Exhibit E to Resolution 17-4824

Geotechnical Data Report
Willamette Falls Riverwalk
Public Yard / Alcove Area
Oregon City, Oregon

Prepared For

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NGI Project No. 2919.1.1

Northwest Geotech, Inc.
Northwest Testing, Inc.

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1.0 INTRODUCTION

The purposes of this subsurface investigation and Geotechnical Data Report were limited to:

- identification of the depth to bedrock across the exploration area,
- characterization of the fill proposed to be removed,
- and data acquisition to guide future investigations, preliminary engineering and estimating.

Geotechnical Data Reports are the standard for inclusion in contract/bid documents for infrastructure projects and are focused on providing subsurface data to establish existing conditions.

2.0 SITE AND PROJECT DESCRIPTIONS

The area of investigation is located within the former Blue Heron paper mill just south of downtown Oregon City, and adjacent to the Willamette River. Figure 1 provides an approximate outline of the area explored. This general area was created by filling and is commonly referred to as the "yard" since it is relatively open. Concept design plans call for the removal of a significant portion of the historic fill to re-expose the bedrock surface and potentially create a restored habitat and expanded shoreline area. Public open space is proposed in the area north and east of the proposed fill removal. Project documents refer to this portion of the project as the Public Yard and Alcove.

3.0 SUBSURFACE EXPLORATIONS

3.1 Borings

The subsurface explorations consisted of drilling four (4) exploratory borings utilizing a sonic coring rig capable of rapidly advancing in the rocky fill and into the basalt bedrock. These borings are designated S-1 through S-4 and ranged in depth from 20.0 feet to 38.0 feet below the ground surface. The plotted locations of each boring are shown on the Exploration Plan, Figure 2. Additionally sixty seven (67) air track borings identified as B-1 through B-73 were drilled to identify the approximate elevation of bedrock and relative hardness at the locations plotted on Figure 2. Six (6) of the proposed seventy three (73) air track locations were omitted due to inadequate overhead drill clearance. All boring locations were surveyed by AKS Engineering and Forestry, and the point file was imported into the existing AKS survey file previously provided to NGI by Metro. The surveyed coordinates and elevations of each borehole are presented in Table 1.

The sonic borings were performed by Cascade Drilling utilizing the Terra Sonic TSi 150CC Compact Crawler drill rig which created a roughly 4-inch diameter hole and 3.5 inch diameter core. The air track borings were performed by Aggregate Resources Inc., utilizing a typical track mounted pneumatic percussion drill which creates a 1.5 inch diameter borehole.

Continuous coring of the site fill and underlying soil and bedrock were performed for the entire depth of each sonic boring. Penetration testing utilizing a Dames & Moore (D&M) sampler driven by a 140 pound hammer was utilized at selected locations. No samples were taken during the air-track drilling program as all materials are crushed by the drilling process. The air-track drilling does provide an indication of bedrock hardness based on the size and character of the crushed basalt and operator experience.

Environmental samples were taken at intervals of 5 feet for all soils encountered in the sonic borings. All samples were placed in glass jars and immediately labeled and placed into a cooler to prevent sample degradation and transported back to the laboratory for storage. Environmental samples were picked up by a Maul Foster and Alongi representative and a chain of custody was created.

Each boring was logged by a representative from our office who collected samples and returned them to our laboratory for more thorough logging of the samples and laboratory testing. Formal boring logs are provided in Appendix A, as Figures A-1 through A-4, and describe conditions encountered and the results of the D&M penetration testing.

4.0 GEOLOGY

A reprint of a portion of the 2009 Geologic Map of the Oregon City Quadrangle is provided in Figure 3. It is generally understood that the falls were created by faulting along the Bolton Fault. Over time, the falls regressed upriver. The site basalt has been scoured and is relatively fresh (unweathered) and mapped as the Grand Ronde Basalt, Sentinel Bluffs member of the Columbia River Basalt Group. Site explorations indicated that in general the basalt is somewhat harder above roughly elevation 30, and on the soft side of the spectrum below elevation 30, which also can be interpreted to augment the creation and regression of the falls over geologic time. Summarizing, a period of faulting forms a vertical offset and subsequently the softer underlying rock erodes more rapidly eventually undermining the harder rock layer which then topples resulting in a waterfall that slowly works its way up river. Within the project area, one can expect that changes in elevation of the upper hard basalt will be near vertical and the underlying soft basalt more gradual were the hard basalt has been removed. As an example Boring S-4 encountered a large block (toppled block/boulder or undermined hanging block) of hard basalt in the vicinity of the auto shop where several instances of abrupt changes in the bedrock elevation occur. It is important to note that some of these abrupt changes may also be man-made.

Two sequences of alluvium are interpreted to be present above the bedrock surface:

1. Recent Willamette River Alluvium which is interpreted to have two facies. An upper facies of thinly stratified silty sands deposited in back eddies where high water velocities are absent; these deposits are interpreted to have been deposited following the dam construction since prior to dam construction this area would have been subject to high water velocities prohibiting sand deposition. The underlying facie is primarily subangular to subrounded gravels with some coarse sand matrix, and may also be intermingled with historic spoils from rock excavations in some areas during the dam construction process.

2. An older, over-consolidated sequence of alluvium was encountered as a thin mantle and/or infill above underlying bedrock depressions. This alluvium is moderately weathered gravel with a stiff clay to clayey silt matrix.

A variety of fills overlay the bedrock and alluvium (where present). Fill is anticipated to directly overlay bedrock (alluvium is absent) in areas of bedrock highs, and where the slope of the bedrock steepens adjacent to the river's primary high velocity flow channel such as the northwestern corner of the yard area. Fill interpretation is discussed further in the following section.

5.0 SUBSURFACE CONDITIONS

5.1 Site Fills

The different sequences of site fills encountered can be generally described as sandy gravel with variable silt and clay content. The relative density, age/location, and quantity of construction debris helped differentiate them across the site. The most recent fill in the yard area consisted of a mass fill interpreted to have been constructed simply from dumping at the outward edge of the fill, and working the fill outward towards the river from the yard elevation. This "top-down" fill construction method results in the lowest possible density and can be characterized as a uniformly loose fill. This was evidenced by the consistent lack of a complete core return in the sonic borings as material densified due to the vibration and/or was pushed outward as the core bit progressed. In general, the length of sonic core recovery compared to the core run length provides an indirect indication of the granular fill relative density. Based on the historical photos provided in Figure 4, and the consistency of the mass fill, it appears to have been constructed in in a single phase in the 1960's or early 1970's.

Beneath the loose mass fill, two sequences of older fill were encountered, most notably in boring S-3. While debris in the loose mass fill were somewhat widely scattered and generally limited to concrete and asphaltic concrete fragments, an older sequence of fill was encountered that contained numerous small debris consisting of brick, mortar, and wood fragments and had some more compact zones within it. Sitting atop or embedded into this older fill a remnant mortared basalt boulder structure or foundation was encountered, and while it may have been spoiled there, it appeared intact and rather large at 3.5 to 4 feet thick. The construction materials appeared to be similar to the Grotto Arch.

Roughly 10 feet below the remnant a very old sequence of fill was interpreted to be present primarily based on a concentration of steel fragments such as square nails not encountered elsewhere. The steel fragments are interpreted to have collected in a depression within a prior flow line/channel, but above the oldest fill. This oldest sequence of fill was encountered below this flow line and based on material and lack of any debris it is interpreted to have been placed early in either the dam construction or other initial site development processes. For example the material resembles local basalt aggregate pit material following its excavation/break-out and prior to the crushing process. This fill was also relatively compact based on high core return and core inspection, and roughly consisted almost entirely of course angular gravel sized particles (2 to 4-inch).

Around the northern and western perimeter of the yard several lifts or sequences of older loose to medium dense fills were encountered in the vicinity of structures. At the northern sonic boring S-2 a sequence of fill encountered near an elevation of 34 feet was relatively compact resulting in a few feet of perched groundwater above it. Five interpretive cross-sections were developed to better illustrate our interpretation of site fill and bedrock conditions, and are provided as Figures 5 through 9. The locations of the sections are shown on the Exploration Plan in Figure 2. While the cross-sections depict relatively smooth bedrock elevation transitions, we would anticipate that many of the elevation transitions between elevation 30 and 45 to be more abrupt (vertical) and have a similar topography as the undeveloped portions of the existing falls.

It should be noted that all site fills may contain boulders (particles greater than 12 inches in diameter) and boulder sized concrete debris.

5.2 Soils and Bedrock

The alluvial deposits encountered were generally discussed previously in Section 3.0 Geology. The alluvial sands graded with depth to gravelly sand and sandy gravel below, some of which may be intermingled with older site fills. The more recent alluvium was encountered only in Boring S-1 and at a relatively high elevation compared to ordinary river levels. The alluvium is interpreted to be loose and anticipated to be somewhat limited in its lateral extent due to the specific lower velocity environment required for deposition and the limits/margins of elevated prior site fills.

The older, overconsolidated alluvium that was encountered directly above the bedrock is anticipated to be limited to discrete pockets in basalt depressions.

The basalt bedrock hardness was typically classified as soft to medium hard (R2-R3) where exposed below elevations 28 to 32 feet roughly. Moving inland, the basalt becomes medium hard to hard (R3-R4) in the vicinity of Boring S-4 where an unconfined compression test fell within the midrange of R3 (medium hard) near elevation 32. Elsewhere, farther inland near the Grotto, basalt hardness indicates R4 (hard) conditions. The majority of the basalt primary joint spacing is anticipated to fall into the moderately close range of 1 to 3 feet. The aggressive nature of the sonic drilling method highly disturbs or breaks the rock and as a result the Rock Quality Index (RQD) was not utilized as a descriptor.

5.3 Groundwater

Ground water measurements were taken in the air track boring locations and results are provided in Table 1, along with approximate depth and elevation of the basalt bedrock. Groundwater elevations vary widely and appear to be influenced by the depth to bedrock. When measuring the depth to water in the air-track boring holes, if the hole had collapsed to the point where only a few inches of water was present prior to encountering soil, the data was omitted from Table 1.

6.0 <u>LABORATORY TESTING</u>

Representative soil samples obtained during our subsurface exploration program were tested in the laboratory to assist with soil classification and engineering properties.

The laboratory testing program consisted of the following:

- Moisture Contents
- Gradation (Dry Sieve)
- Fines content (Washed over No. 200 Sieve)
- Unconfined Rock Compressive Strength

Moisture content tests are applicable or informative for fine grained samples/deposits, of which there were very few. Moisture content test results are provided on the formal boring logs in Appendix A.

Samples for dry sieve gradation testing were selected from core samples/runs that were relatively consistent in materials and representative of the fill sequences proposed for removal. Prior to performing the sieve analysis, large particles (cobbles) that had been cored through were separated; the weight of the separated particles was determined and accounted for, and is only noted herein to remind the user that the particle size content above 4 inches is not represented on the gradation plot, and scattered to numerous cobbles should be anticipated site wide. While the number of removed particles does provide some relative indication of cobble frequency, the loose condition of much of the upper mass fill may have resulted in some larger particles being simply pushed aside. The numbers of particles removed were as follows:

- S-1, 0-15 feet depth core run with low recovery, 10 basalt cobbles removed
- S-1, 20-26 feet depth, 2 basalt cobbles removed
- S-1, 20-26 feet depth, 1 basalt cobble removed
- S-3, 5-13 feet depth, 6 basalt cobbles removed
- S-3, 20-27.5 feet depth, 3 basalt cobbles removed

The results of the five dry gradation tests are provided in Appendix B.

Two samples were selected to determine the fines content (percent silt/clay passing the No. 200 sieve) based on a washed or wet method for comparison to the dry sieve method. One of the samples was selected from the typical loose gravel fill (S-1, 0-15 feet depth), and the other selected sample represented the Willamette River sand alluvium sample. Results are noted at the representative depths on the S-1 bore log in Appendix A. The results indicate that the fines content for the dry sieve gradation tests on the loose gravels is roughly 6% lower (3.4% vs. 9.8%) than that indicated by washing the sample.

The result of the unconfined compressive strength of the basalt was only possible from the S-4 boring as no solid cores long enough to be tested where recovered elsewhere. The test result indicated an unconfined compressive strength of 6,720 psi.

Appendix C presents photographs of the recovered sonic cores prior to removing samples for laboratory testing.

7.0 BOREHOLE CLEARANCE SURVEY

Prior to performing borings, NGI subcontracted GeoPotential, Inc. to clear each hole location for utilities using a variety of methods, most notably a Ground Penetrating Radar (GPR) unit. A report providing the results of the mobile GPR survey is included as Appendix D.

8.0 LIMITATIONS

Within the limitations of scope, schedule, and budget, our services have been completed in accordance with the Client Services Agreement and accepted geotechnical practices in this area at the time this report was prepared. This report was prepared for the exclusive use of NGI's client for the specific project and NGI does not authorize the segmented use of the data herein. The formal boring logs and related information depict generalized subsurface conditions at these specific locations only and at the particular time the subsurface exploration was completed. Soil and groundwater conditions at other locations may differ from the conditions at locations of explorations. Also, the passage of time may result in a change in the soil and groundwater conditions at the site. This report pertains to the subject project area only, and is not applicable to adjacent areas.

This opportunity to be of service is sincerely appreciated. If you should have any questions, please contact our office.

Respectfully submitted,

NORTHWEST GEOTECH, INC.

REGISTERED PROFESSIONAL ENGINEER
15,951
OREGON
JULY 21 1992
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Exp. 12-31-2017

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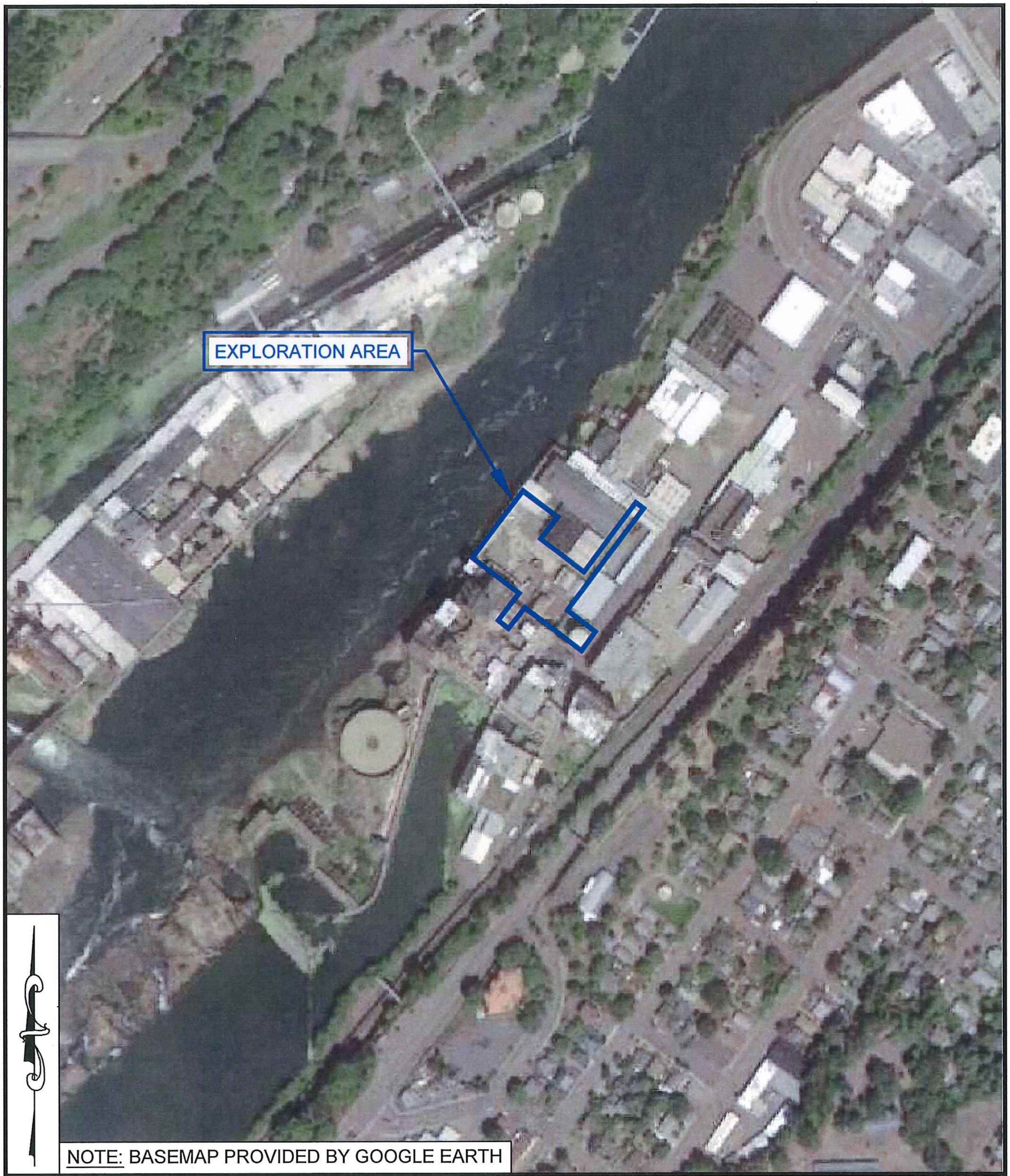
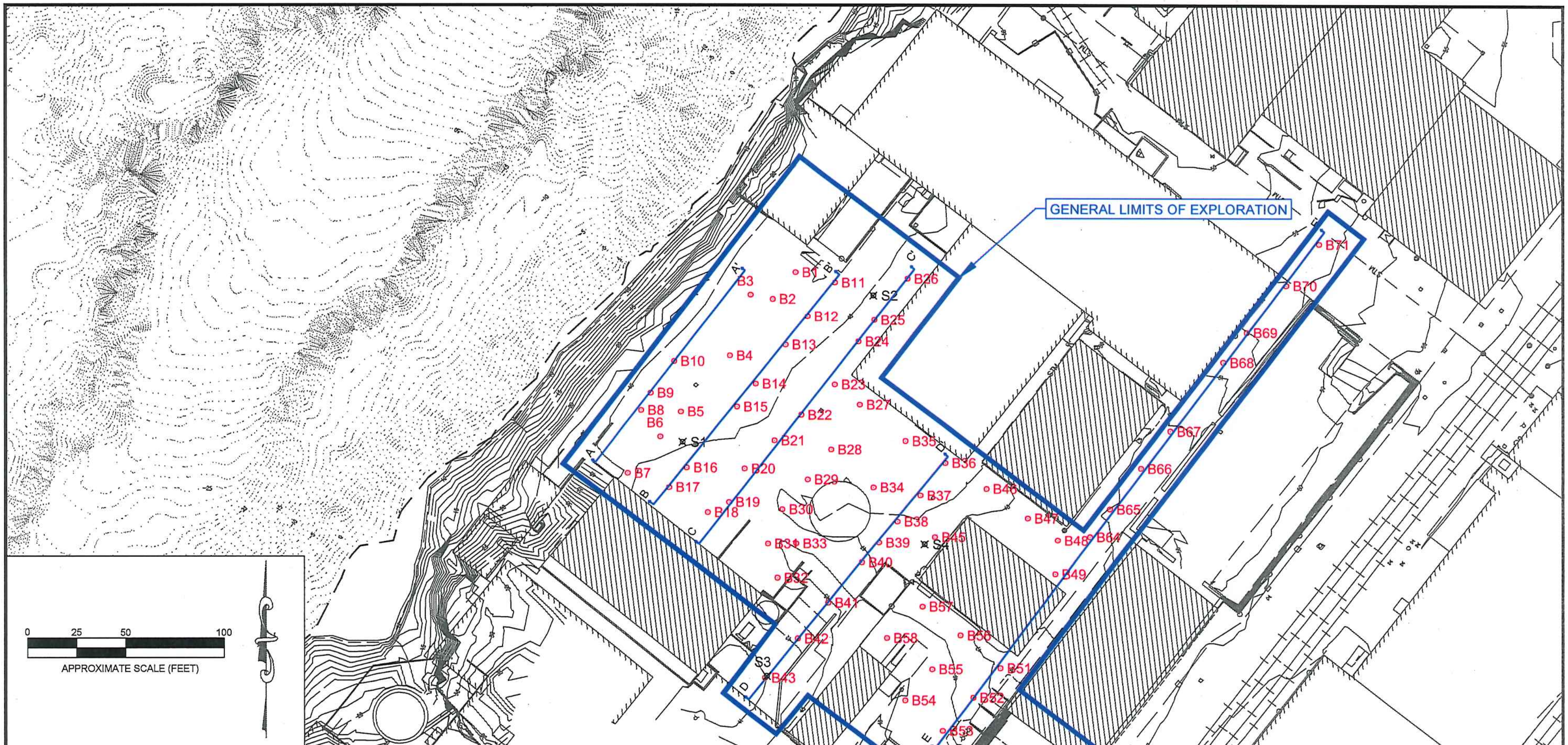


EXPLORATION AREA MAP

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. 1

Northwest Geotech, Inc.

