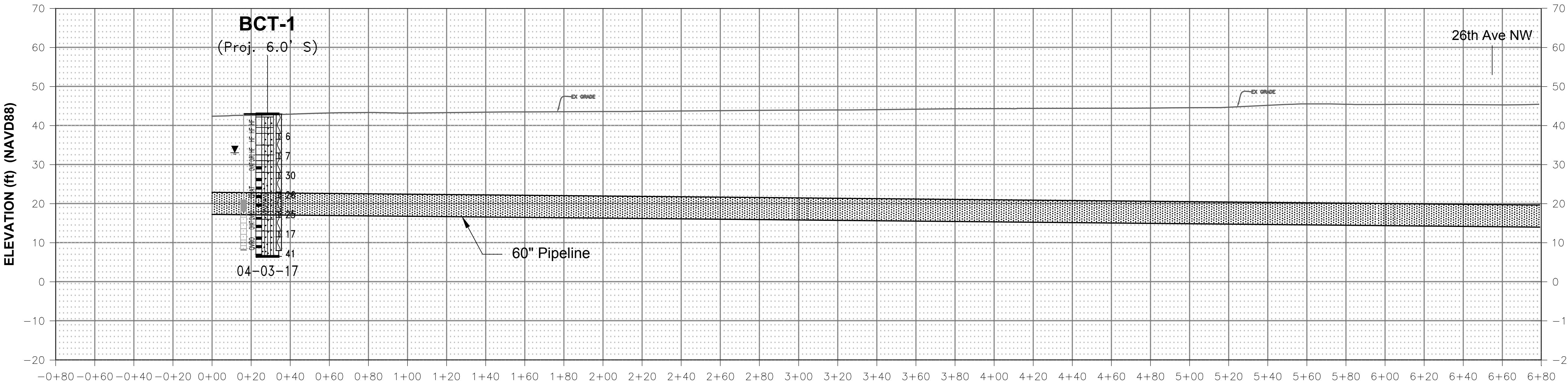
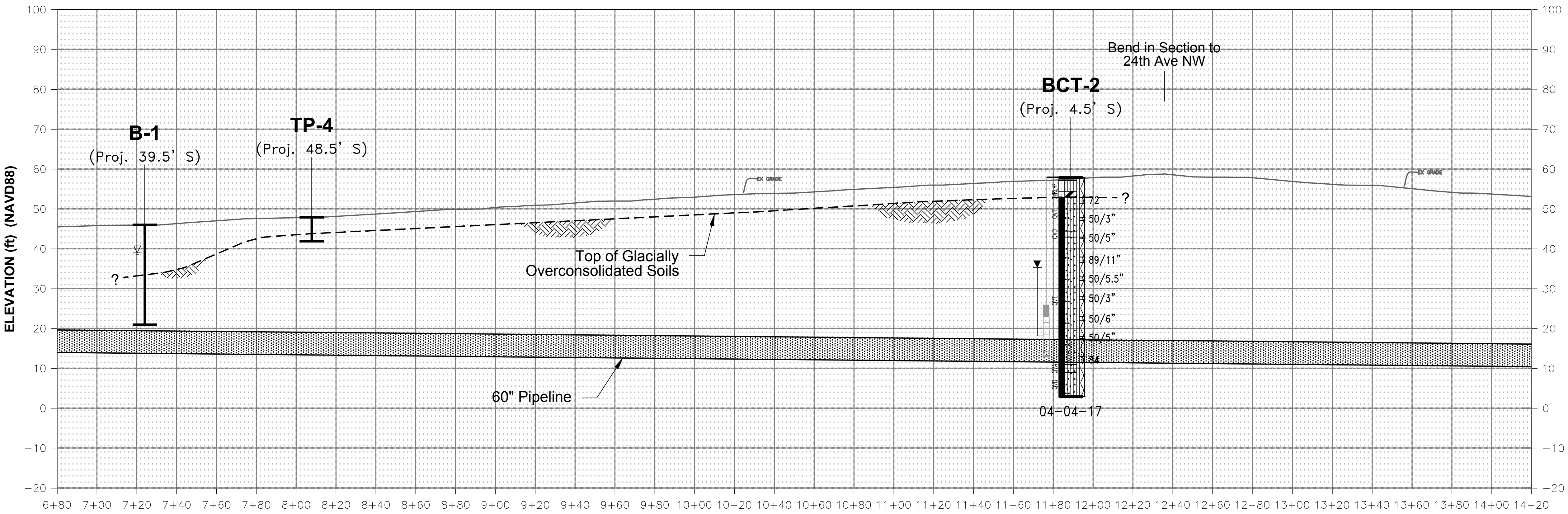
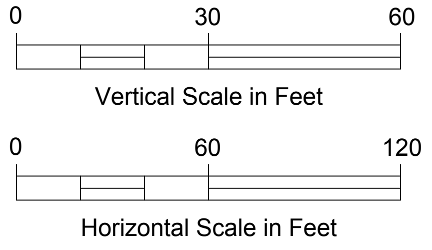
FIG. 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 4.dwg Layout: Exploration Date: 07-19-2017 Login: jrs







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NW 56TH STREET ALIGNMENT SUBSURFACE PROFILE

July 2017 21-1-22329-004

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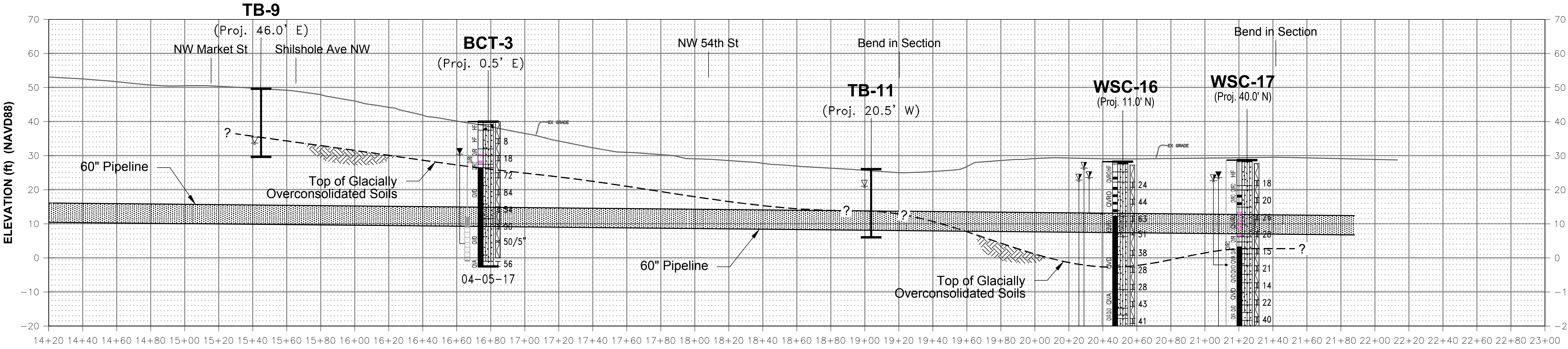
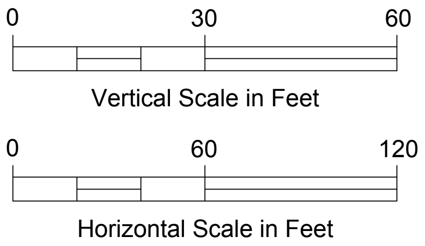
FIG. 3
Sheet 1 of 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 3.dwg Layout: 1 of 2 Date: 07-19-2017 Login: jrs





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NW 56TH STREET ALIGNMENT SUBSURFACE PROFILE

July 2017
21-1-22329-004

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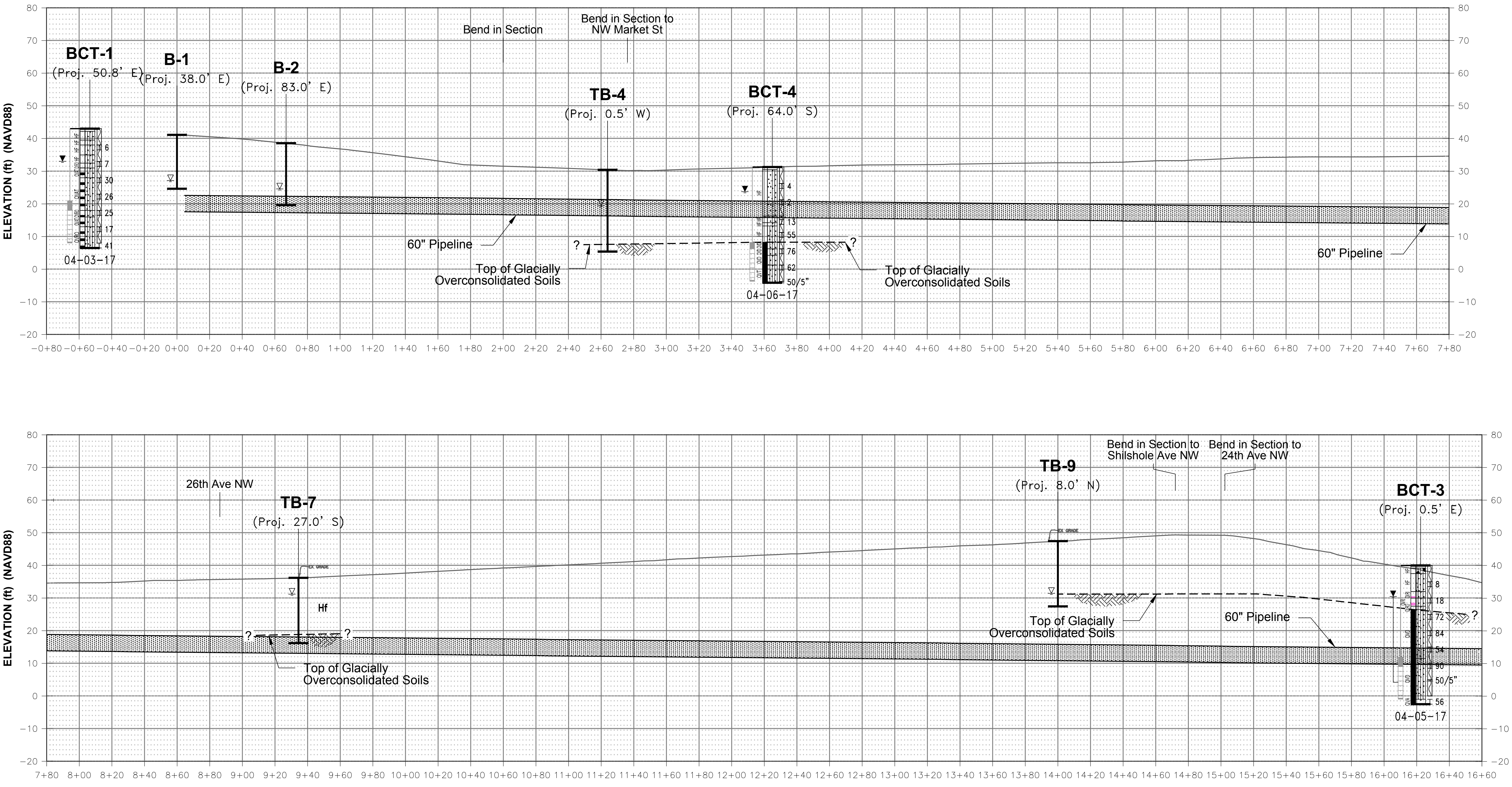
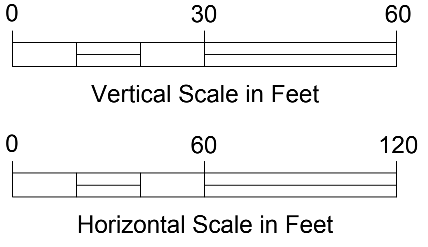
FIG. 3
Sheet 2 of 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 3.dwg Layout: 2 of 2 Date: 07-19-2017 Login: jrs





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NW MARKET STREET ALIGNMENT SUBSURFACE PROFILE

July 2017 21-1-22329-004

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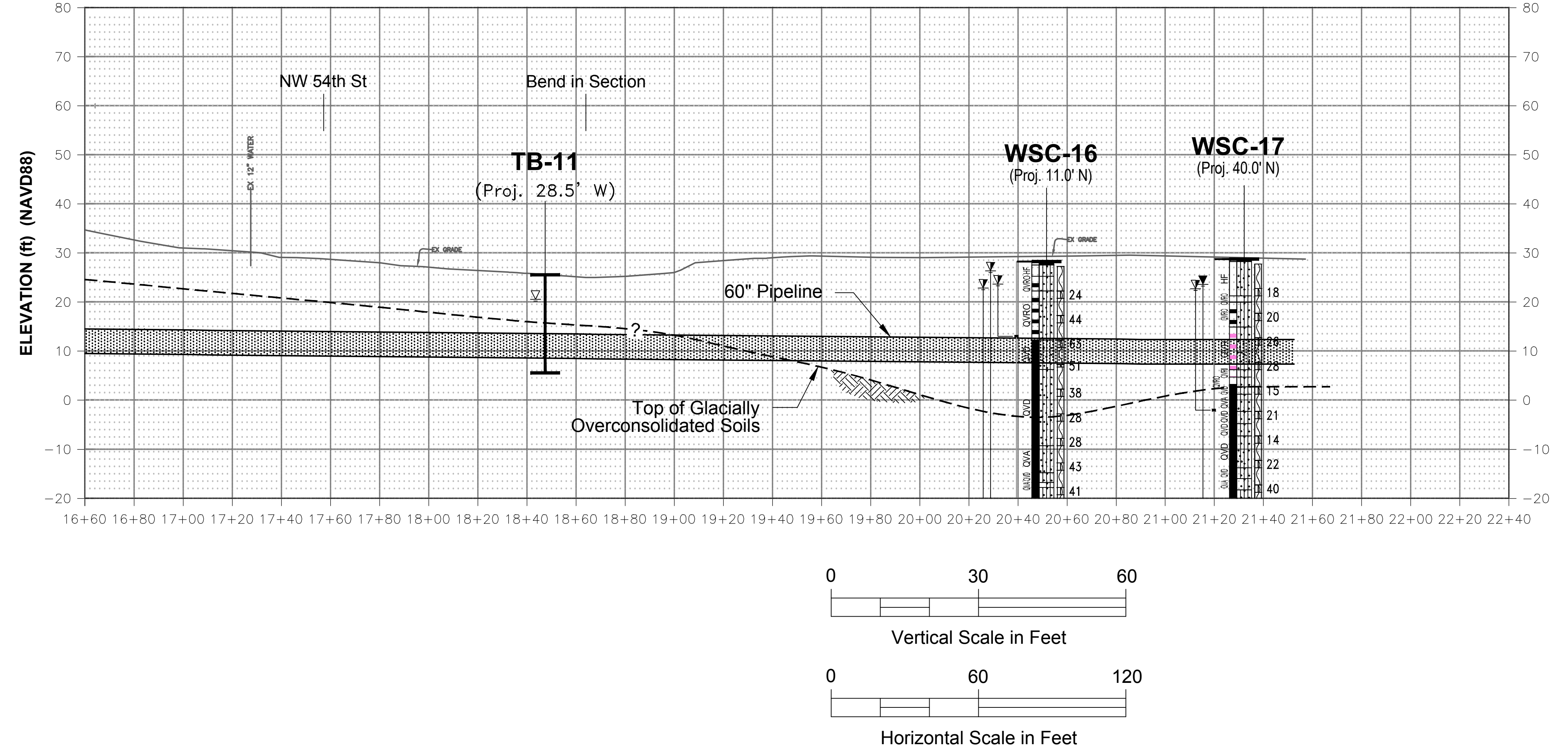
FIG. 4
Sheet 1 of 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 4.dwg Layout: 1 of 2 Date: 07-19-2017 Login: jrs



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NW MARKET STREET ALIGNMENT SUBSURFACE PROFILE

July 2017 21-1-22329-004

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FIG. 4
Sheet 2 of 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 4.dwg Layout: 2 of 2 Date: 07-19-2017 Login: jrs

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

TABLE OF CONTENTS

Page

FIGURES

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

A.1 GENERAL

Subsurface explorations we performed for this project consist of drilling and sampling three soil borings. The approximate locations of the borings are shown in Figure 2.

A.2 DRILLING PROCEDURES

Four borings, designated BCT-1 through BCT-4, were drilled during the period of April 3 and 6, 2017. Cascade Drilling, under subcontract to Shannon & Wilson, Inc. (Shannon & Wilson) drilled the borings using a rubber tracked-mounted drill. The borings were advanced to various depths indicated in Table A-1 using the sonic core drilling method. This method uses high-frequency vibratory motion applied to the top of the drill column, along with down-pressure and rotation, to obtain nearly continuous core samples in soil. Soil samples were obtained using a 4.5-inch-outside-diameter (O.D.) core barrel. The core barrel was advanced into the ground a specific distance (termed a core “run”) and then retrieved for extraction of the sample core. Following retrieval of the core barrel, a temporary casing was advanced to the bottom of the sampled interval. The casing was then cleared of slough, and the next core sample was collected, starting at the bottom of the temporary casing. The soil cuttings were placed into a 55-gallon drum and disposed of by the driller.

A.3 SOIL SAMPLING

A Shannon & Wilson field representative was present to observe drilling, collect samples for subsequent laboratory testing, and prepare descriptive fields logs of the borings. Soil samples were collected from each current exploration for purposes of engineering classification, geologic evaluation, and geotechnical testing. Two different sampling methods were used in each boring, split-spoon sampling and sonic core sampling. The sampling methods are indicated in the exploration logs included in this appendix and are described in the following sections.

A.3.1 Split-Spoon Sampling

Split-spoon samples were collected in conjunction with Standard Penetration Tests (SPTs) at approximately 5-foot intervals in each of the borings. The SPTs were performed in general accordance with the ASTM International Designation: D1586-11, Test Method for

Penetration Test and Split-Barrel Sampling of Soils. For the SPT, a 2-inch-O.D., 1.375-inch-inside-diameter (I.D.), split-spoon sampler is driven with a 140-pound hammer falling 30 inches. The number of blows required to achieve each of three 6-inch increments of sampler penetration is recorded. The number of blows required to achieve the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). When penetration resistances exceeded 50 blows for 6 inches or less of penetration, the test was terminated, and the number of blows along with the penetration distance was recorded on the boring log. The SPT N-value is a useful parameter for determining the relative density or consistency of the soils. Density or consistency as it is related to the SPT N-value is shown in Figure A-1. The recorded N-values are included in the boring logs in Figures A-2 through A-5.

After each split-spoon sampler was removed from the borehole, a Shannon & Wilson field representative opened the sampler and visually examined the soil sample. The field representative then described and classified the sample, removed it from the split-spoon sampler, and sealed the sample in a jar. The jars were stored in boxes and returned to the Shannon & Wilson laboratory for further examination and testing.

A.3.2 Sonic Core Sampling

For the borings drilled using sonic core drilling methods, soil core samples were extracted from the core barrel using a combination of gravity and vibration to extrude the soil into flexible plastic bags. The plastic bags were then placed into wooden core boxes that were marked for the appropriate boring designation, core run number, and depths. Cohesive, hard soils were difficult to extract and occasionally required the use of pressurized air to force the soil out of the core barrel. Disturbance of the core samples (e.g., fragmented cobbles and gravel and distorted bedding planes) result from the coring and extraction process.

Once in the warehouse, the soil cores were opened, photographed, and logged by a Shannon & Wilson geologist. The geologist also obtained grab samples of the soil at depth intervals of about 5 feet; however, additional grab samples were obtained where variable soil conditions were encountered in the core. The sonic core photographs are provided in a separate electronic format.

A.4 BORING LOGS

The boring logs for this project are presented as Figures A-2 through A-5. A boring log is a written record of the subsurface conditions encountered. It describes the geologic units (layers) encountered in the boring and the Unified Soil Classification System symbol of each geologic layer. It also includes the natural water content (where tested), groundwater level observations, approximate surface elevation, types and depths of sampling, and SPT blow counts.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	**FINE-GRAINED SOILS (50% or more fines)**[1]	**COARSE-GRAINED SOILS (less than 50% fines)**[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1] All percentages are by weight of total specimen passing a 3-inch sieve.
[2] The order of terms is: *Modifying Major with Minor*.
[3] Determined based on behavior.
[4] Determined based on which constituent comprises a larger percentage.
[5] Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	**SIEVE NUMBER AND/OR APPROXIMATE SIZE**
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		**COHESIVE SOILS**	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

▧	Bentonite Cement Grout	▩	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▦	Bentonite Chips	▤	Slough
░	Silica Sand	◫	Inclinometer or Non-perforated Casing
⊟	Perforated or Screened Casing	▮	Vibrating Wire Piezometer

PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1] Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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SOIL DESCRIPTION AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	●	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	○	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	●	Silty Gravel; Silty Gravel with Sand
			GC	▨	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	⁘	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	⁘	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	▥	Silty Sand; Silty Sand with Gravel
			SC	▨	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	▥	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	▨	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	☰	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	▥	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	▨	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	▨	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	≋	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

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SOIL DESCRIPTION AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
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FIG. A-1
Sheet 2 of 3

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICITY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

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[1] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

[2] Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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SOIL DESCRIPTION AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
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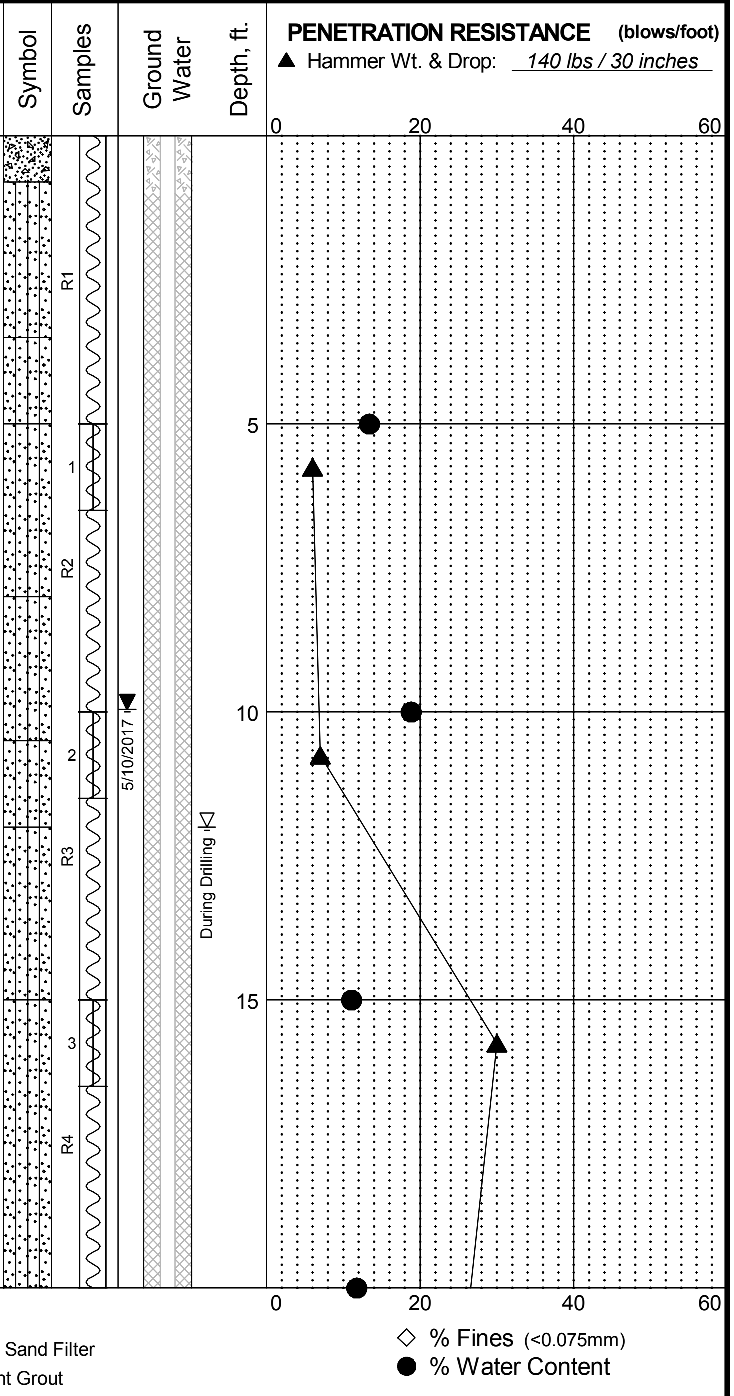
FIG. A-1
Sheet 3 of 3

Total Depth:	*36.5 ft.*	Northing:	~	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*~ 43 ft.*	Easting:	~	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*AWJ*
Vert. Datum:	*NAVD 88*	Station:	~	Drill Rig Equipment:	*Geoprobe 8140 LC*	Hammer Type:	*Automatic*
Horiz. Datum:	*N/A*	Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Concrete.	0.8
Gray and gray-brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; trace organics; trace iron-oxide staining. (Hf)	3.5
Gray, *Silty Sand (SM)*; moist; few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace iron-oxide staining. (Hf)	5.0
Loose, brown, *Silty Sand (SM)*; moist; few fine subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; trace organics; diamict. (Hf)	8.0
Loose, brown to dark brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few organics and wood fragments; trace brick fragments. (Hf)	10.5
Loose, gray-brown, *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subagular gravel; fine to coarse sand; nonplastic fines. (Qvro/Hf)	12.0
Gray-brown to orange-brown, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few pockets with iron-oxide staining; diamict. (Qvat/Qvri)	15.0
Medium dense to dense, gray, *Silty Sand (SM)*; moist to wet; trace to few fine, subrounded to	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ◪ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊞ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING BCT-1

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 2

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

Total Depth:	36.5 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 43 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

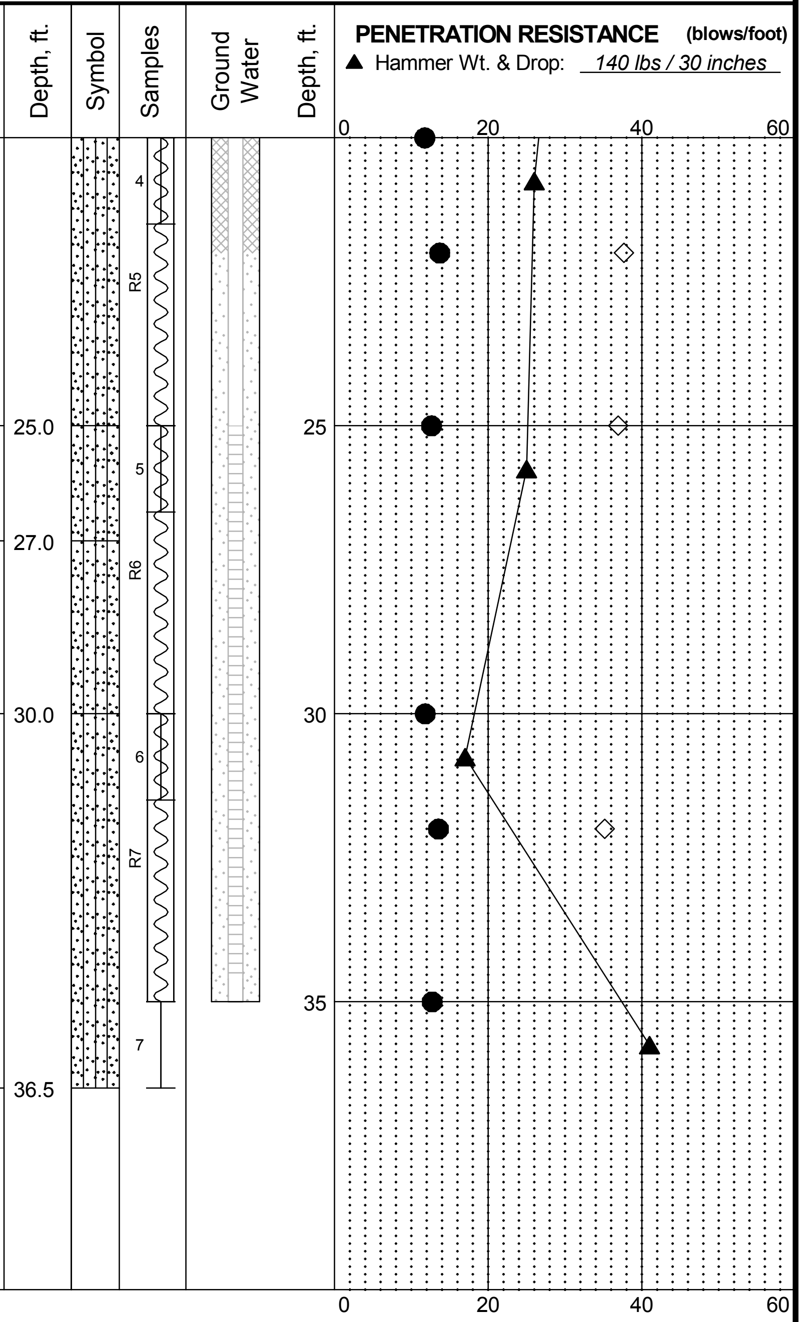
subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvat/Qvd)
- Wet from 20 to 20.5 feet.

Medium dense, gray, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines.
(Qvro/Qva)

Medium dense, gray, *Silty Sand (SM)*; moist; trace to few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvat/Qvd)

Medium dense to dense, gray, *Silty Sand (SM)*; wet; trace fine to coarse, subrounded gravel; fine to coarse sand; nonplastic fines.
(Qvro/Qva)

BOTTOM OF BORING
COMPLETED 4/3/17



LEGEND

- * Sample Not Recovered
- ▨ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING BCT-1

July 2017 21-1-22329-004

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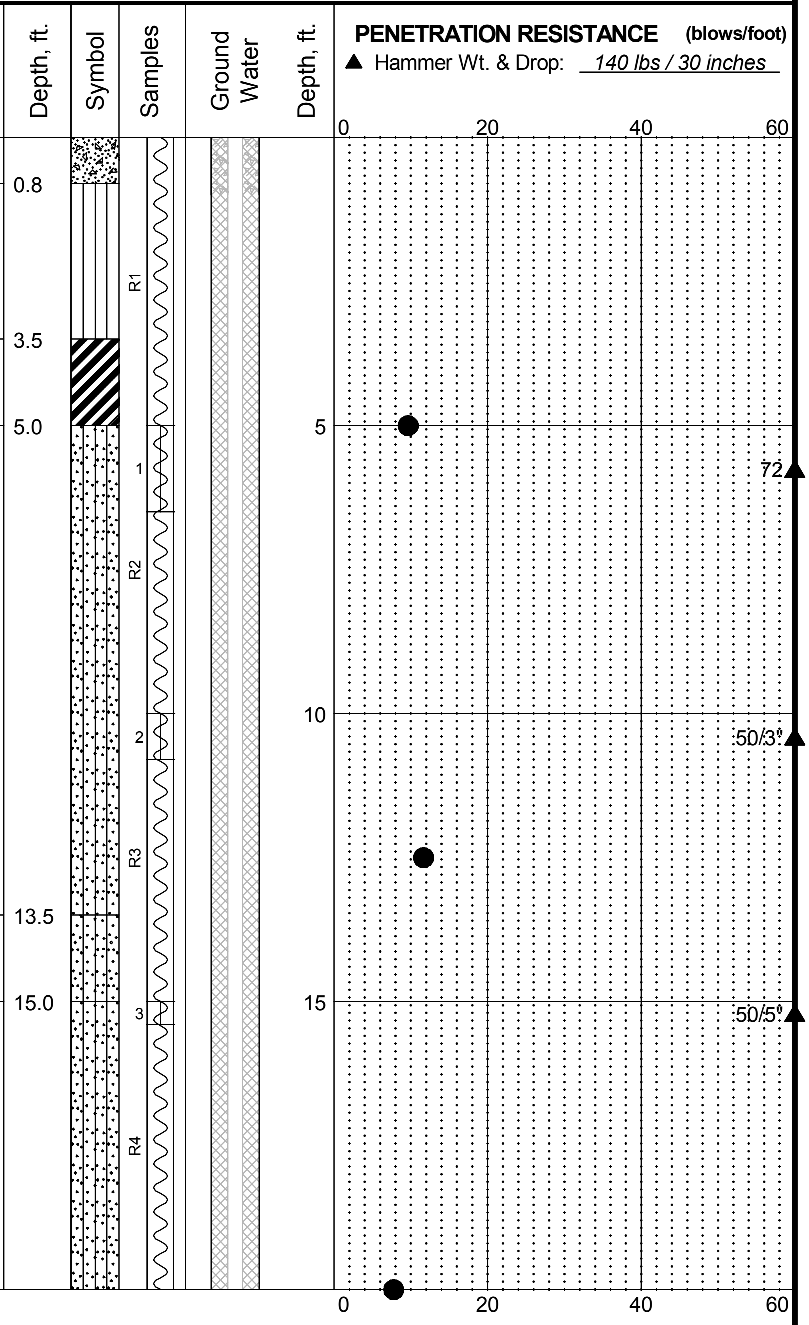
FIG. A-2
Sheet 2 of 2

REV 3 - Approved for Submittal

Total Depth: 55 ft.	Northing: ~	Drilling Method: Sonic Core		Hole Diam.: 6 in.
Top Elevation: ~ 58 ft.	Easting: ~	Drilling Company: Holocene Drilling		Rod Diam.: AWJ
Vert. Datum: NAVD 88	Station: ~	Drill Rig Equipment: Geoprobe 8140 LC		Hammer Type: Automatic
Horiz. Datum: N/A	Offset: ~	Other Comments:		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.



Concrete.

0.8

Brown to orange-brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist; trace fine, subrounded gravel; fine to coarse sand; low plasticity fines; iron-oxide staining; trace organics.
(Hf)

3.5

- Layer of dark brown, silty sand with gravel, with few brick fragments from 2.5 to 3 feet.
- Boulder was encountered at 3 feet.

5.0

Orange-brown and gray, *Fat Clay with Sand (CH)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; medium to high plasticity fines; iron-oxide staining.
(Qvrl/Qvgl)

Very dense, gray to gray-brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; trace iron-oxide staining.
(Qvt/Qvd)

13.5

Very dense, gray-brown, *Silty Sand (SM)*; moist; trace to few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict pockets.
(Qvd)

15.0

Very dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvt)

CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-2

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 1 of 3

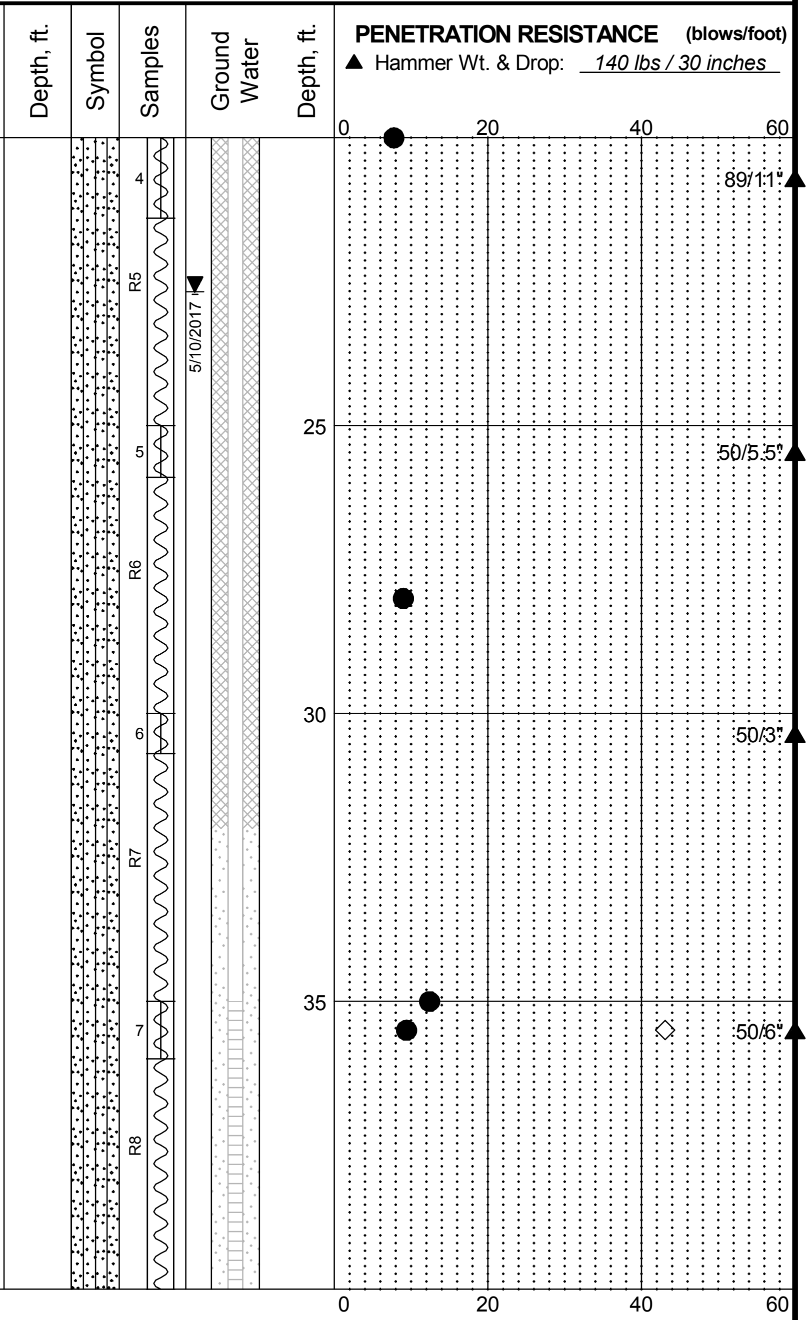
REV 3 - Approved for Submittal

Total Depth: 55 ft.
Top Elevation: ~ 58 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A
Northing: ~
Easting: ~
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Few wet seams below 30 feet.



CONTINUED NEXT SHEET

0 20 40 60

◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
◩ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-2

July 2017
21-1-22329-004

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FIG. A-3
Sheet 2 of 3

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

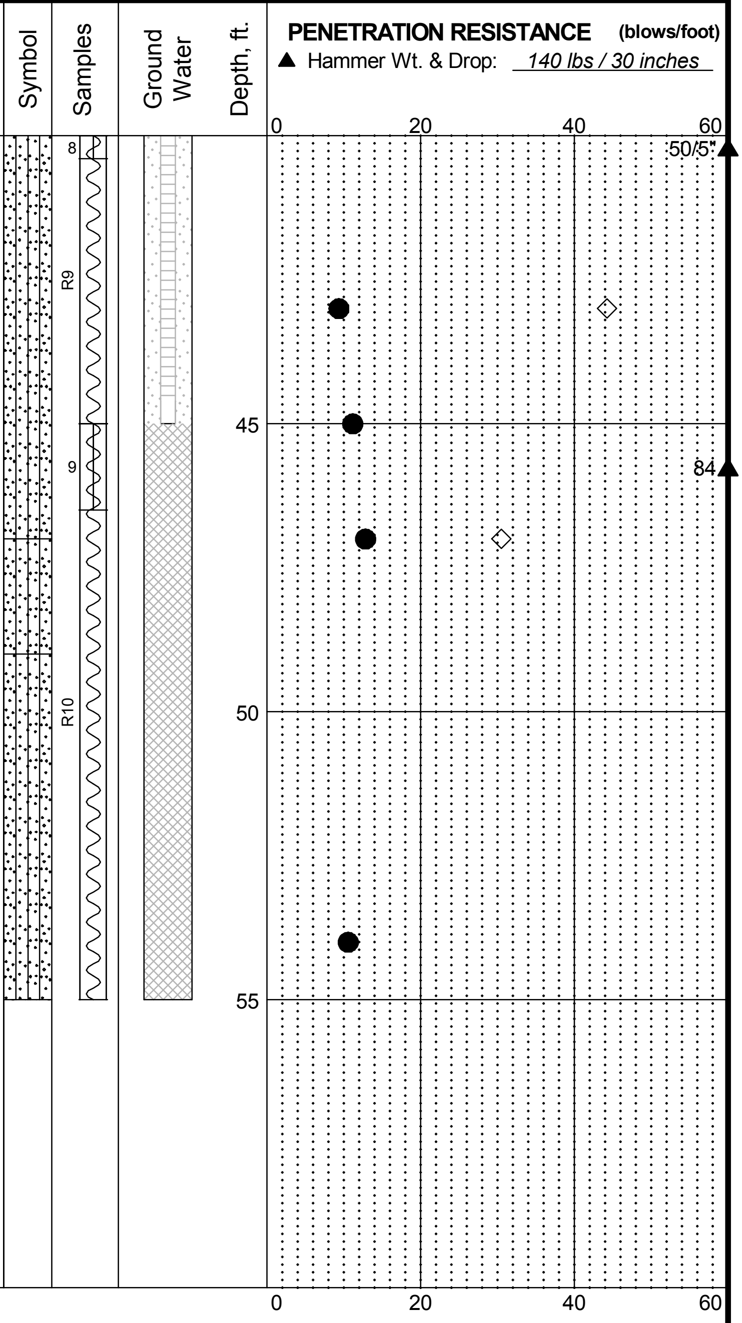
Total Depth:	55 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 58 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
Gray, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines. (Qva)	47.0
Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvd)	49.0
BOTTOM OF BORING COMPLETED 4/6/17	55.0

- BCT-2 was completed to a depth of 45 feet. A second BCT-2 was drilled adjacent to the original boring to a depth of 55 feet. Samples were not collected from the second BCT-2 from the surface to 45 feet. Both borings are compiled on the same BCT-2 boring log.



◇ % Fines (<0.075mm)

● % Water Content

LEGEND

* Sample Not Recovered

▨ Soil Core (as in Sonic Core Borings)

⌶ 2.0" O.D. Split Spoon Sample

▦ Well Screen and Sand Filter

▧ Bentonite-Cement Grout

⊠ Bentonite Chips/Pellets

▨ Bentonite Grout

▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-2

July 2017 21-1-22329-004

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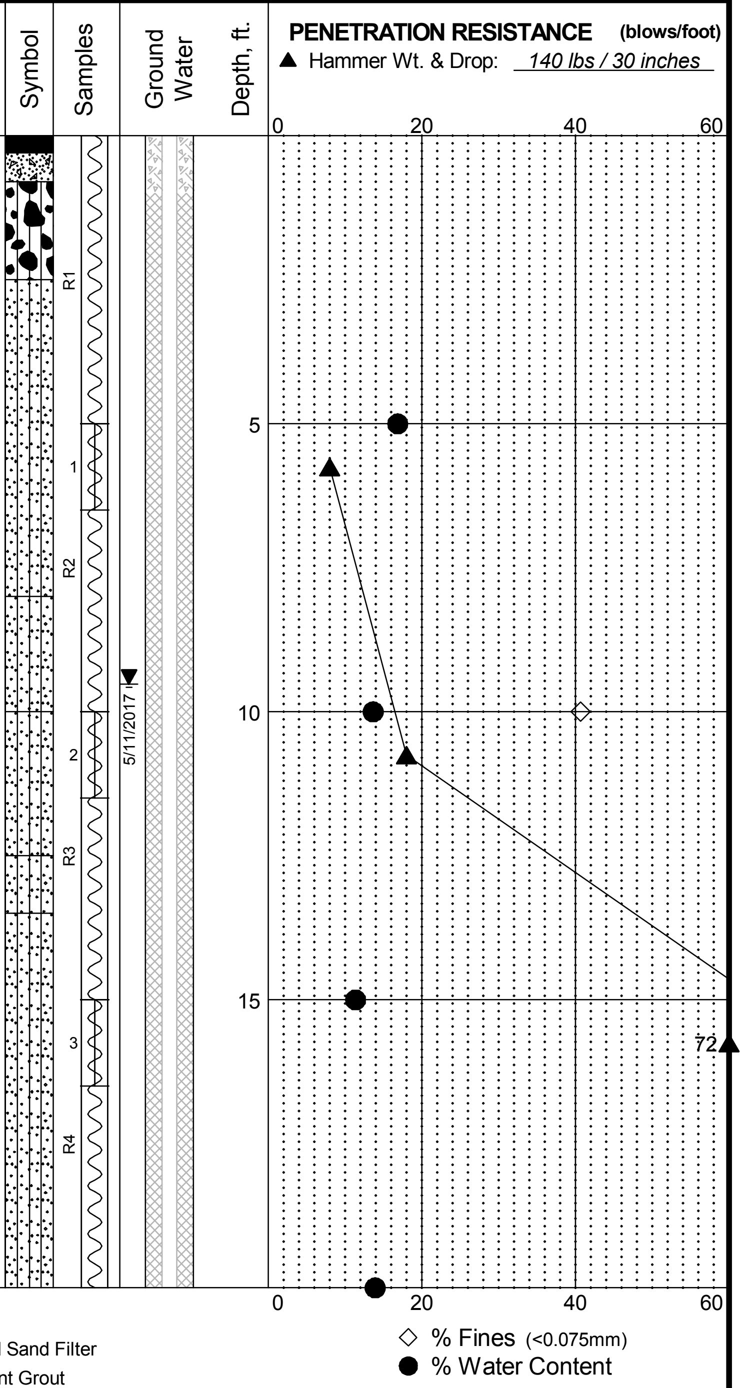
FIG. A-3
Sheet 3 of 3

REV 3 - Approved for Submittal

Total Depth:	42.5 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 40 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Asphalt.	0.3
Concrete.	0.8
Dark brown, *Silty Gravel with Sand (GM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace organics. (Hf)	2.5
Loose, brown, *Silty Sand (SM)* to *Sandy Silt (ML)*; moist; few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; trace brick fragments; trace pockets with iron-oxide staining. (Hf) - Layer of dark brown, silty gravel with sand from 5 to 5.5 feet.	8.0
Loose, gray, *Silty Sand (SM)*; moist; trace fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace pockets with iron-oxide staining. (Qvri/Hf)	10.0
Medium dense, brown, *Silty Sand (SM)*; moist to wet; trace fine to coarse, subrounded gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvri/Hf)	12.5
	13.5
Medium dense, brown, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines. (Qvro/Qvri)	
Very dense, brown to gray-brown, *Silty Sand (SM)*; moist; few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd) - Layer of wet, silty sand from 19.5 to 20 feet.	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
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FIG. A-4
Sheet 1 of 3

REV 3 - Approved for Submittal

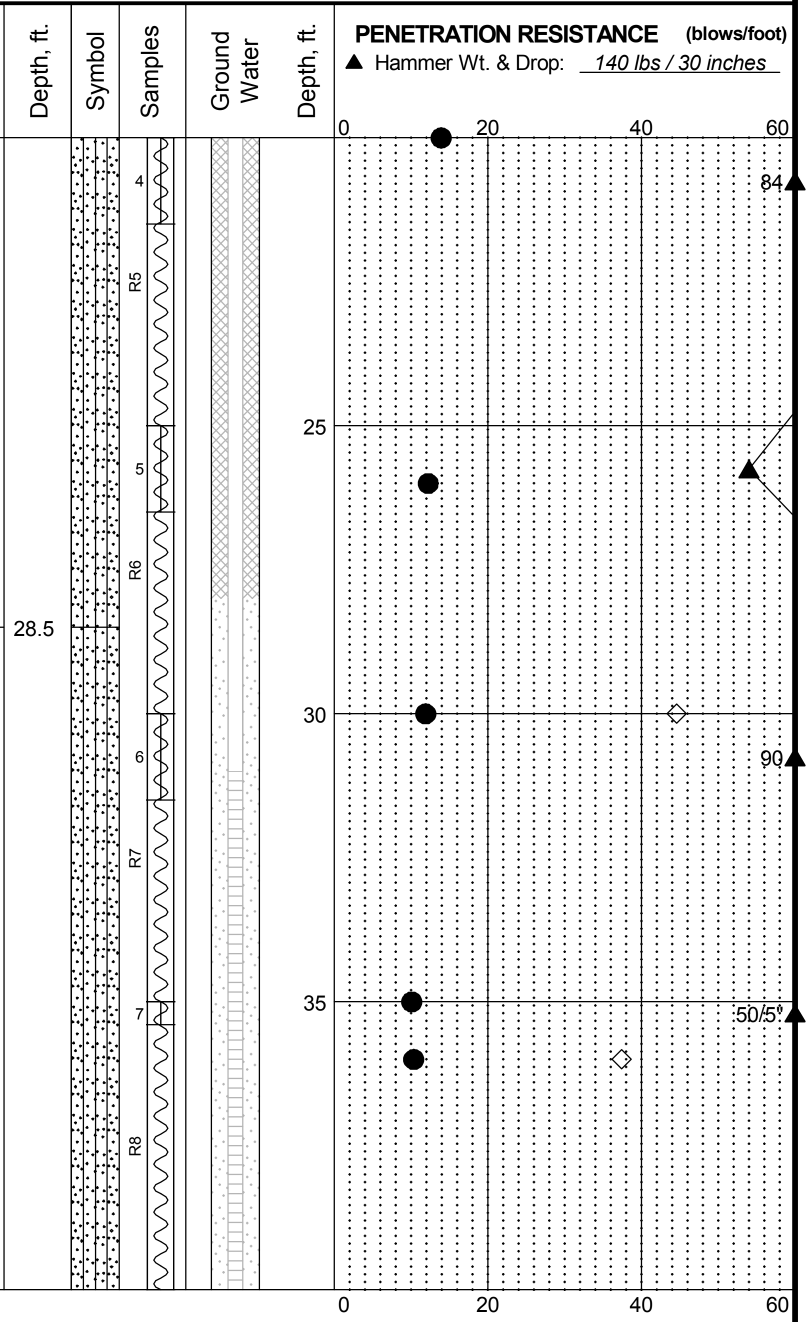
Total Depth: 42.5 ft.
Top Elevation: ~ 40 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A
Northing: ~
Easting: ~
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Few wet, silty sand seams from 21 to 22 feet.
- Layer of wet, poorly graded sand with silt with iron-oxide staining at 24.5 feet.
- Few pockets with iron-oxide staining below 26 feet.

Very dense, gray, *Silty Sand (SM)*; moist to wet; trace to few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ☐ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ▦ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

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FIG. A-4
Sheet 2 of 3

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

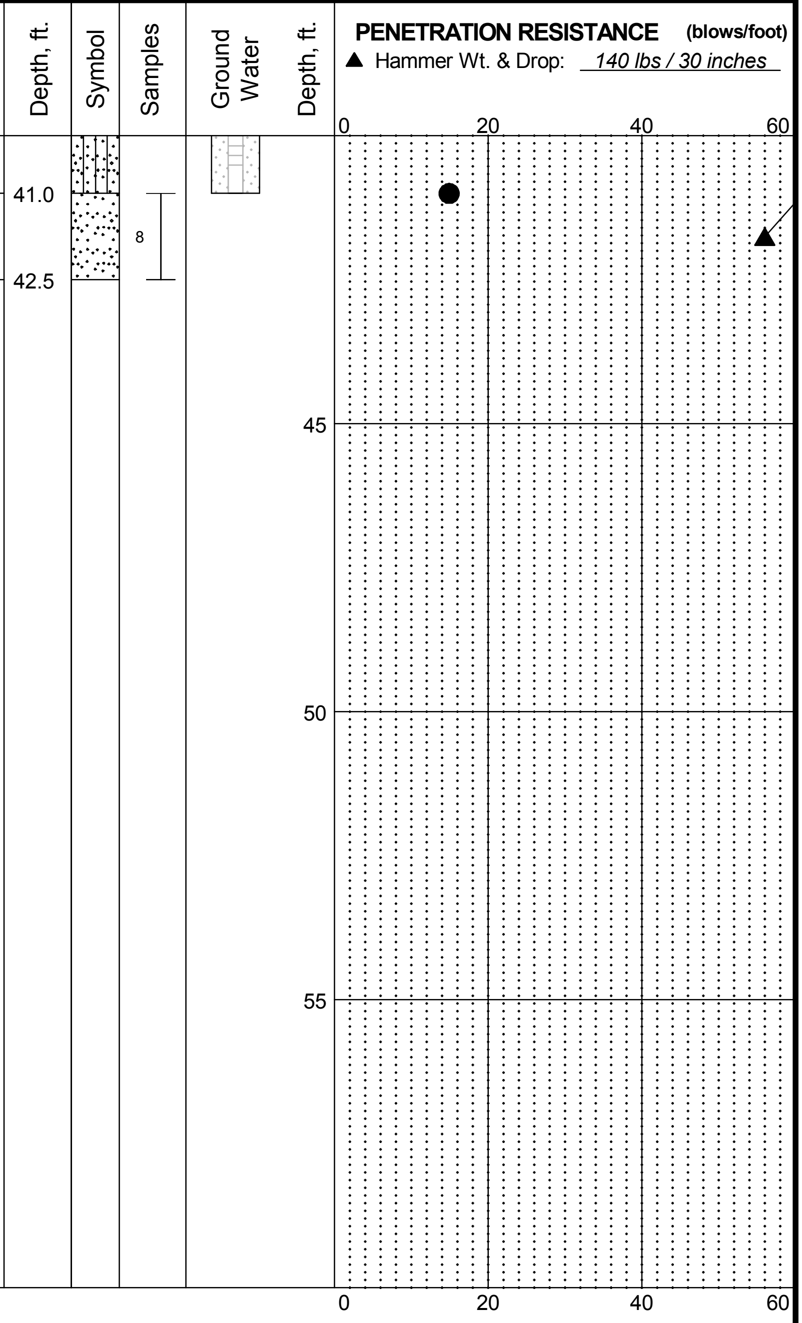
Total Depth:	42.5 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 40 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, gray, *Poorly Graded Sand with Gravel (SP)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

BOTTOM OF BORING
COMPLETED 4/5/17



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

*	Sample Not Recovered
◪	Soil Core (as in Sonic Core Borings)
⌶	2.0" O.D. Split Spoon Sample
⬚	Well Screen and Sand Filter
▧	Bentonite-Cement Grout
⊠	Bentonite Chips/Pellets
▨	Bentonite Grout
▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

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FIG. A-4
Sheet 3 of 3

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

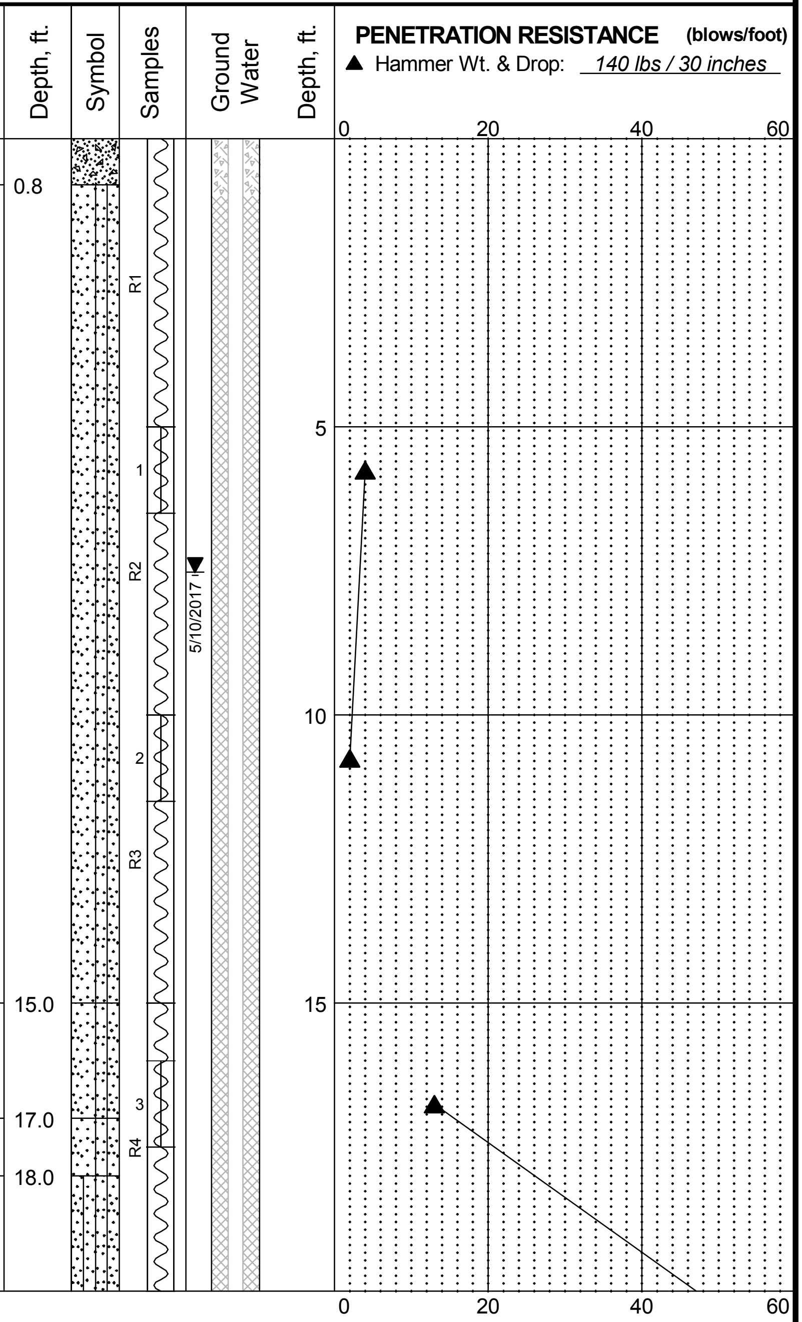
MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

Total Depth:	35.4 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 31 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Concrete.	0.8
Very loose to loose, brown, *Poorly Graded Sand with SIlt and Gravel (SP-SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few silty sand seams. (Hf) - Contaminated from 5 to 15 feet.	15.0
Medium dense, gray-brown, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few organics and wood fragments. (Hf)	17.0 18.0
Brown, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Hf)	



CONTINUED NEXT SHEET

LEGEND

*	Sample Not Recovered	⊡	Well Screen and Sand Filter
◪	Soil Core (as in Sonic Core Borings)	▧	Bentonite-Cement Grout
⌶	2.0" O.D. Split Spoon Sample	⊠	Bentonite Chips/Pellets
		▨	Bentonite Grout
		▼	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-4

July 2017 21-1-22329-004

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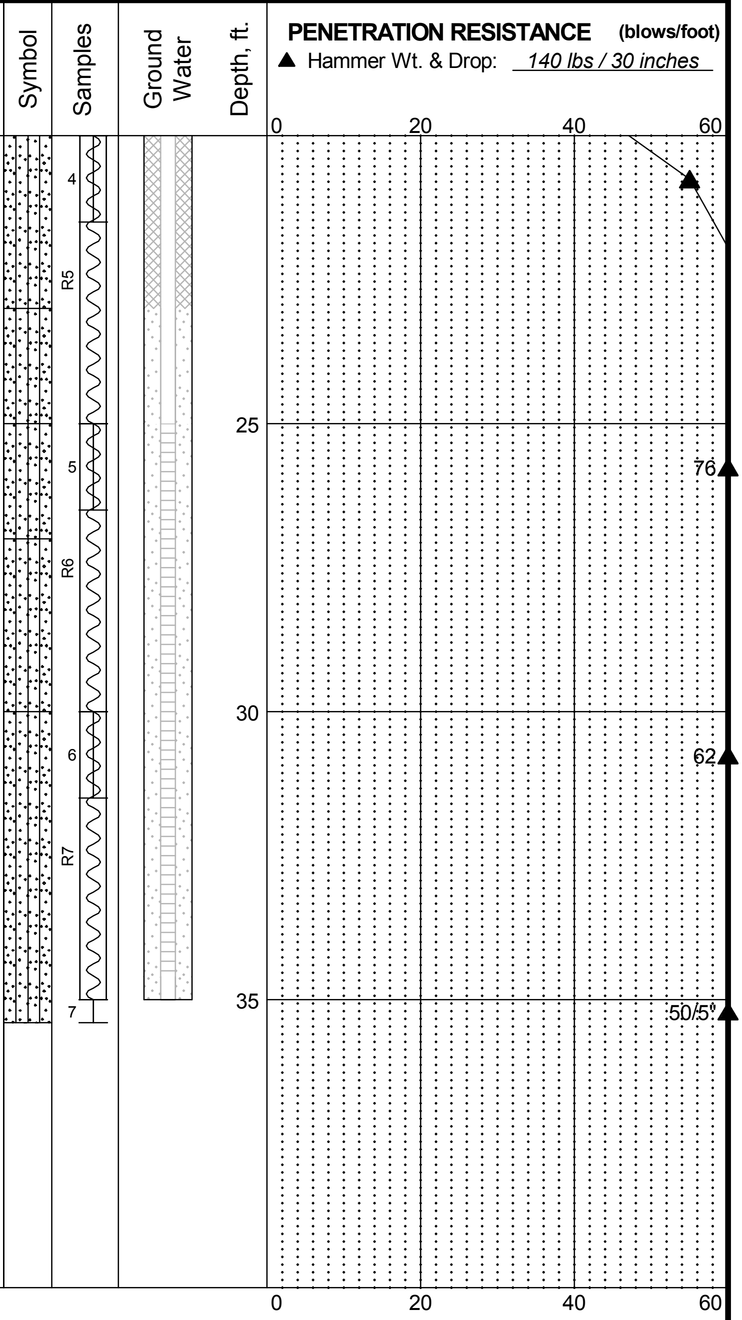
FIG. A-5
Sheet 1 of 2

REV 3 - Approved for Submittal

Total Depth:	*35.4 ft.*	Northing:	~	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*~ 31 ft.*	Easting:	~	Drilling Company:	*Holocene Drilling*	Rod Diam.:	*AWJ*
Vert. Datum:	*NAVD 88*	Station:	~	Drill Rig Equipment:	*Geoprobe 8140 LC*	Hammer Type:	*Automatic*
Horiz. Datum:	*N/A*	Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Very dense, gray, *Silty Sand (SM)*; moist; few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few wood fragments. (Hf) - Contaminated from 20 to 23 feet.	23.0
Very dense, gray, *Silty Sand (SM)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; odor. (Qvd)	25.0
Very dense, gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; slight odor. (Qvd)	27.0
Very dense, gray, *Silty Sand (SM)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd)	30.0
Very dense, gray, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvt)	35.4
BOTTOM OF BORING COMPLETED 4/6/17	



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
☒ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-4

July 2017 21-1-22329-004

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FIG. A-5
Sheet 2 of 2

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

REV 3 - Approved for Submittal

APPENDIX B

EXISTING EXPLORATION DATA

APPENDIX B

EXISTING EXPLORATION DATA

TABLE OF CONTENTS

FIGURES

SOIL AND BORING COMPLETION LOG

PROJECT NUMBER : JN 23073

BORING NUMBER : B-1

LOCATION : 13' E & 10' S of NWC

PROJECT : Noland Ballard Development

GROUND SURFACE ELEVATION (ft msl) : Street

WATER LEVEL AND DATE (ft bgs) : 14' ATD

LOGGER : Mark K. Dodds, P.E.

DEPTH BELOW SURFACE (FT)	WATER LEVEL	SAMPLE NUMBER	SAMPLE STANDARD PENETRATION 6"-6"-6" - (N)	SAMPLE SYMBOL	SAMPLE DESCRIPTION USCS SYMBOL	SAMPLE DESCRIPTION	COMMENTS
0					Fill	Light brown to brown Gravelly Sandy Silt Fill to Gravelly Silty Sandy Fill, slightly moist to moist, loose to medium-dense.	
1							
2							
3							
4							
5							
6		1	22	▨			
7							
8							
9							
10							
11		2	7	▨			
12							
13							
14	▼						
15					SM	Gray Gravelly Silty Sand, wet, very dense.	
16		3	82	▨			
17						Stopped at 16.5 feet. GWT at 14.0 feet ATD.	
18							
19							
20							

B-1

SOIL AND BORING COMPLETION LOG

PROJECT NUMBER : JN 23073

BORING NUMBER : B-2

LOCATION : 11' W & 15' N of SEC

PROJECT : Noland Ballard Development

GROUND SURFACE ELEVATION (ft msl) : Alley

WATER LEVEL AND DATE (ft bgs) : 14' ATD

LOGGER : Mark K. Dodds, P.E.

DEPTH BELOW SURFACE (FT)	WATER LEVEL	SAMPLE NUMBER	SAMPLE STANDARD PENETRATION 6"-6"-6"- (N)	SAMPLE SYMBOL	SAMPLE DESCRIPTION USCS SYMBOL	SAMPLE DESCRIPTION	COMMENTS
					Fill	Light brown to brown Gravelly Sandy Silt Fill to Gravelly Silty Sandy Fill, slightly moist to moist, loose to medium-dense.	
1							
2							
3		4	6	░			
4							
5							
6							
7							
8		2	7	░			
9							
10							
11							
12							
13		3	49	░			
14	▼						On rock? No recovery.
15					SM	Gray Gravelly Silty Sand, wet, very dense.	
16							
17							
18		4	+100	░			
19						Stopped at 19.0 feet. GWT at 14.0 feet ATD.	
20							

Hole No. B-1

PROJECT: SWC NW57th & 24th NW
DRILL RIG: Trailer Rig
HOLE DIA: 8 in.
INITIAL WATER DEPTH: 13.5 ft.
FINAL WATER DEPTH: ft.

DATE DRILLED: 02/22/01
LOGGED BY: MKD
SAMPLER: SPT
HOLE ELEV: ± Road
TOTAL DEPTH: 24.0 ft.

DESCRIPTION	SOIL TYPE		BLOWS /FT.	REMARKS
2" Asphalt Concrete Brown to gray Silty Sandy Fill with Clayier zones and pieces of brick and glass, wet, loose.	Fill	0		
		4	7	Moisture Content = 10.5%
		10	2	Moisture Content = 15.8%
Gray Silty Sand with layers of Gravelly Silty Sand, wet, very dense. (Glacial Till)	SM	14	74	Moisture Content = 15.5%
		20	+100	Moisture Content = 7.8%
		24	+100	Moisture Content = 9.9%

Refusal at 24.0 feet. Standing groundwater at 13.5 feet during drilling. Test boring located 20 feet west and 18 feet north of property's southeast corner.

Boring No. B-2

Logged by: CRL

Date: 12/12/02

Approximate Elev. 62+/-

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)
(6 inches CONCRETE)					
			⌶	50/4"	8
		5			
Gray silty SAND with gravel, moist. (Glacial till) With zones of silty fine SAND.			⌶	50/6"	10
		10			
	Very Dense		⌶	50/5"	10
		15			
			⌶	50/5"	9
		20			
			⌶	50/5"	13
		25			
		▼	⌶	50/4"	10

Boring terminated at 28.5 feet.
Groundwater seepage encountered at 28 feet.

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

BORING LOG
BALLARD EAGLES SITE
SEATTLE, WASHINGTON

Proj. No. T-5299	Date FEB 2003	Figure A-3

Boring No. B-3

Logged by: CRL

Date: 12/12/02

Approximate Elev. 67+/-

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)
(2 inches ASPHALT CONCRETE)					
			⌶	50/6"	8
		5			
Gray silty SAND with gravel, moist. (Glacial till)			⌶	50/6"	8
		10			
			⌶	50/6"	10
	Very Dense	15 ▼ 1/15/03			
			⌶	50/6"	8
		20			
			⌶	50/5"	7
		25	⌶	50/5"	8
			⌶	50/6"	11
		30			
Becomes wet below 32.5 feet.		▼	⌶	50/5"	9
		35			
			⌶	50/5"	10

Boring terminated at 38.5 feet.
Groundwater seepage encountered at 32.5 feet.
2-inch diameter PVC monitoring well installed with screen set from 27 to 37 feet and sand pack to 12 feet.