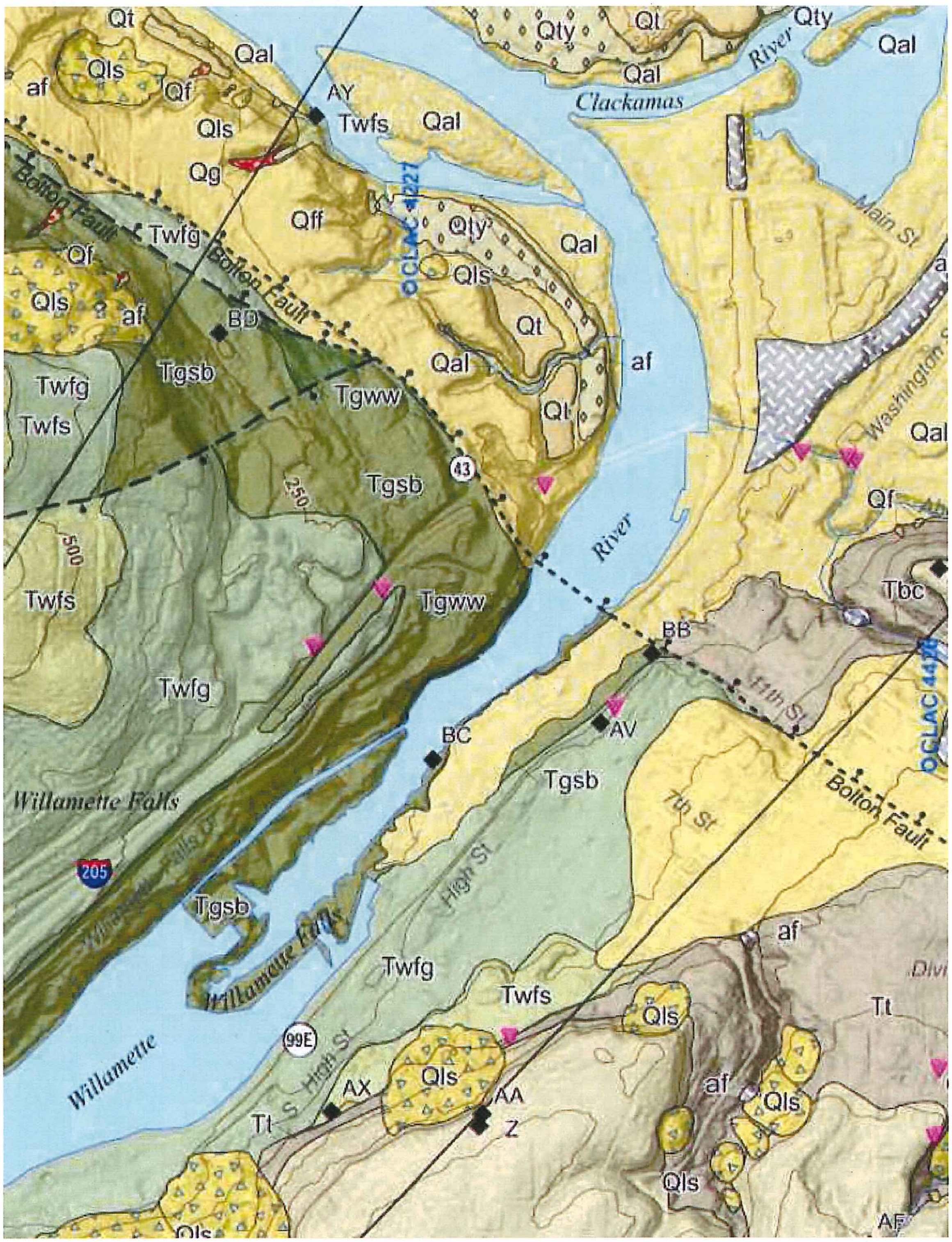


LEGEND:

- B72 AIR TRACK BORING LOCATION
- S4 S4, SONIC BORING LOCATION
- A A' CROSS-SECTION

NOTE: BASEMAP PROVIDED BY AKS ENGINEERING & FORESTRY

PROJECT NO. 2919.1.1	EXPLORATION PLAN	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 2

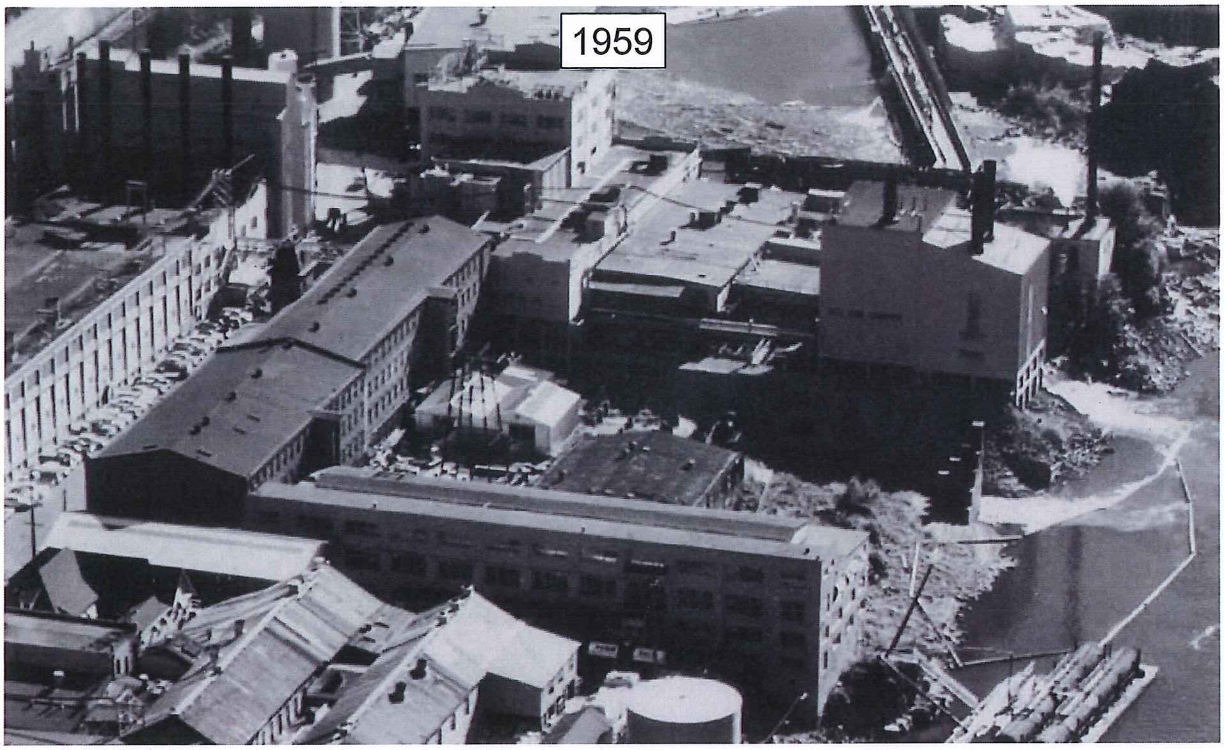


PORTION OF GMS 119-GEOLOGIC MAP OF THE OREGON CITY 7.5' QUADRANGLE, MADIN, 2009

GEOLOGIC MAP

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. 3

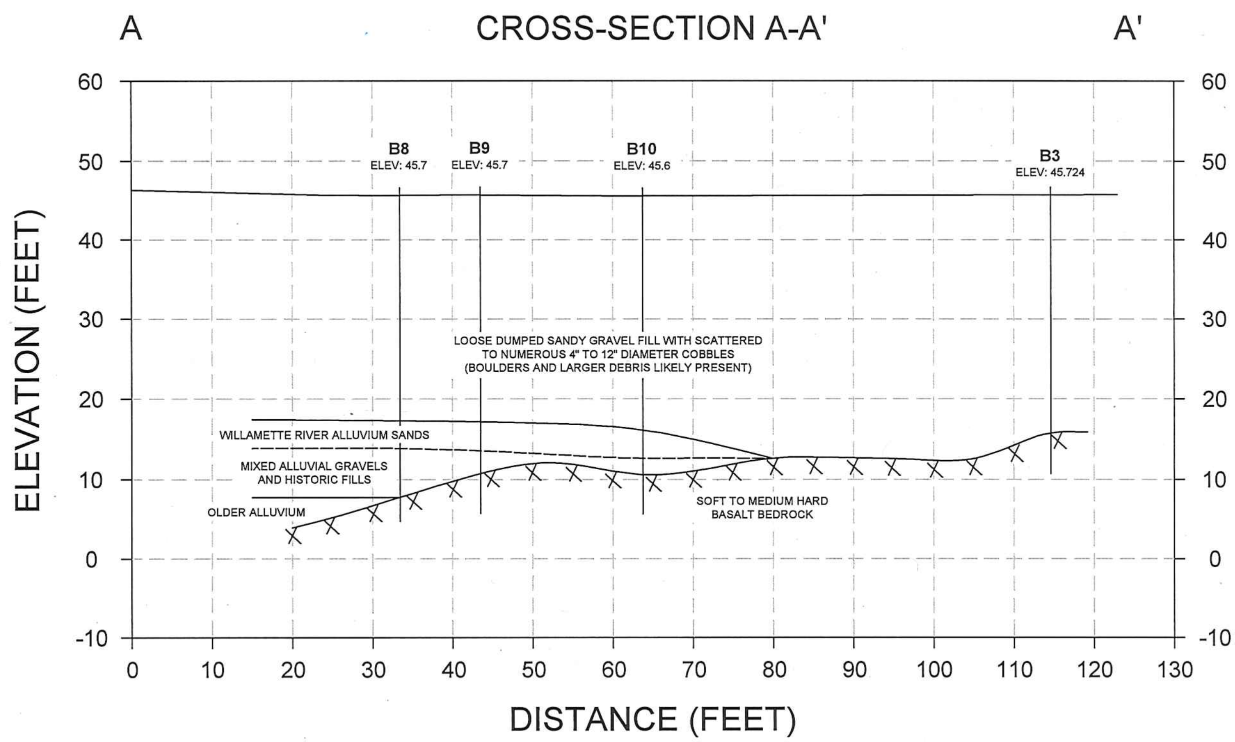
Northwest Geotech, Inc.

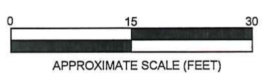


HISTORICAL AERIALS

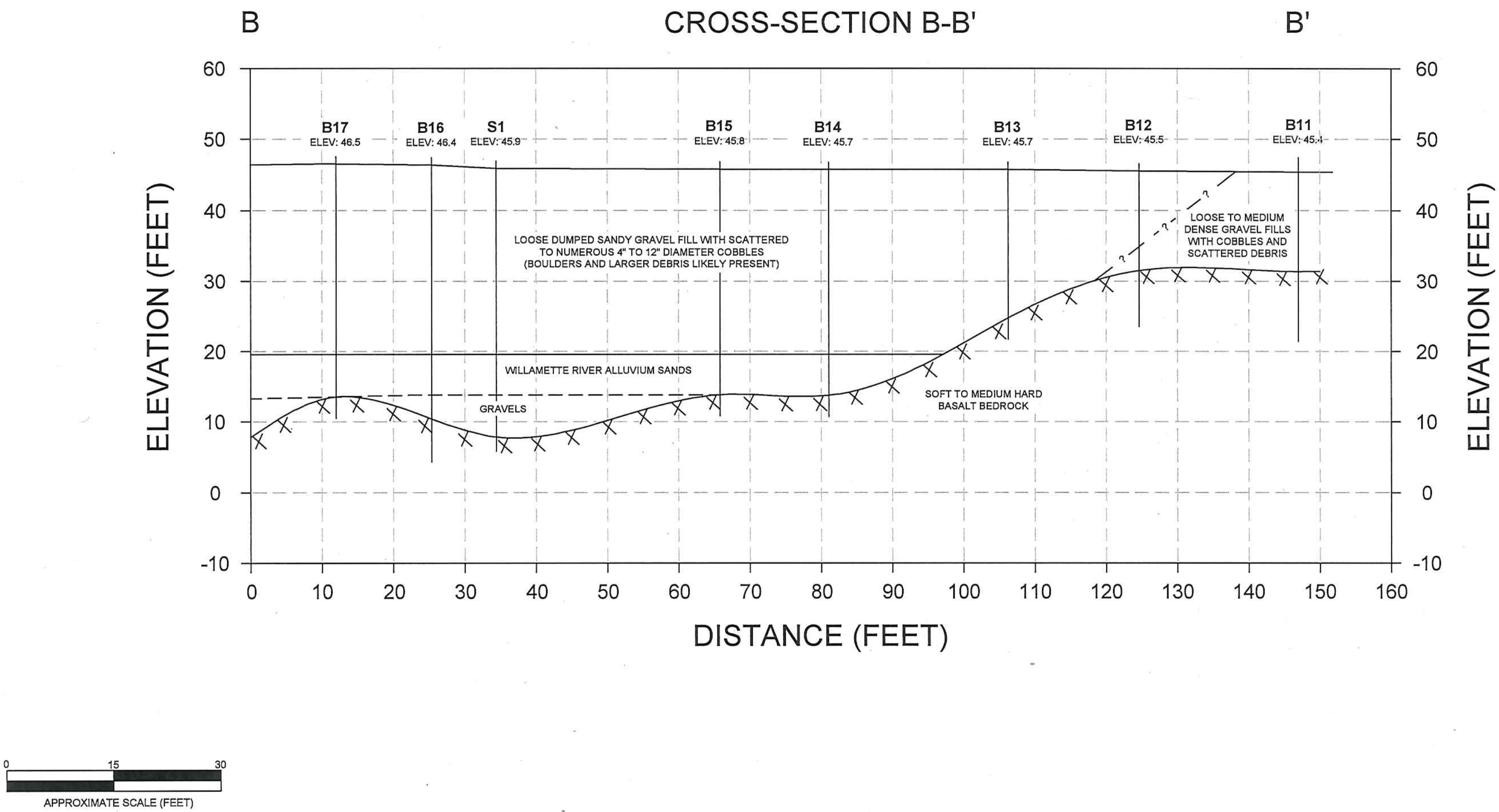
PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. 4

Northwest Geotech, Inc.

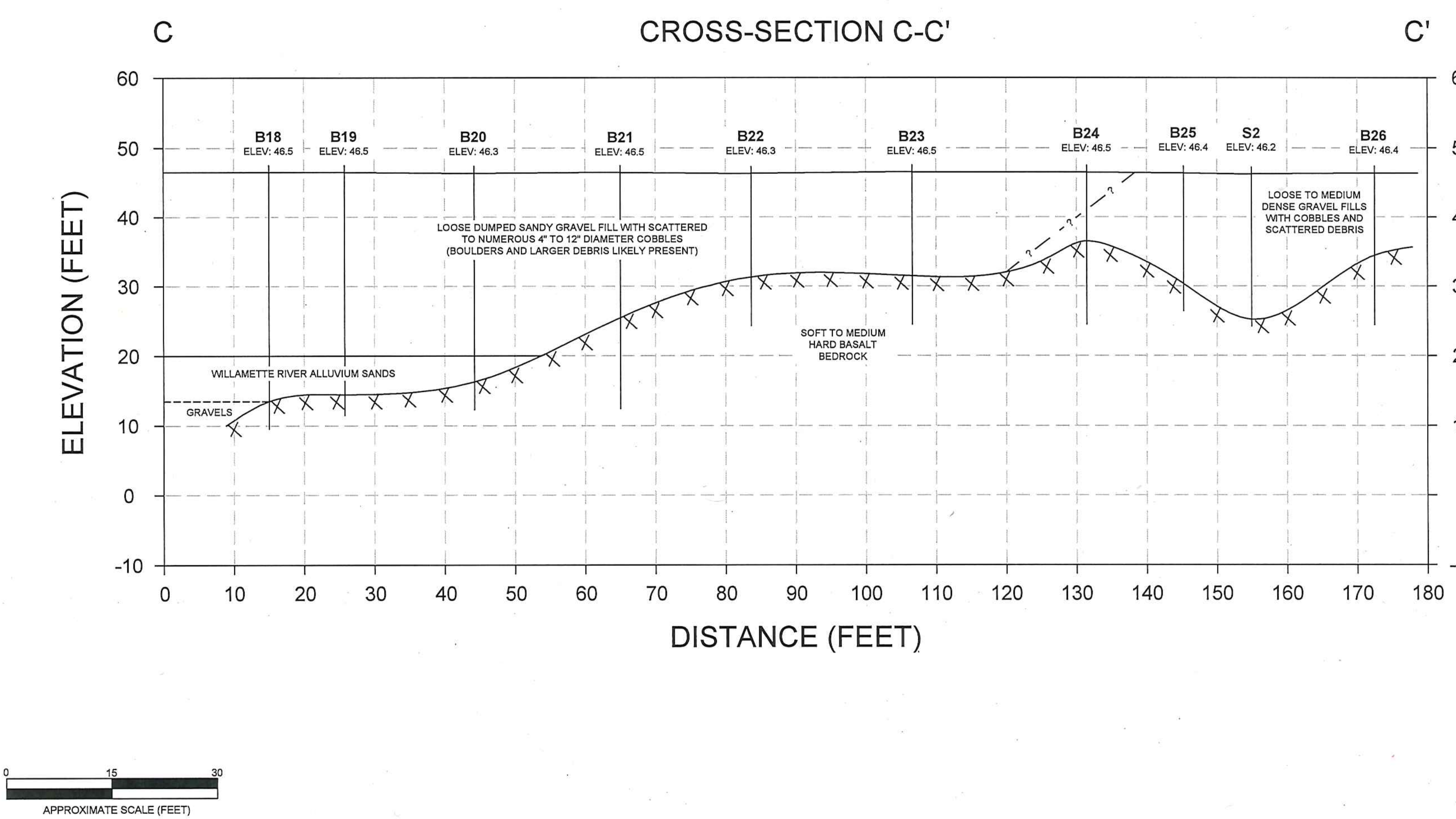




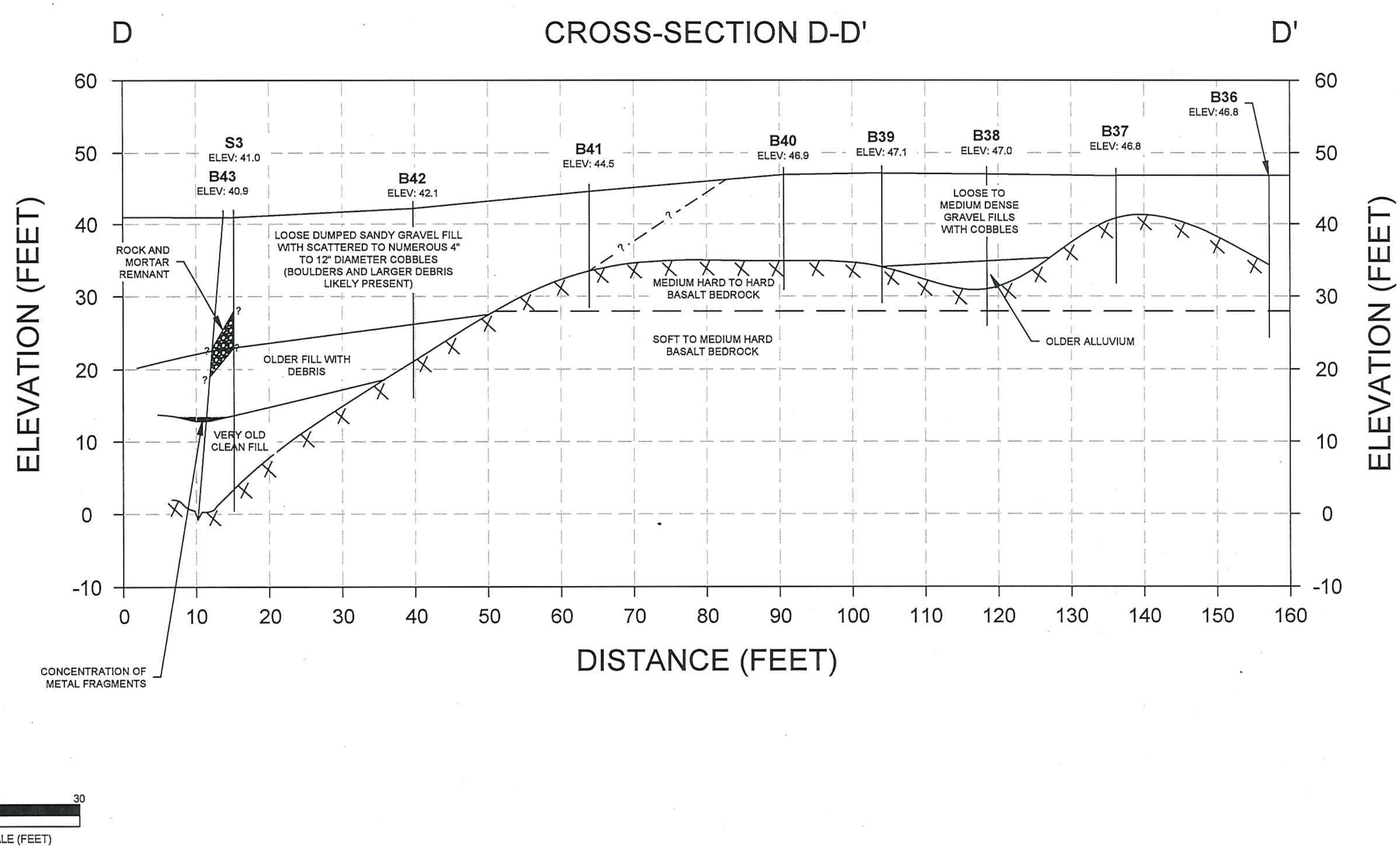
PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION A-A'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 5



PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION B-B'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 6

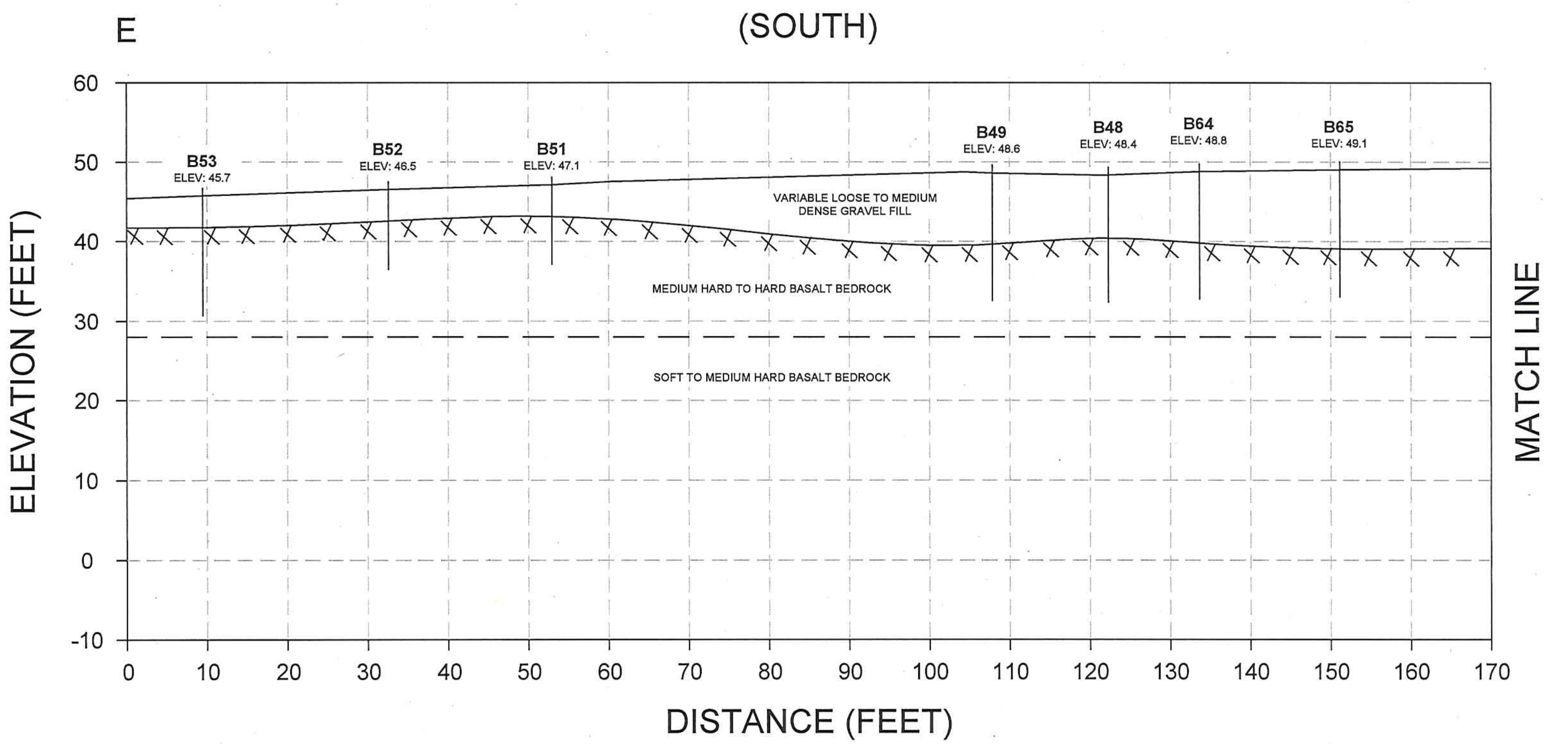


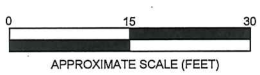
PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION C-C'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 7



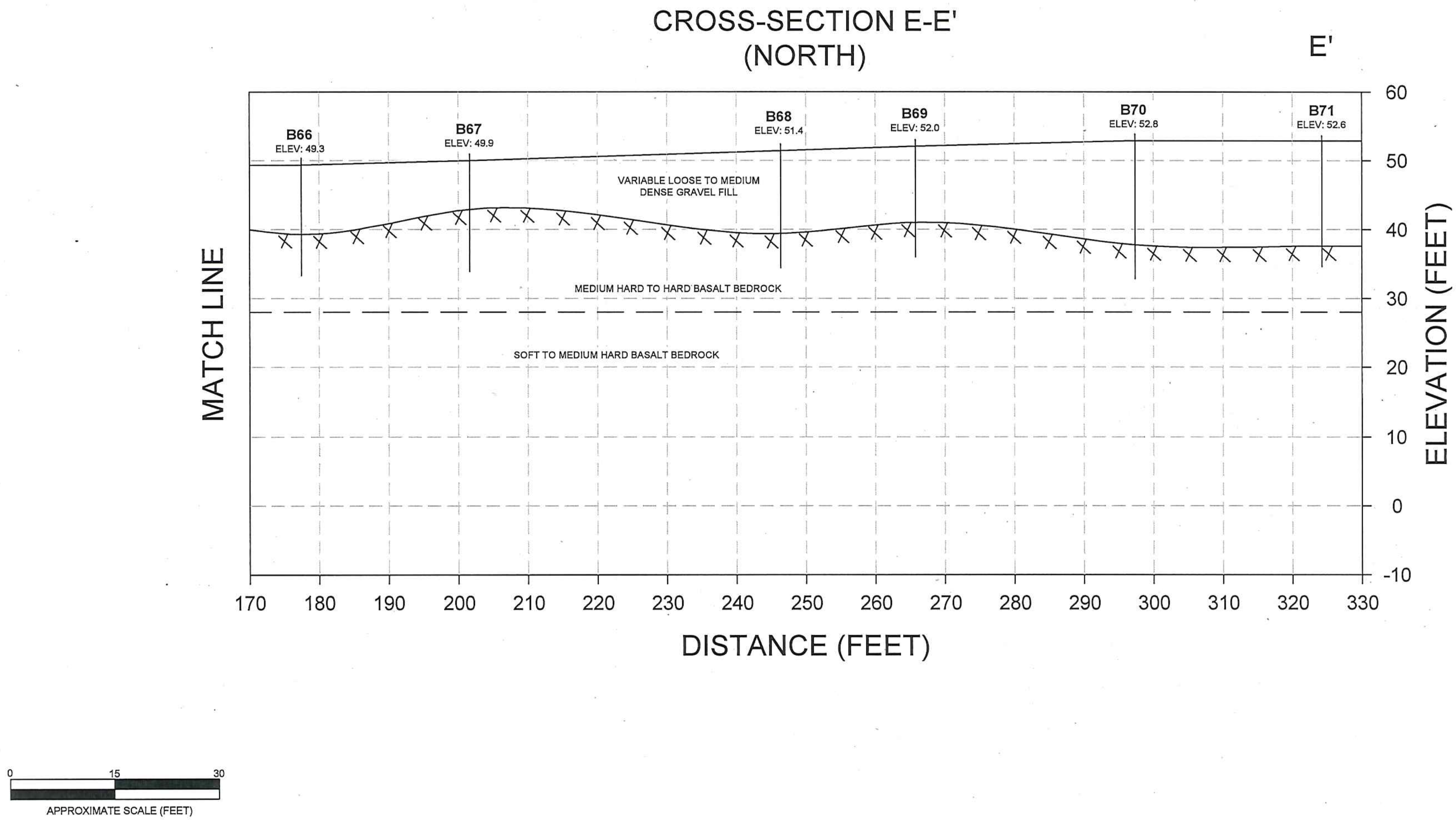
PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION D-D'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 8

CROSS-SECTION E-E'
(SOUTH)





PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION E-E'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 9 (1 OF 2)



PROJECT NO. 2919.1.1	INTERPRETIVE CROSS-SECTION E-E'	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	Northwest Geotech, Inc.	FIGURE NO. 9 (2 OF 2)

TABLE 1
SUMMARY OF BORING LOCATIONS AND ELEVATIONS

Survey Point No.	Boring	Elevation (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock (feet)	Rock Hardness Description, Depth Penetrated (feet)	Groundwater Elevation (feet)
Air Track Borings						
50075	B1	45.33	30	15.3	Soft 30-35	X
50074	B2	45.39	16	29.4	Medium Hard 16-22	X
50073	B3	45.72	30	15.7	Medium Hard 30-35	X
50071	B4	45.62	22	23.6	Soft 22-30	X
50091	B5	45.43	30	15.4	Soft to Medium Hard 30-36	X
50090	B6	45.69	30	15.7	Soft to Medium Hard 30-36	X
50089	B7	45.93	33	12.9	Medium Hard 33-35	X
50086	B8	45.68	38	7.7	Medium Hard 38-41	26.6
50085	B9	45.73	35	10.7	Medium Hard 35-40,	26.5
50084	B10	45.61	35	10.6	Medium Hard 35-40, boulders 32-35	26.3
50077	B11	45.35	14	31.4	Soft 14-24	31.5
50078	B12	45.54	14	31.5	Medium Hard 14-22, boulder 6-9	32.4
50040	B13	45.72	21	24.7	Soft 21-24, boulder 6-9	33.6
50070	B14	45.73	32	13.7	Medium Hard	X
50092	B15	45.77	32	13.8	Medium Hard, boulder 24-27	26.4
50093	B16	46.36	36	10.4	Medium Hard 32, boulder 22	X
50094	B17	46.53	33	13.5	Soft to Medium Hard 33-36, Hard at 36	X
50096	B18	46.50	33	13.5	Soft to Medium Hard 33-37, Some cobbles	X
50097	B19	46.48	32	14.5	Medium Hard 32-35	X
50098	B20	46.34	30	16.3	Medium Hard 30-34	X
50105	B21	46.46	21	25.5	Soft to Medium Hard 21-34	26.7
50069	B22	46.28	15	31.3	Soft 15-22	33.7
50039	B23	46.54	15	31.5	Soft 15-22	X
50079	B24	46.48	10	36.5	Soft to Medium Hard 10-22	37.7
50080	B25	46.38	16	30.4	Soft to Medium Hard 16-20	X
50083	B26	46.35	12	34.4	Soft 12-22, boulder 9-11	37.9
50038	B27	46.63	16	30.6	Medium Hard 16-28	34.9
50068	B28	46.54	13	33.5	Medium Hard 13-22	37.3
50104	B29	46.74	16	30.7	Medium Hard 16-22	34.5
50100	B30	47.02	15	32.0	Medium Hard 15-20	X
50101	B31	46.23	22	24.2	Medium Hard 22-25, boulder 3-5	X
50102	B32	46.41	15	31.4	Medium Hard 15-20	31.9
50103	B33	46.21	10	36.2	Medium Hard 10-18	X
50067	B34	46.71	6	40.7	Medium Hard 6-15	X
50037	B35	46.66	6	40.7	Medium Hard 6-16	X
50036	B36	46.84	6	40.8	Medium Hard 6-16	X
50042	B37	46.77	6	40.8	Medium Hard 6-15	X
50043	B38	47.03	16	31.0	Medium Hard 16-21	38.6
50046	B39	47.14	13	34.1	Medium Hard 13-18	40.1
50047	B40	46.91	12	34.9	Medium Hard to Hard 12-16	38.4
50048	B41	44.54	11	33.5	Medium Hard to Hard 11-16	X
50049	B42	42.14	21	21.1	Soft to Medium Hard 21-26	X

TABLE 1
SUMMARY OF BORING LOCATIONS AND ELEVATIONS

Survey Point No.	Boring	Elevation (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock (feet)	Rock Hardness Description, Depth Penetrated (feet)	Groundwater Elevation (feet)
50050	B43	40.93	40+	Drill bit stuck in log near Elev. 1	Stuck in Log at 40; mortered basalt remnant 18-22	X
50045	B45	47.32	15	32.3	Medium Hard 15-20	X
50035	B46	47.29	6	41.3	Soft 6-16	X
50034	B47	48.34	18	30.3	Soft 18-21	X
50033	B48	48.36	8	40.4	Soft 8-16	X
50031	B49	48.64	9	39.6	Soft 9-16	X
50060	B51	47.10	4	43.1	Hard 4-10	X
50061	B52	46.53	4	42.5	Hard 4-10	X
50062	B53	45.74	4	41.7	Hard 4-10, Soft 10-15	X
50065	B54	45.13	11	34.1	Soft 11-18	34.7
50066	B55	45.58	8	37.6	Soft 8-16	X
50056	B56	46.39	5	41.4	Hard 5-8, Soft 8-10	43.7
50054	B57	46.34	3	43.3	Hard 3-8, Soft 8-10	X
50053	B58	45.69	12	33.7	Medium Hard 12-18	36.2
50019	B63	47.82	5	42.8	Medium Hard 5-10	43.4
50030	B64	48.81	9	39.8	Soft 9-16	X
50029	B65	49.06	10	39.1	Medium Hard 10-16	X
50028	B66	49.34	10	39.3	Medium Hard 10-16	X
50027	B67	49.95	7	42.9	Medium Hard 7-16	45.1
50026	B68	51.39	12	39.4	Medium Hard 12-17	X
50025	B69	51.99	11	41.0	Medium Hard 11-16	X
50024	B70	52.85	15	37.8	Hard 15-20	44.6
50022	B71	52.62	15	37.6	Medium Hard 15-18	43.7
50017	B72	56.89	11	45.9	Medium Hard 11-12, Soft 12-16	X
50016	B73	56.97	10	47.0	Soft 10-15, Hard 15-20	X
Sonic Borings						
50106	S1	45.8758	38	7.9	N/A	N/A
50081	S2	46.2353	21	25.2	N/A	N/A
50051	S3	40.9535	37	4.0	N/A	N/A
50044	S4	47.2534	13	34.3	N/A	N/A

APPENDIX A

DRILLING COMPANY: CASCADE DRILLING	RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER	DATE: 4/4/2017

BORING DIAMETER: 8 IN.	HAMMER WEIGHT: 140 LBS	TYPE: SONIC BORING	ELEVATION: 45.9 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-1
0						4 INCHES OF ASPHALTIC CONCRETE IN POOR CONDITION
	ES-1				GP GW	SANDY GRAVEL, TRACE SILT, TRACE CLAY, BROWN, LOOSE, MOIST, GRAVEL IS SUBANGULAR TO SUBROUNDED, FINE TO COARSE, POORLY GRADED TO WELL GRADED, SCATTERED ASPHALTIC CONCRETE AND BRICK DEBRIS, NUMEROUS COBBLES (FILL)
						INCREASING CLAY CONTENT IN MATRIX FROM 3-5 FEET
5				8.7		FINES CONTENT TEST: 9.8% PASSING NO. 200 SIEVE
					GP GW	SANDY GRAVEL, TRACE SILT, TRACE CLAY, BROWN, VERY LOOSE TO LOOSE, MOIST, GRAVEL IS ANGULAR TO SUBROUNDED, FINE TO COARSE AND POORLY GRADED TO WELL GRADED, SCATTERED TO NUMEROUS COBBLES (FILL)
10	ES-2					2-INCH MINUS, OPEN GRADED, LOOSE GRAVEL FROM 10-12 FEET
						LOW RETURN ON 5-15 FEET CORE RUN, VERY LOOSE
15						BIT PLUGGED BY COBBLE AT 15.0 FEET, NO RETURN 15-20 FEET
	*					
20				7.2	GP GW	SANDY GRAVEL, SLIGHTLY SILTY, SLIGHTLY CLAYEY, BROWN, LOOSE, WET, GRAVEL IS ANGULAR TO SUBROUNDED, FINE TO COARSE, SCATTERED COBBLES (FILL)
	ES-3					
25						SCATTERED BRICK AND CONCRETE DEBRIS FROM 25-26 FEET
	ES-4			28.0	SM	SILTY SAND WITH SANDY SILT LENSES, TRACE GRAVEL, TRACE CLAY, BROWN, LOOSE, WET, STRATIFIED, SAND PARTICLES ARE SUB ANGULAR TO SUBROUNDED AND FINE TO MEDIUM GRAINED (WILLAMETTE RIVER ALLUVIUM) INCREASING GRAVEL CONTENT FINES CONTENT TEST: 19.4% PASSING NO. 200 SIEVE
30						

BORING LOG S-1

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-1 (1 OF 2)

DRILLING COMPANY: CASCADE DRILLING	RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER	DATE: 4/4/2017	
BORING DIAMETER: 8 IN.	HAMMER WEIGHT: 140 LBS	TYPE: SONIC BORING	ELEVATION: 45.9 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-1
30	ES-5			27.3	SM	GRAVELLY SILTY SAND, TRACE CLAY WITH SANDY CLAY LENSES, BROWN AND GRAY, LOOSE, WET, FREQUENT ORGANICS SUCH AS WOOD FRAGMENTS (WILLAMETTE RIVER ALLUVIUM)
35					GM	SILTY SANDY GRAVEL, TRACE CLAY, BROWN, LOOSE TO MEDIUM DENSE, WET, GRAVEL IS SUBANGULAR TO ROUND, SCATTERED SUBANGULAR COBBLES (WILLAMETTE RIVER ALLUVIUM)
	ES-6				ML	GRAVELLY SANDY SILT, SLIGHTLY CLAYEY, GRAY MOTTLED, STIFF, WET, LOW TO MEDIUM PLASTICITY MATRIX, GRAVEL IS ROUND (OLDER OVERCONSOLIDATED ALLUVIUM)
40						BASALT BEDROCK, GRAY, SLIGHTLY WEATHERED, MEDIUM HARD (R3), CLOSELY JOINTED, TRACE VESICLES (COLUMBIA RIVER BASALT GROUP)
45						TOTAL DEPTH: 40 FEET GROUNDWATER NOT ENCOUNTERED
50						
55						
60						

CORE RUN LENGTH WITH RECOVERY LENGTH INDICATED BY HATCH

* NO SAMPLE RECOVERY

BORING LOG S-1

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-1 (2 OF 2)

Northwest Geotech, Inc.

DRILLING COMPANY: CASCADE DRILLING | RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER | DATE: 4/4/2017

BORING DIAMETER: 8 IN. | HAMMER WEIGHT: 140 LBS | TYPE: SONIC BORING | ELEVATION: 46.2 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-2
0						4 INCHES OF ASPHALTIC CONCRETE IN POOR CONDITION
	ES-1				GP GW	SANDY GRAVEL, SLIGHTLY SILTY, BROWN, MEDIUM DENSE, MOIST, SUBANGULAR GRAVEL, NUMEROUS COBBLES AND SCATTERED 1 TO 4 INCH CONCRETE DEBRIS, FEW WOOD PARTICLES, SOME WHITE CLAY SUBSTANCE IN MATRIX (FILL)
5	S-1	10			GP SM	SANDY GRAVEL TO GRAVELLY SILTY SAND, BROWN, LOOSE, MOIST, GRAVEL IS SUBROUNDED TO ROUND AND FINE TO MEDIUM GRAINED, SCATTERED COBBLES (FILL)
	ES-2					BECOMES WET
10	S-2	34/2"				
					GM	SILTY TO SANDY GRAVEL, TRACE CLAY, GRAY-BROWN, MEDIUM DENSE, WET, GRAVEL IS SUBANGULAR TO ROUND, SCATTERED COBBLES (FILL)
	ES-3				GP	SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, RED-BROWN, MEDIUM DENSE, WET BECOMING MOIST TO DAMP AT 14 FEET, GRAVEL IS SUBANGULAR TO ROUND AND FINE TO COARSE, NUMEROUS COBBLES (FILL)
15	ES-4					
	ES-5				GP	SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, DARK BROWN TO BROWN, MEDIUM DENSE, MOIST, GRAVEL IS SUBANGULAR TO ROUND AND FINE TO COARSE, SCATTERED COBBLES (FILL)
20						
	ES-6					BASALT BEDROCK, GRAY, SLIGHTLY WEATHERED, SOFT (R2), SOME VESICLES, JOINT SPACING MAY BE WIDE (COLUMBIA RIVER BASALT GROUP)
25						
30						

TOTAL DEPTH: 22 FEET
GROUNDWATER NOT ENCOUNTERED

DAMES & MOORE SAMPLER

SPT SAMPLER

CORE RUN LENGTH WITH RECOVERY LENGTH INDICATED BY HATCH

BORING LOG S-2

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-2

Northwest Geotech, Inc.