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

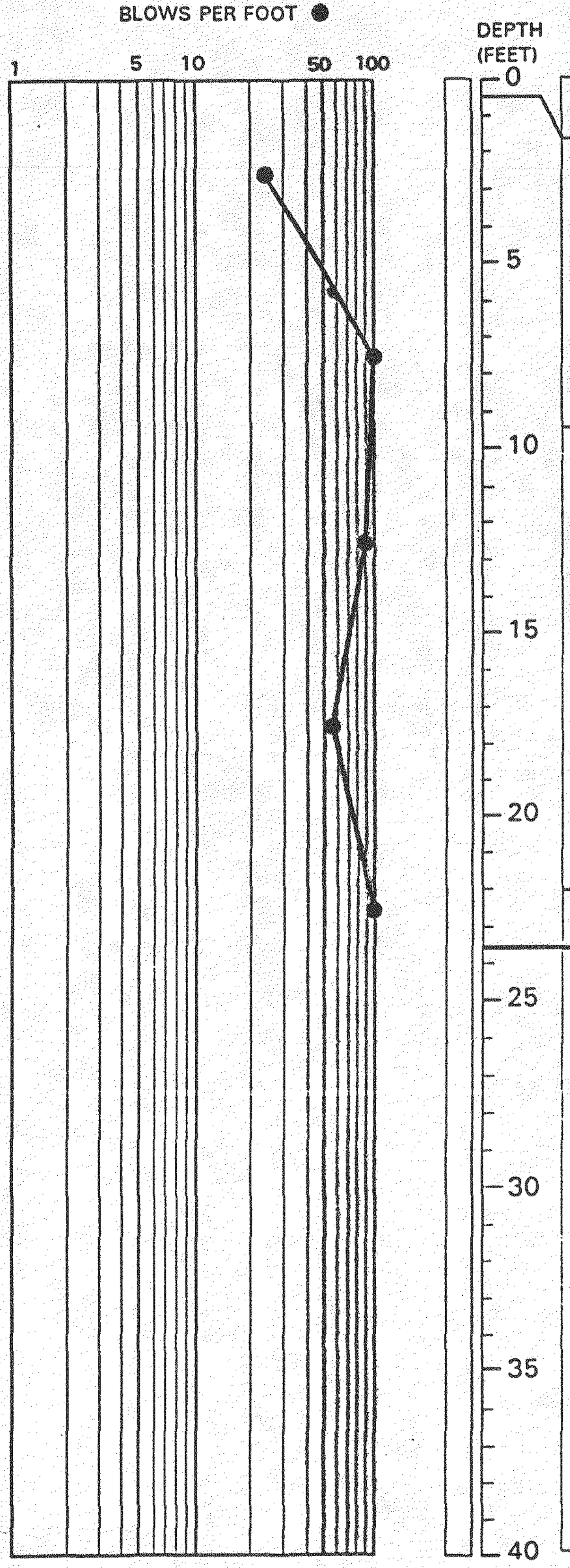
BORING LOG
BALLARD EAGLES SITE
SEATTLE, WASHINGTON

Proj. No. T-5299	Date FEB 2003	Figure A-4

NELSON-COUVRETTE & ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS
AND ENVIRONMENTAL SCIENTISTS

PENETRATION RESISTANCE

GROUND SURFACE ELEVATION:



SOIL DESCRIPTION

SM	BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST) (FILL)
SM	GREY-BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (DENSE TO VERY DENSE,MOIST) (TILL)
SM SP	GREY-BROWN FINE TO MEDIUM SAND WITH SILT (VERY DENSE,MOIST) (ADVANCE OUTWASH)
ML	GREY-BROWN SILT (HARD,MOIST)
	END OF BORING AT 23.5 FEET ON APRIL 13, 1993 GROUND WATER WAS ENCOUNTERED AT 12.5 FEET

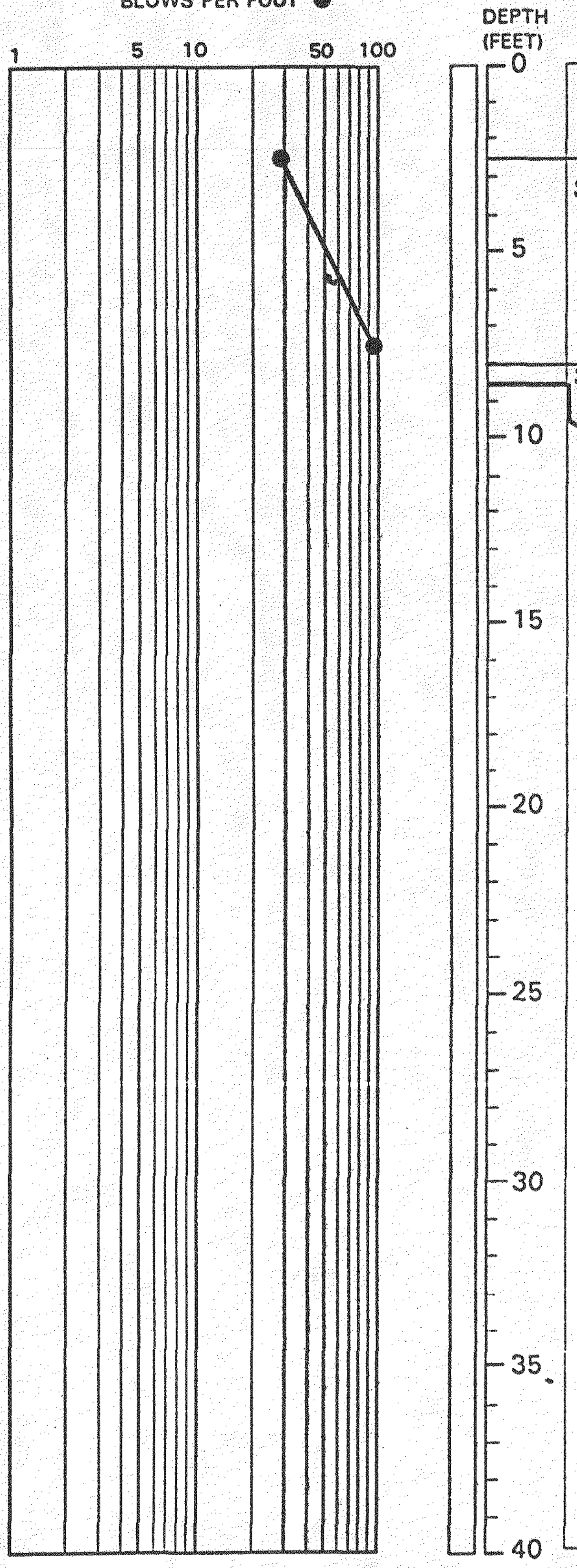
BORING LOG 1

OLYMPIC ASSOCIATES
SHILSOLE AVE.
COMMERCIAL BUILDING
NCA FILE NO. 1051A93
FIGURE 4

PENETRATION RESISTANCE

BLOWS PER FOOT ●

GROUND SURFACE ELEVATION:



SOIL DESCRIPTION

SM	BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST) (FILL)
SM	GREY-BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE,MOIST) (TILL)
SM SP	GREY-BROWN FINE TO MEDIUM SAND WITH SILT (DENSE,MOIST) (ADVANCE OUTWASH)

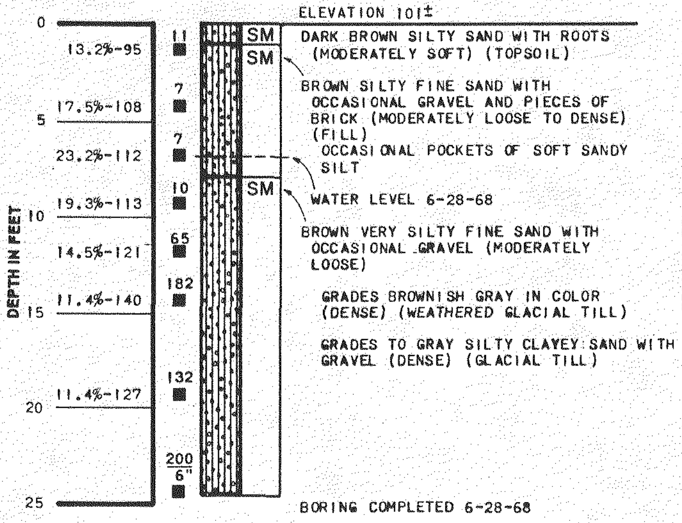
END OF BORING AT 8.5 FEET
GROUND WATER WAS NOT ENCOUNTERED

BORING LOG 2

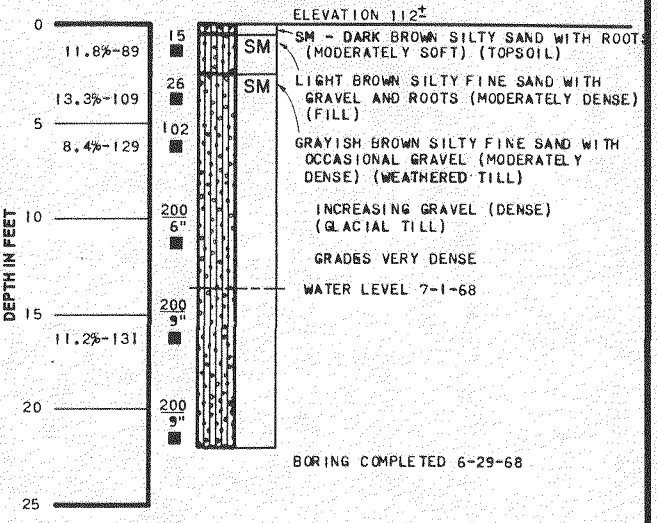
OLYMPIC ASSOCIATES
SHILSOLE AVE.
COMMERCIAL BUILDING
NCA FILE NO. 1051A93
FIGURE 5

MICROFILMED

BORING 1



BORING 2



KEY:

MOISTURE CONTENT
19.4%-126
DRY DENSITY IN PCF

BLOWS REQUIRED TO DRIVE SAMPLER ONE FOOT WEIGHT= 260 LBS., STROKE= 36 INCHES.

8 ■ INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED.

NOTE: BORING ELEVATIONS REFER TO ASSUMED ELEVATION AS SHOWN ON PLOT PLAN.

LOG OF BORINGS

BY ______ DATE ______
BY ______ DATE ______
PLATE ______ OF ______

Seattle - Hous. Auth.
BY Dick Arnold DATE 7-11-68
CHECKED BY ______ DATE ______

DAMES & MOORE

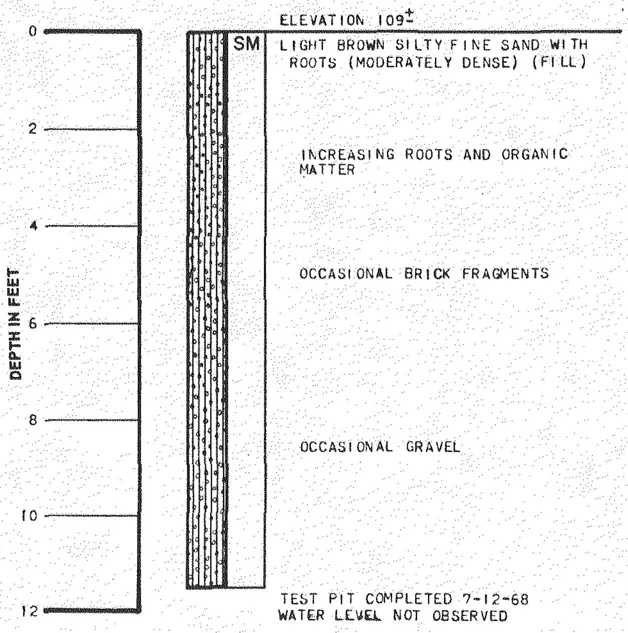
PLATE A-1

BY____DATE____
BY____DATE____
PLATE____OF____

7081-003
BY Dick Arnolo DATE 7-17-68
CHECKED BY____DATE____

MICROFILMED

TEST PIT 1



ELEVATION 109±

LIGHT BROWN SILTY FINE SAND WITH ROOTS (MODERATELY DENSE) (FILL)

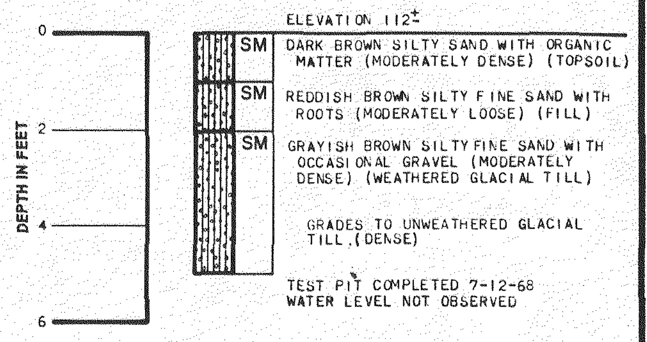
INCREASING ROOTS AND ORGANIC MATTER

OCCASIONAL BRICK FRAGMENTS

OCCASIONAL GRAVEL

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

TEST PIT 2



ELEVATION 112±

DARK BROWN SILTY SAND WITH ORGANIC MATTER (MODERATELY DENSE) (TOPSOIL)

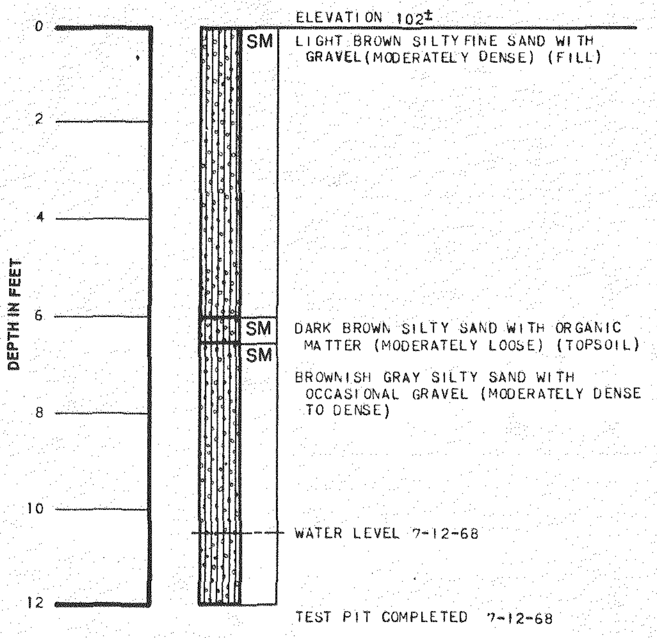
REDDISH BROWN SILTY FINE SAND WITH ROOTS (MODERATELY LOOSE) (FILL)

GRAYISH BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MODERATELY DENSE) (WEATHERED GLACIAL TILL)

GRADES TO UNWEATHERED GLACIAL TILL (DENSE)

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

TEST PIT 3



ELEVATION 102±

LIGHT BROWN SILTY FINE SAND WITH GRAVEL (MODERATELY DENSE) (FILL)

DARK BROWN SILTY SAND WITH ORGANIC MATTER (MODERATELY LOOSE) (TOPSOIL)

BROWNISH GRAY SILTY SAND WITH OCCASIONAL GRAVEL (MODERATELY DENSE TO DENSE)

WATER LEVEL 7-12-68

TEST PIT COMPLETED 7-12-68

NOTE: PLEASE NOTE THAT LOG OF TEST PITS ON PLATES A-2 AND A-3 ARE PRESENTED TO DIFFERENT VERTICAL SCALE THAN BORING LOTS ON PLATE A-1.
TEST PIT ELEVATIONS REFER TO ASSUMED ELEVATION AS SHOWN ON PLOT PLAN.

LOG OF TEST PITS

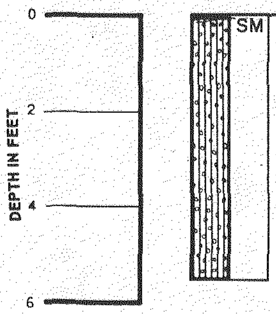
DAMES & MOORE

PLATE A-2

MICROFILMED

TEST PIT 4

ELEVATION 103±



2" OF ASPHALTIC PAVEMENT (DRIVEWAY)

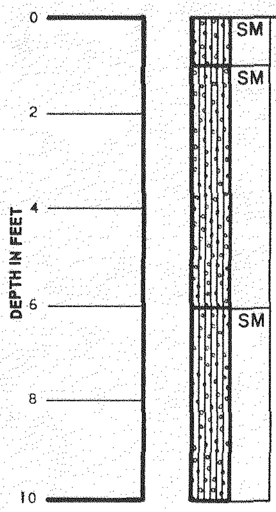
GRAYISH BROWN SILTY SAND WITH SOME GRAVEL (MODERATELY DENSE) (WEATHERED TILL)

GRADES TO UNWEATHERED TILL, (DENSE)

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

TEST PIT 5

ELEVATION 103±



GRAY SILTY FINE SAND WITH CONSIDERABLE ROOTS (MODERATELY LOOSE) (TOPSOIL)

BROWN SILTY SAND WITH OCCASIONAL GRAVEL AND ROOTS (MODERATELY DENSE) (FILL)

PIECE OF WOOD

BROWNISH GRAY SILTY SAND WITH OCCASIONAL GRAVEL (MODERATELY DENSE) (WEATHERED TILL)

GRADES TO UNWEATHERED GLACIAL TILL (DENSE)

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

BY ______ DATE ______
BY ______ DATE ______
PLATE ______ OF ______

[illegible]-002
BY Dick Arnold DATE 7-17-68
CHECKED BY ______ DATE ______

LOG OF TEST PITS

DAMES & MOORE

PLATE A-3

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 3
PROJECT Ballard #1 Cont. #1 WEATHER
LOCATION 28th Ave NW & R.R. 50' N & 9' E of Bldg

WATER TABLE
Not taken

GRD.EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				
						BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A	1	1		14	Ash	Organic	Loose	Moist	Blk
5										
		18"								
	B	2			1	Ash	Organic	Loose	Wet	Blk
10										
	C	4	3	4	7	Sand	Trace Gravel	Loose	Wet	Gray
15										
	D	6	15	18	33	No	Recovery	Firm		
20										
							Gov. Froze			
							Cutter Head installed			
							& drilled down			
		4	7	15	22	Sand	Silt Layers	Firm	Sat	Brn
25										

INSPECTOR:

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 4
PROJECT Ballard #1. Cont. #1 WEATHER
LOCATION NW Market & 28th NW 40' E. of ℄ 8' S. of c/l

WATER TABLE
11'1"
3-5-69
WGR

GRD.EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				
						BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A	1	2	2	4	Sand	Silt	Loose	Moist	Brn
5										
	B	2	2	2	4	Sand	Silt Organic	Loose	Moist	Blk Gray
10	B1					8" Sand			Moist	Brn
	C	2	3	6	9	Sand	Silt Layers	Loose	Sat	Brn
15										
	D	10	14	13	27	Silt	Sand: Gravel	Firm	Wet	Gray
20										
	E	22	56	44	100	Silt	Sand Clay	Very Comp	Moist	Gray
25										

INSPECTOR:

05886

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY
LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 7

PROJECT BALLARD #1 CONT. #1 WEATHER

LOCATION NW MARKET & 26TH NW 35' E of cb & 8' N. of cb

WATER TABLE: 5'4" 3-5-69

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A	1	1	2	3	SAND	CLAY	LOOSE	WET	GRAY
5										
			18"							
	B		1			SAND	CLAY	LOOSE	WET	GREEN GRAY
10										
			18"							
	C	← WEIGHT OF HAMMER								
						SAND	SILT	LOOSE	SAT	BRN. GRAY
15										
		← HARDER DRILLING								
	D	30	44	79	123	SAND	SILT GRAVEL	VERY COMP	MOIST	GRAY
20										

INSPECTOR:

LAWN

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY
LOG OF TEST BORING

DATE 2-28-69 HOLE NO. 8

PROJECT BALLARD UNIT 1 CONT. #1 WEATHER

LOCATION 26TH NW. & NW 58TH 40' S. & 15' W of ℄

WATER TABLE: 7'8" 3-5-69

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
							FRACTURE			
	A	38	22	26	48	SAND	SILT - GRAVEL	COMP	MOIST	BRN
5										
			3"							
	B	42	100		200+	SAND	SILT	VERY COMP	MOIST	BRN
10										
		5"								
	C	100			200+	SAND	SILT	VERY COMP	MOIST	BRN.
15										
			5"							
	D	38	100		200+	SAND	SILT-GRAVEL	VERY COMP	MOIST	GRAY
20										

INSPECTOR:

CB 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 6-1-70 HOLE NO. 9
PROJECT BALLARD #1 AREA #4 GRD. ELEV.
LOCATION NW MARKET ST. & 24TH AVE. NW 135± W. & 25±S. OF ℄

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				WATER LEVEL
							COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
LOOSE SILTY SAND	5	A	1	2	3	5	SILTY SAND.	LOOSE	MOIST	BRN	
COMP.-V. COMP. SILTY SAND w/ SILT LAYERS & GRAVEL	10	B	5	8	23	31	SILTY SAND	COMP	MOIST	BRN	
					4"						
	15	C	3	14	50	50+	SILTY SAND w/	V. COMP	MOIST	BRN	6-2-70
							GRAVEL & SILT LAYER				
							GOING WET				
	20	D	10	24	30	54	SILTY SAND w/	V. COMP	WET	BRN	BOTTOM
							TRACE GRAVEL				

INSPECTOR HWR

CB 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 6-3-70 HOLE NO. 10
PROJECT BALLARD #1 AREA #4 GRD. ELEV.
LOCATION NW 57 & 17TH AVE. NW. 30± W. & 18± N. OF ℄

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				WATER LEVEL
							COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
FIRM-FINE SAND w/ TRACE GRAVEL		A	3	6	13	19	SAND (FINE) w/	FIRM	MOIST	BRN	
							TRACE GRAVEL				
V. COMP. SILTY FINE SAND w/ SAND LAYERS & TRACE GRAVEL	5						HARDER DRILLING				6-5-70
			4½"								OPEN HOLE
		B	50			50+	SILTY SAND (FINE)				
	10						w/ TRACE GRAVEL	V. COMP	MOIST	BRN	
			5½"								
		C	50			50+	SILT w/	V. COMP	MOIST	GRAY	
13.	15						SAND LAYERS		WET		

INSPECTOR

05914

7111

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1-11-72

HOLE NO. 11

PROJECT NW. 54TH SAN. SEWER

GRD. ELEV.

LOCATION 24TH AVE. NW. & NW. 54TH S.E. CORNER

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				WATER LEVEL
							COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
FIRM-V. COMP. SILTY FINE SAND W/TRACE GRAVEL & SILT LAYER							BLK SILTY ORGANIC				
											1-17-72
											▽ 1-13-72
	5	A	3	10	11	21	SILTY FINE SAND	FIRM	WET? MOIST	BRN	
							W/ SILT LAYERS				
											1-11-72
											▽
	10	B	7	10	13	23	SILTY FINE SAND	FIRM	WET MOIST	BRN	2
							W/ GRAVEL				
							& SILT LAYERS				
	15	C	13	29	27	56	SILTY FINE SAND	V.COMP	MOIST	BRN	
							W/TRACE GRAVEL				
											SAND
	20	D	9	20	32	56	SILTY FINE SAND	V.COMP	WET	BRN GREY	
							W/ GRAVEL				
											PIEZOMETER INSTALLED 1-11-72

INSPECTOR H W KOCITA

LOG OF BORING [redacted]

Sheet 1 of 1

Date drilled 4/1/93 Sampler and Driving Weight R,300lb. Elevation (ft) 25

Depth, ft	Elevation	Samples	Blows/6"	Graphic Symbol	This log is part of the report prepared by Converse Consultants NW for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered. DESCRIPTION	Observation Well	Dry density pcf	Moisture Content, %	Other tests
	25				FILL				
		1	1 1 3		SILTY SAND WITH GRAVEL; brown, fine to coarse, fine gravel, wood debris, silt chunks, very loose, moist to very moist			15	
		2	1 1 1		SILTY SAND WITH GRAVEL; brown to dark brown, fine to medium, trace coarse sand, silt chunks, root structures; very loose, moist to very moist				
5	20	3	3 1 3		SILTY SAND; dark brown to black, fine to medium, trace fine gravel, silt chunks, some iron oxidation staining, wood debris; loose, very moist to wet				
		4	4 8 10		WEATHERED GLACIAL TILL SILTY SAND WITH GRAVEL; brown, fine to coarse sand; loose to medium dense, very moist to wet				
10	15	5	17 51/5"		UNWEATHERED GLACIAL TILL SILTY SAND; gray to brown, fine sand, few medium to coarse sand; very dense, wet			14	
					Bottom of boring at depth 13.5 feet. Boring backfilled with bentonite chips and cuttings. Groundwater encountered at depth 10.23 feet.				
15	10								
	5								

OFF THE WALL MARKET STREET SITES

Seattle, Washington

OFF THE WALL

Project No.

93-35508-02

Converse Consultants NW

Geotechnical Engineering
and Applied Earth Sciences

Figure No.

A-4

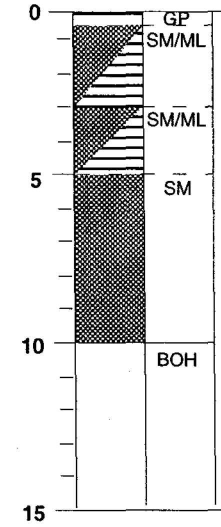
Logged by: MT
Date: 5/8/02

Test Pit No. 1

Elevation: 100.0 feet± *

Depth

Symbols **Soil Description** **W (%)**



Parking lot - asphalt surfacing.
Brown red-brown, black silty fine to coarse SAND, sandy SILT, moist, medium dense, few rounded gravel, bits of plastic, concrete [Fill].

Red-brown silty fine to coarse SAND to sandy SILT, moist, medium dense, partially cemented.

- Sandier with depth.

Gray silty fine to coarse SAND, moist, dense, few rounded gravel, partially cemented.

- Increasing cementation with depth.

Test Pit terminated at 10.0 feet below existing grade.
No groundwater seepage encountered during excavation.

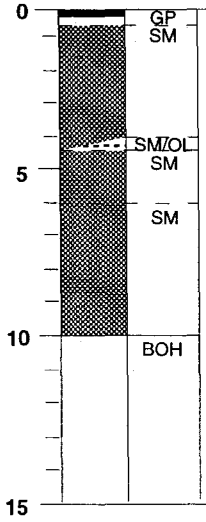
* Test Pit elevations approximately determined by eye with respect to a temporary benchmark, the ground surface at the NE corner of the site, at an assumed elevation of 100 feet.

Logged by: MT
Date: 5/9/02

Test Pit No. 2

Elevation: 95.0 feet±

Soil Description



Parking lot - asphalt surfcing.
Reddish-gray-brown silty fine to coarse SAND, moist, medium dense, few rounded gravel [Fill].

Black carbon (charcoal) layer ~4" thick.

Reddish-brown silty fine to coarse SAND, moist, loose to medium , little rounded gravel (Weathered inplace).

Gray sitly fine to coarse SAND, moist, medium dense, reddish oxidation zones, slightly cemented.

- Few round gravel.
- Becomes saturated at 8-feet.
- Increasing cementation below 8-feet.

Test Pit terminated at 10.0 feet below existing grade.
No groundwater seepage encountered during excavation.

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis, and judgement. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

02-2420 / 5.15.2002

CEO **Creative Engineering Options** INC.
A Firm Practicing in the Geosciences

TEST PIT LOG

Plate
9

Logged by: MT
Date: 5/8/02

Test Pit No. 3

Elevation: 93.5 feet±

Depth	Symbols	Soil Description	W (%)
0	GP	Parking lot - asphalt surfacing.	
	SM	Brown-gray silty fine to coarse SAND, moist, medium dense, few rounded gravel [Fill].	
5	SM	Black & brown silty fine to coarse SAND, moist, loose to medium dense, little wood debris (stake), very slight organic - 1/2" dia. root [Fill].	
	SM	Reddish-gray silty fine to coarse SAND, moist, medium dense, few round gravel oxidized.	
	SM	Gray silty fine to coarse SAND, moist, medium dense to dense, partially, cemented - increases with depth.	
10	BOH	Test Pit terminated at 10.0 feet below existing grade. No groundwater seepage encountered during excavation.	
15			

Creative Engineering Options INC.
CEO
A Firm Practicing in the Geosciences

TEST PIT LOG

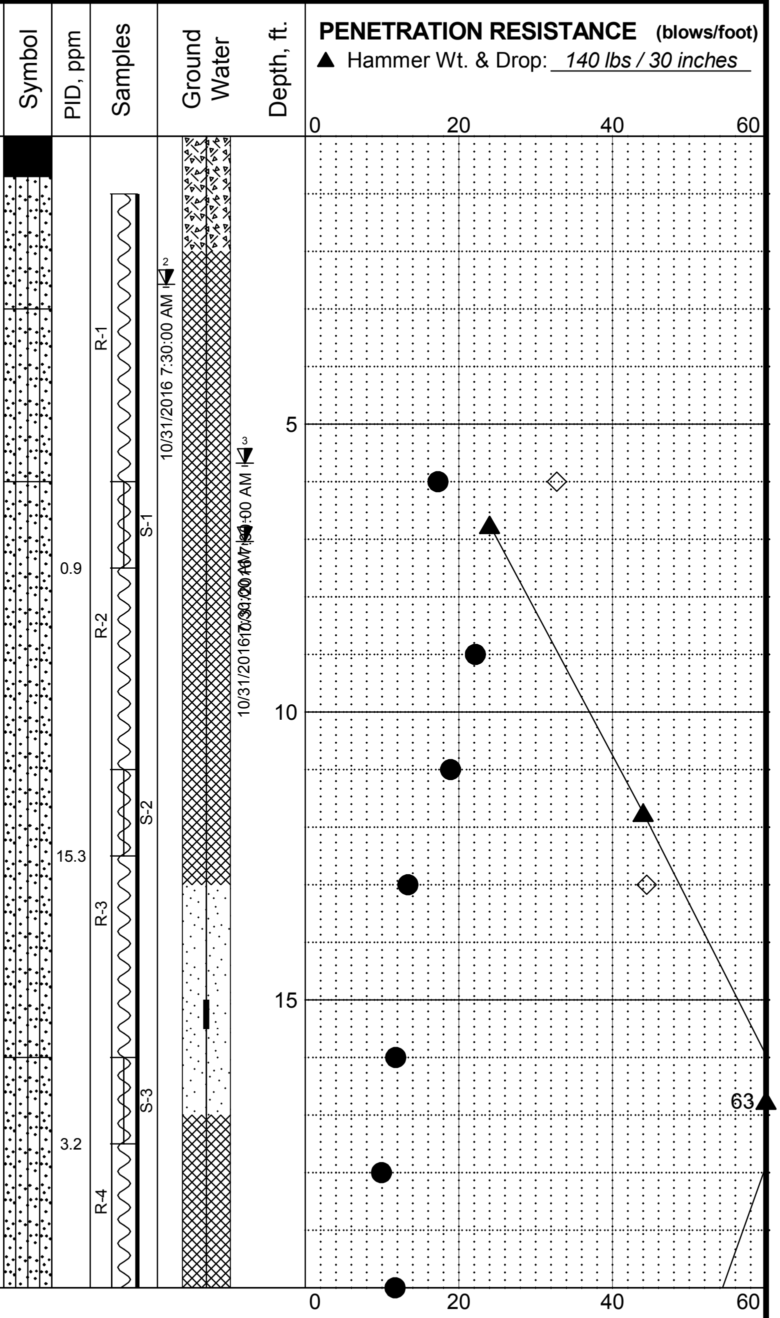
Plate
10

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	-	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	-	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Asphalt.	0.7
Brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace to few organics. (Hf)	3.0
Gray-brown, *Silty Sand (SM)*; moist; less than 5% fine, subrounded gravel; fine to medium sand; nonplastic fines; few pockets with iron-oxide staining. (Qvro)	6.0
Medium dense, gray-brown, *Silty Sand (SM)*; wet; less than 5% fine, subrounded to angular gravel; fine to medium sand; nonplastic fines; trace iron-oxide staining. (Qvro) - Few seams with iron-oxide staining below 8 feet.	16.0
Very dense, gray-brown, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; few wet, silty sand seams; trace pockets with iron-oxide staining. (Qvd)	



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
▨	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 1 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*
Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: -
Offset: -
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*
Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

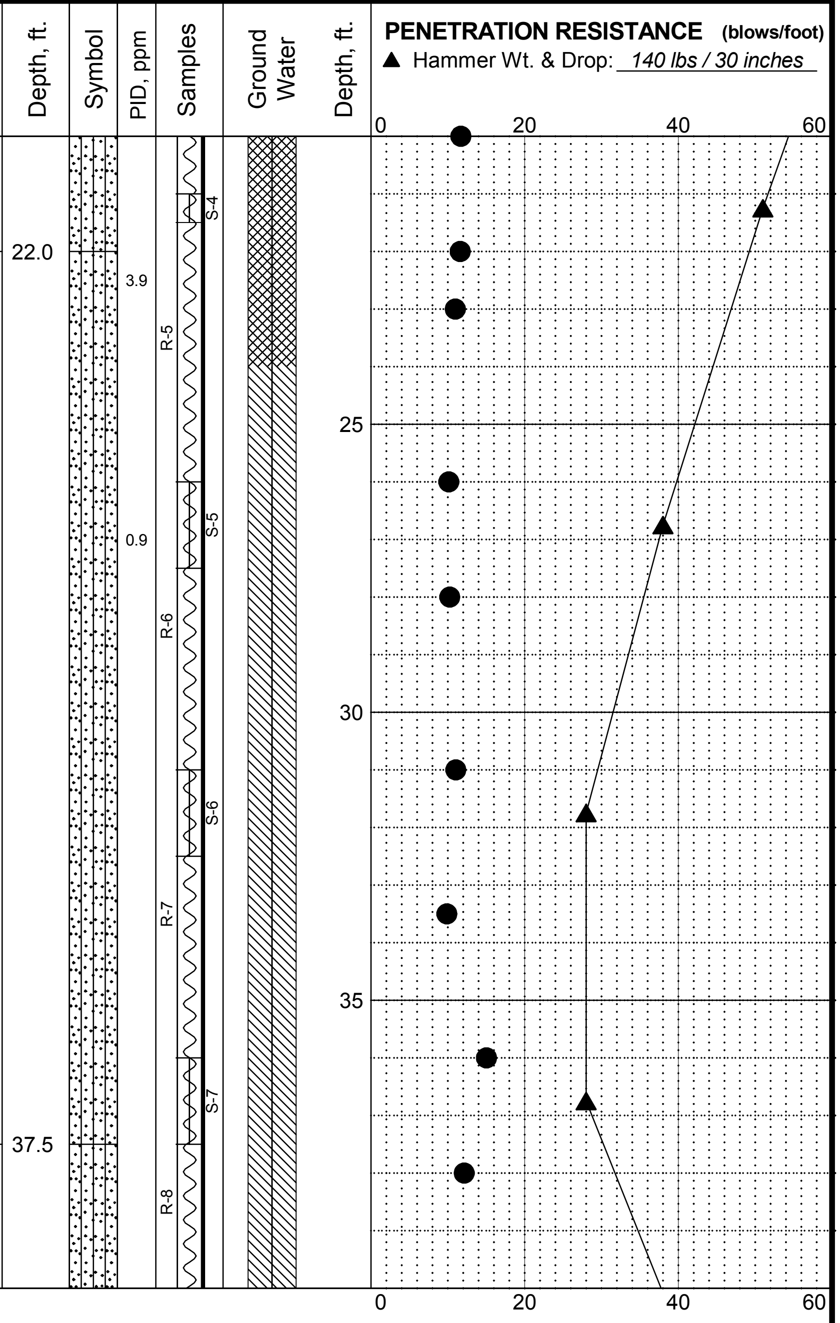
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

22.0

Medium dense to very dense, gray, *Silty Sand (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; few silt seams.
(Qvd)
- Moist to wet below 24 feet.
- Layer of silty gravel with sand from 30 to 30.5 feet.
- Layer of wet, silty sand from 31.5 to 32.3 feet.
- Layer of silty sand with gravel from 34.3 to 35 feet.

37.5

Medium dense to dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 2 of 11

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.7 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project
Northing: 575,438 ft.
Easting: 1,585,696 ft.
Station: -
Offset: -
Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller switched to lexan liners at 61 feet.
Hole Diam.: 6 in.
Rod Diam.: 2.625"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

diamict pockets.
(Qva)

43.0

Dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

45.0

46.0

Dense, gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

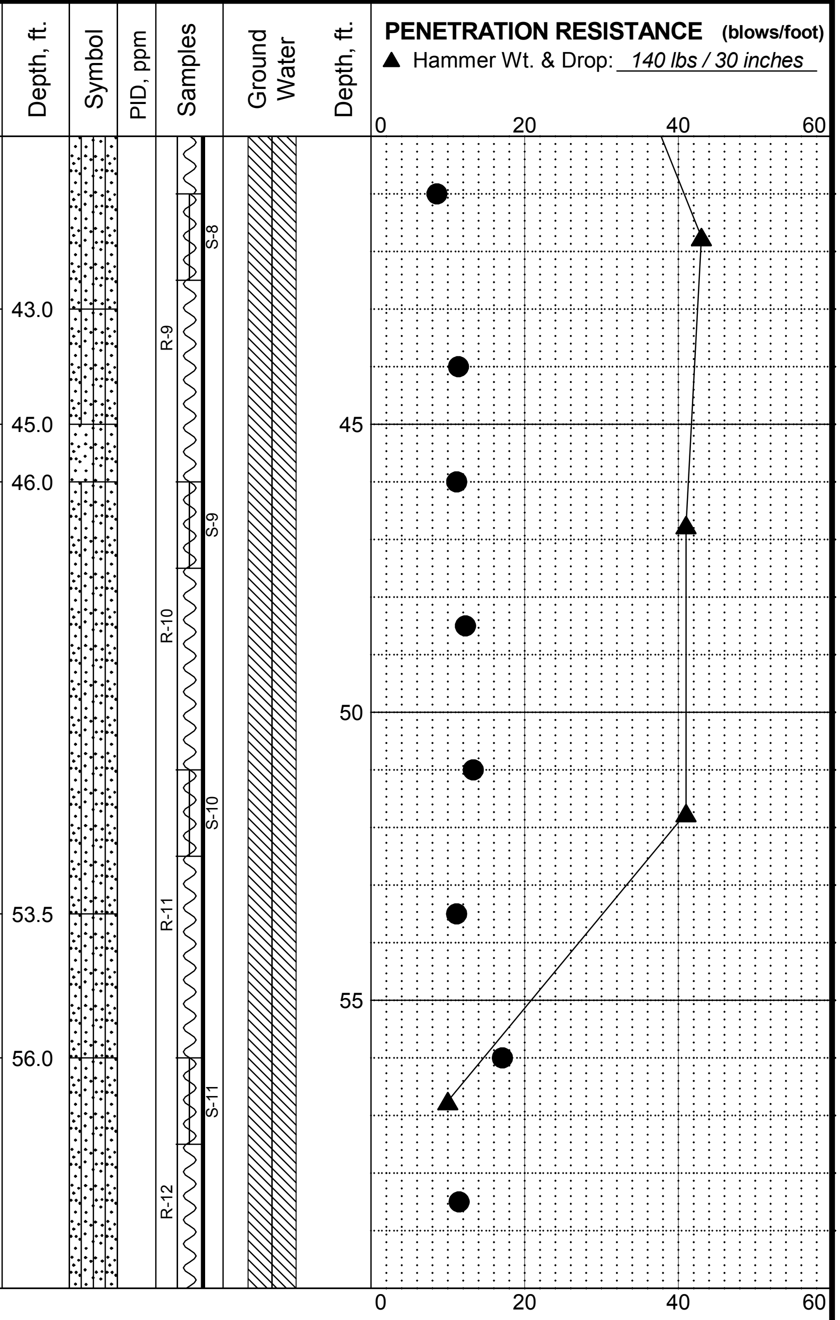
Dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few diamict pockets.
(Qvd)
- 5 feet of heave at 51 feet.

53.5

Dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)

56.0

Medium dense, gray, *Silty Sand (SM)*; moist to wet; less than 10% fine to coarse, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qva)
- Blow counts at 56 feet may be artificially low due to slough in boring.



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
▨	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016
21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 3 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: *-*
Offset: *-*

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines.
(Qva)

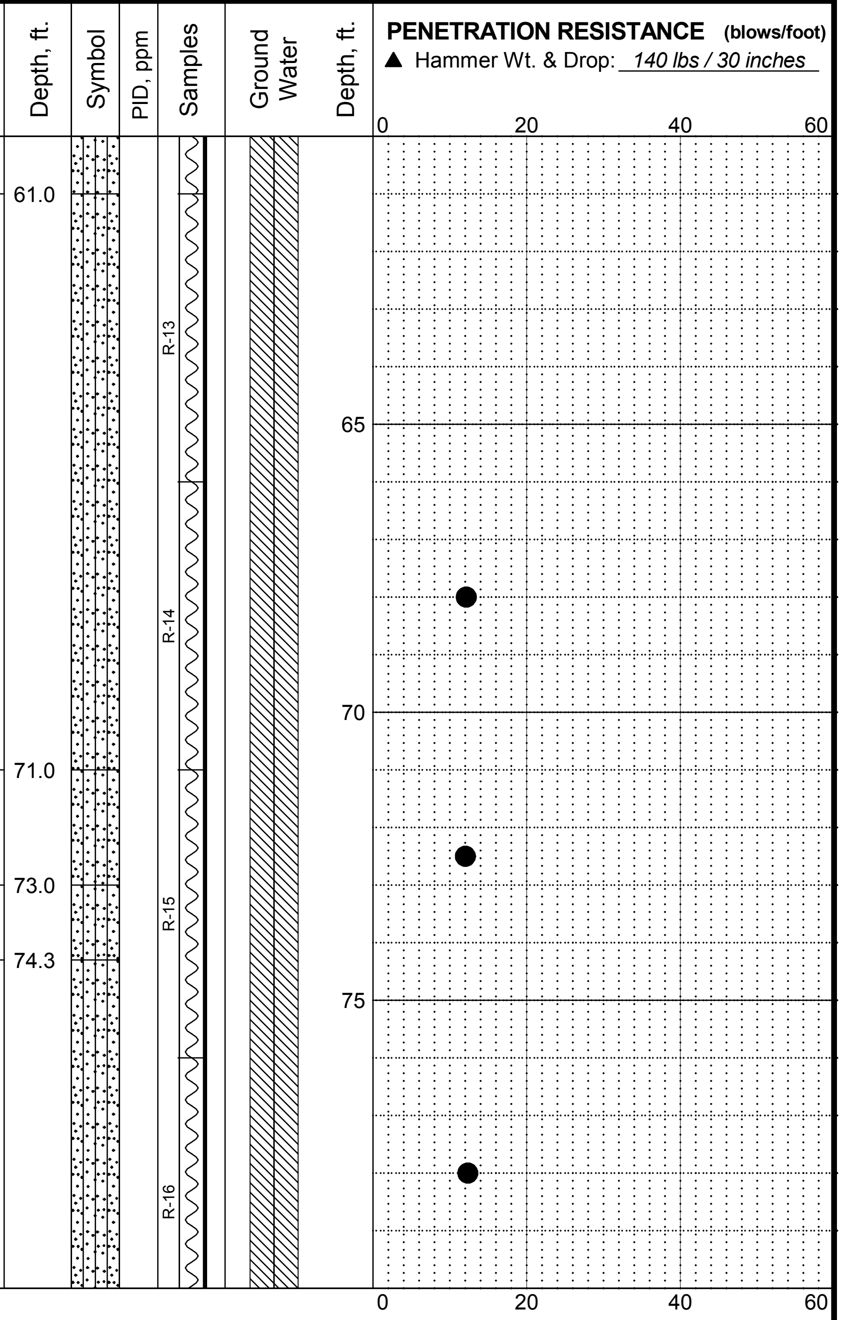
- Layer of silt at 64.3 feet.

- Layer of wet, sandy silt from 66.5 to 67 feet.

Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)

Gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; low plasticity fines; diamict.
(Qvd)



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

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SHANNON & WILSON, INC.
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FIG. A-17
Sheet 4 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: *-*
Offset: *-*

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

86.0 — Gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qva)

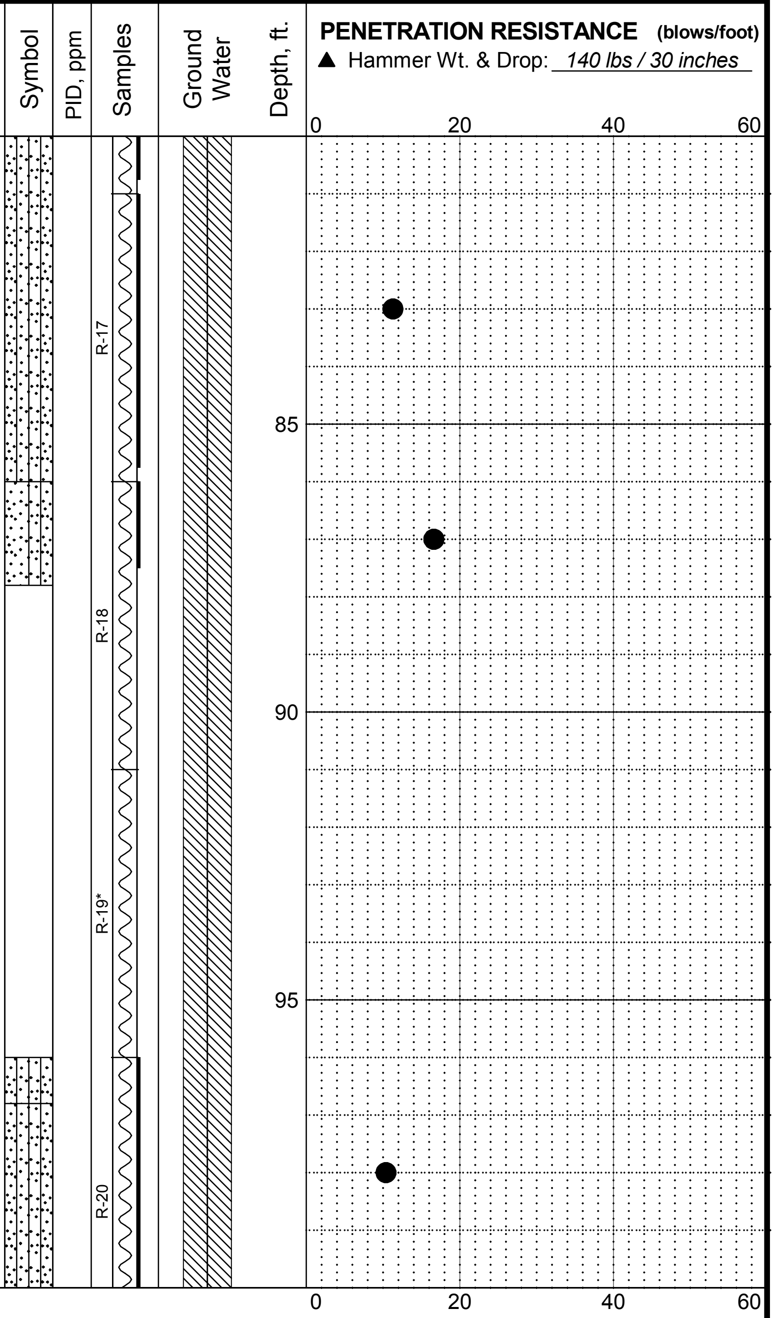
87.8 — No recovery from 87.8 to 96 feet.

- Driller switched to bag samples from 96 to 111 feet.

96.0 — Gray to green-gray, *Silty Sand (SM)*; wet; less than 15% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; iron-oxide staining. (Qva)

96.8 — Gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine

CONTINUED NEXT SHEET



LEGEND

I Sample Recovery
* Sample Not Recovered
⊠ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
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FIG. A-17
Sheet 5 of 11

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.7 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,438 ft.
Easting: 1,585,696 ft.
Station: -
Offset: -

Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller switched to lexan liners at 61 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

to medium sand; nonplastic to low plasticity fines.
(Qva)

- Layer of wet, poorly graded, fine to medium sand from 99.8 to 101.4 feet.

102.0

Gray, *Sandy Silt (ML)* to *Silt with Sand (ML)*; moist; less than 5% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qpgl)

107.0

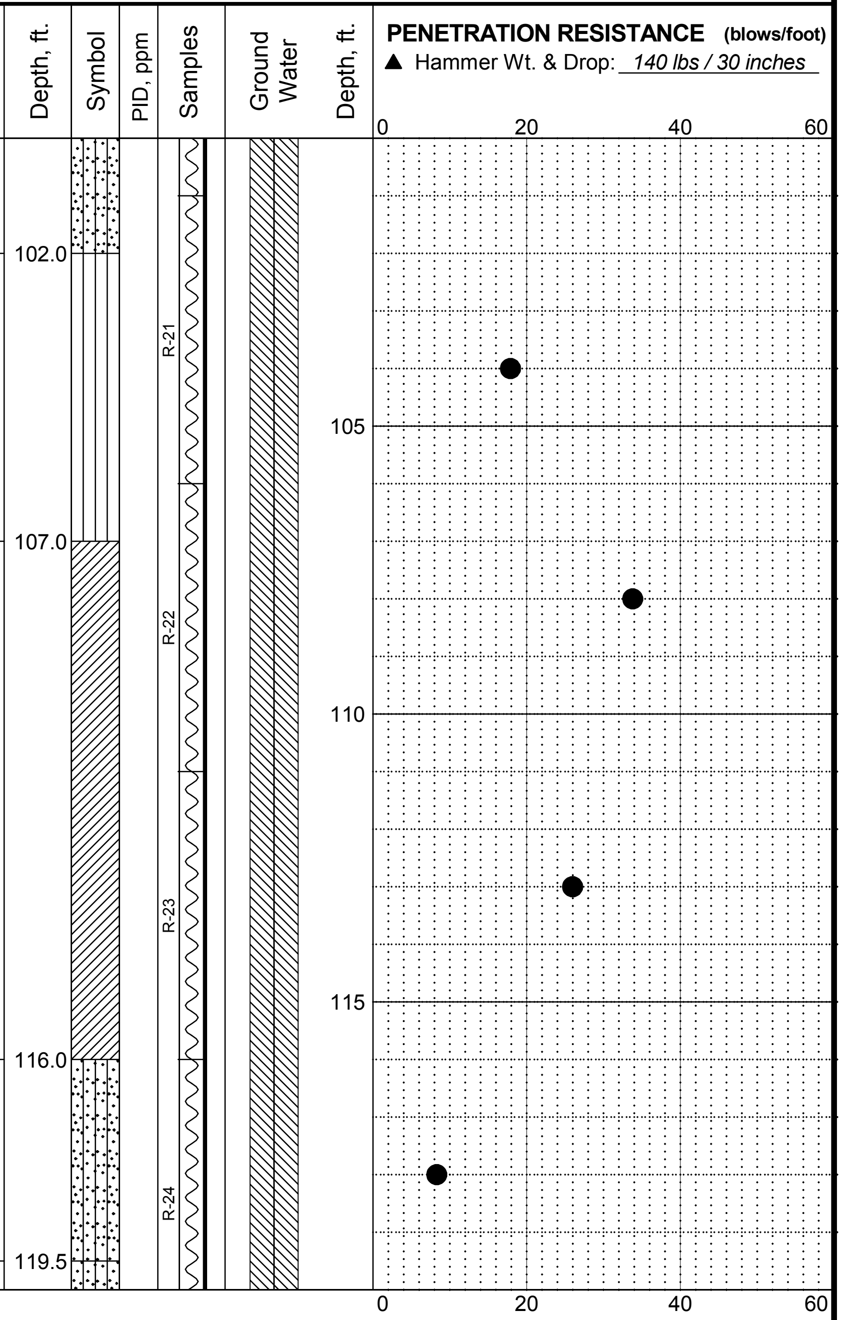
Gray, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 5% fine, subrounded to subangular gravel; less than 10% fine to coarse sand; low to medium plasticity fines; few silty sand seams and pockets, trace fine clay seams with slickensides.
(Qpgl)

- Slightly diced to blocky texture below 111 feet.

116.0

Gray, *Silty Sand (SM)*; moist; less than 5% fine, subrounded to subangular gravel; fine sand; nonplastic fines.
(Qpgo)

119.5



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ▨ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
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FIG. A-17
Sheet 6 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

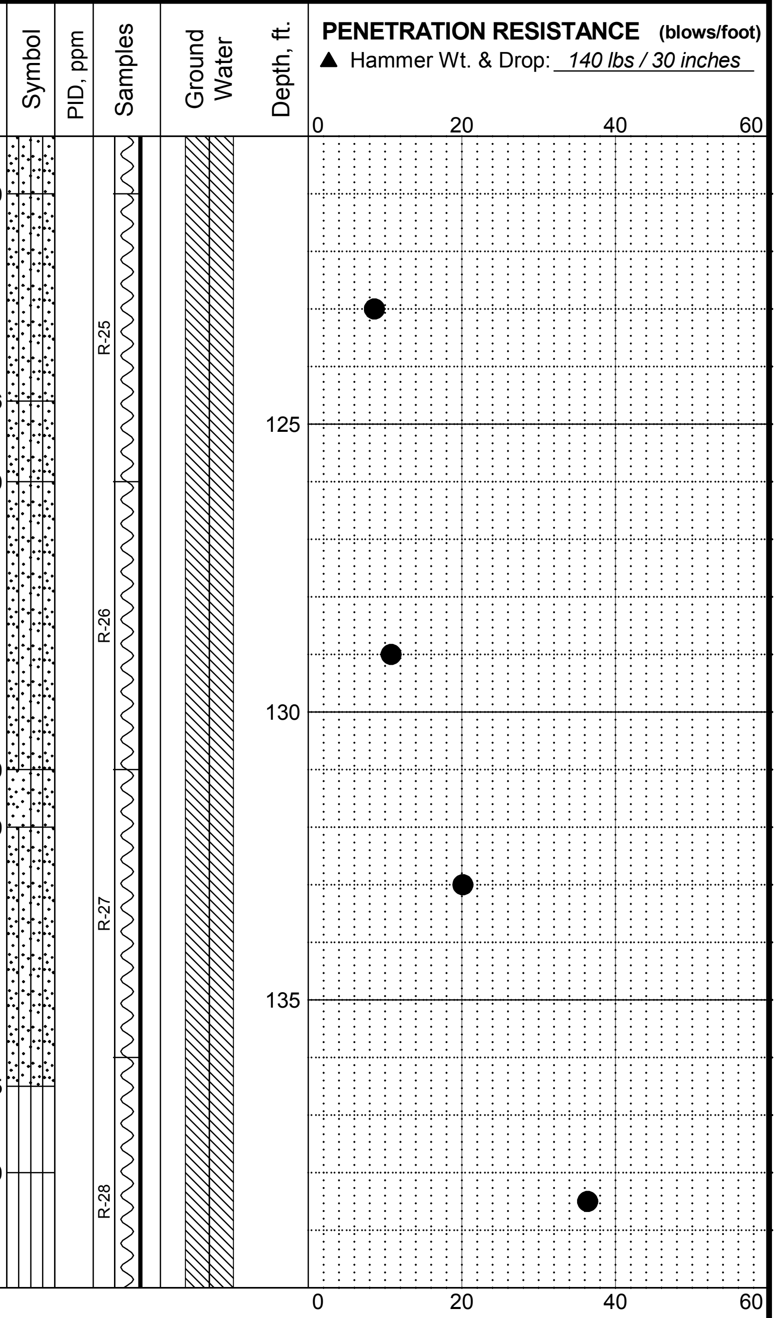
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Gray, *Silty Sand (SM)*; moist; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines; diamict. (Qpgt)	121.0
Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qpgt)	124.6
Gray, *Silty Sand (SM)*; moist; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qpgd)	126.0
Gray, *Silty Sand with Gravel (SM)*; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qpgt)	131.0
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 5% fine, subrounded gravel; fine to medium sand; nonplastic fines. (Qpnf)	132.0
Gray to gray-brown, *Silty Sand (SM);* wet; fine to medium sand; nonplastic fines; few organics. (Qpnf)	136.5
Gray-brown *Silt with Sand (ML)*; moist; fine sand; low plasticity fines; trace to few organics. (Qpnl)	138.0
Gray-brown *Silt (ML)* to *Lean Clay (CL)*; moist; less than 10% fine sand; low to	



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ▨ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 7 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.7 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,438 ft.
Easting: 1,585,696 ft.
Station: -
Offset: -

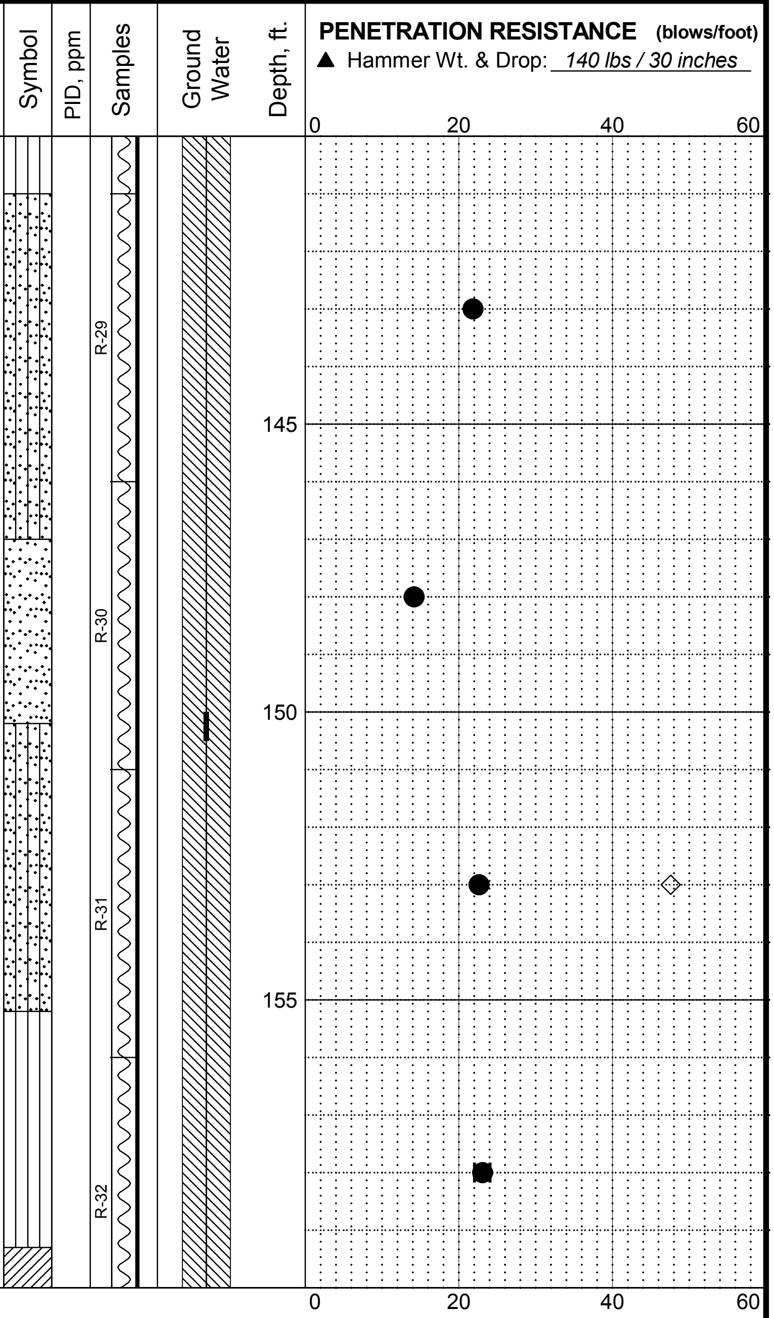
Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller switched to lexan liners at 61 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
medium plasticity fines; trace to few organics. (Qpnl)	141.0
Gray to gray-brown, *Silty Sand (SM)*; moist to wet; fine to medium sand; nonplastic fines; trace to few organics; trace shell fragments. (Qpnf) - Layer of wet, poorly graded sand with silt from 146.5 to 147 feet.	147.0
Gray, *Poorly Graded Sand (SP)*; wet; fine to medium sand; less than 5% nonplastic fines. (Qpnf)	150.2
Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace to few organics; few sandy silt seams. (Qpnf) - Seam with little organics at 150.5 feet. - Wood fragments at 151.7 feet.	155.2
Gray-brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist to wet; fine sand; nonplastic fines; trace to few organics; slightly blocky texture. (Qpnl)	159.3



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
☒ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 8 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Gray-brown, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 10% fine sand; low to medium plastlcity fines; trace organics; slight blocky texture.
(Qpnl)

161.0

Gray, *Lean Clay (CL)* to *Fat Clay (CH)*; moist; less than 5% fine sand; medium to high plasticity fines; trace organics; trace shell fragments; blocky texture; trace slickensides.
(Qpnl)
- Diced texture from 163.2 to 163.5 feet.

164.6

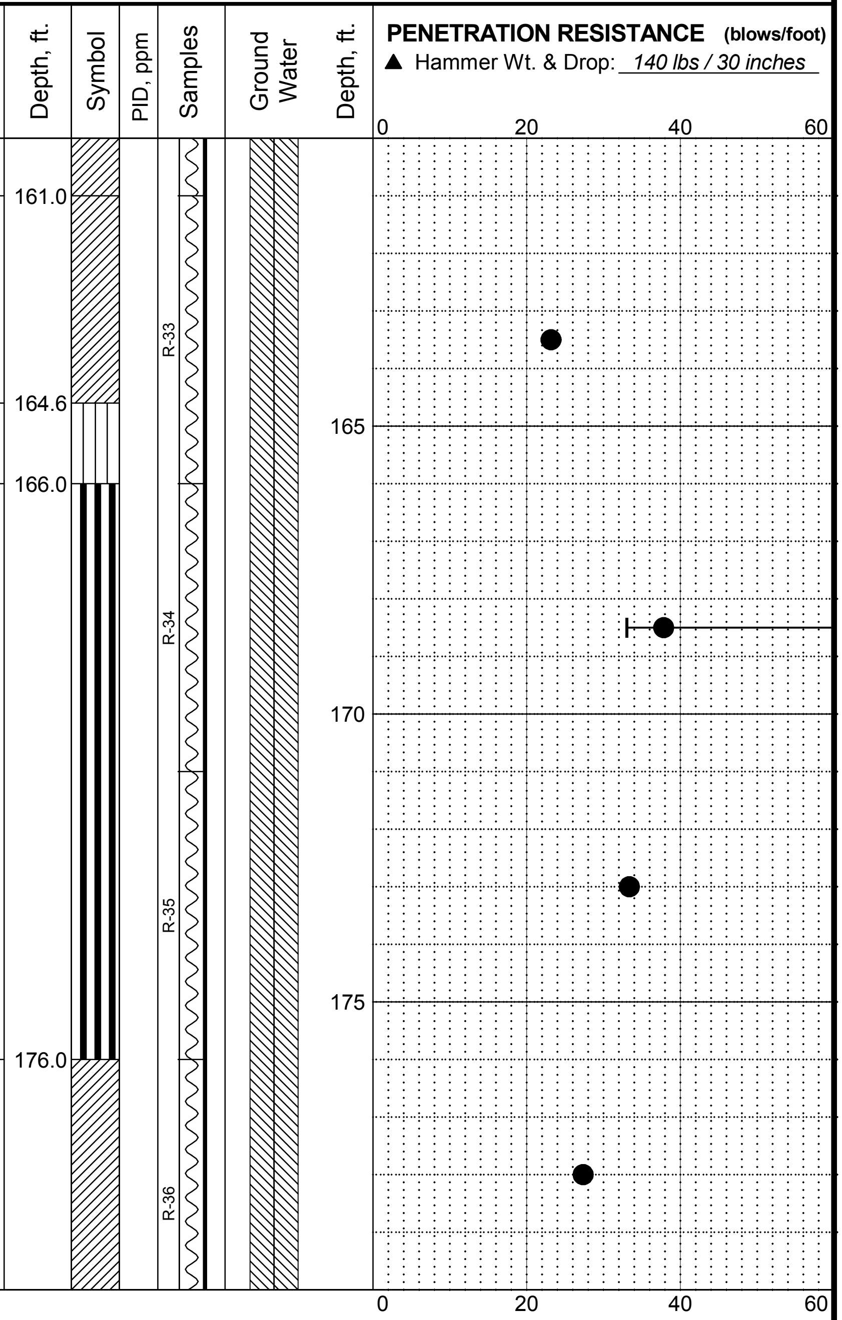
Gray-brown *Silt with Sand (ML)* to *Lean Clay with Sand (CL)*; moist; fine sand; low to medium plasticity fines; trace organics.
(Qpnl)

166.0

Gray to gray-brown, *Elastic Silt (MH)* to *Silt (ML)*; moist; less than 10% fine sand; low to medium plasticity fines; blocky texture; trace organics.
(Qpnl)
- Trace silty sand seams from 167.5 to 168 feet.

176.0

Gray, *Lean Clay (CL)* ; moist; less than 5% fine, subrounded to subangular gravel; less than 5% fine to coarse sand; medium plasticity fines; trace to few shell fragments; blocky to diced texture.
(Qpnl)



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
⍁	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 9 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

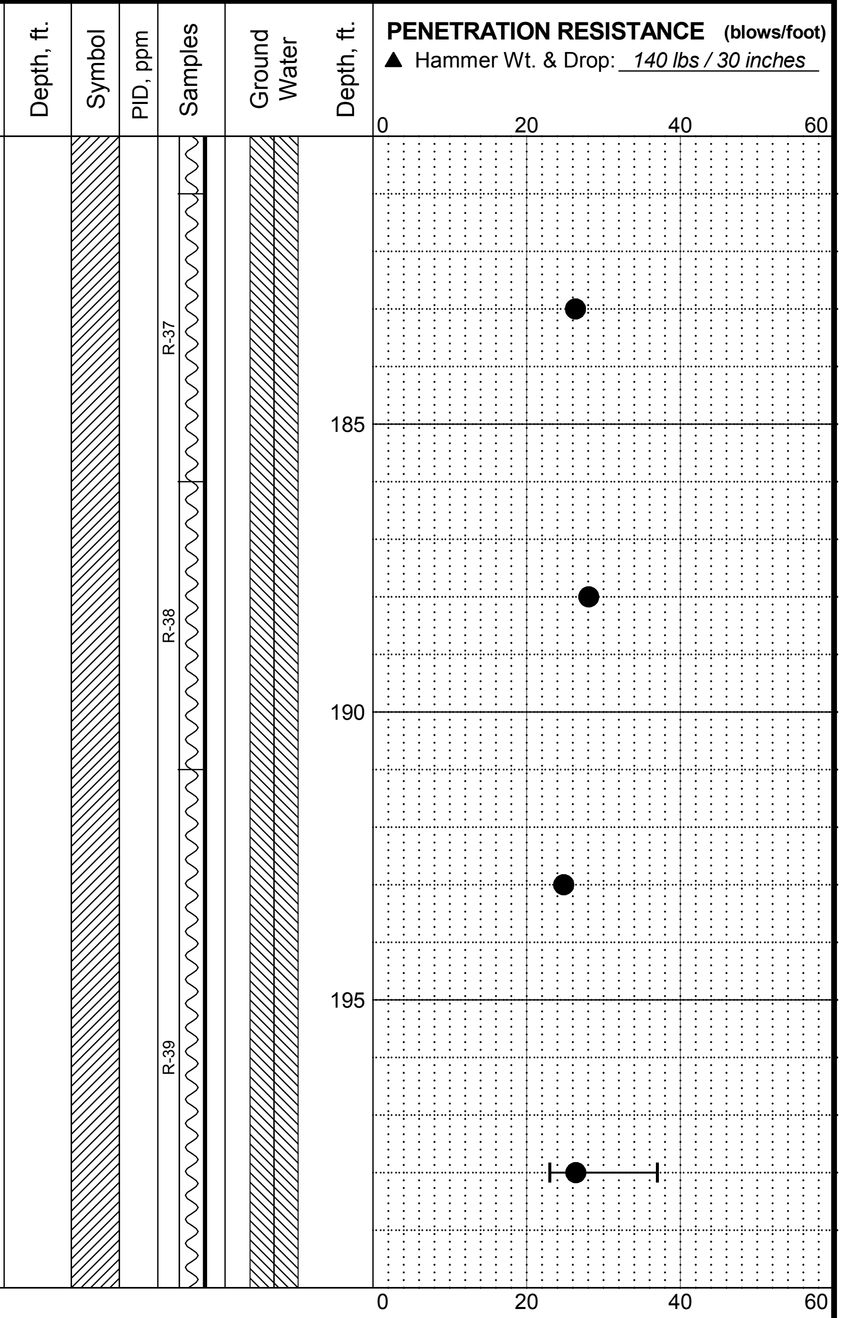
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	-	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	-	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

- Layer of wet, silty, fine to medium sand from 196.6 to 196.9 feet.
- Layer of moist, sandy, lean clay from 196.9 to 197.6 feet.
- 4-inch cobble at 197.6 feet.



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ☒ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 10 of 11

REV 3 - Approved for Submittal

B-18 (10/11)

Log: EAS Rev: EAS Typ: LKN

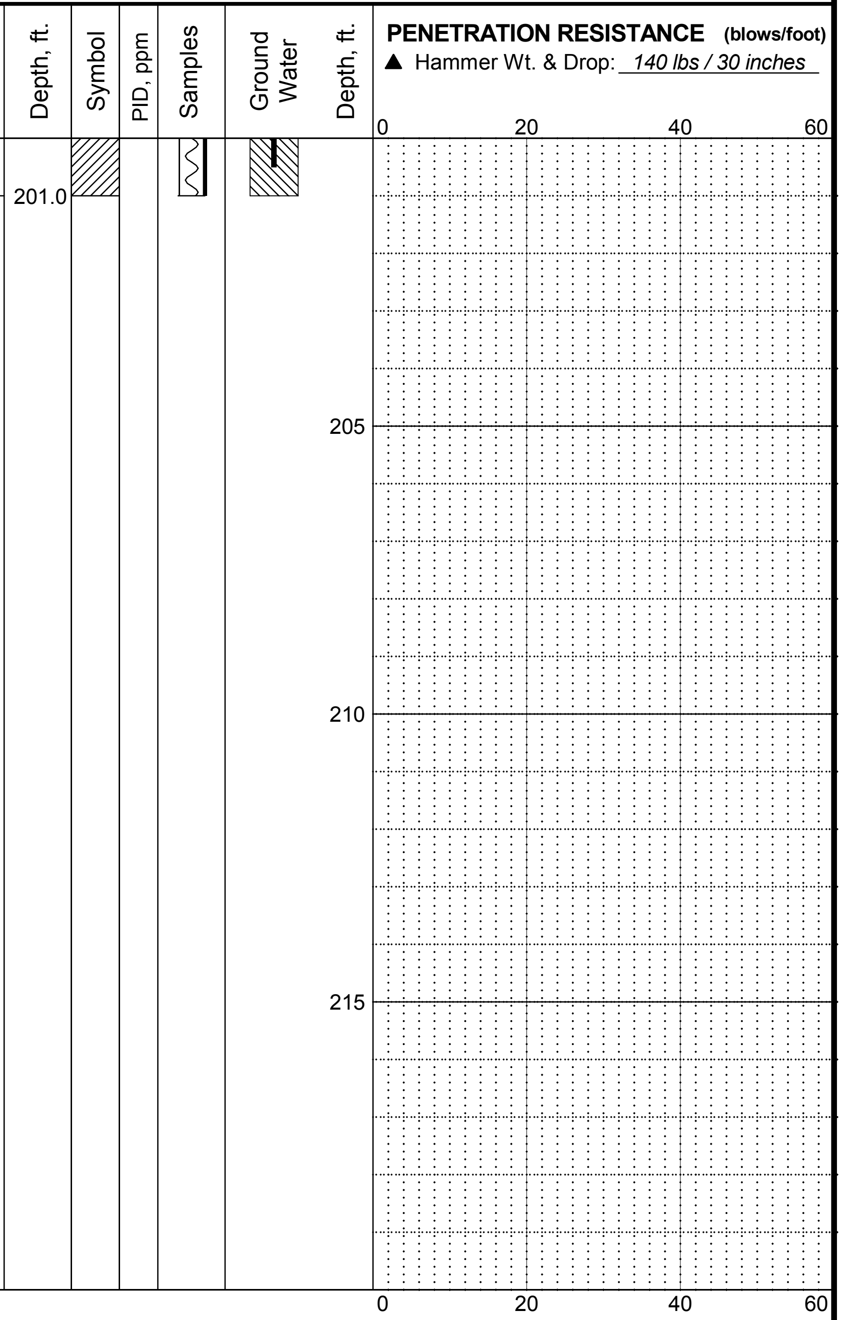
MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

BOTTOM OF BORING
COMPLETED 9/22/2015



LEGEND

I	Sample Recovery
*	Sample Not Recovered
▨	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
⊻	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

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SHANNON & WILSON, INC.
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FIG. A-17
Sheet 11 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	201 ft.	Northing:	575,398 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	28.4 ft.	Easting:	1,585,771 ft.	Drilling Company:	Cascade Drilling	Rod Diam.:	2.625
Vert. Datum:	NAVD 88	Station:	-	Drill Rig Equipment:	Truck-Mounted Sonic	Hammer Type:	Automatic
Horiz. Datum:	Project	Offset:	-	Other Comments:	Driller sitched to lexan liners at 91 feet.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Asphalt.

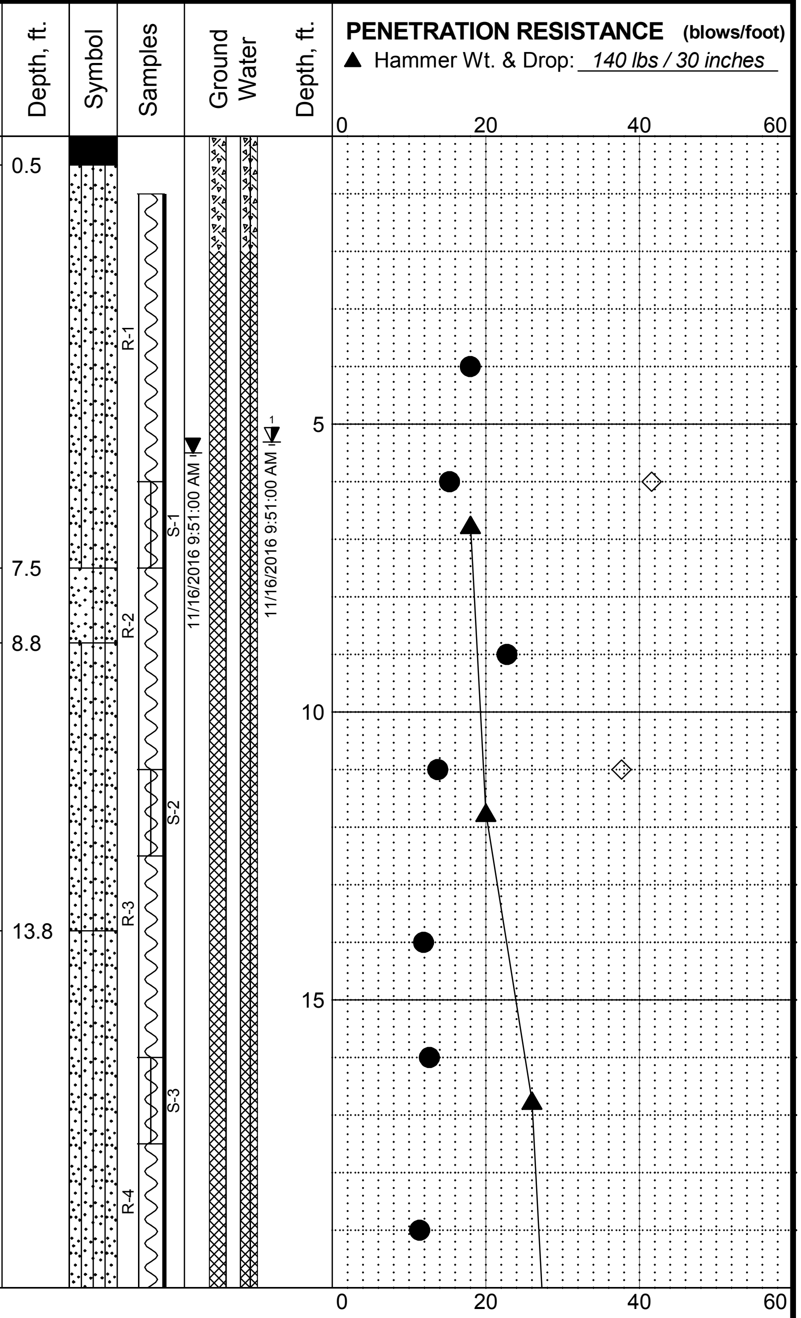
Medium dense, brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace pockets with iron-oxide staining; slight diamict texture.
(Hf)

Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines.
(Qvro)

Medium dense, brown, *Silty Sand (SM)*; wet; less than 5% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few seams with iron-oxide staining above 10 feet.
(Qvro)

Medium dense, gray-brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace pockets of poorly graded sand.
(Qvri)

- Few wet, silty sand seams below 19 feet.