DRILLING COMPANY: CASCADE DRILLING	RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER	DATE: 4/4/2017

BORING DIAMETER: 8 IN.	HAMMER WEIGHT: 140 LBS	TYPE: SONIC BORING	ELEVATION: 40.9 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-3
0						5 INCHES OF ASPHALTIC CONCRETE IN POOR CONDITION UNDERLAIN BY 12 INCHES OF ALLUVIAL PIT AGGREGATE BASE
	ES-1			15.1	GP GW	SANDY GRAVEL, TRACE SILT, TRACE CLAY, BROWN, LOOSE, MOIST, GRAVEL IS ANGULAR TO ROUND, FINE TO COARSE, POORLY GRADED TO WELL GRADED, SCATTERED ASPHALTIC CONCRETE AND BRICK/TILE DEBRIS, SCATTERED TO NUMEROUS COBBLES (FILL)
5						
	ES-2					
10						
	ES-3					
						3.5 TO 4 FEET THICK REMNANT FOUNDATION AS WELL MORTARED BASALT BOULDERS, SIMILAR TO GROTTO ARCH
15						
	ES-4			18.8	GP GW	SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, BROWN, LOOSE TO MEDIUM DENSE, MOIST TO WET, GRAVEL IS SUBANGULAR TO SUBROUNDED AND FINE TO COARSE, NUMEROUS BRICK, MORTAR, AND WOOD FRAGMENTS, SCATTERED TO NUMEROUS COBBLES (FILL)
20						
	ES-5			21.0		
25						
						BECOMES BLACK, 12 INCH BOULDER
	ES-6					
						AN ABUNDANCE OF METAL FRAGMENTS ENCOUNTERED AT 29.5 FEET, SQUARE NAILS
30						

BORING LOG S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-3 (1 OF 2)

Northwest Geotech, Inc.

DRILLING COMPANY: CASCADE DRILLING	RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER	DATE: 4/4/2017	
BORING DIAMETER: 8 IN.	HAMMER WEIGHT: 140 LBS	TYPE: SONIC BORING	ELEVATION: 40.9 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-3
30	ES-7			17.0	GP GW	SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, BROWN, LOOSE TO MEDIUM DENSE, MOIST TO WET, GRAVEL IS SUBANGULAR TO SUBROUNDED AND FINE TO COARSE, NUMEROUS BRICK, MORTAR, AND WOOD FRAGMENTS, SCATTERED TO NUMEROUS COBBLES (FILL)
35					GP	SANDY GRAVEL, SLIGHTLY SILTY, TRACE TO SLIGHTLY CLAYEY, DARK BROWN-GRAY, LOOSE TO MEDIUM DENSE, POORLY GRADED, GRAVEL IS ANGULAR TO SUBANGULAR AND FINE TO COARSE, SCATTERED COBBLES (OLDER CLEAN FILL)
	ES-8					BASALT BEDROCK, GRAY, FRESH, MEDIUM HARD (R3), CLOSELY JOINTED, TRACE VESICLES (COLUMBIA RIVER BASALT GROUP)
40						TOTAL DEPTH: 40 FEET GROUNDWATER NOT ENCOUNTERED CORE RUN LENGTH WITH RECOVERY LENGTH INDICATED BY HATCH
45						
50						
55						
60						

BORING LOG S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-3 (2 OF 2)

Northwest Geotech, Inc.

DRILLING COMPANY: CASCADE DRILLING	RIG: TERRA SONIC TSI 150CC COMPACT CRAWLER	DATE: 4/4/2017

BORING DIAMETER: 8 IN.	HAMMER WEIGHT: 140 LBS	TYPE: SONIC BORING	ELEVATION: 47.3 FEET

DEPTH (FEET)	SAMPLE	DRIVE SAMPLE BLOWS/FOOT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	SOIL CLASS (U.S.C.S.)	SOIL DESCRIPTION BORING NO. S-4
0	ES-1				GP	5 INCHES OF ASPHALTIC CONCRETE IN POOR CONDITION SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, BROWN, MEDIUM DENSE, MOIST, SUBANGULAR GRAVEL WITH SCATTERED 1 TO 4 INCH CONCRETE DEBRIS (FILL)
5					SP-SM	SILTY SAND, BLACK, LOOSE, MOIST, WITH NUMEROUS PIECES OF GLASS AND WOOD AND A PIECE OF METAL WITH A STRONG OIL ODOR (FILL)
	ES-2				GP	SANDY GRAVEL, SLIGHTLY SILTY, TRACE CLAY, GRAY-BROWN, LOOSE, MOIST, UNDERLAIN BY BASALT BOULDER FROM 7 TO 10 FEET (FILL)
10	S-1	45		18.9	GP	SANDY GRAVEL, SLIGHTLY SILTY, SLIGHTLY CLAYEY, BROWN, MEDIUM DENSE, MEDIUM PLASTICITY MATRIX, MOIST, GRAVEL IS SUBANGULAR TO SUBROUNDED AND FINE TO COARSE, SCATTERED COBBLES (OLDER ALLUVIUM)
15	ES-3 ES-4					BASALT BEDROCK, GRAY, SLIGHTLY WEATHERED, MEDIUM HARD (R3), CLOSE TO MODERATELY CLOSE JOINTING, SOME VESICLES (COLUMBIA RIVER BASALT GROUP) UNCONFINED COMPRESSIVE STRENGTH TEST = 6720 PSI
20						TOTAL DEPTH: 20 FEET GROUNDWATER NOT ENCOUNTERED
25						
30						

SPT SAMPLER

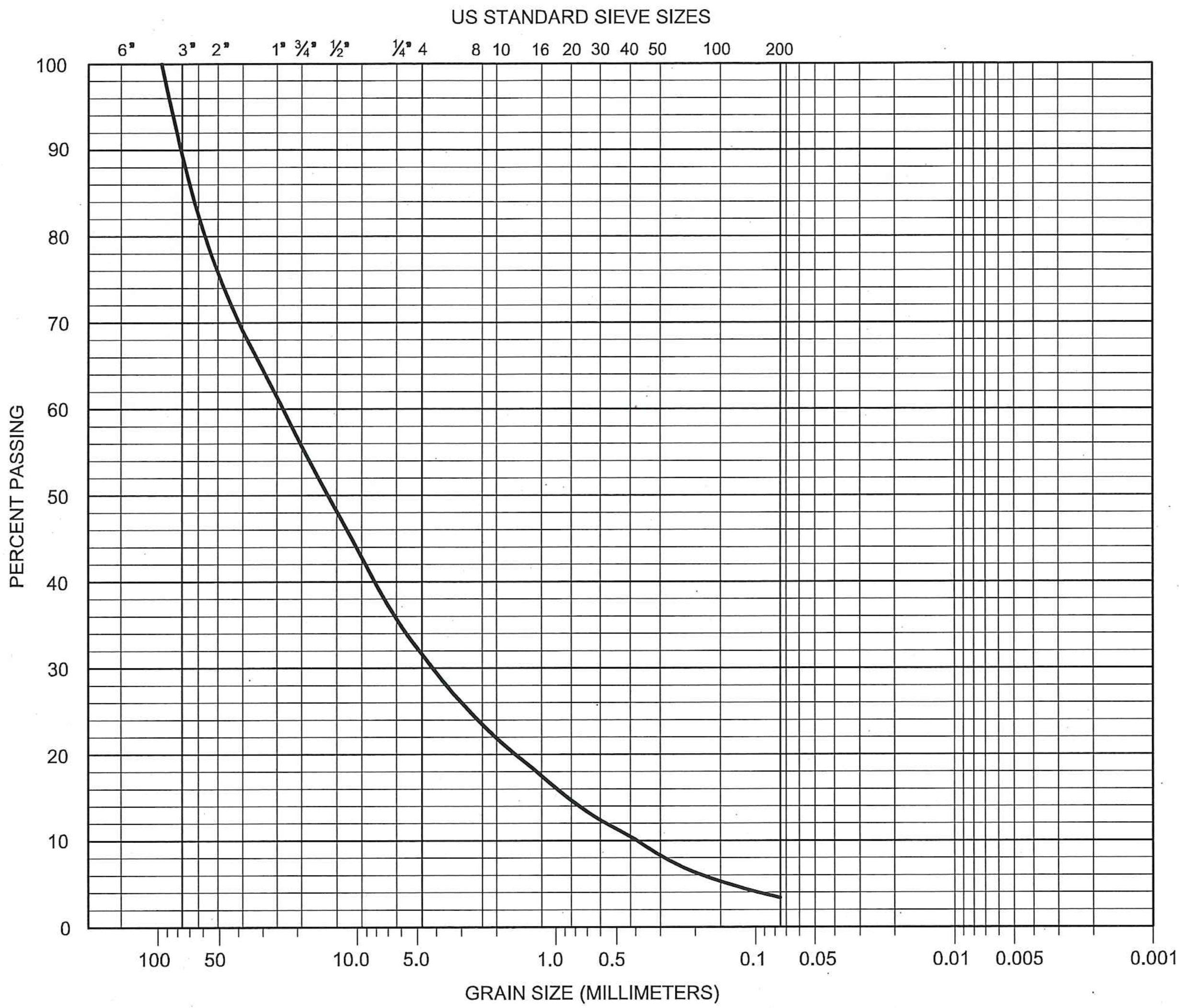
CORE RUN LENGTH WITH RECOVERY LENGTH INDICATED BY HATCH

BORING LOG S-4

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. A-4

Northwest Geotech, Inc.

APPENDIX B



COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

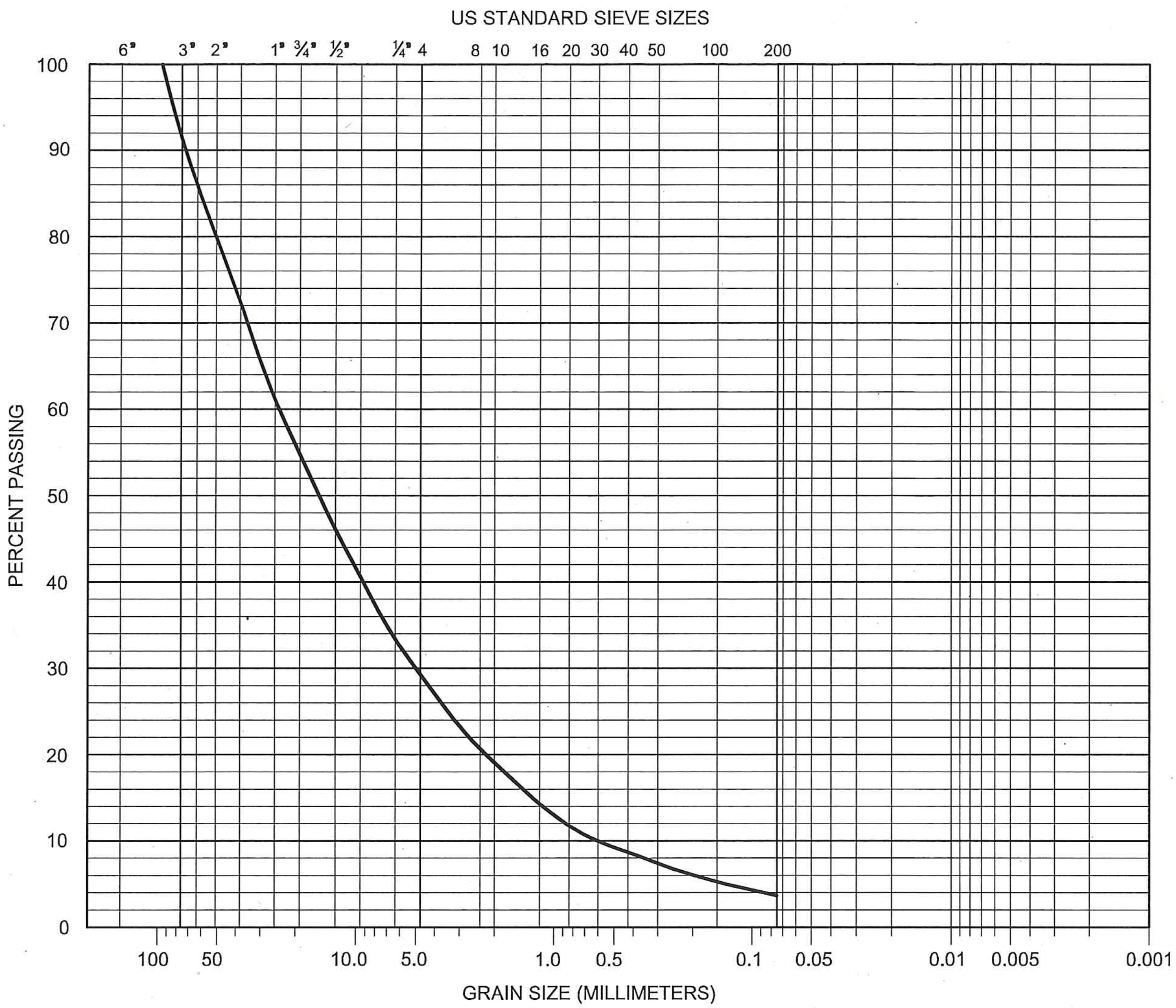
SYMBOL	SAMPLE LOCATION AND DEPTH	FIELD MOISTURE (%)	% PASSING NO. 200 SIEVE	% PASSING 2 μ	UNIFIED SOIL CLASSIFICATION
———	S-1 @ 0 - 15 FT.	8.7	3.4	--	GW

<u>NOTE:</u> CORE DIAMETER ~ 3.7 INCHES: SAMPLE LIMITED TO PARTICLES LESS THAN 3.5 INCHES

GRADATION TEST RESULTS - ASTM C136

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. B-1

Northwest Geotech, Inc.



COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

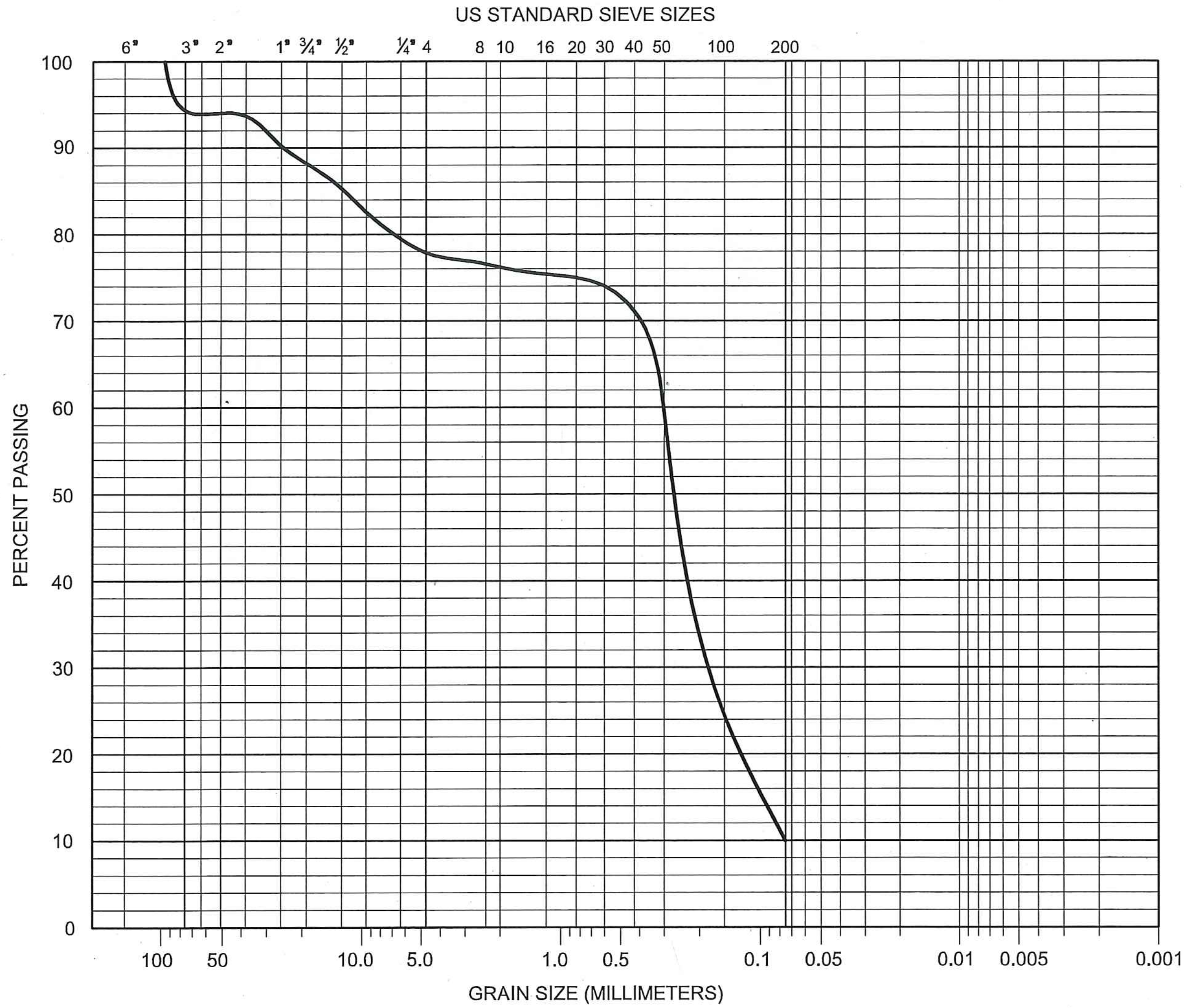
SYMBOL	SAMPLE LOCATION AND DEPTH	FIELD MOISTURE (%)	% PASSING NO. 200 SIEVE	% PASSING 2 μ	UNIFIED SOIL CLASSIFICATION
———	S-1 @ 20 - 26 FT.	7.2	3.7	--	GW

NOTE: CORE DIAMETER ~ 3.7 INCHES: SAMPLE LIMITED TO PARTICLES LESS THAN 3.5 INCHES

GRADATION TEST RESULTS - ASTM C136

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. B-2

Northwest Geotech, Inc.



COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

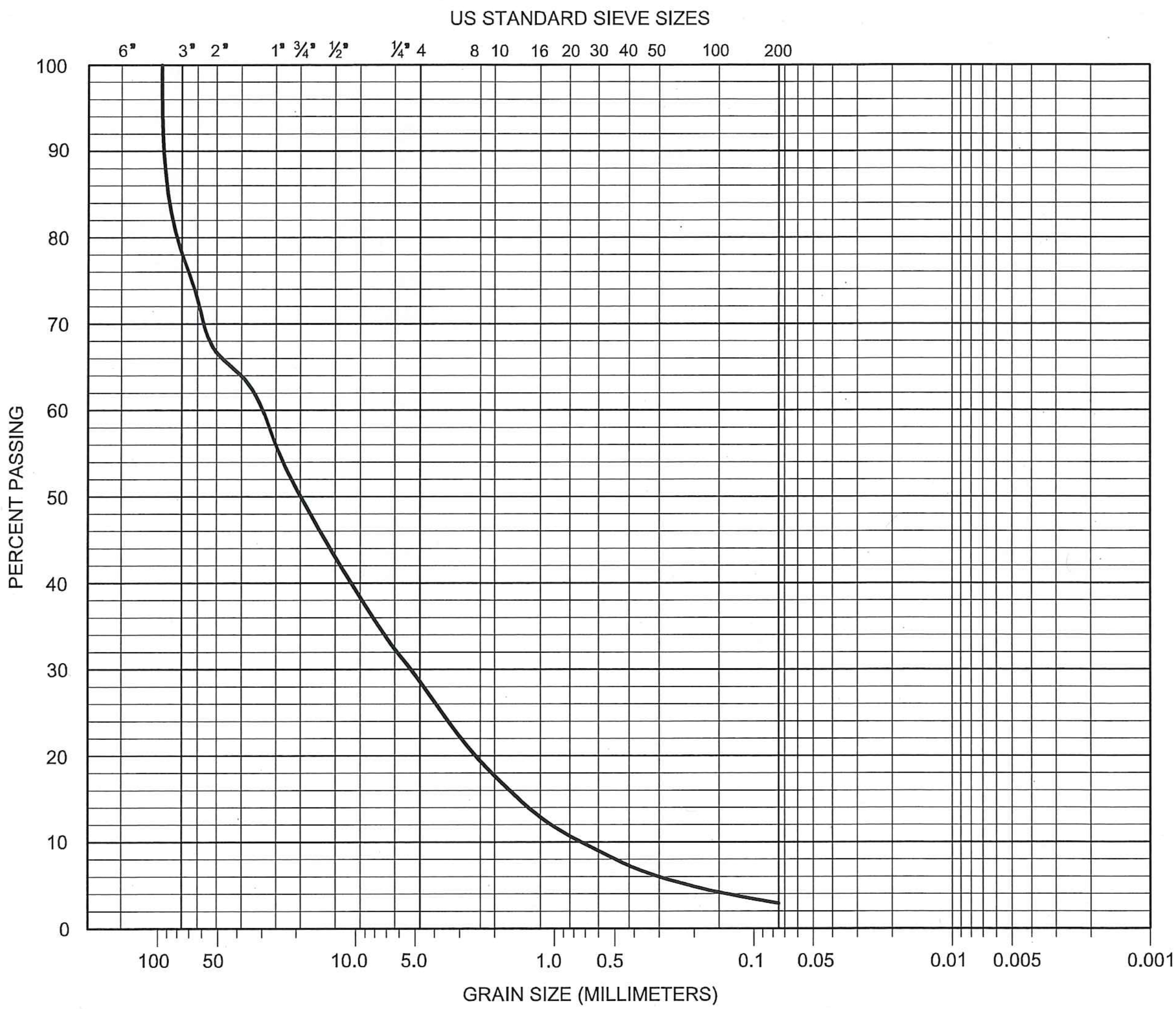
SYMBOL	SAMPLE LOCATION AND DEPTH	FIELD MOISTURE (%)	% PASSING NO. 200 SIEVE	% PASSING 2 μ	UNIFIED SOIL CLASSIFICATION
———	S-1 @ 26 - 30 FT.	28.0	10.0	--	SP-SM

NOTE: CORE DIAMETER ~ 3.7 INCHES: SAMPLE LIMITED TO PARTICLES LESS THAN 3.5 INCHES

GRADATION TEST RESULTS - ASTM C136

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. B-3

Northwest Geotech, Inc.



COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

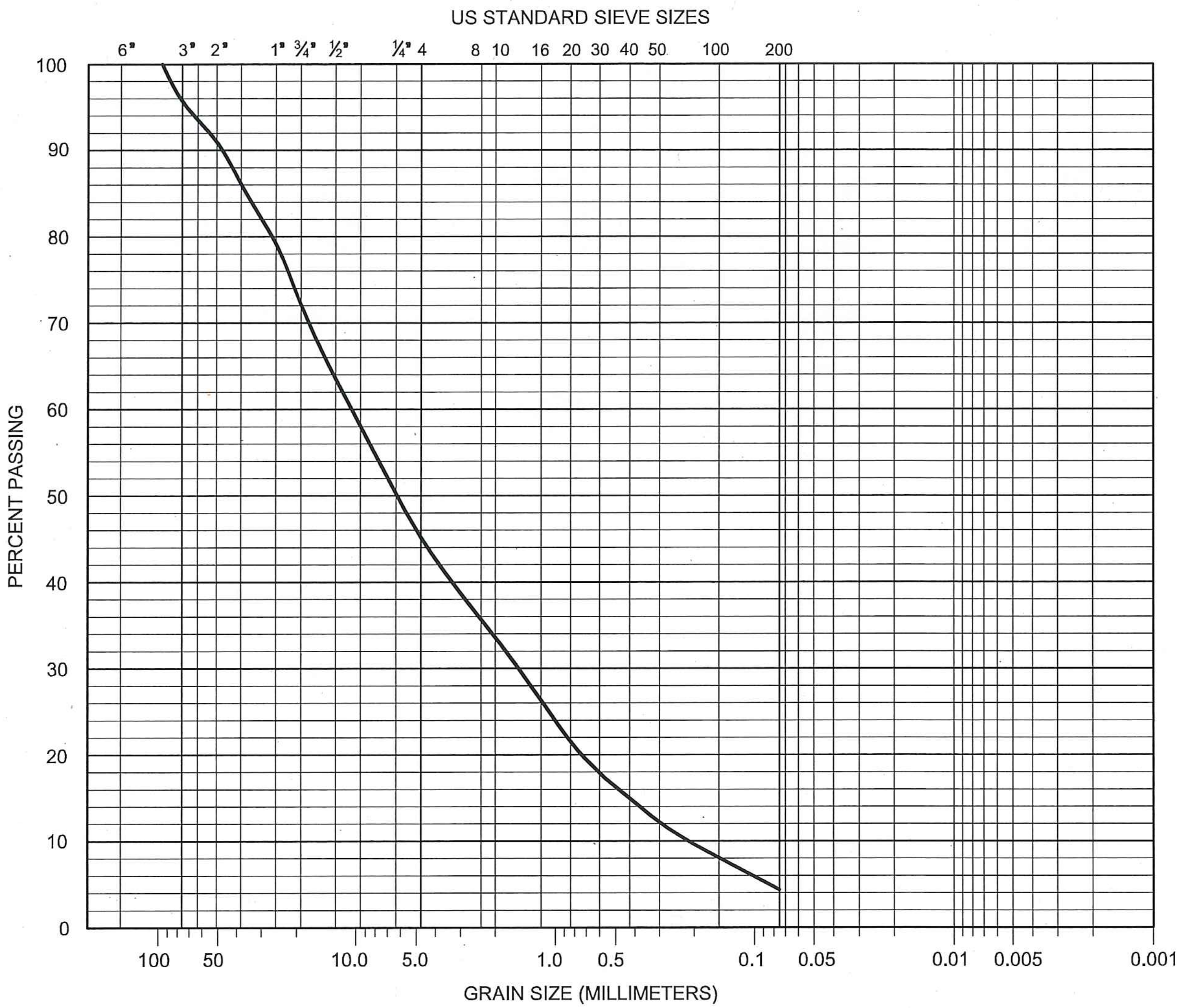
SYMBOL	SAMPLE LOCATION AND DEPTH	FIELD MOISTURE (%)	% PASSING NO. 200 SIEVE	% PASSING 2 μ	UNIFIED SOIL CLASSIFICATION
———	S-3 @ 5 - 13 FT.	9.8	2.9	--	GW

NOTE: CORE DIAMETER ~ 3.7 INCHES: SAMPLE LIMITED TO PARTICLES LESS THAN 3.5 INCHES

GRADATION TEST RESULTS - ASTM C136

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. B-4

Northwest Geotech, Inc.



COBBLES	GRAVEL		SAND			SILT AND CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	SAMPLE LOCATION AND DEPTH	FIELD MOISTURE (%)	% PASSING NO. 200 SIEVE	% PASSING 2 µ	UNIFIED SOIL CLASSIFICATION
———	S-3 @ 20 - 27.5 FT.	13.9	4.4	--	GW

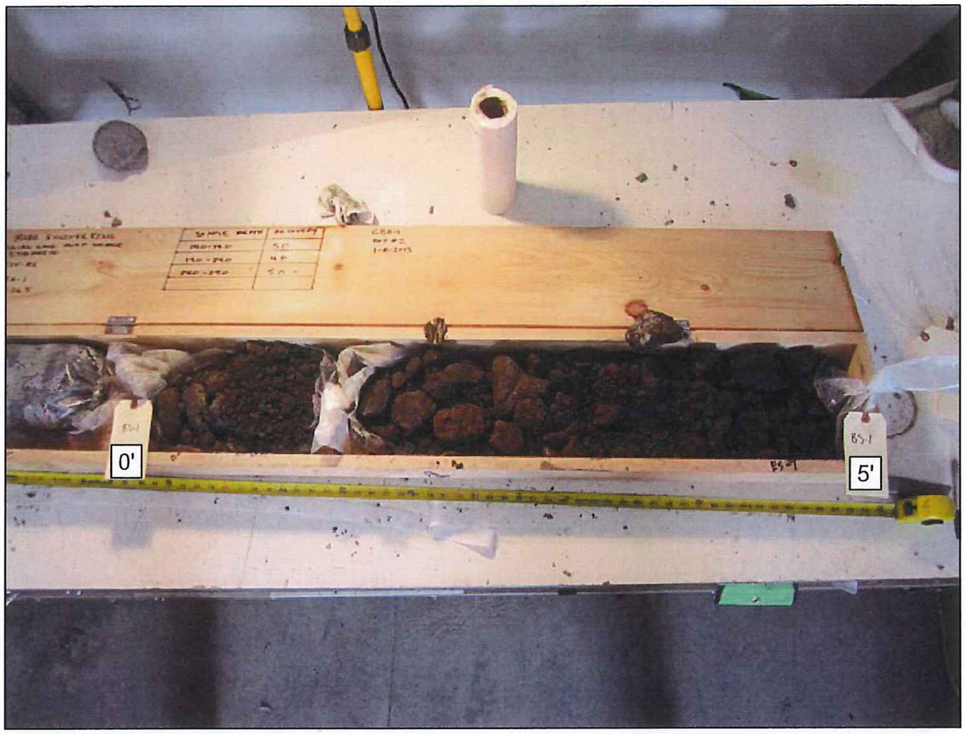
NOTE: CORE DIAMETER ~ 3.7 INCHES: SAMPLE LIMITED TO PARTICLES LESS THAN 3.5 INCHES

GRADATION TEST RESULTS - ASTM C136

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. B-5

Northwest Geotech, Inc.

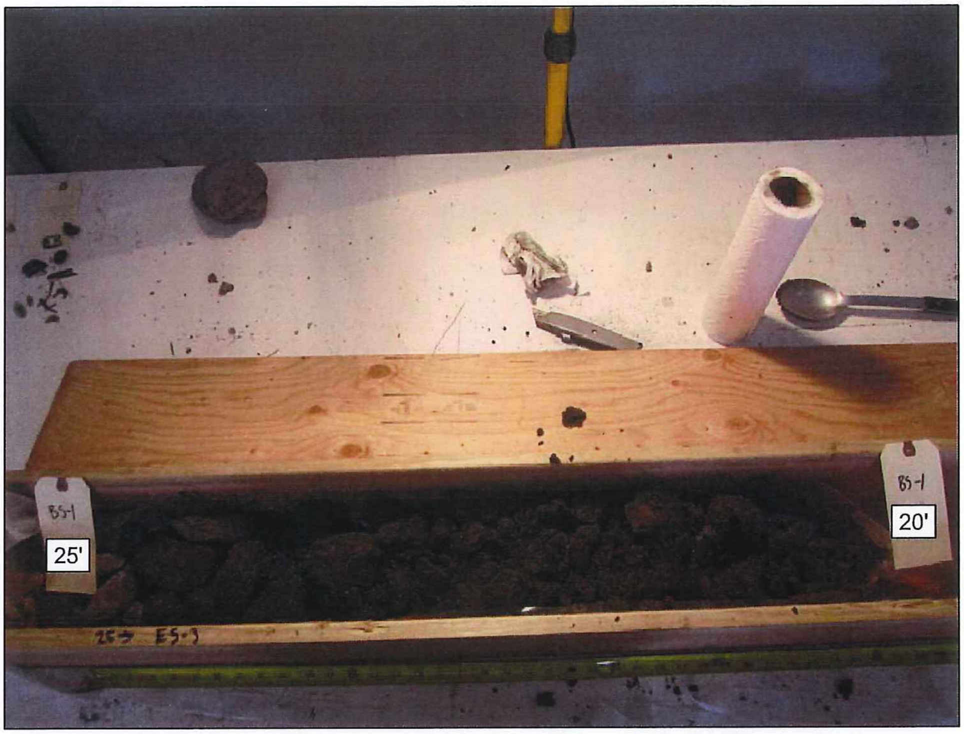
APPENDIX C

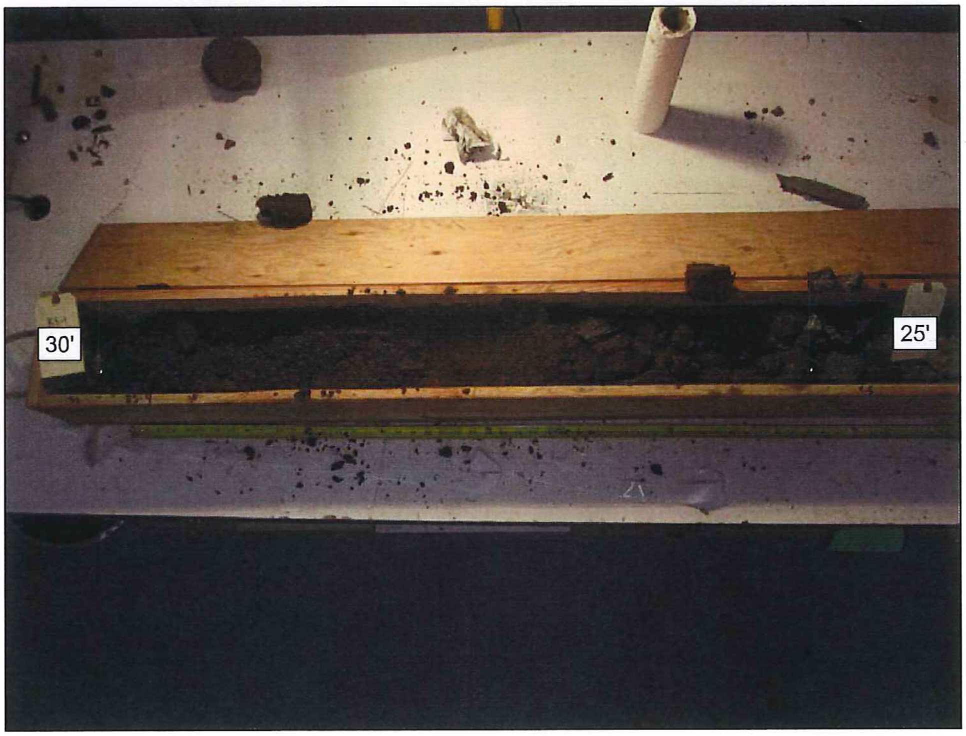


CORE LOG PHOTO S-1

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-1 (1 OF 3)

Northwest Geotech, Inc.

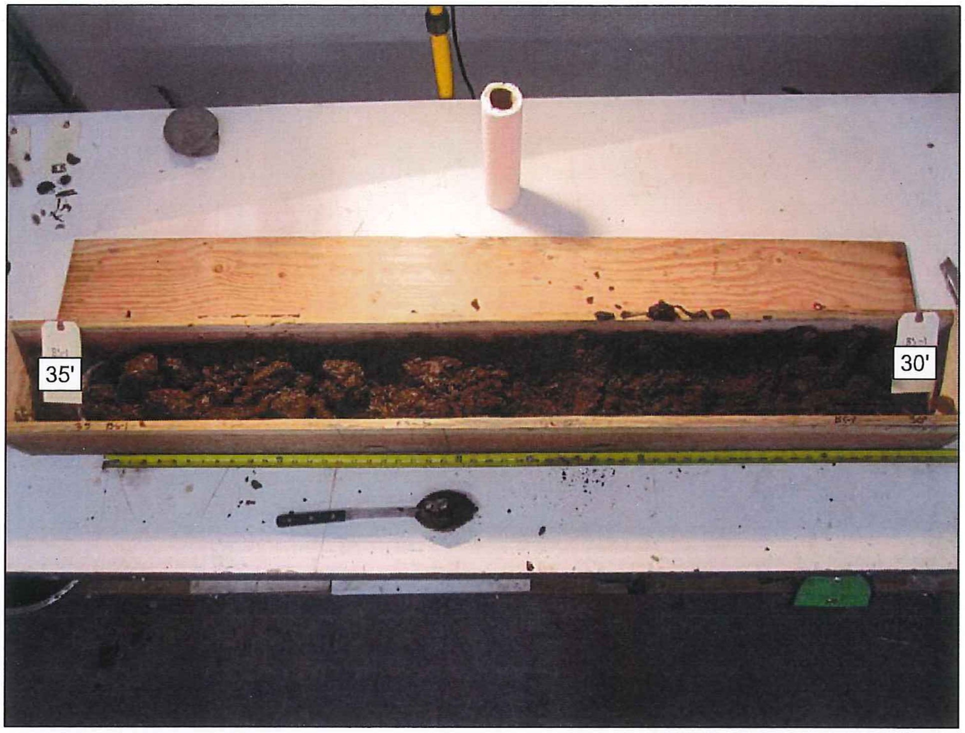


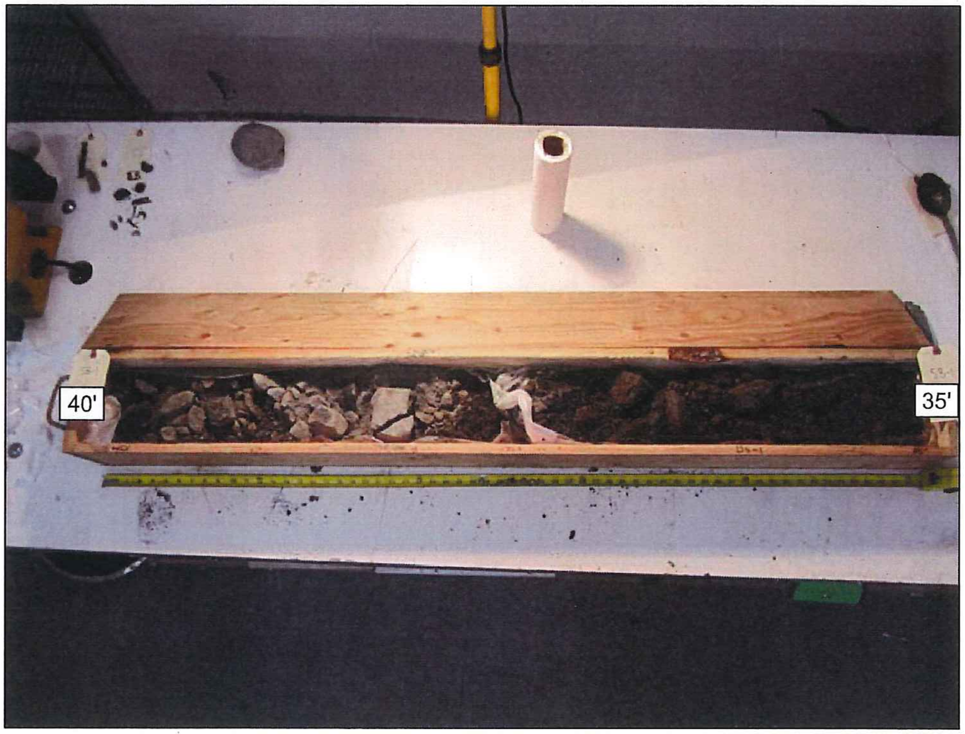


CORE LOG PHOTO S-1

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-1 (2 OF 3)

Northwest Geotech, Inc.

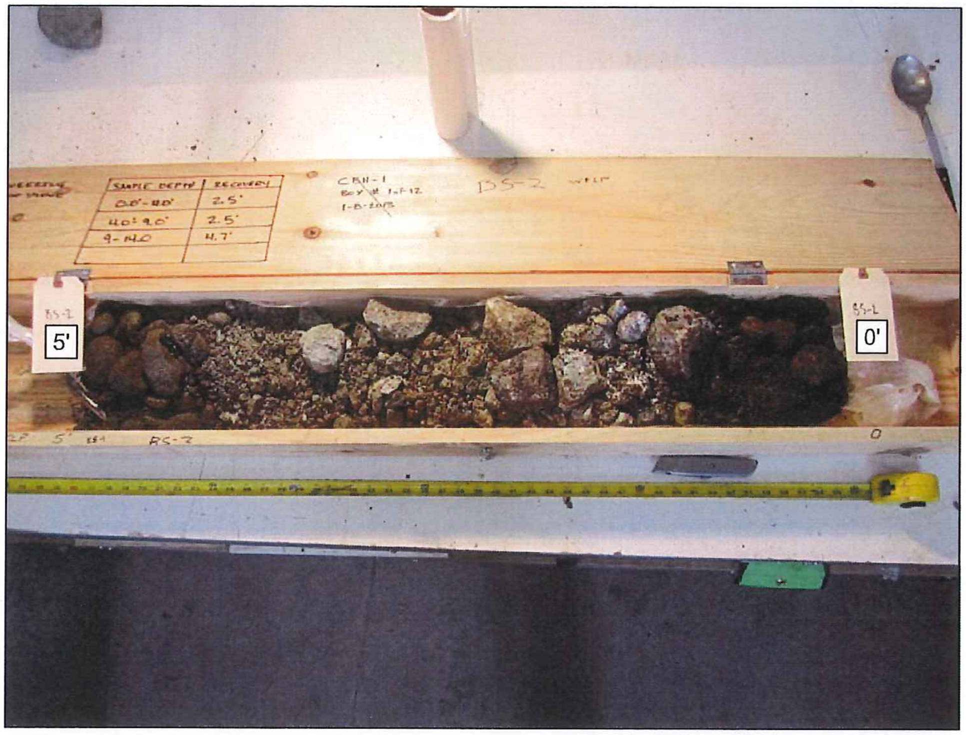


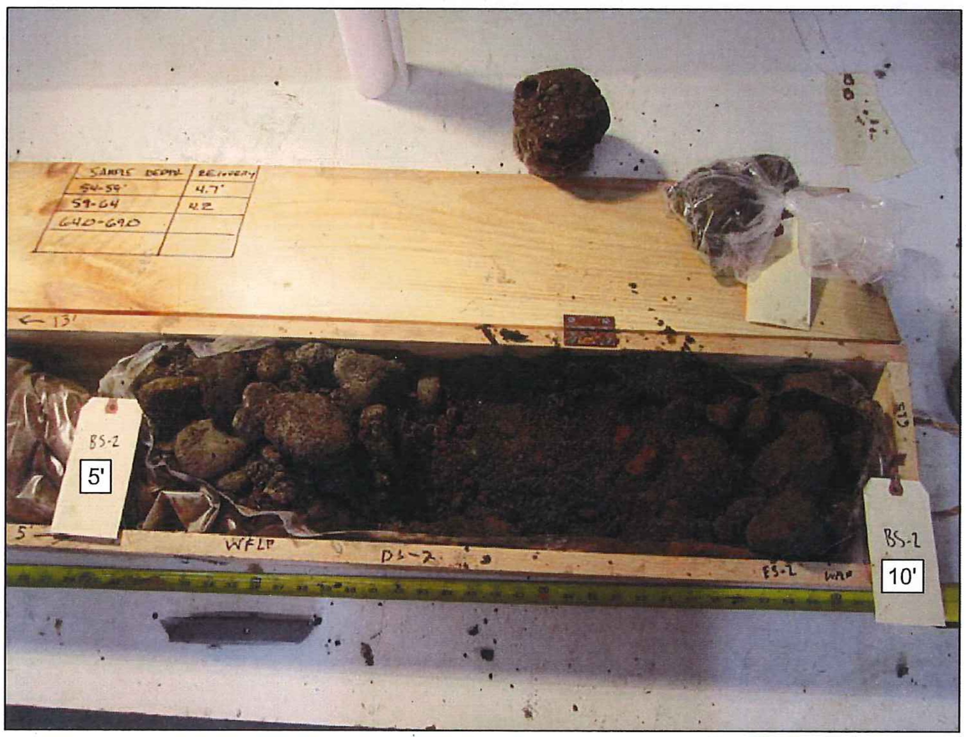


CORE LOG PHOTO S-1

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-1 (3 OF 3)

Northwest Geotech, Inc.