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ⊠ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 1 of 11

MASTER LOG BFW 21-21979.GPJ SHAN WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: -
Offset: -

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense, gray-brown, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few diamict pockets.
(Qvri)

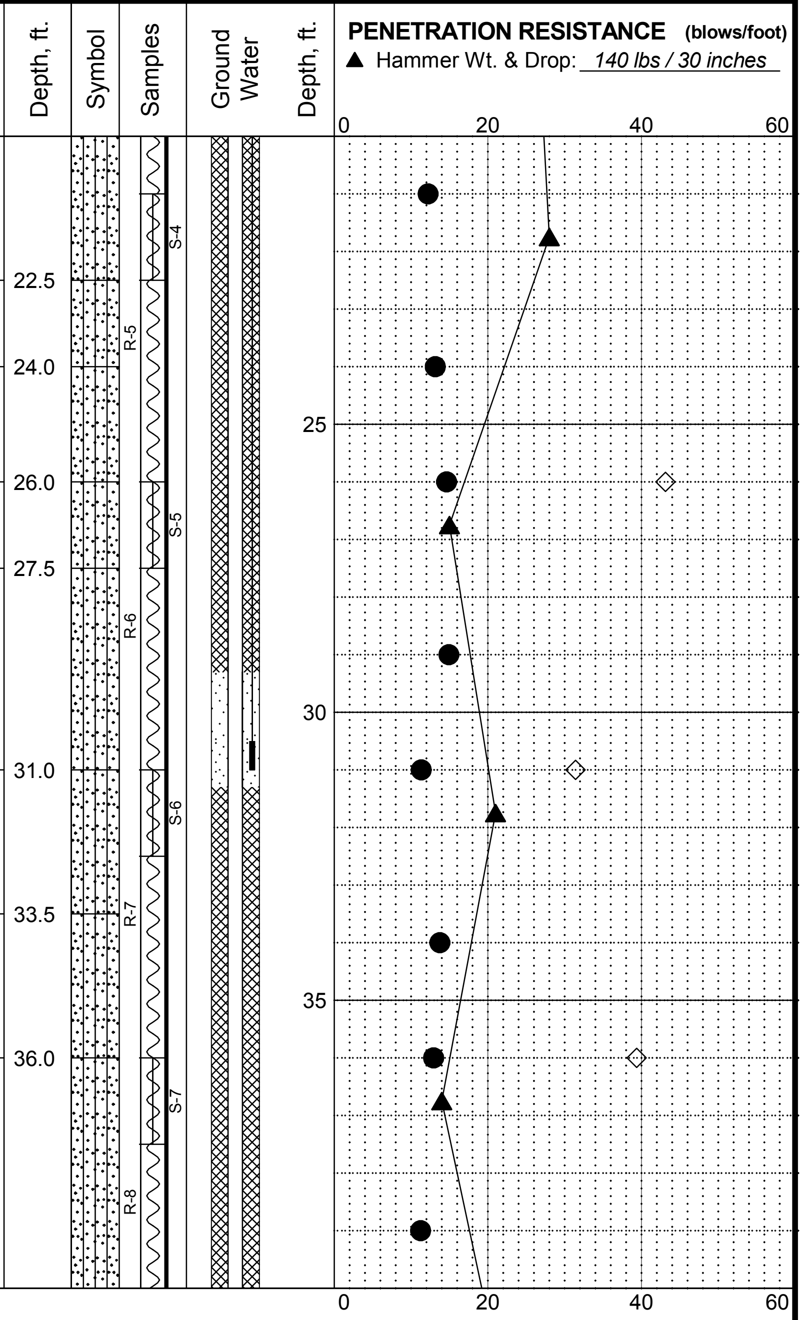
Medium dense, gray-brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 5% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qvro)

Medium dense, gray-brown, *Silty Sand with Gravel (SM)* to *Silty Sand (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; slight diamict texture.
(Qvd)

Medium dense, gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

Medium dense, gray, *Silty Sand (SM)*; moist; less than 15% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

Medium dense, gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines;



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in Well
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016
21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 2 of 11

Total Depth: 201 ft.
Top Elevation: 28.4 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,398 ft.
Easting: 1,585,771 ft.
Station: -
Offset: -

Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller sitched to lexan liners at 91 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

slight diamict texture.
(Qvd)

Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)
- Layer of wet, poorly graded sand with silt at 38.9 feet.
- Layer of wet, poorly graded sand with silt from 41 to 41.7 feet.

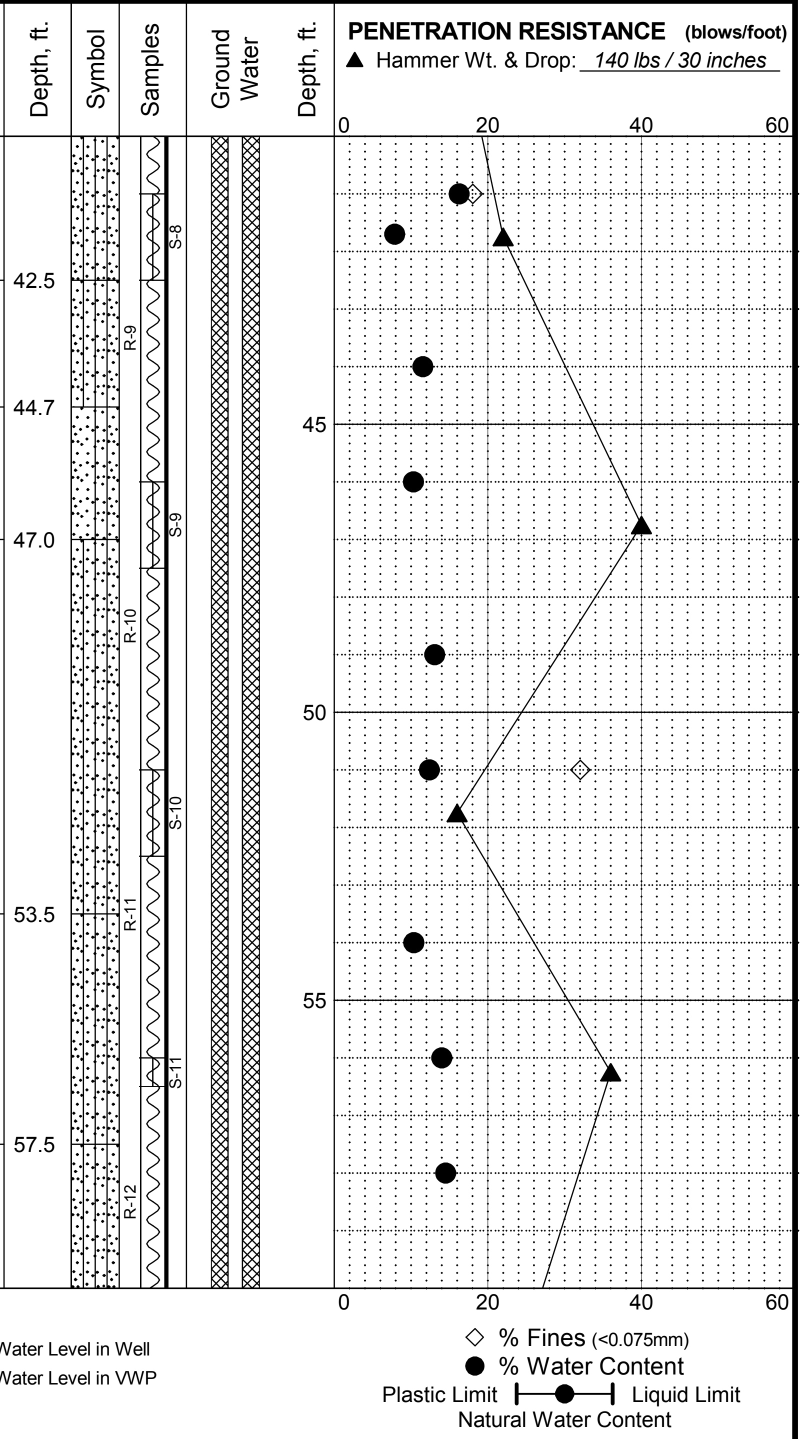
Medium dense, gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; slight diamict texture.
(Qvd)

Medium dense to dense, gray, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; wet; less than 10% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

Medium dense to dense, gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict pockets.
(Qvd)
- Few wet, poorly graded sand with silt seams from 51 to 53.5 feet.

Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel* (SM); moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

Medium dense to dense, gray, *Silty Sand (SM)*; wet; less than 10% fine to coarse,



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
☒	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016
21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 3 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace low plasticity silt seams.
(Qva)

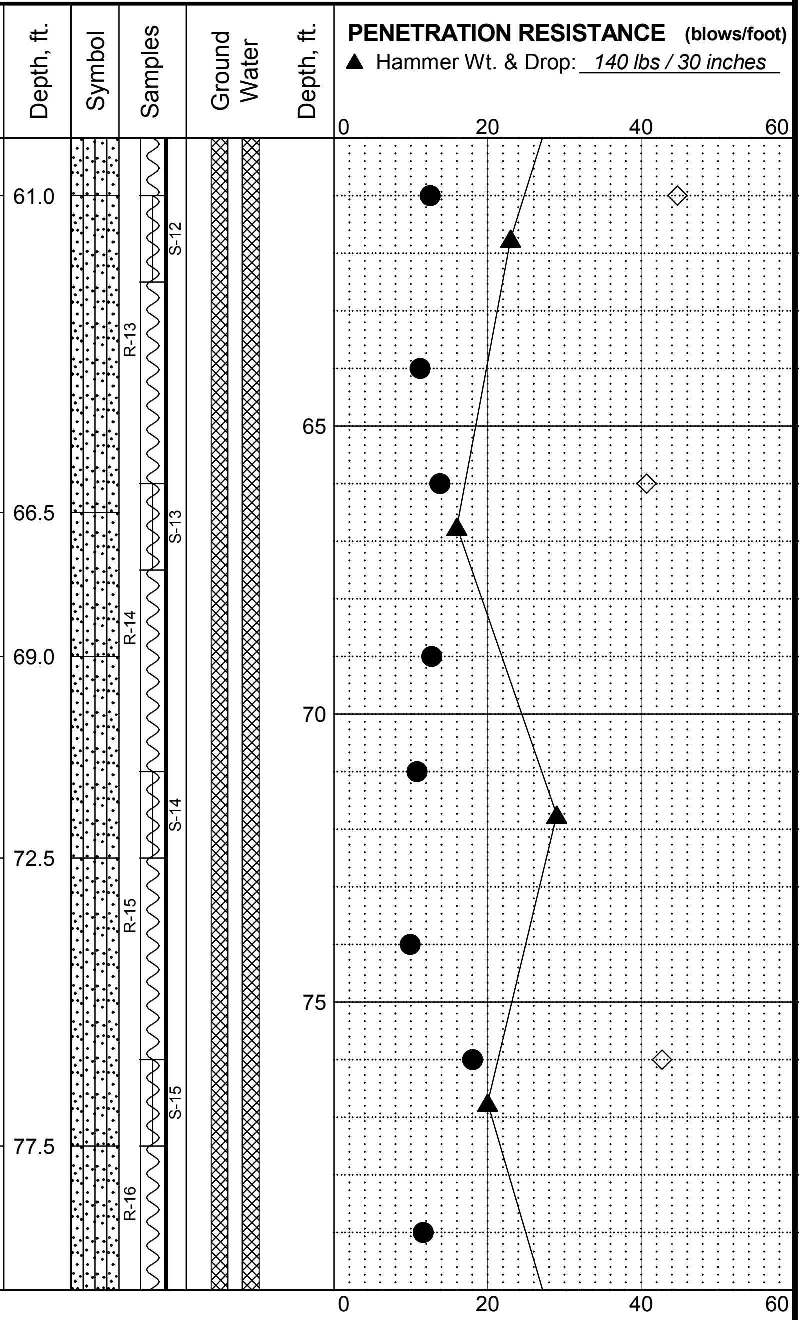
Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)
- Wet, poorly graded sand with silt seam at 61 feet.
- Wet, poorly graded gravel with silt and sand seam at 62 feet.

Medium dense, gray, *Silty Sand (SM)*; moist to wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qvd)
- Layer of wet, poorly graded sand with silt from 67.5 to 68 feet.

Medium dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)
- Layer of wet, poorly graded sand with silt and gravel from 70.5 to 70.8 feet.

Medium dense, gray, *Silty Sand (SM)*; wet; less than 15% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines.
(Qva)
- Silt seam at 75 feet.

Medium dense, gray, *Silty Sand (SM)*; moist; less than 15% fine to coarse, subrounded to



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

I Sample Recovery
* Sample Not Recovered
☒ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample

▼ Ground Water Level in Well
▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 4 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)

87.0

Very dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

93.6

Gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

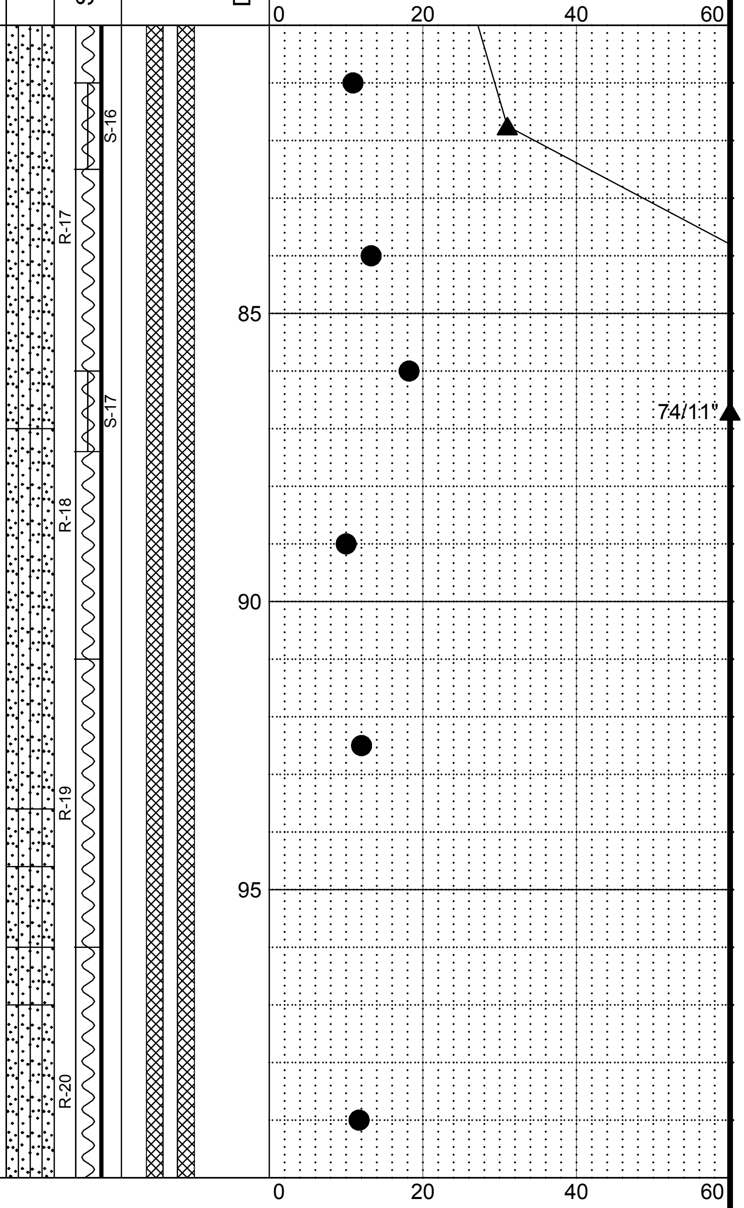
94.6

96.0

Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

97.0

Gray, *Silty Sand with Gravel (SM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine to coarse, subrounded to subangular



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery	▼	Ground Water Level in Well
*	Sample Not Recovered	▼	Ground Water Level in VWP
☒	Sonic Core Sample		
⌶	2.0" O.D. Split Spoon Sample		

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
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LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 5 of 11

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

gravel; fine to coarse sand; nonplastic fines.
(Qva)

101.0

Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)
- Wet from 100.5 to 101 feet.

102.7

Gray, *Poorly Graded Sand (SP)*; wet; fine to medium sand; less than 5% nonplastic fines; few low plasticity silt seams.
(Qva)

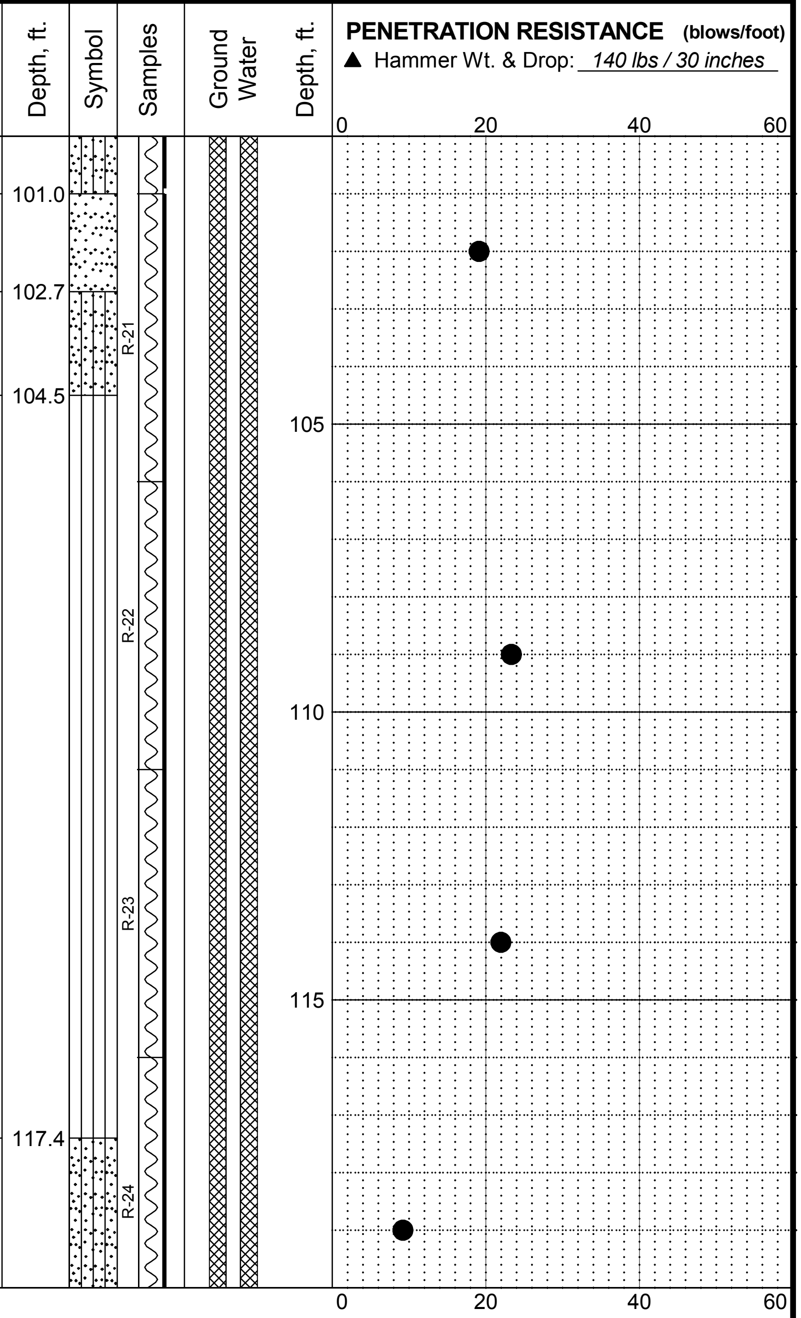
104.5

Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)

Gray *Silt (ML)*; moist; less than 5% fine, rounded to subangular gravel; less than 10% fine to coarse sand; nonplastic to low plasticity fines; trace light gray silt partings.
(Qpgl)

117.4

Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qpgt)



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
⊠	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 6 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

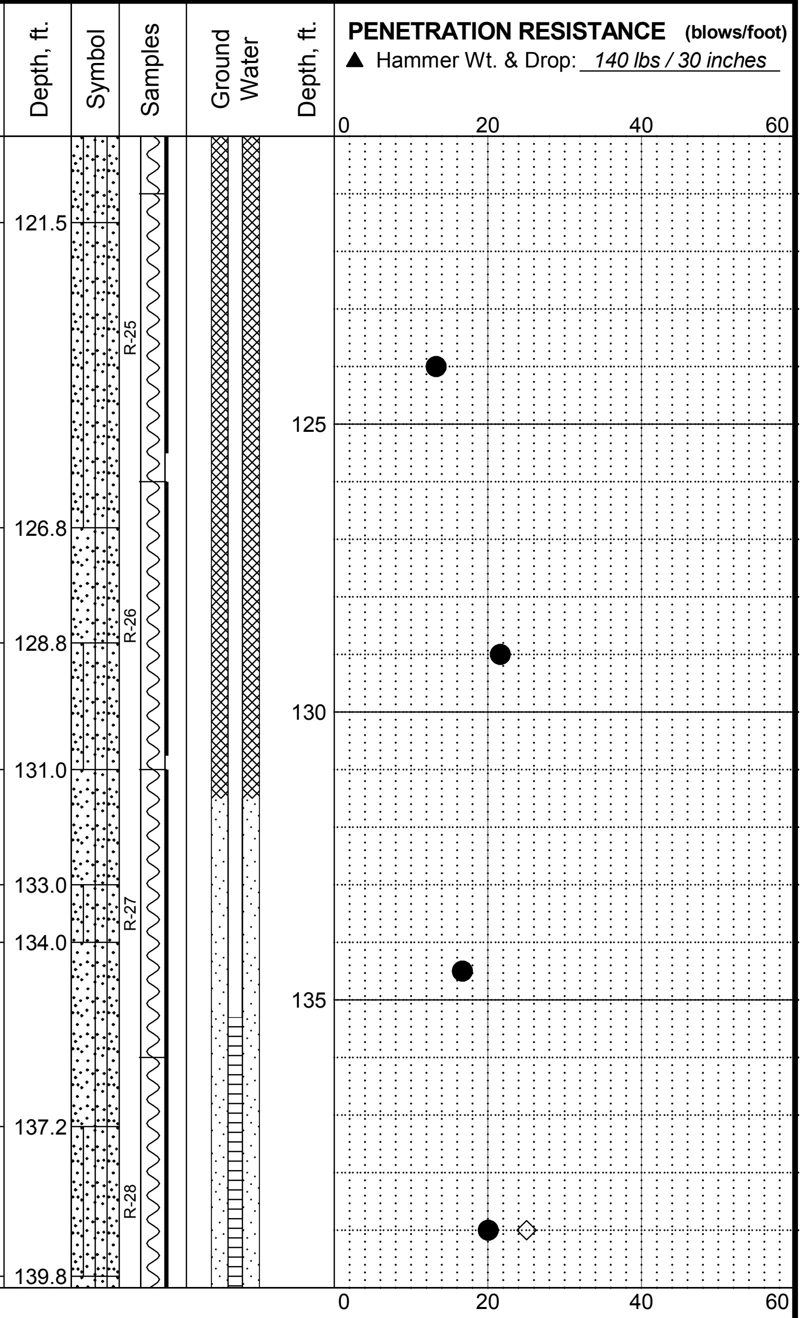
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
121.5	Gray to dark gray-brown, *Silty Sand (SM)*; moist to wet; less than 5% subrounded gravel; fine to coarse sand; nonplastic to low plasticity fines; few organics and wood debris. (Qpnf)
126.8	Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to coarse sand; nonplastic fines. (Qpnf)
128.8	Dark gray-brown, *Silty Sand (SM)*; wet; less than 5% subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace organics. (Qpnf)
131.0	Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to coarse sand; nonplastic fines. (Qpnf)
133.0	Gray to gray-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace organics. (Qpnf)
134.0	Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Qpnf)
137.2	Gray-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; few organics; trace wood fragments. (Qpnf)
139.8	



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ▨ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

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SHANNON & WILSON, INC.
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FIG. A-18
Sheet 7 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Qpnf)

141.4

Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace organics. (Qpnf)

- Layer of moist, brown, sandy silt from 143 to 143.8 feet.

146.0

Gray-brown and brown, *Silty Sand (SM)* and *Sandy Silt (ML)*; moist; fine sand; nonplastic fines; few organics; trace seams with mostly organics; interbedded. (Qpnf)

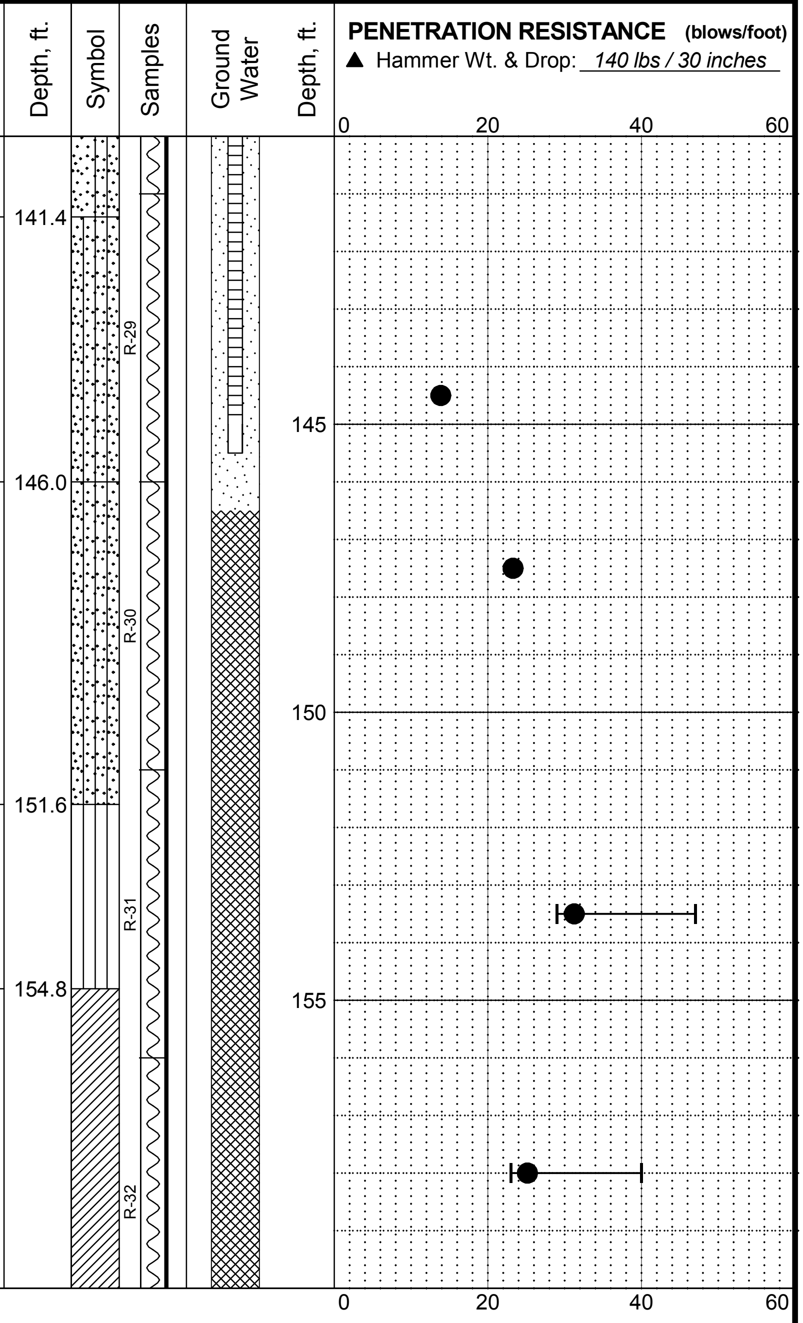
151.6

Gray-brown *Silt (ML)* to *Lean Clay (CL)*; moist; less than 10% fine sand; low to medium plasticity fines; trace organics; trace silty, fine sand partings. (Qpnl)

- Layer of wet, silty sand from 154.5 to 154.8 feet.

154.8

Gray, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 5% subrounded to subangular gravel; less than 5% fine to coarse sand; low to medium plasticity fines; trace silty sand seams; trace shell fragments. (Qpnl)



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery	▼	Ground Water Level in Well
*	Sample Not Recovered	▼	Ground Water Level in VWP
☒	Sonic Core Sample		
⌶	2.0" O.D. Split Spoon Sample		

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├●┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
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LOG OF SONIC CORE WSC-17

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SHANNON & WILSON, INC.
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FIG. A-18
Sheet 8 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.4 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,398 ft.
Easting: 1,585,771 ft.
Station: -
Offset: -

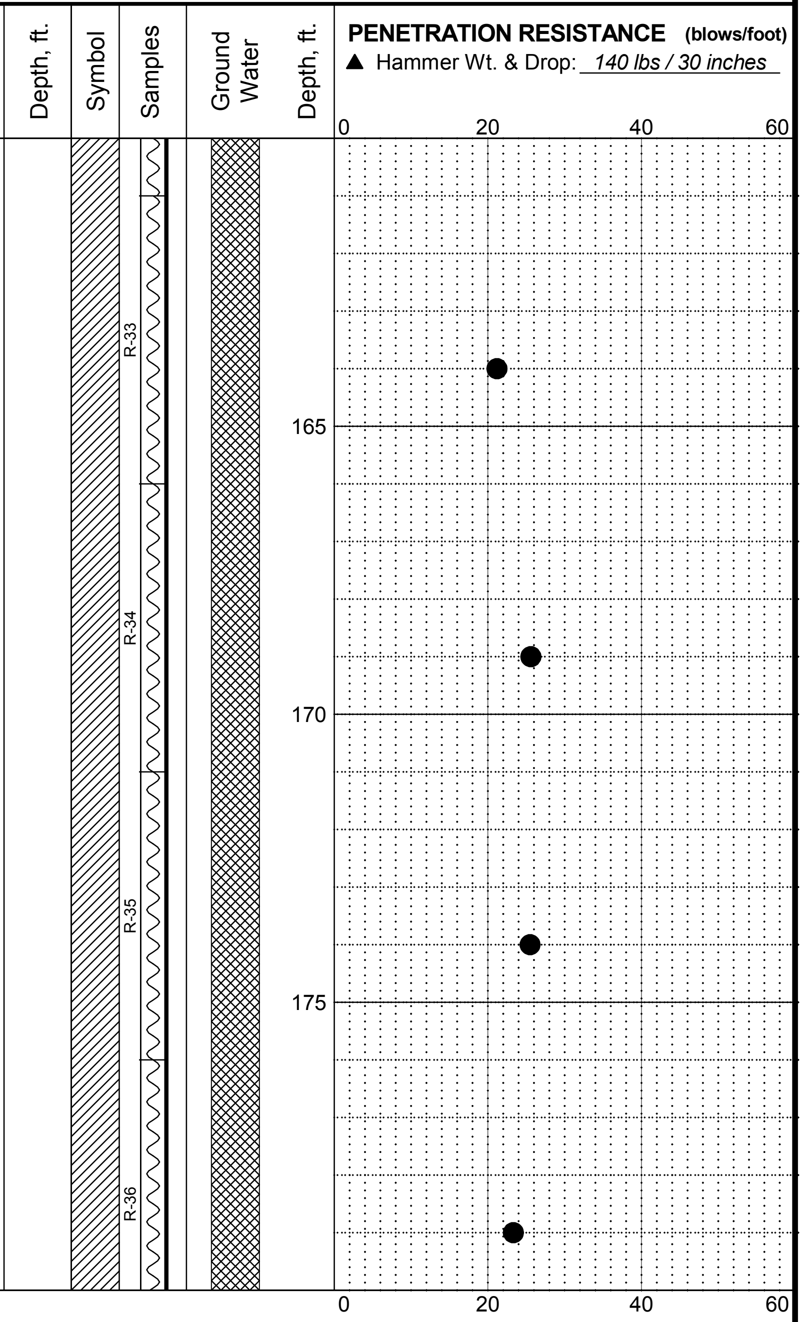
Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller sitched to lexan liners at 91 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Slightly blocky texture from 166 to 167.8 feet.



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in Well
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 9 of 11

REV 3 - Approved for Submittal

B-19 (9/11)

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*
Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*
Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

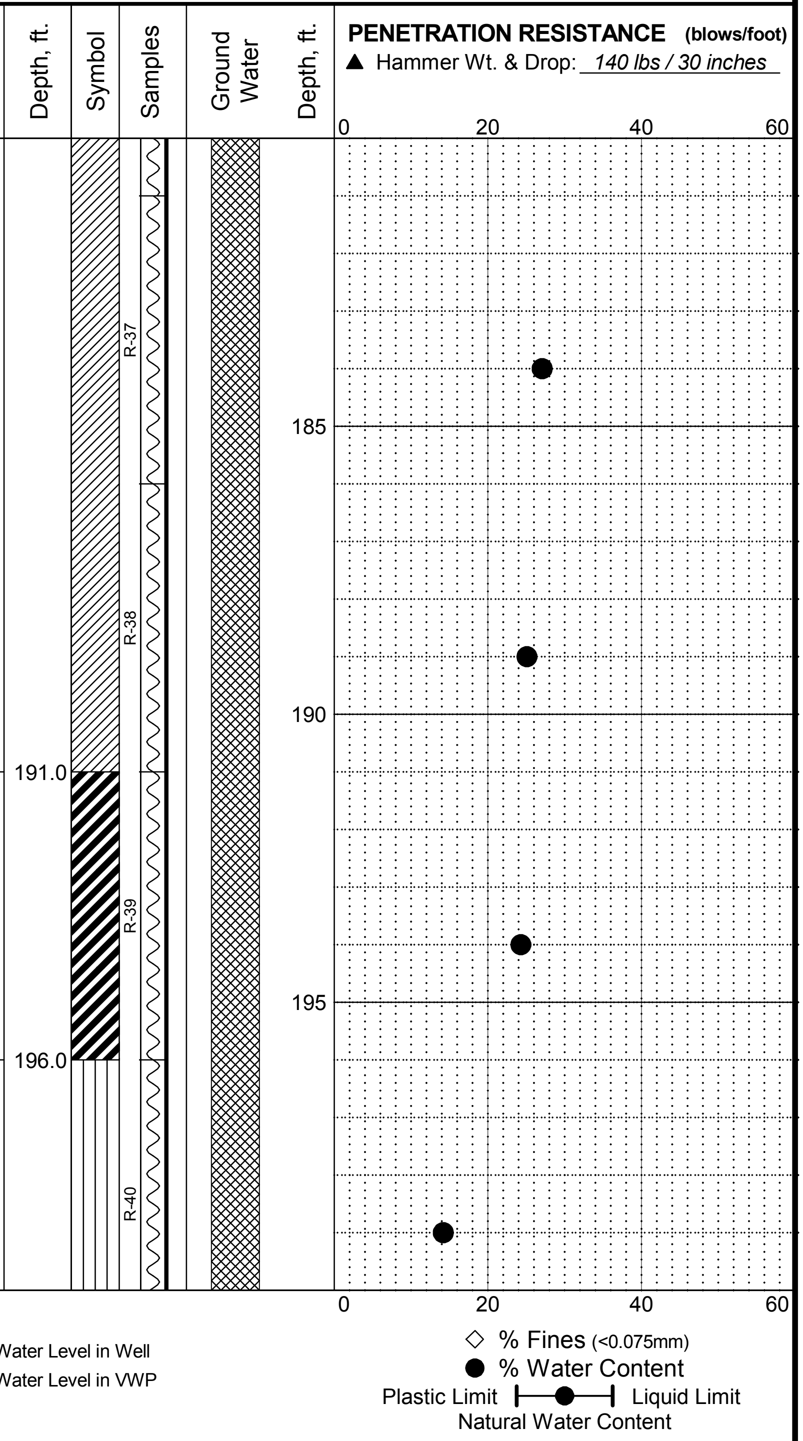
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Slightly blocky texture from 181 to 182.2 feet.
- Diced texture from 185.4 to 186 feet.

Gray, *Fat Clay (CH)*; moist; less than 5% fine, subrounded to subangular gravel; less than 5% fine to coarse sand; high plasticity fines; few slickensides.
(Qpnl)

Gray *Silt (ML)*; moist; less than 5% fine, subrounded gravel; less than 5% fine to coarse sand; nonplastic to low plasticity fines; trace silty, fine sand partings.
(Qpnl)



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
Sonic Core Sample
2.0" O.D. Split Spoon Sample
Ground Water Level in Well
Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

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Geotechnical and Environmental Consultants

FIG. A-18
Sheet 10 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: -
Offset: -

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

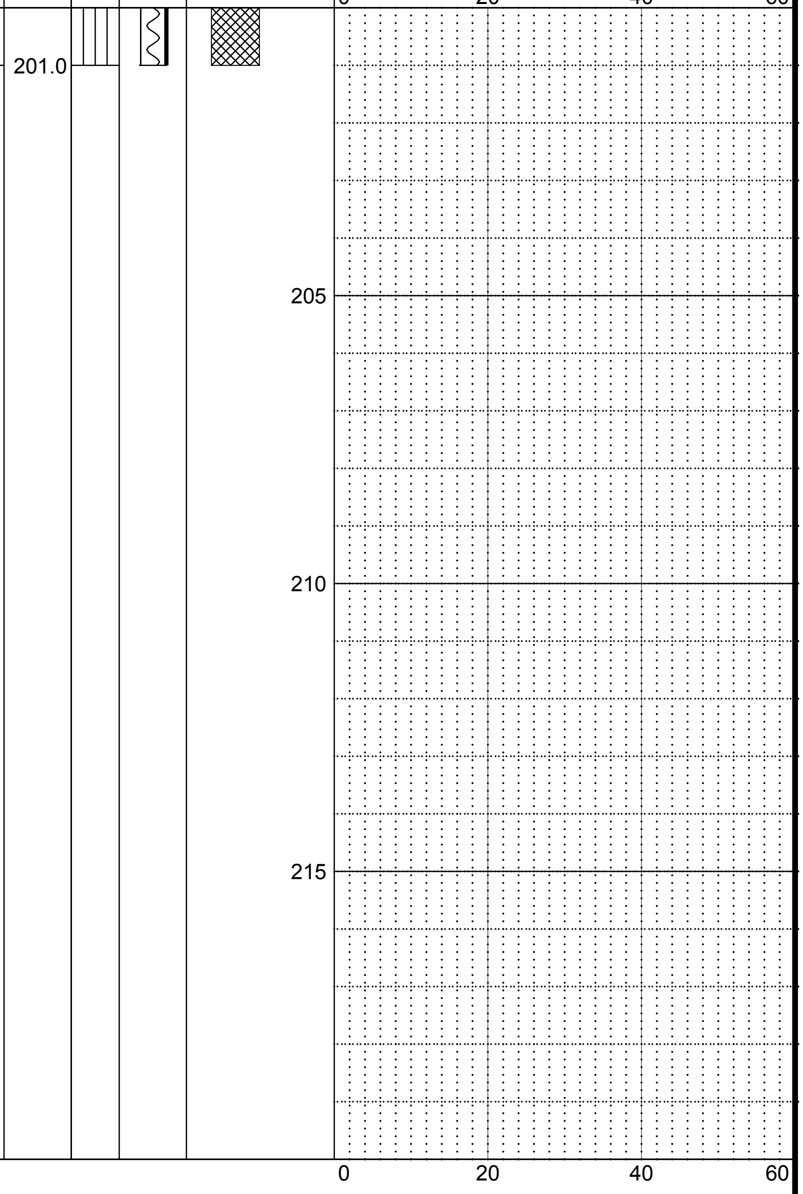
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

BOTTOM OF BORING
COMPLETED 9/24/2015



LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample

Ground Water Level in Well
Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

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FIG. A-18
Sheet 11 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

B-19 (11/11)

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

TABLE OF CONTENTS

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FIGURE

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

C.1 GENERAL

Laboratory tests were performed on selected soil samples retrieved from the geotechnical borings. The laboratory testing program included tests to classify the soils and to provide data for engineering studies.

Soil samples recovered from the borings were visually reclassified in our laboratory using a system based on ASTM International (ASTM) Designation: D2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). This visual classification method allows for convenient and consistent comparison of soils from widespread geographic areas. Using this method, the soils are classified using the Unified Soil Classification System (USCS). The individual sample classifications have been incorporated into the boring logs presented in Appendix A.

Due to high levels of lead contamination in BCT-4, no geotechnical laboratory tests were performed on samples from this boring.

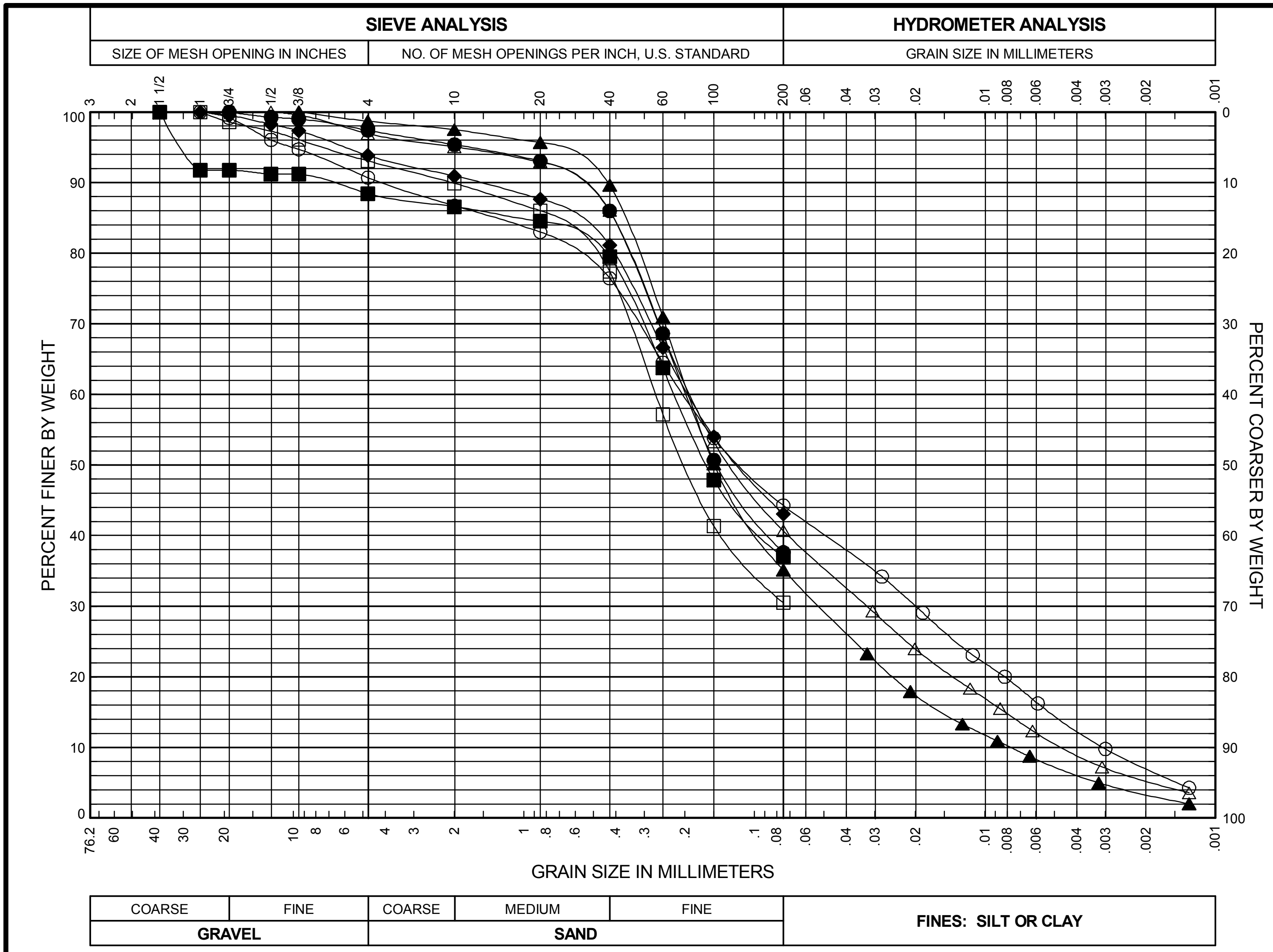
C.2 NATURAL WATER CONTENTS

The natural water content of select soil samples recovered from the field exploration was determined in general accordance with ASTM Designation: D2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. Comparison of water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. Water content, where tested, is plotted on each of the boring logs presented in Appendix A.

C.3 GRAIN SIZE ANALYSES

Grain size distribution analyses were performed on two samples in general accordance with ASTM Designation: D422, Standard Method for Particle-Size Analysis of Soils or D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-microgram) Sieve. The general procedures to determine the grain size distribution of a soil sample include sieve analysis, hydrometer analysis, combined analysis, and percentage of fines passing the No. 200 sieve.

Grain size distributions are used to assist in classifying soils and to provide correlation with soil properties, including permeability, behavior when excavated, capillary action, and sensitivity to moisture. Results of the grain size analyses are shown on grain size distribution curves shown in Figure C-1. Along with each grain size distribution is a tabulated summary containing the group symbol according to the USCS, the sample description, percentage of fines passing the No. 200 sieve, and the natural water content.



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

G_s: Specific gravity

*: *Sample specimen weight did not meet required minimum mass for ASTM test method.*

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● BCT-1, R-5	22.0	SM	Silty Sand (Assumed G_s = 2.7)		3	60	38			13.7			AKV	JFL	D422
■ BCT-1, S-5*	25.0	SM	Silty Sand		12	52	37			12.6			AKV	JFL	C136
▲ BCT-1, R-7	32.0	SM	Silty Sand (Assumed G_s = 2.7)		1	64	35	17	3	13.5			AKV	JFL	D422
◆ BCT-2, R-8*	35.5	SM	Silty Sand		6	51	43			9.4			AKV	JFL	C136
○ BCT-2, R-9	43.0	SM	Silty Sand (Assumed G_s = 2.7)		9	46	44	30	7	9.4			AKV	JFL	D422
□ BCT-2, R-10*	47.0	SM	Silty Sand		7	63	30			12.8			AKV	JFL	C136
△ BCT-3, S-2	10.0	SM	Silty Sand (Assumed G_s = 2.7)		3	56	41	24	5	13.7			AKV	JFL	D422

Ballard Conveyance
Seattle, Washington

GRAIN SIZE DISTRIBUTION

July 2017
21-1-22329-004

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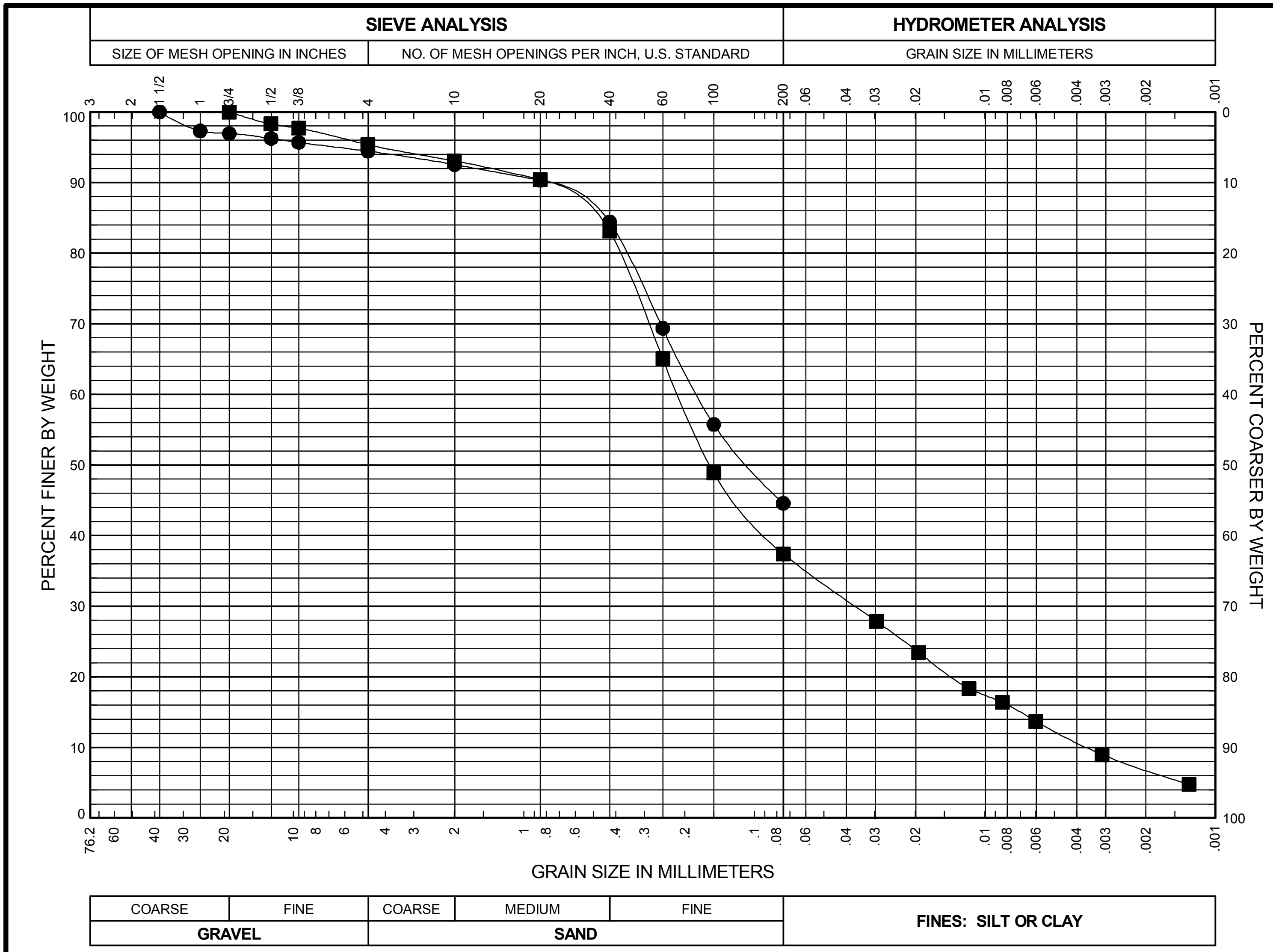
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 1 of 2

AASHTO GSA TESTA 21-22329.GPJ SHAN_WIL.GDT 7/19/17

FIG. C-1



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

G_s: Specific gravity

*: *Sample specimen weight did not meet required minimum mass for ASTM test method.*

AASHTO_GSA_TESTA 21-22329.GPJ SHAN_WIL.GDT 7/19/17

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● BCT-3, R-7*	30.0	SM	Silty Sand		6	50	45			11.9			AKV	JFL	C136
■ BCT-3, R-8	36.0	SM	Silty Sand (Assumed G_s = 2.7)		5	58	37	24	7	10.3			AKV	JFL	D422

Ballard Conveyance
Seattle, Washington

GRAIN SIZE DISTRIBUTION

July 2017
21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 2 of 2

FIG. C-1

APPENDIX D

ANALYTICAL LABORATORY TESTING

APPENDIX D

ANALYTICAL LABORATORY TESTING

REPORT

Report to Shannon & Wilson, Inc., from Fremont Analytical, 4/20/2017 (32 pages).
Samples included: BCT-04-ENV.

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Shannon & Wilson
Dave Randall
400 N. 34th Street, Suite 100
Seattle, WA 98103

RE: Ballard Conveyance
Work Order Number: 1704169

April 20, 2017

Attention Dave Randall:

Fremont Analytical, Inc. received 1 sample(s) on 4/13/2017 for the analyses presented in the following report.

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.
Gasoline by NWTPH-Gx
Mercury by EPA Method 7471
Sample Moisture (Percent Moisture)
Total Metals by EPA Method 6020
Volatile Organic Compounds by EPA Method 8260C

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Mike Ridgeway
Laboratory Director

DoD/ELAP Certification #L2371, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Shannon & Wilson
Project: Ballard Conveyance
Work Order: 1704169

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1704169-001	BCT-04-ENV	04/13/2017 11:30 AM	04/13/2017 11:52 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1704169**
Date: **4/20/2017**

CLIENT: Shannon & Wilson
Project: Ballard Conveyance

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Client: Shannon & Wilson
Collection Date: 4/13/2017 11:30:00 AM
Project: Ballard Conveyance
Lab ID: 1704169-001
Matrix: Soil
Client Sample ID: **BCT-04-ENV**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.				Batch ID: 16783		Analyst: SB
Diesel (Fuel Oil)	ND	23.6		mg/Kg-dry	1	4/15/2017 9:14:33 AM
Heavy Oil	1,330	59.1		mg/Kg-dry	1	4/15/2017 9:14:33 AM
Surr: 2-Fluorobiphenyl	50.4	50-150		%Rec	1	4/15/2017 9:14:33 AM
Surr: o-Terphenyl	53.0	50-150		%Rec	1	4/15/2017 9:14:33 AM
Gasoline by NWTPH-Gx				Batch ID: 16767		Analyst: NG
Gasoline	ND	5.37		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Surr: Toluene-d8	102	65-135		%Rec	1	4/13/2017 9:10:49 PM
Surr: 4-Bromofluorobenzene	99.8	65-135		%Rec	1	4/13/2017 9:10:49 PM
Volatile Organic Compounds by EPA Method 8260C				Batch ID: 16767		Analyst: NG
Dichlorodifluoromethane (CFC-12)	ND	0.0645	Q	mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloromethane	0.0688	0.0645		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Vinyl chloride	ND	0.00215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromomethane	ND	0.0967		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Trichlorofluoromethane (CFC-11)	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloroethane	ND	0.0645		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloroethene	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Methylene chloride	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
trans-1,2-Dichloroethene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Methyl tert-butyl ether (MTBE)	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloroethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
2,2-Dichloropropane	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
cis-1,2-Dichloroethene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloroform	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,1-Trichloroethane (TCA)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloropropene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Carbon tetrachloride	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichloroethane (EDC)	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Benzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Trichloroethene (TCE)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichloropropane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromodichloromethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Dibromomethane	ND	0.0430		mg/Kg-dry	1	4/13/2017 9:10:49 PM
cis-1,3-Dichloropropene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Toluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
trans-1,3-Dichloropropylene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM

Analytical Report

Work Order: **1704169**
Date Reported: **4/20/2017**

Client: Shannon & Wilson

Collection Date: 4/13/2017 11:30:00 AM

Project: Ballard Conveyance

Lab ID: 1704169-001

Matrix: Soil

Client Sample ID: **BCT-04-ENV**

Volatile Organic Compounds by EPA Method 8260C

Batch ID: 16767 Analyst: NG

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
1,1,2-Trichloroethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3-Dichloropropane	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Tetrachloroethene (PCE)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Dibromochloromethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dibromoethane (EDB)	ND	0.00537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,1,2-Tetrachloroethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Ethylbenzene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
m,p-Xylene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
o-Xylene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Styrene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Isopropylbenzene	ND	0.0860		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromoform	ND	0.0215	Q	mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,2,2-Tetrachloroethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
n-Propylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromobenzene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3,5-Trimethylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
2-Chlorotoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
4-Chlorotoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
tert-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,3-Trichloropropane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,4-Trichlorobenzene	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
sec-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
4-Isopropyltoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,4-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
n-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dibromo-3-chloropropane	ND	0.537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,4-Trimethylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Hexachlorobutadiene	ND	0.107		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Naphthalene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,3-Trichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Surr: Dibromofluoromethane	90.3	56.5-129		%Rec	1	4/13/2017 9:10:49 PM
Surr: Toluene-d8	96.1	64.5-151		%Rec	1	4/13/2017 9:10:49 PM
Surr: 1-Bromo-4-fluorobenzene	97.3	63.1-141		%Rec	1	4/13/2017 9:10:49 PM

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Analytical Report

Client: Shannon & Wilson

Collection Date: 4/13/2017 11:30:00 AM

Project: Ballard Conveyance

Lab ID: 1704169-001

Matrix: Soil

Client Sample ID: **BCT-04-ENV**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Mercury by EPA Method 7471				Batch ID: 16786		Analyst: WF
Mercury	0.553	0.316		mg/Kg-dry	1	4/14/2017 1:09:38 PM
Total Metals by EPA Method 6020				Batch ID: 16779		Analyst: TN
Arsenic	18.2	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Barium	123	0.506		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Cadmium	1.68	0.202		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Chromium	23.2	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Lead	10,700	20.2	D	mg/Kg-dry	100	4/17/2017 12:02:46 PM
Selenium	0.803	0.506		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Silver	0.569	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Sample Moisture (Percent Moisture)				Batch ID: R35537		Analyst: BB
Percent Moisture	26.8			wt%	1	4/14/2017 9:45:32 AM

Date: *4/20/2017*

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.

Sample ID **MB-16783** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **MBLKS** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681244**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	20.0									
Heavy Oil	ND	50.0									
Surr: 2-Fluorobiphenyl	22.3		20.00		112	50	150				
Surr: o-Terphenyl	22.1		20.00		110	50	150				

Sample ID **LCS-16783** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **LCSS** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681011**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	414	20.0	500.0	0	82.8	65	135				
Surr: 2-Fluorobiphenyl	22.2		20.00		111	50	150				
Surr: o-Terphenyl	23.2		20.00		116	50	150				

Sample ID **1704174-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681607**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	19.1						0		30	
Heavy Oil	ND	47.9						0		30	
Surr: 2-Fluorobiphenyl	20.7		19.15		108	50	150		0		
Surr: o-Terphenyl	20.7		19.15		108	50	150		0		

Sample ID **1704174-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681608**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	351	18.3	457.4	0	76.7	65	135				
Surr: 2-Fluorobiphenyl	14.8		18.30		80.7	50	150				
Surr: o-Terphenyl	15.4		18.30		84.4	50	150				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.

Sample ID **1704174-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681608**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID **1704174-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681609**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	504	18.9	473.3	0	106	65	135	350.6	35.9	30	R
Surr: 2-Fluorobiphenyl	17.4		18.93		92.0	50	150		0		
Surr: o-Terphenyl	18.8		18.93		99.2	50	150		0		

NOTES:
R - High RPD observed, spike recoveries are within range.

Sample ID **1704172-008ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/15/2017** SeqNo: **681606**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	20.3						0		30	
Heavy Oil	ND	50.7						72.60	53.6	30	
Surr: 2-Fluorobiphenyl	20.6		20.27		102	50	150		0		
Surr: o-Terphenyl	21.0		20.27		104	50	150		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Gasoline by NWTPH-Gx

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680808**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	23.7	5.00	25.00	0	94.9	65	135				
Surr: Toluene-d8	1.24		1.250		99.3	65	135				
Surr: 4-Bromofluorobenzene	1.31		1.250		105	65	135				

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680809**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	ND	5.00									
Surr: Toluene-d8	1.24		1.250		99.1	65	135				
Surr: 4-Bromofluorobenzene	1.26		1.250		101	65	135				

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680800**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	ND	2.23						0		30	
Surr: Toluene-d8	0.561		0.5566		101	65	135		0		
Surr: 4-Bromofluorobenzene	0.544		0.5566		97.7	65	135		0		

Sample ID **1704147-008BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680802**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	10.0	2.43	12.17	0	82.2	65	135				
Surr: Toluene-d8	0.617		0.6087		101	65	135				
Surr: 4-Bromofluorobenzene	0.610		0.6087		100	65	135				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Gasoline by NWTPH-Gx

Sample ID **1704147-008BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680803**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	10.2	2.43	12.17	0	83.5	65	135	10.00	1.63	30	
Surr: Toluene-d8	0.616		0.6087		101	65	135		0		
Surr: 4-Bromofluorobenzene	0.615		0.6087		101	65	135		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Mercury by EPA Method 7471

Sample ID **MB-16786** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **MBLKS** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680921**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	ND	0.250									

Sample ID **LCS-16786** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **LCSS** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680922**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.518	0.250	0.5000	0	104	80	120				

Sample ID **1704169-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680924**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.623	0.311						0.5530	11.8	20	

Sample ID **1704169-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680925**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	1.29	0.316	0.6328	0.5530	117	70	130				E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID **1704169-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680926**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	1.02	0.316	0.6328	0.5530	74.0	70	130	1.291	23.3	20	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Sample Moisture (Percent Moisture)

Sample ID **1704166-002ADUP** SampType: **DUP** Units: **wt%** Prep Date: **4/14/2017** RunNo: **35537**
Client ID: **BATCH** Batch ID: **R35537** Analysis Date: **4/14/2017** SeqNo: **680754**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Percent Moisture	19.3	0.500						16.07	18.2	20	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **MB-16779** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **MBLKS** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681091**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.0719									
Barium	ND	0.360									
Cadmium	ND	0.144									
Chromium	ND	0.0719									
Lead	ND	0.144									
Selenium	ND	0.360									
Silver	ND	0.0719									

Sample ID **1704161-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681094**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	23.1	0.0949						20.31	12.8	20	
Barium	195	0.475						152.6	24.2	20	R
Cadmium	0.217	0.190						0.1538	34.1	20	
Chromium	34.4	0.0949						27.77	21.4	20	R
Selenium	3.14	0.475						2.766	12.8	20	
Silver	0.0954	0.0949						0.07518	23.8	20	

NOTES:
R - High RPD observed. The method is in control as indicated by the LCS.

Sample ID **1704161-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681096**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	71.0	0.0949	47.46	20.31	107	75	125				
Barium	248	0.475	47.46	152.6	202	75	125				S
Cadmium	3.11	0.190	2.373	0.1538	125	75	125				
Chromium	92.9	0.0949	47.46	27.77	137	75	125				S
Lead	78.6	0.190	23.73	80.56	-8.04	75	125				S
Selenium	8.17	0.475	4.746	2.766	114	75	125				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **1704161-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681096**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Silver	1.90	0.0949	2.373	0.07518	77.0	75	125				

NOTES:

S - Outlying spike recovery(ies) observed for Barium and Lead. A duplicate analysis was performed with similar results indicating a possible matrix effect.
S - Outlying spike recovery observed for Chromium. A duplicate analysis was performed and recovered within range.

Sample ID **1704161-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681099**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	67.0	0.0942	47.11	20.31	99.2	75	125	70.98	5.72	20	
Barium	219	0.471	47.11	152.6	140	75	125	248.2	12.7	20	S
Cadmium	2.81	0.188	2.355	0.1538	113	75	125	3.111	10.3	20	
Chromium	83.2	0.0942	47.11	27.77	118	75	125	92.91	11.1	20	
Lead	84.4	0.188	23.55	80.56	16.5	75	125	78.65	7.11	20	S
Selenium	7.26	0.471	4.711	2.766	95.4	75	125	8.172	11.8	20	
Silver	1.55	0.0942	2.355	0.07518	62.6	75	125	1.901	20.5	20	RS

NOTES:

S - Outlying spike recovery(ies) observed for Barium and Lead. A duplicate analysis was performed with similar results indicating a possible matrix effect.
S/R - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Sample ID **LCS-16779** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **LCSS** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681161**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	37.3	0.0725	36.23	0	103	80	120				
Barium	37.2	0.362	36.23	0	103	80	120				
Cadmium	1.83	0.145	1.812	0	101	80	120				
Chromium	33.8	0.0725	36.23	0	93.2	80	120				
Lead	18.8	0.145	18.12	0	104	80	120				
Selenium	3.44	0.362	3.623	0	94.9	80	120				
Silver	1.45	0.0725	1.812	0	79.9	80	120				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **1704161-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/17/2017** SeqNo: **681402**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Lead	73.1	0.190						80.56	9.65	20	

Sample ID **CCV-16779F** SampType: **CCV** Units: **µg/L** Prep Date: **4/17/2017** RunNo: **35557**
Client ID: **CCV** Batch ID: **16779** Analysis Date: **4/17/2017** SeqNo: **681405**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Lead	52.9	2.00	50.00	0	106	90	110				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.770	0.0600	1.000	0	77.0	14.3	167				
Chloromethane	0.907	0.0600	1.000	0	90.7	46	144				
Vinyl chloride	0.947	0.00200	1.000	0	94.7	44	142				
Bromomethane	0.979	0.0900	1.000	0	97.9	40.9	157				
Trichlorofluoromethane (CFC-11)	0.955	0.0500	1.000	0	95.5	36.9	156				
Chloroethane	0.936	0.0600	1.000	0	93.6	33.4	155				
1,1-Dichloroethene	0.942	0.0500	1.000	0	94.2	49.7	142				
Methylene chloride	0.927	0.0200	1.000	0	92.7	46.3	140				
trans-1,2-Dichloroethene	0.946	0.0200	1.000	0	94.6	68	130				
Methyl tert-butyl ether (MTBE)	0.983	0.0500	1.000	0	98.3	66.3	145				
1,1-Dichloroethane	0.979	0.0200	1.000	0	97.9	61.9	137				
2,2-Dichloropropane	1.29	0.0500	1.000	0	129	35.5	186				
cis-1,2-Dichloroethene	0.960	0.0200	1.000	0	96.0	71.3	135				
Chloroform	0.959	0.0200	1.000	0	95.9	69	145				
1,1,1-Trichloroethane (TCA)	0.960	0.0200	1.000	0	96.0	69	132				
1,1-Dichloropropene	0.967	0.0200	1.000	0	96.7	72.7	131				
Carbon tetrachloride	0.954	0.0200	1.000	0	95.4	63.4	137				
1,2-Dichloroethane (EDC)	0.959	0.0300	1.000	0	95.9	61.9	136				
Benzene	1.03	0.0200	1.000	0	103	64.3	133				
Trichloroethene (TCE)	0.951	0.0200	1.000	0	95.1	65.5	137				
1,2-Dichloropropane	1.01	0.0200	1.000	0	101	63.2	142				
Bromodichloromethane	0.950	0.0200	1.000	0	95.0	73.2	131				
Dibromomethane	0.955	0.0400	1.000	0	95.5	70	130				
cis-1,3-Dichloropropene	1.07	0.0200	1.000	0	107	59.1	143				
Toluene	1.06	0.0200	1.000	0	106	67.3	138				
trans-1,3-Dichloropropylene	1.04	0.0300	1.000	0	104	49.2	149				
1,1,2-Trichloroethane	0.937	0.0300	1.000	0	93.7	74.5	129				
1,3-Dichloropropane	0.955	0.0500	1.000	0	95.5	70	130				
Tetrachloroethene (PCE)	1.00	0.0200	1.000	0	100	52.7	150				
Dibromochloromethane	0.975	0.0300	1.000	0	97.5	70.6	144				
1,2-Dibromoethane (EDB)	0.931	0.00500	1.000	0	93.1	70	130				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorobenzene	0.990	0.0200	1.000	0	99.0	76.1	123				
1,1,1,2-Tetrachloroethane	0.976	0.0300	1.000	0	97.6	65.9	141				
Ethylbenzene	1.07	0.0300	1.000	0	107	74	129				
m,p-Xylene	2.15	0.0200	2.000	0	107	70	124				
o-Xylene	1.07	0.0200	1.000	0	107	68.1	139				
Styrene	0.979	0.0200	1.000	0	97.9	76.8	130				
Isopropylbenzene	0.990	0.0800	1.000	0	99.0	70	130				
Bromoform	0.818	0.0200	1.000	0	81.8	67	154				
1,1,2,2-Tetrachloroethane	0.923	0.0200	1.000	0	92.3	60	130				
n-Propylbenzene	0.998	0.0200	1.000	0	99.8	74.8	125				
Bromobenzene	0.985	0.0300	1.000	0	98.5	49.2	144				
1,3,5-Trimethylbenzene	1.00	0.0200	1.000	0	100	74.6	123				
2-Chlorotoluene	0.997	0.0200	1.000	0	99.7	76.7	129				
4-Chlorotoluene	0.993	0.0200	1.000	0	99.3	77.5	125				
tert-Butylbenzene	1.01	0.0200	1.000	0	101	66.2	130				
1,2,3-Trichloropropane	0.915	0.0200	1.000	0	91.5	67.9	136				
1,2,4-Trichlorobenzene	0.991	0.0500	1.000	0	99.1	62.6	143				
sec-Butylbenzene	1.06	0.0200	1.000	0	106	75.6	133				
4-Isopropyltoluene	1.10	0.0200	1.000	0	110	76.8	131				
1,3-Dichlorobenzene	1.04	0.0200	1.000	0	104	72.8	128				
1,4-Dichlorobenzene	1.04	0.0200	1.000	0	104	72.6	126				
n-Butylbenzene	1.18	0.0200	1.000	0	118	65.3	136				
1,2-Dichlorobenzene	1.03	0.0200	1.000	0	103	72.8	126				
1,2-Dibromo-3-chloropropane	0.864	0.500	1.000	0	86.4	61.2	139				
1,2,4-Trimethylbenzene	1.03	0.0200	1.000	0	103	77.5	129				
Hexachlorobutadiene	1.11	0.100	1.000	0	111	42	151				
Naphthalene	0.956	0.0300	1.000	0	95.6	62.3	134				
1,2,3-Trichlorobenzene	0.905	0.0200	1.000	0	90.5	54.8	143				
Surr: Dibromofluoromethane	1.24		1.250		99.2	56.5	129				
Surr: Toluene-d8	1.27		1.250		102	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	1.31		1.250		105	63.1	141				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0600									Q
Chloromethane	ND	0.0600									
Vinyl chloride	ND	0.00200									
Bromomethane	ND	0.0900									
Trichlorofluoromethane (CFC-11)	ND	0.0500									
Chloroethane	ND	0.0600									
1,1-Dichloroethene	ND	0.0500									
Methylene chloride	ND	0.0200									
trans-1,2-Dichloroethene	ND	0.0200									
Methyl tert-butyl ether (MTBE)	ND	0.0500									
1,1-Dichloroethane	ND	0.0200									
2,2-Dichloropropane	ND	0.0500									
cis-1,2-Dichloroethene	ND	0.0200									
Chloroform	ND	0.0200									
1,1,1-Trichloroethane (TCA)	ND	0.0200									
1,1-Dichloropropene	ND	0.0200									
Carbon tetrachloride	ND	0.0200									
1,2-Dichloroethane (EDC)	ND	0.0300									
Benzene	ND	0.0200									
Trichloroethene (TCE)	ND	0.0200									
1,2-Dichloropropane	ND	0.0200									
Bromodichloromethane	ND	0.0200									
Dibromomethane	ND	0.0400									
cis-1,3-Dichloropropene	ND	0.0200									
Toluene	ND	0.0200									

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
trans-1,3-Dichloropropylene	ND	0.0300									
1,1,2-Trichloroethane	ND	0.0300									
1,3-Dichloropropane	ND	0.0500									
Tetrachloroethene (PCE)	ND	0.0200									
Dibromochloromethane	ND	0.0300									
1,2-Dibromoethane (EDB)	ND	0.00500									
Chlorobenzene	ND	0.0200									
1,1,1,2-Tetrachloroethane	ND	0.0300									
Ethylbenzene	ND	0.0300									
m,p-Xylene	ND	0.0200									
o-Xylene	ND	0.0200									
Styrene	ND	0.0200									
Isopropylbenzene	ND	0.0800									
Bromoform	ND	0.0200									Q
1,1,2,2-Tetrachloroethane	ND	0.0200									
n-Propylbenzene	ND	0.0200									
Bromobenzene	ND	0.0300									
1,3,5-Trimethylbenzene	ND	0.0200									
2-Chlorotoluene	ND	0.0200									
4-Chlorotoluene	ND	0.0200									
tert-Butylbenzene	ND	0.0200									
1,2,3-Trichloropropane	ND	0.0200									
1,2,4-Trichlorobenzene	ND	0.0500									
sec-Butylbenzene	ND	0.0200									
4-Isopropyltoluene	ND	0.0200									
1,3-Dichlorobenzene	ND	0.0200									
1,4-Dichlorobenzene	ND	0.0200									
n-Butylbenzene	ND	0.0200									
1,2-Dichlorobenzene	ND	0.0200									
1,2-Dibromo-3-chloropropane	ND	0.500									
1,2,4-Trimethylbenzene	ND	0.0200									

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hexachlorobutadiene	ND	0.100									
Naphthalene	ND	0.0300									
1,2,3-Trichlorobenzene	ND	0.0200									
Surr: Dibromofluoromethane	1.19		1.250		95.2	56.5	129				
Surr: Toluene-d8	1.22		1.250		97.7	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	1.22		1.250		97.4	63.1	141				

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680775**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0267						0		30	Q
Chloromethane	0.0318	0.0267						0.02936	8.00	30	
Vinyl chloride	ND	0.000891						0		30	
Bromomethane	ND	0.0401						0		30	
Trichlorofluoromethane (CFC-11)	ND	0.0223						0		30	
Chloroethane	ND	0.0267						0		30	
1,1-Dichloroethene	ND	0.0223						0		30	
Methylene chloride	ND	0.00891						0		30	
trans-1,2-Dichloroethene	ND	0.00891						0		30	
Methyl tert-butyl ether (MTBE)	ND	0.0223						0		30	
1,1-Dichloroethane	ND	0.00891						0		30	
2,2-Dichloropropane	ND	0.0223						0		30	
cis-1,2-Dichloroethene	ND	0.00891						0		30	
Chloroform	ND	0.00891						0		30	
1,1,1-Trichloroethane (TCA)	ND	0.00891						0		30	
1,1-Dichloropropene	ND	0.00891						0		30	
Carbon tetrachloride	ND	0.00891						0		30	
1,2-Dichloroethane (EDC)	ND	0.0134						0		30	

Date: *4/20/2017*

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-001BDUP**	SampType: **DUP**	Units: **mg/Kg-dry**	Prep Date: **4/13/2017**	RunNo: **35538**				
Client ID: **BATCH**	Batch ID: **16767**		Analysis Date: **4/13/2017**	SeqNo: **680775**				

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Benzene	ND	0.00891						0		30	
Trichloroethene (TCE)	ND	0.00891						0		30	
1,2-Dichloropropane	ND	0.00891						0		30	
Bromodichloromethane	ND	0.00891						0		30	
Dibromomethane	ND	0.0178						0		30	
cis-1,3-Dichloropropene	ND	0.00891						0		30	
Toluene	ND	0.00891						0		30	
trans-1,3-Dichloropropylene	ND	0.0134						0		30	
1,1,2-Trichloroethane	ND	0.0134						0		30	
1,3-Dichloropropane	ND	0.0223						0		30	
Tetrachloroethene (PCE)	ND	0.00891						0		30	
Dibromochloromethane	ND	0.0134						0		30	
1,2-Dibromoethane (EDB)	ND	0.00223						0		30	
Chlorobenzene	ND	0.00891						0		30	
1,1,1,2-Tetrachloroethane	ND	0.0134						0		30	
Ethylbenzene	ND	0.0134						0		30	
m,p-Xylene	ND	0.00891						0		30	
o-Xylene	ND	0.00891						0		30	
Styrene	ND	0.00891						0		30	
Isopropylbenzene	ND	0.0356						0		30	
Bromoform	ND	0.00891						0		30	Q
1,1,2,2-Tetrachloroethane	ND	0.00891						0		30	
n-Propylbenzene	ND	0.00891						0		30	
Bromobenzene	ND	0.0134						0		30	
1,3,5-Trimethylbenzene	ND	0.00891						0		30	
2-Chlorotoluene	ND	0.00891						0		30	
4-Chlorotoluene	ND	0.00891						0		30	
tert-Butylbenzene	ND	0.00891						0		30	
1,2,3-Trichloropropane	ND	0.00891						0		30	
1,2,4-Trichlorobenzene	ND	0.0223						0		30	
sec-Butylbenzene	ND	0.00891						0		30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680775**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4-Isopropyltoluene	ND	0.00891						0		30	
1,3-Dichlorobenzene	ND	0.00891						0		30	
1,4-Dichlorobenzene	ND	0.00891						0		30	
n-Butylbenzene	ND	0.00891						0		30	
1,2-Dichlorobenzene	ND	0.00891						0		30	
1,2-Dibromo-3-chloropropane	ND	0.223						0		30	
1,2,4-Trimethylbenzene	ND	0.00891						0		30	
Hexachlorobutadiene	ND	0.0445						0		30	
Naphthalene	ND	0.0134						0		30	
1,2,3-Trichlorobenzene	ND	0.00891						0		30	
Surr: Dibromofluoromethane	0.497		0.5566		89.2	56.5	129		0		
Surr: Toluene-d8	0.533		0.5566		95.8	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.530		0.5566		95.1	63.1	141		0		

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.442	0.0321	0.5357	0	82.4	43.5	121				
Chloromethane	0.569	0.0321	0.5357	0.03912	98.9	45	130				
Vinyl chloride	0.518	0.00107	0.5357	0	96.6	51.2	146				
Bromomethane	0.371	0.0482	0.5357	0.02986	63.7	21.3	120				
Trichlorofluoromethane (CFC-11)	0.408	0.0268	0.5357	0	76.1	35	131				
Chloroethane	0.468	0.0321	0.5357	0	87.3	31.9	123				
1,1-Dichloroethene	0.506	0.0268	0.5357	0	94.4	61.9	141				
Methylene chloride	0.531	0.0107	0.5357	0	99.1	54.7	142				
trans-1,2-Dichloroethene	0.528	0.0107	0.5357	0	98.5	52	136				
Methyl tert-butyl ether (MTBE)	0.613	0.0268	0.5357	0.01279	112	54.4	132				
1,1-Dichloroethane	0.531	0.0107	0.5357	0	99.1	51.8	141				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
2,2-Dichloropropane	0.535	0.0268	0.5357	0	99.8	36	123				
cis-1,2-Dichloroethene	0.521	0.0107	0.5357	0	97.2	58.6	136				
Chloroform	0.512	0.0107	0.5357	0	95.6	53.2	129				
1,1,1-Trichloroethane (TCA)	0.496	0.0107	0.5357	0	92.5	58.3	145				
1,1-Dichloropropene	0.548	0.0107	0.5357	0	102	55.1	138				
Carbon tetrachloride	0.471	0.0107	0.5357	0	87.9	53.3	144				
1,2-Dichloroethane (EDC)	0.549	0.0161	0.5357	0	102	51.3	139				
Benzene	0.543	0.0107	0.5357	0.02096	97.4	63.5	133				
Trichloroethene (TCE)	0.508	0.0107	0.5357	0	94.8	68.6	132				
1,2-Dichloropropane	0.544	0.0107	0.5357	0	101	59	136				
Bromodichloromethane	0.418	0.0107	0.5357	0	78.0	50.7	141				
Dibromomethane	0.501	0.0214	0.5357	0	93.4	50.6	137				
cis-1,3-Dichloropropene	0.542	0.0107	0.5357	0	101	50.4	138				
Toluene	0.551	0.0107	0.5357	0.02369	98.4	63.4	132				
trans-1,3-Dichloropropylene	0.541	0.0161	0.5357	0	101	44.1	147				
1,1,2-Trichloroethane	0.524	0.0161	0.5357	0	97.8	51.6	137				
1,3-Dichloropropane	0.539	0.0268	0.5357	0	101	53.1	134				
Tetrachloroethene (PCE)	0.543	0.0107	0.5357	0	101	35.6	158				
Dibromochloromethane	0.440	0.0161	0.5357	0	82.2	55.3	140				
1,2-Dibromoethane (EDB)	0.518	0.00268	0.5357	0	96.7	50.4	136				
Chlorobenzene	0.542	0.0107	0.5357	0	101	60	133				
1,1,1,2-Tetrachloroethane	0.484	0.0161	0.5357	0	90.4	53.1	142				
Ethylbenzene	0.568	0.0161	0.5357	0.02044	102	54.5	134				
m,p-Xylene	1.14	0.0107	1.071	0.04232	102	53.1	132				
o-Xylene	0.578	0.0107	0.5357	0.02144	104	53.3	139				
Styrene	0.555	0.0107	0.5357	0	104	51.1	132				
Isopropylbenzene	0.562	0.0429	0.5357	0	105	58.9	138				
Bromoform	0.352	0.0107	0.5357	0	65.7	57.9	130				
1,1,2,2-Tetrachloroethane	0.521	0.0107	0.5357	0	97.2	51.9	131				
n-Propylbenzene	0.573	0.0107	0.5357	0	107	53.6	140				
Bromobenzene	0.559	0.0161	0.5357	0	104	54.2	140				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
1,3,5-Trimethylbenzene	0.564	0.0107	0.5357	0	105	51.8	136				
2-Chlorotoluene	0.548	0.0107	0.5357	0	102	51.6	136				
4-Chlorotoluene	0.560	0.0107	0.5357	0	104	50.1	139				
tert-Butylbenzene	0.569	0.0107	0.5357	0	106	50.5	135				
1,2,3-Trichloropropane	0.550	0.0107	0.5357	0	103	50.5	131				
1,2,4-Trichlorobenzene	0.694	0.0268	0.5357	0	129	50.8	130				
sec-Butylbenzene	0.619	0.0107	0.5357	0	116	52.6	141				
4-Isopropyltoluene	0.634	0.0107	0.5357	0	118	52.9	134				
1,3-Dichlorobenzene	0.563	0.0107	0.5357	0	105	52.6	131				
1,4-Dichlorobenzene	0.575	0.0107	0.5357	0	107	52.9	129				
n-Butylbenzene	0.670	0.0107	0.5357	0	125	52.6	130				
1,2-Dichlorobenzene	0.567	0.0107	0.5357	0	106	55.8	129				
1,2-Dibromo-3-chloropropane	0.429	0.268	0.5357	0	80.0	40.5	131				
1,2,4-Trimethylbenzene	0.613	0.0107	0.5357	0	114	50.6	137				
Hexachlorobutadiene	0.693	0.0536	0.5357	0	129	40.6	158				
Naphthalene	0.744	0.0161	0.5357	0	139	52.3	124				S
1,2,3-Trichlorobenzene	0.651	0.0107	0.5357	0	121	54.4	124				
Surr: Dibromofluoromethane	0.579		0.6696		86.4	56.5	129				
Surr: Toluene-d8	0.663		0.6696		99.0	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	0.725		0.6696		108	63.1	141				

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.442	0.0321	0.5357	0	82.6	43.5	121	0.4416	0.155	30	
Chloromethane	0.558	0.0321	0.5357	0.03912	96.9	45	130	0.5688	1.90	30	
Vinyl chloride	0.504	0.00107	0.5357	0	94.1	51.2	146	0.5177	2.72	30	
Bromomethane	0.381	0.0482	0.5357	0.02986	65.6	21.3	120	0.3710	2.78	30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Trichlorofluoromethane (CFC-11)	0.462	0.0268	0.5357	0	86.3	35	131	0.4079	12.5	30	
Chloroethane	0.482	0.0321	0.5357	0	89.9	31.9	123	0.4679	2.91	30	
1,1-Dichloroethene	0.515	0.0268	0.5357	0	96.2	61.9	141	0.5057	1.83	30	
Methylene chloride	0.511	0.0107	0.5357	0	95.3	54.7	142	0.5308	3.86	30	
trans-1,2-Dichloroethene	0.528	0.0107	0.5357	0	98.6	52	136	0.5277	0.124	30	
Methyl tert-butyl ether (MTBE)	0.570	0.0268	0.5357	0.01279	104	54.4	132	0.6125	7.15	30	
1,1-Dichloroethane	0.533	0.0107	0.5357	0	99.5	51.8	141	0.5309	0.397	30	
2,2-Dichloropropane	0.539	0.0268	0.5357	0	101	36	123	0.5346	0.739	30	
cis-1,2-Dichloroethene	0.516	0.0107	0.5357	0	96.4	58.6	136	0.5208	0.850	30	
Chloroform	0.508	0.0107	0.5357	0	94.9	53.2	129	0.5124	0.804	30	
1,1,1-Trichloroethane (TCA)	0.505	0.0107	0.5357	0	94.3	58.3	145	0.4955	1.95	30	
1,1-Dichloropropene	0.547	0.0107	0.5357	0	102	55.1	138	0.5477	0.134	30	
Carbon tetrachloride	0.515	0.0107	0.5357	0	96.1	53.3	144	0.4709	8.93	30	
1,2-Dichloroethane (EDC)	0.507	0.0161	0.5357	0	94.6	51.3	139	0.5488	7.98	30	
Benzene	0.537	0.0107	0.5357	0.02096	96.3	63.5	133	0.5428	1.11	30	
Trichloroethene (TCE)	0.514	0.0107	0.5357	0	95.9	68.6	132	0.5081	1.12	30	
1,2-Dichloropropane	0.530	0.0107	0.5357	0	99.0	59	136	0.5436	2.51	30	
Bromodichloromethane	0.422	0.0107	0.5357	0	78.8	50.7	141	0.4180	0.992	30	
Dibromomethane	0.480	0.0214	0.5357	0	89.7	50.6	137	0.5005	4.13	30	
cis-1,3-Dichloropropene	0.535	0.0107	0.5357	0	99.8	50.4	138	0.5425	1.47	30	
Toluene	0.550	0.0107	0.5357	0.02369	98.3	63.4	132	0.5510	0.108	30	
trans-1,3-Dichloropropylene	0.529	0.0161	0.5357	0	98.8	44.1	147	0.5410	2.23	30	
1,1,2-Trichloroethane	0.489	0.0161	0.5357	0	91.2	51.6	137	0.5241	7.03	30	
1,3-Dichloropropane	0.503	0.0268	0.5357	0	94.0	53.1	134	0.5386	6.73	30	
Tetrachloroethene (PCE)	0.544	0.0107	0.5357	0	102	35.6	158	0.5434	0.175	30	
Dibromochloromethane	0.430	0.0161	0.5357	0	80.2	55.3	140	0.4401	2.39	30	
1,2-Dibromoethane (EDB)	0.482	0.00268	0.5357	0	89.9	50.4	136	0.5182	7.30	30	
Chlorobenzene	0.530	0.0107	0.5357	0	98.8	60	133	0.5420	2.32	30	
1,1,1,2-Tetrachloroethane	0.482	0.0161	0.5357	0	90.0	53.1	142	0.4844	0.461	30	
Ethylbenzene	0.554	0.0161	0.5357	0.02044	99.6	54.5	134	0.5677	2.41	30	
m,p-Xylene	1.11	0.0107	1.071	0.04232	99.2	53.1	132	1.136	2.76	30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
o-Xylene	0.555	0.0107	0.5357	0.02144	99.6	53.3	139	0.5780	4.07	30	
Styrene	0.529	0.0107	0.5357	0	98.8	51.1	132	0.5554	4.80	30	
Isopropylbenzene	0.546	0.0429	0.5357	0	102	58.9	138	0.5616	2.80	30	
Bromoform	0.341	0.0107	0.5357	0	63.6	57.9	130	0.3521	3.26	30	
1,1,2,2-Tetrachloroethane	0.463	0.0107	0.5357	0	86.5	51.9	131	0.5207	11.7	30	
n-Propylbenzene	0.544	0.0107	0.5357	0	102	53.6	140	0.5730	5.09	30	
Bromobenzene	0.519	0.0161	0.5357	0	96.8	54.2	140	0.5591	7.51	30	
1,3,5-Trimethylbenzene	0.537	0.0107	0.5357	0	100	51.8	136	0.5640	4.90	30	
2-Chlorotoluene	0.531	0.0107	0.5357	0	99.1	51.6	136	0.5485	3.24	30	
4-Chlorotoluene	0.532	0.0107	0.5357	0	99.3	50.1	139	0.5596	5.05	30	
tert-Butylbenzene	0.550	0.0107	0.5357	0	103	50.5	135	0.5690	3.32	30	
1,2,3-Trichloropropane	0.466	0.0107	0.5357	0	87.0	50.5	131	0.5504	16.6	30	
1,2,4-Trichlorobenzene	0.626	0.0268	0.5357	0	117	50.8	130	0.6935	10.3	30	
sec-Butylbenzene	0.584	0.0107	0.5357	0	109	52.6	141	0.6188	5.79	30	
4-Isopropyltoluene	0.593	0.0107	0.5357	0	111	52.9	134	0.6342	6.65	30	
1,3-Dichlorobenzene	0.566	0.0107	0.5357	0	106	52.6	131	0.5631	0.492	30	
1,4-Dichlorobenzene	0.570	0.0107	0.5357	0	106	52.9	129	0.5750	0.915	30	
n-Butylbenzene	0.671	0.0107	0.5357	0	125	52.6	130	0.6697	0.243	30	
1,2-Dichlorobenzene	0.562	0.0107	0.5357	0	105	55.8	129	0.5675	1.03	30	
1,2-Dibromo-3-chloropropane	0.383	0.268	0.5357	0	71.5	40.5	131	0.4288	11.3	30	
1,2,4-Trimethylbenzene	0.560	0.0107	0.5357	0	105	50.6	137	0.6134	9.04	30	
Hexachlorobutadiene	0.684	0.0536	0.5357	0	128	40.6	158	0.6932	1.31	30	
Naphthalene	0.633	0.0161	0.5357	0	118	52.3	124	0.7442	16.1	30	
1,2,3-Trichlorobenzene	0.577	0.0107	0.5357	0	108	54.4	124	0.6505	12.0	30	
Surr: Dibromofluoromethane	0.620		0.6696		92.5	56.5	129		0		
Surr: Toluene-d8	0.659		0.6696		98.4	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.699		0.6696		104	63.1	141		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680789**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0284						0		30	Q
Chloromethane	0.0363	0.0284						0.03933	8.01	30	
Vinyl chloride	ND	0.000946						0		30	
Bromomethane	ND	0.0426						0		30	
Trichlorofluoromethane (CFC-11)	ND	0.0236						0		30	
Chloroethane	ND	0.0284						0		30	
1,1-Dichloroethene	ND	0.0236						0		30	
Methylene chloride	ND	0.00946						0		30	
trans-1,2-Dichloroethene	ND	0.00946						0		30	
Methyl tert-butyl ether (MTBE)	ND	0.0236						0		30	
1,1-Dichloroethane	ND	0.00946						0		30	
2,2-Dichloropropane	ND	0.0236						0		30	
cis-1,2-Dichloroethene	ND	0.00946						0		30	
Chloroform	ND	0.00946						0		30	
1,1,1-Trichloroethane (TCA)	ND	0.00946						0		30	
1,1-Dichloropropene	ND	0.00946						0		30	
Carbon tetrachloride	ND	0.00946						0		30	
1,2-Dichloroethane (EDC)	ND	0.0142						0		30	
Benzene	ND	0.00946						0		30	
Trichloroethene (TCE)	ND	0.00946						0		30	
1,2-Dichloropropane	ND	0.00946						0		30	
Bromodichloromethane	ND	0.00946						0		30	
Dibromomethane	ND	0.0189						0		30	
cis-1,3-Dichloropropene	ND	0.00946						0		30	
Toluene	ND	0.00946						0		30	
trans-1,3-Dichloropropylene	ND	0.0142						0		30	
1,1,2-Trichloroethane	ND	0.0142						0		30	
1,3-Dichloropropane	ND	0.0236						0		30	
Tetrachloroethene (PCE)	ND	0.00946						0		30	
Dibromochloromethane	ND	0.0142						0		30	
1,2-Dibromoethane (EDB)	ND	0.00236						0		30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680789**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorobenzene	ND	0.00946						0		30	
1,1,1,2-Tetrachloroethane	ND	0.0142						0		30	
Ethylbenzene	ND	0.0142						0		30	
m,p-Xylene	ND	0.00946						0		30	
o-Xylene	ND	0.00946						0		30	
Styrene	ND	0.00946						0		30	
Isopropylbenzene	ND	0.0378						0		30	
Bromoform	ND	0.00946						0		30	Q
1,1,2,2-Tetrachloroethane	ND	0.00946						0		30	
n-Propylbenzene	ND	0.00946						0		30	
Bromobenzene	ND	0.0142						0		30	
1,3,5-Trimethylbenzene	ND	0.00946						0		30	
2-Chlorotoluene	ND	0.00946						0		30	
4-Chlorotoluene	ND	0.00946						0		30	
tert-Butylbenzene	ND	0.00946						0		30	
1,2,3-Trichloropropane	ND	0.00946						0		30	
1,2,4-Trichlorobenzene	ND	0.0236						0		30	
sec-Butylbenzene	ND	0.00946						0		30	
4-Isopropyltoluene	ND	0.00946						0		30	
1,3-Dichlorobenzene	ND	0.00946						0		30	
1,4-Dichlorobenzene	ND	0.00946						0		30	
n-Butylbenzene	ND	0.00946						0		30	
1,2-Dichlorobenzene	ND	0.00946						0		30	
1,2-Dibromo-3-chloropropane	ND	0.236						0		30	
1,2,4-Trimethylbenzene	ND	0.00946						0		30	
Hexachlorobutadiene	ND	0.0473						0		30	
Naphthalene	ND	0.0142						0		30	
1,2,3-Trichlorobenzene	ND	0.00946						0		30	
Surr: Dibromofluoromethane	0.500		0.5912		84.5	56.5	129		0		
Surr: Toluene-d8	0.568		0.5912		96.2	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.569		0.5912		96.2	63.1	141		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680789**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Fremont Analytical

Sample Log-In Check List

Client Name: **SW**	Work Order Number: **1704169**
Logged by: **Clare Griggs**	Date Received: **4/13/2017 11:52:00 AM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☐ Not Required ☑
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >0°C to 10.0°C* Yes ☐ No ☑ NA ☐

Sample received straight from field

8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☑ No ☐ NA ☐ MeOH
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: ____ Date ____
By Whom: ____ Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding: ____
Client Instructions: ____

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	6.4
Sample	13.5
Temp Blank	9.9

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 4/13/2017 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1704169

Special Remarks:

Client: STW

Address: 400 N. 34 ST

City, State, Zip: SEATTLE , WA

Telephone: 206-~~224-4~~695-6918

Fax:

Project Name: BALLARD CONVEYANCE

Project No: 21-1-22329-002

Collected by: JAA

Location: BALLARD

Report To (PM): ~~djr@s~~han DAVID RANDALL

PM Email: djr@shanwil.com

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)					Comments
1	BCT-04-ENV	4/13/2017	11:30	SOIL	X			X		X				X								
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 [✓ RCRA-8] Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

*****Anions (Circle):** Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Jorge Avalos Date/Time 4/13/17 11:55

Received x Date/Time 4/13/17 11:52

Relinquished x Date/Time

Received x Date/Time

Turn-around Time:

☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ (specify)

APPENDIX E

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-22329-004

Date: July 19, 2017
To: Seattle Public Utilities
Seattle, Washington

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

APPENDIX H:

VALUE MODELING TECHNICAL MEMORANDUM.

Seattle Public Utilities

Value Modeling Technical Memorandum

Date Prepared	June 1, 2018
Project Phase	Options Analysis/Stage Gate 2
Prepared By	Emiko Takahashi, SPU
Project Name	Ballard Conveyance
Activity Number	C315506
Fund & Business Area	Drainage & Waste Water Fund
Sub-Budget Control Level	Ship Canal Water Quality Program
Executive Sponsor	Madeline Goddard
DWW LOB Representative	Alex Mockos
Project Manager	Richard Fernandez

1 PROJECT SCOPE

This memorandum documents the value modeling process with the overall goal of helping SPU choose an alignment for the Ballard Conveyance for the Ship Canal Water Quality Project.

Value Modeling is a tool that SPU uses to a) evaluate the project alternatives based on quantifiable and non-quantifiable project objectives, b) communicate tradeoffs between competing objectives from multiple stakeholders, and c) document the process and rationale for choosing a preferred project alternative.

The value modeling process involved six major steps
1) define the relevant evaluation criteria and sub-criteria,
2) define performance measures,
3) assign weight,
4) score each evaluation criteria,
5) calculate a value score, and
6) compare the value against project cost.

The first two steps were initiated and refined during concept development. As the team was conducting options analysis for the three proposed alignments, they convened on August 3, 2017 and September 12, 2017 to discuss and agree on the evaluation criteria, sub-criteria, and performance measures; assign weights; and assign, discuss, and agree on the final scores of the Options.

2 PROJECT BACKGROUND

The Ship Canal Project storage is a deep tunnel constructed under the Ballard, Fremont and Wallingford neighborhoods, on the north side of the Ship Canal (Figure 2-1). It will control the Ballard CSO Basins 150/151 and 152, Fremont Basin 174 and Wallingford Basin 147A and 147B; and DNRP 3rd Avenue W Basin, and 11th Avenue NW Basin. The main components of the Ship Canal Project are the 18-foot 10-inch diameter storage tunnel, appurtenances, and conveyance facilities to convey SPU and DNRP CSO flows into the tunnel and a pump station and force main to drain flows from the tunnel to King County's treatment facility.

One of the elements of the Ship Canal Project is Ballard Conveyance system that collects CSOs from SPU Ballard Basins 150/151 and 152 and routes it to the tunnel storage. The scope of the Ballard Conveyance project includes the planning, design and construction of the flow conveyance to the storage tunnel, including the piping, and diversion structures.

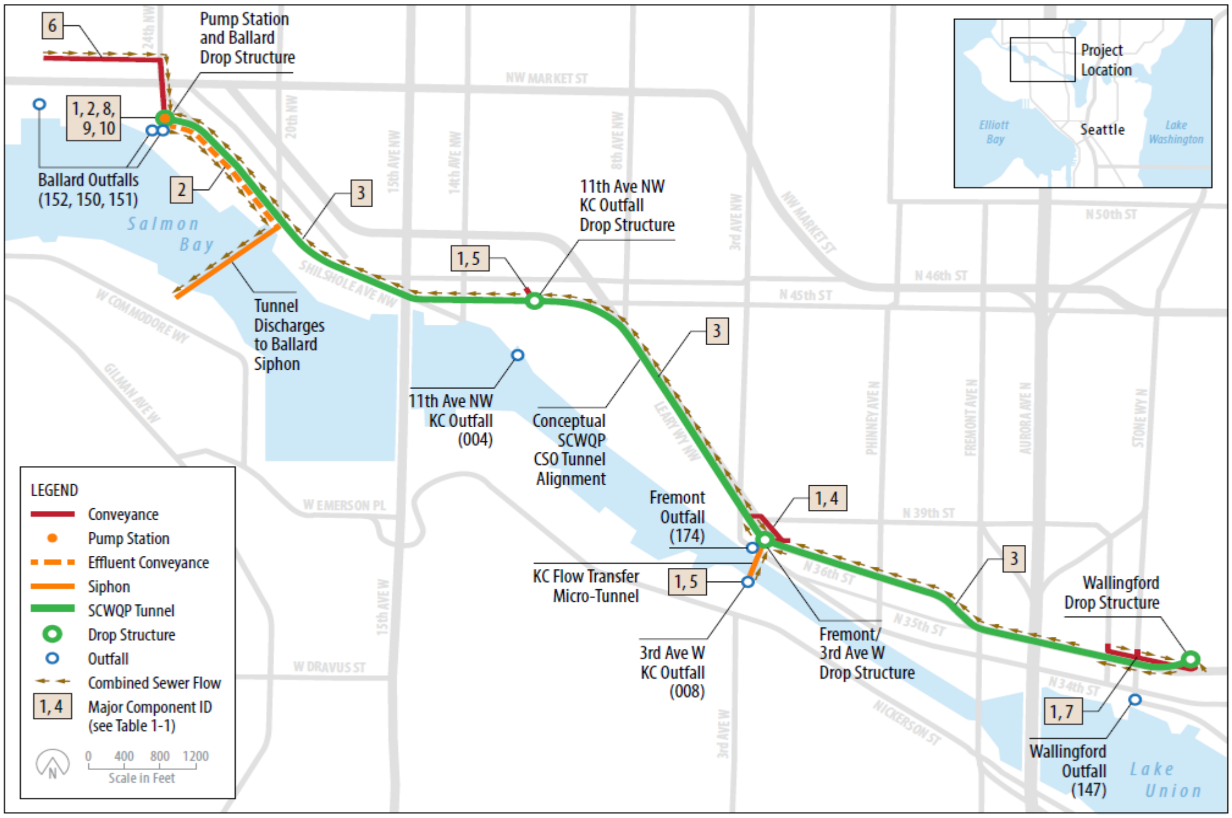


Figure 2-1. Ship Canal Water Quality Project extents

3 OPTION OVERVIEW

From the options analysis process and goals, SPU developed three options for analysis

Option 1 (NW 56th Street): The land-use of this alignment is mainly residential with single family and multi-family residences along NW 56th Street and businesses and mixed development along 24th Avenue NW. It extends from the proposed diversion structure near the intersection of NW 56th Street and 28th Avenue NW east on NW 56th Street and south on 24th Avenue NW to the Tunnel Effluent Pump Station (TEPS) site southeast of the intersection between NW 54th Street (Figure 3-1). It accommodates transit traffic on the commercial street of 24th Avenue NW.

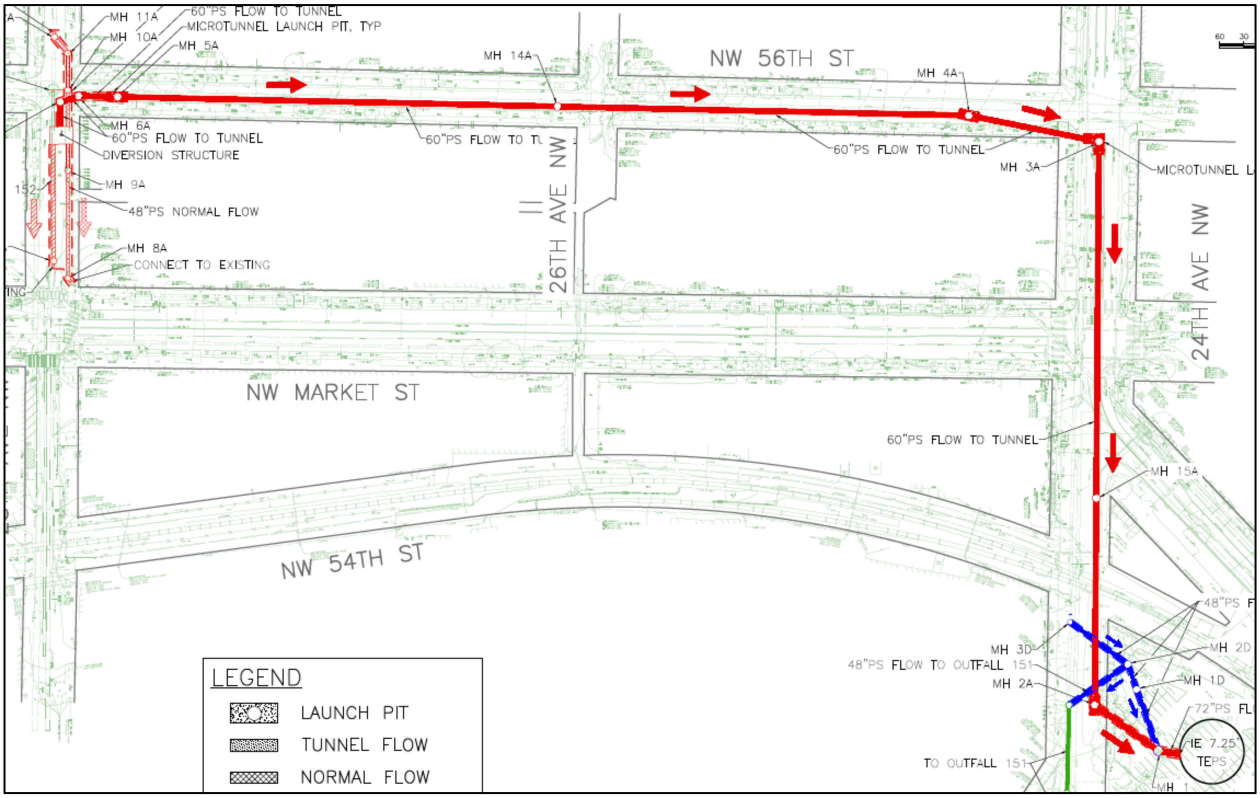


Figure 3-1. Option 1 – NW 56th Street Alignment

Alternative 2 (NW Market Street):
The land-use along the alignment of the conveyance pipes, NW Market Street and 24th Avenue NW, is composed of commercial and business use. It extends from the proposed diversion structure near the intersection of NW 56th Street and 28th Avenue NW south on 28th Avenue NW, east on NW Market Street and south on 24th Avenue NW to the TEPS site (Figure 3-2). Both streets are minor arterials with high traffic volumes and transit traffic. In addition, NW Market Street is selected for the Burke Gilman Missing Link project alignment and is proposed to add a bicycle lane.

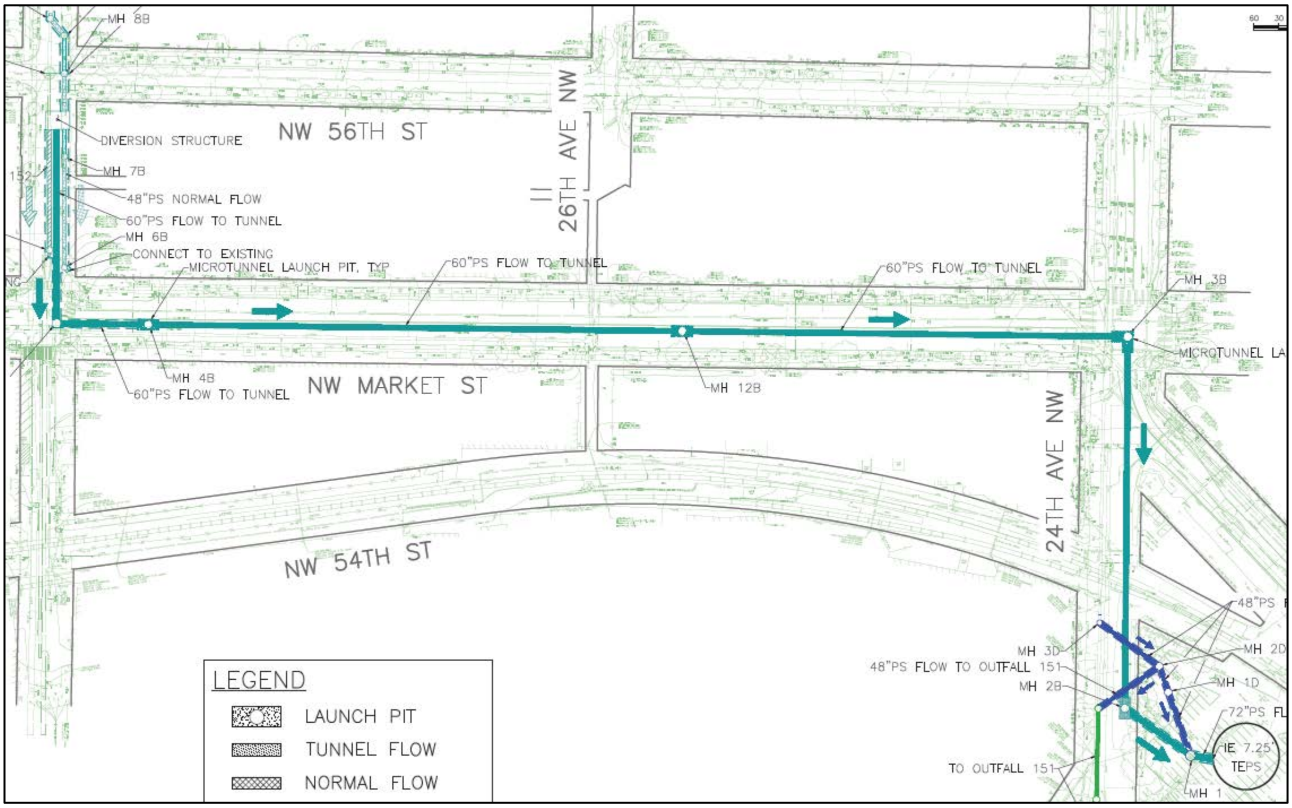


Figure 3-2. Option 2 – NW Market Street Alignment

Option 3 (NW 54th Street): The land-use for this alignment along NW 54th Street is mainly industrial. It extends from the proposed diversion structure near the intersection of NW 56th Street and 28th Avenue NW south on 28th Avenue NW, east on NW 54th Street to the TEPS site (Figure 3-3). The existing "road" is extremely narrow, has a split-level section and is not a City right-of-way. This alignment also houses railroad tracks and a 12" watermain that would need to be relocated between 26th Avenue NW and 24th Avenue NW along NW 54th Street requiring extensive shoring adjacent to the existing railroad.

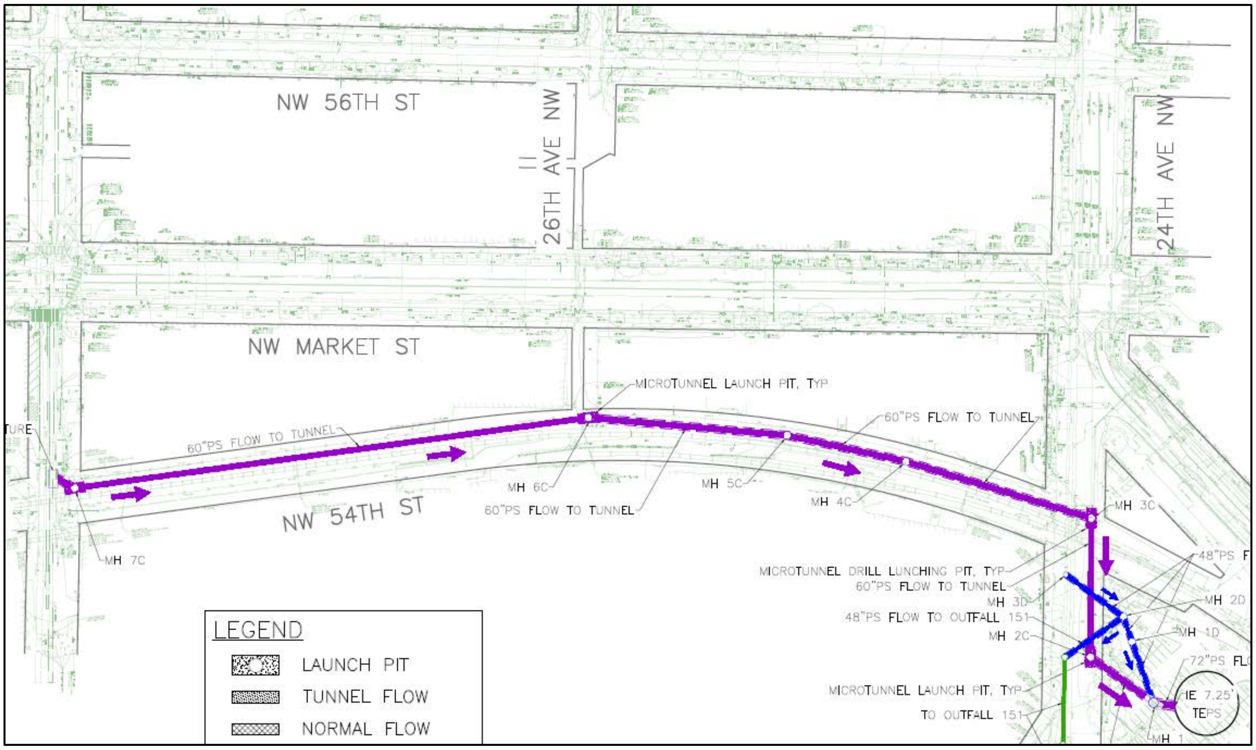


Figure 3-3. Option 3 -NW 54th Street Alignment

4 VALUE MODELING PROCESS AND EVALUATION PERFORMANCE

4.1. Define Evaluation Criteria

Evaluation criteria were developed to measure how well each Option would meet project objectives. The following Project team members Richard Fernandez (Project Manager), Eset Alemu (Project Engineer), Alex Mockos (LOB Representative), Rachel Ramey (Community Outreach), Brian Mickelson (Community Outreach), Vicky Raya (Race and Social Justice), Cynthia Blazina (Construction Management), Jonathan Batara (Maintenance) and Emiko Takahashi (Economics) developed the following 3 categories of evaluation criteria in advance of a meeting with the entire team.

- Criterion #1: Short-term Impact to Community
- Criterion #2: Long term Community Impact from Maintenance
- Criterion #3: Construction risk
- Criterion #4: Ease and Safety of Maintenance
- Criterion #5: Construction complexity

The project team wanted to capture the very different short-term construction impacts the three options would have on the community. They identified different stakeholders that would be impacted including: residents, business owners, transit riders, drivers along arterial, users of the Burke Gilman Trail, and those served by the railroad along NW 54th Street. The first criteria of Short-term Construction impact to Community was broken down into sub-criteria based on the impacted groups. The sub-criteria were:

2.1.1 Access to Residences, Business and Industrial Facilities
2.1.2 Impact on Transit Riders
2.1.3 Impact on Vehicular and Truck Traffic
2.1.4 Railroad loss of use
2.1.5 Impact on Business Activities
2.1.6 Impact on Future Burke Gilman

Sub Criteria 2.1.1 Access to Residences, Business and Industrial Facilities measures the construction impact to residents, businesses and industrial facility owners' ability to access their properties. These sub-criteria were measured with the 'number of days entries/exits/driveways were obstructed or blocked'. The term 'obstructed' was defined as construction happening on street causing delays or detours and "blocked' meant no ability to access driveway or entry. Obstructions were considered less adverse than blocked and therefore were only counted as ½ of a much as 'blocked'. To develop the measure, the number of entry/exits from residences/business/lanes of traffic that would be obstructed and/or blocked were counted and multiplied by the number of construction days as shown in Table 4-1. The impact on the ROW was measured by the access to parking spots in the ROW.

Table 4-1. Loss of Access Impacts Along the Alignments

Options	Stakeholders	Number of Obstructed or Blocked Days
Option 1 – NW 56th Street	Residences	24,140
	Businesses	-
	ROW	34,200
Option 2 – NW Market Street	Residences	-
	Businesses	25,200
	ROW	46,800
Option 3 – NW 54th Street	Residences	-
	Businesses	27,600
	ROW	21,300

From the data above, it is apparent that Option 1 has a sizable impact on Residences while Option 2 and 3 has an impact on Businesses and on the ROW (NW Market Street and NW 54th Street).

For sub-criteria 2.1.2 impact to Transit, the number of bus trips per week were counted and was used as a proxy of the potential disruptions to transit if construction was along an alignment. Option 2's alignment includes NW Market Street, a major arterial with many buses running along trolley lines. Option 2 had the most number of trips per week with Option 3 having no transit along it's alignment. Option 1 had some impact as buses that run north/south along 24th Avenue NW. A map of the bus routes is below in Figure 4-1. Bus routes #44, and #40 run frequently whereas the other lines run only at peak hours.

Figure 4-1. Map of Bus Routes in Project Options

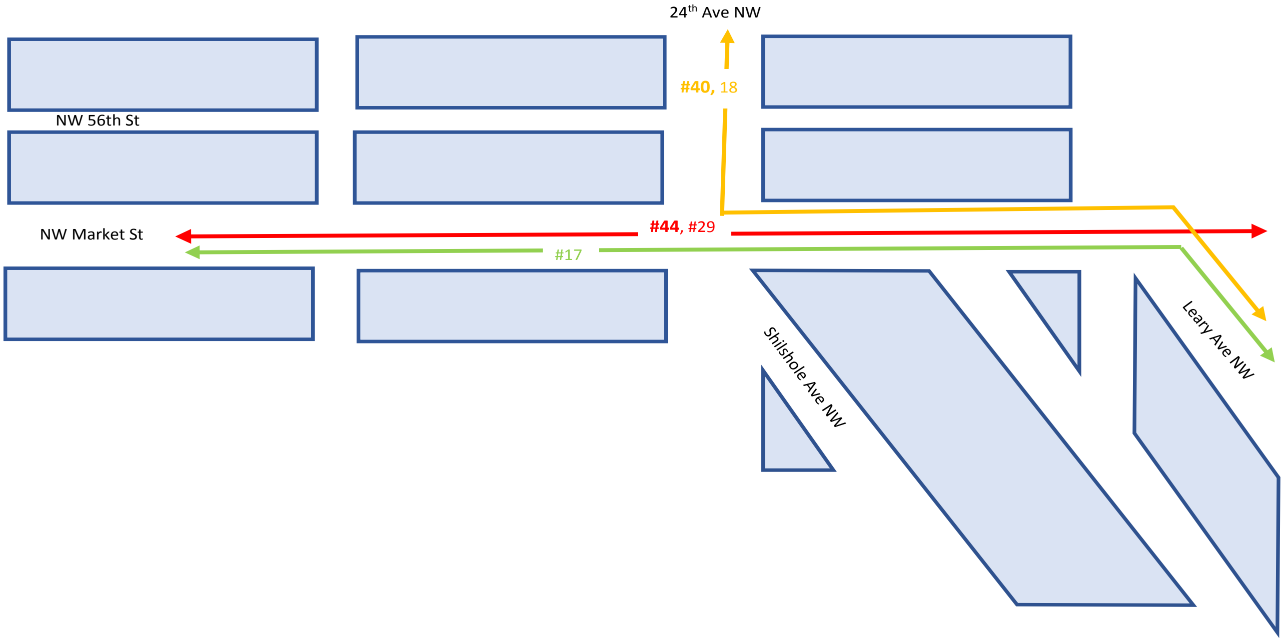


Figure 4-2. Number of Bus Trips Per Week

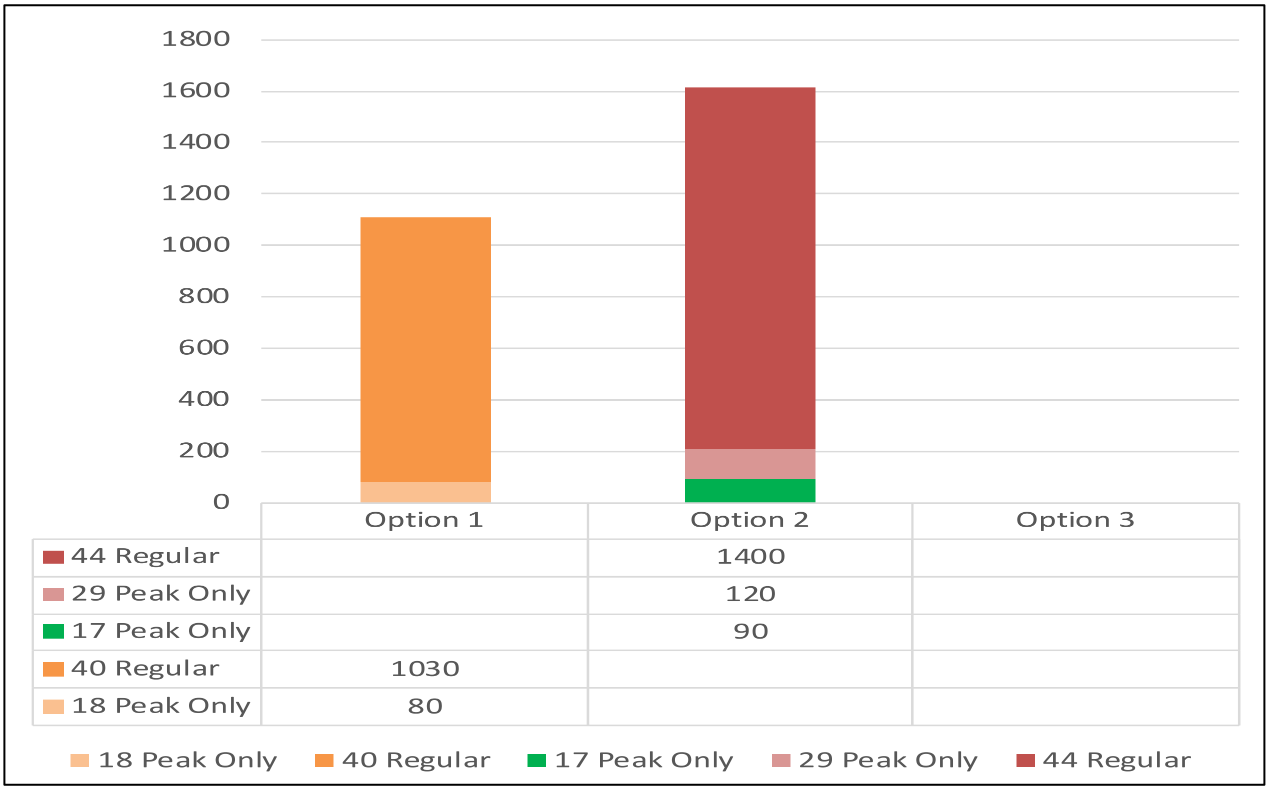


Table 4-1 and Figure 4-2 above show the 1610 trips/week along NW Market Street in Option 2 and the 1110 trips/week along 24th Avenue NW in Option 1.

For Sub-Criteria 2.1.5 Impact on Businesses, the number of businesses that could be impacted by construction was based Google map's street view and looking up company websites. From the research, it was determined that the Option1 alignment could affect 7 businesses and 24th Avenue NW and Option 2 would affect 24 businesses mostly on NW Market Street and Option 3 would affect 10 businesses mostly along NW 56th Street:

During first value model meeting, on August 3, 2017, two additional criteria "2.2 Long-term impacts on community" and "2.4 Ease of Maintenance" were added. SPU FOM was concerned that the land use and width of the alignments may impact the ease of future replacements.

Sub-criteria that would have an equally scored rating for all Options were excluded because they did not add to helping differentiate between options.

The performance measures for all the evaluation criteria and sub -criterion are shown in Table 4-2.

Table 4-2 Outcome of Sub-Criteria and Performance Measures Screening

Evaluation Criteria	Sub-Criteria	Measure
2.1 Short-term Community Impacts	2.1.1 Access to Residences, Business and Industrial Facilities	Impacted/Obstructed total number of days
	2.1.2 Impact on Transit Riders	Buses per week
	2.1.3 Impact on Vehicular and Truck Traffic	Average vehicle per week
	2.1.4 Railroad loss of use	Trips per week
	2.1.5 Impact on Business Activities	Number of business
	2.1.6 Impact on Future Burke Gilman	Cyclists and Pedestrians per week in 2022
2.2 Long term Community Impact		Scale 1-5
2.3 Construction Risk	2.3.1 Reduces risk of finding contaminated soils beyond what was expected and causes increased costs and delay in schedule.	Scale 1-5
	2.3.2 risk of property or easement acquisitions can be completed in timely manner	Scale 1-5
2.4 Practical and Safe to Maintain	2.4.1 Ease of Future Replacement	Scale 1-5
	2.4.2 Practicality of maintenance (e.g., access, safety)	Scale 1-5
2.5 Construction Complexity		Scale 1-5

4.1 Performance Measures

The performance scale for Criterion #1 Short-term impact to the community had a high score of 0 (where there was no impact) to a low score for the highest impact to the community. For example, if an option such as Option 3, had no impact on transit, it scored 0 which meant it had no impact which is good at minimizing the impact on the community, while Option 2 scored the worst by having the potential to impact 1610 transit trips/week and scored 1610. Performance measures for other sub-criterion were qualitatively described on a performance scale of 1 to 5, where 1 was the lowest score and 5 was the best possible score.

4.2 Assign Weights

During the 1st team meeting on August 3, 2017, project team members individually assigned weights to each evaluation criteria which were then averaged to come up with a starting point for criteria weights for each evaluation criteria. The team discussed and agreed that the project team average for each evaluation criteria was a good representation of the relative importance of each criterion. The averages are show in Table 4-3 below:

Table 4-3 Weights Assigned to Evaluation Criteria

Criteria	Weight
2.1 Short-term Community Impacts	30.3
2.2 Long term Community Impact from Maintenance	11.3
2.3 Construction Risk	18.8
2.4 Ease of Maintenance	25.9
2.5 Construction Complexity	13.8

Total of weights equals 100%.

For simplicity, the sub-criteria of each evaluation criteria were initially assumed to have equal weight within the major evaluation criteria. For example, the five sub-criteria of an evaluation criterion “Short-term impact on Community” were each given an equal weight of 6 percent each, which is one-fifth of 30% as shown in Table 4-4.

Table 4-4. Sub-Criteria Weighting Distribution for Criterion #2.1

	Sub-Criteria	Weight
2.1.1	Access to Residences, Business and Industrial Facilities	6.1%
2.1.2	Impact on Transit Riders	6.1%
2.1.3	Impact on Vehicular and Truck Traffic	6.1%
2.1.4	Railroad loss of use	6.1%
2.1.5	Impact on Business Activities	6.1%
2.1.6	Impact on Future Burke Gilman	6.1%

In the second workshop, the project team reviewed, discussed and agreed to the averages of individual weights were a good representation of the relative importance of the criteria and confirmed that changes to their initial weights were not necessary.

4.3 Scoring Options against Performance Measures and Rationale

The smaller sub-team completed an initial scoring and provided rationale based on the information obtained during the options analysis and without a construction management report. During the second value modeling workshop on September 12, 2017 project team members reviewed and reconciled the performance scale value and rationale for each sub-criterion. The agreed upon project team scores and rationale are provided in Table 4-5. The green shading in the table below illustrates that the option did well relative to that criteria, whereas red shading highlights that an option scored poorly in the criteria.

Table 4-5 Sub-Criteria Scoring

	Measure	Option 1. NW 56th St	Option 2. NW Market St	Option 3. NW 54th St
2.1 Short-term Community Impacts				
2.1.1 Access to Residences, Business and Industrial Facilities	Impacted/ Obstructed total number of days	58,320	72,000	48,900
2.1.2 Impact on Transit Riders	Buses per week	1,110	1,610	0
2.1.3 Impact on Vehicular and Truck Traffic	Average vehicle per week	12,920	18,630	1,200
2.1.4 Railroad loss of use	Trips per week	0	0	1
2.1.5 Impact on Business Activities	Number of business	7	24	10
2.1.6 Impact on Future Burke Gilman	Cyclists and Pedestrians per week in 2022	0	2,659	0
2.2 Long term Community Impact				
2.2.1 Impact from Long Term Maintenance	Scale 1-5	3	2	4.5
2.3 Construction Risk				
2.3.1 Reduces risk of finding contaminated soils beyond what was expected and causes increased costs and delay in schedule.	Scale 1-5	5	1	1
2.3.2 risk of property or easement acquisitions can be completed in timely manner	Scale 1-5	5	5	1
2.4 Ease of Maintenance				
2.4.1 Ease of Future Replacement	Scale 1-5	3	2	4
2.4.2 Practicality of maintenance (e.g., access, safety)	Scale 1-5	3	2	5
2.5 Construction Complexity	Scale 1-5	3	2	2

4.4 Calculation of Total Values Scores

After scoring, each performance measure was normalized to a scale of zero-to-one by a linear transformation of each score according to its distance from the scale endpoints. The total value score for each option was calculated using a weighted averaging process, in which the total value score is the sum of the percentage-weighted, normalized scores of each sub-criterion.

Value scores were then normalized again to be between 0 and 100, where higher scores indicate that an option performed well on the evaluation criteria. The value scores of the options, from highest to lowest, are 62 for Option 1, 55 for Option 3, and 27 for Planning Option 2. The details of the scores are shown in Figure 4-3.

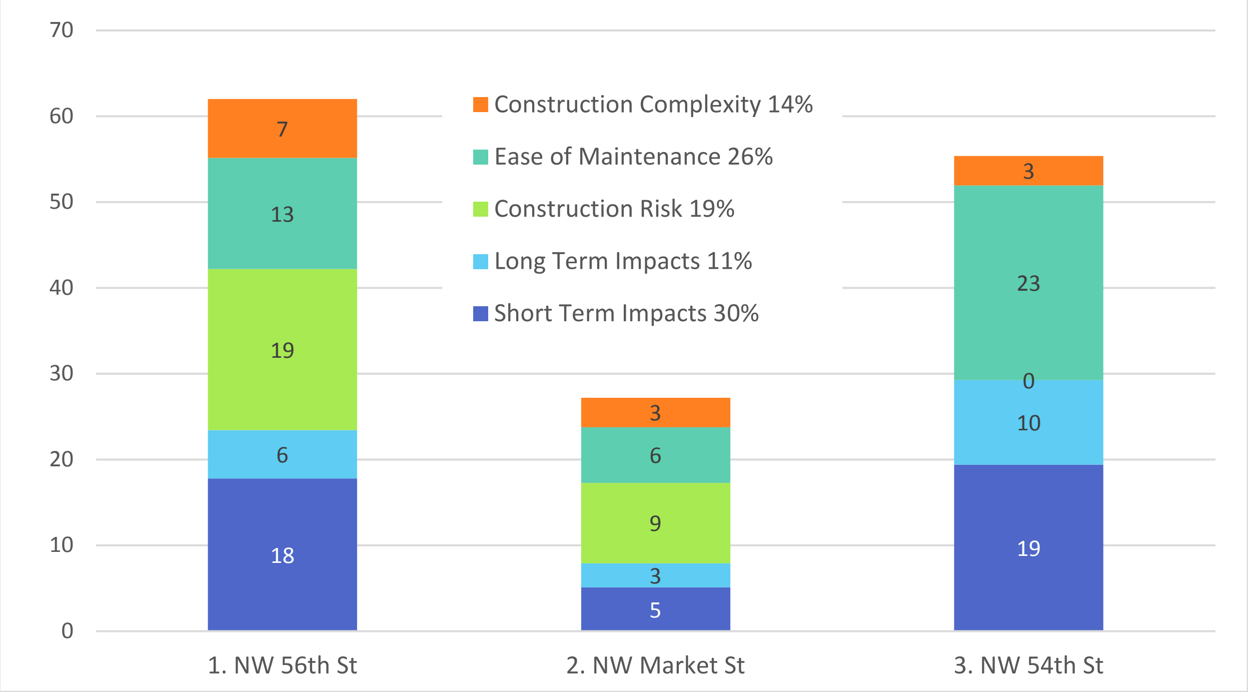


Figure 4-3. Final Value Score for Options #1, #2, and #3

Table 4-6 Criteria and Rationale for Scores

Value Hierarchy		Performance Scales	Option 1 - NW 56th St	Option 2 - NW Market St	Option 3 - NW 54th St
1. Long-run life cycle cost		Minimal land, easement costs, permit fees to SDOT; minimal long-term operation, maintenance and replacement costs			
2.1. Short-term Community Impacts	2.1.1 Access to Residences, Business and Industrial Facilities	Lowest number of loss of access days			
	2.1.2 Impact on Transit Rider	Lowest number of bus trips detoured/week			
	2.1.3 Impact on Vehicular and Truck Traffic	No impact on users. During construction number of users can remain unchanged.			
	2.1.4 Railroad loss of use	No impact on users. During construction number of users can remain unchanged.			
	2.1.5 Impact on Business Activities	No impact on businesses during construction business remain unchanged.			
	2.1.6 Impact on Future Burke Gilman	No impact on cyclist/runners/walkers. During construction number of users can remain unchanged.			
2.2. Long -term Community Impact	2.2.1 Impact from Long Term Maintenance	Minimal impact from Maintenance activities or maintenance activity is consistent with nearby activities	Maintenance will have impact on residential street.	Maintenance on commercial street will occasionally disrupt traffic and business.	Maintenance will have little impact on street that typically has other truck traffic.
2.3. Construction Risk	2.3.1 Risk of finding contaminated soils beyond what was expected and causes increased costs and delay in schedule.	Low risk of contaminated soils based of geotechnical report and past use history	Low risk due to historical use as residential.	Moderate risk as small point with high concentrations of contamination has already been found. High ground water and seepage could help contamination to migrate	High risk as current and historical use has been industrial. High ground water and seepage could help contamination to migrate
	2.3.2 Risk of property or easement acquisitions can be completed in timely manner	No property or easements required as all construction is in City ROW.	All work in ROW	All work in ROW	Will require easements, ownership of parcels is unclear, the area is not ROW.
2.4. Ease of Maintenance	2.4.1 Ease of Future Replacement	Easy to replace components in future. There is space available to replace or repair assets as needed	Deep pipes difficult to replace	Even a temporary reduction in street parking on NW Market Street will not provide ample space for workspace	Option provides the least space and working next to Railroad is difficult. Future repair in area with railroad would be difficult
	2.4.2 Practicality of maintenance (e.g., access, safety)	Maintenance will be more convenient and safe for SPU workers because of access point location (e.g. sidewalk) and accessible at all times. Requires less frequency	Maintenance is difficult with deep maintenance holes	Maintenance will be along NW Market Street which is a busy street. Will require closure of street in case of maintenance.	Maintenance is easy on industrial street which typically has other truck traffic.
2.5. Construction Complexity	Minimal conflicts in location of workspace, staging and trenchless launch and retrieval pits with community activities	Construction locations are away from most community activities or are located where there is space to accommodate construction	Temporary parking restriction and traffic control on low traffic street. Depth of pipe difficult to access and maintain.	Even a temporary reduction in parking on NW Market Street will not provide enough space for workspace	Option provides the least space and working next to Railroad is difficult. Construction area with railroad would be difficult

5 Economic Analysis

The capital cost developed for each option is documented in the Basis of Estimate and summarized below.

5.1 Capital (Total Cost[1])

The construction cost estimate for Option #1 of $16.6 million is higher than Options 2 and 3, which are at $14.9 million and $13.2 million, respectively. The cost drivers for Option #1 is the microtunneling as it has the longest alignment. All options assumed the same percentage for allowance for indeterminates (25%), soft costs (49%), and management reserves (20%). Table 5-1 summarizes the breakdown of the AACE Class 4 construction cost estimate for the options. Figure 5-1 depicts the breakdown of the total capital costs.

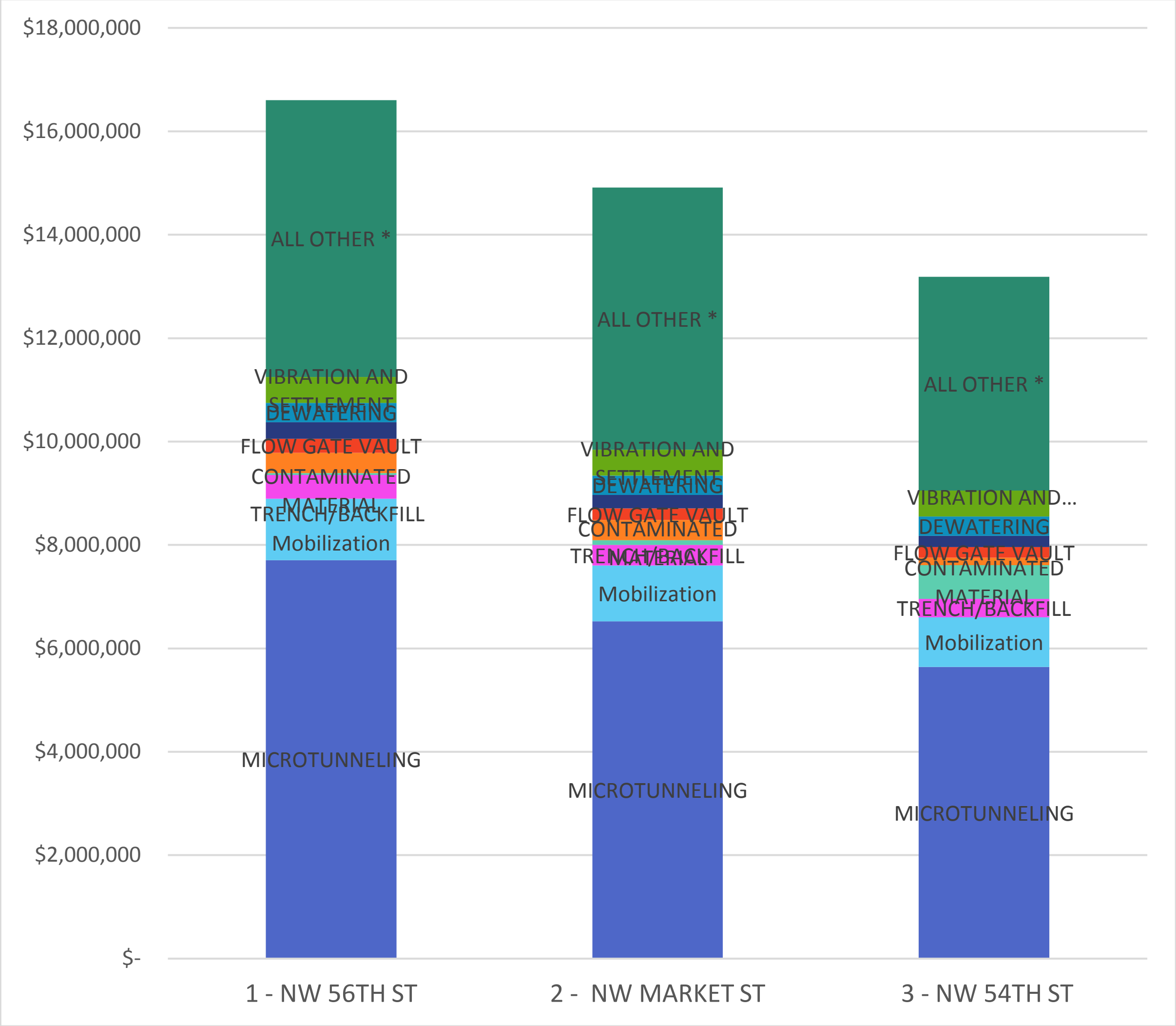
Table 5-1. AACE Class 4 cost estimate for Options

Bid Item	Option 1	Option2	Option 3
Microtunneling	$ 7,708,000	$ 6,520,000	$5,640,000
Mobilization	$ 1,208,000	$ 1,085,000	$960,000
Trench/Backfill	$ 462,500	$ 395,000	$360,000
Contaminated soils and water	$ 31,445	$ 89,860	$650,900
Diversion Structure	$ 393,400	$ 393,400	$142,700
Flow Gate Vault	$ 272,500	$ 222,600	$207,000
Utility Relocate	$ 321,500	$ 264,000	$217,370
Dewater	$ 373,500	$ 373,500	$373,500
Vibration and Settlement Monitoring	$ 500,000	$ 500,000	$500,000
All Other *	$ 5,334,000	$ 5,069,000	$4,138,000
TOTAL	$ 16,605,000	$ 14,913,000	$13,189,000

Notes:

1. Estimated cost of options in millions of $2018.
2. These costs do not include the funds already spent to date on modeling and options analysis
3. “All Other” is a sum of smaller construction cost items. Those that were less than $250,000/each.

Figure 5-1. Cost of options by Major Components



Option #2 costs were similar to those of Option#1, with lower cost of microtunneling due to it's shorter length. Option #3 cost estimate included allowances for dewatering and disposal of contaminated soils, which were not needed for Option #1 or #2. "All Other" was the sum of smaller construction cost items that were less than $250,000/each. These were summed together for simplicity. The graphic does not show the -20% and +30% range of cost uncertainty for a Class 4 cost estimate.

5.1.1 Present Value

The present value of the capital costs is based on a 2.5% discount rate with a proposed construction start date during the first quarter of 2021 and a completion date during the 4th quarter of 2022.

5.1.2 Operation and Maintenance Costs

Operation and maintenance costs (for the options was $6,000/year including:

- Maintenance of Diversion Structure
- Annual Gate and Valve Maintenance
- Every 7th year CCTV of the piped system

The present value cost over 100 years of the project at a 2.5% discount rate was $403,000 to $348,000. With NW 54th Street having the lowest cost due to having the shortest distance of pipe needing CCTV.

The O&M activities of inspecting the Diversion Structures and gate valve maintenance and CCTV every 7 years will be done by SPU Facilities, Operations and Maintenance (FOM).

Table 5-2.Estimated Operations and Maintenance Costs (All Options)

Operations and Maintenance Item Option #1	Cost	Frequency
Type 3 Motorized Diversion Structure	$ 3060	Annual
Structure Cleaning	$650	Annual
Structure Inspection	$876	Annual
Gate Valve Maintenance	$1,494	Annual
CCTV	$5760 to $4140	Every 7 years

.

5.1.3 Life-Cycle Costs

The life-cycle costs for the project (Capital Costs and O&M Costs) are shown in Figure 5-2 and Table 5-3.