CORE LOG PHOTO S-2

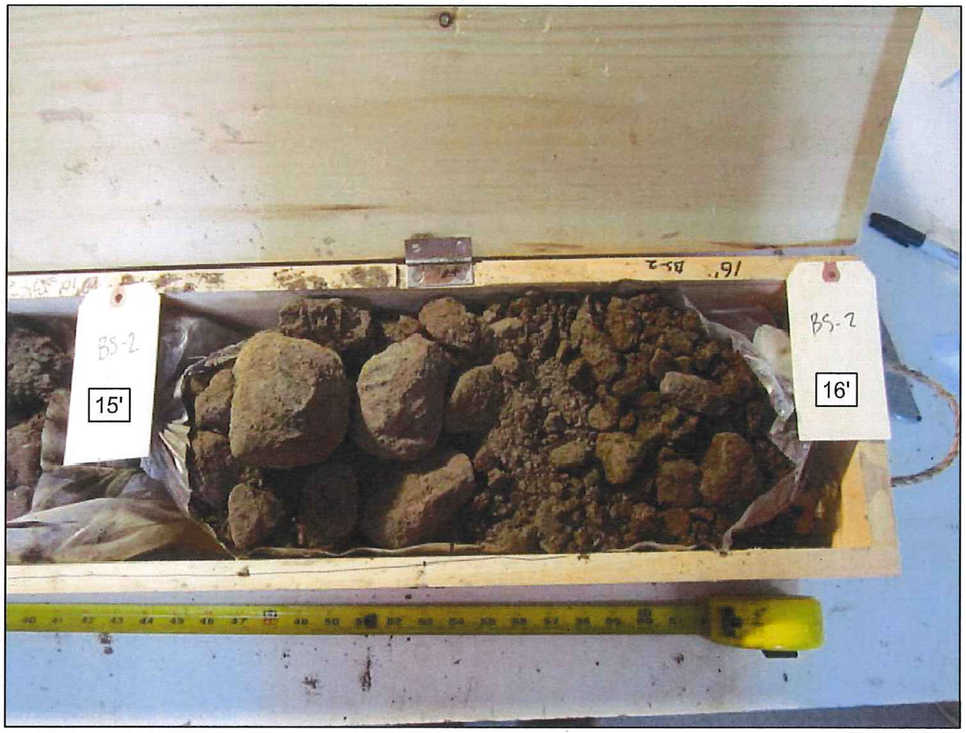
PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-2 (1 OF 4)

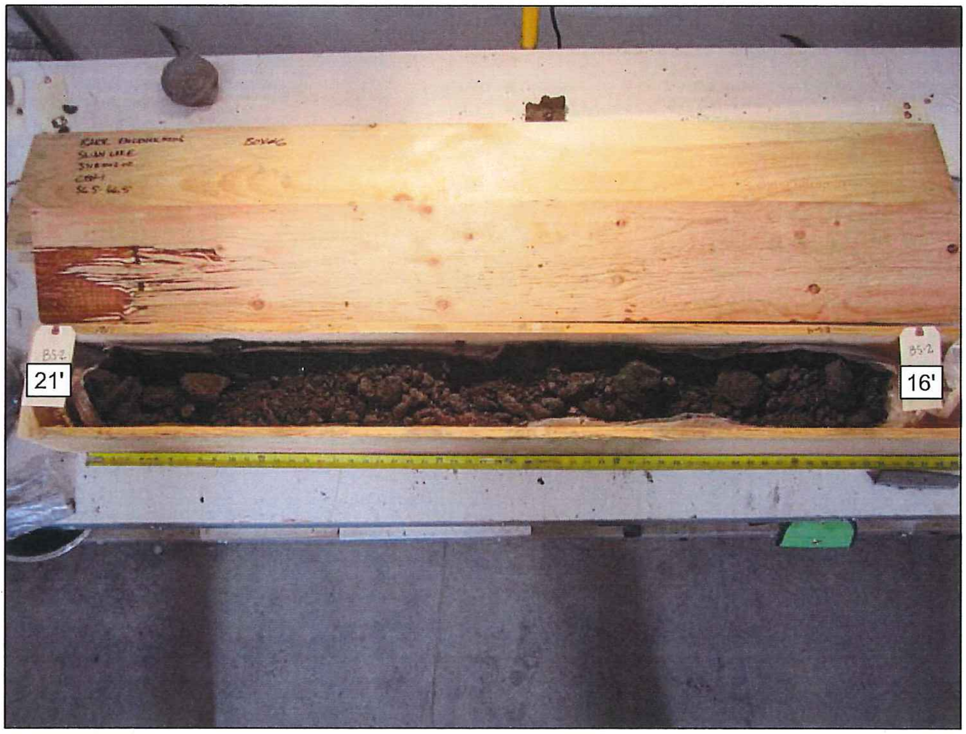
Northwest Geotech, Inc.

CORE LOG PHOTO S-2

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-2 (2 OF 4)

Northwest Geotech, Inc.





CORE LOG PHOTO S-2

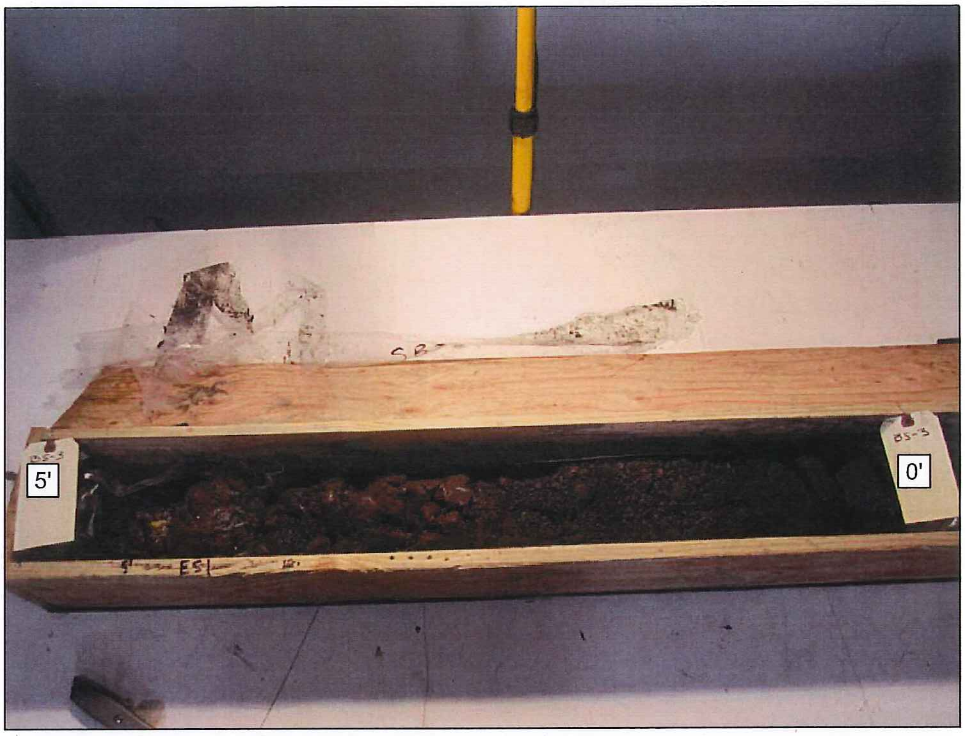
PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-2 (3 OF 4)

Northwest Geotech, Inc.

CORE LOG PHOTO S-2

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-2 (4 OF 4)

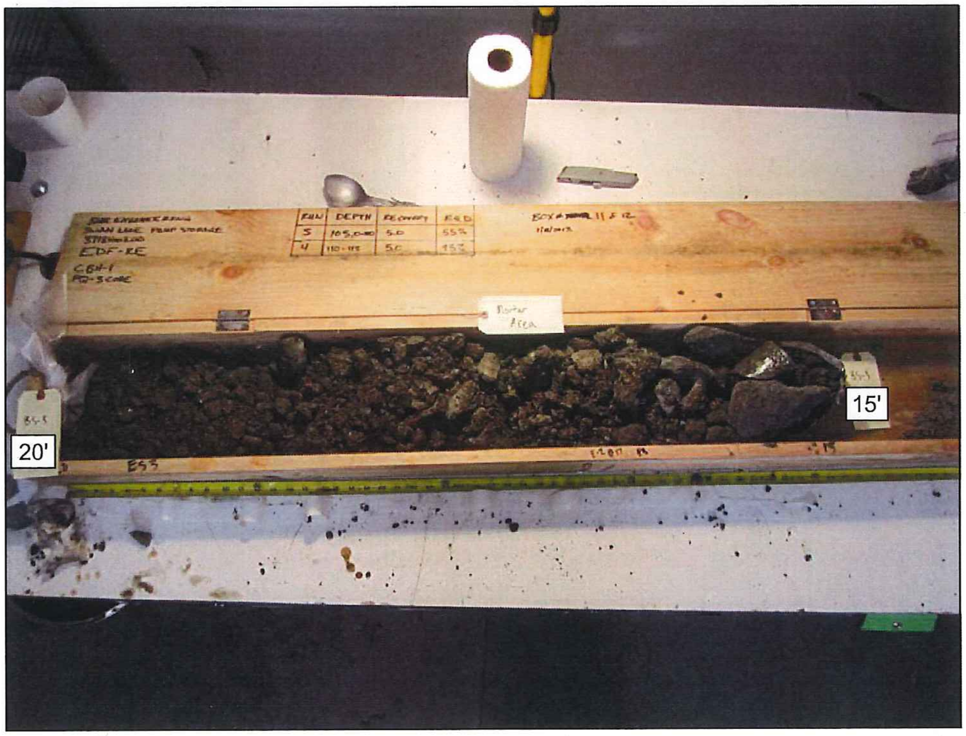
Northwest Geotech, Inc.



CORE LOG PHOTO S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-3 (1 OF 5)

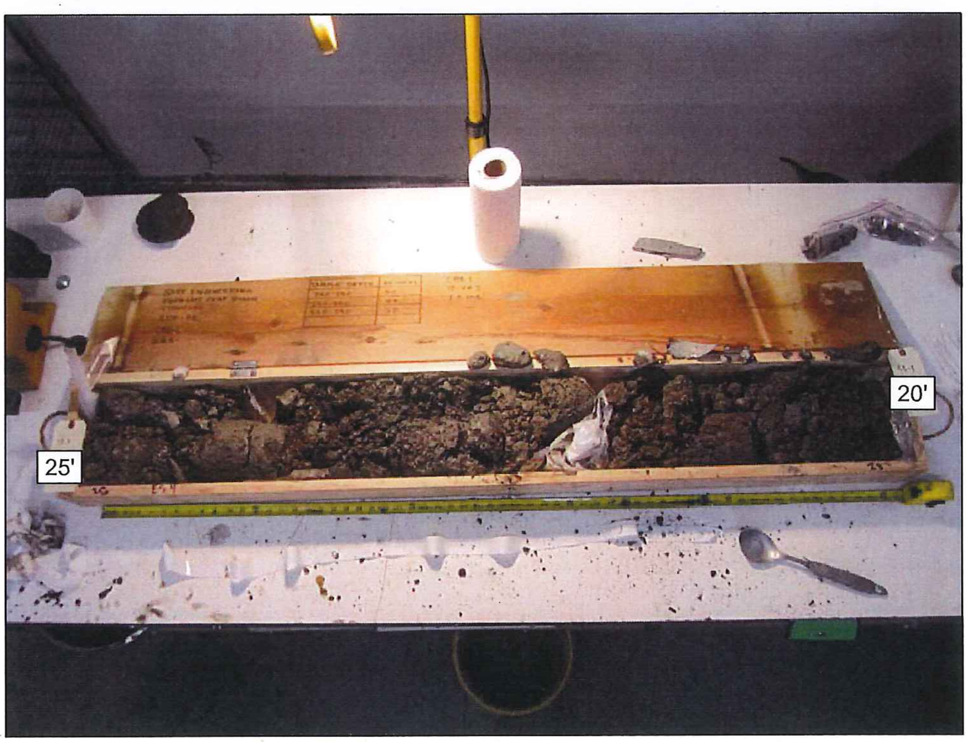
Northwest Geotech, Inc.



CORE LOG PHOTO S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-3 (2 OF 5)

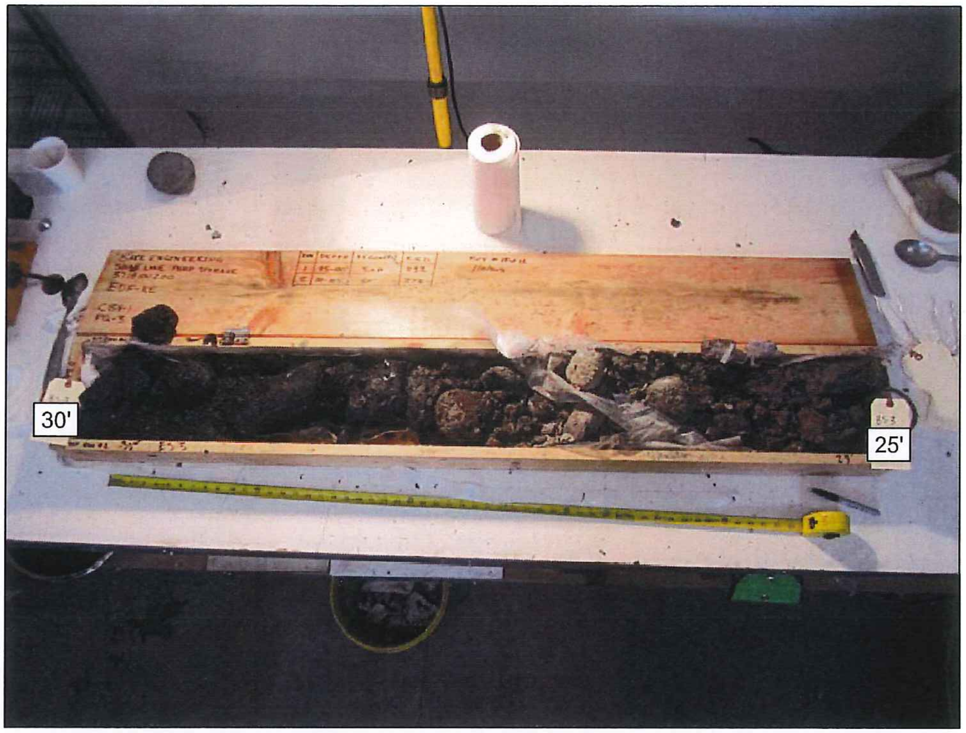
Northwest Geotech, Inc.

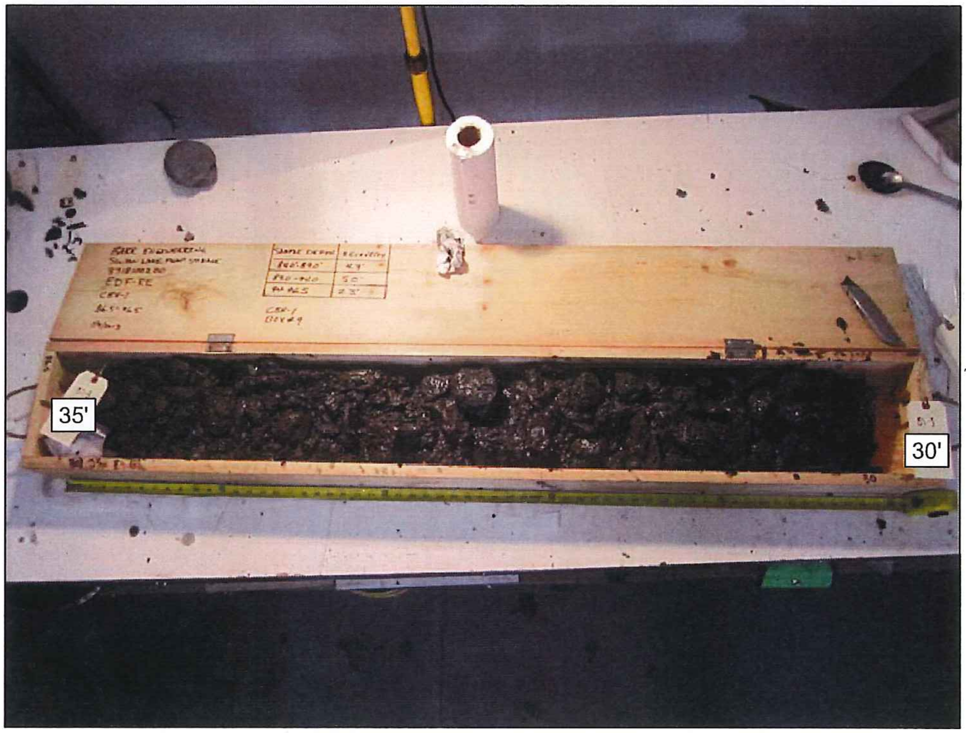


CORE LOG PHOTO S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-3 (3 OF 5)

Northwest Geotech, Inc.





CORE LOG PHOTO S-3

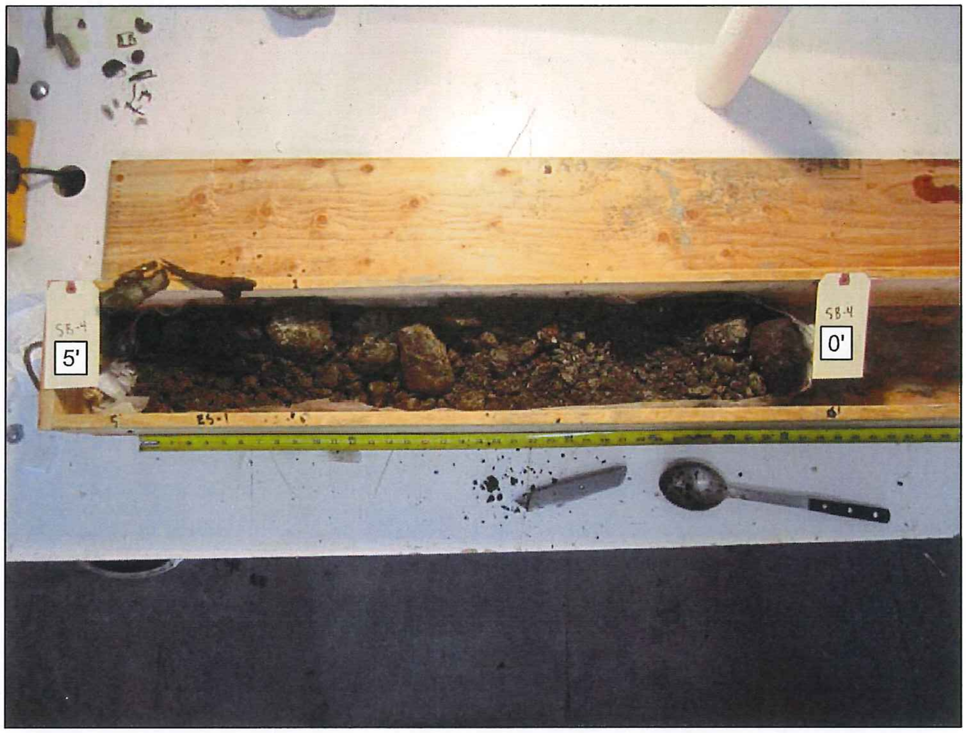
PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-3 (4 OF 5)

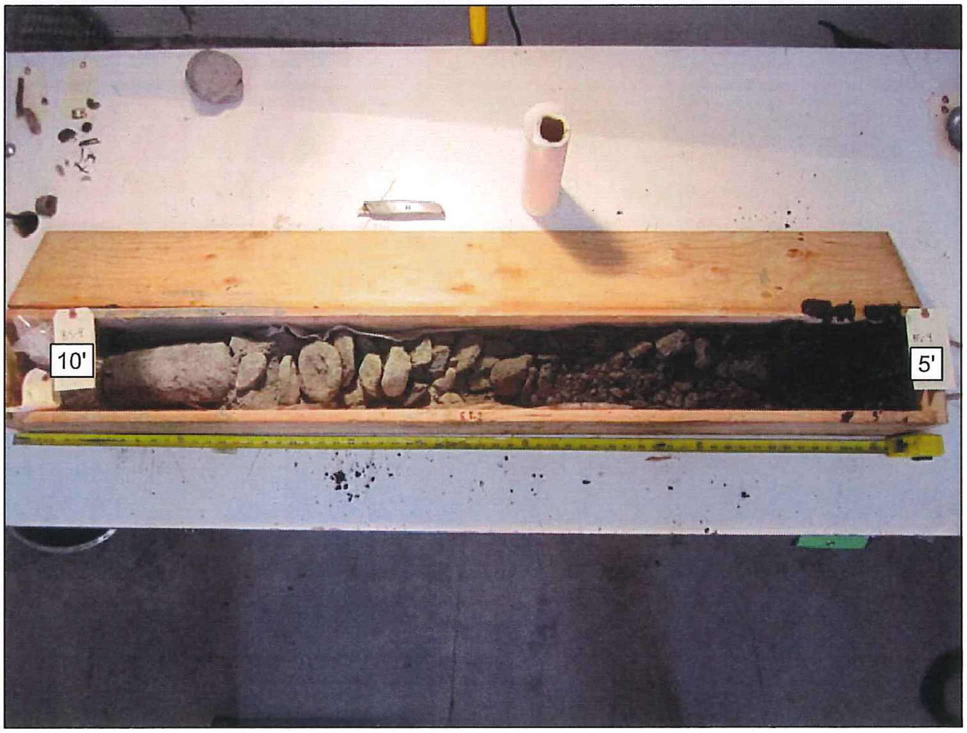
Northwest Geotech, Inc.

CORE LOG PHOTO S-3

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-3 (5 OF 5)

Northwest Geotech, Inc.

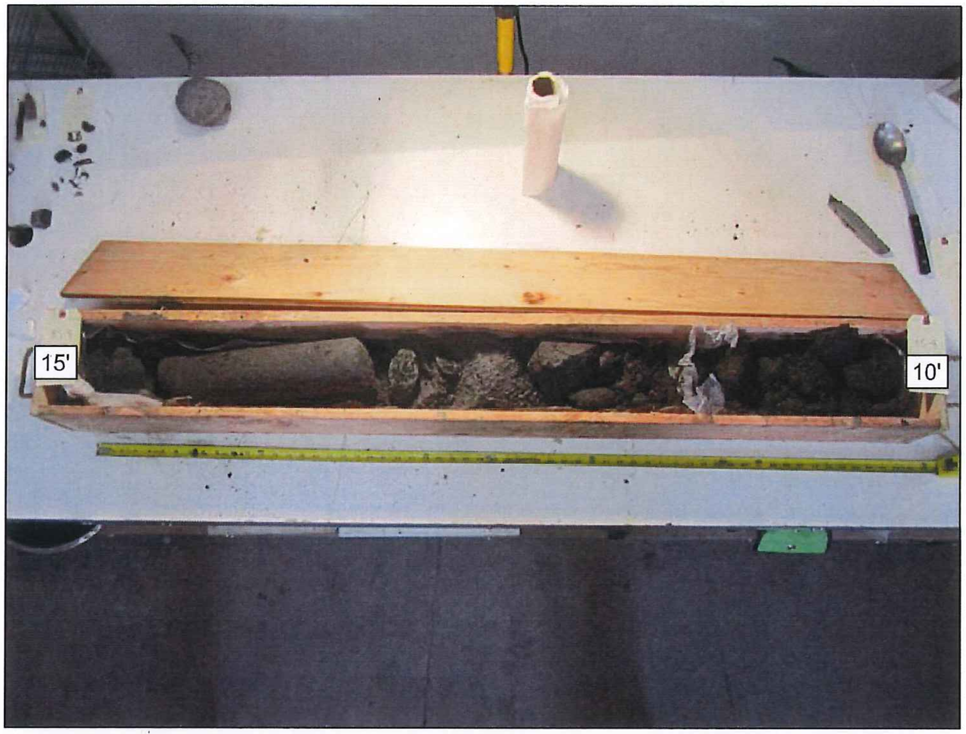




CORE LOG PHOTO S-4

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-4 (1 OF 2)

Northwest Geotech, Inc.



CORE LOG PHOTO S-4

PROJECT NO. 2919.1.1	WILLAMETTE FALLS RIVERWALK OREGON CITY, OREGON	FIGURE NO. C-4 (2 OF 2)

Northwest Geotech, Inc.

APPENDIX D

GeoPotential

ENVIRONMENTAL & EXPLORATION GEOPHYSICS

22323 East Wild Fern Lane, Brightwood, Oregon 97011 • PH (503) 622-0154 • FAX (503) 622-0526
WEB http://www.geopotential.biz/ E-MAIL GeoPotential@geopotential.biz

SUMMARY REPORT

BORE HOLE CLEARANCE SURVEY

Former Blue Heron Mill
Willamette Falls Legacy Project
Oregon City, Oregon

CLIENT

Northwest Geotech, Inc.
9120 SW Pioneer Court, Suite B
Wilsonville, Oregon 97070

DATE OF SURVEY

May 27, April 3, 2017

GeoPotential Project Number: 9757

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FIGURES

APPENDICES

SUMMARY

A Bore Hole Clearance Survey (BHCS) was conducted over a portion of the former Blue Heron Mill site in Oregon City, Oregon as part of the Willamette Falls Legacy Project. The purpose of the survey was to assure utilities or other subsurface obstructions were not encountered during drilling of Bore Holes.

Ground Penetrating Radar (GPR) Surveys and hand held magnetic and electromagnetic scanners were used for the project.

Interpreted utilities and trenches along GPR Profiles were posted on a Map of the Site.

The results from the drilling were used to generate contour maps for Surface Elevation, Bedrock Elevation and Sediment Isopach Thickness.

INTRODUCTION

Ralph Soule & Tony Rukavina of GeoPotential conducted the Subsurface Mapping Survey. Allan Bean was the on-site representatives for Northwest Geotech. Fieldwork was conducted on May 27 & April 3, 2017. The report was completed and e-mailed to NW Geotech on April 17, 2017.

Subsurface mapping surveys are geophysical surveys utilizing geophysical methods and data to detect and locate natural and manmade subsurface features. Magnetic Surveys are used to detect and map the locations of buried **ferrous** (iron-bearing) objects . Ground Penetrating Radar (GPR) Surveys are used to map both natural and manmade subsurface features such as USTs, utilities, backfilled pits, etc. (see Appendix B.). Pipe and cable locators are used to map the locations of buried utilities and piping.

Once subsurface ferrous objects are detected from a magnetic survey then hand held scanners and GPR surveys are used to map the locations, depths, sizes and shapes of the objects.

SURVEY OBJECTIVES

The objectives of this subsurface mapping survey were:

1. Perform a BHCS over 77 proposed bore hole locations.
2. Map the locations of detected subsurface utilities & trenches along GPR Profiles.
3. Generate Contour Surface Elevation, Bedrock Elevation and Sediment Isopach Thickness maps from the results of the drilling.

SURVEY SITE

The survey Site is shown on Figures 1. through 5. The Site consisted of a portion of the former Blue Heron Mill Company.

SURVEY EQUIPMENT

The following geophysical instruments were used to conduct the survey:

- MALA RAMAC Ground Penetrating Radar System with a 200 MHz antenna (GPR Survey).
- Schonstedt GA52 Magnetic Gradiometer.
- Aqua-Tronics A6 Pipe & Cable locator.
- Heath Sure- lock Pipe & Cable locator.

This equipment and the procedures used to meet the survey objectives of this project have been proven effective in detecting metallic objects and mapping non-metallic features such as disturbed soil from backfilled pits.

Geophysical techniques are excellent at detecting changes in the subsurface caused by natural and manmade objects; however, they are poor at actually identifying subsurface features. Complementary methods may be used to assist in the interpretation; however, the only sure way of identifying a buried feature is by excavation.

Brief descriptions of the radar method is included in the Appendix.

PROCEDURE

Ground Penetrating Radar Surveys

Over areas that were designated as bore hole locations by Northwest Geotech. GPR Profiles were acquired using a 200 MHz antenna. The GPR data were processed and interpreted to locate utilities and trenches along GPR profiles as shown on Figure 2. GPR Interpretation Map.

Pipe and Cable Survey

Hand held magnetic and electromagnetic scanners were used to help identify utilities over bore hole locations.

Map Generation

The locations of 19 GPR Profiles and 77 bore hole locations were surveyed in by geodetic surveyors. Northwest Geotech provided GeoPotential with a spreadsheet (Appendix 1) showing geographic locations in Oregon State Plane coordinates, Surface Elevations, Bedrock Elevations and Depth to Bedrock. Figure 2. shows the locations of these data. This data were then used to generate contour maps of; Figure 3. Surface Elevations, Figure 4. Bedrock Elevations and Figure 5. Sedimentary Isopach Thickness Map.

RESULTS

Results are shown on Figures 2 through 5.

Figure 2 shows the interpretation of utilities from GPR anomalies along GPR Profiles. The interpretation was difficult due to disturbed sedimentary material. The locations and depths of piping is shown as blue circles or green circles where it could be determined that the pipe was a sewer pipe. Trench areas are shown as orange rectangles. One boulder was intersected during drilling along GPR Profile G2 as shown on Fig. 2.

LIMITATIONS

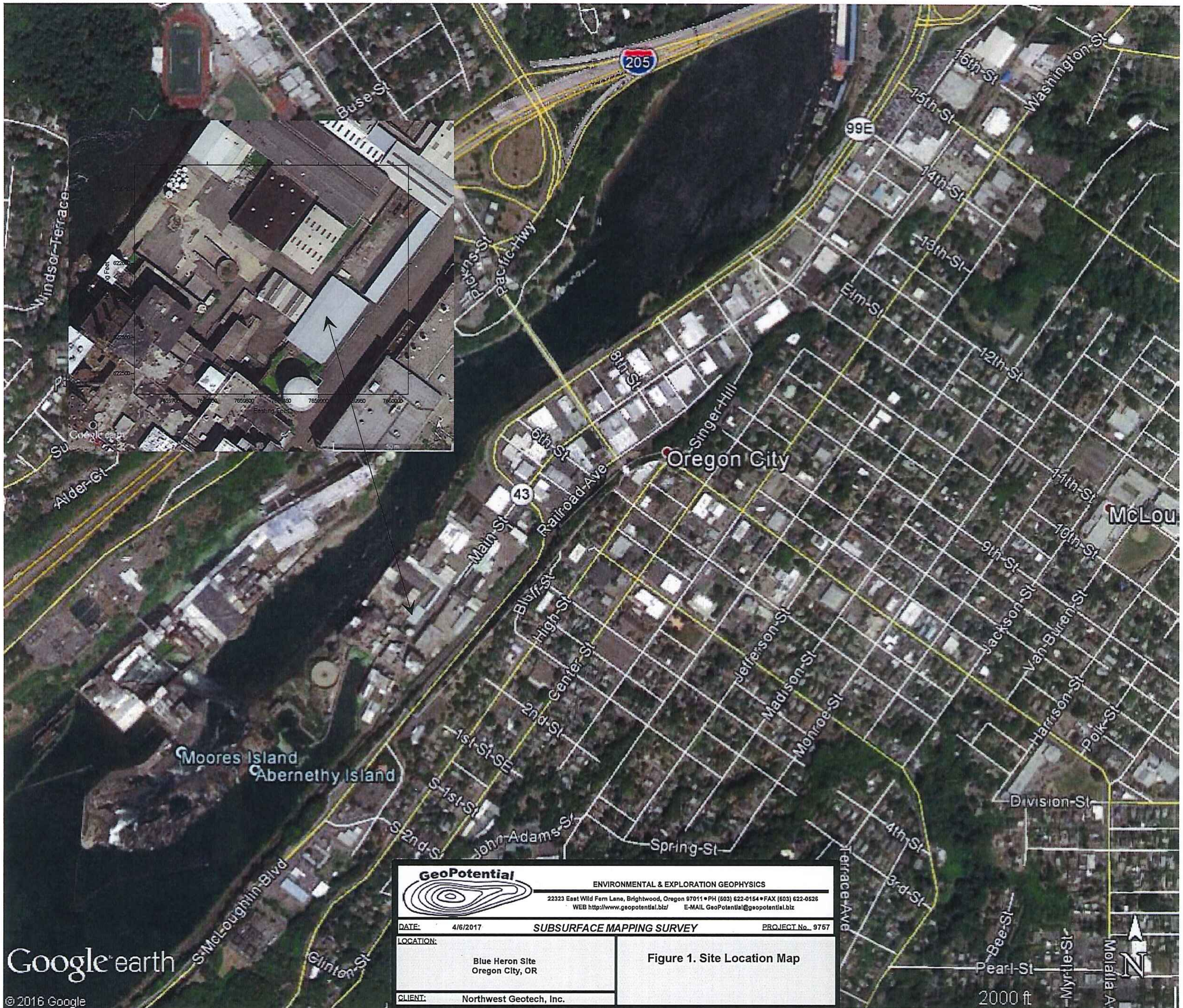
Limitations of magnetometer and GPR surveys can be seen in the Appendices.

Geophysical surveys consist of interpreting geophysical responses from subsurface features. Since a variety of subsurface features can produce identical geophysical responses, it is necessary to confirm the geophysical interpretation with intrusive investigations such as excavating or drilling. In addition, many subsurface features may produce no geophysical response.

Ralph Soule

Ralph Soule
GeoPotential

April 17, 2017



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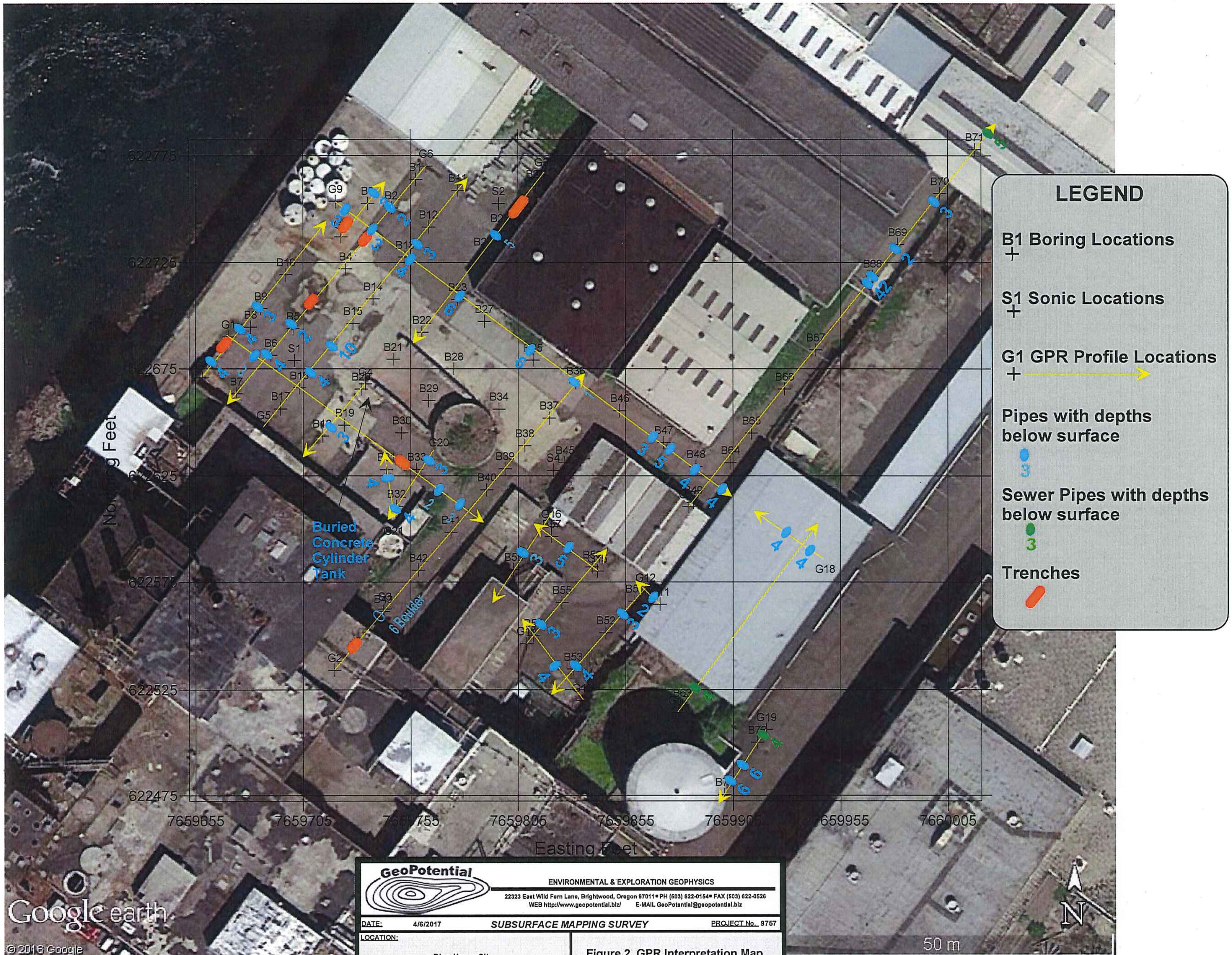
DATE: 4/6/2017 SUBSURFACE MAPPING SURVEY PROJECT No. 9757

LOCATION: Blue Heron Site, Oregon City, OR

Figure 1. Site Location Map

CLIENT: Northwest Geotech, Inc.



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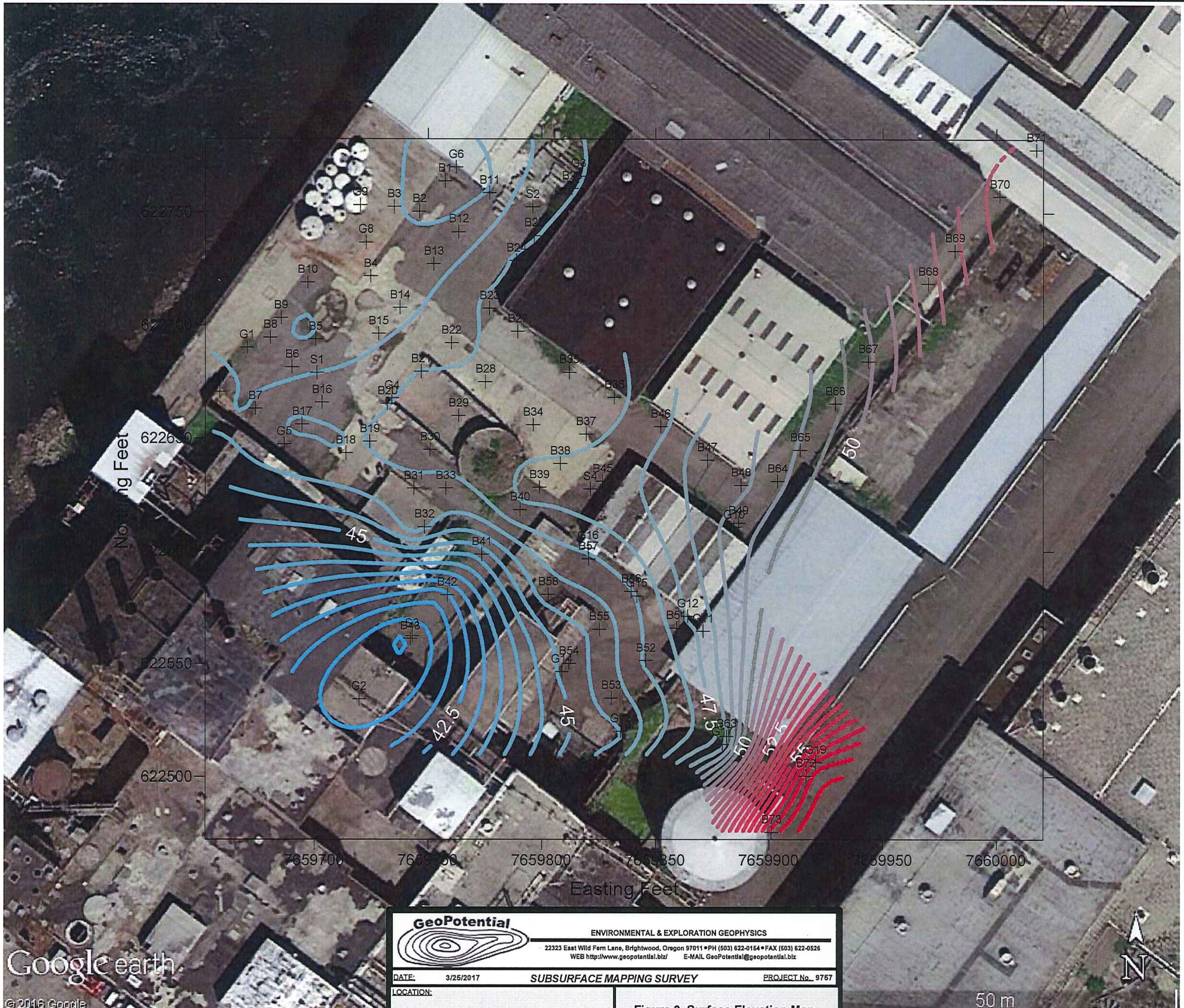
DATE: 4/6/2017	SUBSURFACE MAPPING SURVEY	PROJECT No. 9757
LOCATION: Blue Heron Site, Oregon City, OR	Figure 2. GPR Interpretation Map	
CLIENT: Northwest Geotech, Inc.	7	



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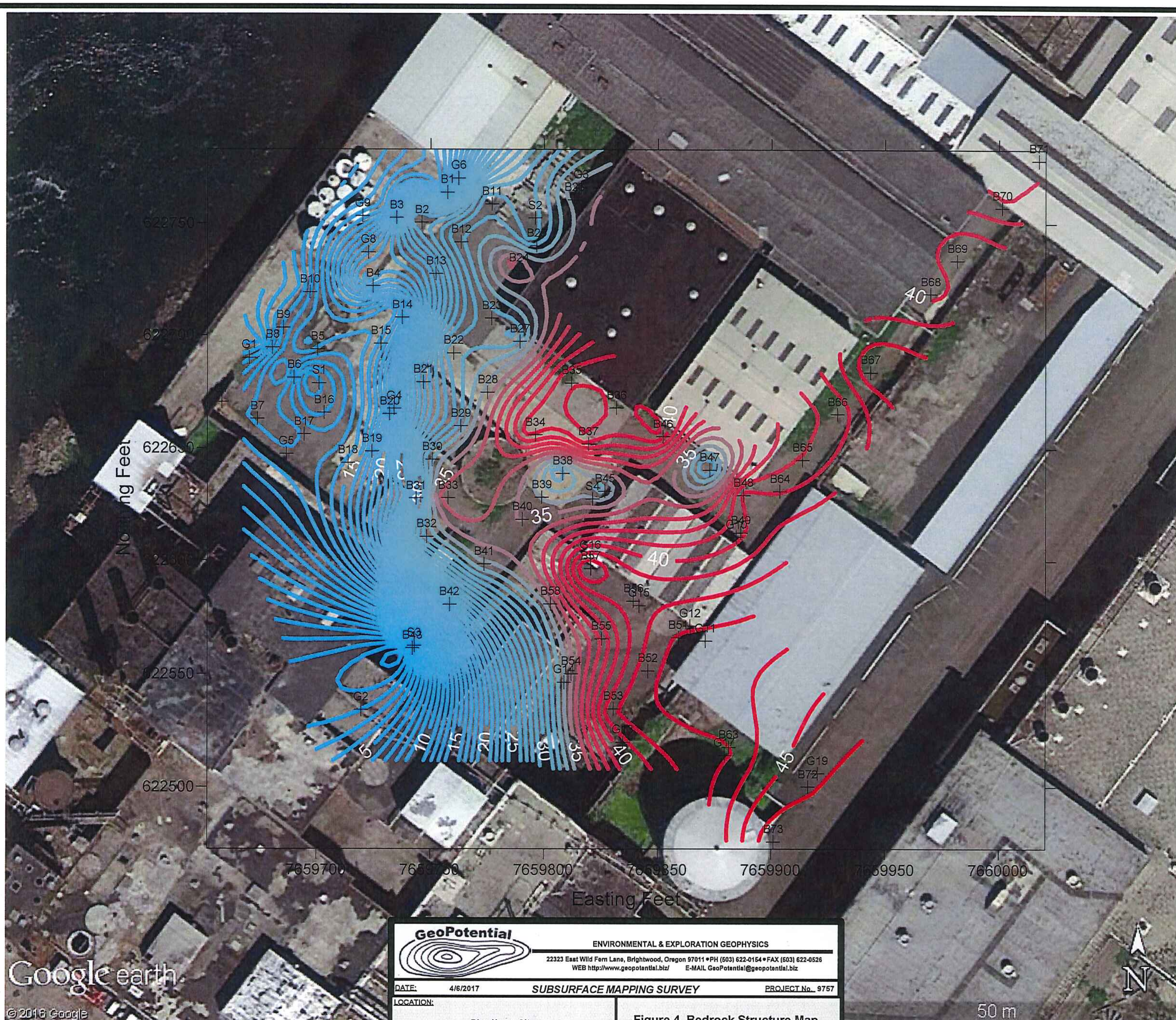
DATE: 3/25/2017	SUBSURFACE MAPPING SURVEY	PROJECT No. 9757
LOCATION: Blue Heron Site Oregon City, OR	Figure 3. Surface Elevation Map (Contour Interval = 0.5 Feet)	
CLIENT: Northwest Geotech, Inc.		



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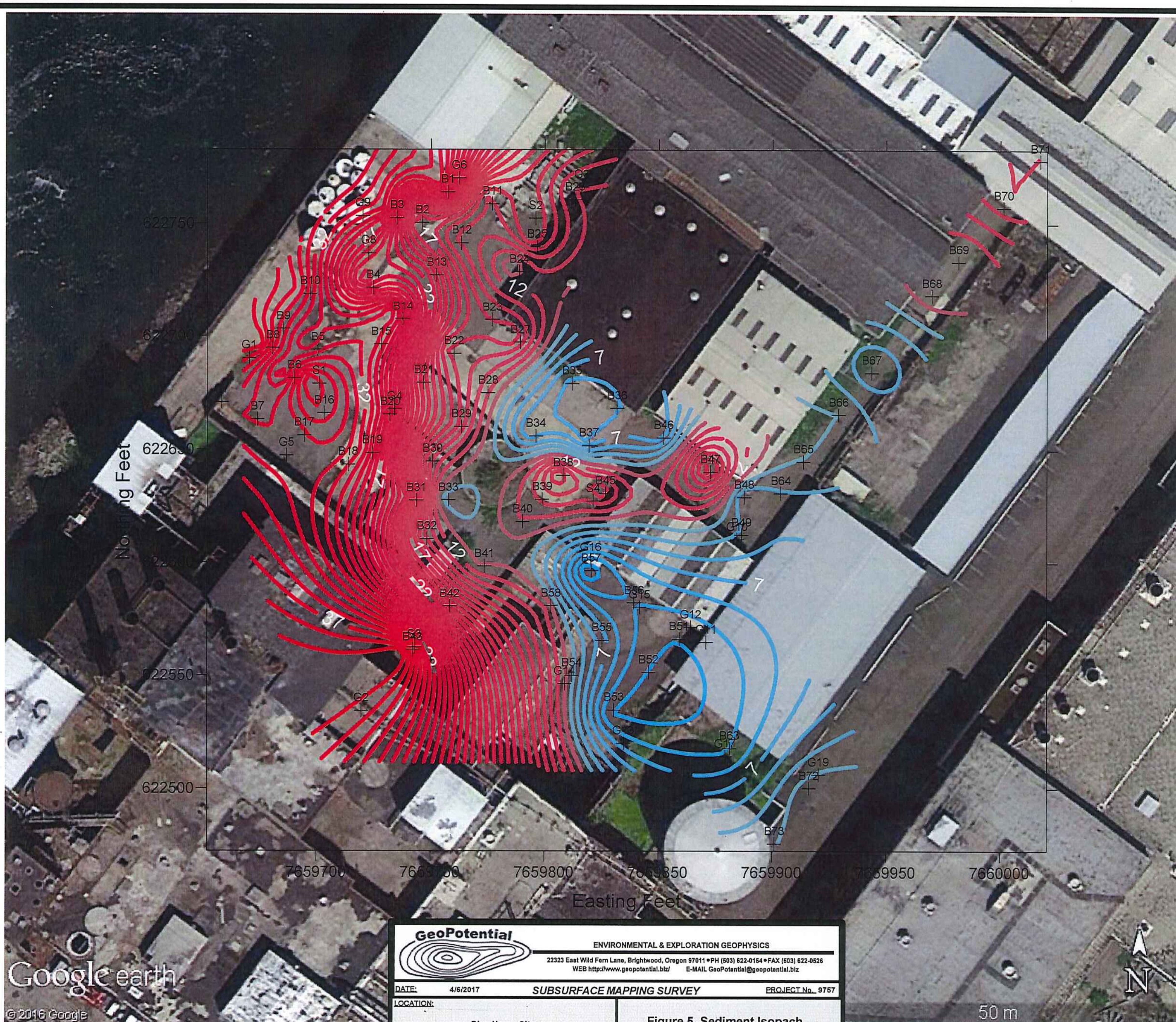
DATE: 4/6/2017	SUBSURFACE MAPPING SURVEY	PROJECT No. 9757
LOCATION: Blue Heron Site, Oregon City, OR	Figure 4. Bedrock Structure Map (Contour Interval = 1.0 Foot)	
CLIENT: Northwest Geotech, Inc.		



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DATE: 4/6/2017	SUBSURFACE MAPPING SURVEY	PROJECT No. 9757
LOCATION: Blue Heron Site, Oregon City, OR	Figure 5. Sediment Isopach Thickness Map (Contour Interval = 1.0 Foot)	
CLIENT: Northwest Geotech, Inc.	10	

Appendix A
Table of Surveying and Boring Results

TABLE 1
SUMMARY OF BORING LOCATIONS AND ELEVATIONS
WILLAMETTE FALLS LEGACY PROJECT

Point	Description	Northing	Easting	Elevation (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock (feet)
Air Track Borings						
50075	B1	622768.2211	7659753.7	45.3277	30	15.3
50074	B2	622754.4921	7659742.1	45.3877	16	29.4
50073	B3	622756.6411	7659730.7	45.7238	30	15.7
50071	B4	622725.2998	7659720.1	45.6224	22	23.6
50091	B5	622696.4345	7659695.1	45.425	30	15.4
50090	B6	622683.6378	7659684.6	45.6945	30	15.7
50089	B7	622664.8866	7659668.1	45.9325	33	12.9
50086	B8	622697.2109	7659674.9	45.6835	38	7.7
50085	B9	622706.1687	7659679.7	45.7341	35	10.7
50084	B10	622722.4481	7659691.8	45.6092	35	10.6
50077	B11	622762.8852	7659773.8	45.351	14	31.4
50078	B12	622745.4469	7659759.8	45.5426	14	31.5
50040	B13	622730.9209	7659748.5	45.7205	21	24.7
50070	B14	622710.8443	7659733.3	45.7341	32	13.7
50092	B15	622698.9876	7659723.7	45.7689	32	13.8
50093	B16	622667.7206	7659698.1	46.3632	36	10.4
50094	B17	622657.7101	7659689.2	46.5266	33	13.5
50096	B18	622644.7301	7659708.9	46.504	33	13.5
50097	B19	622649.9431	7659719.7	46.4779	32	14.5
50098	B20	622667.1718	7659727.6	46.3426	30	16.3
50105	B21	622681.667	7659742.9	46.4595	21	25.5
50069	B22	622694.7058	7659756.5	46.2766	15	31.3
50039	B23	622710.4654	7659773.7	46.5381	15	31.5
50079	B24	622732.4689	7659785.8	46.4753	10	36.5
50080	B25	622743.6593	7659793.9	46.3819	16	30.4
50083	B26	622764.8944	7659810.9	46.3543	12	34.4
50038	B27	622699.9724	7659786.4	46.6344	16	30.6
50068	B28	622676.9921	7659771.8	46.5431	13	33.5
50104	B29	622661.6252	7659759.8	46.7374	16	30.7
50100	B30	622646.2502	7659746.9	47.0167	15	32.0
50101	B31	622628.579	7659739.6	46.2343	22	24.2
50102	B32	622611.0889	7659744.4	46.4079	15	31.4
50103	B33	622628.6807	7659754	46.2125	10	36.2
50067	B34	622657.5339	7659793.4	46.714	6	40.7
50037	B35	622681.2957	7659809.7	46.6589	6	40.7
50036	B36	622670.036	7659830	46.8394	6	40.8
50042	B37	622653.3078	7659817.3	46.7735	6	40.8
50043	B38	622639.9841	7659805.7	47.025	16	31.0
50046	B39	622629.0629	7659796.2	47.1435	13	34.1
50047	B40	622618.9005	7659787.5	46.9083	12	34.9
50048	B41	622598.5639	7659770.3	44.5414	11	33.5
50049	B42	622580.2422	7659754.7	42.1394	21	21.1
50050	B43	622560.4028	7659738	40.9319	40+	Drill bit stuck in log (0.93-)
50045	B45	622631.861	7659824.7	47.3248	15	32.3
50035	B46	622656.7701	7659851	47.2942	6	41.3

TABLE 1
SUMMARY OF BORING LOCATIONS AND ELEVATIONS
WILLAMETTE FALLS LEGACY PROJECT

Point	Description	Northing	Easting	Elevation (feet)	Approximate Depth to Bedrock (feet)	Approximate Elevation of Bedrock (feet)
50034	B47	622641.5743	7659872	48.3411	18	30.3
50033	B48	622630.081	7659887.3	48.361	8	40.4
50031	B49	622612.9225	7659886	48.6387	9	39.6
50060	B51	622565.2684	7659858.1	47.1046	4	43.1
50061	B52	622550.2365	7659844.2	46.5253	4	42.5
50062	B53	622533.0585	7659828.6	45.7391	4	41.7
50065	B54	622548.8881	7659809.6	45.1305	11	34.1
50066	B55	622564.727	7659823.3	45.575	8	37.6
50056	B56	622581.7663	7659837.7	46.3921	5	41.4
50054	B57	622596.5496	7659818.4	46.3428	3	43.3
50053	B58	622580.5082	7659800.2	45.6886	12	33.7
50019	B63	622515.74	7659880.7	47.8216	5	42.8
50030	B64	622631.9116	7659903.7	48.8068	9	39.8
50029	B65	622646.1504	7659913.9	49.0618	10	39.1
50028	B66	622667.1492	7659929.7	49.3368	10	39.3
50027	B67	622686.2425	7659944.6	49.945	7	42.9
50026	B68	622721.797	7659971.7	51.3858	12	39.4
50025	B69	622737.0864	7659983.7	51.9925	11	41.0
50024	B70	622761.4216	7660003.9	52.8468	15	37.8
50022	B71	622782.5274	7660020.5	52.6169	15	37.6
50017	B72	622497.7269	7659916.5	56.8934	11	45.9
50016	B73	622472.3893	7659901	56.9744	10	47.0
Sonic Borings						
50106	S1	622681.0653	7659695.9	45.8758	37	8.9
50081	S2	622756.4733	7659793.2	46.2353	16	30.2
50051	S3	622561.5715	7659738.8	40.9535	37.5	3.5
50044	S4	622628.3248	7659819.3	47.2534	13	34.3
Ground Penetrating Radar Line Initiation Points						
50087	G1	622692.555	7659664.4	45.7443	N/A	N/A
50052	G2	622532.6244	7659714.9	41.1321	N/A	N/A
50082	G3	622770.4124	7659813.9	46.3521	N/A	N/A
50099	G4	622669.622	7659729.7	46.3641	N/A	N/A
50095	G5	622648.7624	7659681.1	46.3807	N/A	N/A
50076	G6	622774.5357	7659758.7	45.2847	N/A	N/A
50088	G7	622672.6446	7659652	46.4156	N/A	N/A
50072	G8	622740.7449	7659718	45.7545	N/A	N/A
50041	G9	622757.4391	7659715.4	45.9319	N/A	N/A
50032	G10	622610.9288	7659884	48.7471	N/A	N/A
50058	G11	622563.8224	7659870.1	47.5648	N/A	N/A
50059	G12	622570.635	7659863.2	47.5237	N/A	N/A
50063	G13	622518.0143	7659832.9	45.3785	N/A	N/A
50064	G14	622545.1156	7659806.4	44.9993	N/A	N/A
50057	G15	622579.7595	7659840.2	46.4397	N/A	N/A
50055	G16	622601.4724	7659818.2	46.5946	N/A	N/A
50020	G17	622512.1089	7659878.8	47.8787	N/A	N/A
50018	G19	622503.9003	7659920.8	56.935	N/A	N/A

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APPENDIX B
GROUND PENETRATING RADAR SURVEYS

Ground Penetrating Radar (GPR) can be a valuable tool to accurately locate both metallic and non-metallic UST's and utilities, buried drums and hazardous material at some sites. It may detect objects below reinforced concrete floors and slabs. GPR may delineate trenches and excavations and, under some conditions, it may be used to locate contaminant plumes. It has been used as an archaeological tool to look for buried artifacts. It may accurately profile fresh water lake bottoms either from a boat or from a frozen lake surface. GPR may be used to locate voids below roads and runways. GPR has numerous engineering applications. It can be used in non-destructive testing of engineering material, for example, locating rebar in concrete structures and determining the thickness of concrete and other structural material.

GPR uses short impulses of high frequency radio waves directed into the ground to acquire information about the subsurface. The energy radiated into the ground is reflected back to the antenna by features having different electrical properties to that of the surrounding material. The greater the contrast, the stronger the reflection. Typical reflectors include water table, bedrock, bedding, fractures, voids, contaminant plumes and man-made objects such as UST's and metal and plastic utilities. Materials having little electrical contrast like clay and concrete pipes may not produce strong reflections and may not be seen. Data are digitally recorded or downloaded to a laptop computer for filtering and processing.

The frequency of the radar signal used for a survey is a trade off. Low frequencies (250 MHz – 50 MHz) give better penetration but low resolution so that pipes and utilities may not be seen. Pipes and utilities may be seen using higher frequencies (500 MHz) but the depth of penetration may be limited to only a few feet especially in the wet, clayey soils found in many areas of the NW USA. The GPR frequency is dependent upon the antenna. Once an antenna is selected, nothing the operator can do can increase the depth of penetration.

Radar data is ambiguous. Many buried objects produce echoes that may be similar to the echo expected from the target object. Boulders and debris produce reflections that are similar to pipes and tanks. Subtle changes in the electrical properties along a traverse caused by changes in soil type, mineralogy, grain size, and moisture content all produce "noise" that can make interpretation difficult. Interpreting radargrams is an art as much as a science.

Under some conditions, although a UST itself may not be clearly visible in a GPR record, the excavation or trench in which the UST is buried is evident. Usually GPR data is used to compliment data from other "tools". For example, a trench-like reflection but no clear UST reflection, combined with a "tank" shaped magnetic anomaly suggests the presence of a UST. Although the UST itself could not be seen using GPR, the radar showed a trench-like reflection. The magnetic data showed a large ferrous object. We would report a possible UST at that location.

GPR is often used in conjunction with magnetometer surveys. Magnetometer Surveys are very fast and large areas can be covered cost effectively. Magnetic anomalies are marked in the field, and then may be further investigated using radar.

GPR, like other geophysical tools, is excellent at detecting changes across a site, but it is poor at actually identifying the cause of the change. **The only definite way to identify buried objects is through excavation.**

ADVANTAGES - General

- When GPR data is properly interpreted subsurface objects can usually be confidently identified. This often requires the GPR data be combined with other geophysical data, surface features and historical information.
- GPR provides continuous records along traverses which, depending on the goal of the survey, may be interpreted in the field.
- At flat, open sites, for reconnaissance purposes, the antenna can be towed behind a vehicle at several mph.
- Many GPR antennas are shielded and are unaffected by surface and overhead objects and power lines.
- GPR can be used in conjunction with magnetic or EM surveys to accurately locate buried objects.

ADVANTAGES – Site specific

- With a low frequency antenna, in clean, dry, sandy soil, reflections from targets as deep as 100 feet are possible. Geologic features such as bedrock and cross bedding may be seen at some sites.
- The resolution of data is very high particularly for high frequency antennas.
- Shallow, man-made objects generally can be detected.
- Fiberglass UST's and plastic pipes can be detected using GPR.

LIMITATIONS - General

- To acquire the highest quality data, proper coupling between the antenna and the ground surface is necessary. Poor data may be obtained at sites covered with debris, an uneven surface, tall grass and brush. Objects located at curbs are difficult to see.
- Acquiring GPR data is slow. The antenna must be over the target. The signal from the antenna is cone-shaped. Reflections from objects to the side of the antenna may be seen, but their actual location relative to the antenna is not obvious.
- Penetration of the GPR signal is "site specific" and its depth of penetration at a particular site cannot be predicted ahead of time. Near surface conductive material, such as salty or contaminated ground water and wet, clay-rich soil, may attenuate the radar signal, limiting the

effective depth of the survey to several feet. Reinforced concrete also can attenuate the signal. Rebar may produce reflections that look like pipes.

- GPR may not be cost-effective for some projects. For a detailed survey mapping underground storage tanks and utilities, it may be necessary to collect data in orthogonal directions at 5-foot line spacing.

LIMITATIONS – Interpretation

- Interpretation can be difficult. Radar data are ambiguous. Subsurface objects can be detected but, in general, they cannot be identified. USTs and utilities have a characteristic reflection; however, large rocks and boulders have a similar reflection.

- The reflection visible in a GPR record is very complex and may be caused by small changes in the electrical properties of the soil. The target in mind may not produce the reflection. Due to "noise", the target may be missed. USTs and deep utilities may be missed if they are under debris and/or other pipes.

- Other methods may be necessary to aid in the interpretation of the data (use a magnetometer to detect a large metallic mass, then GPR to determine if the object is tank-like, or a utility locator to determine if there are feed lines and fill pipes leading to the object).

- Adequate contrast between the ground and the target is required to obtain reflections. UST's may be missed if they are badly corroded. Utilities made of "earth" materials like clay and concrete may not be detected since their electrical properties are similar to the surrounding soil.

- To determine the depth to an object without "ground truth", assumptions must be made regarding soil properties. Even with ground truth at several locations on the same site, changes in material across a site (therefore changes in signal velocity) can cause errors in depth measurements at other locations.