Figure 5-2. Present Value of Capital and O&M by Option

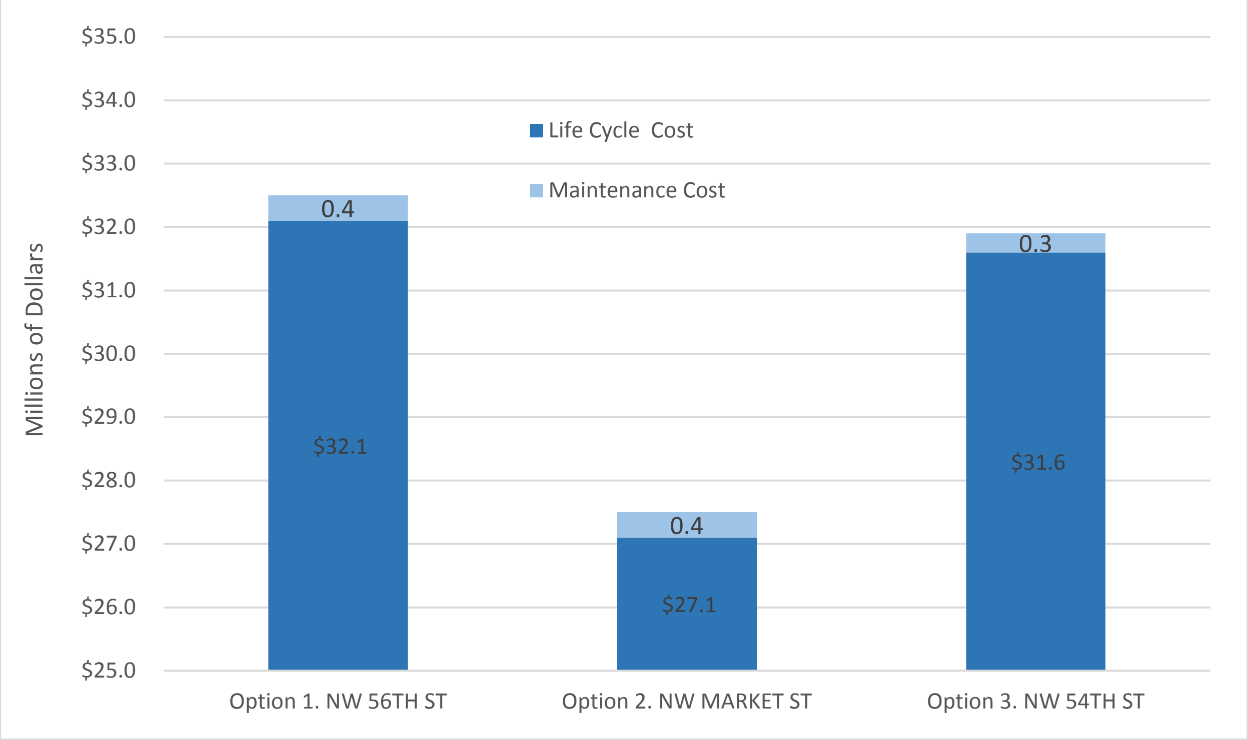


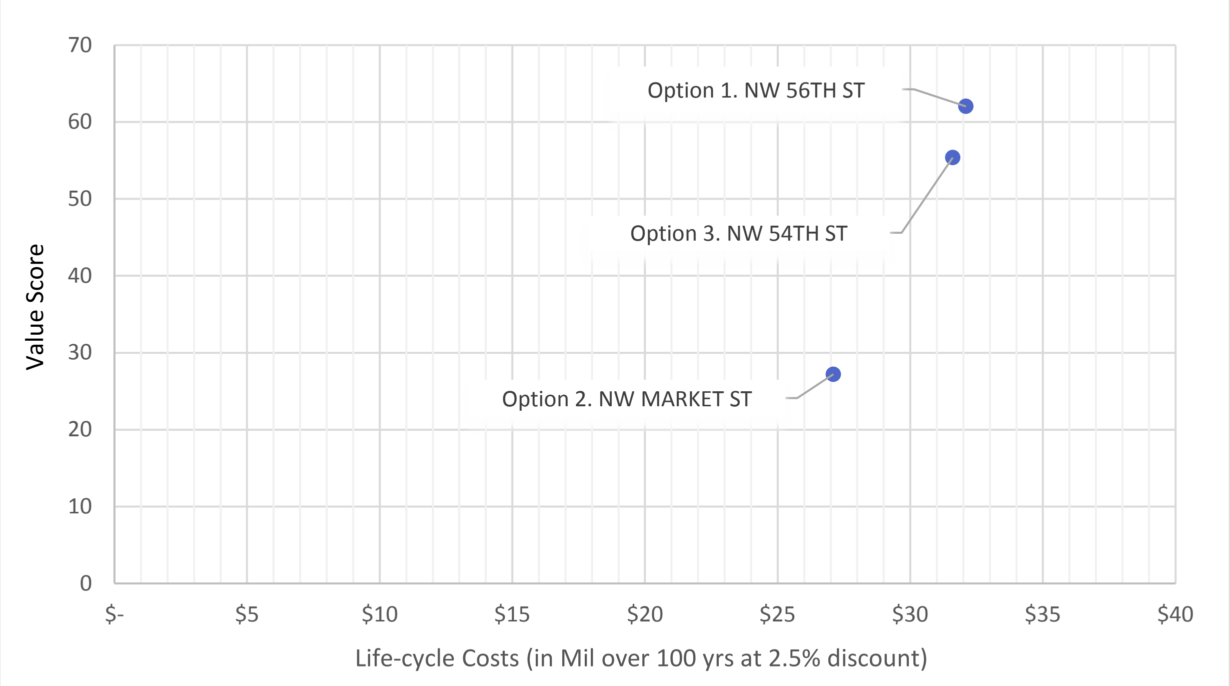
Table 5-3. Life Cycle Cost for each Option in Millions (2018 costs)

Options	Capital Cost	Maintenance Cost	Life-cycle Cost
NW 56th Street	$31.7	$0.4	$32.1
NW Market Street	$26.7	$0.4	$27.1
NW 54th Street	$31.3	$0.3	$31.6
*Present Value over 100 years at 2.5%			

5.2 Value Modeling Results and Discussion

Figure 5-3 shows the trade-off between value and cost by comparing the value modeling scores with the estimated life-cycle project costs.

Figure 5-3. Value Score vs. Cost for Options #1, #2, and #3



Option #1 had the highest cost and highest value score (62). Option 1 did well in all criteria. It especially did better than the other options in scoring well in minimizing construction complexity and construction risk. Unfortunately, it was also the highest cost at $32.1 Million due to the cost and length of microtunneling being the longest.

- Option #3 scored 55 and was $0.5M less than Option #1 and had a slightly lower value score of 55. Compared to Option #1 it had higher construction risk due to the uncertainty of ownership and the potential of contaminated soils.
- Option #2 had the lowest value score of 27 and the least cost of $27.1 Million. It was eliminated from consideration because it was outperformed by Option 1 and 3. It would be optimal for SPU to implement Option 2 and construct on NW Market Street as the other two perform better on all the evaluation criteria and also be lower cost.

The team agreed that Option2 should be dropped from consideration.

Preliminary Geotechnical Report
Ship Canal Water Quality Project
Ballard Conveyance
Seattle, Washington

July 19, 2017

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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SHIP CANAL WATER QUALITY PROJECT
BALLARD CONVEYANCE
SEATTLE, WASHINGTON

1.0 INTRODUCTION

The Ship Canal Water Quality Project has been broken out into a number of work packages, one of which is the Ballard Conveyance work. This report summarizes our geotechnical studies for the Ballard Conveyance project (Project) in the Ballard neighborhood of Seattle, Washington (Figure 1). The purpose of our geotechnical studies was to evaluate the subsurface conditions related to the geotechnical feasibility and geotechnical risk associated with constructing the conveyance pipeline using trenchless methods. This geotechnical report was prepared for the exclusive use of HDR Engineering, Inc. and Seattle Public Utilities (SPU) for planning-level purposes. Our conclusions are based on limited explorations and testing and a literature search and should not be used for final design of the Project. Additional explorations, testing, and analyses are required to develop final design recommendations for this Project.

2.0 PROJECT AND SITE DESCRIPTION

The purpose of the Project is to collect flows from Basin 152 and convey them to the Tunnel Effluent Pump Station (TEPS) to be located near the intersection of Shilshole Avenue NW and 24th Avenue NW. This report covers two alignments that are currently being considered for the proposed 60-inch-diameter conveyance pipeline. Both proposed alignments start near the intersection of NW 56th Street and 28th Avenue NW. The NW 56th Street alignment follows NW 56th Street east to 24th Avenue NW where it turns south and follows 24th Avenue NW to the TEPS site. The alternative NW Market Street alignment follows 28th Avenue NW south to NW Market Street where it turns east and follows NW Market Street to 24th Avenue NW. At 24th Avenue NW, it turns south and extends to the TEPS site. The approximate locations of these two alignments are shown in Figure 2.

The site is in an urban neighborhood that includes residential, commercial, and industrial land use. The proposed alignments are primarily located within public right-of-way and under paved roads. The site topography generally slopes from north to south, with the surface elevation varying from about 42 feet to 28 feet, respectively.

3.0 PURPOSE AND SCOPE

We understand this geotechnical report will be used for planning-level purposes only. This report should not be used for other purposes without Shannon & Wilson, Inc.'s (Shannon & Wilson's) review. Our geotechnical scope of services included:

- Collecting and reviewing existing geotechnical exploration logs.
- Developing a geotechnical exploration plan.
- Performing geotechnical explorations at four locations.
- Performing geotechnical laboratory testing on selected samples obtained from the explorations.
- Evaluating the feasibility of trenchless construction for two alignments.
- Preparing this preliminary geotechnical report.

If a service is not specifically indicated in this report, do not assume that it was performed.

4.0 BASIS OF REPORT

Our conclusions and considerations presented in this report are based on:

- The limitations of our approved scope, schedule, and budget described in the executed Amendment 01 to Task Order 0005 for the Project.
- Our understanding of the Project and information provided by SPU during the development of our scope of services included in the aforementioned amended task order and our February 3, 2017, kick-off meeting with SPU and HDR Engineering, Inc.
- Subsurface conditions we observed in the borings as they existed during drilling between April 3 and 6, 2017.
- The results of testing performed in the borings and on samples we collected from the borings.

5.0 SUBSURFACE EXPLORATION PROGRAM

Our subsurface exploration program consisted of collecting and reviewing existing geotechnical exploration logs along the proposed alignments, preparing a site exploration plan (Shannon & Wilson, 2017), and performing four geotechnical borings in accordance with the approved site exploration plan.

We performed a search of the Department of Natural Resources database (Washington State Division of Geology and Earth Resources [DGER], 2012) and our project files to identify and collect existing geotechnical exploration logs along the proposed alignments. The approximate locations of the explorations are presented in Figure 2 and the exploration logs are included in Appendix B, Existing Exploration Data.

In addition to collecting existing geotechnical exploration logs, our scope of services included drilling and sampling four borings, designated BCT-1 through BCT-4. These borings were drilled and sampled to depths of 35 to 55 feet to characterize the subsurface conditions. The site and exploration plan (Figure 2) shows the approximate boring locations. Observation wells were installed in all four borings. Descriptions of the methodologies and procedures used for drilling and sampling the borings and constructing the observation wells are included in Appendix A, Project Subsurface Explorations. The boring logs are presented in Appendix A as Figures A-2 through A-5 and a soil description and log key is included as Figure A-1.

6.0 GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory tests were performed on selected samples retrieved from the borings. The geotechnical laboratory testing was performed in the Shannon & Wilson laboratory in Seattle, Washington, and included visual classification, water content determinations, grain size analyses, and hydrometer analyses. A description of the methodology and testing procedures is discussed in Appendix C, Geotechnical Laboratory Testing.

7.0 GEOLOGY AND SUBSURFACE CONDITIONS

The geology and subsurface conditions along the proposed alignments were evaluated based on:

- Conditions encountered in the subsurface explorations performed for this study,
- A review of borings previously completed at the site, and
- The Geologic Map of Northwest Seattle (Booth and others, 2005).

The geotechnical explorations were performed to evaluate the subsurface soil and groundwater conditions along the proposed alignments. Our observations are specific to the locations and depths noted on the boring logs and may not be applicable to all areas of the alignments. No number of explorations or testing can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. Potential variations include, but are not limited to:

- The conditions between and below explorations and testing may be different;
- The passage of time or intervening causes (natural and manmade) may result in changes to site and subsurface conditions;
- Groundwater levels and flow directions may fluctuate due to seasonal variations;

- Groundwater flow between different aquifers can occur. No soil layer should be assumed to be continuous and/or watertight;
- Standard penetration test results in gravelly soils may be unrealistic. Actual soil density may be lower than estimated if the test was performed on a gravel or cobble; and
- Obstructions such as boulders, fill debris (rubble), and wood may be present in the subsurface.

The following sections present a description of the site geology and the subsurface conditions encountered in our borings.

7.1 Site Geology

The Project is in the central portion of the Puget Lowland, an elongated topographic and structural depression filled with a complex sequence of glacial and nonglacial sediments that overlie bedrock. The area has been glaciated six or more times in the past 2 million years. The distribution of the sediments is complex, because each glacial advance deposited new sediments and partially eroded previous sediments. Between glacial episodes, the complete or partial erosion or the reworking of deposits, as well as the local deposition of other sediments, took place. During the Vashon Stade of the Fraser Glaciation, about 15,000 to 13,000 years before present, the lobe of the Cordilleran Ice Sheet that covered the Puget Lowland was locally over 3,000 feet thick. When the glacial ice sheet receded from the area about 13,500 years ago, it left behind topography characterized by low-rolling relief about 500 feet above sea level with some deeply cut ravines and broad valleys. Since then, present-day geologic processes, such as erosion and deposition by streams and landsliding, as well as human activity, have modified the ground surface and further complicated the geology.

7.2 Site Subsurface Conditions

The subsurface conditions along the NW 56th Street and NW Market Street alignments are presented in Figures 3 and 4, respectively. The subsurface profiles are interpreted from materials observed in the explorations and existing geotechnical exploration logs. Variations between the interpretations shown and actual conditions will exist.

Along the NW 56th Street alignment between 28th Avenue NW and 26th Avenue NW, the subsurface conditions consist of fill over recessional deposits. The fill is about 12 feet thick consisting of loose, silty sand. The recessional deposits are not glacially overridden and consist primarily of medium dense to dense, silty sand. Groundwater was measured at 9 feet below ground surface (bgs) at BCT-1.

Between 26th Avenue NW and 24th Avenue NW, the subsurface conditions consist of shallow fill over glacial till and till-like deposits. The depth to glacial till is about 14 feet bgs at existing boring B-1 (Station [Sta.] 7+24) and becomes shallower to the east along the alignment, about 5 feet bgs in boring BCT-2 (Sta. 11+90). The till and till-like deposits are glacially overridden and consist of very dense, silty sand and silty sand with gravel. Cobbles and boulders may be present within the glacial till and till-like deposits. Groundwater was measured at 22 feet bgs at BCT-2.

From NW 56th Street to 24th Avenue NW along the NW Market Street alignment, the subsurface conditions consist of fill over recessional deposits and glacial till and till-like deposits. The thickness of the fill ranges between 10 and 20 feet and consists of very loose to medium dense, silty sand, and sand with silt and gravel. Along the NW Market Street portion of this alignment, the glacial till and till-like deposits were observed about 15 to 25 feet bgs and consist of very dense, silty sand. Groundwater was measured at 7 feet bgs at BCT-4.

Along 24th Avenue NW between NW 56th Street and NW 54th Street, the subsurface conditions consist of fill over recessional deposits and glacial till and till-like deposits. Near NW 54th Street, the recessional deposits become thicker. Till-like deposits are also observed near NW 54th Street; however, they do not display the typical density characteristics of glacially overconsolidated till and may be weathered, disturbed, or an ablation till deposit.

Groundwater is encountered at an elevation of about 35 feet along NW 56th Street and about 25 feet along NW Market Street. The elevation will vary by season and rainfall quantities.

7.3 Environmental Findings

Field screening of soil samples were performed for worker protection and to assist with the proper disposal of investigation-derived waste. Soil samples were field screened by the field representative for contamination using a combination of: (a) visual observations, (b) photoionization detector measurements, (c) olfactory observations, and/or (d) sheen tests.

One soil sample was collected for environmental testing from boring BCT-4 based on the field screening. The results of the environmental testing show the soil to be lead-contaminated between 5 and 15 feet bgs. The test results are presented in Appendix D.

7.4 Seismic Hazards

The Project is located in a region where numerous small to moderate earthquakes and occasional strong shocks have occurred in recorded history. Much of this seismicity is the result of ongoing relative movement and collision between the tectonic plates that underlie North America and the Pacific Ocean. These tectonic plates include the Juan de Fuca Plate and the North American Plate, and the intersection of these two plates is called the Cascadia Subduction Zone (CSZ). As these two plates collide, the Juan de Fuca Plate is being driven northeast (subducted), beneath the North American Plate.

Within the present understanding of the regional tectonic framework and historical seismicity, three broad earthquake source zones are identified. These include a shallow crustal source zone, a deep source zone within the portion of the Juan de Fuca Plate subducted beneath the North American Plate (deep subcrustal zone), and an interplate zone where the Juan de Fuca and North American Plates are in contact in the CSZ. The anticipated earthquakes related to these sources are summarized below:

- Shallow Crustal Zone: Geophysical lineaments in Western Washington are believed to be capable of producing earthquakes with magnitudes up to 7.5. The closest of these geophysical lineaments to the site is the Seattle Fault (or Seattle Fault Zone). Geologic studies suggest that this is an active fault with an estimated magnitude 7.0 event occurring approximately 1,100 years ago. Historical shallow crustal seismicity has also been observed between a depth of 1 and 10 miles. Based on the U.S. Geological Survey (USGS) Interactive Fault Map (USGS, 2017), the Project alignment is located about 5 miles north of the nearest mapped fault splay of the Seattle Fault.
- Deep Subcrustal Zone: The largest historical earthquakes (magnitudes up to 7.1) to affect the site were in the subducted Juan de Fuca Plate (deep subcrustal zone) at depths of 32 miles or greater. The depth of this zone is estimated at about 34 miles below the Project alignment.
- Interplate Zone (CSZ): The CSZ has produced, and remains capable of producing, strong earthquakes. Work to date suggests that earthquake magnitudes may range from 8.0 to 9.0 and may occur at time intervals ranging from about 400 to 1,000 years. The Project alignment is located about 60 miles east of this zone. Based on work by Goldfinger and others (2012), the last earthquake produced by the CSZ was about 315 years ago.

Based on our review, the site is located north of the generally accepted limits of the Seattle Fault Zone. Consistent with accepted local engineering practice, we did not consider conjectural lineaments.

We note that risk of fault rupture, liquefaction, and lateral spreading is all low along the two currently identified trenchless alignments. We also note that the hazards are the same for either open-cut or trenchless construction.

8.0 ENGINEERING STUDIES AND RECOMMENDATIONS

Based on the subsurface conditions encountered in field explorations and our current understanding of the proposed Project, we performed engineering studies to develop conclusions and recommendations regarding our opinion of soil engineering parameters and recommendations related to the proposed pipeline. Our conclusions and recommendations are presented in the following sections.

For purposes of our analyses, recommendations, and conclusions, it was necessary for us to assume that the results of the explorations, testing, and monitoring are representative of conditions throughout the Project site. However, as stated in Section 7.2, subsurface conditions should be expected to vary. We may need to revise our recommendations during future design phases if different conditions are encountered.

8.1 Trenchless Methods

All the trenchless methods discussed in this preliminary geotechnical report are suitable for the likely depths required to provide gravity conveyance from the Ballard 152 Conveyance Structure to the TEPS site. The methods have different degrees of inherent risks, but are generally suitable for the construction of 60-inch-diameter, gravity conveyance pipeline.

All the trenchless methods discussed require the construction of shafts. The entry shaft for each method is typically 20 feet wide by 40 feet long. The receiving or exit shaft for each method is typically about 15 feet wide by 15 feet long. The location of the shafts will depend on the trenchless method selected since the length that can be excavated between shafts varies by method. Section 8.3 discusses the potential shaft locations and spacing in more detail.

8.1.1 Pipe Ramming

Pipe ramming utilizes a double-acting pneumatic hammer to drive an open-ended steel casing between two shafts. Pipe ramming is typically limited to lengths of about 300 feet. For line- and grade-sensitive utilities, lengths of 100 to 200 feet are more common. Some or all of the soil can be left in the pipe during driving to limit ground loss and control groundwater. When possible, the soil is removed from the pipe after the drive is completed, but more commonly, at least some soil is removed during drilling to reduce the weight of the pipe and decrease drag. Pipe ramming is a non-steerable method, which is a source of risk on a gravity pipeline project. Although some preliminary methods have been established to analyze pipe ramming feasibility, the prediction of constructability is more commonly based on previous experience in similar ground than on engineering analyses or design.

A stiffening ring is typically welded to the leading edge of the casing to help prevent deformation of the pipe and provide some overcut to reduce the friction on the outside of the pipe. Bullet teeth bits can also be welded to the leading edge to assist with pipe ramming in denser soil and where cobbles and boulders are present.

Bentonite slurry can also be injected through regularly spaced ports around the circumference of the pipe to fill the overcut annular space. The injected bentonite slurry around the pipe helps reduce settlement and friction between the soil and the pipe.

As discussed, pipe ramming lengths are typically limited to about 300 feet. Longer alignments can be facilitated by telescoping the casing. This process involves ramming a larger diameter casing, clearing out the soil, and then ramming a smaller diameter casing within the larger casing.

Pipe ramming below the groundwater table requires special considerations, including mechanical seals in both shafts and a stable soil plug within the pipe to reduce potential groundwater inflow into the pipe and entry shaft. Removal of soil from within the casing or telescoping the casing is more difficult when ramming below the groundwater table. Removing the soil can result in loss of ground support in the pipe and water and soil flowing into the pipe and entry shaft. Also, because pipe ramming is a non-steerable method, deviations in the alignment and profile can make it difficult to anticipate where the pipe will breach the receiving shaft. This complicates the construction of the receiving shaft and could require modifications to the receiving shaft geometry or the groundwater control methods prior to the pipe entering the receiving shaft.

Vibrations generated at the cutting shoe during ramming can damage adjacent structures and utilities. Additional analysis of potential vibration impacts would be required during final design.

For gravity pipelines, oversizing the casing to facilitate adjustment to the carrier pipe grade using shims or spacers can be used to mitigate some of the steerability risk.

Pipe ramming can accommodate some obstructions. Large wood debris and buried logs can be difficult to pipe ram through. The wood tends to absorb energy and reduce the ability of the pipe to cut through the ground. However, pipe ramming is commonly selected for use on projects with gravels, cobbles, and boulders, since these potential obstructions can commonly be ingested by the open-ended pipe.

For purposes of this Project, pipe ramming is only considered to be marginally applicable in the ground conditions anticipated along the alignments. In our opinion, given the lack of steerability and construction vibrations, pipe ramming does not provide a significant advantage over the other methods described in this report.

8.1.2 Auger Boring

Auger boring uses an auger slightly smaller than the shoe or shield diameter to perform the excavation. Auger boring is typically limited to lengths of about 300 to 400 feet. As the pipe is jacked into the ground, the auger excavates the soil and transports it back to the driving shaft for removal. An oversized cutting shoe or shield is normally attached to the leading edge of the pipe string to stiffen the end of the pipe and to provide some steerability. The auger can be positioned in advance of the cutting shoe, flush with the cutting shoe, or within the casing to facilitate construction and manage overexcavation. To avoid overexcavation, such as can occur with the auger in advance of the cutting shoe, the auger can be withdrawn approximately one diameter inside the casing so that a soil plug forms at the entrance of the casing pipe. The soil plug helps maintain a stable heading and reduces the likelihood of ground loss. Flowing or running ground, if encountered, could result in excessive ground loss and could cause settlement or sink holes to develop at the ground surface.

The cutting shoe or leading edge of the shield is typically larger in diameter than the pipe, creating an annular space between the pipe and the surrounding ground. This annular space in combination with the injection of bentonite slurry reduces the friction and jacking forces along the pipe. The injection of the bentonite slurry into the annular space reduces the potential for ground loss and associated settlement and allows some steering and adjustments to the pipe alignment.

Auger boring is generally not suitable in granular soils below the water table unless the alignment is dewatered or the ground is modified by grouting or freezing. Flowing or running ground, if encountered, could result in excessive ground loss and settlement or sink holes at the ground surface.

Auger boring can accommodate some obstructions. Based on a 60-inch-diameter pipe, the auger bore can handle gravels, cobbles, and boulders up to one-third of the pipe diameter (20-inch-diameter boulder). For boulders larger than one-third of the pipe diameter, and where groundwater is not present or it is controlled, the auger can be removed and the boulder mechanically broken and removed from within the pipe.

For purposes of this Project, auger boring is considered to be marginally applicable in ground conditions anticipated along the alignments. In our opinion, given the limited bore lengths of 300 to 400 feet and the need for more shafts and dewatering, auger boring does not provide a significant advantage over microtunneling, as discussed below.

8.1.3 Pipe Jacking

Pipe jacking consists of installing a continuous string of pipes by hydraulic jacking from a driving shaft located at one side of the crossing to a receiving shaft located at the opposite end. Pipe jacking is typically limited to lengths of about 600 to 700 feet. For trenchless construction in the Pacific Northwest, a rotating cutter face is commonly located at the leading edge of the shield. Openings on the cutter face (wheel) can be partially closed to allow for some control of running or flowing ground. The shield may be articulated to provide limited steering corrections in the vertical and horizontal direction. In unsaturated or dewatered soils, sand decks or doors can be used to limit the amount of material excavated as the pipe is jacked into place. Soils are typically excavated by hand or excavator and removed from within the pipe by auger, conveyor, muck bucket, or similar manner.

The cutting shoe or leading edge of the tunneling shield is typically only about 1½ to 2 inches larger in diameter than the jacking pipe itself. During pipe jacking, bentonite slurry can be pumped through regularly spaced ports around the circumference of the pipe to fill this annular space, which reduces the friction and jacking forces along the pipe. The injection of the bentonite slurry into the overcut annulus also reduces the potential for ground loss and associated settlement and allows some steering and adjustments to the pipe alignment.

Pipe jacking is generally not suited for alignments in granular soils below the groundwater table unless the alignment is dewatered or the ground is modified by grouting and freezing. Flowing or running ground, if encountered, could result in excessive ground loss, settlement at the ground surface, and could endanger personnel working within the shield, casing, or jacking shaft.

For purposes of this Project, pipe jacking is considered to be marginally applicable in the ground conditions anticipated along the alignments. In our opinion, given the limited bore lengths and the need for more shafts and dewatering, pipe jacking does not provide a significant advantage over microtunneling, as discussed below.

8.1.4 Microtunneling

Microtunneling consists of installing a continuous string of pipes by hydraulic jacking from a driving shaft located at one side of the crossing to a receiving shaft located at the opposite end. Microtunneling is typically limited to lengths of about 1,250 to 1,500 feet in length. A tunneling shield attached to the leading edge of the pipe string is used to cut through the ground, support the face of the excavation, and control the amount of material excavated as the pipe is jacked into place. The shield is articulated to provide limited steering corrections in the vertical and horizontal direction. Typically, microtunneling utilizes a closed-face slurry shield, which is designed to maintain pressure on the excavated soil face and prevent soil and water from flowing into the shield, pipe string, and driving shaft.

The leading edge of the tunneling shield is typically only about 1½ to 2 inches larger in diameter than the jacking pipe itself. This small annulus reduces the potential for ground loss and associated surface settlement while allowing some steering and alignment control. During microtunneling, bentonite slurry is commonly pumped through regularly spaced ports around the circumference of the pipe to fill this annular space, which reduces settlement and the friction between the soil and the pipe.

A closed-face microtunneling machine does not require personnel working within the machine and is usually used for tunneling below the groundwater level to mitigate the risk of the groundwater and flowing ground. The flowing ground would create a hazard for personnel working within an open-face and could lead to significant loss of ground, sinkholes, and flooding of the shafts. Microtunneling below the groundwater table requires special considerations, including mechanical seals in the shafts and grouting or other ground improvement outside the entrance and exit location of the shafts to reduce groundwater and soil inflow into the shaft.

The microtunneling machine circulates slurry through the mixing chamber located behind the rotating cutter head. The slurry mixed with the soil cuttings is pumped to the ground surface where it is then processed in a slurry separation plant to remove the soil cuttings from the slurry. A slurry balanced tunneling machine can control groundwater and prevent flowing ground from entering the tunnel excavation.

For purposes of this Project, microtunneling is considered to be the most applicable method for the ground conditions anticipated along the alignments. Microtunnel reduces the number of required shafts and the groundwater control requirements. While it does not mitigate the risk of encountering an obstruction to the degree of the other methods discussed in this report, microtunneling has been successfully used in similar soils such as the recently completed King County Fremont Siphon project.

8.2 Direction of Trenchless Excavation

We anticipate that the direction of the trenchless pipeline excavation for either alignment would generally be from south to north and east to west. The reason for this is two-fold; first, based on the anticipated soils and second based on the proposed grade of pipeline.

Where contacts between relatively loose and very dense materials are encountered, it is advantageous for trenchless systems to excavate in a direction that approaches the looser soils. Trenchless systems tend to follow the path of least resistance. So, if the direction of excavation were reversed, it would increase the risk of alignment and grade deviation, since the advancing pipe could deflect upward along the very dense till and follow the contact between the loose and very dense deposits. Therefore, based on the expected subsurface conditions, we anticipate that both the NW Market Street and NW 56th Street alignments would be excavated from east to west between 24th Avenue NW and 28th Avenue NW.

For the north-south portions of both the NW Market Street and NW 56th Street alignments, the anticipated soils are relatively consistent, so the decision on which direction to excavate is not expected to be made based on subsurface conditions. Instead, the general preference to excavate upgrade to allow any groundwater, process water or slurry in the pipe to drain by gravity will likely result in the excavation being performed from south to north.

8.3 Shaft Locations

The discussion in this section assumes that microtunneling is the preferred method to construct the conveyance pipelines. Methods other than microtunneling would require additional shafts to those discussed below. Pipe jacking would require shafts about every 600 to 700 feet, while auger boring would require shafts about every 300 to 400 feet. Pipe ramming drive lengths are generally limited to about 300 feet in length or less. Note that the 300-foot spacing for pipe ramming would carry some additional risk regarding line and grade control.

The trenchless methods discussed in this report require shafts at the beginning and ends of the drive and at any bends in the alignment. For the NW 56th Street alignment, the microtunneling alternative would require a minimum of three shafts. These shafts would be located at the start and end of the alignment and at the bend in the alignment at the NW 56th Street/24th Avenue NW intersection. In our opinion, a combination of two driving shafts and a single receiving would likely be used. One driving shaft would be located at the southern end of the alignment, a combination driving/receiving shaft would be located at the bend in the alignment and a receiving shaft would be located at the western end of the alignment. Alternatively, consideration could be given to a single larger driving shaft located at the bend in the alignment with receiving shafts at the western and southern ends of the Project. This arrangement would have a longer duration of surface impact at a single location and a larger driving shaft footprint.

For the NW Market Street alignment, the microtunneling alternative would require a minimum of four shafts. One shaft at each end and shafts at the turn points in the alignment at the intersections of 28th Avenue NW/NW Market Street and 24th Avenue NW/NW Market Street. The driving operation would need to be performed from three shafts, most likely the southern shaft near the TEPS site and at the two intersections discussed above. Consideration could be given for larger driving shafts at the bends in the alignment at 28th Avenue NW/NW Market Street and 24th Avenue NW/NW Market Street with receiving shafts at the northern and southern ends of the Project. This would reduce the number of driving shafts from three to two. However, this arrangement would have a longer duration of surface impact at a two locations and larger driving shaft footprints.

8.4 Groundwater Control

Groundwater levels are between 10 and 25 feet above the invert of the pipe. Dewatering along the alignment would be required for pipe jacking and auger boring methods to reduce risks associate with excavating below the groundwater table. Without dewatering, there is a risk that saturated sand layers could result in localized flowing ground conditions, ground loss, and resulting surface settlement. Pipe ramming might require dewatering if excavation of the soil plug is required or a sufficient soil plug is not formed. Microtunneling is best suited for excavating below the groundwater table as it can provide face stabilization by applying a pressurized slurry at the face, as discussed in Section 8.1.4. This ability would reduce the risk of ground loss associated with the other methods.

Dewatering or some sort of watertight shoring will likely be required at the shaft locations. Where dewatering and associated drawdown occurs solely within glacially overconsolidated soil, the potential for groundwater-drawdown induced settlement is low. Where overlying recessional and fill soils are actively dewatered or where a hydraulic connection exists between the soil being dewatering and these looser and soft soils, there is an increased risk for inducing settlement. While additional testing and analysis will be required during final design, for planning purposes, we recommend assuming that wells are required to control the groundwater. If the additional testing and analysis indicates an unacceptable risk for settlement, then watertight shoring for the pits, tremied base seals, and microtunneling could be selected to reduce the risk.

8.5 Obstructions

There is a moderate risk of encountering obstructions or ground conditions that could impact the trenchless feasibility. These areas of moderate risk include:

- The presence of glacial till at shallow depths at multiple points along both alignments increases the likelihood of encountering cobbles and boulders that could obstruct the advancement or impede the steerability of some trenchless methods.
- Buried erosional contacts (e.g., where the recessional outwash overlies the glacial till) are also areas where there is an increased likelihood of encountering cobbles and boulders.
- Wood debris is commonly encountered in non-engineered fill deposits. Like cobbles and boulders, depending on the size, concentration, and location, the presence of wood debris can be an obstruction for some trenchless methods.

Abundant cobbles and scattered boulders should be anticipated in all of the soils along the alignments. Boulders encountered in glacial soils generally range from 1 to 10 feet in diameter, with the most common size being between about 1 and 3 feet. Concentrations of cobbles and boulders are often found near contacts between geologic units.

While it is difficult to determine if a boulder is encountered during microtunneling, boulders can be measured and counted if pipe jacking, pipe ramming, or auger boring is used. During final design, an estimated boulder quantity should be developed to assist with characterizing the risks and associated design and contractual mitigation.

Pipe jacking provides the easiest access to the excavation face for removal of obstructions. For pipe ramming and auger boring methods, the removal of obstructions will require the removal of the soil plug or removal of the auger, respectively. Microtunneling machines typically do not provide any access to the excavation face for removal of obstructions. If a boulder is encountered that is large enough to impede the progress of the microtunneling machine, a rescue shaft will be required.

8.6 Preliminary Preferred Alignment

Based on the completed explorations and available geotechnical data reviewed, for the two alignments included in the scope of this geotechnical study, the NW 56th Street alignment, in our opinion, has less geotechnical and environmental risk. The NW Market Street alignment requires one more pit than the NW 56th Street alignment. This increases the project risk for claims associated with groundwater control and associated dewatering impacts. In addition, the contamination encountered in BCT-4, combined with the more permeable soils encountered in

BCT-4 compared to the other borings, also suggests additional project risk and cost with the NW Market Street alignment.

8.7 Geotechnical Instrumentation

Prior to the start of construction, we recommend that a preconstruction survey be conducted to document the existing condition of nearby structures and utilities. In addition, geotechnical instrumentation should be installed to monitor the response of the ground and adjacent structures, utilities, and pavement to the construction activities.

In general, preconstruction surveys should be conducted on existing surface structures located within a horizontal distance equal to 1.5 times the open-cut and trenchless excavation depth. In addition, preconstruction surveys should also be conducted on existing gravity pipelines located within a horizontal distance equal to the open-cut and trenchless excavation depth. For structures, the preconstruction survey should include diagrams, sketches, and photographs. These records should include, but not be limited to, the number, locations, and length and width of existing cracks, etc. The surveys should be conducted by a Professional Engineer registered in the state of Washington and should be completed with the owner, Contractor, and resident engineer present. A formal report should then be developed and signed by each member of the group. For accessible gravity pipelines, they should be scanned with video equipment. If damage claims are made, then follow-up surveys should be made to compare the original documented condition to the current condition.

Geotechnical instrumentation should be installed to monitor the response of the ground and adjacent structures, utilities, and pavement to the construction of the pipeline, manholes, and appurtenant structures. Data collected from the monitoring program would be used to assess:

- The validity of any claims.
- Effectiveness of remedial measures.
- Performance of the shoring.
- Performance of the dewatering system.

The construction of the Project will require relatively deep shored excavations, dewatering, and trenchless construction. Each of these construction activities could result in deformations or ground losses that may lead to vertical settlements adjacent to excavations, which may affect adjacent structures, utilities, and pavements. Each of these and other related elements should be monitored prior to construction and during construction, as required. For preliminary design, we recommend assuming the following geotechnical instrumentation systems:

- Surface settlement points for monitoring curbs, sidewalks, and roadways that will remain after construction that are within a distance equal to 1.5 times the excavation depth or within an area that could be influenced by construction vibrations.
- Utility settlement points should be established on settlement-sensitive utilities such as sewers and water mains that cross above and/or parallel to the pipe excavations and are within a distance equal to 1.5 times the excavation depth or within an area that could be influenced by construction vibrations.
- Structure settlement points should be established on all residences where preconstruction surveys were conducted, structures within 100 feet of pipe ramming operations, and structures within a distance equal to 1.5 times the excavation depth.
- Vibration monitors for measuring vibration levels at adjacent structures and utilities within 100 feet of where pipe ramming is conducted.
- Groundwater monitoring wells located at property boundaries adjacent to dewatering activities.

The design and related specifications and drawings for the geotechnical instrumentation should be developed as part of final design.

Assuming microtunneling is the selected trenchless alternative, in our opinion and for planning-level costing purposes only, we recommend assuming that the cost of monitoring ground movements, vibrations, and groundwater for either alignment will be $70,000.

8.8 Other Risks

Methane has been identified by exploration programs and encountered during tunneling on several projects in the Seattle area, including the Lake City Trunk Sewer, Mercer Street Tunnel, Alki CSO Tunnel, and West Point Sewer Tunnel. Hydrogen sulfide associated with bacterial anaerobic decay can also be encountered in glacial soil. However, testing in this area performed as part of the Ship Canal Water Quality Project suggests methane and hydrogen sulfide are unlikely to be encountered in concentrations that would require changes to typical construction means and methods. Therefore, for planning purposes, it is our opinion that the risk of encountering methane or hydrogen sulfide at levels that would require special consideration during excavation is low.

The current NW Market Street alignment is within the zone of lead contamination encountered in BCT-4. There is a moderate to high risk that this highly contaminated soil will also be encountered in excavations through this area. The presence of lead contamination does not necessarily preclude the selection of a trenchless method, but rather any contaminated soils encountered would require special handling and disposal, which would increase the project costs and could risk the safety of workers in the excavation.

9.0 CLOSURE

We have prepared the document “Important Information About Your Geotechnical Report/Environmental Report” (Appendix E) to assist you and others in understanding the use and limitations of this report. Please read this document to learn how you can lower your risks for this Project.

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19 JUL 2017

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JCS:DCW:MDH:MSK/dcw

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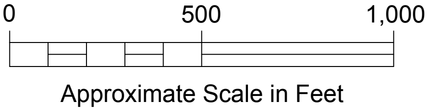

Approximate Scale in Feet

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

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VICINITY MAP

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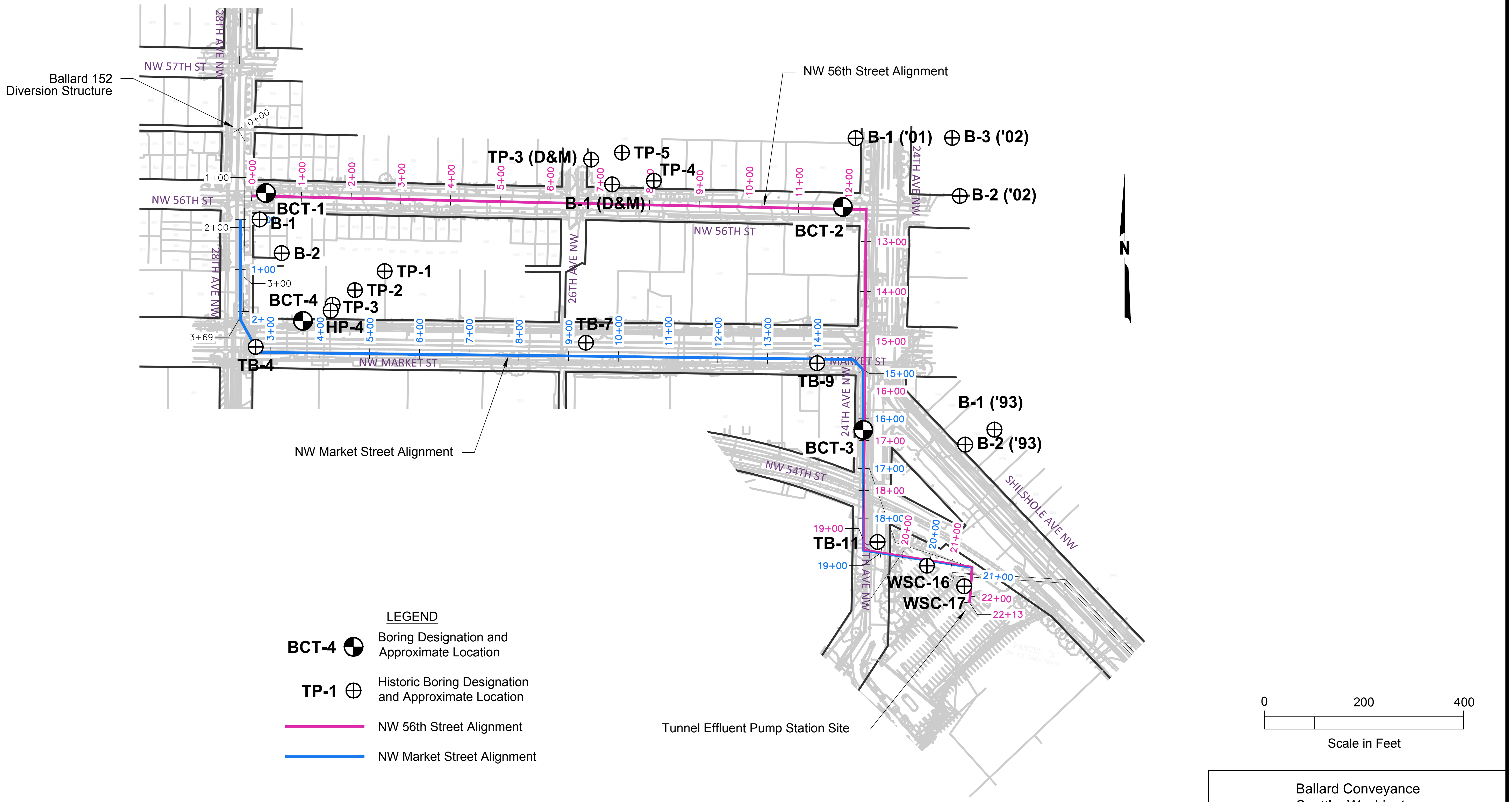
FIG. 1

Filename: J:\211\22329\004\21-1-22329-004 Fig 1.dwg Date: 07-19-2017 Login: jrs



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SITE AND EXPLORATION PLAN

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FIG. 2

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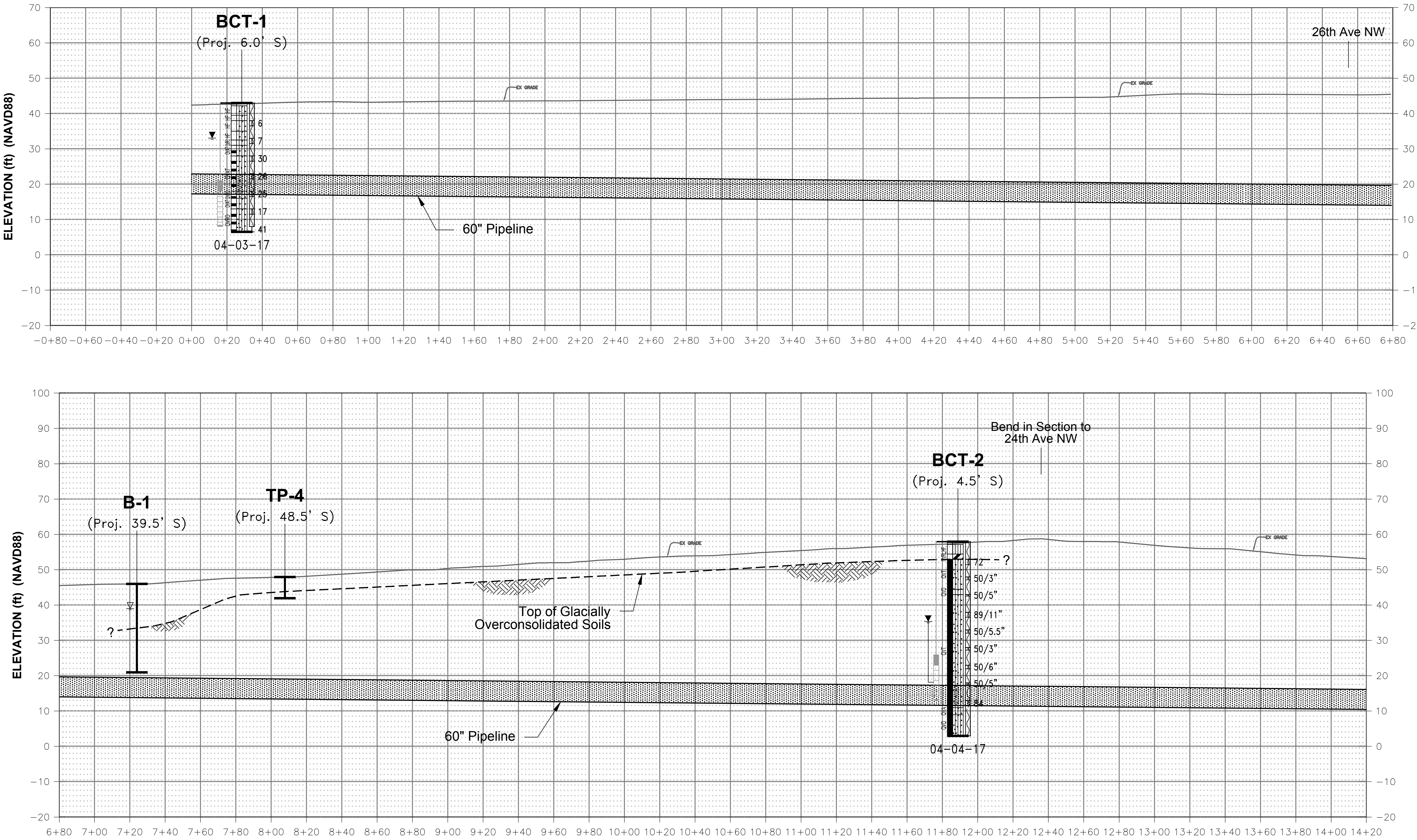

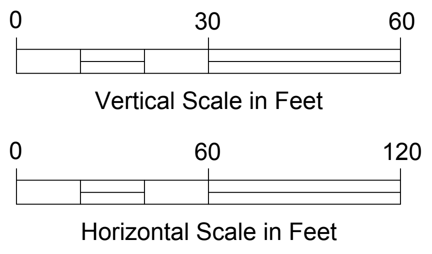

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NW 56TH STREET ALIGNMENT SUBSURFACE PROFILE

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FIG. 3
Sheet 1 of 2

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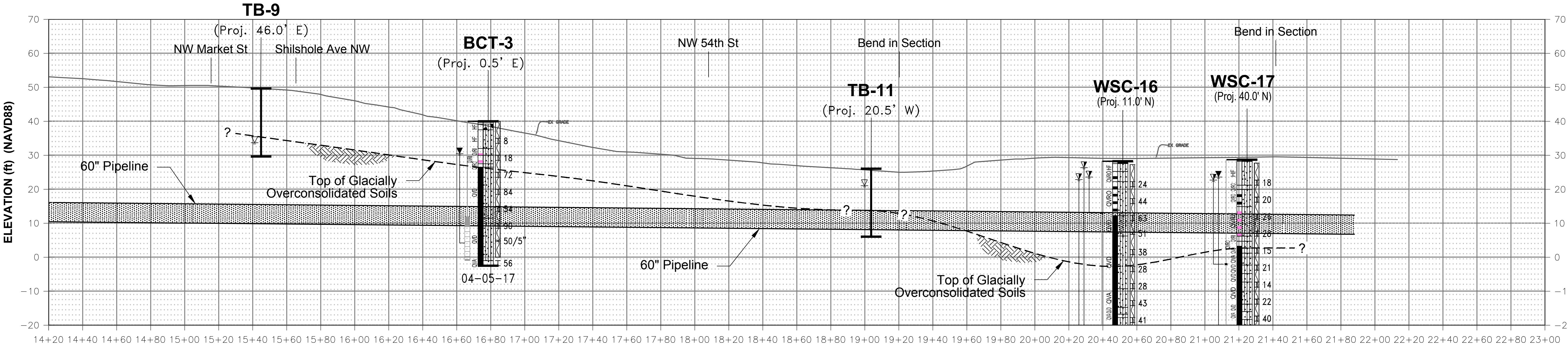

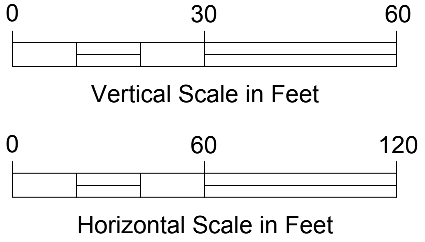

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NW 56TH STREET ALIGNMENT SUBSURFACE PROFILE

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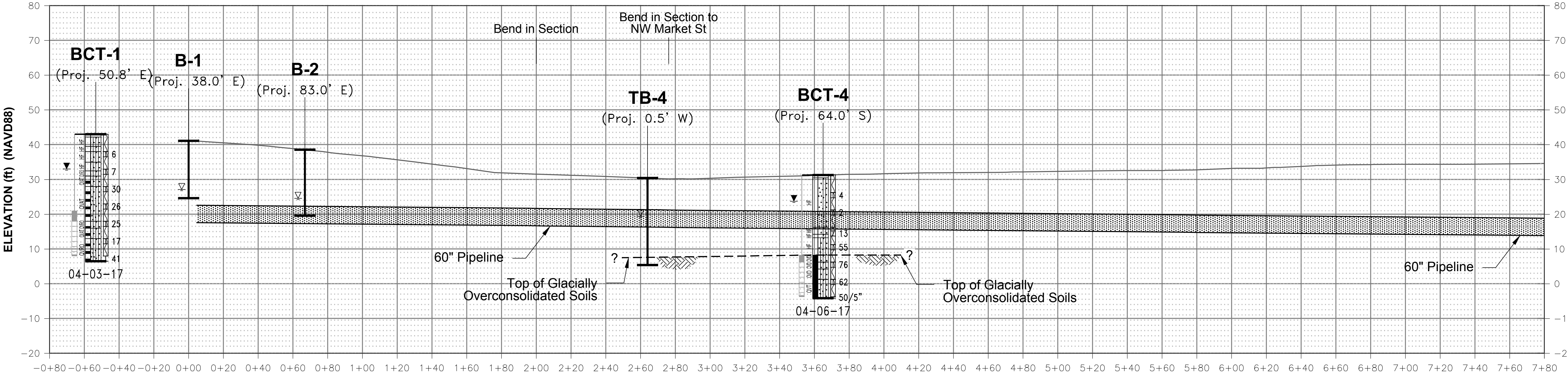
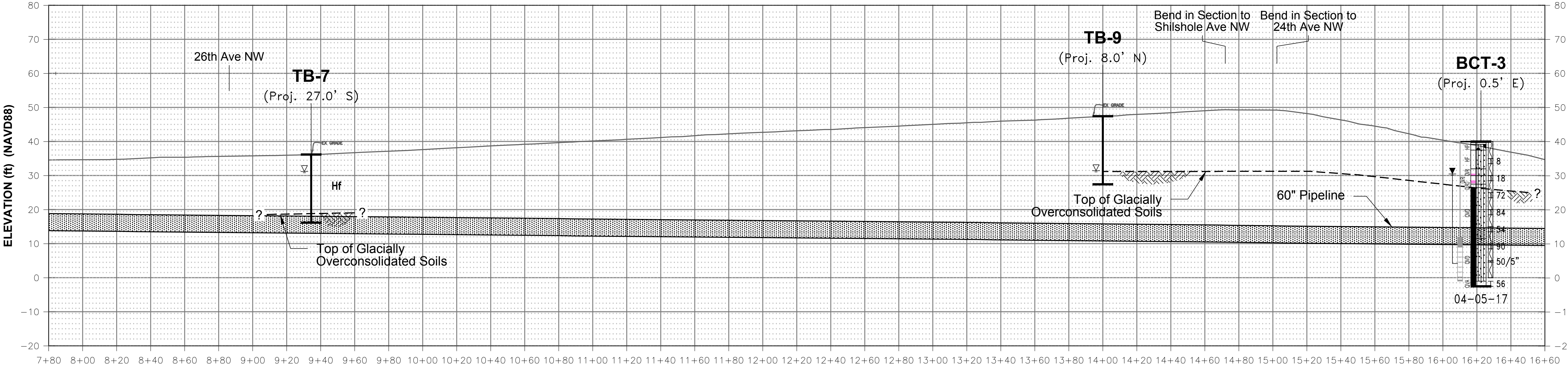
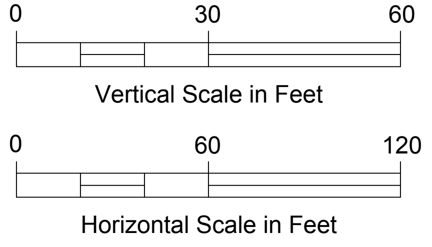
FIG. 3
Sheet 2 of 2







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NW MARKET STREET ALIGNMENT SUBSURFACE PROFILE

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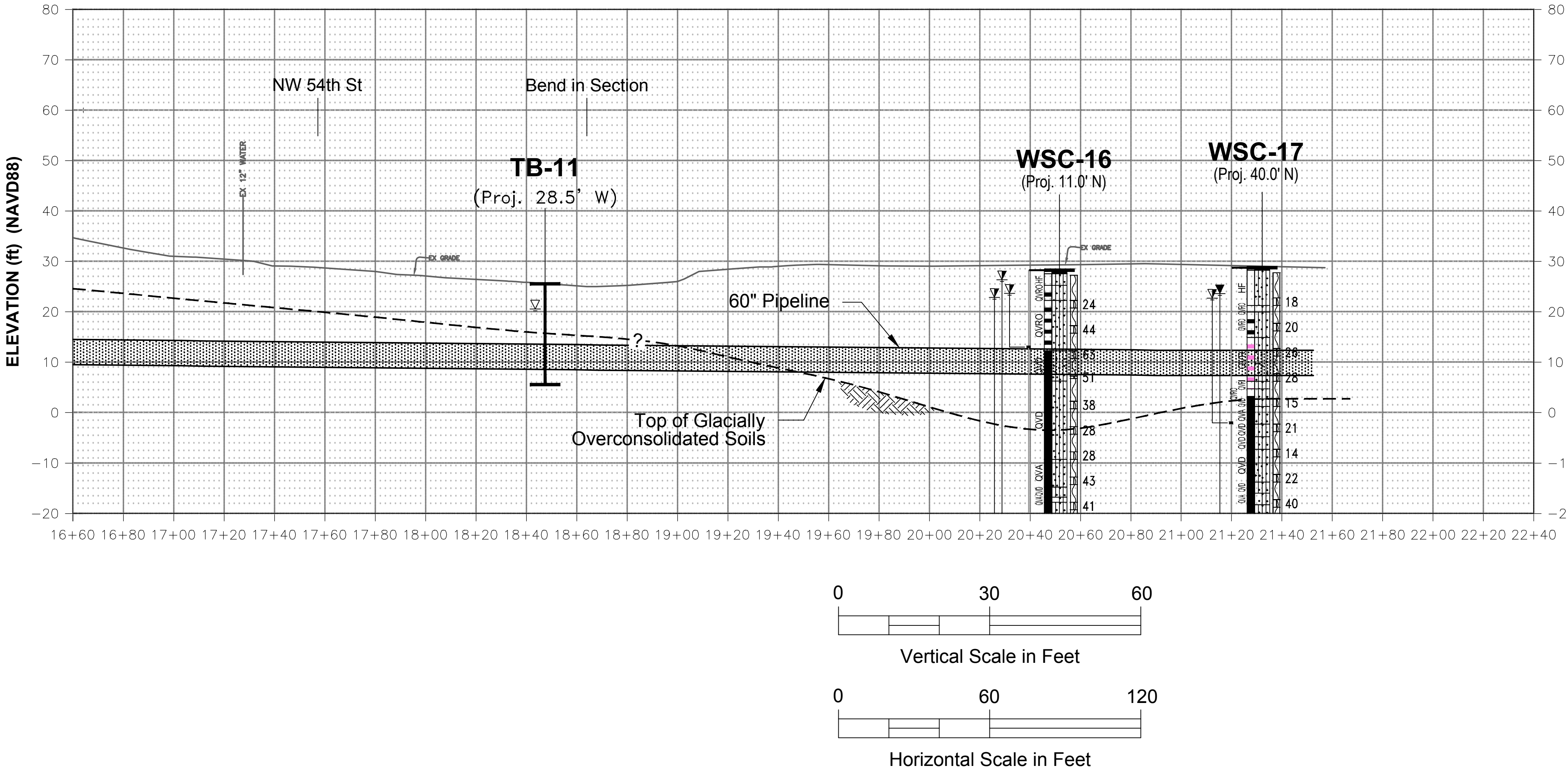
FIG. 4
Sheet 1 of 2

Filename: J:\211\22329\004\21-1-22329-004 Fig 4.dwg Layout: 1 of 2 Date: 07-19-2017 Login: jrs



Ballard Conveyance
Seattle, Washington

NW MARKET STREET ALIGNMENT SUBSURFACE PROFILE

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4
Sheet 2 of 2

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

TABLE OF CONTENTS

Page

FIGURES

APPENDIX A

PROJECT SUBSURFACE EXPLORATIONS

A.1 GENERAL

Subsurface explorations we performed for this project consist of drilling and sampling three soil borings. The approximate locations of the borings are shown in Figure 2.

A.2 DRILLING PROCEDURES

Four borings, designated BCT-1 through BCT-4, were drilled during the period of April 3 and 6, 2017. Cascade Drilling, under subcontract to Shannon & Wilson, Inc. (Shannon & Wilson) drilled the borings using a rubber tracked-mounted drill. The borings were advanced to various depths indicated in Table A-1 using the sonic core drilling method. This method uses high-frequency vibratory motion applied to the top of the drill column, along with down-pressure and rotation, to obtain nearly continuous core samples in soil. Soil samples were obtained using a 4.5-inch-outside-diameter (O.D.) core barrel. The core barrel was advanced into the ground a specific distance (termed a core “run”) and then retrieved for extraction of the sample core. Following retrieval of the core barrel, a temporary casing was advanced to the bottom of the sampled interval. The casing was then cleared of slough, and the next core sample was collected, starting at the bottom of the temporary casing. The soil cuttings were placed into a 55-gallon drum and disposed of by the driller.

A.3 SOIL SAMPLING

A Shannon & Wilson field representative was present to observe drilling, collect samples for subsequent laboratory testing, and prepare descriptive fields logs of the borings. Soil samples were collected from each current exploration for purposes of engineering classification, geologic evaluation, and geotechnical testing. Two different sampling methods were used in each boring, split-spoon sampling and sonic core sampling. The sampling methods are indicated in the exploration logs included in this appendix and are described in the following sections.

A.3.1 Split-Spoon Sampling

Split-spoon samples were collected in conjunction with Standard Penetration Tests (SPTs) at approximately 5-foot intervals in each of the borings. The SPTs were performed in general accordance with the ASTM International Designation: D1586-11, Test Method for

Penetration Test and Split-Barrel Sampling of Soils. For the SPT, a 2-inch-O.D., 1.375-inch-inside-diameter (I.D.), split-spoon sampler is driven with a 140-pound hammer falling 30 inches. The number of blows required to achieve each of three 6-inch increments of sampler penetration is recorded. The number of blows required to achieve the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). When penetration resistances exceeded 50 blows for 6 inches or less of penetration, the test was terminated, and the number of blows along with the penetration distance was recorded on the boring log. The SPT N-value is a useful parameter for determining the relative density or consistency of the soils. Density or consistency as it is related to the SPT N-value is shown in Figure A-1. The recorded N-values are included in the boring logs in Figures A-2 through A-5.

After each split-spoon sampler was removed from the borehole, a Shannon & Wilson field representative opened the sampler and visually examined the soil sample. The field representative then described and classified the sample, removed it from the split-spoon sampler, and sealed the sample in a jar. The jars were stored in boxes and returned to the Shannon & Wilson laboratory for further examination and testing.

A.3.2 Sonic Core Sampling

For the borings drilled using sonic core drilling methods, soil core samples were extracted from the core barrel using a combination of gravity and vibration to extrude the soil into flexible plastic bags. The plastic bags were then placed into wooden core boxes that were marked for the appropriate boring designation, core run number, and depths. Cohesive, hard soils were difficult to extract and occasionally required the use of pressurized air to force the soil out of the core barrel. Disturbance of the core samples (e.g., fragmented cobbles and gravel and distorted bedding planes) result from the coring and extraction process.

Once in the warehouse, the soil cores were opened, photographed, and logged by a Shannon & Wilson geologist. The geologist also obtained grab samples of the soil at depth intervals of about 5 feet; however, additional grab samples were obtained where variable soil conditions were encountered in the core. The sonic core photographs are provided in a separate electronic format.

A.4 BORING LOGS

The boring logs for this project are presented as Figures A-2 through A-5. A boring log is a written record of the subsurface conditions encountered. It describes the geologic units (layers) encountered in the boring and the Unified Soil Classification System symbol of each geologic layer. It also includes the natural water content (where tested), groundwater level observations, approximate surface elevation, types and depths of sampling, and SPT blow counts.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1] All percentages are by weight of total specimen passing a 3-inch sieve.
[2] The order of terms is: *Modifying Major with Minor*.
[3] Determined based on behavior.
[4] Determined based on which constituent comprises a larger percentage.
[5] Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

▧	Bentonite Cement Grout	▩	Surface Cement Seal
▨	Bentonite Grout	■	Asphalt or Cap
▦	Bentonite Chips	▨	Slough
░	Silica Sand	◫	Inclinometer or Non-perforated Casing
▤	Perforated or Screened Casing	◨	Vibrating Wire Piezometer

PERCENTAGES TERMS[1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1] Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Ballard Conveyance
Seattle, Washington

SOIL DESCRIPTION AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	●	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	○	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	●	Silty Gravel; Silty Gravel with Sand
			GC	▨	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	⁘	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	⁘	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	⁘	Silty Sand; Silty Sand with Gravel
			SC	▨	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	▥	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	▨	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	▤	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	▥	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	▨	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	▨	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	≋	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

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SOIL DESCRIPTION
AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
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FIG. A-1
Sheet 2 of 3

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASTICITY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

Ballard Conveyance
Seattle, Washington

SOIL DESCRIPTION AND LOG KEY

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 3 of 3

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[1] Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

[2] Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Total Depth: 36.5 ft.
Top Elevation: ~ 43 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A
Northing: ~
Easting: ~
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Concrete.

Gray and gray-brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; trace organics; trace iron-oxide staining.
(Hf)

Gray, *Silty Sand (SM)*; moist; few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace iron-oxide staining.
(Hf)

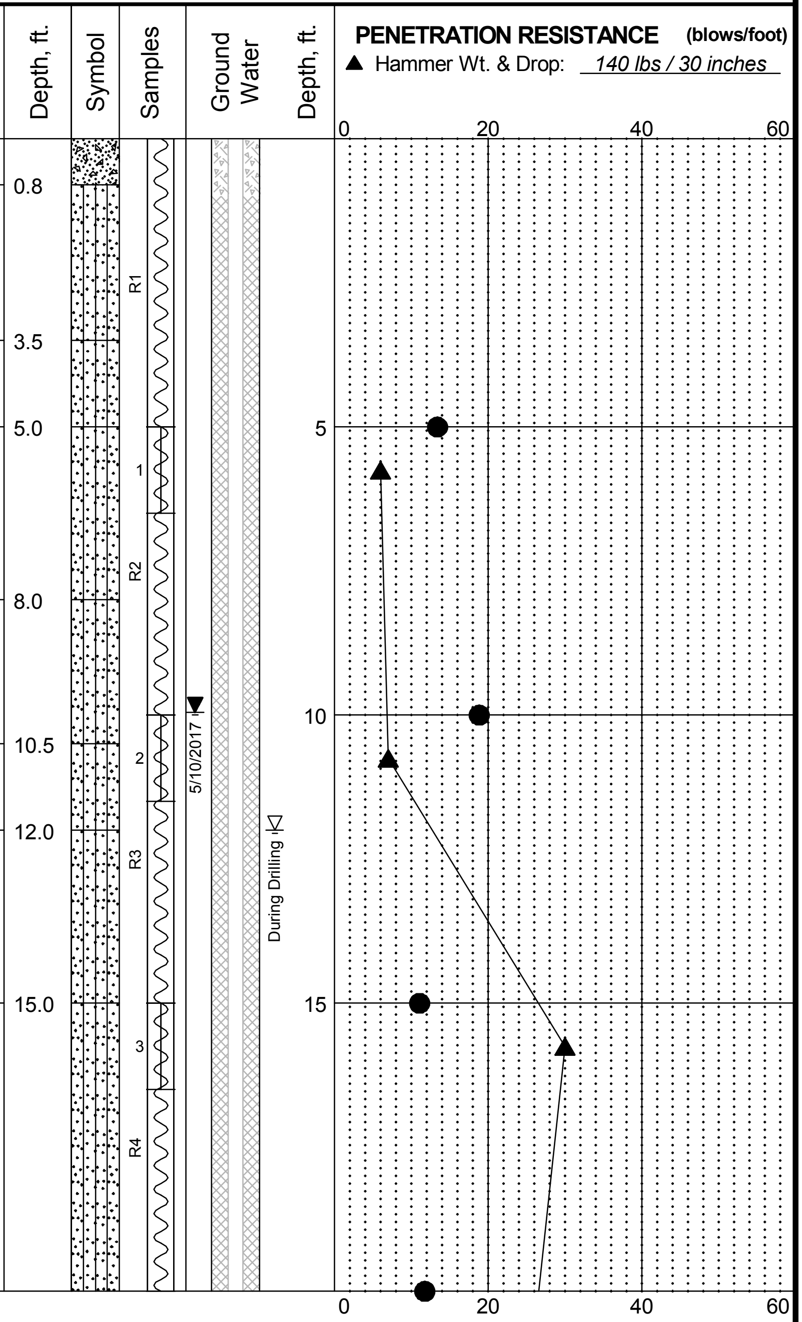
Loose, brown, *Silty Sand (SM)*; moist; few fine subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; trace organics; diamict.
(Hf)

Loose, brown to dark brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few organics and wood fragments; trace brick fragments.
(Hf)

Loose, gray-brown, *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subagular gravel; fine to coarse sand; nonplastic fines.
(Qvro/Hf)

Gray-brown to orange-brown, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few pockets with iron-oxide staining; diamict.
(Qvat/Qvri)

Medium dense to dense, gray, *Silty Sand (SM)*; moist to wet; trace to few fine, subrounded to



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-1

July 2017
21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 2

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

Total Depth: 36.5 ft.
Top Elevation: ~ 43 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A
Northing: ~
Easting: ~
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

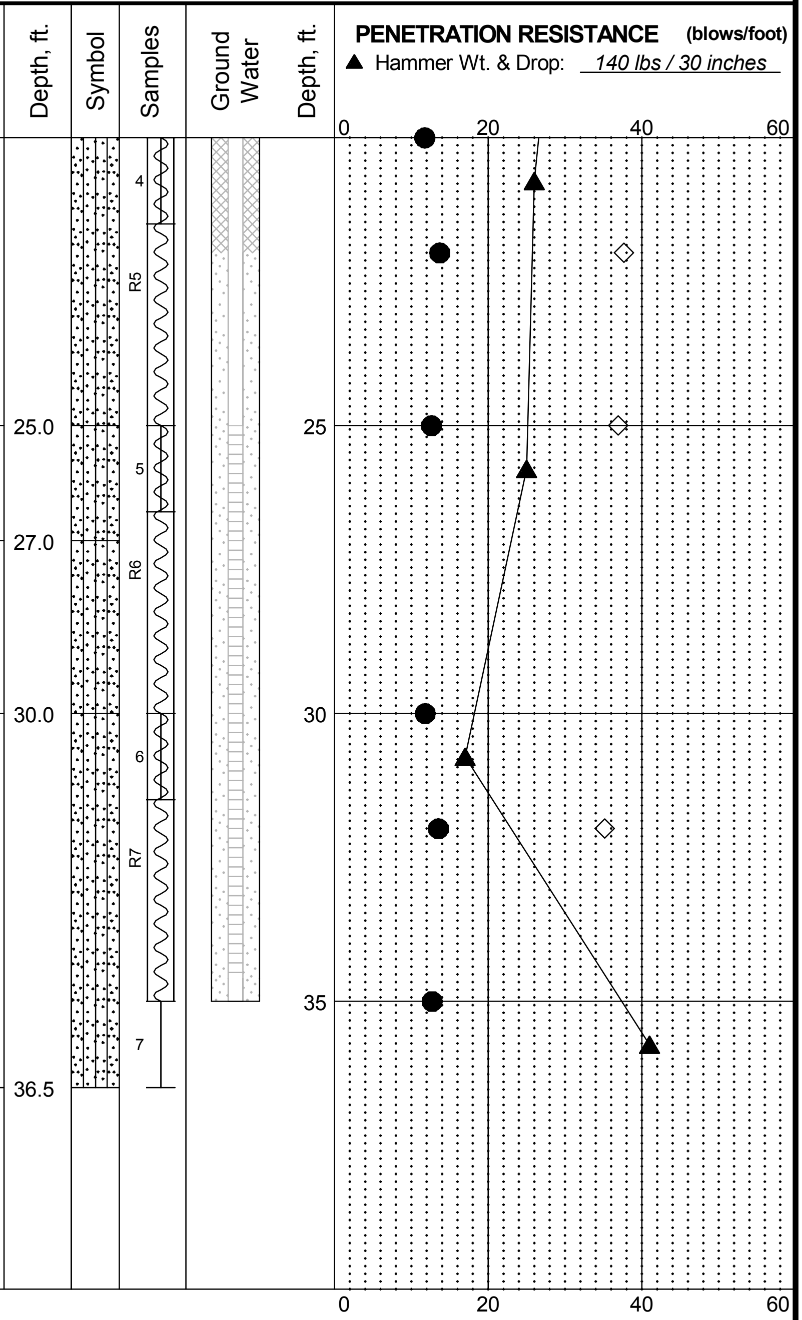
subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvat/Qvd)
- Wet from 20 to 20.5 feet.

Medium dense, gray, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines.
(Qvro/Qva)

Medium dense, gray, *Silty Sand (SM)*; moist; trace to few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvat/Qvd)

Medium dense to dense, gray, *Silty Sand (SM)*; wet; trace fine to coarse, subrounded gravel; fine to coarse sand; nonplastic fines.
(Qvro/Qva)

BOTTOM OF BORING
COMPLETED 4/3/17



LEGEND

* Sample Not Recovered
▯ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▤ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
▩ Bentonite Chips/Pellets
▨ Bentonite Grout
▽ Ground Water Level ATD
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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LOG OF BORING BCT-1

July 2017
21-1-22329-004

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FIG. A-2
Sheet 2 of 2

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

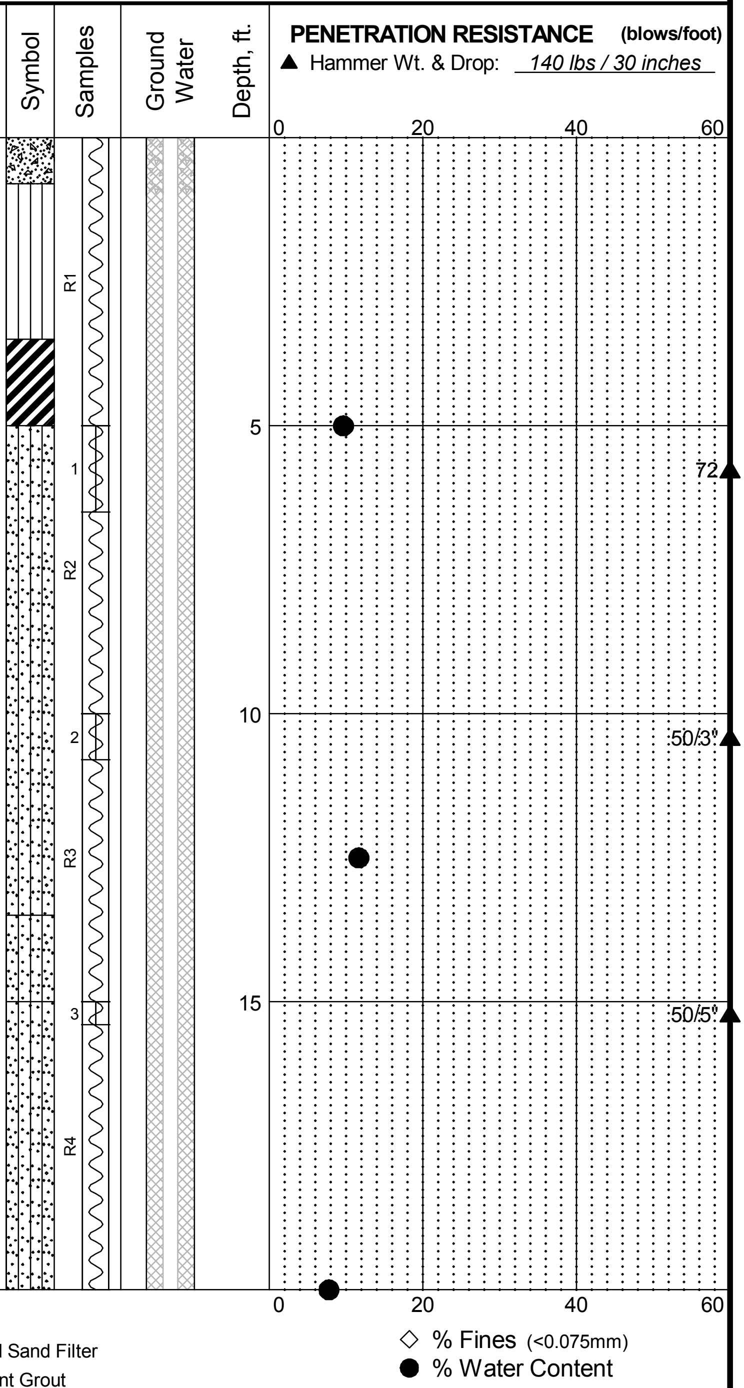
REV 3 - Approved for Submittal

Total Depth:	55 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 58 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Concrete.	
Brown to orange-brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist; trace fine, subrounded gravel; fine to coarse sand; low plasticity fines; iron-oxide staining; trace organics. (Hf)	0.8
- Layer of dark brown, silty sand with gravel, with few brick fragments from 2.5 to 3 feet. - Boulder was encountered at 3 feet.	3.5
Orange-brown and gray, *Fat Clay with Sand (CH)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; medium to high plasticity fines; iron-oxide staining. (Qvrl/Qvgl)	5.0
Very dense, gray to gray-brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; trace iron-oxide staining. (Qvt/Qvd)	
Very dense, gray-brown, *Silty Sand (SM)*; moist; trace to few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict pockets. (Qvd)	13.5
Very dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvt)	15.0



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
◪ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample

▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

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Seattle, Washington

LOG OF BORING BCT-2

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 1 of 3

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

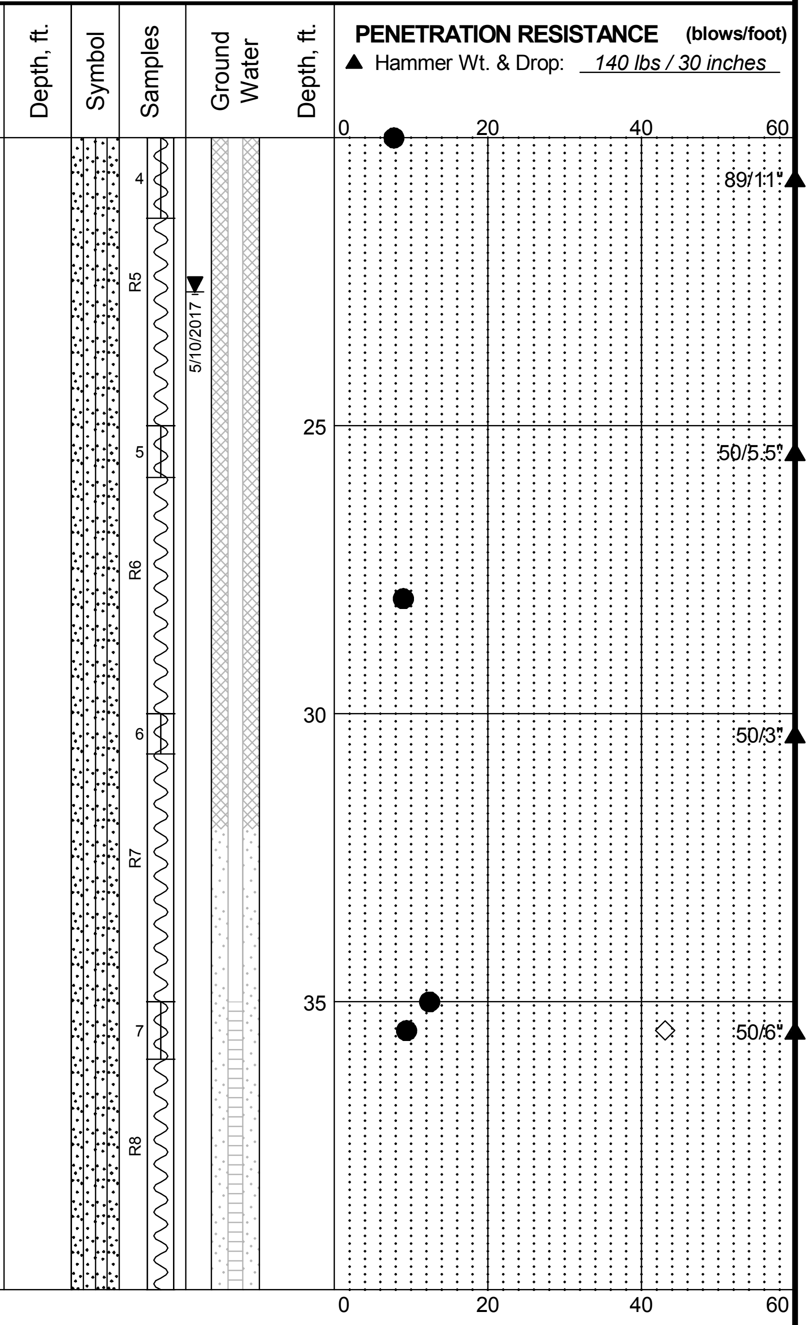
REV 3 - Approved for Submittal

Total Depth: 55 ft.
Top Elevation: ~ 58 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A
Northing: ~
Easting: ~
Station: ~
Offset: ~
Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Few wet seams below 30 feet.



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- ⍁ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊡ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
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LOG OF BORING BCT-2

July 2017
21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 2 of 3

REV 3 - Approved for Submittal

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

Log: JAA Rev: EAS Typ: LK

Total Depth:	55 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 58 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

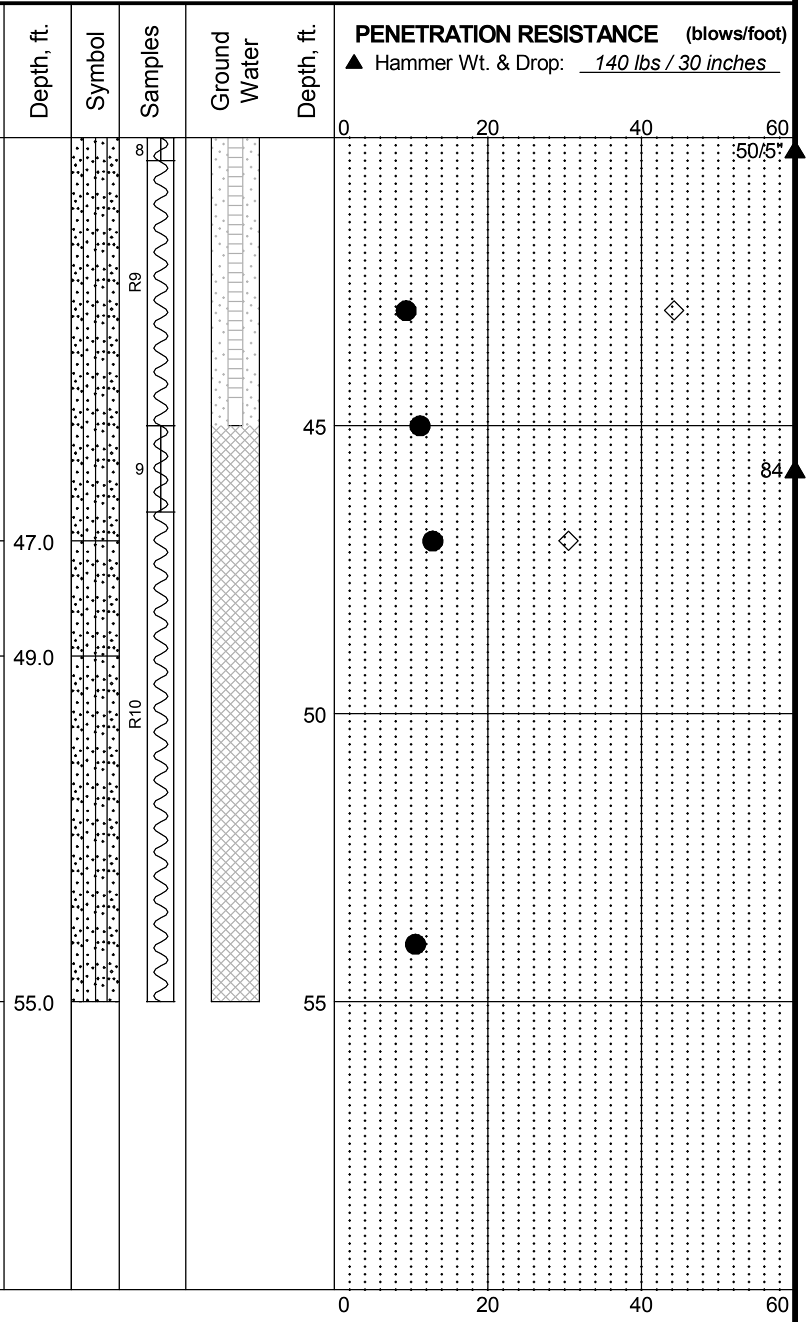
47.0 — Gray, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines.
(Qva)

49.0 — Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

55.0

BOTTOM OF BORING
COMPLETED 4/6/17

- BCT-2 was completed to a depth of 45 feet. A second BCT-2 was drilled adjacent to the original boring to a depth of 55 feet. Samples were not collected from the second BCT-2 from the surface to 45 feet. Both borings are compiled on the same BCT-2 boring log.



Log: JAA Rev: EAS Typ: LK

LEGEND

- * Sample Not Recovered
- ◪ Soil Core (as in Sonic Core Borings)
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊞ Well Screen and Sand Filter
- ▧ Bentonite-Cement Grout
- ⊠ Bentonite Chips/Pellets
- ▨ Bentonite Grout
- ▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-2

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 3 of 3

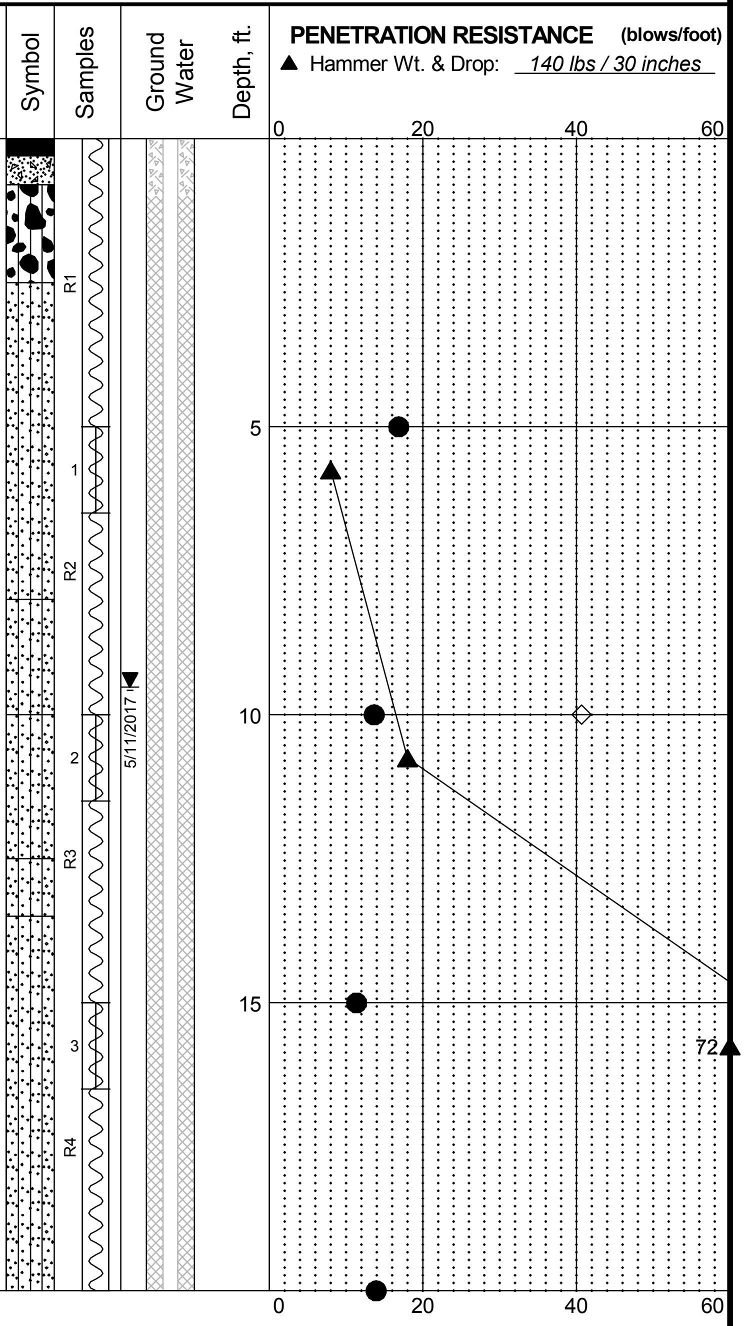
REV 3 - Approved for Submittal

Total Depth:	42.5 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 40 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Asphalt.	0.3
Concrete.	0.8
Dark brown, *Silty Gravel with Sand (GM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace organics. (Hf)	2.5
Loose, brown, *Silty Sand (SM)* to *Sandy Silt (ML)*; moist; few fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; trace brick fragments; trace pockets with iron-oxide staining. (Hf) - Layer of dark brown, silty gravel with sand from 5 to 5.5 feet.	8.0
Loose, gray, *Silty Sand (SM)*; moist; trace fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace pockets with iron-oxide staining. (Qvri/Hf)	10.0
Medium dense, brown, *Silty Sand (SM)*; moist to wet; trace fine to coarse, subrounded gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvri/Hf)	12.5
	13.5
Medium dense, brown, *Silty Sand (SM)*; wet; trace fine, subrounded gravel; fine to coarse sand; nonplastic fines. (Qvro/Qvri)	
Very dense, brown to gray-brown, *Silty Sand (SM)*; moist; few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd) - Layer of wet, silty sand from 19.5 to 20 feet.	



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Soil Core (as in Sonic Core Borings)
- 2.0" O.D. Split Spoon Sample
- Well Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 1 of 3

REV 3 - Approved for Submittal

Log: JAA Rev: EAS Typ: LK

Total Depth: 42.5 ft.
Top Elevation: ~ 40 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A

Northing: ~
Easting: ~
Station: ~
Offset: ~

Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:

Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

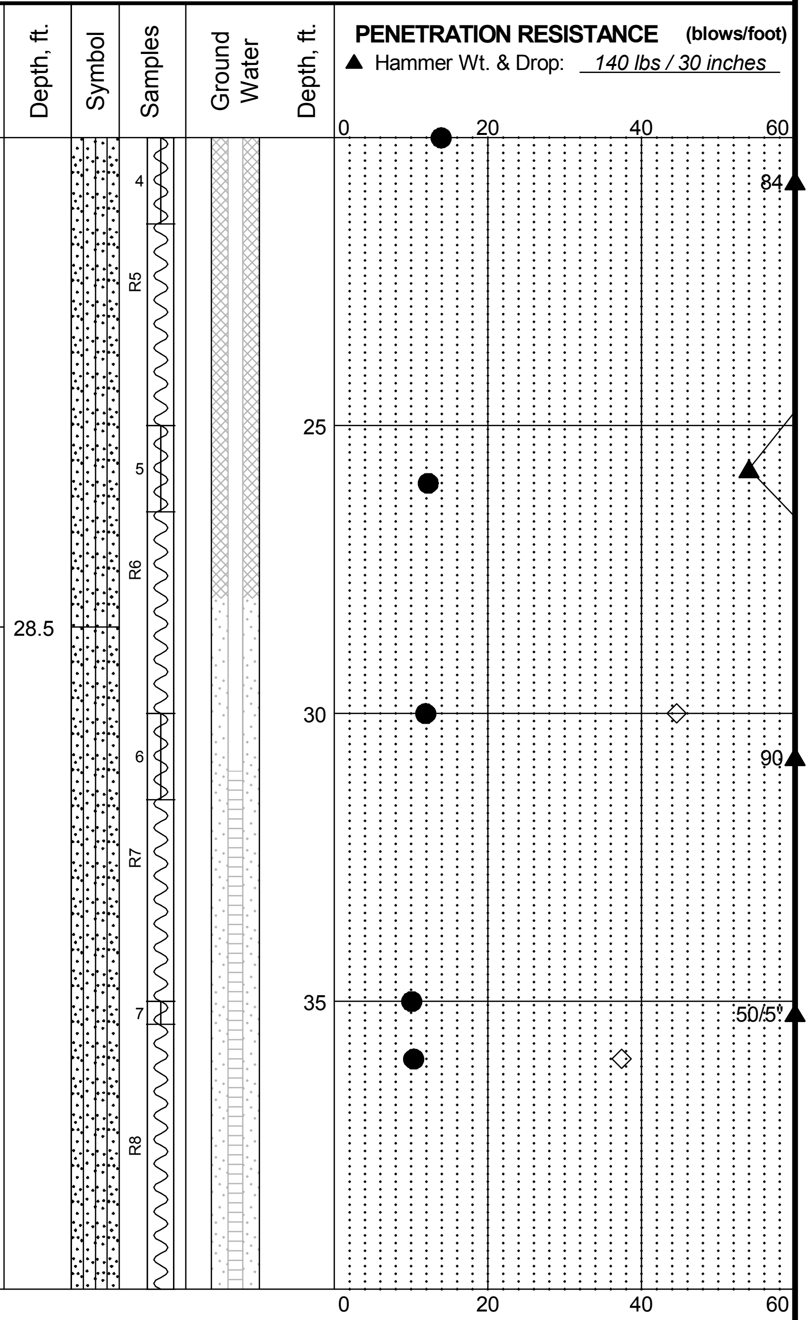
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Few wet, silty sand seams from 21 to 22 feet.

- Layer of wet, poorly graded sand with silt with iron-oxide staining at 24.5 feet.

- Few pockets with iron-oxide staining below 26 feet.

Very dense, gray, *Silty Sand (SM)*; moist to wet; trace to few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)



CONTINUED NEXT SHEET

LEGEND

- * Sample Not Recovered
- Soil Core (as in Sonic Core Borings)
- 2.0" O.D. Split Spoon Sample
- Well Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 3

REV 3 - Approved for Submittal

Total Depth: 42.5 ft.
Top Elevation: ~ 40 ft.
Vert. Datum: NAVD 88
Horiz. Datum: N/A

Northing: ~
Easting: ~
Station: ~
Offset: ~

Drilling Method: Sonic Core
Drilling Company: Holocene Drilling
Drill Rig Equipment: Geoprobe 8140 LC
Other Comments:

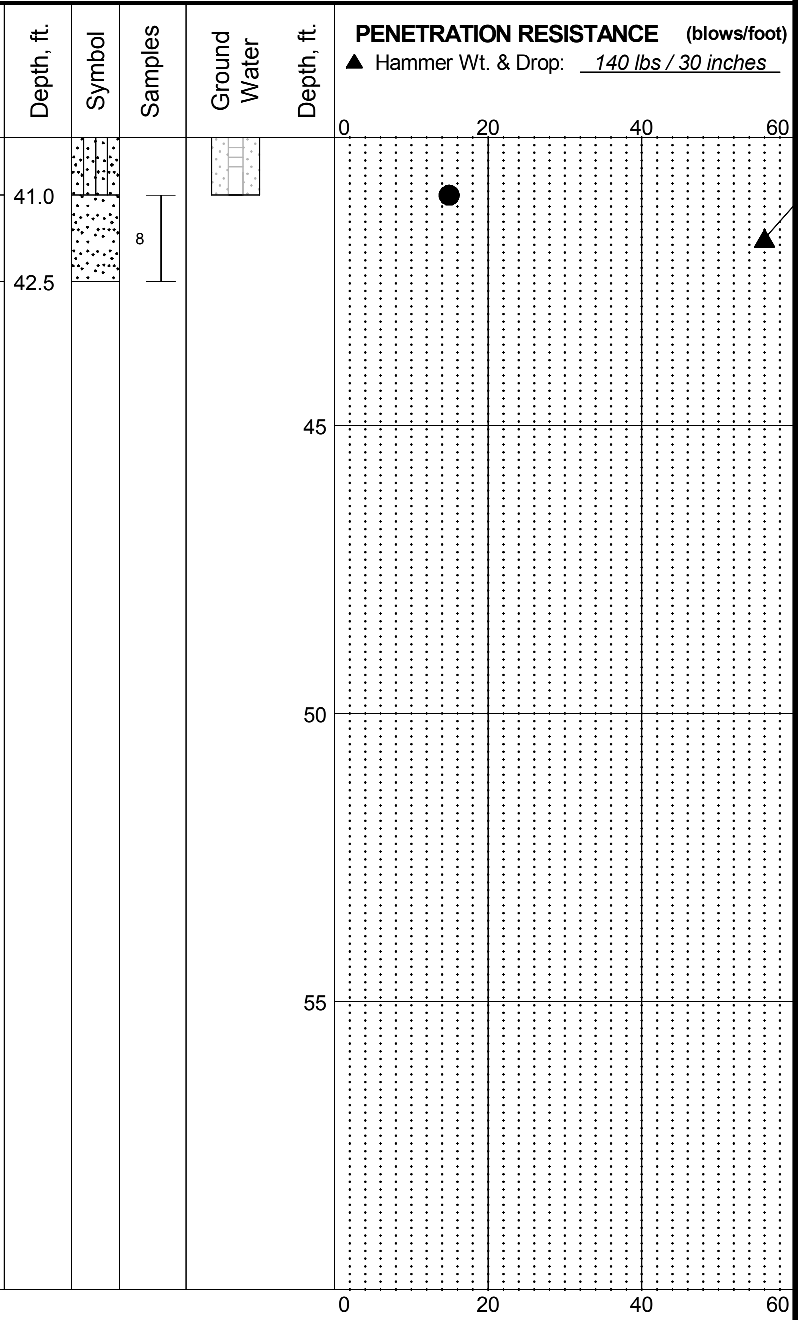
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, gray, *Poorly Graded Sand with Gravel (SP)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

BOTTOM OF BORING
COMPLETED 4/5/17



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-3

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 3

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

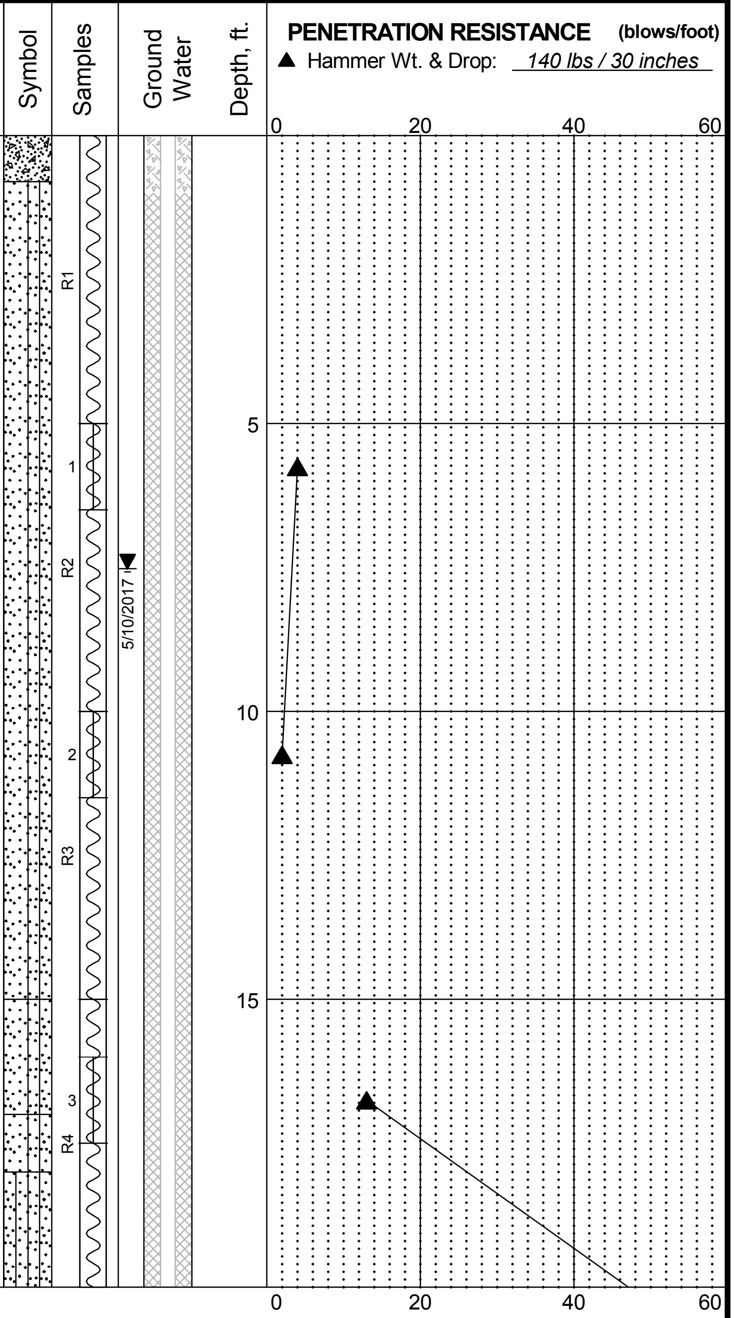
REV 3 - Approved for Submittal

Total Depth:	35.4 ft.	Northing:	~	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	~ 31 ft.	Easting:	~	Drilling Company:	Holocene Drilling	Rod Diam.:	AWJ
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC	Hammer Type:	Automatic
Horiz. Datum:	N/A	Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Concrete.	0.8
Very loose to loose, brown, *Poorly Graded Sand with SIlt and Gravel (SP-SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few silty sand seams. (Hf) - Contaminated from 5 to 15 feet.	15.0
Medium dense, gray-brown, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few organics and wood fragments. (Hf)	17.0
	18.0
Brown, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Hf)	



CONTINUED NEXT SHEET

LEGEND

* Sample Not Recovered
▨ Soil Core (as in Sonic Core Borings)
⌶ 2.0" O.D. Split Spoon Sample
▦ Well Screen and Sand Filter
▧ Bentonite-Cement Grout
⊠ Bentonite Chips/Pellets
▨ Bentonite Grout
▼ Ground Water Level in Well

◇ % Fines (<0.075mm)
● % Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-4

July 2017
21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 1 of 2

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

REV 3 - Approved for Submittal

Total Depth:	35.4 ft.	Northing:	~	Drilling Method:	Sonic Core
Top Elevation:	~ 31 ft.	Easting:	~	Drilling Company:	Holocene Drilling
Vert. Datum:	NAVD 88	Station:	~	Drill Rig Equipment:	Geoprobe 8140 LC
Horiz. Datum:	N/A	Offset:	~	Other Comments:	

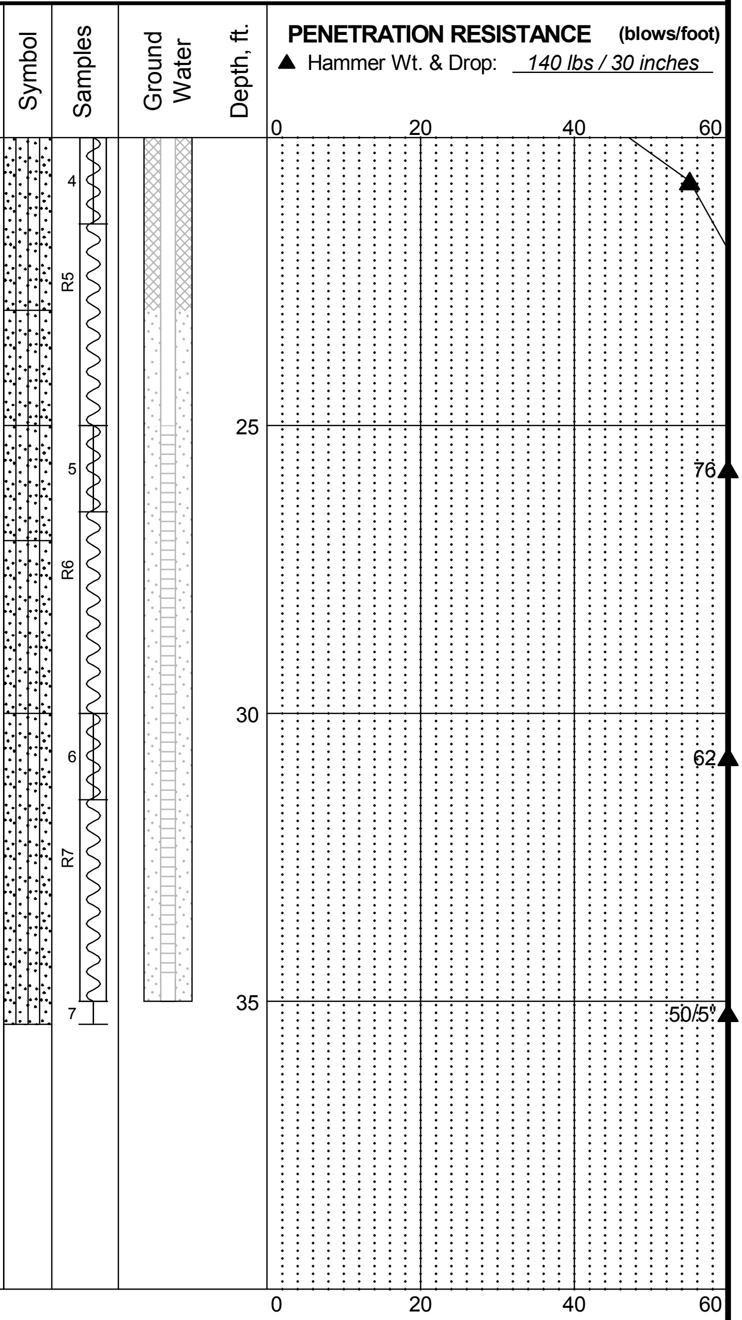
Hole Diam.: 6 in.
Rod Diam.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
Very dense, gray, *Silty Sand (SM)*; moist; few fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; few wood fragments. (Hf) - Contaminated from 20 to 23 feet.	23.0
Very dense, gray, *Silty Sand (SM)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; odor. (Qvd)	25.0
Very dense, gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; slight odor. (Qvd)	27.0
Very dense, gray, *Silty Sand (SM)*; moist; trace fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd)	30.0
Very dense, gray, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvt)	35.4

BOTTOM OF BORING
COMPLETED 4/6/17



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered	Well Screen and Sand Filter
Soil Core (as in Sonic Core Borings)	Bentonite-Cement Grout
2.0" O.D. Split Spoon Sample	Bentonite Chips/Pellets
	Bentonite Grout
	Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.
4. The hole location was measured from existing site features and should be considered approximate.

Ballard Conveyance
Seattle, Washington

LOG OF BORING BCT-4

July 2017 21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5
Sheet 2 of 2

Log: JAA Rev: EAS Typ: LK

MASTER_LOG_E 21-22329.GPJ SHAN_WIL.GDT 7/19/17

REV 3 - Approved for Submittal

APPENDIX B

EXISTING EXPLORATION DATA

APPENDIX B

EXISTING EXPLORATION DATA

TABLE OF CONTENTS

FIGURES

SOIL AND BORING COMPLETION LOG

PROJECT NUMBER : JN 23073

BORING NUMBER : B-1

LOCATION : 13' E & 10' S of NWC

PROJECT : Noland Ballard Development

GROUND SURFACE ELEVATION (ft msl) : Street

WATER LEVEL AND DATE (ft bgs) : 14' ATD

LOGGER : Mark K. Dodds, P.E.

DEPTH BELOW SURFACE (FT)	WATER LEVEL	SAMPLE			SAMPLE DESCRIPTION		COMMENTS
		NUMBER	STANDARD PENETRATION 6"-6"-6" - (N)	SYMBOL	USCS SYMBOL		
1					Fill	Light brown to brown Gravelly Sandy Silt Fill to Gravelly Silty Sandy Fill, slightly moist to moist, loose to medium-dense.	
2							
3							
4							
5							
6		1	22	░			
7							
8							
9							
10							
11		2	7	░			
12							
13							
14	▼				SM	Gray Gravelly Silty Sand, wet, very dense.	
15							
16		3	82	░			
17						Stopped at 16.5 feet. GWT at 14.0 feet ATD.	
18							
19							
20							

B-1

SOIL AND BORING COMPLETION LOG

PROJECT NUMBER : JN 23073

BORING NUMBER : B-2

LOCATION : 11' W & 15' N of SEC

PROJECT : Noland Ballard Development

GROUND SURFACE ELEVATION (ft msl) : Alley

WATER LEVEL AND DATE (ft bgs) : 14' ATD

LOGGER : Mark K. Dodds, P.E.

DEPTH BELOW SURFACE (FT)	WATER LEVEL	SAMPLE			SAMPLE DESCRIPTION		COMMENTS
		NUMBER	STANDARD PENETRATION 6"-6"-6"- (N)	SYMBOL	USCS SYMBOL		
0					Fill	Light brown to brown Gravelly Sandy Silt Fill to Gravelly Silty Sandy Fill, slightly moist to moist, loose to medium-dense.	
1							
2							
3		4	6	▨			
4							
5							
6							
7							
8		2	7	▨			
9							
10							
11							
12							
13		3	49	▨			On rock? No recovery.
14	▼						
15					SM	Gray Gravelly Silty Sand, wet, very dense.	
16							
17							
18		4	+100	▨			
19						Stopped at 19.0 feet. GWT at 14.0 feet ATD.	
20							

B-2

Hole No. B-1

PROJECT: SWC NW57th & 24th NW
DRILL RIG: Trailer Rig
HOLE DIA: 8 in.
INITIAL WATER DEPTH: 13.5 ft.
FINAL WATER DEPTH: ft.

DATE DRILLED: 02/22/01
LOGGED BY: MKD
SAMPLER: SPT
HOLE ELEV: ± Road
TOTAL DEPTH: 24.0 ft.

DESCRIPTION	SOIL TYPE	GRAPHIC LOG		SAMPLES	BLOWS /FT.	REMARKS
2" Asphalt Concrete Brown to gray Silty Sandy Fill with Clayier zones and pieces of brick and glass, wet, loose.	Fill		0			
			2			
			4		7	Moisture Content = 10.5%
			6			
			8			
			10		2	Moisture Content = 15.8%
			12			
Gray Silty Sand with layers of Gravelly Silty Sand, wet, very dense. (Glacial Till)	SM		14		74	Moisture Content = 15.5%
			16			
			18			
			20		+100	Moisture Content = 7.8%
			22			
			24		+100	Moisture Content = 9.9%

Refusal at 24.0 feet. Standing groundwater at 13.5 feet during drilling. Test boring located 20 feet west and 18 feet north of property's southeast corner.

DODDS GEOSCIENCES INC.

PAGE 1 OF 1

BORING LOG

Boring No. B-2

Logged by: CRL

Date: 12/12/02

Approximate Elev. 62+/-

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)
(6 inches CONCRETE)					
			⌶	50/4"	8
		5			
			⌶	50/6"	10
Gray silty SAND with gravel, moist. (Glacial till) With zones of silty fine SAND.					
		10			
	Very Dense				
			⌶	50/5"	10
		15			
			⌶	50/5"	9
		20			
			⌶	50/5"	13
		25			
		▼	⌶	50/4"	10

Boring terminated at 28.5 feet.
Groundwater seepage encountered at 28 feet.

Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

BORING LOG
BALLARD EAGLES SITE
SEATTLE, WASHINGTON

Proj. No. T-5299	Date FEB 2003	Figure A-3

Boring No. B-3

Logged by: CRL

Date: 12/12/02

Approximate Elev. 67+/-

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)
(2 inches ASPHALT CONCRETE)					
			⌶	50/6"	8
		5			
Gray silty SAND with gravel, moist. (Glacial till)			⌶	50/6"	8
		10			
			⌶	50/6"	10
	Very Dense	15 ▼ 1/15/03			
			⌶	50/6"	8
		20			
			⌶	50/5"	7
		25	⌶	50/5"	8
			⌶	50/6"	11
		30			
Becomes wet below 32.5 feet.		▼	⌶	50/5"	9
		35			
			⌶	50/5"	10

Boring terminated at 38.5 feet.
Groundwater seepage encountered at 32.5 feet.
2-inch diameter PVC monitoring well installed with screen set from 27 to 37 feet and sand pack to 12 feet.

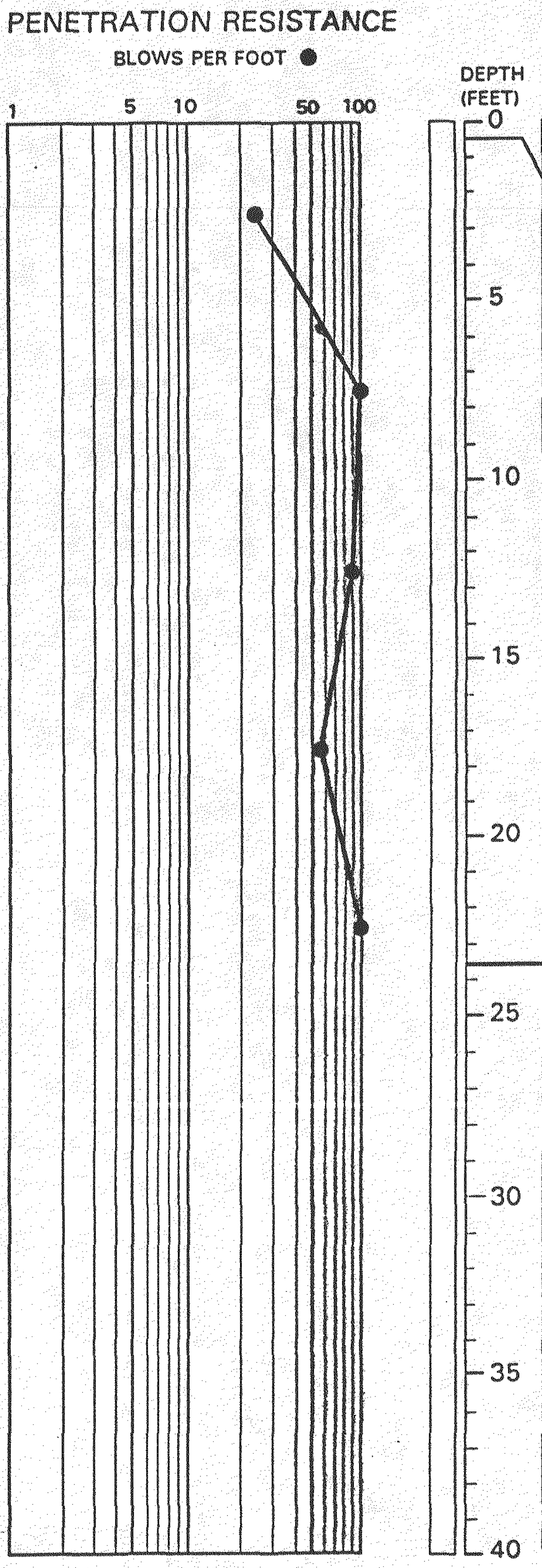
Terra Associates, Inc.
Consultants in Geotechnical Engineering
Geology and
Environmental Earth Sciences

BORING LOG
BALLARD EAGLES SITE
SEATTLE, WASHINGTON

Proj. No. T-5299 | Date FEB 2003 | Figure A-4

NELSON-COUVRETTE & ASSOCIATES, INC.
CONSULTING GEOTECHNICAL ENGINEERS, GEOLOGISTS
AND ENVIRONMENTAL SCIENTISTS

GROUND SURFACE ELEVATION:



SOIL DESCRIPTION

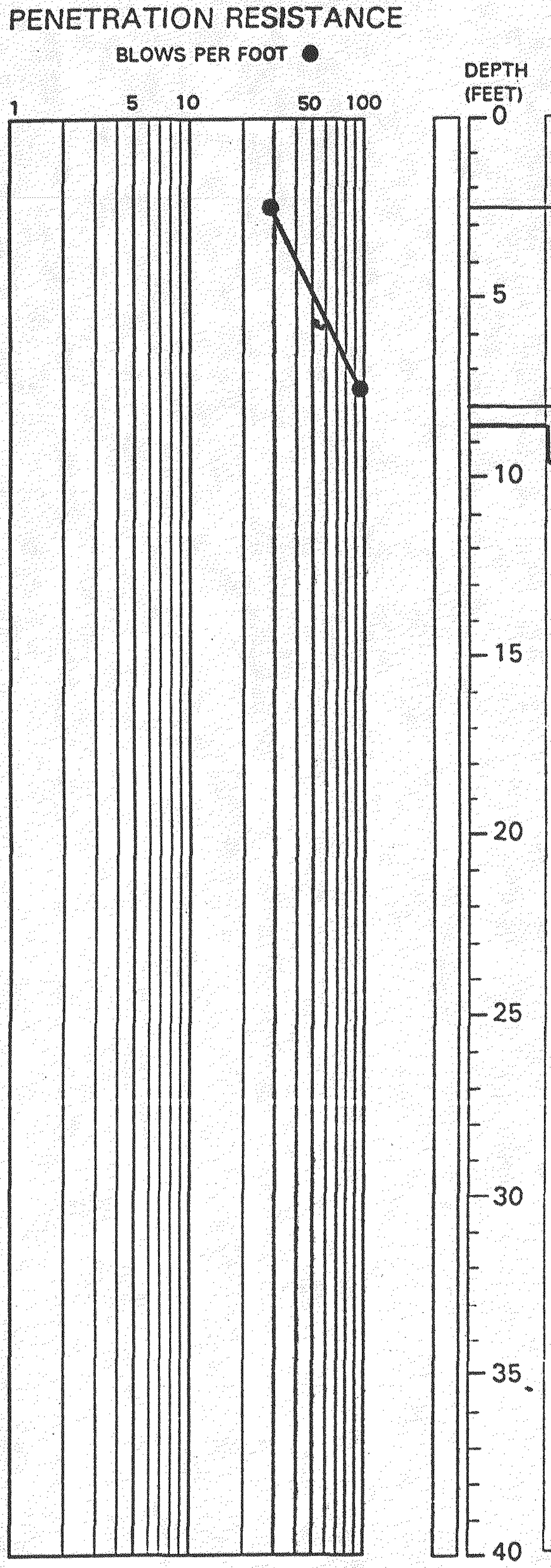
SM	BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST) (FILL)
SM	GREY-BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (DENSE TO VERY DENSE,MOIST) (TILL)
SM SP	GREY-BROWN FINE TO MEDIUM SAND WITH SILT (VERY DENSE,MOIST) (ADVANCE OUTWASH)
ML	GREY-BROWN SILT (HARD,MOIST)

END OF BORING AT 23.5 FEET ON APRIL 13, 1993
GROUND WATER WAS ENCOUNTERED AT 12.5 FEET

BORING LOG 1

OLYMPIC ASSOCIATES
SHILSOLE AVE.
COMMERCIAL BUILDING
NCA FILE NO. 1051A93
FIGURE 4

GROUND SURFACE ELEVATION:



SOIL DESCRIPTION

SM	BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST) (FILL)
SM	GREY-BROWN SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST) (TILL)
SM/SP	GREY-BROWN FINE TO MEDIUM SAND WITH SILT (DENSE, MOIST) (ADVANCE OUTWASH)

END OF BORING AT 8.5 FEET
GROUND WATER WAS NOT ENCOUNTERED

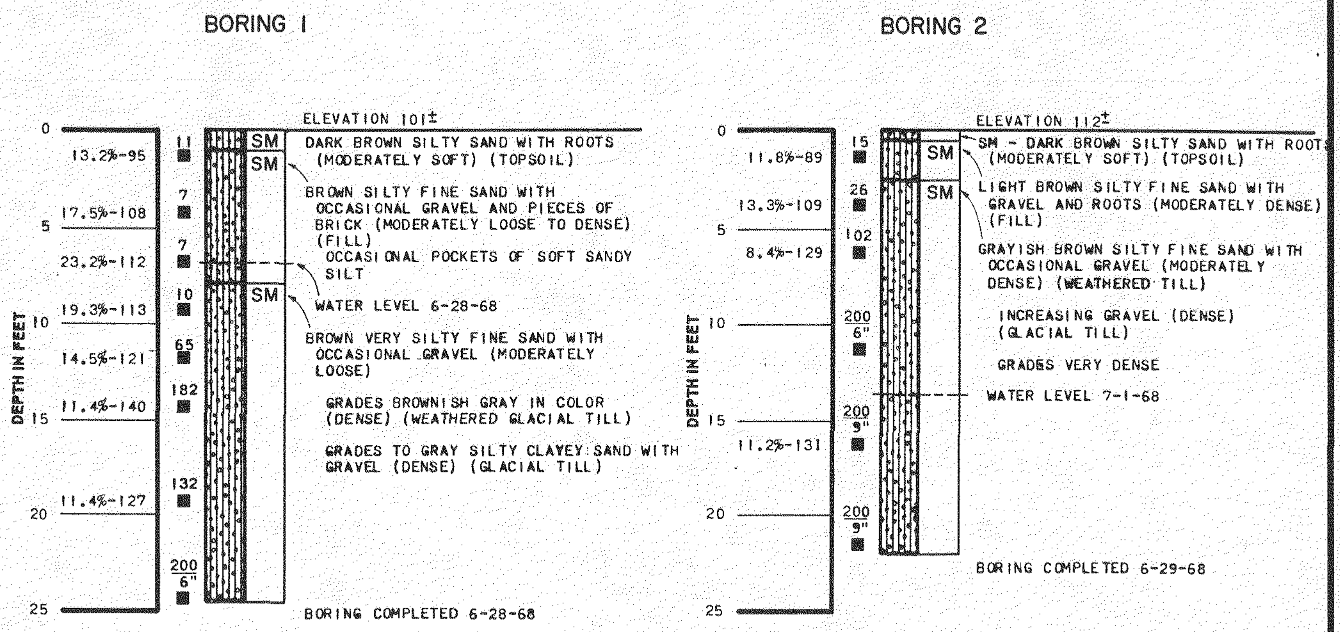
BORING LOG 2

OLYMPIC ASSOCIATES
SHILSOLE AVE.
COMMERCIAL BUILDING
NCA FILE NO. 1051A93
FIGURE 5

SEATTLE Hous. Auth.
BY Dick Arnold DATE 7-11-68
CHECKED BY ________ DATE ________

BY ________ DATE ________
BY ________ DATE ________
PLATE ________ OF ________

MICROFILMED



KEY:

MOISTURE CONTENT
19.4%-126
DRY DENSITY IN PCF

8 ■ BLOWS REQUIRED TO DRIVE SAMPLER ONE FOOT WEIGHT= 260 LBS., STROKE= 36 INCHES.

INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED.

NOTE: BORING ELEVATIONS REFER TO ASSUMED ELEVATION AS SHOWN ON PLOT PLAN.

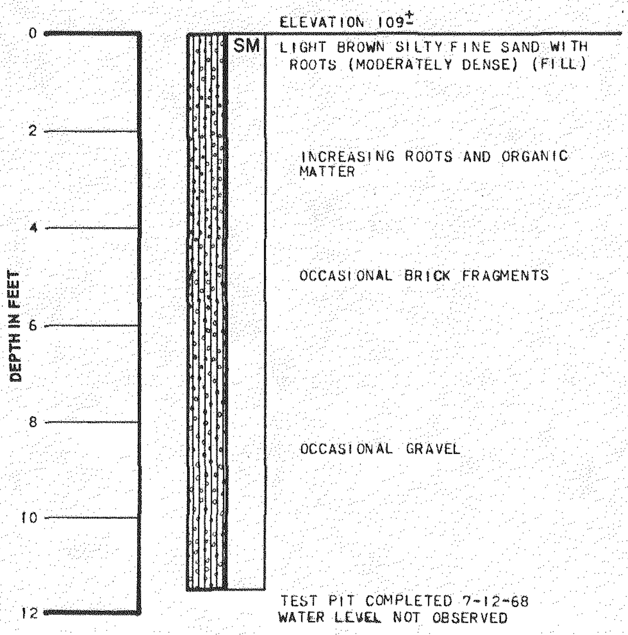
LOG OF BORINGS

DAMES & MOORE

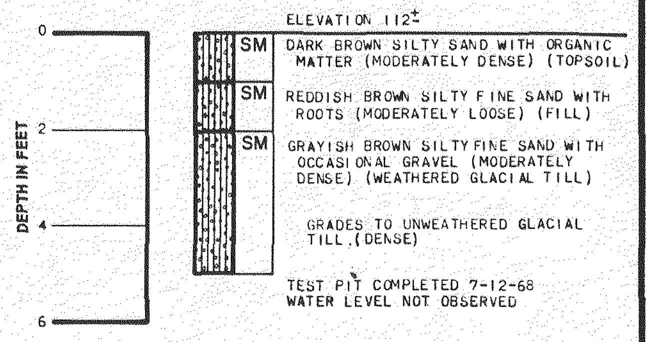
PLATE A-I

MICROFILMED

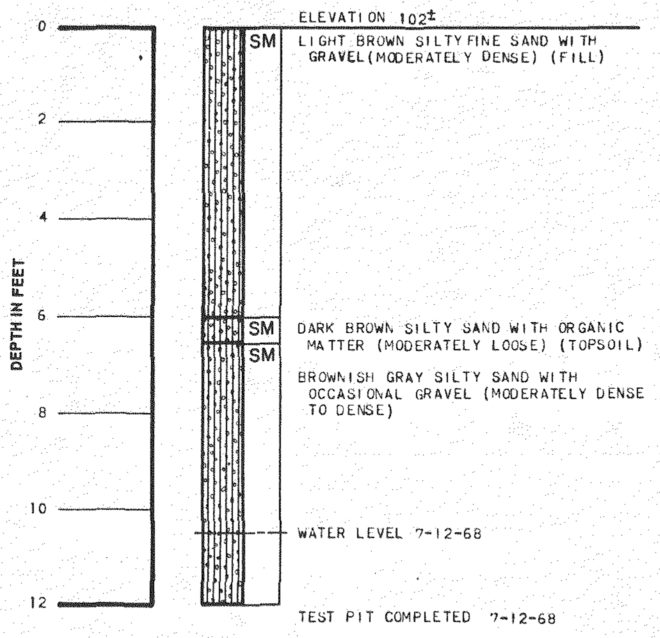
TEST PIT 1



TEST PIT 2



TEST PIT 3



NOTE: PLEASE NOTE THAT LOG OF TEST PITS ON PLATES A-2 AND A-3 ARE PRESENTED TO DIFFERENT VERTICAL SCALE THAN BORING LOTS ON PLATE A-1.
TEST PIT ELEVATIONS REFER TO ASSUMED ELEVATION AS SHOWN ON PLOT PLAN.

LOG OF TEST PITS

DAMES & MOORE

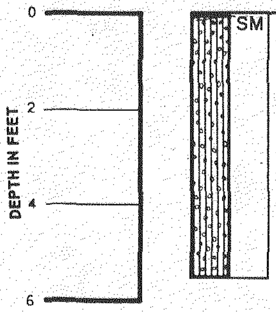
BY____ DATE____
BY____ DATE____
PLATE____ OF____

3081-003
BY Dick Arnold DATE 7-17-68
CHECKED BY____ DATE____

PLATE A-2

MICROFILMED

TEST PIT 4



ELEVATION 103±

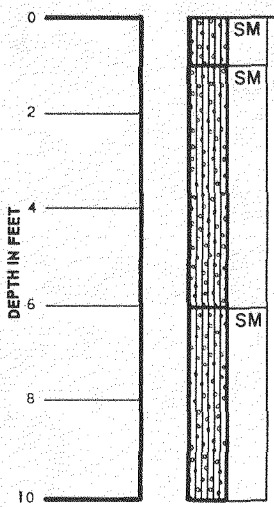
2" OF ASPHALTIC PAVEMENT (DRIVEWAY)

GRAYISH BROWN SILTY SAND WITH SOME GRAVEL (MODERATELY DENSE) (WEATHERED TILL)

GRADES TO UNWEATHERED TILL, (DENSE)

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

TEST PIT 5



ELEVATION 103±

GRAY SILTY FINE SAND WITH CONSIDERABLE ROOTS (MODERATELY LOOSE) (TOPSOIL)

BROWN SILTY SAND WITH OCCASIONAL GRAVEL AND ROOTS (MODERATELY DENSE) (FILL)

PIECE OF WOOD

BROWNISH GRAY SILTY SAND WITH OCCASIONAL GRAVEL (MODERATELY DENSE) (WEATHERED TILL)

GRADES TO UNWEATHERED GLACIAL TILL (DENSE)

TEST PIT COMPLETED 7-12-68
WATER LEVEL NOT OBSERVED

LOG OF TEST PITS

DAMES & MOORE

PLATE A-3

BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

1681-002
BY Dick Arnold DATE 7-17-68
CHECKED BY ____ DATE ____

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 3
PROJECT BALLARD #1 CONT. #1 WEATHER
LOCATION 28TH AVE NW & R.R. 50' N & 9' E of BLDG

WATER TABLE: Not taken

GRD.EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A	1	1		14	ASH	ORGANIC	LOOSE	MOIST	BLK
5										
			18"							
	B		2		1	ASH	ORGANIC	LOOSE	WET	BLK
10										
	C	4	3	4	7	SAND	TRACE GRAVEL	LOOSE	WET	GRAY
15										
	D	6	15	18	33	NO	RECOVERY	FIRM		
20										
							GOV. FROZE			
							CUTTER HEAD INSTALLED			
							& DRILLED DOWN			
		4	7	15	22	SAND	SILT LAYERS	FIRM	SAT	BRN
25										

INSPECTOR:

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 4
PROJECT BALLARD #1. CONT. #1 WEATHER
LOCATION NW MARKET & 28TH NW 40' E. of ℄ 8' S. of ℄

WATER TABLE: ▽ 11'1" 3-5-69

GRD.EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A	1	2	2	4	SAND	SILT	LOOSE	MOIST	BRN
5										
	B	2	2	2	4	SAND	SILT ORGANIC	LOOSE	MOIST	BLK GRAY
10	B1					8" SAND			MOIST	BRN
	C	2	3	6	9	SAND	SILT LAYERS	LOOSE	SAT	BRN
15										
	D	10	14	13	27	SILT	SAND GRAVEL	FIRM	WET	GRAY
20										
	E	22	56	44	100	SILT	SAND CLAY	VERY COMP	MOIST	GRAY
25										

INSPECTOR:

05886

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 3-4-69 HOLE NO. 7
PROJECT BALLARD #1 Cont. #1 WEATHER
LOCATION NW Market & 26th NW 35' E of cb & 8' N. of cb

WATER TABLE ▽ 5'4" 3-5-69 JSR

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
	A									
		1	1	2	3	SAND	CLAY	LOOSE	WET	GRAY
5										
			18"							
	B		1			SAND	CLAY	LOOSE	WET	GREEN GRAY
10										
			18"							
	C	42 — WEIGHT OF HAMMER								
						SAND	SILT	LOOSE	SAT	BRN GRAY
15										
		HARDER DRILLING								
	D	30	44	79	123	SAND	SILT GRAVEL	VERY COMP	MOIST	GRAY
20										

INSPECTOR:

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LAWN

LOG OF TEST BORING

DATE 2-28-69 HOLE NO. 8
PROJECT BALLARD UNIT 1 Cont. #1 WEATHER
LOCATION 26th NW. & NW 58th 40' S. & 15' W of ℄

WATER TABLE ▽ 7'8" 3-5-69

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
							FRACTURE			
	A	38	22	26	48	SAND	SILT - GRAVEL	COMP	MOIST	BRN
5										
			3"							
	B	42	100		200+	SAND	SILT	VERY COMP	MOIST	BRN
10										
		5"								
	C	100			200+	SAND	SILT	VERY COMP	MOIST	BRN
15										
			5"							
	D	38	100		200+	SAND	SILT-GRAVEL	VERY COMP	MOIST	GRAY
20										

INSPECTOR:

05888

B-12

CS 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 6-1-70 HOLE NO. 9
PROJECT Ballard #1 Area #4 GRD. ELEV.
LOCATION NW Market St. & 24th Ave. NW 135' W. & 25' S. of ℄

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
LOOSE SILTY SAND	5	A	1	2	3	5	SILTY SAND	LOOSE	MOIST	BRN	
COMP.-V. COMP. SILTY SAND w/ SILT LAYERS & GRAVEL	10	B	5	8	23	31	SILTY SAND	COMP	MOIST	BRN	
	15	C	3	14	4" 50	50+	SILTY SAND w/ GRAVEL & SILT LAYER	V. COMP	MOIST	BRN	6-2-70
							GOING WET				BOTTOM
	20	D	10	24	30	54	SILTY SAND w/ TRACE GRAVEL	V. COMP	WET	BRN	

INSPECTOR HWR

CS 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 6-3-70 HOLE NO. 10
PROJECT Ballard #1 Area #4 GRD. ELEV.
LOCATION NW 57 & 17th Ave. NW. 30' W. & 18' N. of ℄

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
FIRM-FINE SAND w/ TRACE GRAVEL		A	3	6	13	19	SAND (FINE) w/ TRACE GRAVEL	FIRM	MOIST	BRN	
V. COMP. SILTY FINE SAND w/ [illegible]	5						HARDER DRILLING				OPEN HOLE 6-5-70 ▽
	10	B	4½" 50			50+	SILTY SAND (FINE) w/ TRACE GRAVEL	V. COMP	MOIST	BRN	
13.5	15	C	5½" 50			50+	SILT w/ SAND LAYERS	V. COMP	MOIST WET	GRAY	

INSPECTOR

05914

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1-11-72

HOLE NO. 11

PROJECT N.W. 54TH SAN. SEWER

GRD. ELEV.

LOCATION 24TH AVE. N.W. & N.W. 54TH S.E. CORNER

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL				WATER LEVEL
							COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
FIRM- V. COMP. SILTY FINE SAND w/ TRACE GRAVEL + SILT LAYER							BLK SILTY ORGANIC				
											1-17-72
											▽ 1-13-72
	5	A	3	10	11	21	SILTY FINE SAND	FIRM	WET? MOIST	BRN	
							w/ SILT LAYERS				
											1-11-72 ▽ 3
	10	B	7	10	13	23	SILTY FINE SAND	FIRM	WET MOIST	BRN	
							w/ GRAVEL				
							+ SILT LAYERS				
	15	C	13	29	27	56	SILTY FINE SAND	V.COMP	MOIST	BRN	
							w/ TRACE GRAVEL				
											SAND
	20	D	9	20	32	56	SILTY FINE SAND	V.COMP	WET	BRN GRAY	
							w/ GRAVEL				
											PIEZOMETER INSTALLED 1-11-72

INSPECTOR H W KOCITA

LOG OF BORING NO. [redacted]

Sheet 1 of 1

Date drilled 4/1/93 Sampler and Driving Weight R,300lb. Elevation (ft) 25

Depth, ft	Elevation	Samples	Blows/6"	Graphic Symbol	This log is part of the report prepared by Converse Consultants NW for the named project and should be read together with that report for complete interpretation. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented are a simplification of actual conditions encountered. DESCRIPTION	Observation Well	Dry density pcf	Moisture Content, %	Other tests
	25				FILL				
		1	1 1 3		SILTY SAND WITH GRAVEL; brown, fine to coarse, fine gravel, wood debris, silt chunks, very loose, moist to very moist			15	
		2	1 1 1		SILTY SAND WITH GRAVEL; brown to dark brown, fine to medium, trace coarse sand, silt chunks, root structures; very loose, moist to very moist				
5	20	3	3 1 3		SILTY SAND; dark brown to black, fine to medium, trace fine gravel, silt chunks, some iron oxidation staining, wood debris; loose, very moist to wet				
		4	4 8 10		WEATHERED GLACIAL TILL SILTY SAND WITH GRAVEL; brown, fine to coarse sand; loose to medium dense, very moist to wet				
10	15	5	17 51/5"		UNWEATHERED GLACIAL TILL SILTY SAND; gray to brown, fine sand, few medium to coarse sand; very dense, wet			14	
					Bottom of boring at depth 13.5 feet. Boring backfilled with bentonite chips and cuttings. Groundwater encountered at depth 10.23 feet.				
15	10								
	5								

Project No.

OFF THE WALL MARKET STREET SITES

Seattle, Washington

OFF THE WALL

93-35508-02

Converse Consultants NW

Geotechnical Engineering
and Applied Earth Sciences

Figure No.

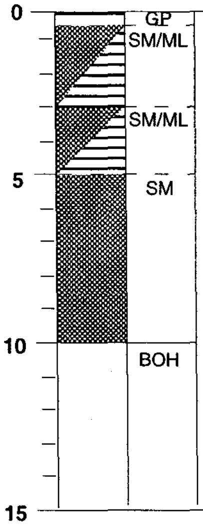
A-4

Logged by: MT
Date: 5/8/02

Test Pit No. 1

Elevation: 100.0 feet± *

Depth / Symbols	Soil Description	W (%)



Parking lot - asphalt surfacing.
Brown red-brown, black silty fine to coarse SAND, sandy SILT, moist, medium dense, few rounded gravel, bits of plastic, concrete [Fill].

Red-brown silty fine to coarse SAND to sandy SILT, moist, medium dense, partially cemented.

- Sandier with depth.

Gray silty fine to coarse SAND, moist, dense, few rounded gravel, partially cemented.

- Increasing cementation with depth.

Test Pit terminated at 10.0 feet below existing grade.
No groundwater seepage encountered during excavation.

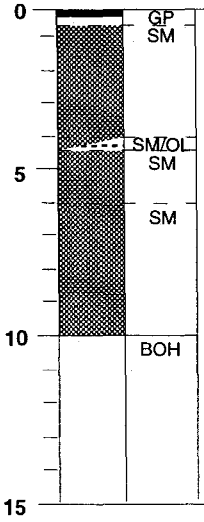
* Test Pit elevations approximately determined by eye with respect to a temporary benchmark, the ground surface at the NE corner of the site, at an assumed elevation of 100 feet.

Logged by: MT
Date: 5/9/02

Test Pit No. 2

Elevation: 95.0 feet±

Soil Description



Parking lot - asphalt surfcing.
Reddish-gray-brown silty fine to coarse SAND, moist, medium dense, few rounded gravel [Fill].

Black carbon (charcoal) layer ~4" thick.

Reddish-brown silty fine to coarse SAND, moist, loose to medium , little rounded gravel (Weathered inplace).

Gray sitly fine to coarse SAND, moist, medium dense, reddish oxidation zones, slightly cemented.

- Few round gravel.
- Becomes saturated at 8-feet.
- Increasing cementation below 8-feet.

Test Pit terminated at 10.0 feet below existing grade.
No groundwater seepage encountered during excavation.

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis, and judgement. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

Creative Engineering Options INC. CEO A Firm Practicing in the Geosciences	TEST PIT LOG	Plate 9

Logged by: MT
Date: 5/8/02

Test Pit No. 3

Elevation: 93.5 feet±

Depth	Symbols	Soil Description	W (%)
0	GP	Parking lot - asphalt surfacing.	
	SM	Brown-gray silty fine to coarse SAND, moist, medium dense, few rounded gravel [Fill].	
5	SM	Black & brown silty fine to coarse SAND, moist, loose to medium dense, little wood debris (stake), very slight organic - 1/2" dia. root [Fill].	
	SM	Reddish-gray silty fine to coarse SAND, moist, medium dense, few round gravel oxidized.	
	SM	Gray silty fine to coarse SAND, moist, medium dense to dense, partially, cemented - increases with depth.	
10	BOH	Test Pit terminated at 10.0 feet below existing grade. No groundwater seepage encountered during excavation.	
15			

02-2420 / 5.15.2002

Creative Engineering Options INC.
CEO
A Firm Practicing in the Geosciences

TEST PIT LOG

Plate
10

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: *-*
Offset: *-*

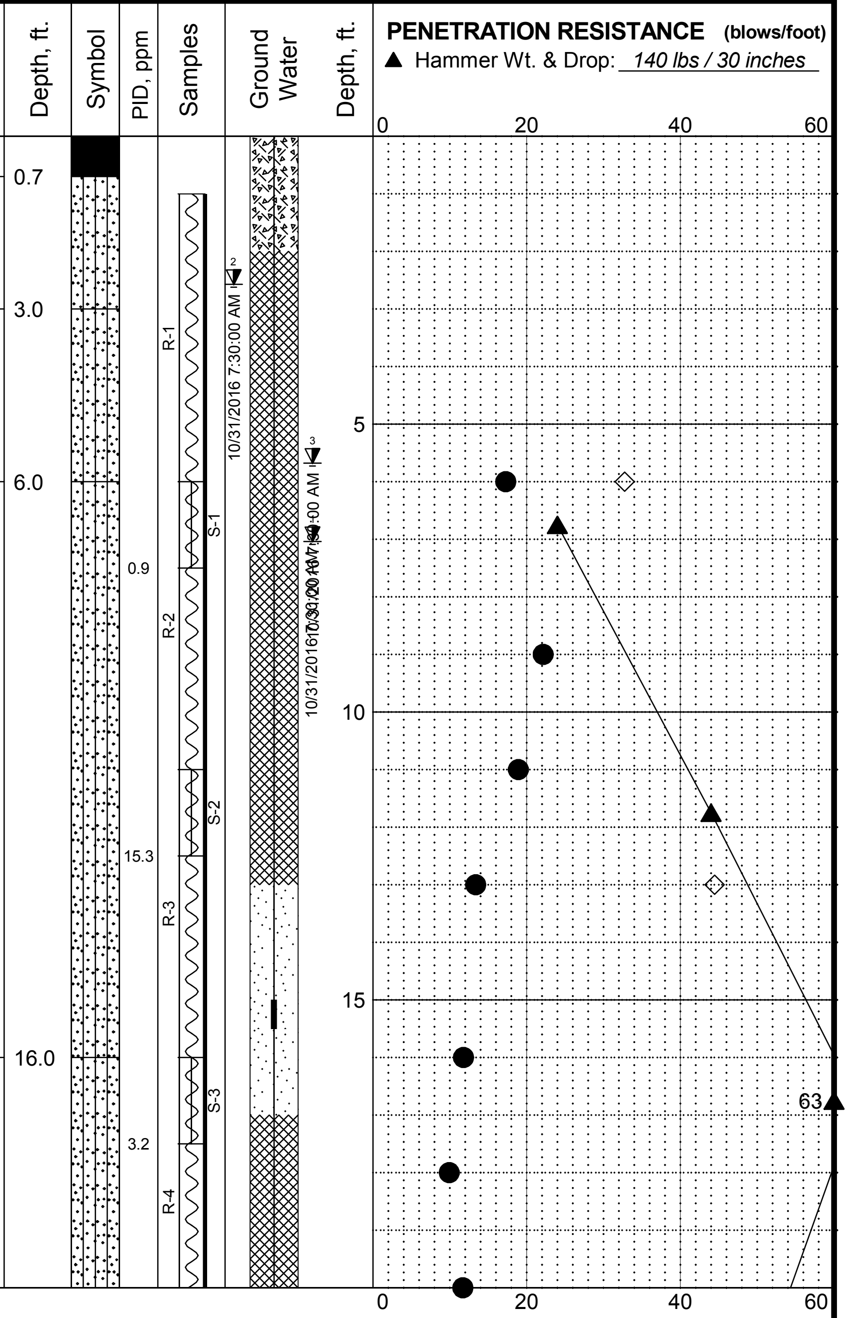
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
Asphalt.	0.7
Brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace to few organics. (Hf)	3.0
Gray-brown, *Silty Sand (SM)*; moist; less than 5% fine, subrounded gravel; fine to medium sand; nonplastic fines; few pockets with iron-oxide staining. (Qvro)	6.0
Medium dense, gray-brown, *Silty Sand (SM)*; wet; less than 5% fine, subrounded to angular gravel; fine to medium sand; nonplastic fines; trace iron-oxide staining. (Qvro) - Few seams with iron-oxide staining below 8 feet.	16.0
Very dense, gray-brown, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; few wet, silty sand seams; trace pockets with iron-oxide staining. (Qvd)	



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 1 of 11

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: *-*
Offset: *-*

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

22.0

Medium dense to very dense, gray, *Silty Sand (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict; few silt seams.
(Qvd)
- Moist to wet below 24 feet.

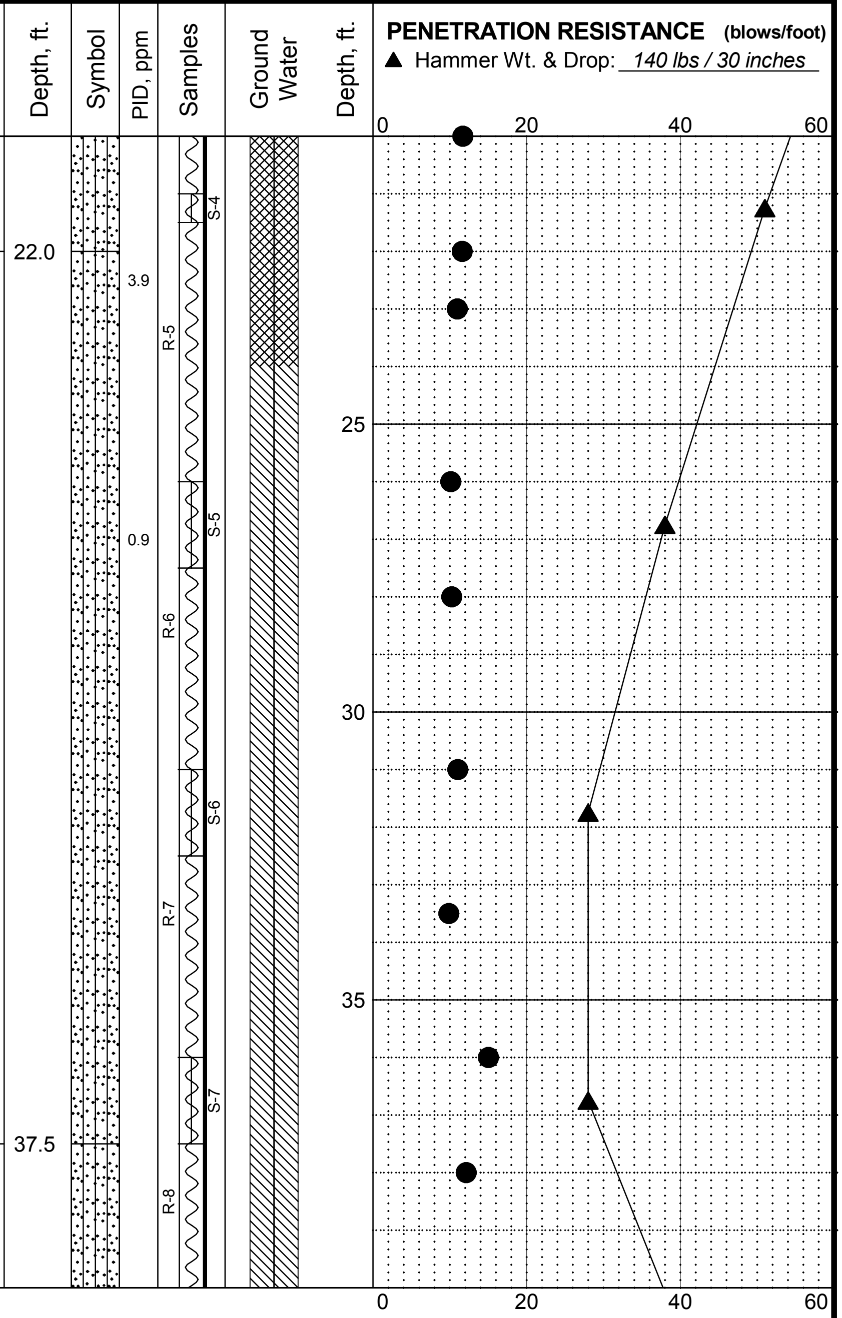
- Layer of silty gravel with sand from 30 to 30.5 feet.

- Layer of wet, silty sand from 31.5 to 32.3 feet.

- Layer of silty sand with gravel from 34.3 to 35 feet.

37.5

Medium dense to dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
☒ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 2 of 11

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

diamict pockets.
(Qva)

43.0

Dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

45.0

46.0

Dense, gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

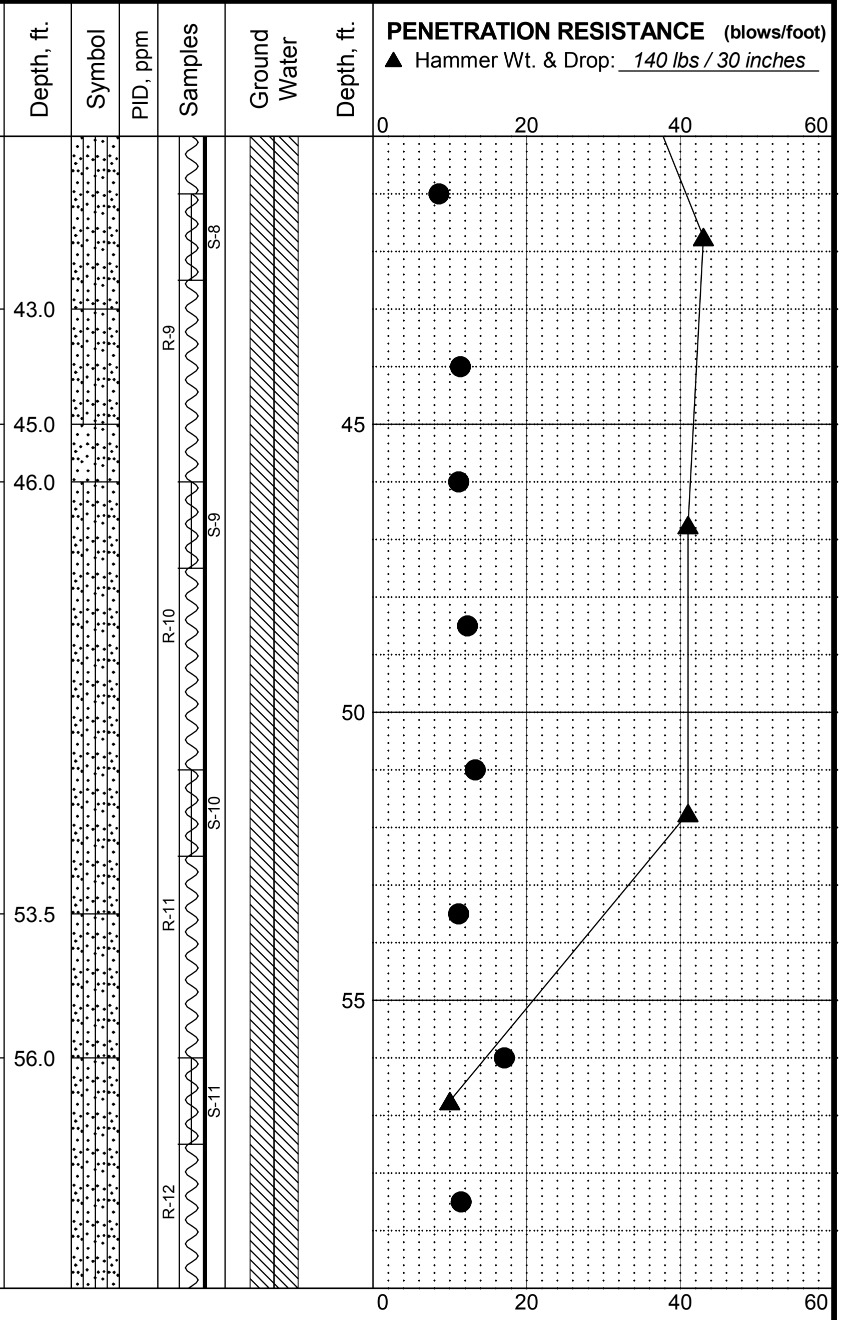
Dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few diamict pockets.
(Qvd)
- 5 feet of heave at 51 feet.

53.5

Dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)

56.0

Medium dense, gray, *Silty Sand (SM)*; moist to wet; less than 10% fine to coarse, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qva)
- Blow counts at 56 feet may be artificially low due to slough in boring.



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery	⊻	Ground Water Level in VWP
*	Sample Not Recovered		
⊠	Sonic Core Sample		
⌶	2.0" O.D. Split Spoon Sample		

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

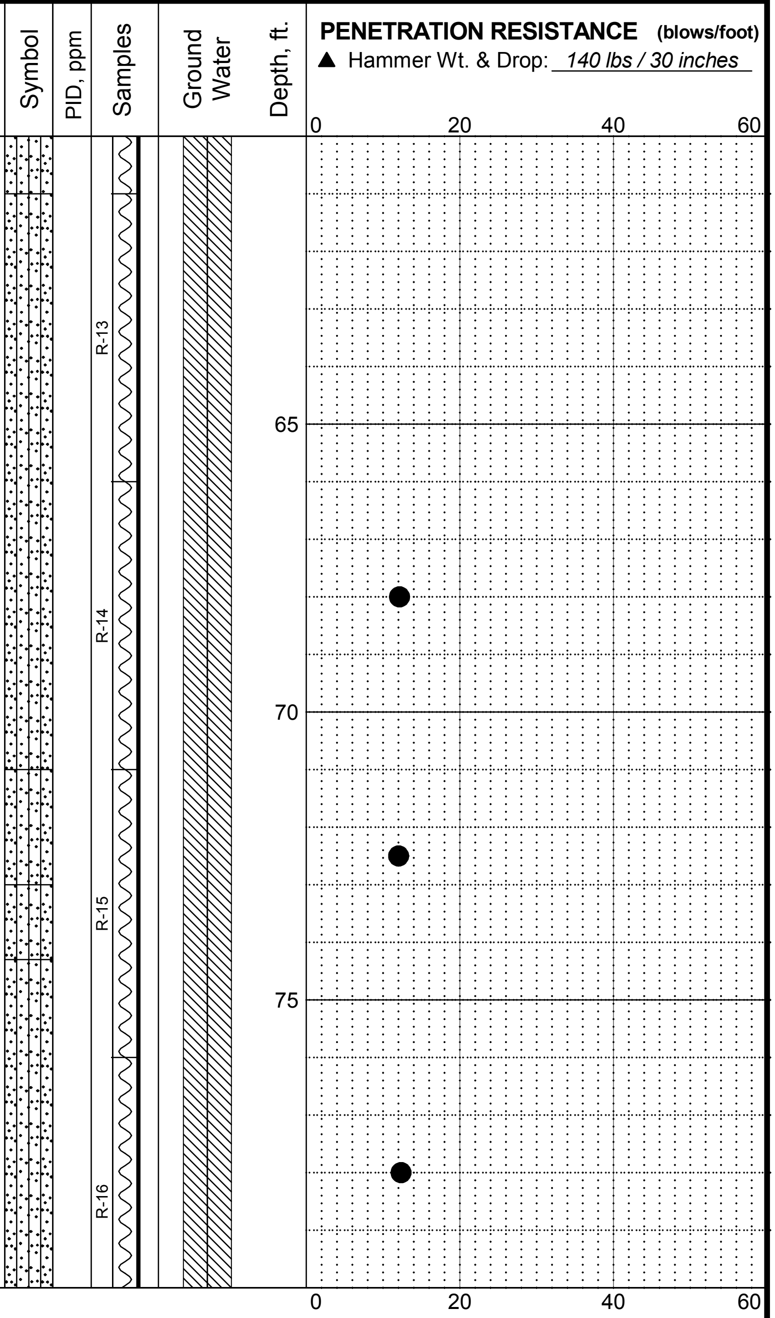
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 3 of 11

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.
Gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines. (Qva) - Layer of silt at 64.3 feet. - Layer of wet, sandy silt from 66.5 to 67 feet.	61.0
Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd)	71.0
Gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qva)	73.0
Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; low plasticity fines; diamict. (Qvd)	74.3



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery

* Sample Not Recovered

▨ Sonic Core Sample

⌶ 2.0" O.D. Split Spoon Sample

▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 4 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

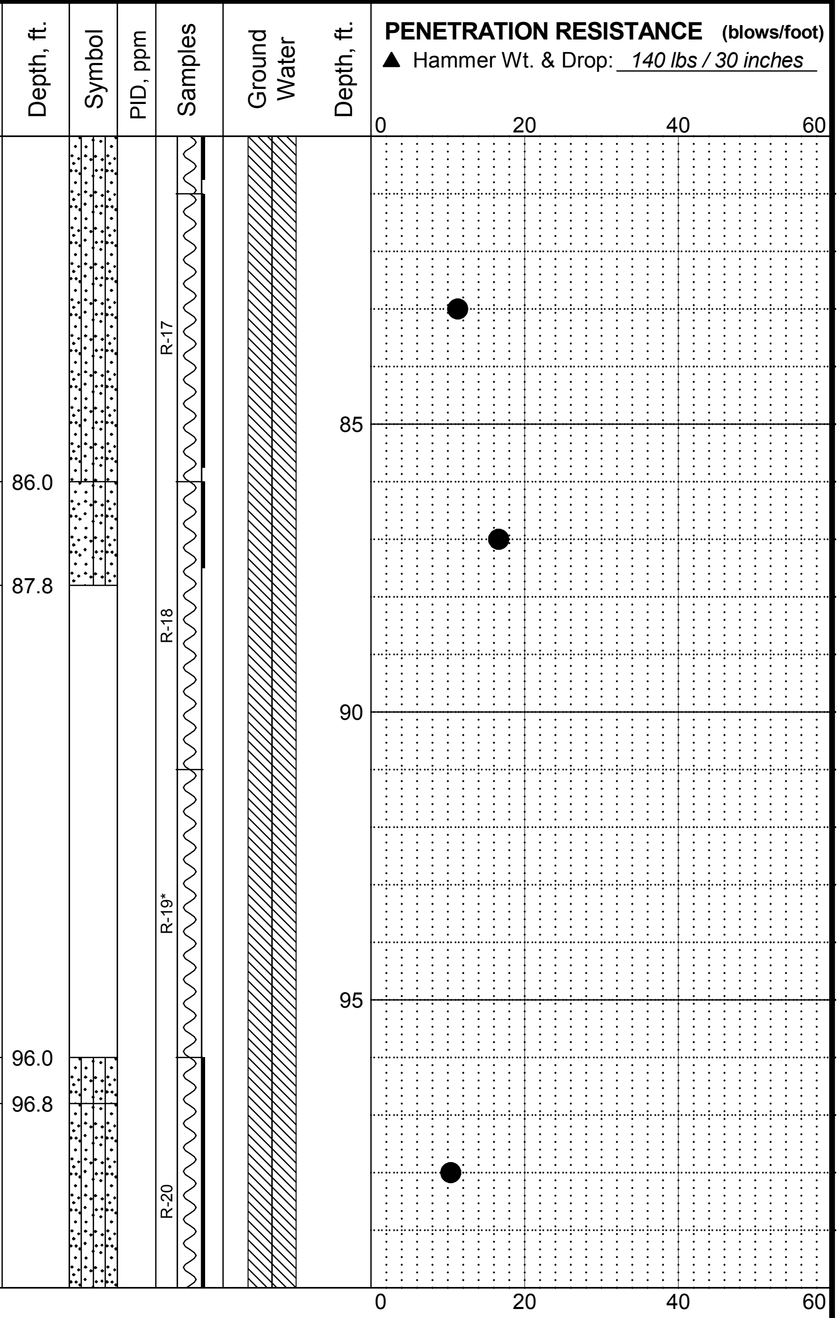
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
	86.0
Gray, *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qva)	87.8
No recovery from 87.8 to 96 feet.	
- Driller switched to bag samples from 96 to 111 feet.	96.0
Gray to green-gray, *Silty Sand (SM)*; wet; less than 15% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; iron-oxide staining. (Qva)	96.8
Gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine	



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
⊠	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▼	Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 5 of 11

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: -
Offset: -

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

to medium sand; nonplastic to low plasticity fines.
(Qva)

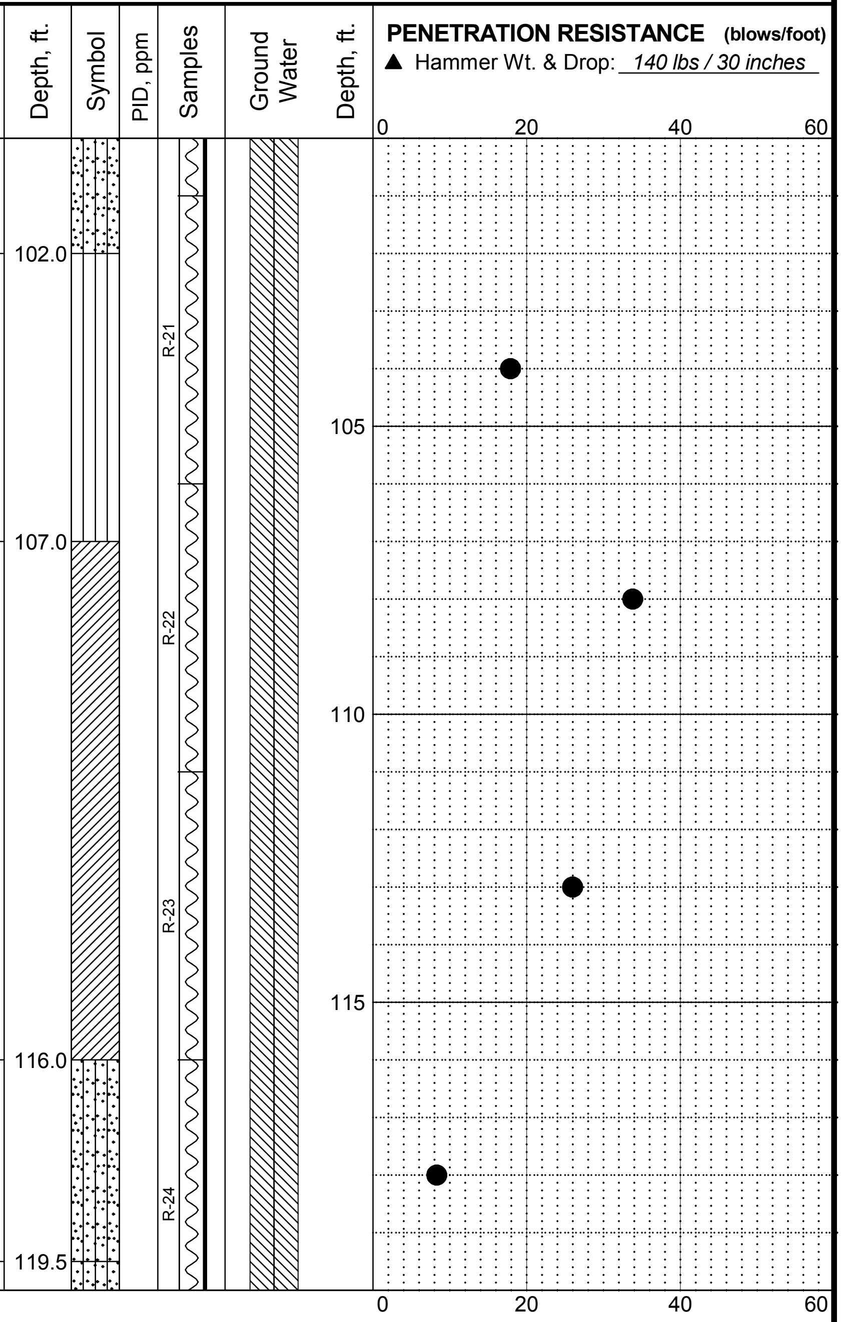
- Layer of wet, poorly graded, fine to medium sand from 99.8 to 101.4 feet.

Gray, *Sandy Silt (ML)* to *Silt with Sand (ML)*; moist; less than 5% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qpgl)

Gray, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 5% fine, subrounded to subangular gravel; less than 10% fine to coarse sand; low to medium plasticity fines; few silty sand seams and pockets, trace fine clay seams with slickensides.
(Qpgl)

- Slightly diced to blocky texture below 111 feet.

Gray, *Silty Sand (SM)*; moist; less than 5% fine, subrounded to subangular gravel; fine sand; nonplastic fines.
(Qpgo)



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
⊻ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016　21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 6 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: -
Offset: -

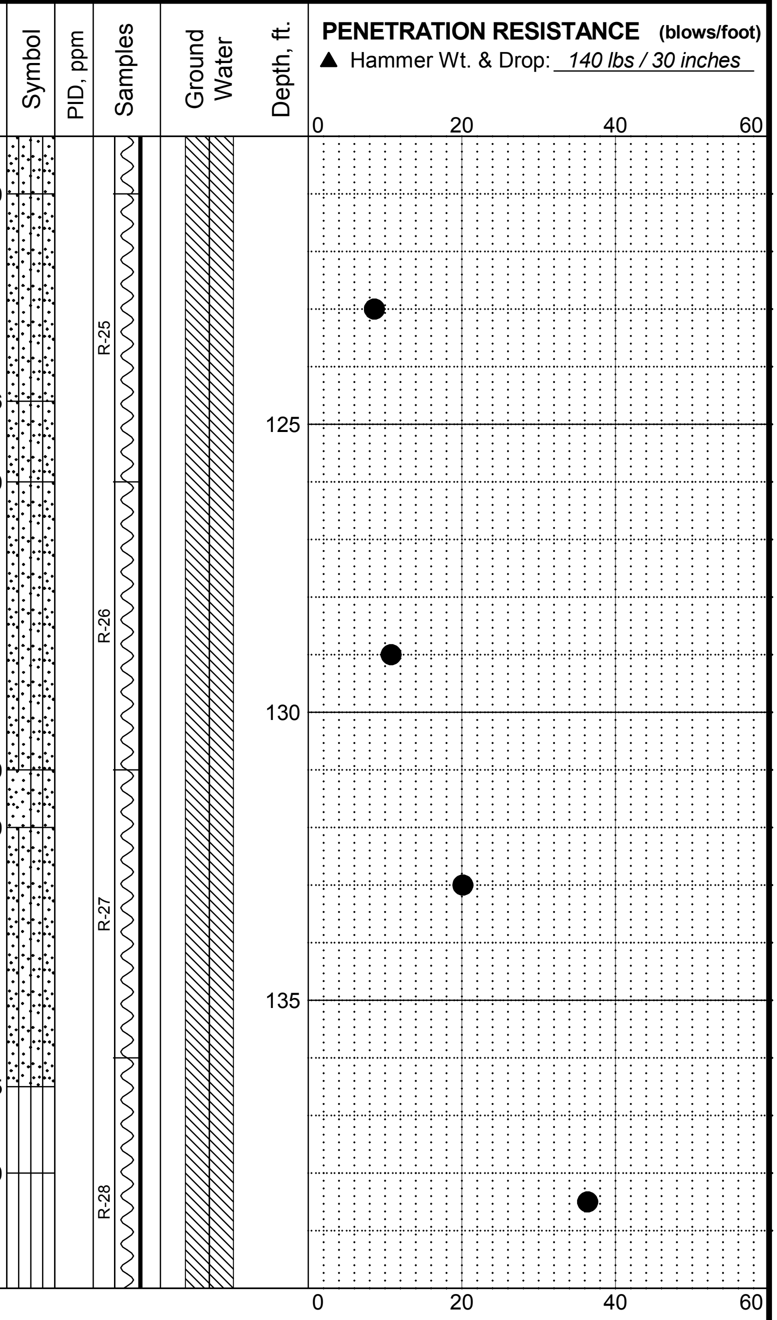
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Gray, *Silty Sand (SM)*; moist; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines; diamict. (Qpgt)	121.0
Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qpgt)	124.6
Gray, *Silty Sand (SM)*; moist; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qpgd)	126.0
Gray, *Silty Sand with Gravel (SM)*; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qpgt)	131.0
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 5% fine, subrounded gravel; fine to medium sand; nonplastic fines. (Qpnf)	132.0
Gray to gray-brown, *Silty Sand (SM);* wet; fine to medium sand; nonplastic fines; few organics. (Qpnf)	136.5
Gray-brown *Silt with Sand (ML)*; moist; fine sand; low plasticity fines; trace to few organics. (Qpnl)	138.0
Gray-brown *Silt (ML)* to *Lean Clay (CL)*; moist; less than 10% fine sand; low to	



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ☒ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ⊻ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 7 of 11

Log: EAS Rev: EAS Typ: LKN

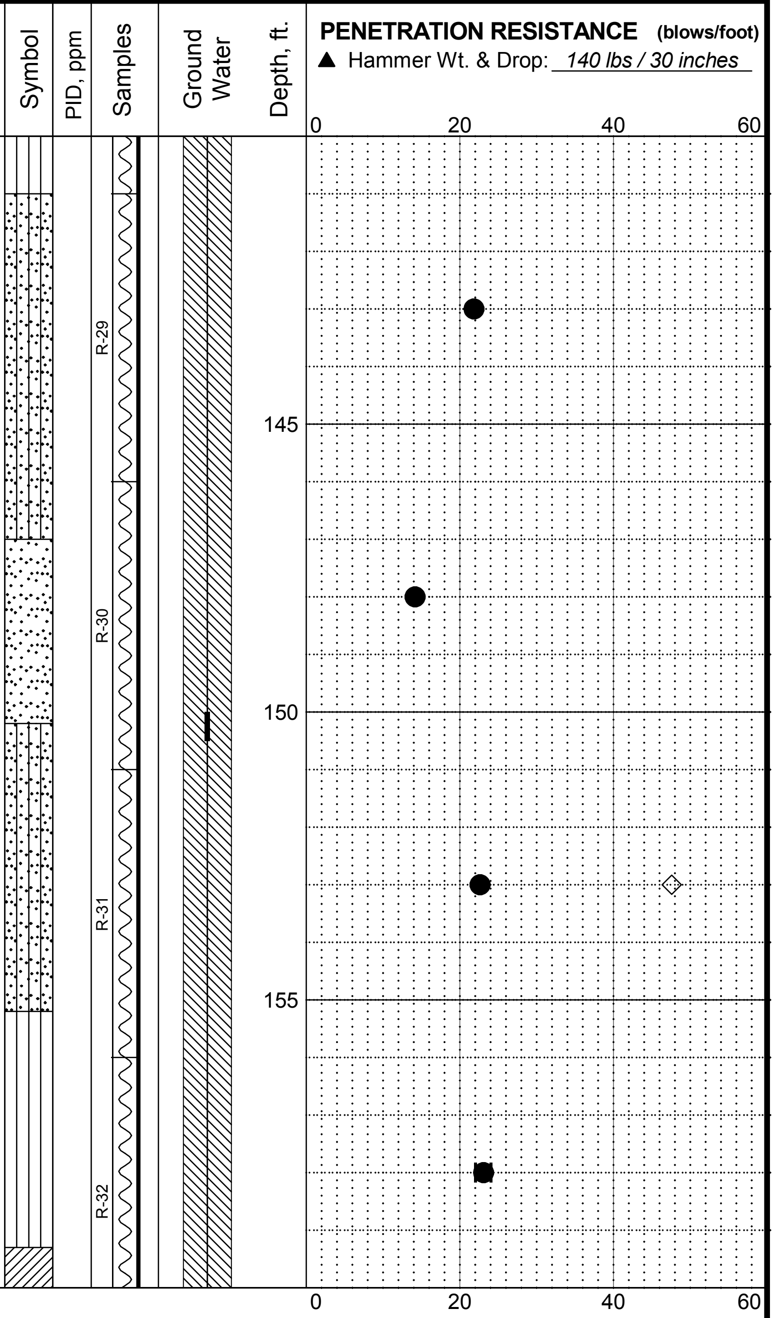
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,438 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.7 ft.*	Easting:	*1,585,696 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625"*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller switched to lexan liners at 61 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
medium plasticity fines; trace to few organics. (Qpnl)	141.0
Gray to gray-brown, *Silty Sand (SM)*; moist to wet; fine to medium sand; nonplastic fines; trace to few organics; trace shell fragments. (Qpnf) - Layer of wet, poorly graded sand with silt from 146.5 to 147 feet.	147.0
Gray, *Poorly Graded Sand (SP)*; wet; fine to medium sand; less than 5% nonplastic fines. (Qpnf)	150.2
Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace to few organics; few sandy silt seams. (Qpnf) - Seam with little organics at 150.5 feet. - Wood fragments at 151.7 feet.	155.2
Gray-brown, *Sandy Silt (ML)* to *Silty Sand (SM)*; moist to wet; fine sand; nonplastic fines; trace to few organics; slightly blocky texture. (Qpnl)	159.3



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ☒ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 8 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER LOG BFW 21-21979.GPJ SHAN WIL.GDT 11/29/16

REV 3 - Approved for Submittal

Total Depth:	201 ft.	Northing:	575,438 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	28.7 ft.	Easting:	1,585,696 ft.	Drilling Company:	Cascade Drilling	Rod Diam.:	2.625"
Vert. Datum:	NAVD 88	Station:	-	Drill Rig Equipment:	Truck-Mounted Sonic	Hammer Type:	Automatic
Horiz. Datum:	Project	Offset:	-	Other Comments:	Driller switched to lexan liners at 61 feet.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

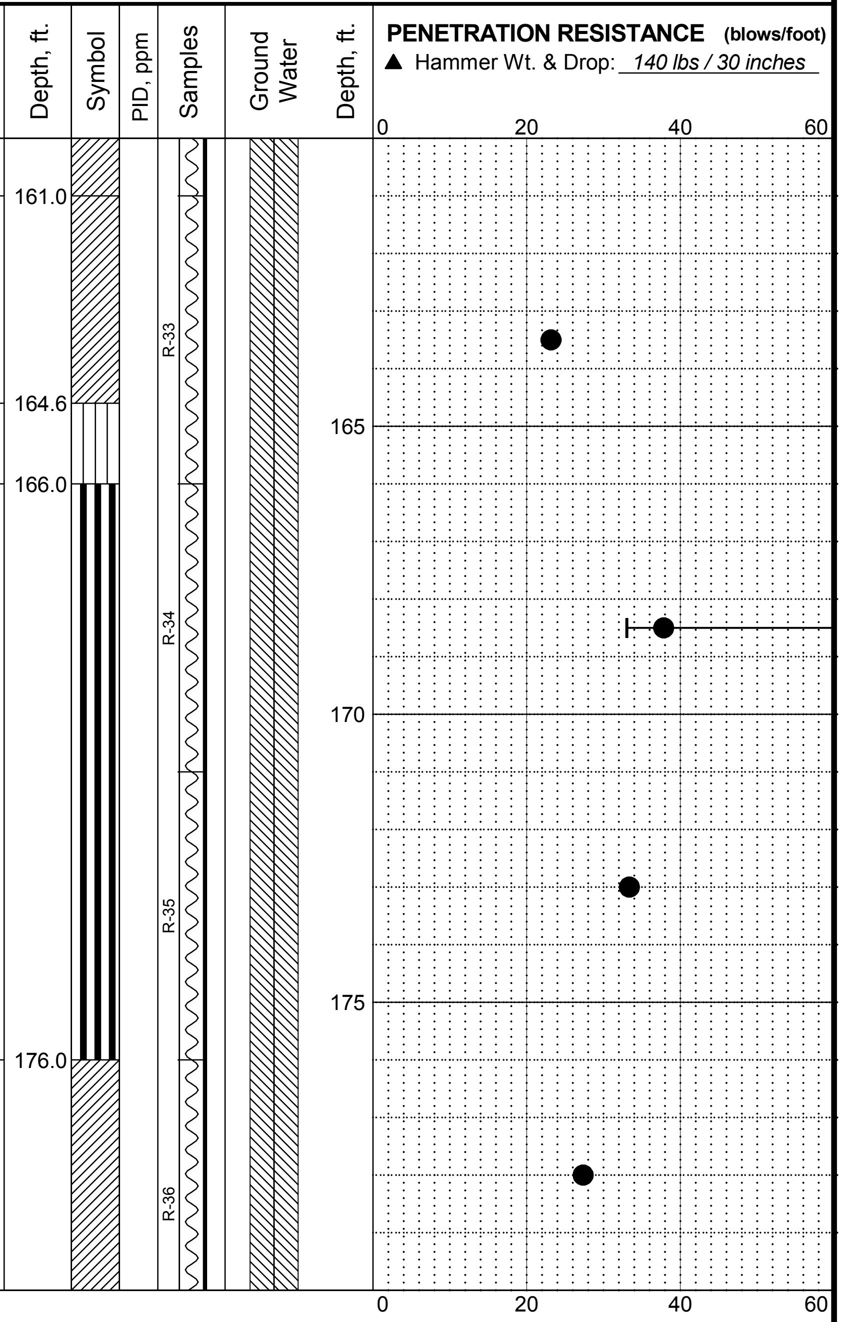
Gray-brown, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 10% fine sand; low to medium plastlcity fines; trace organics; slight blocky texture.
(Qpnl)

Gray, *Lean Clay (CL)* to *Fat Clay (CH)*; moist; less than 5% fine sand; medium to high plasticity fines; trace organics; trace shell fragments; blocky texture; trace slickensides.
(Qpnl)
- Diced texture from 163.2 to 163.5 feet.

Gray-brown *Silt with Sand (ML)* to *Lean Clay with Sand (CL)*; moist; fine sand; low to medium plasticity fines; trace organics.
(Qpnl)

Gray to gray-brown, *Elastic Silt (MH)* to *Silt (ML)*; moist; less than 10% fine sand; low to medium plasticity fines; blocky texture; trace organics.
(Qpnl)
- Trace silty sand seams from 167.5 to 168 feet.

Gray, *Lean Clay (CL)* ; moist; less than 5% fine, subrounded to subangular gravel; less than 5% fine to coarse sand; medium plasticity fines; trace to few shell fragments; blocky to diced texture.
(Qpnl)



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
▨	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▽	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

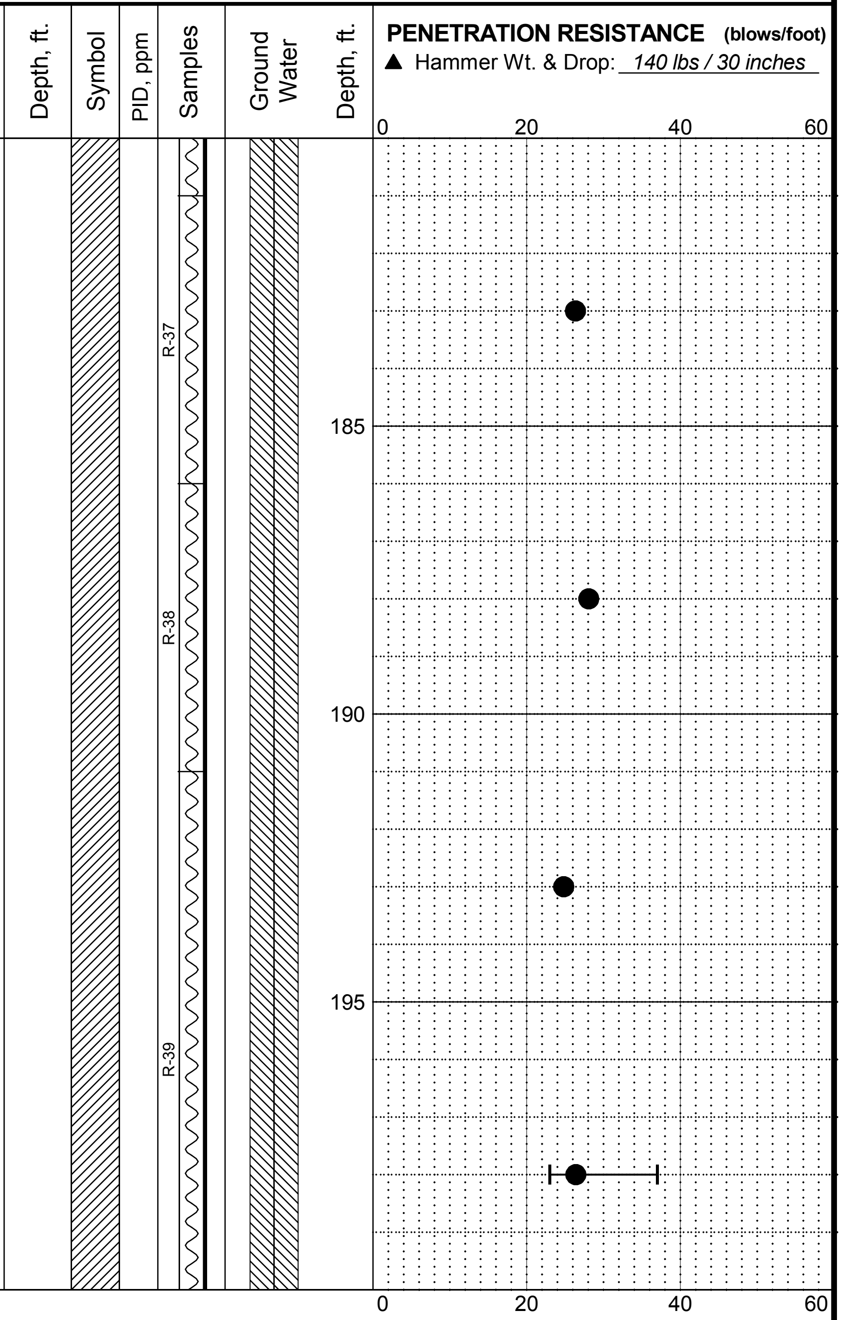
FIG. A-17
Sheet 9 of 11

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.7 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*
Northing: *575,438 ft.*
Easting: *1,585,696 ft.*
Station: *-*
Offset: *-*
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller switched to lexan liners at 61 feet.*
Hole Diam.: *6 in.*
Rod Diam.: *2.625"*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.



- Layer of wet, silty, fine to medium sand from 196.6 to 196.9 feet.
- Layer of moist, sandy, lean clay from 196.9 to 197.6 feet.
- 4-inch cobble at 197.6 feet.

CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
⊠ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016
21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 10 of 11

Log: EAS Rev: EAS Typ: LKN

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.7 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,438 ft.
Easting: 1,585,696 ft.
Station: -
Offset: -

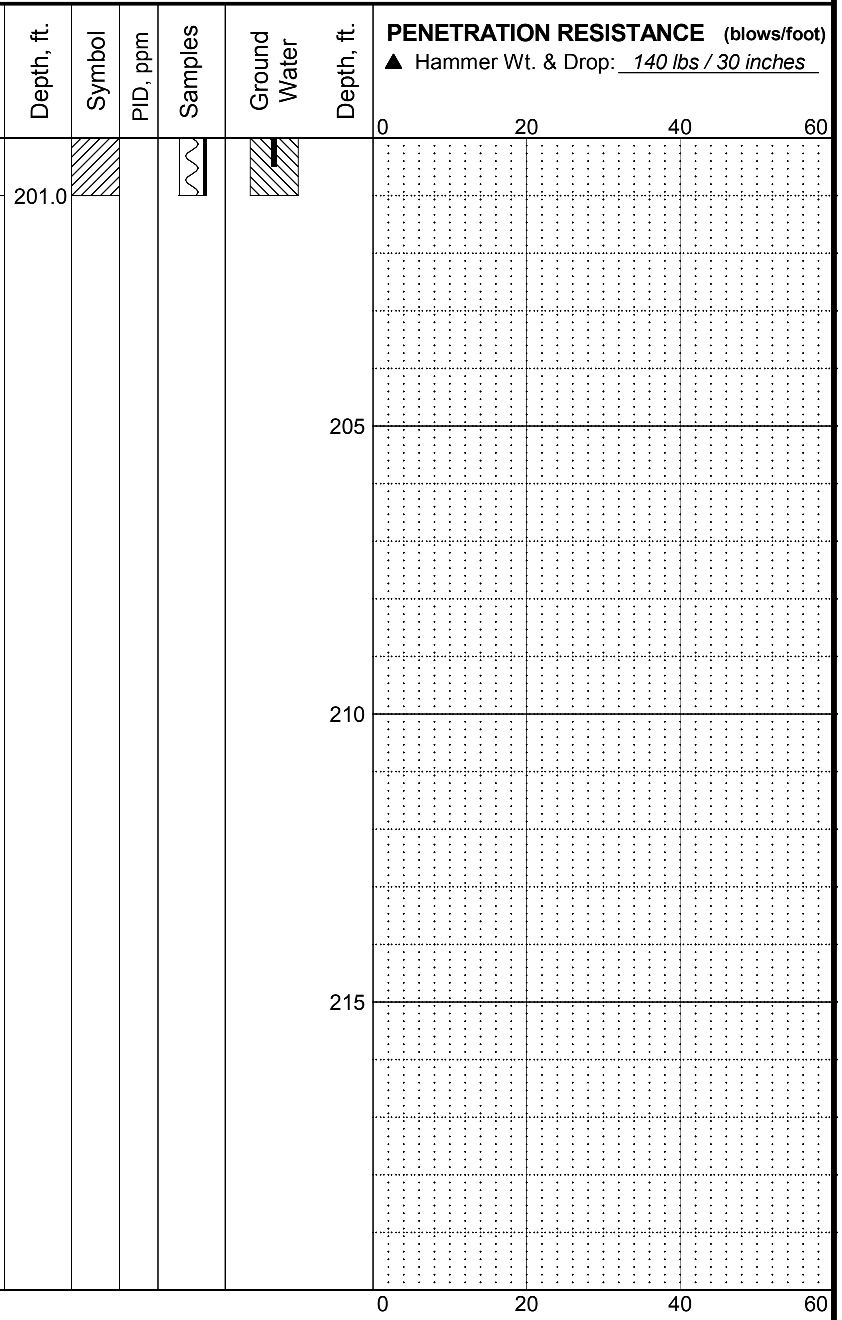
Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller switched to lexan liners at 61 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625"
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines represent the approximate boundaries between material types, and the transition may be gradual.

BOTTOM OF BORING
COMPLETED 9/22/2015



LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-16

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17
Sheet 11 of 11

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*

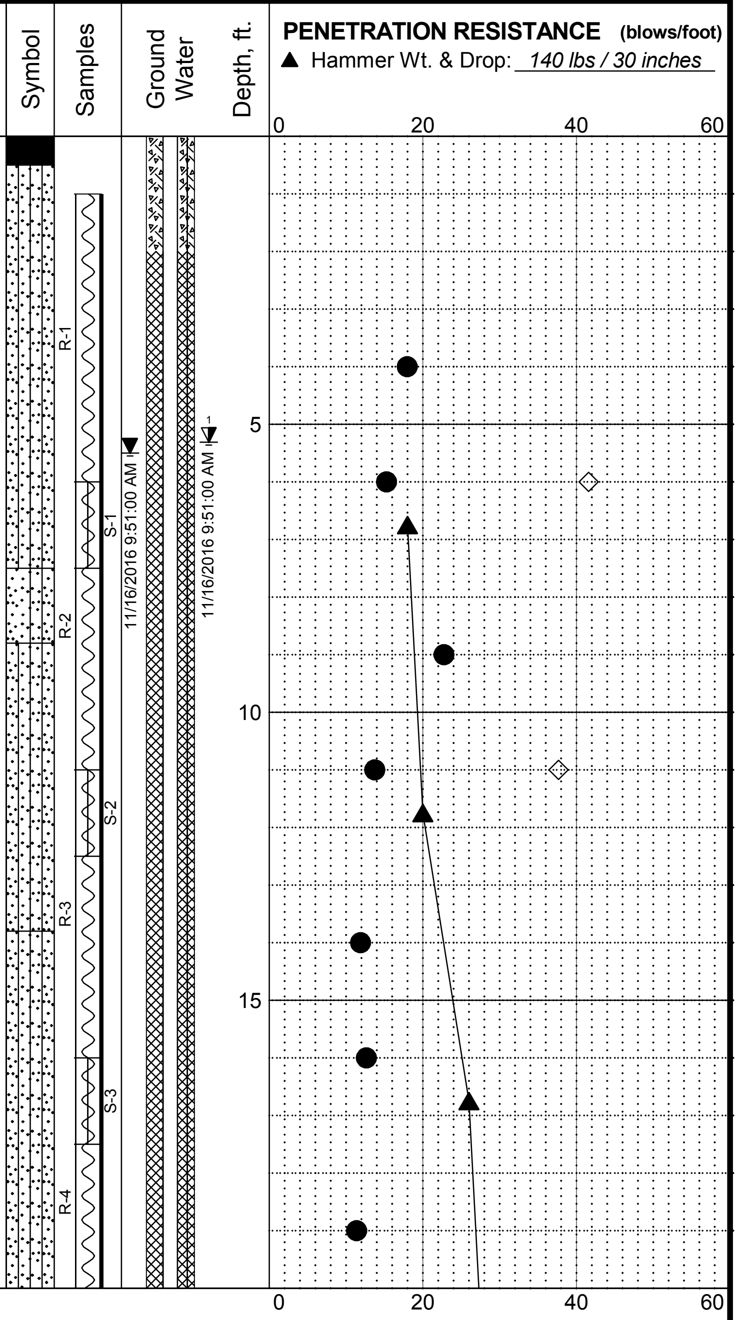
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Asphalt.	0.5
Medium dense, brown, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace pockets with iron-oxide staining; slight diamict texture. (Hf)	7.5
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines. (Qvro)	8.8
Medium dense, brown, *Silty Sand (SM)*; wet; less than 5% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few seams with iron-oxide staining above 10 feet. (Qvro)	13.8
Medium dense, gray-brown, *Silty Sand with Gravel (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict; trace pockets of poorly graded sand. (Qvri) - Few wet, silty sand seams below 19 feet.	



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LEGEND

I Sample Recovery
* Sample Not Recovered
▨ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample

▼ Ground Water Level in Well
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 1 of 11

REV 3 - Approved for Submittal

Total Depth: 201 ft.
Top Elevation: 28.4 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,398 ft.
Easting: 1,585,771 ft.
Station: -
Offset: -

Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller sitched to lexan liners at 91 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense, gray-brown, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; few diamict pockets.
(Qvri)

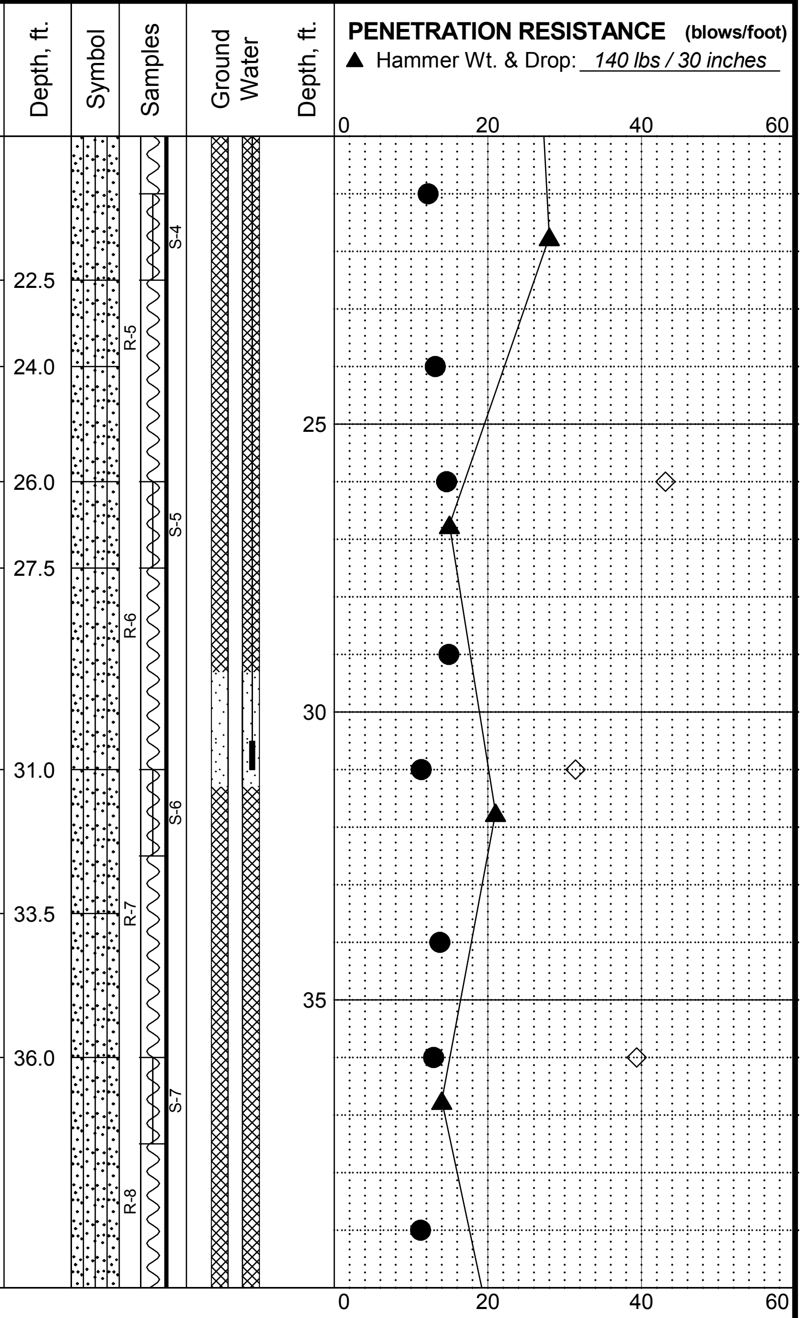
Medium dense, gray-brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM)*; wet; less than 5% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qvro)

Medium dense, gray-brown, *Silty Sand with Gravel (SM)* to *Silty Sand (SM)*; moist; fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; slight diamict texture.
(Qvd)

Medium dense, gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

Medium dense, gray, *Silty Sand (SM)*; moist; less than 15% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

Medium dense, gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines;



CONTINUED NEXT SHEET

% Fines (<0.075mm)
% Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ⊠ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016
21-1-22176-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18
Sheet 2 of 11

Total Depth:	201 ft.	Northing:	575,398 ft.	Drilling Method:	Sonic Core	Hole Diam.:	6 in.
Top Elevation:	28.4 ft.	Easting:	1,585,771 ft.	Drilling Company:	Cascade Drilling	Rod Diam.:	2.625
Vert. Datum:	NAVD 88	Station:	-	Drill Rig Equipment:	Truck-Mounted Sonic	Hammer Type:	Automatic
Horiz. Datum:	Project	Offset:	-	Other Comments:	Driller sitched to lexan liners at 91 feet.		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

slight diamict texture.
(Qvd)

Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)
- Layer of wet, poorly graded sand with silt at 38.9 feet.
- Layer of wet, poorly graded sand with silt from 41 to 41.7 feet.

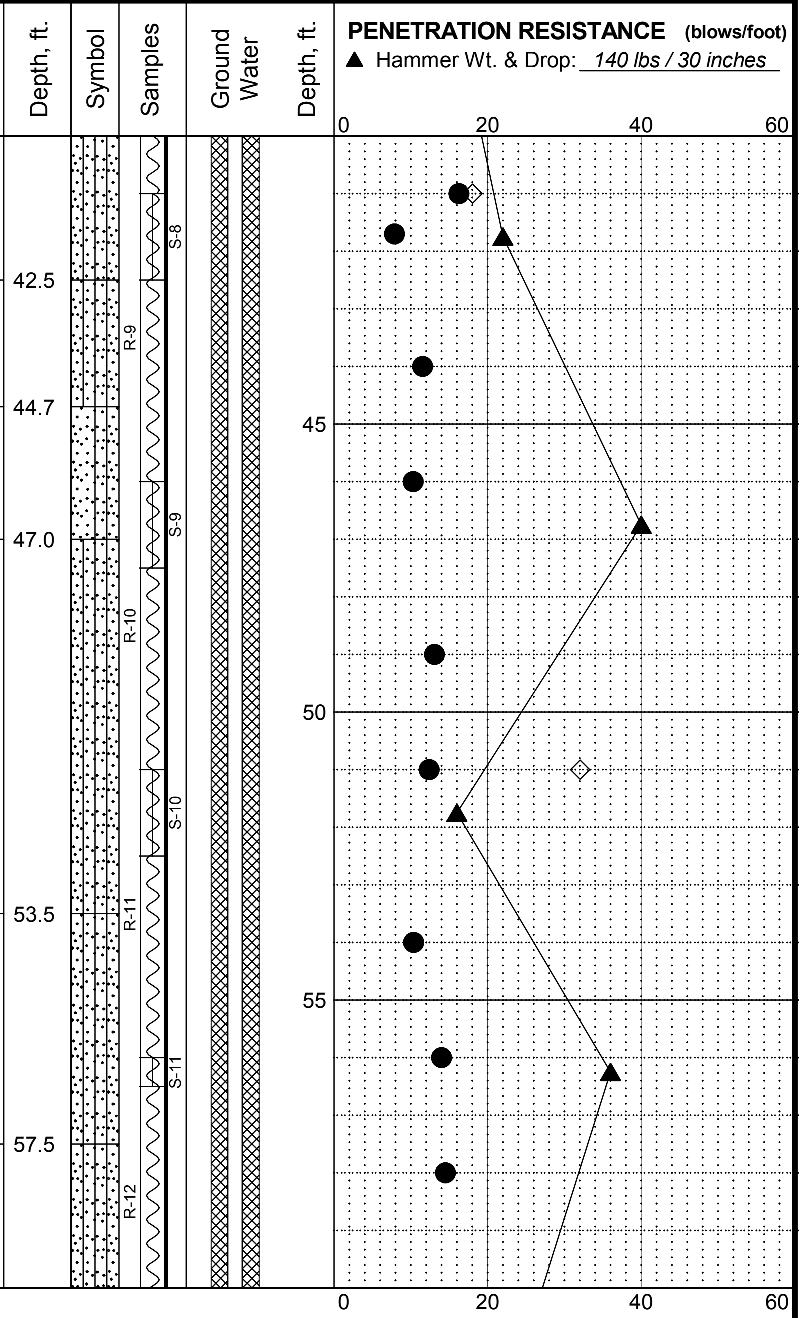
Medium dense, gray, *Silty Sand with Gravel (SM)*; wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; slight diamict texture.
(Qvd)

Medium dense to dense, gray, *Poorly Graded Sand with Silt (SP-SM)* to *Silty Sand (SM)*; wet; less than 10% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines.
(Qva)

Medium dense to dense, gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict pockets.
(Qvd)
- Few wet, poorly graded sand with silt seams from 51 to 53.5 feet.

Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel* (SM); moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict.
(Qvd)

Medium dense to dense, gray, *Silty Sand (SM)*; wet; less than 10% fine to coarse,



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery	▼	Ground Water Level in Well
*	Sample Not Recovered	▼	Ground Water Level in VWP
▨	Sonic Core Sample		
⌶	2.0" O.D. Split Spoon Sample		

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

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FIG. A-18
Sheet 3 of 11

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*
Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*
Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace low plasticity silt seams.
(Qva)

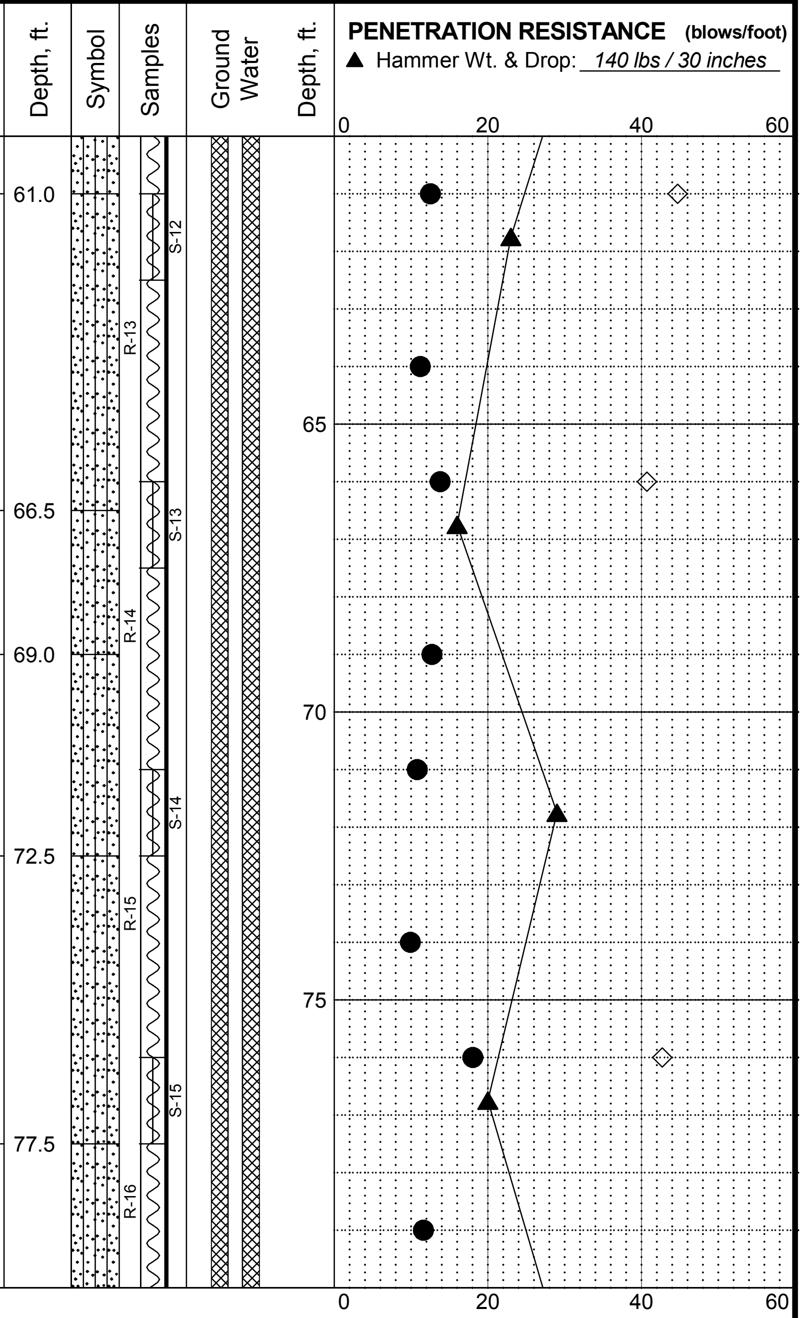
Medium dense, gray, *Silty Sand (SM)* to *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)
- Wet, poorly graded sand with silt seam at 61 feet.
- Wet, poorly graded gravel with silt and sand seam at 62 feet.

Medium dense, gray, *Silty Sand (SM)*; moist to wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; low plasticity fines.
(Qvd)
- Layer of wet, poorly graded sand with silt from 67.5 to 68 feet.

Medium dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict.
(Qvd)
- Layer of wet, poorly graded sand with silt and gravel from 70.5 to 70.8 feet.

Medium dense, gray, *Silty Sand (SM)*; wet; less than 15% fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines.
(Qva)
- Silt seam at 75 feet.

Medium dense, gray, *Silty Sand (SM)*; moist; less than 15% fine to coarse, subrounded to



CONTINUED NEXT SHEET

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

I	Sample Recovery
*	Sample Not Recovered
▨	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
Sheet 4 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

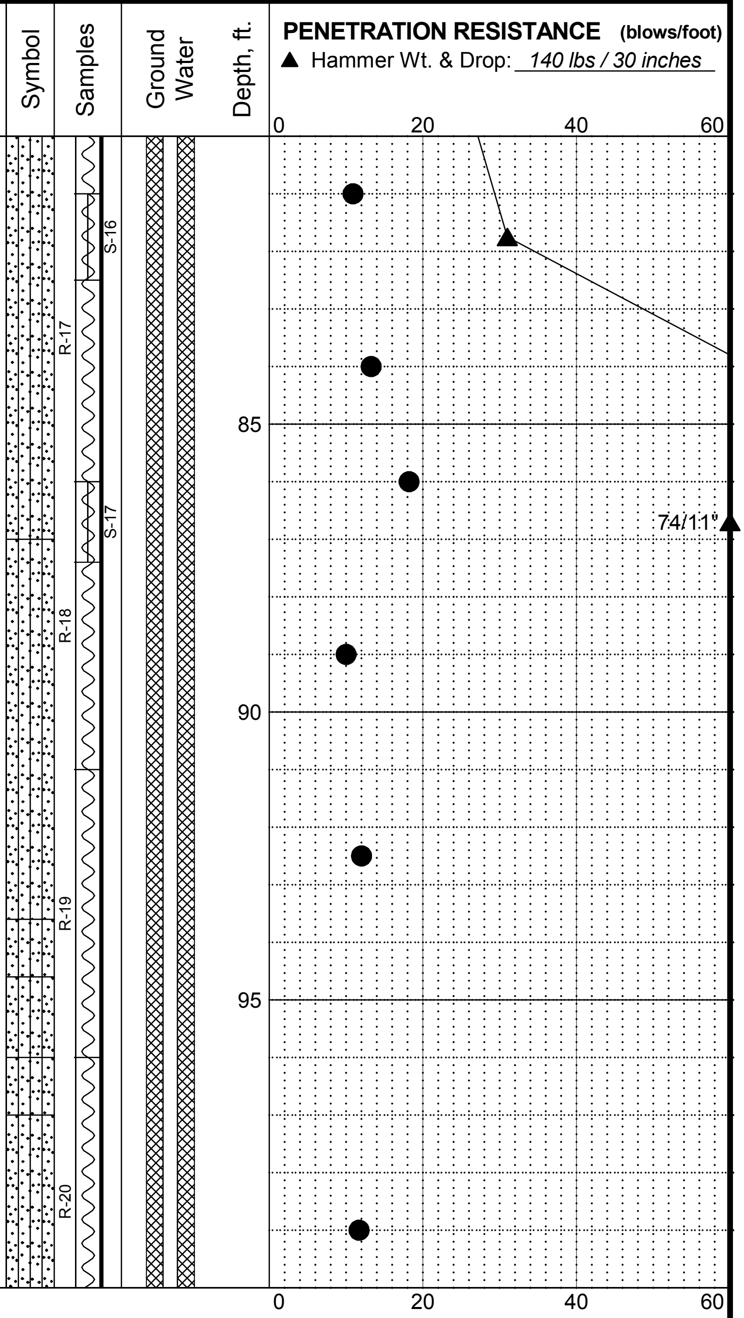
REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd)	
Very dense, gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvd)	87.0
Gray, *Silty Sand (SM)*; wet; less than 10% fine, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. (Qva)	93.6 94.6
Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvd)	96.0 97.0
Gray, *Silty Sand with Gravel (SM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM)*; wet; fine to coarse, subrounded to subangular	



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ⊠ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
Sheet 5 of 11

MASTER_LOG BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*

Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

gravel; fine to coarse sand; nonplastic fines. (Qva)

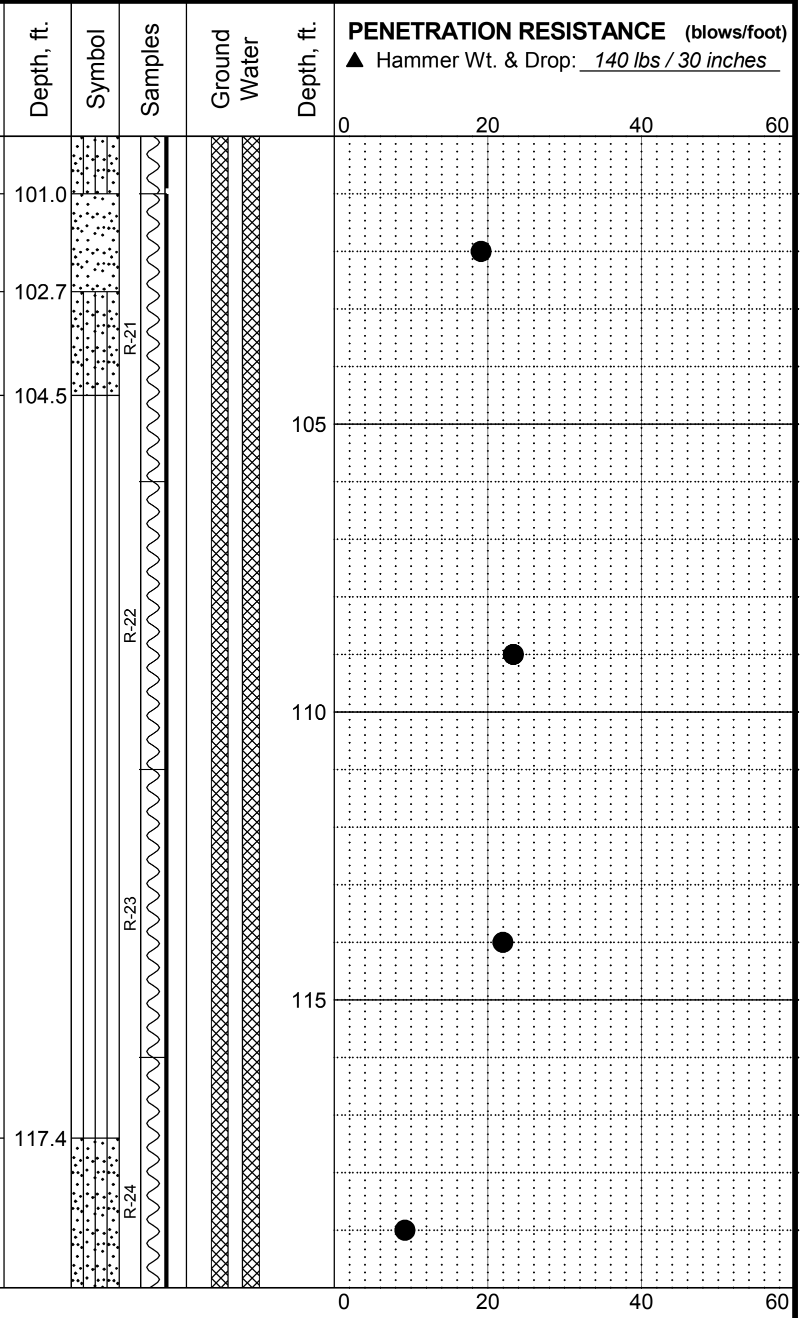
Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qvd)
- Wet from 100.5 to 101 feet.

Gray, *Poorly Graded Sand (SP)*; wet; fine to medium sand; less than 5% nonplastic fines; few low plasticity silt seams. (Qva)

Gray, *Silty Sand with Gravel (SM)*; moist to wet; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic to low plasticity fines; diamict. (Qvd)

Gray *Silt (ML)*; moist; less than 5% fine, rounded to subangular gravel; less than 10% fine to coarse sand; nonplastic to low plasticity fines; trace light gray silt partings. (Qpgl)

Gray, *Silty Sand with Gravel (SM)*; moist; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines; diamict. (Qpgt)



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
☒ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in Well
▼ Ground Water Level in VWP

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
Sheet 6 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*

Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*

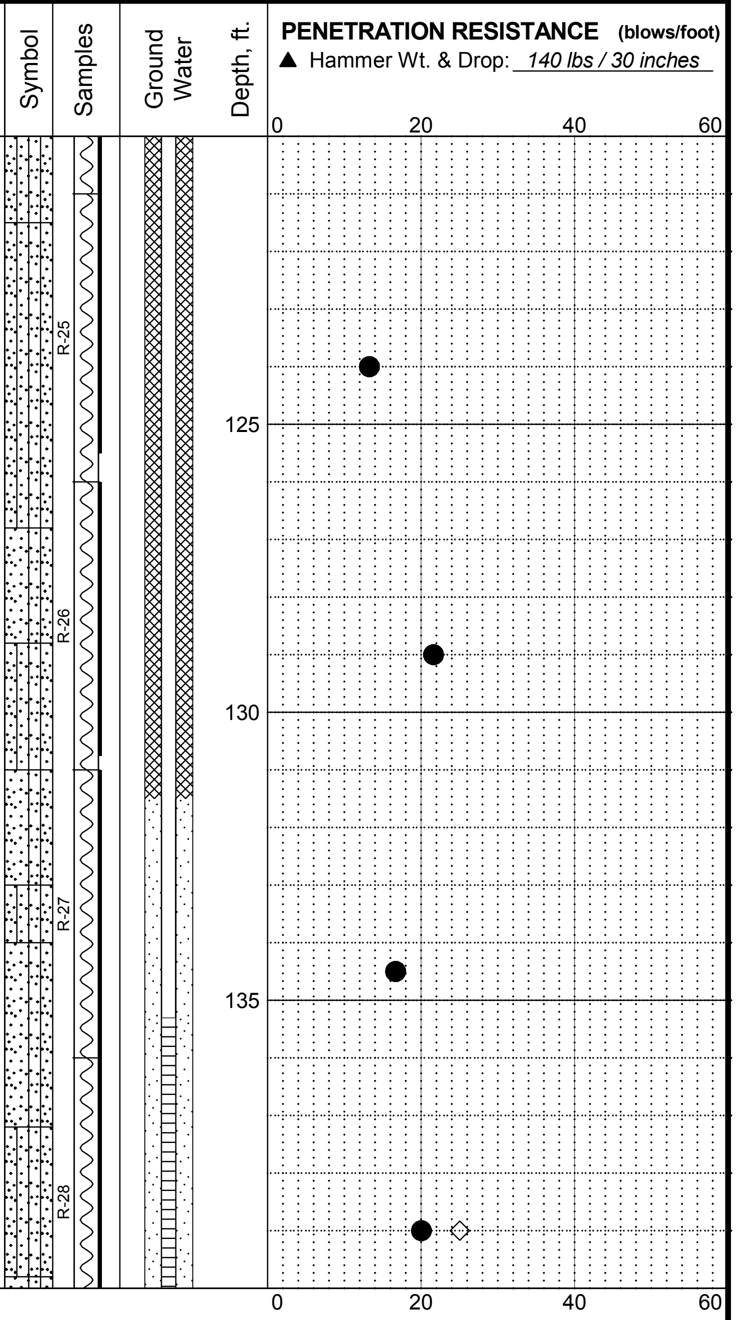
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*

Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.
Gray to dark gray-brown, *Silty Sand (SM)*; moist to wet; less than 5% subrounded gravel; fine to coarse sand; nonplastic to low plasticity fines; few organics and wood debris. (Qpnf)	121.5
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to coarse sand; nonplastic fines. (Qpnf)	126.8
Dark gray-brown, *Silty Sand (SM)*; wet; less than 5% subrounded to subangular gravel; fine to coarse sand; nonplastic fines; trace organics. (Qpnf)	128.8
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to coarse sand; nonplastic fines. (Qpnf)	131.0
Gray to gray-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace organics. (Qpnf)	133.0
Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Qpnf)	134.0
Gray-brown, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; few organics; trace wood fragments. (Qpnf)	137.2
	139.8



CONTINUED NEXT SHEET

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ◩ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016
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FIG. A-18
Sheet 7 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16
Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

Total Depth:	*201 ft.*	Northing:	*575,398 ft.*	Drilling Method:	*Sonic Core*	Hole Diam.:	*6 in.*
Top Elevation:	*28.4 ft.*	Easting:	*1,585,771 ft.*	Drilling Company:	*Cascade Drilling*	Rod Diam.:	*2.625*
Vert. Datum:	*NAVD 88*	Station:	*-*	Drill Rig Equipment:	*Truck-Mounted Sonic*	Hammer Type:	*Automatic*
Horiz. Datum:	*Project*	Offset:	*-*	Other Comments:	*Driller sitched to lexan liners at 91 feet.*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.

Gray, *Poorly Graded Sand with Silt (SP-SM)*; wet; fine to medium sand; nonplastic fines. (Qpnf)

141.4

Gray, *Silty Sand (SM)*; wet; fine to medium sand; nonplastic fines; trace organics. (Qpnf)

- Layer of moist, brown, sandy silt from 143 to 143.8 feet.

146.0

Gray-brown and brown, *Silty Sand (SM)* and *Sandy Silt (ML)*; moist; fine sand; nonplastic fines; few organics; trace seams with mostly organics; interbedded. (Qpnf)

151.6

Gray-brown *Silt (ML)* to *Lean Clay (CL)*; moist; less than 10% fine sand; low to medium plasticity fines; trace organics; trace silty, fine sand partings. (Qpnl)

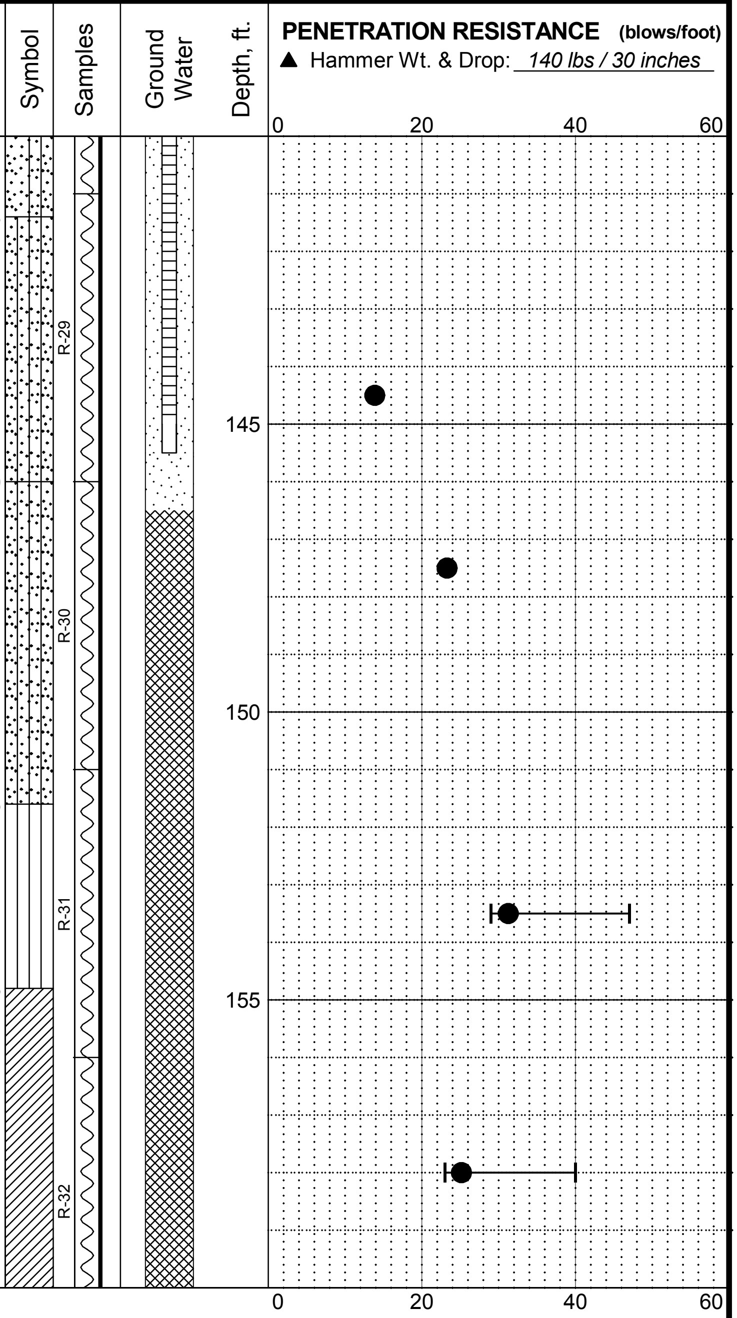
- Layer of wet, silty sand from 154.5 to 154.8 feet.

154.8

Gray, *Lean Clay (CL)* to *Silt (ML)*; moist; less than 5% subrounded to subangular gravel; less than 5% fine to coarse sand; low to medium plasticity fines; trace silty sand seams; trace shell fragments. (Qpnl)

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery	▼	Ground Water Level in Well
*	Sample Not Recovered	▼	Ground Water Level in VWP
☒	Sonic Core Sample		
⌶	2.0" O.D. Split Spoon Sample		

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
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REV 3 - Approved for Submittal

B-19 (8/11)

MASTER LOG BFW 21-21979.GPJ SHAN WIL.GDT 11/29/16

Log: EAS Rev: EAS Typ: LKN

Total Depth: 201 ft.
Top Elevation: 28.4 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,398 ft.
Easting: 1,585,771 ft.
Station: -
Offset: -

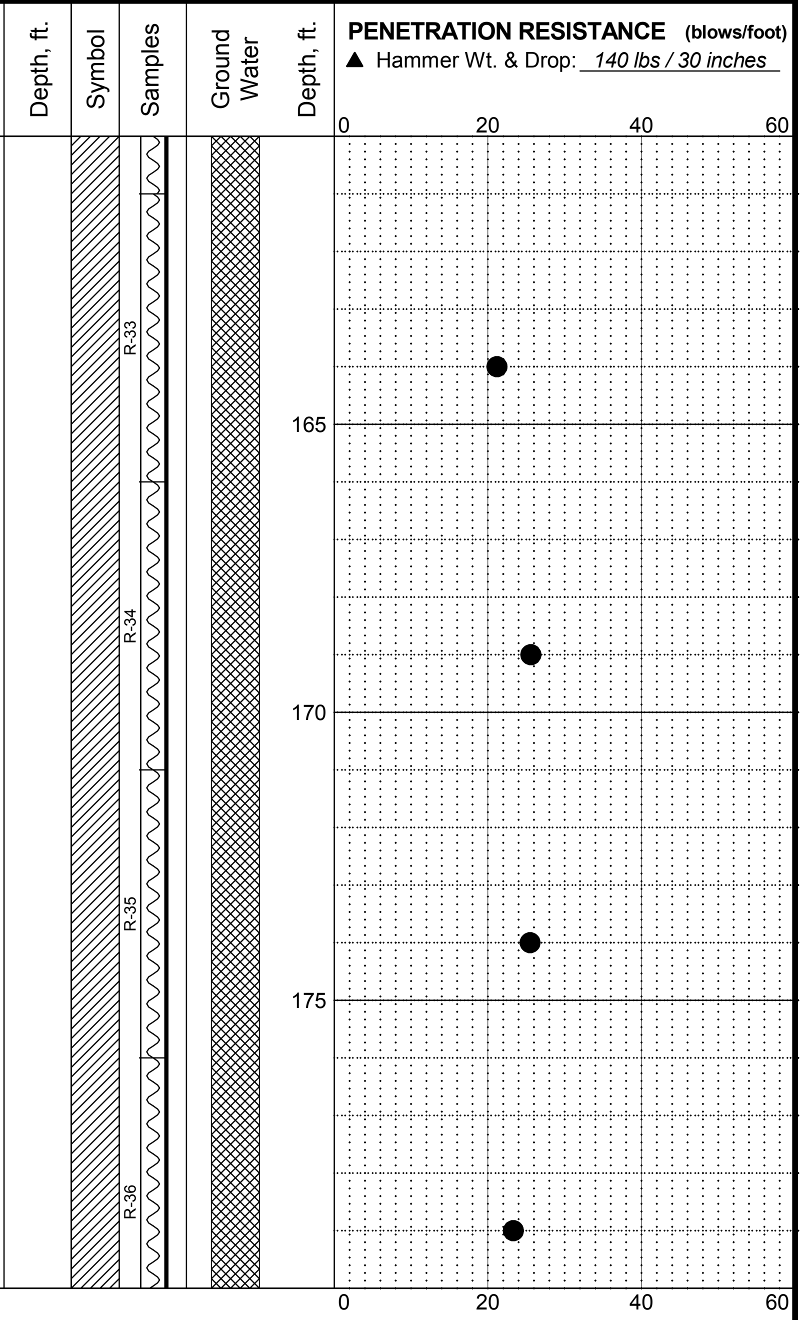
Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller sitched to lexan liners at 91 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

- Slightly blocky texture from 166 to 167.8 feet.



CONTINUED NEXT SHEET

LEGEND

I Sample Recovery
* Sample Not Recovered
☒ Sonic Core Sample
⌶ 2.0" O.D. Split Spoon Sample
▼ Ground Water Level in Well
▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

Ship Canal Water Quality Project
Seattle, Washington

LOG OF SONIC CORE WSC-17

November 2016 21-1-22176-003

SHANNON & WILSON, INC.
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FIG. A-18
Sheet 9 of 11

Total Depth: 201 ft.
Top Elevation: 28.4 ft.
Vert. Datum: NAVD 88
Horiz. Datum: Project

Northing: 575,398 ft.
Easting: 1,585,771 ft.
Station: -
Offset: -

Drilling Method: Sonic Core
Drilling Company: Cascade Drilling
Drill Rig Equipment: Truck-Mounted Sonic
Other Comments: Driller sitched to lexan liners at 91 feet.

Hole Diam.: 6 in.
Rod Diam.: 2.625
Hammer Type: Automatic

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

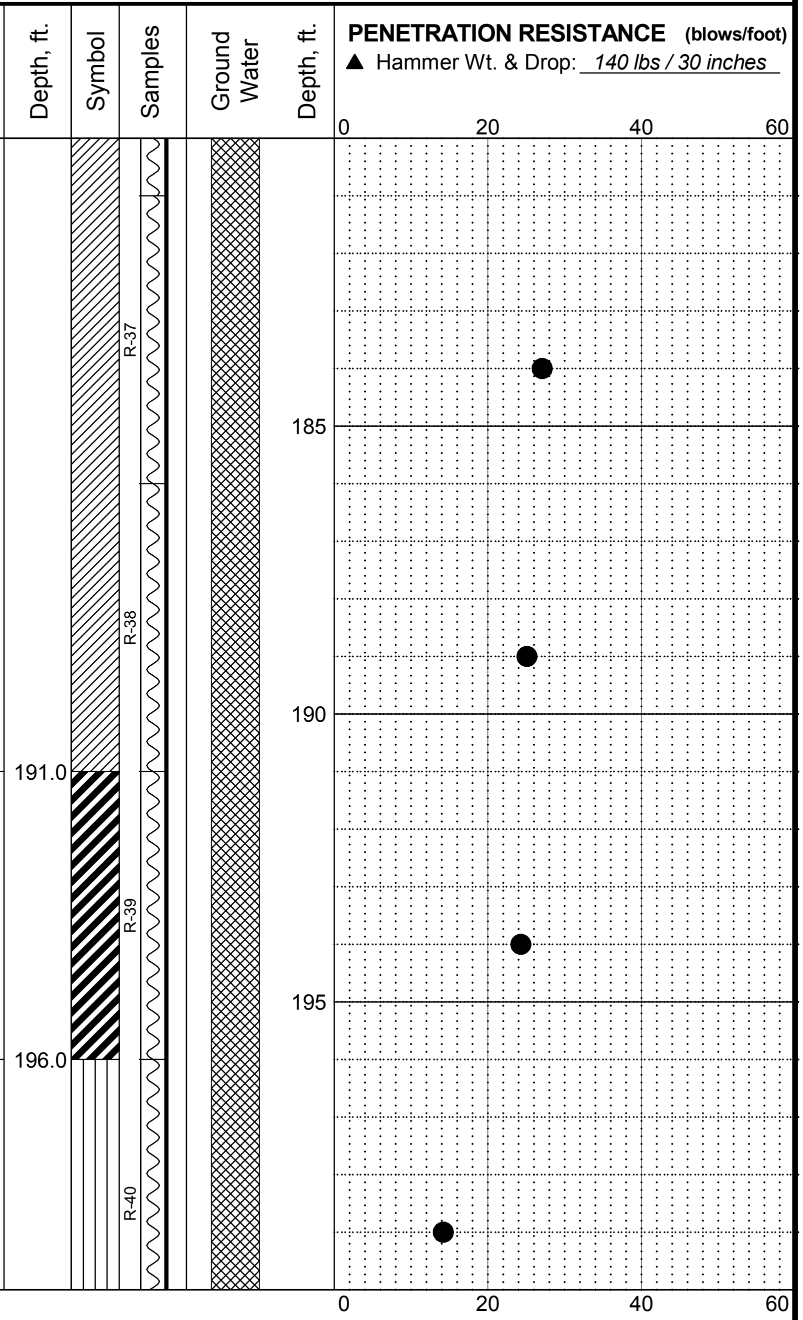
- Slightly blocky texture from 181 to 182.2 feet.
- Diced texture from 185.4 to 186 feet.

191.0

Gray, *Fat Clay (CH)*; moist; less than 5% fine, subrounded to subangular gravel; less than 5% fine to coarse sand; high plasticity fines; few slickensides.
(Qpnl)

196.0

Gray *Silt (ML)*; moist; less than 5% fine, subrounded gravel; less than 5% fine to coarse sand; nonplastic to low plasticity fines; trace silty, fine sand partings.
(Qpnl)



CONTINUED NEXT SHEET

LEGEND

I	Sample Recovery
*	Sample Not Recovered
⊠	Sonic Core Sample
⌶	2.0" O.D. Split Spoon Sample
▼	Ground Water Level in Well
▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
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MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

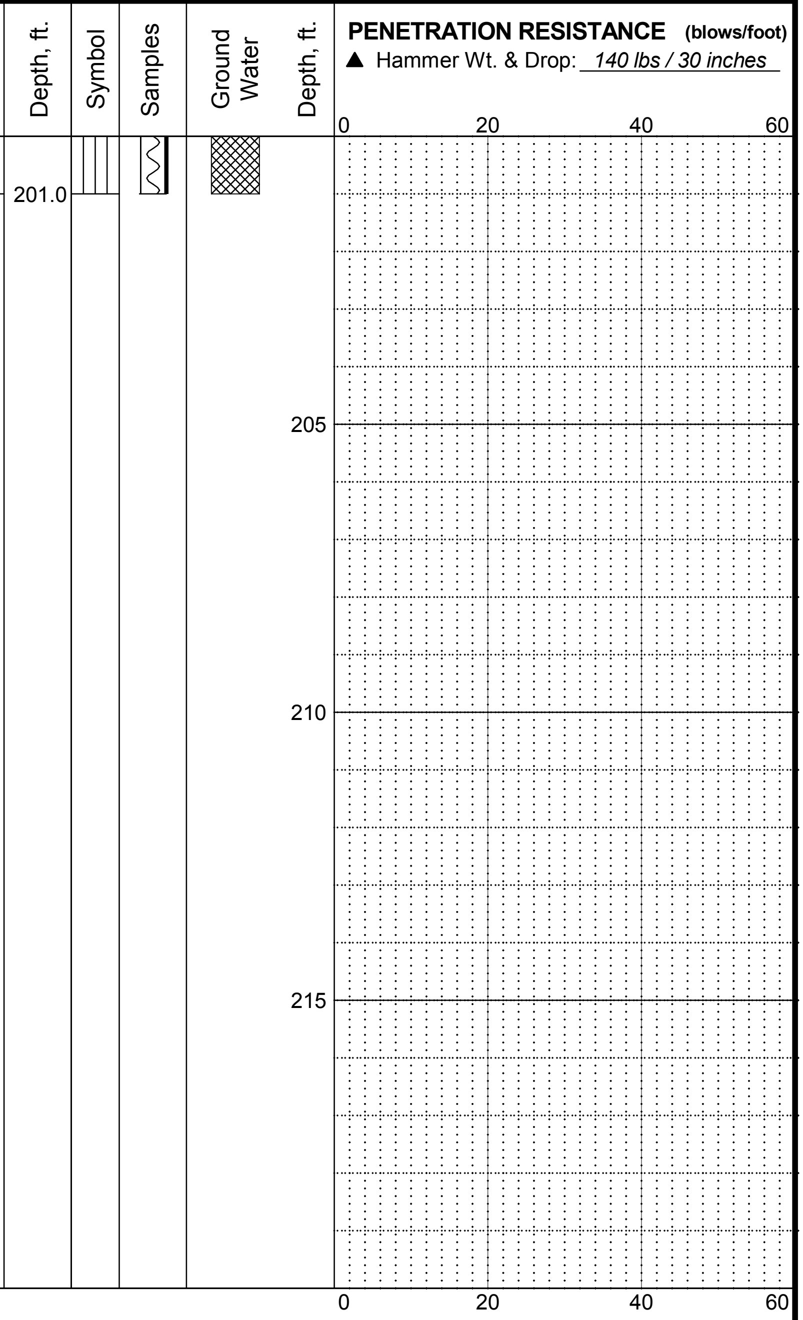
REV 3 - Approved for Submittal

Total Depth: *201 ft.*
Top Elevation: *28.4 ft.*
Vert. Datum: *NAVD 88*
Horiz. Datum: *Project*
Northing: *575,398 ft.*
Easting: *1,585,771 ft.*
Station: *-*
Offset: *-*
Drilling Method: *Sonic Core*
Drilling Company: *Cascade Drilling*
Drill Rig Equipment: *Truck-Mounted Sonic*
Other Comments: *Driller sitched to lexan liners at 91 feet.*
Hole Diam.: *6 in.*
Rod Diam.: *2.625*
Hammer Type: *Automatic*

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

BOTTOM OF BORING
COMPLETED 9/24/2015



▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

LEGEND

- I Sample Recovery
- * Sample Not Recovered
- ▨ Sonic Core Sample
- ⌶ 2.0" O.D. Split Spoon Sample
- ▼ Ground Water Level in Well
- ▼ Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. USCS designation is based on visual-manual classification and selected lab testing.

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Seattle, Washington

LOG OF SONIC CORE WSC-17

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FIG. A-18
Sheet 11 of 11

MASTER_LOG_BFW 21-21979.GPJ SHAN_WIL.GDT 11/29/16 Log: EAS Rev: EAS Typ: LKN

REV 3 - Approved for Submittal

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

TABLE OF CONTENTS

FIGURE

APPENDIX C

GEOTECHNICAL LABORATORY TESTING

C.1 GENERAL

Laboratory tests were performed on selected soil samples retrieved from the geotechnical borings. The laboratory testing program included tests to classify the soils and to provide data for engineering studies.

Soil samples recovered from the borings were visually reclassified in our laboratory using a system based on ASTM International (ASTM) Designation: D2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). This visual classification method allows for convenient and consistent comparison of soils from widespread geographic areas. Using this method, the soils are classified using the Unified Soil Classification System (USCS). The individual sample classifications have been incorporated into the boring logs presented in Appendix A.

Due to high levels of lead contamination in BCT-4, no geotechnical laboratory tests were performed on samples from this boring.

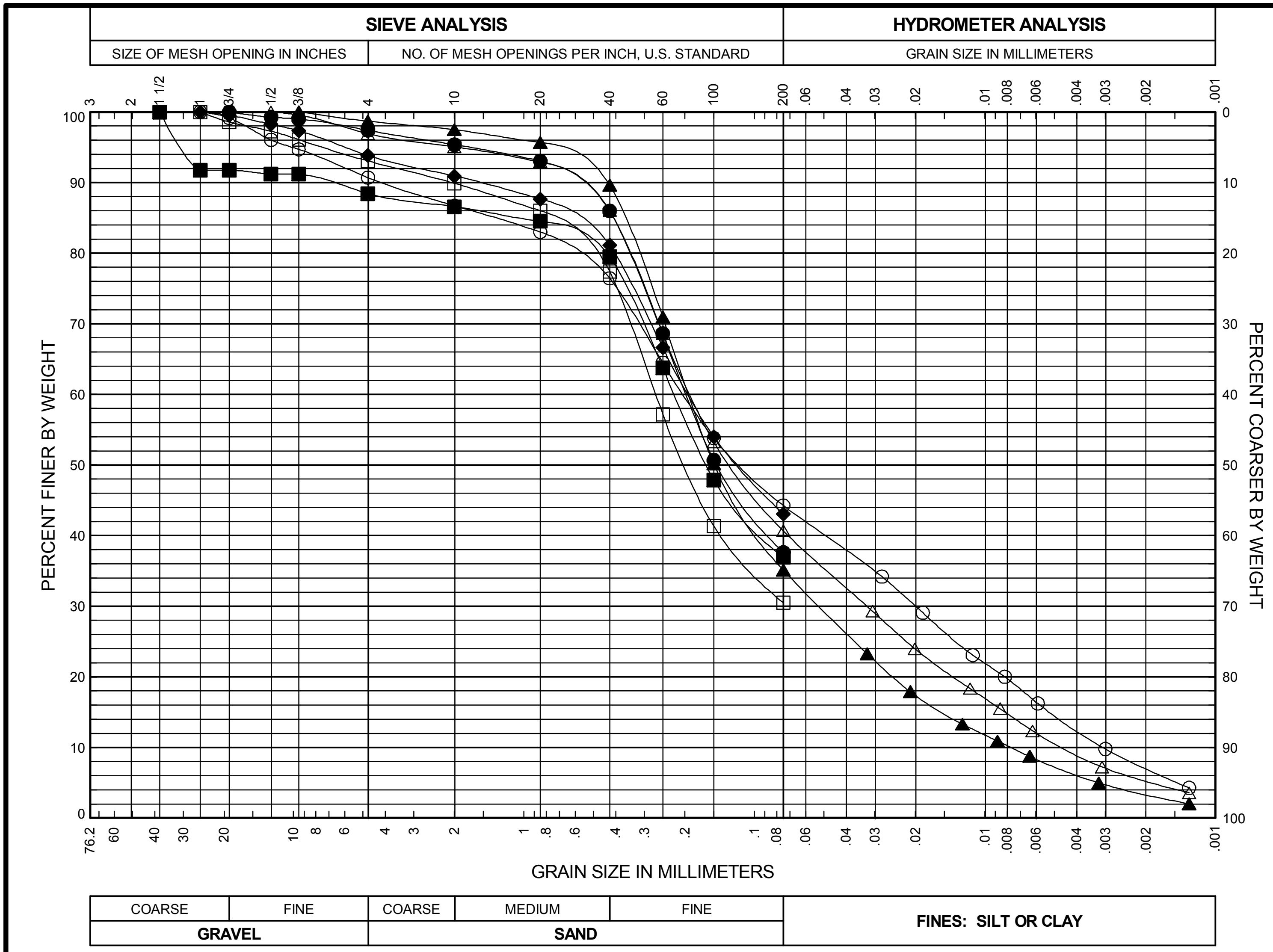
C.2 NATURAL WATER CONTENTS

The natural water content of select soil samples recovered from the field exploration was determined in general accordance with ASTM Designation: D2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. Comparison of water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength. Water content, where tested, is plotted on each of the boring logs presented in Appendix A.

C.3 GRAIN SIZE ANALYSES

Grain size distribution analyses were performed on two samples in general accordance with ASTM Designation: D422, Standard Method for Particle-Size Analysis of Soils or D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-microgram) Sieve. The general procedures to determine the grain size distribution of a soil sample include sieve analysis, hydrometer analysis, combined analysis, and percentage of fines passing the No. 200 sieve.

Grain size distributions are used to assist in classifying soils and to provide correlation with soil properties, including permeability, behavior when excavated, capillary action, and sensitivity to moisture. Results of the grain size analyses are shown on grain size distribution curves shown in Figure C-1. Along with each grain size distribution is a tabulated summary containing the group symbol according to the USCS, the sample description, percentage of fines passing the No. 200 sieve, and the natural water content.



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

G_s: Specific gravity

*: *Sample specimen weight did not meet required minimum mass for ASTM test method.*

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● BCT-1, R-5	22.0	SM	Silty Sand (Assumed G_s = 2.7)		3	60	38			13.7			AKV	JFL	D422
■ BCT-1, S-5*	25.0	SM	Silty Sand		12	52	37			12.6			AKV	JFL	C136
▲ BCT-1, R-7	32.0	SM	Silty Sand (Assumed G_s = 2.7)		1	64	35	17	3	13.5			AKV	JFL	D422
◆ BCT-2, R-8*	35.5	SM	Silty Sand		6	51	43			9.4			AKV	JFL	C136
○ BCT-2, R-9	43.0	SM	Silty Sand (Assumed G_s = 2.7)		9	46	44	30	7	9.4			AKV	JFL	D422
□ BCT-2, R-10*	47.0	SM	Silty Sand		7	63	30			12.8			AKV	JFL	C136
△ BCT-3, S-2	10.0	SM	Silty Sand (Assumed G_s = 2.7)		3	56	41	24	5	13.7			AKV	JFL	D422

Ballard Conveyance
Seattle, Washington

GRAIN SIZE DISTRIBUTION

July 2017

21-1-22329-004

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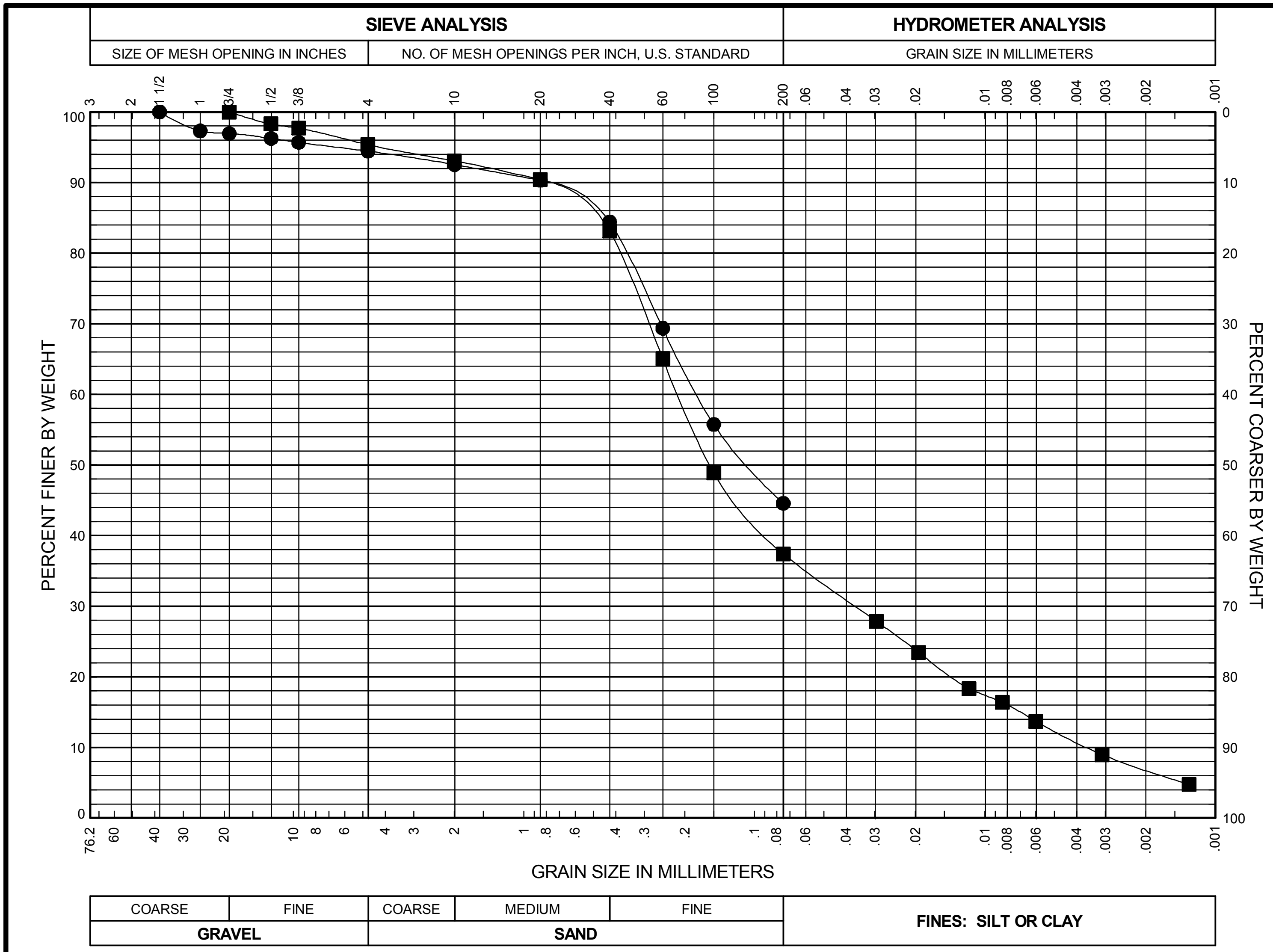
FIG. C-1
Sheet 1 of 2

AASHTO_GSA_TESTA 21-22329.GPJ SHAN_WIL.GDT 7/19/17

FIG. C-1

AASHTO GSA TESTA 21-22329.GPJ SHAN_WIL.GDT 7/19/17



LEGEND

USCS: Unified Soil Classification System

COBBLE %: Percentage of cobbles in test specimen; based on pre-removal total dry mass for normalized tests

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

G_s: Specific gravity

*: *Sample specimen weight did not meet required minimum mass for ASTM test method.*

BORING AND SAMPLE NO.	DEPTH (feet)	USCS GROUP SYMBOL	USCS GROUP NAME	COBBLE %	GRAVEL %	SAND %	FINES %	< 0.02mm %	< 2um %	NAT WC %	Cu	Cc	TEST BY	REVIEW BY	ASTM DES
● BCT-3, R-7*	30.0	SM	Silty Sand		6	50	45			11.9			AKV	JFL	C136
■ BCT-3, R-8	36.0	SM	Silty Sand (Assumed G_s = 2.7)		5	58	37	24	7	10.3			AKV	JFL	D422

Ballard Conveyance
Seattle, Washington

GRAIN SIZE DISTRIBUTION

July 2017

21-1-22329-004

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-1
Sheet 2 of 2

FIG. C-1

APPENDIX D

ANALYTICAL LABORATORY TESTING

APPENDIX D

ANALYTICAL LABORATORY TESTING

REPORT

Report to Shannon & Wilson, Inc., from Fremont Analytical, 4/20/2017 (32 pages).
Samples included: BCT-04-ENV.

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Shannon & Wilson
Dave Randall
400 N. 34th Street, Suite 100
Seattle, WA 98103

RE: Ballard Conveyance
Work Order Number: 1704169

April 20, 2017

Attention Dave Randall:

Fremont Analytical, Inc. received 1 sample(s) on 4/13/2017 for the analyses presented in the following report.

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.
Gasoline by NWTPH-Gx
Mercury by EPA Method 7471
Sample Moisture (Percent Moisture)
Total Metals by EPA Method 6020
Volatile Organic Compounds by EPA Method 8260C

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Mike Ridgeway
Laboratory Director

DoD/ELAP Certification #L2371, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Shannon & Wilson
Project: Ballard Conveyance
Work Order: 1704169

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1704169-001	BCT-04-ENV	04/13/2017 11:30 AM	04/13/2017 11:52 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1704169**
Date: **4/20/2017**

CLIENT: Shannon & Wilson
Project: Ballard Conveyance

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Client: Shannon & Wilson **Collection Date:** 4/13/2017 11:30:00 AM
Project: Ballard Conveyance
Lab ID: 1704169-001 **Matrix:** Soil
Client Sample ID: BCT-04-ENV

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.				Batch ID: 16783		Analyst: SB
Diesel (Fuel Oil)	ND	23.6		mg/Kg-dry	1	4/15/2017 9:14:33 AM
Heavy Oil	1,330	59.1		mg/Kg-dry	1	4/15/2017 9:14:33 AM
Surr: 2-Fluorobiphenyl	50.4	50-150		%Rec	1	4/15/2017 9:14:33 AM
Surr: o-Terphenyl	53.0	50-150		%Rec	1	4/15/2017 9:14:33 AM
Gasoline by NWTPH-Gx				Batch ID: 16767		Analyst: NG
Gasoline	ND	5.37		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Surr: Toluene-d8	102	65-135		%Rec	1	4/13/2017 9:10:49 PM
Surr: 4-Bromofluorobenzene	99.8	65-135		%Rec	1	4/13/2017 9:10:49 PM
Volatile Organic Compounds by EPA Method 8260C				Batch ID: 16767		Analyst: NG
Dichlorodifluoromethane (CFC-12)	ND	0.0645	Q	mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloromethane	0.0688	0.0645		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Vinyl chloride	ND	0.00215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromomethane	ND	0.0967		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Trichlorofluoromethane (CFC-11)	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloroethane	ND	0.0645		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloroethene	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Methylene chloride	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
trans-1,2-Dichloroethene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Methyl tert-butyl ether (MTBE)	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloroethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
2,2-Dichloropropane	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
cis-1,2-Dichloroethene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chloroform	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,1-Trichloroethane (TCA)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1-Dichloropropene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Carbon tetrachloride	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichloroethane (EDC)	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Benzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Trichloroethene (TCE)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichloropropane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromodichloromethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Dibromomethane	ND	0.0430		mg/Kg-dry	1	4/13/2017 9:10:49 PM
cis-1,3-Dichloropropene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Toluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
trans-1,3-Dichloropropylene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM

Client: Shannon & Wilson
Project: Ballard Conveyance
Lab ID: 1704169-001
Client Sample ID: **BCT-04-ENV**

Collection Date: 4/13/2017 11:30:00 AM
Matrix: Soil

Volatile Organic Compounds by EPA Method 8260C

Batch ID: 16767 Analyst: NG

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
1,1,2-Trichloroethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3-Dichloropropane	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Tetrachloroethene (PCE)	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Dibromochloromethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dibromoethane (EDB)	ND	0.00537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Chlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,1,2-Tetrachloroethane	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Ethylbenzene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
m,p-Xylene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
o-Xylene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Styrene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Isopropylbenzene	ND	0.0860		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromoform	ND	0.0215	Q	mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,1,2,2-Tetrachloroethane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
n-Propylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Bromobenzene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3,5-Trimethylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
2-Chlorotoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
4-Chlorotoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
tert-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,3-Trichloropropane	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,4-Trichlorobenzene	ND	0.0537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
sec-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
4-Isopropyltoluene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,3-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,4-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
n-Butylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2-Dibromo-3-chloropropane	ND	0.537		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,4-Trimethylbenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Hexachlorobutadiene	ND	0.107		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Naphthalene	ND	0.0322		mg/Kg-dry	1	4/13/2017 9:10:49 PM
1,2,3-Trichlorobenzene	ND	0.0215		mg/Kg-dry	1	4/13/2017 9:10:49 PM
Surr: Dibromofluoromethane	90.3	56.5-129		%Rec	1	4/13/2017 9:10:49 PM
Surr: Toluene-d8	96.1	64.5-151		%Rec	1	4/13/2017 9:10:49 PM
Surr: 1-Bromo-4-fluorobenzene	97.3	63.1-141		%Rec	1	4/13/2017 9:10:49 PM

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Analytical Report

Work Order: **1704169**
Date Reported: **4/20/2017**

Client: Shannon & Wilson

Collection Date: 4/13/2017 11:30:00 AM

Project: Ballard Conveyance

Lab ID: 1704169-001

Matrix: Soil

Client Sample ID: **BCT-04-ENV**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Mercury by EPA Method 7471				Batch ID: 16786		Analyst: WF
Mercury	0.553	0.316		mg/Kg-dry	1	4/14/2017 1:09:38 PM
Total Metals by EPA Method 6020				Batch ID: 16779		Analyst: TN
Arsenic	18.2	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Barium	123	0.506		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Cadmium	1.68	0.202		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Chromium	23.2	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Lead	10,700	20.2	D	mg/Kg-dry	100	4/17/2017 12:02:46 PM
Selenium	0.803	0.506		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Silver	0.569	0.101		mg/Kg-dry	1	4/14/2017 3:35:13 PM
Sample Moisture (Percent Moisture)				Batch ID: R35537		Analyst: BB
Percent Moisture	26.8			wt%	1	4/14/2017 9:45:32 AM

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.

Sample ID **MB-16783** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **MBLKS** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681244**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	20.0									
Heavy Oil	ND	50.0									
Surr: 2-Fluorobiphenyl	22.3		20.00		112	50	150				
Surr: o-Terphenyl	22.1		20.00		110	50	150				

Sample ID **LCS-16783** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **LCSS** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681011**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	414	20.0	500.0	0	82.8	65	135				
Surr: 2-Fluorobiphenyl	22.2		20.00		111	50	150				
Surr: o-Terphenyl	23.2		20.00		116	50	150				

Sample ID **1704174-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681607**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	19.1						0		30	
Heavy Oil	ND	47.9						0		30	
Surr: 2-Fluorobiphenyl	20.7		19.15		108	50	150		0		
Surr: o-Terphenyl	20.7		19.15		108	50	150		0		

Sample ID **1704174-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681608**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	351	18.3	457.4	0	76.7	65	135				
Surr: 2-Fluorobiphenyl	14.8		18.30		80.7	50	150				
Surr: o-Terphenyl	15.4		18.30		84.4	50	150				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Diesel and Heavy Oil by NWTPH-Dx/Dx Ext.

Sample ID **1704174-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681608**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID **1704174-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/14/2017** SeqNo: **681609**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	504	18.9	473.3	0	106	65	135	350.6	35.9	30	R
Surr: 2-Fluorobiphenyl	17.4		18.93		92.0	50	150		0		
Surr: o-Terphenyl	18.8		18.93		99.2	50	150		0		

NOTES:
R - High RPD observed, spike recoveries are within range.

Sample ID **1704172-008ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35552**
Client ID: **BATCH** Batch ID: **16783** Analysis Date: **4/15/2017** SeqNo: **681606**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Diesel (Fuel Oil)	ND	20.3						0		30	
Heavy Oil	ND	50.7						72.60	53.6	30	
Surr: 2-Fluorobiphenyl	20.6		20.27		102	50	150		0		
Surr: o-Terphenyl	21.0		20.27		104	50	150		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Gasoline by NWTPH-Gx

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680808**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	23.7	5.00	25.00	0	94.9	65	135				
Surr: Toluene-d8	1.24		1.250		99.3	65	135				
Surr: 4-Bromofluorobenzene	1.31		1.250		105	65	135				

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680809**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	ND	5.00									
Surr: Toluene-d8	1.24		1.250		99.1	65	135				
Surr: 4-Bromofluorobenzene	1.26		1.250		101	65	135				

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680800**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	ND	2.23						0		30	
Surr: Toluene-d8	0.561		0.5566		101	65	135		0		
Surr: 4-Bromofluorobenzene	0.544		0.5566		97.7	65	135		0		

Sample ID **1704147-008BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680802**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	10.0	2.43	12.17	0	82.2	65	135				
Surr: Toluene-d8	0.617		0.6087		101	65	135				
Surr: 4-Bromofluorobenzene	0.610		0.6087		100	65	135				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Gasoline by NWTPH-Gx

Sample ID **1704147-008BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35539**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680803**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Gasoline	10.2	2.43	12.17	0	83.5	65	135	10.00	1.63	30	
Surr: Toluene-d8	0.616		0.6087		101	65	135		0		
Surr: 4-Bromofluorobenzene	0.615		0.6087		101	65	135		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Mercury by EPA Method 7471

Sample ID **MB-16786** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **MBLKS** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680921**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	ND	0.250									

Sample ID **LCS-16786** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **LCSS** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680922**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.518	0.250	0.5000	0	104	80	120				

Sample ID **1704169-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680924**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	0.623	0.311						0.5530	11.8	20	

Sample ID **1704169-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680925**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	1.29	0.316	0.6328	0.5530	117	70	130				E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID **1704169-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35543**
Client ID: **BCT-04-ENV** Batch ID: **16786** Analysis Date: **4/14/2017** SeqNo: **680926**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Mercury	1.02	0.316	0.6328	0.5530	74.0	70	130	1.291	23.3	20	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Sample Moisture (Percent Moisture)

Sample ID **1704166-002ADUP** SampType: **DUP** Units: **wt%** Prep Date: **4/14/2017** RunNo: **35537**
Client ID: **BATCH** Batch ID: **R35537** Analysis Date: **4/14/2017** SeqNo: **680754**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Percent Moisture	19.3	0.500						16.07	18.2	20	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **MB-16779** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **MBLKS** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681091**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	ND	0.0719									
Barium	ND	0.360									
Cadmium	ND	0.144									
Chromium	ND	0.0719									
Lead	ND	0.144									
Selenium	ND	0.360									
Silver	ND	0.0719									

Sample ID **1704161-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681094**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	23.1	0.0949						20.31	12.8	20	
Barium	195	0.475						152.6	24.2	20	R
Cadmium	0.217	0.190						0.1538	34.1	20	
Chromium	34.4	0.0949						27.77	21.4	20	R
Selenium	3.14	0.475						2.766	12.8	20	
Silver	0.0954	0.0949						0.07518	23.8	20	

NOTES:
R - High RPD observed. The method is in control as indicated by the LCS.

Sample ID **1704161-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681096**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	71.0	0.0949	47.46	20.31	107	75	125				
Barium	248	0.475	47.46	152.6	202	75	125				S
Cadmium	3.11	0.190	2.373	0.1538	125	75	125				
Chromium	92.9	0.0949	47.46	27.77	137	75	125				S
Lead	78.6	0.190	23.73	80.56	-8.04	75	125				S
Selenium	8.17	0.475	4.746	2.766	114	75	125				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **1704161-001AMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681096**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Silver	1.90	0.0949	2.373	0.07518	77.0	75	125				

NOTES:
S - Outlying spike recovery(ies) observed for Barium and Lead. A duplicate analysis was performed with similar results indicating a possible matrix effect.
S - Outlying spike recovery observed for Chromium. A duplicate analysis was performed and recovered within range.

Sample ID **1704161-001AMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681099**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	67.0	0.0942	47.11	20.31	99.2	75	125	70.98	5.72	20	
Barium	219	0.471	47.11	152.6	140	75	125	248.2	12.7	20	S
Cadmium	2.81	0.188	2.355	0.1538	113	75	125	3.111	10.3	20	
Chromium	83.2	0.0942	47.11	27.77	118	75	125	92.91	11.1	20	
Lead	84.4	0.188	23.55	80.56	16.5	75	125	78.65	7.11	20	S
Selenium	7.26	0.471	4.711	2.766	95.4	75	125	8.172	11.8	20	
Silver	1.55	0.0942	2.355	0.07518	62.6	75	125	1.901	20.5	20	RS

NOTES:
S - Outlying spike recovery(ies) observed for Barium and Lead. A duplicate analysis was performed with similar results indicating a possible matrix effect.
S/R - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Sample ID **LCS-16779** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **LCSS** Batch ID: **16779** Analysis Date: **4/14/2017** SeqNo: **681161**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Arsenic	37.3	0.0725	36.23	0	103	80	120				
Barium	37.2	0.362	36.23	0	103	80	120				
Cadmium	1.83	0.145	1.812	0	101	80	120				
Chromium	33.8	0.0725	36.23	0	93.2	80	120				
Lead	18.8	0.145	18.12	0	104	80	120				
Selenium	3.44	0.362	3.623	0	94.9	80	120				
Silver	1.45	0.0725	1.812	0	79.9	80	120				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Total Metals by EPA Method 6020

Sample ID **1704161-001ADUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/14/2017** RunNo: **35557**
Client ID: **BATCH** Batch ID: **16779** Analysis Date: **4/17/2017** SeqNo: **681402**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Lead	73.1	0.190						80.56	9.65	20	

Sample ID **CCV-16779F** SampType: **CCV** Units: **µg/L** Prep Date: **4/17/2017** RunNo: **35557**
Client ID: **CCV** Batch ID: **16779** Analysis Date: **4/17/2017** SeqNo: **681405**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Lead	52.9	2.00	50.00	0	106	90	110				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.770	0.0600	1.000	0	77.0	14.3	167				
Chloromethane	0.907	0.0600	1.000	0	90.7	46	144				
Vinyl chloride	0.947	0.00200	1.000	0	94.7	44	142				
Bromomethane	0.979	0.0900	1.000	0	97.9	40.9	157				
Trichlorofluoromethane (CFC-11)	0.955	0.0500	1.000	0	95.5	36.9	156				
Chloroethane	0.936	0.0600	1.000	0	93.6	33.4	155				
1,1-Dichloroethene	0.942	0.0500	1.000	0	94.2	49.7	142				
Methylene chloride	0.927	0.0200	1.000	0	92.7	46.3	140				
trans-1,2-Dichloroethene	0.946	0.0200	1.000	0	94.6	68	130				
Methyl tert-butyl ether (MTBE)	0.983	0.0500	1.000	0	98.3	66.3	145				
1,1-Dichloroethane	0.979	0.0200	1.000	0	97.9	61.9	137				
2,2-Dichloropropane	1.29	0.0500	1.000	0	129	35.5	186				
cis-1,2-Dichloroethene	0.960	0.0200	1.000	0	96.0	71.3	135				
Chloroform	0.959	0.0200	1.000	0	95.9	69	145				
1,1,1-Trichloroethane (TCA)	0.960	0.0200	1.000	0	96.0	69	132				
1,1-Dichloropropene	0.967	0.0200	1.000	0	96.7	72.7	131				
Carbon tetrachloride	0.954	0.0200	1.000	0	95.4	63.4	137				
1,2-Dichloroethane (EDC)	0.959	0.0300	1.000	0	95.9	61.9	136				
Benzene	1.03	0.0200	1.000	0	103	64.3	133				
Trichloroethene (TCE)	0.951	0.0200	1.000	0	95.1	65.5	137				
1,2-Dichloropropane	1.01	0.0200	1.000	0	101	63.2	142				
Bromodichloromethane	0.950	0.0200	1.000	0	95.0	73.2	131				
Dibromomethane	0.955	0.0400	1.000	0	95.5	70	130				
cis-1,3-Dichloropropene	1.07	0.0200	1.000	0	107	59.1	143				
Toluene	1.06	0.0200	1.000	0	106	67.3	138				
trans-1,3-Dichloropropylene	1.04	0.0300	1.000	0	104	49.2	149				
1,1,2-Trichloroethane	0.937	0.0300	1.000	0	93.7	74.5	129				
1,3-Dichloropropane	0.955	0.0500	1.000	0	95.5	70	130				
Tetrachloroethene (PCE)	1.00	0.0200	1.000	0	100	52.7	150				
Dibromochloromethane	0.975	0.0300	1.000	0	97.5	70.6	144				
1,2-Dibromoethane (EDB)	0.931	0.00500	1.000	0	93.1	70	130				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorobenzene	0.990	0.0200	1.000	0	99.0	76.1	123				
1,1,1,2-Tetrachloroethane	0.976	0.0300	1.000	0	97.6	65.9	141				
Ethylbenzene	1.07	0.0300	1.000	0	107	74	129				
m,p-Xylene	2.15	0.0200	2.000	0	107	70	124				
o-Xylene	1.07	0.0200	1.000	0	107	68.1	139				
Styrene	0.979	0.0200	1.000	0	97.9	76.8	130				
Isopropylbenzene	0.990	0.0800	1.000	0	99.0	70	130				
Bromoform	0.818	0.0200	1.000	0	81.8	67	154				
1,1,2,2-Tetrachloroethane	0.923	0.0200	1.000	0	92.3	60	130				
n-Propylbenzene	0.998	0.0200	1.000	0	99.8	74.8	125				
Bromobenzene	0.985	0.0300	1.000	0	98.5	49.2	144				
1,3,5-Trimethylbenzene	1.00	0.0200	1.000	0	100	74.6	123				
2-Chlorotoluene	0.997	0.0200	1.000	0	99.7	76.7	129				
4-Chlorotoluene	0.993	0.0200	1.000	0	99.3	77.5	125				
tert-Butylbenzene	1.01	0.0200	1.000	0	101	66.2	130				
1,2,3-Trichloropropane	0.915	0.0200	1.000	0	91.5	67.9	136				
1,2,4-Trichlorobenzene	0.991	0.0500	1.000	0	99.1	62.6	143				
sec-Butylbenzene	1.06	0.0200	1.000	0	106	75.6	133				
4-Isopropyltoluene	1.10	0.0200	1.000	0	110	76.8	131				
1,3-Dichlorobenzene	1.04	0.0200	1.000	0	104	72.8	128				
1,4-Dichlorobenzene	1.04	0.0200	1.000	0	104	72.6	126				
n-Butylbenzene	1.18	0.0200	1.000	0	118	65.3	136				
1,2-Dichlorobenzene	1.03	0.0200	1.000	0	103	72.8	126				
1,2-Dibromo-3-chloropropane	0.864	0.500	1.000	0	86.4	61.2	139				
1,2,4-Trimethylbenzene	1.03	0.0200	1.000	0	103	77.5	129				
Hexachlorobutadiene	1.11	0.100	1.000	0	111	42	151				
Naphthalene	0.956	0.0300	1.000	0	95.6	62.3	134				
1,2,3-Trichlorobenzene	0.905	0.0200	1.000	0	90.5	54.8	143				
Surr: Dibromofluoromethane	1.24		1.250		99.2	56.5	129				
Surr: Toluene-d8	1.27		1.250		102	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	1.31		1.250		105	63.1	141				

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **LCS-16767** SampType: **LCS** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **LCSS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680795**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0600									Q
Chloromethane	ND	0.0600									
Vinyl chloride	ND	0.00200									
Bromomethane	ND	0.0900									
Trichlorofluoromethane (CFC-11)	ND	0.0500									
Chloroethane	ND	0.0600									
1,1-Dichloroethene	ND	0.0500									
Methylene chloride	ND	0.0200									
trans-1,2-Dichloroethene	ND	0.0200									
Methyl tert-butyl ether (MTBE)	ND	0.0500									
1,1-Dichloroethane	ND	0.0200									
2,2-Dichloropropane	ND	0.0500									
cis-1,2-Dichloroethene	ND	0.0200									
Chloroform	ND	0.0200									
1,1,1-Trichloroethane (TCA)	ND	0.0200									
1,1-Dichloropropene	ND	0.0200									
Carbon tetrachloride	ND	0.0200									
1,2-Dichloroethane (EDC)	ND	0.0300									
Benzene	ND	0.0200									
Trichloroethene (TCE)	ND	0.0200									
1,2-Dichloropropane	ND	0.0200									
Bromodichloromethane	ND	0.0200									
Dibromomethane	ND	0.0400									
cis-1,3-Dichloropropene	ND	0.0200									
Toluene	ND	0.0200									

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
trans-1,3-Dichloropropylene	ND	0.0300									
1,1,2-Trichloroethane	ND	0.0300									
1,3-Dichloropropane	ND	0.0500									
Tetrachloroethene (PCE)	ND	0.0200									
Dibromochloromethane	ND	0.0300									
1,2-Dibromoethane (EDB)	ND	0.00500									
Chlorobenzene	ND	0.0200									
1,1,1,2-Tetrachloroethane	ND	0.0300									
Ethylbenzene	ND	0.0300									
m,p-Xylene	ND	0.0200									
o-Xylene	ND	0.0200									
Styrene	ND	0.0200									
Isopropylbenzene	ND	0.0800									
Bromoform	ND	0.0200									Q
1,1,2,2-Tetrachloroethane	ND	0.0200									
n-Propylbenzene	ND	0.0200									
Bromobenzene	ND	0.0300									
1,3,5-Trimethylbenzene	ND	0.0200									
2-Chlorotoluene	ND	0.0200									
4-Chlorotoluene	ND	0.0200									
tert-Butylbenzene	ND	0.0200									
1,2,3-Trichloropropane	ND	0.0200									
1,2,4-Trichlorobenzene	ND	0.0500									
sec-Butylbenzene	ND	0.0200									
4-Isopropyltoluene	ND	0.0200									
1,3-Dichlorobenzene	ND	0.0200									
1,4-Dichlorobenzene	ND	0.0200									
n-Butylbenzene	ND	0.0200									
1,2-Dichlorobenzene	ND	0.0200									
1,2-Dibromo-3-chloropropane	ND	0.500									
1,2,4-Trimethylbenzene	ND	0.0200									

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **MB-16767** SampType: **MBLK** Units: **mg/Kg** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **MBLKS** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680796**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Hexachlorobutadiene	ND	0.100									
Naphthalene	ND	0.0300									
1,2,3-Trichlorobenzene	ND	0.0200									
Surr: Dibromofluoromethane	1.19		1.250		95.2	56.5	129				
Surr: Toluene-d8	1.22		1.250		97.7	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	1.22		1.250		97.4	63.1	141				

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680775**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0267						0		30	Q
Chloromethane	0.0318	0.0267						0.02936	8.00	30	
Vinyl chloride	ND	0.000891						0		30	
Bromomethane	ND	0.0401						0		30	
Trichlorofluoromethane (CFC-11)	ND	0.0223						0		30	
Chloroethane	ND	0.0267						0		30	
1,1-Dichloroethene	ND	0.0223						0		30	
Methylene chloride	ND	0.00891						0		30	
trans-1,2-Dichloroethene	ND	0.00891						0		30	
Methyl tert-butyl ether (MTBE)	ND	0.0223						0		30	
1,1-Dichloroethane	ND	0.00891						0		30	
2,2-Dichloropropane	ND	0.0223						0		30	
cis-1,2-Dichloroethene	ND	0.00891						0		30	
Chloroform	ND	0.00891						0		30	
1,1,1-Trichloroethane (TCA)	ND	0.00891						0		30	
1,1-Dichloropropene	ND	0.00891						0		30	
Carbon tetrachloride	ND	0.00891						0		30	
1,2-Dichloroethane (EDC)	ND	0.0134						0		30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680775**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Benzene	ND	0.00891						0		30	
Trichloroethene (TCE)	ND	0.00891						0		30	
1,2-Dichloropropane	ND	0.00891						0		30	
Bromodichloromethane	ND	0.00891						0		30	
Dibromomethane	ND	0.0178						0		30	
cis-1,3-Dichloropropene	ND	0.00891						0		30	
Toluene	ND	0.00891						0		30	
trans-1,3-Dichloropropylene	ND	0.0134						0		30	
1,1,2-Trichloroethane	ND	0.0134						0		30	
1,3-Dichloropropane	ND	0.0223						0		30	
Tetrachloroethene (PCE)	ND	0.00891						0		30	
Dibromochloromethane	ND	0.0134						0		30	
1,2-Dibromoethane (EDB)	ND	0.00223						0		30	
Chlorobenzene	ND	0.00891						0		30	
1,1,1,2-Tetrachloroethane	ND	0.0134						0		30	
Ethylbenzene	ND	0.0134						0		30	
m,p-Xylene	ND	0.00891						0		30	
o-Xylene	ND	0.00891						0		30	
Styrene	ND	0.00891						0		30	
Isopropylbenzene	ND	0.0356						0		30	
Bromoform	ND	0.00891						0		30	Q
1,1,2,2-Tetrachloroethane	ND	0.00891						0		30	
n-Propylbenzene	ND	0.00891						0		30	
Bromobenzene	ND	0.0134						0		30	
1,3,5-Trimethylbenzene	ND	0.00891						0		30	
2-Chlorotoluene	ND	0.00891						0		30	
4-Chlorotoluene	ND	0.00891						0		30	
tert-Butylbenzene	ND	0.00891						0		30	
1,2,3-Trichloropropane	ND	0.00891						0		30	
1,2,4-Trichlorobenzene	ND	0.0223						0		30	
sec-Butylbenzene	ND	0.00891						0		30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-001BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/13/2017** SeqNo: **680775**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
4-Isopropyltoluene	ND	0.00891						0		30	
1,3-Dichlorobenzene	ND	0.00891						0		30	
1,4-Dichlorobenzene	ND	0.00891						0		30	
n-Butylbenzene	ND	0.00891						0		30	
1,2-Dichlorobenzene	ND	0.00891						0		30	
1,2-Dibromo-3-chloropropane	ND	0.223						0		30	
1,2,4-Trimethylbenzene	ND	0.00891						0		30	
Hexachlorobutadiene	ND	0.0445						0		30	
Naphthalene	ND	0.0134						0		30	
1,2,3-Trichlorobenzene	ND	0.00891						0		30	
Surr: Dibromofluoromethane	0.497		0.5566		89.2	56.5	129		0		
Surr: Toluene-d8	0.533		0.5566		95.8	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.530		0.5566		95.1	63.1	141		0		

NOTES:

Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.442	0.0321	0.5357	0	82.4	43.5	121				
Chloromethane	0.569	0.0321	0.5357	0.03912	98.9	45	130				
Vinyl chloride	0.518	0.00107	0.5357	0	96.6	51.2	146				
Bromomethane	0.371	0.0482	0.5357	0.02986	63.7	21.3	120				
Trichlorofluoromethane (CFC-11)	0.408	0.0268	0.5357	0	76.1	35	131				
Chloroethane	0.468	0.0321	0.5357	0	87.3	31.9	123				
1,1-Dichloroethene	0.506	0.0268	0.5357	0	94.4	61.9	141				
Methylene chloride	0.531	0.0107	0.5357	0	99.1	54.7	142				
trans-1,2-Dichloroethene	0.528	0.0107	0.5357	0	98.5	52	136				
Methyl tert-butyl ether (MTBE)	0.613	0.0268	0.5357	0.01279	112	54.4	132				
1,1-Dichloroethane	0.531	0.0107	0.5357	0	99.1	51.8	141				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
2,2-Dichloropropane	0.535	0.0268	0.5357	0	99.8	36	123				
cis-1,2-Dichloroethene	0.521	0.0107	0.5357	0	97.2	58.6	136				
Chloroform	0.512	0.0107	0.5357	0	95.6	53.2	129				
1,1,1-Trichloroethane (TCA)	0.496	0.0107	0.5357	0	92.5	58.3	145				
1,1-Dichloropropene	0.548	0.0107	0.5357	0	102	55.1	138				
Carbon tetrachloride	0.471	0.0107	0.5357	0	87.9	53.3	144				
1,2-Dichloroethane (EDC)	0.549	0.0161	0.5357	0	102	51.3	139				
Benzene	0.543	0.0107	0.5357	0.02096	97.4	63.5	133				
Trichloroethene (TCE)	0.508	0.0107	0.5357	0	94.8	68.6	132				
1,2-Dichloropropane	0.544	0.0107	0.5357	0	101	59	136				
Bromodichloromethane	0.418	0.0107	0.5357	0	78.0	50.7	141				
Dibromomethane	0.501	0.0214	0.5357	0	93.4	50.6	137				
cis-1,3-Dichloropropene	0.542	0.0107	0.5357	0	101	50.4	138				
Toluene	0.551	0.0107	0.5357	0.02369	98.4	63.4	132				
trans-1,3-Dichloropropylene	0.541	0.0161	0.5357	0	101	44.1	147				
1,1,2-Trichloroethane	0.524	0.0161	0.5357	0	97.8	51.6	137				
1,3-Dichloropropane	0.539	0.0268	0.5357	0	101	53.1	134				
Tetrachloroethene (PCE)	0.543	0.0107	0.5357	0	101	35.6	158				
Dibromochloromethane	0.440	0.0161	0.5357	0	82.2	55.3	140				
1,2-Dibromoethane (EDB)	0.518	0.00268	0.5357	0	96.7	50.4	136				
Chlorobenzene	0.542	0.0107	0.5357	0	101	60	133				
1,1,1,2-Tetrachloroethane	0.484	0.0161	0.5357	0	90.4	53.1	142				
Ethylbenzene	0.568	0.0161	0.5357	0.02044	102	54.5	134				
m,p-Xylene	1.14	0.0107	1.071	0.04232	102	53.1	132				
o-Xylene	0.578	0.0107	0.5357	0.02144	104	53.3	139				
Styrene	0.555	0.0107	0.5357	0	104	51.1	132				
Isopropylbenzene	0.562	0.0429	0.5357	0	105	58.9	138				
Bromoform	0.352	0.0107	0.5357	0	65.7	57.9	130				
1,1,2,2-Tetrachloroethane	0.521	0.0107	0.5357	0	97.2	51.9	131				
n-Propylbenzene	0.573	0.0107	0.5357	0	107	53.6	140				
Bromobenzene	0.559	0.0161	0.5357	0	104	54.2	140				

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMS** SampType: **MS** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680780**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
1,3,5-Trimethylbenzene	0.564	0.0107	0.5357	0	105	51.8	136				
2-Chlorotoluene	0.548	0.0107	0.5357	0	102	51.6	136				
4-Chlorotoluene	0.560	0.0107	0.5357	0	104	50.1	139				
tert-Butylbenzene	0.569	0.0107	0.5357	0	106	50.5	135				
1,2,3-Trichloropropane	0.550	0.0107	0.5357	0	103	50.5	131				
1,2,4-Trichlorobenzene	0.694	0.0268	0.5357	0	129	50.8	130				
sec-Butylbenzene	0.619	0.0107	0.5357	0	116	52.6	141				
4-Isopropyltoluene	0.634	0.0107	0.5357	0	118	52.9	134				
1,3-Dichlorobenzene	0.563	0.0107	0.5357	0	105	52.6	131				
1,4-Dichlorobenzene	0.575	0.0107	0.5357	0	107	52.9	129				
n-Butylbenzene	0.670	0.0107	0.5357	0	125	52.6	130				
1,2-Dichlorobenzene	0.567	0.0107	0.5357	0	106	55.8	129				
1,2-Dibromo-3-chloropropane	0.429	0.268	0.5357	0	80.0	40.5	131				
1,2,4-Trimethylbenzene	0.613	0.0107	0.5357	0	114	50.6	137				
Hexachlorobutadiene	0.693	0.0536	0.5357	0	129	40.6	158				
Naphthalene	0.744	0.0161	0.5357	0	139	52.3	124				S
1,2,3-Trichlorobenzene	0.651	0.0107	0.5357	0	121	54.4	124				
Surr: Dibromofluoromethane	0.579		0.6696		86.4	56.5	129				
Surr: Toluene-d8	0.663		0.6696		99.0	64.5	151				
Surr: 1-Bromo-4-fluorobenzene	0.725		0.6696		108	63.1	141				

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	0.442	0.0321	0.5357	0	82.6	43.5	121	0.4416	0.155	30	
Chloromethane	0.558	0.0321	0.5357	0.03912	96.9	45	130	0.5688	1.90	30	
Vinyl chloride	0.504	0.00107	0.5357	0	94.1	51.2	146	0.5177	2.72	30	
Bromomethane	0.381	0.0482	0.5357	0.02986	65.6	21.3	120	0.3710	2.78	30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Trichlorofluoromethane (CFC-11)	0.462	0.0268	0.5357	0	86.3	35	131	0.4079	12.5	30	
Chloroethane	0.482	0.0321	0.5357	0	89.9	31.9	123	0.4679	2.91	30	
1,1-Dichloroethene	0.515	0.0268	0.5357	0	96.2	61.9	141	0.5057	1.83	30	
Methylene chloride	0.511	0.0107	0.5357	0	95.3	54.7	142	0.5308	3.86	30	
trans-1,2-Dichloroethene	0.528	0.0107	0.5357	0	98.6	52	136	0.5277	0.124	30	
Methyl tert-butyl ether (MTBE)	0.570	0.0268	0.5357	0.01279	104	54.4	132	0.6125	7.15	30	
1,1-Dichloroethane	0.533	0.0107	0.5357	0	99.5	51.8	141	0.5309	0.397	30	
2,2-Dichloropropane	0.539	0.0268	0.5357	0	101	36	123	0.5346	0.739	30	
cis-1,2-Dichloroethene	0.516	0.0107	0.5357	0	96.4	58.6	136	0.5208	0.850	30	
Chloroform	0.508	0.0107	0.5357	0	94.9	53.2	129	0.5124	0.804	30	
1,1,1-Trichloroethane (TCA)	0.505	0.0107	0.5357	0	94.3	58.3	145	0.4955	1.95	30	
1,1-Dichloropropene	0.547	0.0107	0.5357	0	102	55.1	138	0.5477	0.134	30	
Carbon tetrachloride	0.515	0.0107	0.5357	0	96.1	53.3	144	0.4709	8.93	30	
1,2-Dichloroethane (EDC)	0.507	0.0161	0.5357	0	94.6	51.3	139	0.5488	7.98	30	
Benzene	0.537	0.0107	0.5357	0.02096	96.3	63.5	133	0.5428	1.11	30	
Trichloroethene (TCE)	0.514	0.0107	0.5357	0	95.9	68.6	132	0.5081	1.12	30	
1,2-Dichloropropane	0.530	0.0107	0.5357	0	99.0	59	136	0.5436	2.51	30	
Bromodichloromethane	0.422	0.0107	0.5357	0	78.8	50.7	141	0.4180	0.992	30	
Dibromomethane	0.480	0.0214	0.5357	0	89.7	50.6	137	0.5005	4.13	30	
cis-1,3-Dichloropropene	0.535	0.0107	0.5357	0	99.8	50.4	138	0.5425	1.47	30	
Toluene	0.550	0.0107	0.5357	0.02369	98.3	63.4	132	0.5510	0.108	30	
trans-1,3-Dichloropropylene	0.529	0.0161	0.5357	0	98.8	44.1	147	0.5410	2.23	30	
1,1,2-Trichloroethane	0.489	0.0161	0.5357	0	91.2	51.6	137	0.5241	7.03	30	
1,3-Dichloropropane	0.503	0.0268	0.5357	0	94.0	53.1	134	0.5386	6.73	30	
Tetrachloroethene (PCE)	0.544	0.0107	0.5357	0	102	35.6	158	0.5434	0.175	30	
Dibromochloromethane	0.430	0.0161	0.5357	0	80.2	55.3	140	0.4401	2.39	30	
1,2-Dibromoethane (EDB)	0.482	0.00268	0.5357	0	89.9	50.4	136	0.5182	7.30	30	
Chlorobenzene	0.530	0.0107	0.5357	0	98.8	60	133	0.5420	2.32	30	
1,1,1,2-Tetrachloroethane	0.482	0.0161	0.5357	0	90.0	53.1	142	0.4844	0.461	30	
Ethylbenzene	0.554	0.0161	0.5357	0.02044	99.6	54.5	134	0.5677	2.41	30	
m,p-Xylene	1.11	0.0107	1.071	0.04232	99.2	53.1	132	1.136	2.76	30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-005BMSD** SampType: **MSD** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680781**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
o-Xylene	0.555	0.0107	0.5357	0.02144	99.6	53.3	139	0.5780	4.07	30	
Styrene	0.529	0.0107	0.5357	0	98.8	51.1	132	0.5554	4.80	30	
Isopropylbenzene	0.546	0.0429	0.5357	0	102	58.9	138	0.5616	2.80	30	
Bromoform	0.341	0.0107	0.5357	0	63.6	57.9	130	0.3521	3.26	30	
1,1,2,2-Tetrachloroethane	0.463	0.0107	0.5357	0	86.5	51.9	131	0.5207	11.7	30	
n-Propylbenzene	0.544	0.0107	0.5357	0	102	53.6	140	0.5730	5.09	30	
Bromobenzene	0.519	0.0161	0.5357	0	96.8	54.2	140	0.5591	7.51	30	
1,3,5-Trimethylbenzene	0.537	0.0107	0.5357	0	100	51.8	136	0.5640	4.90	30	
2-Chlorotoluene	0.531	0.0107	0.5357	0	99.1	51.6	136	0.5485	3.24	30	
4-Chlorotoluene	0.532	0.0107	0.5357	0	99.3	50.1	139	0.5596	5.05	30	
tert-Butylbenzene	0.550	0.0107	0.5357	0	103	50.5	135	0.5690	3.32	30	
1,2,3-Trichloropropane	0.466	0.0107	0.5357	0	87.0	50.5	131	0.5504	16.6	30	
1,2,4-Trichlorobenzene	0.626	0.0268	0.5357	0	117	50.8	130	0.6935	10.3	30	
sec-Butylbenzene	0.584	0.0107	0.5357	0	109	52.6	141	0.6188	5.79	30	
4-Isopropyltoluene	0.593	0.0107	0.5357	0	111	52.9	134	0.6342	6.65	30	
1,3-Dichlorobenzene	0.566	0.0107	0.5357	0	106	52.6	131	0.5631	0.492	30	
1,4-Dichlorobenzene	0.570	0.0107	0.5357	0	106	52.9	129	0.5750	0.915	30	
n-Butylbenzene	0.671	0.0107	0.5357	0	125	52.6	130	0.6697	0.243	30	
1,2-Dichlorobenzene	0.562	0.0107	0.5357	0	105	55.8	129	0.5675	1.03	30	
1,2-Dibromo-3-chloropropane	0.383	0.268	0.5357	0	71.5	40.5	131	0.4288	11.3	30	
1,2,4-Trimethylbenzene	0.560	0.0107	0.5357	0	105	50.6	137	0.6134	9.04	30	
Hexachlorobutadiene	0.684	0.0536	0.5357	0	128	40.6	158	0.6932	1.31	30	
Naphthalene	0.633	0.0161	0.5357	0	118	52.3	124	0.7442	16.1	30	
1,2,3-Trichlorobenzene	0.577	0.0107	0.5357	0	108	54.4	124	0.6505	12.0	30	
Surr: Dibromofluoromethane	0.620		0.6696		92.5	56.5	129		0		
Surr: Toluene-d8	0.659		0.6696		98.4	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.699		0.6696		104	63.1	141		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680789**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Dichlorodifluoromethane (CFC-12)	ND	0.0284						0		30	Q
Chloromethane	0.0363	0.0284						0.03933	8.01	30	
Vinyl chloride	ND	0.000946						0		30	
Bromomethane	ND	0.0426						0		30	
Trichlorofluoromethane (CFC-11)	ND	0.0236						0		30	
Chloroethane	ND	0.0284						0		30	
1,1-Dichloroethene	ND	0.0236						0		30	
Methylene chloride	ND	0.00946						0		30	
trans-1,2-Dichloroethene	ND	0.00946						0		30	
Methyl tert-butyl ether (MTBE)	ND	0.0236						0		30	
1,1-Dichloroethane	ND	0.00946						0		30	
2,2-Dichloropropane	ND	0.0236						0		30	
cis-1,2-Dichloroethene	ND	0.00946						0		30	
Chloroform	ND	0.00946						0		30	
1,1,1-Trichloroethane (TCA)	ND	0.00946						0		30	
1,1-Dichloropropene	ND	0.00946						0		30	
Carbon tetrachloride	ND	0.00946						0		30	
1,2-Dichloroethane (EDC)	ND	0.0142						0		30	
Benzene	ND	0.00946						0		30	
Trichloroethene (TCE)	ND	0.00946						0		30	
1,2-Dichloropropane	ND	0.00946						0		30	
Bromodichloromethane	ND	0.00946						0		30	
Dibromomethane	ND	0.0189						0		30	
cis-1,3-Dichloropropene	ND	0.00946						0		30	
Toluene	ND	0.00946						0		30	
trans-1,3-Dichloropropylene	ND	0.0142						0		30	
1,1,2-Trichloroethane	ND	0.0142						0		30	
1,3-Dichloropropane	ND	0.0236						0		30	
Tetrachloroethene (PCE)	ND	0.00946						0		30	
Dibromochloromethane	ND	0.0142						0		30	
1,2-Dibromoethane (EDB)	ND	0.00236						0		30	

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP** SampType: **DUP** Units: **mg/Kg-dry** Prep Date: **4/13/2017** RunNo: **35538**
Client ID: **BATCH** Batch ID: **16767** Analysis Date: **4/14/2017** SeqNo: **680789**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chlorobenzene	ND	0.00946						0		30	
1,1,1,2-Tetrachloroethane	ND	0.0142						0		30	
Ethylbenzene	ND	0.0142						0		30	
m,p-Xylene	ND	0.00946						0		30	
o-Xylene	ND	0.00946						0		30	
Styrene	ND	0.00946						0		30	
Isopropylbenzene	ND	0.0378						0		30	
Bromoform	ND	0.00946						0		30	Q
1,1,2,2-Tetrachloroethane	ND	0.00946						0		30	
n-Propylbenzene	ND	0.00946						0		30	
Bromobenzene	ND	0.0142						0		30	
1,3,5-Trimethylbenzene	ND	0.00946						0		30	
2-Chlorotoluene	ND	0.00946						0		30	
4-Chlorotoluene	ND	0.00946						0		30	
tert-Butylbenzene	ND	0.00946						0		30	
1,2,3-Trichloropropane	ND	0.00946						0		30	
1,2,4-Trichlorobenzene	ND	0.0236						0		30	
sec-Butylbenzene	ND	0.00946						0		30	
4-Isopropyltoluene	ND	0.00946						0		30	
1,3-Dichlorobenzene	ND	0.00946						0		30	
1,4-Dichlorobenzene	ND	0.00946						0		30	
n-Butylbenzene	ND	0.00946						0		30	
1,2-Dichlorobenzene	ND	0.00946						0		30	
1,2-Dibromo-3-chloropropane	ND	0.236						0		30	
1,2,4-Trimethylbenzene	ND	0.00946						0		30	
Hexachlorobutadiene	ND	0.0473						0		30	
Naphthalene	ND	0.0142						0		30	
1,2,3-Trichlorobenzene	ND	0.00946						0		30	
Surr: Dibromofluoromethane	0.500		0.5912		84.5	56.5	129		0		
Surr: Toluene-d8	0.568		0.5912		96.2	64.5	151		0		
Surr: 1-Bromo-4-fluorobenzene	0.569		0.5912		96.2	63.1	141		0		

Work Order: 1704169
CLIENT: Shannon & Wilson
Project: Ballard Conveyance

QC SUMMARY REPORT

Volatile Organic Compounds by EPA Method 8260C

Sample ID **1704147-012BDUP**	SampType: **DUP**		Units: **mg/Kg-dry**		Prep Date: **4/13/2017**			RunNo: **35538**			
Client ID: **BATCH**	Batch ID: **16767**				Analysis Date: **4/14/2017**			SeqNo: **680789**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF).

Fremont Analytical

Sample Log-In Check List

Client Name: **SW**
Work Order Number: **1704169**
Logged by: **Clare Griggs**
Date Received: **4/13/2017 11:52:00 AM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐

4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☐ Not Required ☑

6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐

7. Were all items received at a temperature of >0°C to 10.0°C* Yes ☐ No ☑ NA ☐

Sample received straight from field

8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☑ No ☐ NA ☐ MeOH
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐

15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: Date
By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	6.4
Sample	13.5
Temp Blank	9.9

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 4/13/2017 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1704169

Special Remarks:

Project Name: BALLARD CONVEYANCE

Project No: 21-1-22329-002

Collected by: JAA

Location: BALLARD

Report To (PM): ~~djr@~~shan DAVID RANDALL

PM Email: djr@shanwil.com

Client: STW

Address: 400 N. 34 ST

City, State, Zip: SEATTLE, WA

Telephone: 206-~~224-4~~695-6918

Fax:

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)					Comments
1	BCT-04-ENV	4/13/2017	11:30	Soil	X			X		X				X								
2																						
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 [✓ RCRA-8] Priority Pollutants TAL *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

***Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:

☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Jorge Avalos	Date/Time 4/13/17 11:55	Received x	Date/Time 4/13/17 11:52
Relinquished x	Date/Time	Received x	Date/Time

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APPENDIX E

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-22329-004

Date: July 19, 2017
To: Seattle Public Utilities
Seattle, Washington

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland