REPORT OF PAVEMENT AND GEOTECHNICAL ENGINEERING SERVICES

Ice Age Drive Final Design
Between SW Oregon Street and SW 124th Avenue
Sherwood, Oregon

For
Kittelson & Associates, Inc.
June 8, 2023

Project: SherwoodC-10-02

June 8, 2023

Kittelson & Associates, Inc.
851 SW 6th Avenue, Suite 600
Portland, OR 97204

Attention: Tony Roos

Report of Pavement and Geotechnical Engineering Services
Ice Age Drive Final Design
Between SW Oregon Street and SW 124th Avenue
Sherwood, Oregon
Project: SherwoodC-10-02

NV5 is pleased to submit this report of pavement and geotechnical engineering services for the construction of Ice Age Drive between SW Oregon Street and SW 124th Avenue in Sherwood, Oregon. This project has been prepared in general accordance with Amendment #1 dated March 16, 2023, of our Subconsultant Agreement to Kittelson & Associates, Inc., dated April 18, 2022.

We appreciate the opportunity to be of service to you and the City of Sherwood. Please contact us if you have questions regarding this report.

Sincerely,

NV5

Jeffery D. Tucker, P.E., G.E.
Principal Engineer

cc: Claire Dougherty, Kittelson & Associates, Inc.

JJP:SJ:JDT:kt
Attachments
One copy submitted
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EXECUTIVE SUMMARY

GENERAL

NV5 performed pavement and geotechnical engineering services for the proposed Ice Age Drive new alignment and widening of SW Oregon Street. This section summarizes our explorations, findings, and recommendations whereas the report provides greater detail and should be used in implementing the recommendations summarized in this section. We recommend the following project considerations:

- We reviewed available information of the east and west ends of the alignment from prior projects, including developments on the east and west ends of the alignment and a water supply facility on the east side of the alignment.
- Shallow and surface basalt bedrock was observed in some explorations, which will result in difficult explorations and will likely include blasting and advanced trenching methods.
- Existing structures and improvements are present at or near the alignment. Accordingly, some undocumented fill and other concerns related to past improvements are likely during construction.
- We completed infiltration testing in one location. Further infiltration testing should be considered once final site infiltration locations are determined.
- The near-surface soil is primarily fine grained or rich in fines. This fine-grained soil is easily disturbed during wet weather or when at a moisture content that is above optimum. If not carefully executed, site preparation, grading, utility trench work, and roadway excavation in this soil can create extensive soft areas. Significant subgrade repair costs can result.
- Given the variable subgrade conditions from east to west on the alignment, including topsoil, forest duff, organic silt, and shallow basalt, field observations will be required to establish adequate pavement subgrade support during construction.

PAVEMENT

We reviewed the subsurface information and design standards from ODOT, AASHTO, and the City of Sherwood. We used the available information to estimate the future traffic loading on Ice Age Drive and the subgrade resilient modulus on the alignment. In addition, we reviewed the pavement design recommendations for the water treatment facility on the east end. We recommend the project team select one of the two following pavement thickness options:

Pavement Section Ice Age Drive – Based on Preliminary Traffic Information (5.0 inches of AC over 9.0 inches of aggregate base)

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 3.0 inches of Level 2, ½-inch, dense ACP (base course)
- 9.0 inches of aggregate base
- Stabilization aggregate (if required)
- Subgrade geotextile

Pavement Section Ice Age Drive – WWSP Project (6.0 inches of AC over 12.0 inches of aggregate base)

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 4.0 inches of Level 2, ½-inch, dense ACP (base course, two lifts)
- 12.0 inches of aggregate base
- Stabilization aggregate (if required)
- Subgrade geotextile

Pavement Section SW Oregon Street (variable thickness of AC and aggregate base)

- 8.0 to 12.0 inches of Level 3, ½-inch, dense ACP
- 12.0 to 16.0 inches of aggregate base
- Stabilization aggregate (if required)
- Subgrade geotextile

Pavement Section East-West Roadway (5.0 inches of AC over 12.0 inches of aggregate base)

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 3.0 inches of Level 2, ½-inch, dense ACP (base course)
- 9.0 inches of aggregate base
- 3.0 inch leveling rock course
- Subgrade geotextile

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ACRONYMS AND ABBREVIATIONS

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	asphalt concrete
ACP	asphalt concrete pavement
ADT	average daily traffic
AOS	apparent opening size
ASTM	American Society for Testing and Materials
BGS	below ground surface
BPA	Bonneville Power Administration
CRBG	Columbia River Basalt Group
DCP	dynamic cone penetrometer
ESAL	equivalent single-axle load
FHWA	Federal Highway Administration
H:V	horizontal to vertical
LiDAR	light detection and ranging
ODOT	Oregon Department of Transportation
OSHA	Occupational Safety and Health Administration
OSSC	2021 Oregon Standard Specifications for Construction
PG	performance graded
psi	pounds per square inch
RQD	rock quality designation
SPT	standard penetration test
SSC	Sherwood Commerce Center
WWSP	Willamette Water Supply Program

1.0 INTRODUCTION

NV5 is pleased to submit this report of pavement and geotechnical engineering services for construction of Ice Age Drive between SW Oregon Street and SW 124th Avenue in Sherwood, Oregon. We understand the City of Sherwood (City) will construct a new road within the project limits with a new stormwater collection system, lighting, and bicycle lanes, as well as the widening of SW Oregon Street.

Figure 1 shows the approximate location of the road section. Figure 2 provides a site plan identifying the approximate locations of our exploration and the project limits. Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

1.1 BACKGROUND

Our recommendations are based on both the borings completed for this project and geotechnical explorations on nearby prior projects as outlined below:

- SW Dahlke Development (NV5, 2022b)
- Willamette Water Supply Program, WTP_1.0 Project (listed as the "WWSP project" in this report; McMillen Jacobs, 2020)
- Sherwood Commerce Center (listed as the "SCC project" in this report; GeoDesign, Inc., 2020)
- Preliminary Subsurface Investigation for Pre-purchase Due Diligence (listed as the "GRI project" in this report; GRI, 2016).

Explorations within the proposed Ice Age Drive alignment are shown on Figure 2. Exploration data includes borings, test pits, and air knife excavations from the WWSP project; test pits from the SCC project; test pits from the SW Dahlke Development; and depth to basalt from the GRI project.

2.0 PURPOSE AND SCOPE

The geotechnical and pavement investigations were performed to provide recommendations for construction within the project limits. The pavement project elements are limited to pavement and geotechnical considerations with the following scope:

- Obtained one-call utility locates for our exploration and obtained permits through the City, Washington County, and BPA.
- Reviewed nearby geotechnical and geological reports provided by the City and from NV5's database.
- Drilled 18 borings with rock coring along the proposed alignment to depths between 15 and 30.9 feet BGS.
- Completed one infiltration test at a depth of 5 feet BGS.
- Conducted DCP testing at one boring location in SW Oregon Street.
- Evaluated DCP results and soil classification results to estimate the resilient modulus of the subgrade soil.

- Conducted the following laboratory tests on soil samples collected from the explorations:
  - Twelve moisture content determinations in general accordance with ASTM D2216
  - One particle-size analysis in general accordance with ASTM D1140 for use in infiltration calculations
  - Two Atterberg limits tests in general accordance with ASTM D4318
- Provided the results of the infiltration testing.
- Estimated the traffic loading by reviewing traffic counts from nearby projects and traffic analysis completed by the design team.
- Evaluated pavement options based on subgrade conditions, soil borings, laboratory testing results, and traffic calculations.
- Provided pavement recommendations for roadway construction.
- Provided recommendations for geotechnical construction materials.
- Provided construction recommendations for site preparation, utility installation, structural fill compaction criteria, and wet/dry weather earthwork procedures based on our explorations, our review of the nearby geotechnical information, and our assumptions.

3.0 SITE CONDITIONS

3.1 SURFACE CONDITIONS

The proposed alignment follows an approximately 4,500-foot-long, east to west, curved route. The approximate alignment location is shown on Figure 2. Site grades vary from elevations of approximately 210 to 255 feet above mean sea level. The area shows signs of varied past use. The alignment of Ice Age Drive is a largely unimproved area with grasses, gravel, trees, and exposed basalt intermixed with isolated areas that have assorted structures, such as power poles and fences, debris, random structures, and some paved areas.

3.2 GEOLOGIC SETTING

3.2.1 Regional Setting

The site is in the Tualatin Basin physiographic province, which is a northwest to southeast-trending, pull-apart sub-basin of the Willamette Valley (Wilson, 1998). The Tualatin Basin is separated from adjacent sub-basins of the Willamette Valley by slightly folded and faulted basalt flows of the CRBG, which form topographic divides between adjacent basins (Popowski, 1997). The Coast Range and Chehalem Mountains bound the Tualatin Basin to the west and south, respectively, and the Tualatin Mountains (Portland Hills) bound the Portland Basin to the north and east. The region has undergone large-scale and localized tectonic activity, which has contributed to form the hills and valleys in the Willamette Valley.

3.2.2 Site Geology

The generalized geologic profile of the site consists of recent alluvium, catastrophic Missoula flood deposits, and basalt bedrock of the CRBG. The mapped geologic units are generally composed of unconsolidated sediments derived from transport and deposition processes and from in-place weathering of volcanic bedrock. The CRBG underlies the sedimentary deposits along the proposed alignment and is considered the basement material for the site (Burns et al., 1997; Schlicker and Deacon, 1967).

The following sections describe the specific geologic units that are mapped at the site and were also described in subsurface explorations conducted by others on the site.

3.2.2.1 Recent Alluvium

Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay soil deposited in the last 10,000 years along stream and river drainages and is found within the site vicinity in the Tualatin Valley and along Rock and Coffee Lake creeks.

3.2.2.2 Missoula Flood Deposits

The recent alluvium is underlain by Pleistocene Age (15,500 to 13,000 years before present) catastrophic Missoula flood deposits, which consist of poorly consolidated, fine- to coarse-grained sand, silt, and clay. The Missoula flood deposits resulted from a series of catastrophic late Pleistocene glacial outburst floods. During this time interval, enormous floods would periodically flow across eastern Washington and down the Columbia River Valley caused by failures of a glacial ice dam that impounded a large lake located in southwestern Montana (Lake Missoula). Floodwater would inundate the Willamette Valley and Tualatin Basin, leaving deposits of gravel, sand, and silt to elevations ranging from 250 to 400 feet.

In the general vicinity of the site, the Missoula floodwaters were large enough to overtop the pre-existing topographic divide between the Tualatin Valley and Willamette Valley near Sherwood, Oregon. High velocity floodwaters carved deep channels into the CRBG in the area, creating what is known as the Tonquin Scablands (Wilson, 1998). In places, the floodwaters removed decomposed and weathered basalt and eventually down cut and entrenched into less weathered material. Evidence of numerous scoured bedrock channels near the site are identifiable using LiDAR data.

Based on mapping in the area, Missoula flood deposits are anticipated along the west boundary of the site. The flood deposits are generally thin and lap onto the weathered surface of the CRBG, which occupies higher elevations at the site.

3.2.2.3 CRBG

Underlying the alluvium and flood deposits is the middle Miocene Age (20 million to 10 million years before present) CRBG. The CRBG represents the oldest geologic unit encountered at the site, which is exposed in outcrops and quarry excavations on the site and forms many of the topographic highlands within the Tualatin Valley (Wilson, 1998). The CRBG is up to 1,000 feet thick within the Tualatin Valley (Schlicker and Deacon, 1967) with individual flows ranging between 10 and 100 feet thick. The CRBG is composed of a series of basalt flows erupted from linear vent systems in southeastern Washington that flowed down the course of the ancestral Columbia River until reaching the Pacific Ocean. Some of these lava flows ponded and cooled in the northern Willamette Valley, resulting in a stacked series of basalt units. Sediments deposited on the surface of an individual basalt flow would be covered by subsequent flows, resulting in a stacked sequence of basalt flows and sedimentary interbeds. These thick flows were subsequently folded and faulted by compressional tectonics in the region.

An idealized CRBG lava flow consists of two sub-units, termed the flow top and flow interior. The flow top is often a porous, vesicular zone resulting from gas bubbles trapped during rapid cooling of the lava surface. This zone is typically intensely to moderately fractured or brecciated, the result of rapid cooling, and both vesicles and fractures may be partially filled by secondary mineralization. The flow bottom is similar to the flow top, except the weathering may not be as severe. The flow interior typically consists of very dense, moderately fractured basalt with a high mechanical strength due to crystalline mineral formation resulting from slower cooling of the lava.

A hiatus between lava flow emplacements can create conditions of deep weathering of the basalt, resulting in a breakdown of the rock minerals to clay components forming a soil horizon (saprolite). The hiatus periods may have resulted in thick sections of severely weathered basalt and deposition of sedimentary interbeds between basalt flow units. Unweathered exposures of Columbia River basalt flow interiors are excellent sources of crushed aggregate. Several active quarries in the CRBG are located east and southeast of the study area (Tigard Sand and Gravel Quarry and Knife River-Coffee Lake Quarry). Where the CRBG was exposed for an extensive period of time, the rock is decomposed to form a thick, lateritic soil consisting of clayey gravel or clayey sand containing cobbles and boulders.

3.3 SUBSURFACE CONDITIONS

We drilled 18 borings (B-1 through B-18) to depths between 15 and 30.9 feet BGS at the approximate locations shown on Figure 2. The exploration logs and laboratory testing results are presented in Appendix A. A boring was completed during the 30 percent design phase and the log is presented in Appendix B. Information from additional explorations available from projects in the area as discussed in the “Background” section, which is presented in Appendix C. The approximate locations of all previous explorations are also shown on Figure 2.

Exploration data and soil logs from prior projects in the area vary in the amount of information available at this time. The prior project explorations close to the preliminary Ice Age Drive alignment include 1 boring log (B-4 from the WWSP project), 14 test pits (4 from the SCC project, 9 from the SW Dahlke Development project, and 1 from the WWSP project), 8 air-track excavations from the WWSP project, and 5 borings showing only location and depth to bedrock from the GRI project.

3.3.1 SW Oregon Street Pavement Section

Boring B-18 was completed in SW Oregon Street to a depth of approximately 30.9 feet BGS. The pavement section observed consisted of 12 inches of AC overlying a 12-inch-thick aggregate base rock section.

3.3.2 Fill

Fill consisting of crushed rock surfacing over very dense gravel with silt and sand was observed in the boring completed during the preliminary design phase (B-1; NV5, 2022a) to a depth of 5 feet BGS. A 2- to 8-inch-thick layer of crushed rock surfacing was observed in borings B-15, B-16, and B-17.

3.3.3 Forest Duff/Topsoil/Organic Silt

A 2- to 6-inch-thick forest duff layer was encountered at the ground surface at several of the explorations near the west side of the proposed alignment. Topsoil and organic silt were identified in many of the WWSP air knife explorations as well as at WWSP-B-4; WWSP-TP-3; and the SW Dahlke Development test pits TP-1, TP-2, and TP-4 through TP-9. In addition, the surface soil generally includes a 12- to 22-inch-thick topsoil layer as well as a 4- to 8-inch-thick root zone. The topsoil/organic silt generally consists of very soft to stiff silt and includes variable amounts of organics, sand, gravel, clay, cobbles, and boulders.

3.3.4 Alluvium

The forest duff and topsoil are underlain by silt and clay at the western SCC project test pits within the preliminary alignment. The silt or clay extends to depths between 1.3 and 3 feet BGS. The silt and clay are generally medium stiff to stiff and typically include sand, gravel, cobbles, and boulders.

3.3.5 Decomposed Basalt/Residual Soil

Decomposed basalt and/or residual soil was encountered below the fill, alluvium, and topsoil layers in most of the explorations. In general, the soil unit consists of medium dense to very dense gravel with varying silt and clay content with an interbed of medium stiff to stiff silt and clay. Laboratory testing on select samples indicates moisture contents ranging from 17 to 38 percent at the time of our explorations.

3.3.6 Weathered Basalt and Basalt Bedrock

Weathered basalt and basalt bedrock was identified in 27 of the explorations. Table 1 provides a summary of depth to basalt.

Table 1. Basalt in the Explorations

Exploration	Depth to Basalt (feet BGS)
B-12	10
B-13	6
B-14	10
B-15	5
B-16	5
B-17	5
B-1 (NV5, 2022a)	13
GRI-B-28	Surface
WWSP-P-14	6
GRI-B-29	Surface
GRI-B-30	2
WWSP-P-13	2
WWSP-P-12	3
WWSP-P-11	2
WWSP-TP-3	2
WWSP-P-10	6
GRI-B-16	5
WWSP-P-9	7

Table 1. Basalt in the Explorations (continued)

Exploration	Depth to Basalt (feet BGS)
WWSP-P-8	9
GRI-B-18	4
WWSP-P-7	16
WWSP-B-4	3
TP-5 (NV5, 2022b)	5
TP-6 (NV5, 2022b)	5
TP-7 (NV5, 2022b)	6.5
TP-8 (NV5, 2022b)	6.5
TP-9 (NV5, 2022b)	7.5

Borings from the GRI project and air knife explorations from the WWSP project limit information to generalized basalt characteristics. In general, based on borings B-1 (NV5, 2022a), B-12 through B-17, and WWSP-B-4 and our interpretation of the air knife logs, the basalt is highly weathered to fresh and varies from soft (R2) to very strong (R5). Tests for unconfined compressive strength from the WWSP project range from 12,000 to 34,000 psi throughout all WWSP borings (on and outside of the proposed alignment).

3.3.7 Groundwater

During explorations for the SW Dahlke Development in December 2022, groundwater seepage was observed in test pits TP-1, TP-2, TP-4, and TP-6 at depths between 1.5 and 8 feet BGS, with approximately 6 to 8 inches of standing surface water observed in the north portion of the site. Nearby depth to groundwater mapping suggests that groundwater in the area may be present at an elevation of approximately 170 feet (Snyder, 2008), which is well below most of the site. In our opinion, the water seepage observed during our explorations is perched water. Perched groundwater zones are likely to occur along the top of the basalt, particularly during extended periods of wet weather. The depth to groundwater may fluctuate in response to prolonged rainfall, seasonal changes, changes in surface topography, and other factors not observed during this study.

3.4 INFILTRATION TESTING

We conducted one infiltration test at a depth of 5 feet BGS in boring B-1 (NV5, 2022a) and an infiltration test in boring B-4 at a depth of 5 feet BGS. The infiltration testing was performed using the encased falling head method. The exposed soil was saturated prior to performing the testing. The infiltration testing was performed with 2 feet of water head. We evaluated the records of water head and time to approximate the unfactored infiltration rate of each test. A representative soil sample was collected below the infiltration test depths for particle-size analysis.

Table 2 summarizes the results of infiltration testing and particle-size analyses. The exploration logs and results of particle-size analyses are presented in Appendix A and B.

Table 2. Infiltration Test Results

Location	Depth (feet BGS)	Soil Type at Test Depth	Measured Infiltration Rate (inches per hour)	Fines Content[1] (percent)
B-1 (NV5, 2022a)	5	SILT with gravel	>100	Not tested
B-4	5	Clayey SAND	2.6	34

1. Material passing the U.S. Standard No. 200 sieve

As summarized in Table 2, the shallow soil at the location of boring B-4 has very low infiltration capacity.

The infiltration rates presented in Table 2 are short-term field rates and factors of safety have not been applied for the type of infiltration system being considered. Correction factors should be applied to the measured infiltration rate to account for soil variations and the potential for long-term clogging due to siltation and buildup of organic material. Without additional testing, from a geotechnical perspective, we recommend a minimum factor of safety of at least 2 be applied to the field infiltration values presented in Table 2 to account for soil variability with depth.

Other infiltration testing performed in the area has resulted in variable infiltration rates from 0 to in excess of 100 inches per hour and are highly dependent on the location and depth of testing.

4.0 CONCLUSIONS

4.1 GENERAL

Based on the results of our subsurface explorations, our review of prior geotechnical reports in the area, and our engineering analysis, the geotechnical site conditions are suitable for the proposed project.

4.2 PAVEMENT

The standards used for pavement design are as follows:

- *ODOT Pavement Design Guide* (ODOT, 2011), herein referred to as the ODOT guide
- *AASHTO Guide for Design of Pavement Structures* (AASHTO, 1993), herein referred to as the AASHTO guide
- City of Sherwood *Engineering Design and Standard Details Manual* (City of Sherwood, 2022), herein referred to as the City manual

Descriptions of our input parameters and the recommended pavement designs are summarized below. If any of our design assumptions are incorrect, our office should be contacted with the appropriate information so that the pavement designs can be revised. Our specific recommendations for design and construction of the roadway are presented in the following sections. These should be incorporated into the design and implemented during construction.

4.2.1 Ice Age Drive

4.2.1.1 ESAL Calculations

As Ice Age Drive will be new construction, traffic information is estimated based on expected development and nearby data. Based on discussions with Kittelson & Associates, we understand that the ADT is assumed to be a maximum of 5,000 vehicles per day at full build out. For heavy vehicle distribution, the City provided vehicle classification count information for SW Oregon Street just east of SW Murdock Road in the eastbound direction obtained on March 3, 2016. We used the distribution from the traffic classification counts, together with the provided ADT and an assumed compound growth rate of 1.5 percent. We used the procedure in the ODOT guide to estimate a design 20-year ESAL of 402,000. Our calculation sheet is presented in Appendix D.

4.2.1.2 Design Parameters

Other pavement design parameters used in our analysis are as recommended by the ODOT and/or AASHTO guides. These input parameters are summarized as follows:

- Reliability of 85 percent for the collector road section
- An assumed resilient modulus of 7,000 psi based on our review of the subsurface information
- Overall standard deviation value of 0.49
- Initial and terminal serviceability values of 4.2 and 2.5, respectively
- Structural layer coefficients of 0.42 and 0.10 for new AC and new aggregate base, respectively
- Resilient modulus of 20,000 psi for new aggregate base
- Drainage coefficient of 1.0 for aggregate base

4.2.1.3 Required Structural Number

We used the procedure in the AASHTO guide to determine the required rehabilitation structural number based on our calculations and assumptions listed above. We recommend a required structural number of 3.18 for 20-year ESALs.

4.2.1.4 New AC Pavement

We calculated a pavement section of 5.0 inches of ACP over 9.0 inches of aggregate base for Ice Age Drive; however, plans from the WWSP project show a pavement section of 6.0 inches of AC over 12.0 inches of aggregate base. The materials recommended should conform to the specifications presented in the "Pavement Materials" section. Our recommended structure, showing the two options, is as follows:

Pavement Section Ice Age Drive – Based on Preliminary Traffic Information (5.0 inches of AC over 9.0 inches of aggregate base)

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 3.0 inches of Level 2, ½-inch, dense ACP (base course)
- 9.0 inches of aggregate base
- Stabilization aggregate (if required)
- Subgrade geotextile

Pavement Section Ice Age Drive – WWSP Project (6.0 inches of AC over 12.0 inches of aggregate base)

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 4.0 inches of Level 2, ½-inch, dense ACP (base course, two lifts)
- 12.0 inches of aggregate base
- Stabilization aggregate (if required)
- Subgrade geotextile

Note that the aggregate base sections above may not be practical in all areas due to the potential for both undocumented fill (requiring stabilization aggregate) as well as shallow basalt (base section can be reduced to 4.0 inches). In either case, field conditions should be observed during construction and the pavement base materials should be adjusted based subgrade observations and discussions with the City and the project team.

4.2.2 SW Oregon Street

We understand that a section of SW Oregon Street between approximately Stations 48+50 and 58+00 will be widened. Pavement design and recommendations for the widening are discussed below.

4.2.2.1 ESAL Calculations

We used traffic counts and classification data for SW Oregon Street (southwest of SW Tualatin Sherwood Road) from the ODOT TransGIS database. We assumed a 1.5 percent annual traffic growth rate for ESAL calculations. A summary of traffic inputs is presented in Table 3.

Table 3. Traffic Input Summary

Traffic Section	2021 Two-Way AADT	Truck Percentage	Annual Traffic Growth Rate (percent)
SW Oregon Street, southwest of SW Tualatin Sherwood Road	7,728	14.6	1.5

We calculated ESALs using the ODOT method for a 20-year design life. We selected 2,841,000 as the design ESALs for this section.

4.2.2.2 *Subgrade Resilient Modulus*

Borings B-1, B-2, and B-4 were drilled in the vicinity of the widening area. Boring B-18 was drilled in the existing pavement on SW Oregon Street. The subgrade encountered within the upper 4 feet in borings B-1, B-2, and B-4 generally consists of stiff to very stiff silt and clay with varying amounts of sand and gravel. The subgrade encountered within the upper 4.5 feet in boring B-18 generally consists of medium stiff to stiff silt with trace amounts of sand. We performed DCP testing at the location of B-18, and the estimated subgrade resilient modulus based on this test is 4,750 psi. We used this value as the design resilient modulus for subgrade.

4.2.2.3 *Other Design Parameters*

Other pavement design parameters used in our analysis are summarized in Table 4. These input parameters are recommended in the ODOT guide.

Table 4. Other Design Parameters

Parameter	Design Value
Design Reliability Level, percent	85 (Urban Minor Arterial)
Initial Serviceability, Po	4.2
Terminal Serviceability, Pt	2.5
Standard Deviation	0.49
New AC Layer Coefficient	0.42
New Aggregate Base Layer Coefficient	0.10
New Aggregate Base Resilient Modulus, psi	20,000

4.2.2.4 *Required Structural Number for New AC Pavement*

We used the procedures in the AASHTO guide to determine the required structural number for use in our design based on the estimated ESALs, subgrade resilient modulus, and the other design parameters discussed above. The required 20-year structural number amounted to 4.71.

4.2.2.5 *Pavement Design*

We performed the pavement design according to AASHTO procedures. Table 5 shows the 20-year design alternatives.

Table 5. New 20-Year Design Alternatives

Design Section	Design Alternative	AC Thickness (inches)	Aggregate Base Thickness (inches)
SW Oregon Street	1 (Minimum AC Thickness)	7.0	18.0
SW Oregon Street	2	8.0	14.0

4.2.2.6 *Pavement Widening Recommendations*

The existing pavement consists of 12.0 inches of AC over 12.0 inches of aggregate base according to the data from boring B-18. ODOT expresses that pavement widening must provide adequate drainage from underneath the existing pavement. This may require constructing the top of subgrade for the widening at the same elevation as the existing subgrade or, alternatively, an underdrain must be provided at the edge of the existing pavement that outlets beyond the new pavement structure of the widening.

Assuming that the existing pavement structure is uniform throughout the widening limits, any of the alternatives shown in Table 6 would satisfy the drainage depth requirements for the option with no underdrain.

Table 6. Pavement Widening Alternatives

Widening Section	Widening Alternative	AC Thickness[1] (inches)	Aggregate Base Thickness (inches)
SW Oregon Street	1	8.0	16.0
SW Oregon Street	2	9.0	15.0
SW Oregon Street	3	10.0	14.0
SW Oregon Street	4	12.0	12.0

1. Level 3, 1/2-inch, dense ACP

The fourth alternative in Table 6 is to match the existing pavement structure.

4.2.3 East-West Roadway

We understand that a portion of the east-west roadway from Station 1+00 to 6+62 will be constructed as part of the Ace Age Drive project. We understand that the remainder of the east-west roadway will be constructed as part of the SCC project. The approved pavement section for the SCC portion of the roadway is as follows:

- 2.0 inches of Level 2, ½-inch, dense ACP (surface course, same time as rehabilitation surface course)
- 3.0 inches of Level 2, ½-inch, dense ACP (base course)
- 9.0 inches of aggregate base
- 3.0 inch leveling rock course
- Subgrade geotextile

We recommend that the east-west roadway pavement section match the proposed section.

4.3 INFILTRATION SYSTEMS

We understand stormwater infiltration systems are being considered for the proposed development. Infiltration testing was performed in boring B-4 and in boring B-1 (NV5, 2022a). The laboratory testing indicates the near-surface soil has a high fines content.

We note that the weathered to intact basalt encountered in our explorations, which caused refusal to excavation in the SW Dahlke Development project test pits, effectively serves as an aquitard below the gravel material and will likely limit long-term/sustained infiltration. The depth to the weathered/intact basalt (where refusal to excavation was encountered) is highly variable across the site (see Table 1). We also note that due to the presence of weathered/intact basalt, infiltration water will likely migrate laterally and potentially outside the project boundary and could adversely impact neighboring properties.

Based on the subsurface soil and groundwater conditions observed in our explorations, we do not anticipate infiltration will be effective for stormwater management at the proposed infiltration pond locations.

5.0 CONSTRUCTION RECOMMENDATIONS

5.1 EROSION CONTROL

When exposed, the soil at this site can be eroded by wind and water; therefore, erosion control measures should be carefully planned and in place before construction begins. Where feasible, existing pavement and aggregate base should be left in place to protect the ground surface. Measures employed to reduce erosion include, but are not limited to, silt fences, hay bales, plastic sheeting, buffer zones of natural growth, and sedimentation ponds.

5.2 SITE PREPARATION

5.2.1 Demolition

The limits of the required demolition should be determined by the project engineer and the City, although they should include all improvements that will impede construction of the new improvements.

Demolition should include removal of existing pavement, concrete curbs, abandoned utilities, structures, and other buried elements. Demolition material should be transported off site for disposal or recycled and used on site if the material is acceptable for use as structural fill. The sides and bottom of excavations should be cut into firm material and sloped at an inclination no steeper than 1H:1V prior to installing structural fill. The resulting excavations should be backfilled with structural fill. Utility lines should be completely removed or grouted full if left in place.

5.2.2 Stripping and Clearing

Forest duff, organic silt, and topsoil are located across portions of the site. The existing topsoil, forest duff, and root zone should be stripped and removed from all proposed pavement and improvement areas. We anticipate an average stripping depth of approximately 4 to 6 inches. The actual stripping depth should be based on field observation at the time of construction. Stripped material should be transported off site for disposal or used in landscaped areas.

Existing trees and shrubs should be removed from all pavement and improvement areas. In addition, root balls should be grubbed out to the depth of the roots, which could exceed 3 feet BGS. Depending on the methods used to remove root balls, considerable disturbance and loosening of the subgrade could occur during site grubbing. We recommend that soil disturbed during grubbing operations be removed to expose firm, undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

5.2.3 Subgrade Evaluation

Upon completion of excavation and prior to the placement of fill, the exposed subgrade should be evaluated by proof rolling. The subgrade should be proof rolled with a fully loaded dump truck or similarly heavy, rubber tire construction equipment to identify soft, loose, or unsuitable areas. A member of our geotechnical staff should observe proof rolling to evaluate yielding of the ground surface. During wet weather or in areas that cannot be accessed by trucks, subgrade evaluation should be performed by probing with a foundation probe rather than proof rolling. Areas that appear soft or loose should be improved in accordance with subsequent sections of this report.

5.2.4 Construction Considerations

The native soil contains high amounts of fine-grained soil that can be disturbed when wet. If not carefully executed, site preparation, utility trench work, and foundation excavation will create extensive soft areas and significant subgrade repair costs will result. The construction methods and schedule should be carefully considered with respect to preventing trafficking on the subgrade to reduce the need to over-excavate disturbed or softened soil. Site preparation and grading may encounter shallow basalt bedrock, which will require specialized construction equipment and methods.

5.3 WET WEATHER CONSIDERATIONS

The fine-grained soil present on this site is easily disturbed during the wet season. Trafficability on the near-surface soil will likely be possible during dry periods but difficult during extended wet periods. When wet, the surface soil at the site may be easily disturbed and typically provides inadequate support for construction equipment. If not carefully executed, construction activities can create extensive soft areas and significant subgrade repair costs can result. If construction is planned when the surficial soil is wet or may become wet, the construction methods and schedule should be carefully considered with respect to protecting the subgrade to reduce the need to over-excavate disturbed or softened soil. The project budget should reflect the recommendations below if construction is planned during wet weather or when the surficial soil is wet.

In general, a 12- to 18-inch-thick granular pad is sufficient for light staging areas but is not expected to be adequate to support heavy equipment or truck traffic for haul roads and areas with repeated heavy construction. In our experience, an 18- to 24-inch-thick section should be adequate. The actual thickness of haul roads and staging areas should be based on the contractor's approach to site development and the amount and type of construction traffic. Consequently, the contractor should be responsible for selecting the locations of staging areas and haul roads and selecting the appropriate thickness of granular material for these areas.

The imported granular material should be placed in one lift over the prepared, undisturbed subgrade and compacted using a smooth-drum roller without the use of vibratory action. The granular material should meet the specifications for imported granular material in the "Structural Fill" section. In addition, a geotextile fabric can be placed as a barrier between the subgrade and granular material in areas of repeated construction traffic, if required. The geotextile should have a minimum Mullen burst strength of 250 psi and an AOS between U.S. Standard No. 70 and No. 100 sieves.

5.4 EXCAVATION

5.4.1 General Excavation

Most trench cuts should stand vertical to a depth of approximately 4 feet, provided groundwater seepage does not occur. However, sloughing is likely with trench cuts extending into gravel encountered in the test pits for the SCC project and our borings, gravel fill, and likely in undocumented fill, if encountered. Open excavation techniques may be used to excavate trenches with depths between 4 and 10 feet BGS, provided the walls of the excavation are cut at a slope of 1.5H:1V and groundwater seepage is not present. Steeper excavations will be possible in the intact basalt bedrock. Sloughing and caving should also be anticipated if an excavation encounters perched water or seepage or due to the presence of cobbles and boulders. The walls of the trench should be flattened or braced for stability and the area dewatered if seepage is encountered. If shoring is used, we recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation. All shoring should take into consideration the additional depth of excavation associated with subgrade stabilization if required.

5.4.2 Trench Rock Excavation

Decomposed basalt and intact basalt bedrock will be encountered during trench excavations and will result in difficult excavations. Cobbles and boulders were encountered in some of the explorations and are often encountered within the decomposed basalt, which will result in difficult excavation, excavations wider than anticipated, and larger trench volumes and may require specialized equipment. Excavations into the more intact basalt will require rock excavation techniques such as blasting, vertical drilling to weaken the rock, rock hammering, or directional drilling. Blasting, if attempted, will be difficult and need careful planning given the residential/commercial development in the area as well as the presence of existing utilities. Blasting adjacent to commercial and residential structures and utilities will require vibration monitoring. Per OSSC 00335 (Blasting Methods and Protection of Excavation Backslopes), a blasting consultant should be retained by the contractor to prepare a blasting plan for approval by the engineer. Blasting should be performed in accordance with OSSC 00405.42 (Rock Excavation).

5.4.3 Dewatering

Perched water and seepage could be encountered within trench excavations, especially during the rainy season. Dewatering should be expected for deeper excavations and shallow explorations during extended wet weather. The sidewalls of the trenches will need to be shored or flattened if seepage is encountered. If water is present at the base of excavations, we recommend over-excavating the subgrade by 12 to 18 inches and placing stabilization rock in the base. Dewatering of excavations is the sole responsibility of the contractor, as the contractor is in the best position to select these systems based on their means and methods.

5.4.4 Permanent Slopes

Permanent cut and fill slopes should not exceed 2H:1V. Access roads and pavement should be located at least 5 feet from the top of cut and fill slopes. The slopes should be planted with appropriate vegetation to provide protection against erosion as soon as possible after grading. Surface water runoff should be collected and directed away from slopes to prevent water from running down the face of the slope.

5.4.4.1 Stormwater Facility Slopes

The proposed stormwater facility located near SW Oregon Street is anticipated to have cuts of 5 to 10 feet below the existing ground surface. Boring B-4 is located in the approximate vicinity of the stormwater facility. We encountered decomposed basalt consisting of layers of very stiff clay and medium dense to very dense, clayey sand to 15.8 feet BGS. Slopes for the stormwater facility in the clay and clayey sand soil should not exceed 2H:1V.

5.4.5 Temporary Drainage

In addition to erosion control measures (see "Erosion Control" section), during mass grading at the site, the contractor should be made responsible for temporary drainage of surface water as necessary to prevent standing water and/or erosion at the working surface.

5.4.6 Safety

All excavations should be performed in accordance with applicable OSHA and state regulations. While we have described certain approaches to excavations in the foregoing discussions, the contractor is responsible for selecting the excavation and dewatering methods, monitoring the trench excavations for safety, and providing shoring as required to protect personnel and adjacent structures.

5.5 MATERIALS

5.5.1 Structural Fill

5.5.1.1 General

A variety of material may be used as structural fill at the site. Fill should only be placed over subgrade that has been prepared in conformance with the "Site Preparation" section. Structural fill should meet the specifications provided in OSSC 00330 (Earthwork), OSSC 00400 (Drainage and Sewers), and OSSC 02600 (Aggregates), depending on the application. All structural fill should have a maximum particle size of 4 inches, unless otherwise indicated. A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below.

A submittal should be made for each material prior to the start of construction. Each submittal should include the test information necessary to evaluate the degree to which the material's properties comply with the properties that were recommended or specified. The geotechnical engineer and other appropriate members of the design team should review each submittal.

5.5.1.2 On-Site Soil

The on-site silt, clay, and gravel is generally suitable for structural fill, provided that boulders and particles greater than 6 inches in diameter are removed or processed as described in the "Recycled On-Site Materials" section. From a geotechnical perspective, the soil is suitable for use as structural fill, provided it meets the specifications provided in OSSC 00330.12 (Borrow Material). Laboratory testing indicates that the on-site silt/clay soil was generally above optimum moisture content at the time of exploration. Significant moisture conditioning (drying) will be required to use on-site silt/clay soil for structural fill. Accordingly, extended dry weather will be required to adequately condition and place the silt/clay soil as structural fill. It will be difficult, if not impossible, to adequately compact the silt/clay soil during the rainy season or during prolonged periods of rainfall, unless it is cement amended. In general, silt/clay soil should only be used as structural fill during the dry summer months.

The gravel unit contains varying proportions of clay, silt, cobbles, and boulders. Portions of the gravel containing more than approximately 10 percent silt/clay particles will be difficult to compact during periods of wet weather. Boulders and cobbles over 8 inches in diameter should be removed if the material is used as structural fill. Large equipment with high energy will be needed to adequately compact gravel soil containing cobbles.

When used as structural fill, the on-site soil should be placed in lifts with a maximum uncompacted thickness of 12 inches and the fine-grained soil compacted to not less than 92 percent of the maximum dry density and the coarse-grained soil compacted to not less than 95 percent of the maximum dry density, as determined AASHTO T 99.

5.5.1.3 Recycled On-Site Materials

The on-site excavated rock, boulders, and large cobbles may be used as fill if processed to meet the requirements for their intended use. Processing includes crushing and screening, grinding in place, or other methods to meet the requirements for structural fill. The processed material should be fairly well graded and contain no metal, organic, or other deleterious material. The processed material may be mixed with on-site silt and clay or imported fill to assist in achieving the gradation requirements. We recommend that the processed recycled fill have the appropriate maximum particle size as presented in Table 7.

Table 7. Processed Fill Maximum Particle Size

Depth of Placement[1] (feet BGS)	Maximum Particle Size (inches)
0 to 2	Not recommended
2 to 6	4
6 to 10	8
Deeper than 10	12

1. Below subgrade of structural element

5.5.1.4 Imported Granular Material

Imported granular material used as structural fill should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in OSSC 00330.14 (Selected Granular Backfill) or OSSC 00330.15 (Selected Stone Backfill). The imported granular material should also be angular, should be fairly well graded between coarse and fine material, should have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, and should have at least two mechanically fractured faces. Imported granular material should be placed in accordance with OSSC 00596B.47 (Backfill Placement).

5.5.1.5 Stabilization Material

Stabilization material should consist of pit- or quarry-run rock, crushed rock, or crushed gravel and should meet the specifications provided in OSSC 00330.16 (Stone Embankment Material). In addition, the material should have a maximum particle size of 6 inches, should have less than 5 percent by dry weight passing the U.S. Standard No. 4 sieve, and should have at least two mechanically fractured faces. The material should be free of organic material and other deleterious material. Stabilization material should be placed in lifts between 12 and 18 inches thick and compacted to a firm condition.

Where stabilization material is used to stabilize construction haul roads, a geotextile should be placed as a barrier between the soil subgrade and the imported granular material. Placement of the imported granular fill should be done in conformance with the specifications provided in OSSC 00331 (Subgrade Stabilization). The geotextile fabric should meet the specifications provided below for subgrade geotextiles. Geotextile is not required where stabilization material is used at the base of utility trenches.

5.5.1.6 Trench Backfill

Trench backfill placed beneath, adjacent to, and for at least 12 inches above utility lines (i.e., the pipe zone) should consist of well-graded granular material with a maximum particle size of 1½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in OSSC 00405.13 (Pipe Zone Material). The pipe zone backfill should be compacted to at least 90 percent of the maximum dry density, as determined by AASHTO T 99, or as required by the pipe manufacturer or local building department.

Within roadway alignments, the remainder of the trench backfill up to the subgrade elevation should consist of well-graded granular material with a maximum particle size of 2½ inches and less than 7 percent by dry weight passing the U.S. Standard No. 200 sieve and should meet the specifications provided in OSSC 00405.14 (Trench Backfill; Class B, C, or D). This material should be compacted to at least 92 percent of the maximum dry density, as determined AASHTO T 99, or as required by the pipe manufacturer or local building department. The upper 3 feet of the trench backfill should be compacted to at least 95 percent of the maximum dry density, as determined by AASHTO T 99.

Outside of roadway alignments, trench backfill placed above the pipe zone may consist of general fill material that is free of organic material and material over 6 inches in diameter and meets the specifications provided in OSSC 00405.14 (Trench Backfill; Class A, B, C, or D). This general trench backfill should be compacted to at least 90 percent of the maximum dry density, as determined by AASHTO T 99, or as required by the pipe manufacturer or local building department.

5.5.2 Geotextile Fabric

5.5.2.1 Subgrade Geotextile

The subgrade geotextile should meet the specifications provided in OSSC Table 02320-4 – Geotextile Property Values for Subgrade Geotextile (Separation). The geotextile should be installed in conformance with OSSC 00350 (Geosynthetic Installation). A minimum initial aggregate base lift of 6 inches is required over geotextiles. All stabilization material should be underlain by a subgrade geotextile. Geotextile is not required where stabilization material is used at the base of utility trenches.

5.5.2.2 Drainage Geotextile

Drainage geotextile should meet the specifications provided in OSSC Table 02320-1 – Geotextile Property Values for Drainage Geotextile. The geotextile should be installed in conformance with OSSC 00350 (Geosynthetic Installation). A minimum initial aggregate base lift of 6 inches is required over geotextiles.

5.5.3 Pavement Materials

A submittal should be made for each pavement material prior to the start of paving operations. Each submittal should include the test information necessary to evaluate the degree to which the material's properties comply with the properties that were recommended or specified. The geotechnical engineer and other appropriate members of the design team should review each submittal.

5.5.3.1 AC

For Ice Age, the AC should be Level 2, ½-inch, dense ACP and for SW Oregon Street, it should be Level 3, ½-inch, dense ACP according to OSSC 00744 (Asphalt Concrete Pavement). Minimum and maximum lift thicknesses are 2.0 and 3.0 inches for ½-inch ACP, respectively. An adjustment to lift thicknesses outside this range should be reviewed by both NV5 and the City. Asphalt binder should be performance graded. For typical Level 2 and Level 3 ACP, we recommend PG 64-22 binder; however, the binder grade should be adjusted depending on the aggregate gradation and amount of reclaimed asphalt pavement and/or recycled asphalt shingles in the contractor's mix design submittal.

5.5.3.2 Aggregate Base

Imported granular material used as aggregate base should be clean, crushed rock or crushed gravel and sand that are dense graded. The aggregate base should meet the gradation defined in OSSC 00640 (Aggregate Base and Shoulders), with the exception that the aggregate has less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve, a maximum particle size of 1½ inches, and at least two mechanically fractured faces. The aggregate base should be compacted to not less than 95 percent of the maximum dry density, as determined by AASHTO T 99.

5.6 FILL PLACEMENT AND COMPACTION

Fill soil should be compacted at a moisture content that is within 3 percent of optimum. The maximum allowable moisture content varies with the soil gradation and should be evaluated during construction. Fill and backfill material should be placed in uniform, horizontal lifts and compacted with appropriate equipment. The maximum lift thickness will vary depending on the material and compaction equipment used but should generally not exceed the loose thicknesses provided in Table 8. Fill material should be compacted in accordance with the compaction criteria provided in Table 9.

Due to the relatively high proportion of cobbles in the on-site gravel soil, we recommend this material be compacted with large compaction equipment with high energy. NV5 should be consulted to determine if the proposed compaction equipment will be sufficient to compact the gravel soil. It may not be possible to evaluate material containing cobbles with a nuclear density gauge. In this case, NV5 should evaluate compaction based on the contractor's selected means and methods and observing proof rolls for every lift of fill with loaded dump trucks.

Table 8. Recommended Uncompacted Lift Thickness

Compaction Equipment	Recommended Uncompacted Lift Thickness (inches)		
	Silty/Clayey Soil	Granular and Crushed Rock Maximum Particle Size ≤ 1½ Inches	Crushed Rock Maximum Particle Size > 1½ Inches
Hand tools: Plate compactor and jumping jack	4 to 8	4 to 8	Not recommended
Rubber tire equipment	6 to 8	10 to 12	6 to 8
Light roller	8 to 10	10 to 12	8 to 10
Heavy roller	10 to 12	12 to 18	12 to 16
Hoe pack equipment	12 to 16	18 to 24	18 to 24

The table above is based on our experience and is intended to serve only as a guideline. The information provided in this table should not be included in the project specifications.

Table 9. Compaction Criteria

Fill Type	Compaction Requirements in Structural Zones		
	Percent Maximum Dry Density Determined by ASTM D1557		
	0 to 2 Feet Below Subgrade (percent)	Greater Than 2 Feet Below Subgrade (percent)	Pipe Zone (percent)
Area fill (granular)	95	95	-----
Area fill (fine grained)	92	92	-----
Aggregate base	95	95	-----
Trench backfill[1,2]	95	92	90[1,2]
Retaining wall backfill	95[3]	92[3]	-----

1. Trench backfill above the pipe zone in non-structural areas should be compacted to 85 percent.
2. Or as recommended by the pipe manufacturer.
3. Should be reduced to 90 percent within a horizontal distance of 3 feet from the retaining wall.

6.0 OBSERVATION OF CONSTRUCTION

Satisfactory earthwork and pavement performance depend to a large degree on the quality of construction. Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to determine if subsurface conditions change significantly from those anticipated.

7.0 LIMITATIONS

We have prepared this report for use by Kittelson & Associates, Inc., the City of Sherwood, and the design and construction team for the proposed project. The report can be used for bidding or estimating purposes, but our report, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other sites.

Exploration observations indicate soil conditions and pavement conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata, pavement, or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary.

The site development plans and design details were preliminary at the time this report was prepared. When the design has been finalized and if there are changes in the site grades or location, configuration, design loads, or type of construction, the conclusions and recommendations presented may not be applicable. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty, express or implied, should be understood.

♦ ♦ ♦

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

NV5

Jessica Pence, E.I.T.
Project Manager

Jeffery D. Tucker, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
74942PE
OREGON
July 13, 2004
JEFFERY D. TUCKER
EXPIRES: 6/30/24

REFERENCES

AASHTO, 1993, *AASHTO Guide for Design of Pavement Structures,* American Association of State Highway and Transportation Officials

Burns, Scott, Growney, Lawrence, Brodersen, Brett, Yeats, Robert S., Popowski, Thomas A., 1997, Map showing faults, bedrock geology, and sediment thickness of the western half of the Oregon City 1:100,000 quadrangle, Washington, Multnomah, Clackamas, and Marion Counties, Oregon, Oregon Department of Geology and Mineral Industries, IMS-75, scale 1:100,000.

City of Sherwood, 2022, *Engineering Design and Standard Details Manual,* July 1, 2009, revised August 15, 2022.

GeoDesign, Inc., 2020. DRAFT *Due Diligence Engineering Services; Sherwood Commerce Center; 21600 SW Oregon Street; Washington County, Oregon,* dated March 17, 2020.

GRI, 2016. DRAFT *Preliminary Subsurface Investigation for Pre-purchase Due Diligence; 90-Acre Site; 12900 SW Tualatin-Sherwood Road; Sherwood, Oregon,* dated April 13, 2016.

McMillen Jacobs, 2020. *Willamette Water Supply Program, WTP_1.0, Geotechnical Engineering Report*, dated May 12, 2020.

NV5, 2022a. DRAFT *Report of Pavement and Geotechnical Engineering Services; Ice Age Drive Extension; Between SW Oregon Street and SW 124th Avenue; Sherwood, Oregon,* dated July 28, 2022.

NV5, 2022b. *Due Diligence Geotechnical Engineering Report; SW Dahlke Development; 21775 SW Dahlke Lane; Sherwood, Oregon,* dated December 29, 2022.

ODOT, 2011, *ODOT Pavement Design Guide,* Pavement Services Unit, Oregon Department of Transportation, August 2011.

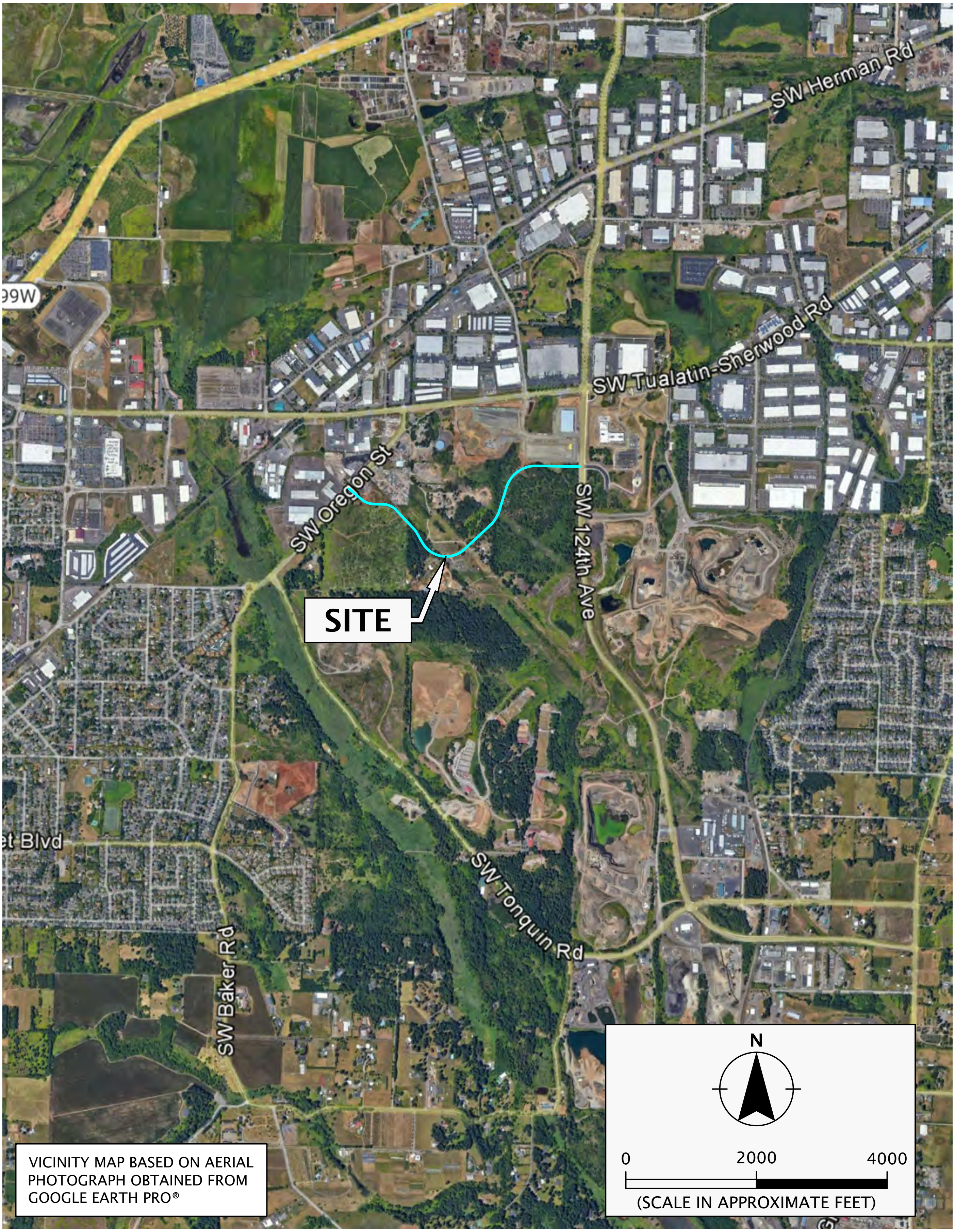
Popowski, Thomas, A., 1997, Geology, Structure, and Tectonic History of the Tualatin Basin, Northwestern Oregon, Unpublished Master of Science Thesis, Oregon State University, 126 p.

Schlicker, Herbert G., and Deacon, Robert J., 1967, Engineering Geology of the Tualatin Valley Region, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 60, 103 p.

Snyder, D. T., 2008. Estimated Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area. Prepared in cooperation with the City of Portland, the City of Gresham, Clackamas County's Water Environment Services, and Multnomah County. USGS Scientific Investigations Report 2008-5059.

Wilson, Doyle C., 1998, Post-middle Miocene Geologic Evolution of the Tualatin Basin, Oregon, Oregon Geology, vol. 60, no. 5., p. 99-116.

FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

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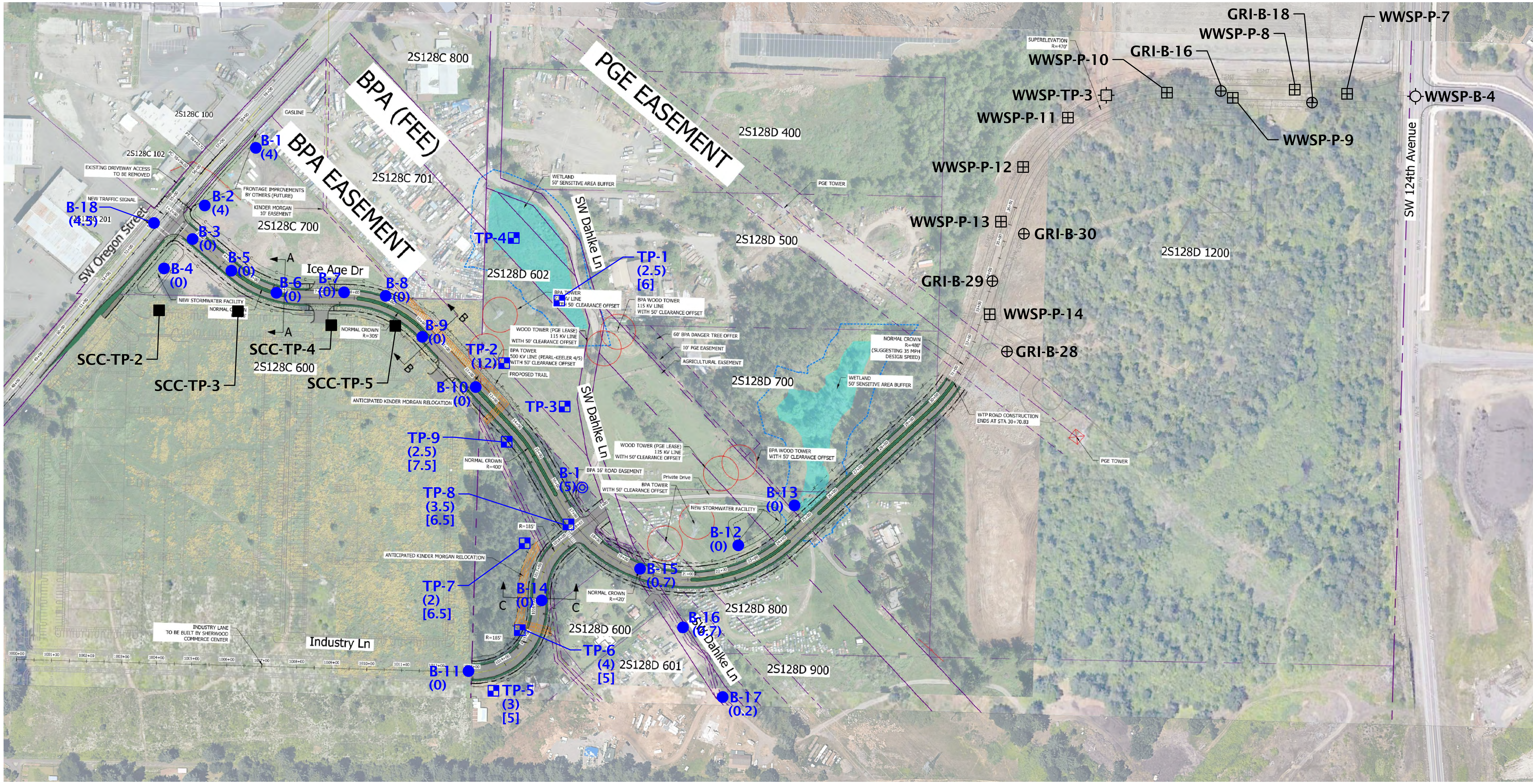
File Name: J:\S-Z\SherwoodC\SherwoodC-10\SherwoodC-10-02\Figures\CAD\SherwoodC-10-02-VM01.dwg | Layout: FIGURE 1

NV5	SHERWOODC-10-02	**VICINITY MAP**	
	JUNE 2023	ICE AGE FINAL DESIGN SHERWOOD, OR	**FIGURE 1**



LEGEND:

B-1 ●	BORING
B-1 ◎	PRIOR BORING (NV5, 2022)
TP-1	PRIOR TEST PIT (NV5, 2022)
(2.5)	DEPTH TO DECOMPOSED BASALT (FEET BGS)
[6]	DEPTH TO REFUSAL ON BASALT (FEET BGS)
SCC-TP-2 ■	PRIOR TEST PIT (GEODESIGN, 2020)
WWSP-B-4	PRIOR BORING (MCMILLEN JACOBS, 2020)
WWSP-TP-3	PRIOR TEST PIT (MCMILLEN JACOBS, 2020)
WWSP-P-7 ⊞	PRIOR PROBE (MCMILLEN JACOBS, 2020)
GRI-B-16 ⊕	PRIOR BORING (GRI, 2016)

N

0 300 600

(SCALE IN FEET)

NOTES:

1. SITE PLAN BASED ON IMAGE OF ICE AGE DRIVE EXTENSION PRELIMINARY PLAN AND PROFILE DATED JUNE 2023, PREPARED BY KITTELSON & ASSOCIATES.
2. AERIAL PHOTOGRAPH DATED JULY 10, 2022, OBTAINED FROM GOOGLE EARTH PRO.

FIGURE 2

SITE PLAN

ICE AGE FINAL DESIGN
SHERWOOD, OR

SHERWOODC-10-02

JUNE 2023

NV5

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APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

We explored the existing conditions by drilling 18 geotechnical borings (B-1 through B-18) between April 11 and 14, 2023; on April 17, 2023; and on May 12, 2023, to depths between 15 to 30.9 feet BGS using hollow-stem auger, mud rotary, and rock drilling methods by Western States Soil Conservation, Inc. of Hubbard, Oregon. The exploration logs are presented in this appendix.

The approximate exploration locations are shown on Figure 2. The exploration locations were determined using a hand-held GPS and should be accurate implied by the methods used. The explorations were completed under the supervision of NV5.

SOIL AND ROCK SAMPLING

We collected soil and rock samples from the boring using the following methods:

- We collected soil samples using a 1½-inch-inside diameter, split-spoon sampler (SPT sampler). The split-spoon sampling was conducted in general accordance with ASTM D1586. The split-spoon sampler was driven into the soil with 140-pound hammer free falling 30 inches. The sampler was driven a total distance of 18 inches. The number of blows required to drive the sampler the final 12 inches is recorded on the boring logs, unless otherwise noted. Disturbed samples were collected from the split barrel for subsequent classification and index testing.
- Rock was cored continuously using HQ wireline rock drilling methods in general accordance with ASTM D2113. Percent core recovery and RQD is noted on the exploration log. RQD is determined by summing the length of intact pieces of core longer than 4 inches and dividing by the length of the core advance.

Sampling methods and intervals are shown on the exploration logs.

The average efficiencies of the automatic SPT hammers used by Western States Soil Conservation, Inc. were 75.1 and 77.5 percent. The results of the calibration testing are presented at the end of this appendix.

SOIL AND ROCK CLASSIFICATION

We classified the soil and rock samples in accordance with the “Exploration Key” (Table A-1), “Soil Classification System” (Table A-2), and “Rock Classification System” Table A-3), which are presented in this appendix. The exploration log indicates the depths at which the soils or rock or their characteristics change, although the change actually could be gradual. Classifications are shown on the exploration log.

LABORATORY TESTING

We visually examined soil samples collected from the explorations to confirm field classifications. We also performed the following laboratory testing.

MOISTURE CONTENT

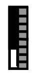
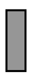
The natural moisture content of select soil samples was determined in general accordance with ASTM D2216. The natural moisture content is a ratio of the weight of the water to the weight of dry soil in a test sample and is expressed as a percentage. The test results are presented in this appendix.

PARTICLE-SIZE ANALYSIS

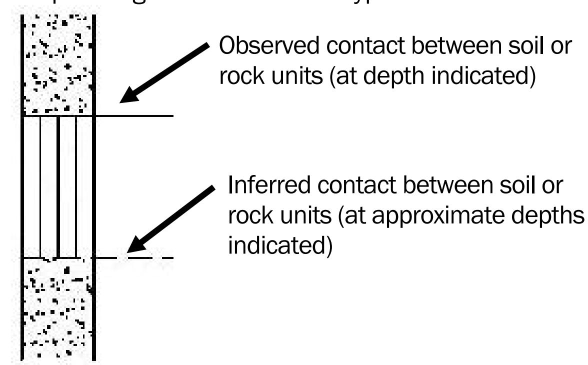
Particle-size analysis was performed on a select soil sample in general accordance with ASTM D1140. This test is a quantitative determination of the amount of material finer than the U.S. Standard No. 200 sieve expressed as a percentage of soil weight. The test results are presented in this appendix.

ATTERBERG LIMITS TESTING

Atterberg limits (plastic and liquid limits) testing was performed on select soil samples in general accordance with ASTM D4318. The plastic limit is defined as the moisture content where the soil becomes brittle. The liquid limit is defined as the moisture content where the soil begins to act similar to a liquid. The plasticity index is the difference between the liquid and plastic limits. The test results are presented in this appendix.

SYMBOL	SAMPLING DESCRIPTION
	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test (SPT) with recovery
	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
	Location of sample collected using 3-inch-outside diameter California split-spoon sampler and 140-pound hammer with recovery
	Location of grab sample
	Rock coring interval
	Water level during drilling
	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS			
ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Non-Plastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS			
CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Test (SPT) Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Test (SPT) Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.

Percent	Silt and Clay In: Fine-Grained Soil	Silt and Clay In: Coarse-Grained Soil	Percent	Sand and Gravel In: Fine-Grained Soil	Sand and Gravel In: Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

NV5	SOIL CLASSIFICATION SYSTEM	TABLE A-2

HARDNESS	DESCRIPTION
Extremely soft (R0)	Indented by thumbnail
Very soft (R1)	Can be peeled by pocket knife or scratched with finger nail
Soft (R2)	Can be peeled by a pocket knife with difficulty
Medium hard (R3)	Can be scratched by knife or pick
Hard (R4)	Can be scratched with knife or pick only with difficulty
Very hard (R5)	Cannot be scratched with knife or sharp pick
WEATHERING	**DESCRIPTION**
Decomposed	Rock mass is completely decomposed
Predominantly decomposed	Rock mass is more than 50% decomposed
Moderately weathered	Rock mass is decomposed locally
Slightly weathered	Rock mass is generally fresh
Fresh	No discoloration in rock fabric
JOINT SPACING	**DESCRIPTION**
Very close	Less than 2 inches
Close	2 inches to 1 foot
Moderate close	1 foot to 3 feet
Wide	3 feet to 10 feet
Very wide	Greater than 10 feet
FRACTURING	**FRACTURE SPACING**
Very intensely fractured	Chips and fragments with a few scattered short core lengths
Intensely fractured	0.1 foot to 0.3 foot with scattered fragments intervals
Moderately fractured	0.3 foot to 1 foot with most lengths 0.6 foot
Slightly fractured	1 foot to 3 feet
Very slightly fractured	Greater than 3 feet
Unfractured	No fractures
HEALING	**DESCRIPTION**
Not healed	Discontinuity surface, fractured zone, sheared material or filling not re-cemented
Partly healed	Less than 50% of fractured or sheared material
Moderately healed	Greater than 50% of fractured or sheared material
Totally healed	All fragments bonded

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT / ● MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0.0	Stiff, brown to orange-brown with black mottled SILT with sand (ML); moist, silt has low plasticity, sand is fine to coarse.					
2.5			ATT	■	14	LL = 44% PL = 28%
4.0	Dense, orange-brown GRAVEL with clay and sand (GP-GC); moist, gravel is fine, rounded to subrounded, and friable, sand is fine to coarse (decomposed basalt).	4.0				
5.0				■	35	
7.5	very dense, pale brown to orange-brown; gravel is subangular to angular at 7.5 feet			■	50/4"	
10.0				■	36-50/5"	
15.0	black with red-brown mottles at 15.0 feet			■	28-50/4"	
20.0				■	50/4"	Surface elevation was not measured at the time of exploration.
20.3	Exploration completed at a depth of 20.3 feet. Hammer efficiency factor is 75.1 percent.	20.3				

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/11/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5 | SHERWOODC-10-02 | **BORING B-1**

JUNE 2023 | ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR | **FIGURE A-1**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	SAMPLE / BLOW COUNT / MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0.0	Very stiff, orange-brown CLAY (CL), minor sand and gravel; moist, clay has low plasticity, sand is fine to coarse, gravel is fine and rounded.			
2.5			Blow count 19	
4.0	Medium dense, orange-brown with black mottled SAND with clay (SP-SC), minor gravel; moist, sand is fine to coarse, gravel is fine, rounded to subrounded, and friable (decomposed basalt).	4.0		
5.0			Blow count 24	
7.5	very dense, pale brown with black, brown, and orange mottles, without gravel at 7.5 feet		50/5"	
10.0	Very dense, gray-brown GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse, subangular to angular, and friable, sand is fine to coarse (decomposed basalt).	10.0	50/2"	
15.0	black with orange-brown mottles; gravel is fine at 15.0 feet		50/5"	
20.0			50/3"	
20.3	Exploration completed at a depth of 20.3 feet. Hammer efficiency factor is 75.1 percent.	20.3		Surface elevation was not measured at the time of exploration.

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC%. Scale: 0, 50, 100.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Freeman
COMPLETED: 04/11/23

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 7/8 inches

NV5	SHERWOODC-10-02	BORING B-2	
	JUNE 2023	ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR	FIGURE A-2

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Very dense, orange-brown GRAVEL with clay and sand (GP-GC); moist, gravel is fine, angular, and friable, sand is fine to coarse (decomposed basalt).					
2.5					18-50/3"	Drill chatter at 2.0 feet.
5.0	dark gray with orange mottles at 5.0 feet				50/5"	
7.5	Very dense, black to dark gray-brown with orange mottled SAND with clay (SP-SC), minor gravel; moist, sand is fine to coarse, gravel is fine, subangular to angular, and friable (decomposed basalt).	7.5			19-50/5"	
10.0					23-36-50/5"	
15.0					49-50/4"	
15.8	Exploration completed at a depth of 15.8 feet. Hammer efficiency factor is 75.1 percent.	15.8				Surface elevation was not measured at the time of exploration.

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0–50–100)

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Freeman
COMPLETED: 04/11/23

BORING METHOD: mud rotary (see document text)
BORING BIT DIAMETER: 4 7/8 inches

NV5

SHERWOODC-10-02

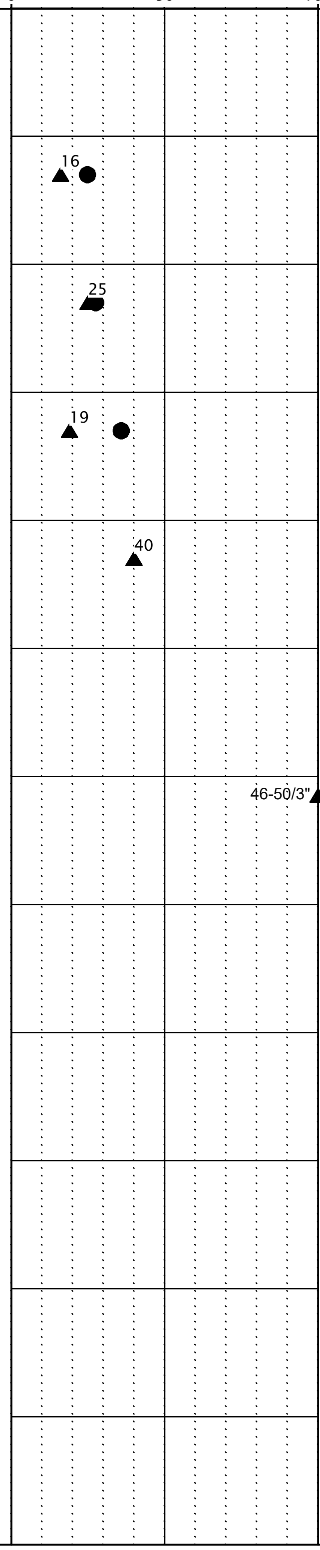
JUNE 2023

BORING B-3

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-3

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Very stiff, orange-brown CLAY (CL), minor sand and gravel; moist, clay has low plasticity, sand is fine to coarse, gravel is fine to coarse and subrounded to subangular (decomposed basalt).					
2.5					■	16	
5.0		Medium dense, orange-brown, clayey SAND (SC), minor gravel; moist, sand is fine to coarse, gravel is fine and subrounded to subangular (decomposed basalt).	4.0	P200	■	25	Grinding and chatter at 4.0 feet. Infiltration test at 5.0 feet. P200 = 34% Switched to 4 7/8-inch-diameter bit at 6.0 feet.
7.5		Very stiff, red-brown CLAY (CL), minor sand; moist, clay has low plasticity, sand is fine to coarse (decomposed basalt).	7.5	ATT	■	19	LL = 47% PL = 23%
10.0					■	40	
12.5							
15.0		Very dense, gray-brown with pale brown mottled, clayey SAND (SC); moist, sand is fine to medium, weak clay cementation (decomposed basalt).	13.0		■	46-50/3"	Driller Comment: Soil becomes more dense at 13.0 feet.
17.5		Exploration completed at a depth of 15.8 feet. Hammer efficiency factor is 75.1 percent.	15.8				Surface elevation was not measured at the time of exploration.
20.0							
22.5							
25.0							
27.5							
30.0							



DRILLED BY: Western States Soil Conservation, Inc.   LOGGED BY: S. Freeman   COMPLETED: 04/11/23

BORING METHOD: hollow-stem auger and mud rotary (see document text)   BORING BIT DIAMETER: 6 inches and 4 7/8 inches

NV5	SHERWOODC-10-02	**BORING B-4**	
	JUNE 2023	ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR	**FIGURE A-4**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
0.0		Medium dense to dense, gray-brown to orange-brown GRAVEL with silt and sand (GP-GM); moist, gravel is fine, subrounded to angular, and friable, sand is fine to coarse (decomposed basalt).					
2.5					X	30	
5.0		Dense, gray-brown to orange-brown with black mottled SAND with clay (SP-SC), minor gravel; moist, sand is fine to coarse, gravel is fine, rounded to angular, and friable (decomposed basalt).	5.0		X	33	Driller Comment: Soil varies between hard and soft while drilling.
7.0		Very stiff, gray with orange mottled CLAY (CL), minor sand; moist, clay has low plasticity, sand is fine to medium (decomposed basalt).	7.0				
7.5					X	25	
10.0		hard, with sand at 10.0 feet			X	43	
15.0		light gray with orange mottles, minor sand at 15.0 feet			X	73	
16.5		Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 75.1 percent.	16.5				Surface elevation was not measured at the time of exploration.

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0–50–100)

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/12/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-5

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-5

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT / ● MOISTURE CONTENT % / RQD% / CORE REC% (0–50–100)	INSTALLATION AND COMMENTS
0.0	Medium dense, gray and orange-brown with black mottled GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse, subrounded, and friable, sand is fine to coarse (decomposed basalt).					
2.5				▮	▲ 28 ●	
5.0	Dense, pale brown with orange mottled, clayey SAND (SC), minor gravel; moist, sand is fine to coarse, gravel is fine and subrounded (decomposed basalt, original textures observed).	4.5		▮	▲ 44	
7.5	medium dense, black with orange and pale yellow-brown mottles, without gravel at 7.5 feet			▮	▲ 20 ●	
10.0	Very stiff, orange-brown to black with orange mottled CLAY (CL), minor sand; moist, clay has low plasticity, sand is fine to coarse (decomposed basalt).	9.5		▮	▲ 23	
12.5						
15.0	with sand at 15.0 feet			▮	▲ 29	
17.5	Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 75.1 percent.	16.5				Surface elevation was not measured at the time of exploration.
20.0						
22.5						
25.0						
27.5						
30.0						

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/12/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5	SHERWOODC-10-02	BORING B-6	
	JUNE 2023	ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR	FIGURE A-6

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Very dense, orange-brown with gray mottled SAND with clay and gravel (SP-SC); moist, sand is fine to coarse, gravel is fine to coarse, subrounded to angular, and friable (2-inch-thick root zone; decomposed basalt).			Boulders (up to 18 inches in diameter) near surface.
2.5			56	
5.0	dense, orange-brown with black mottles, without gravel at 5.0 feet		36	
7.5	Very dense, gray-brown GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse, subangular to angular, and friable, sand is fine to coarse (decomposed basalt).	7.5	50/4"	Boulder from 7.5 to 8.0 feet. Very dense drilling (grinding and chatter) from 9.0 to 13.0 feet.
10.0			50/5"	
13.0	Very stiff, gray with orange mottled CLAY (CL), minor sand; moist, clay has low plasticity, sand is fine to coarse (decomposed basalt).	13.0		Driller Comment: Softer material at 13.0 feet.
15.0			29	
16.5	Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 75.1 percent.	16.5		Surface elevation was not measured at the time of exploration.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/12/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5 | SHERWOODC-10-02 | **BORING B-7**

JUNE 2023 | ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR | **FIGURE A-7**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT / MOISTURE CONTENT % / RQD% / CORE REC%	INSTALLATION AND COMMENTS
0.0	Dense, orange-brown with black and gray mottled, clayey SAND (SC), minor gravel; moist, sand is fine to coarse, gravel is fine, rounded, and friable (decomposed basalt).					Boulders (up to 24 inches in diameter) near surface.
2.5				■	32	
5.0	very dense, gray-brown, without gravel; sand is fine to medium at 5.0 feet			■	33-50/3"	
7.5				■	50/5"	
9.0	Very dense, gray-brown with orange mottled GRAVEL with clay and sand (GP-GC); moist, gravel is fine, subrounded to angular, and friable, sand is fine to coarse (decomposed basalt).	9.0				Grinding and chatter at 9.0 feet.
10.0				■	50/4"	
12.5						
15.0	gray with yellow-brown mottles at 15.0 feet			■	20-42-50/4"	
16.3	Exploration completed at a depth of 16.3 feet.	16.3				Surface elevation was not measured at the time of exploration.
	Hammer efficiency factor is 75.1 percent.					
17.5						
20.0						
22.5						
25.0						
27.5						
30.0						

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/12/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

SHERWOODC-10-02

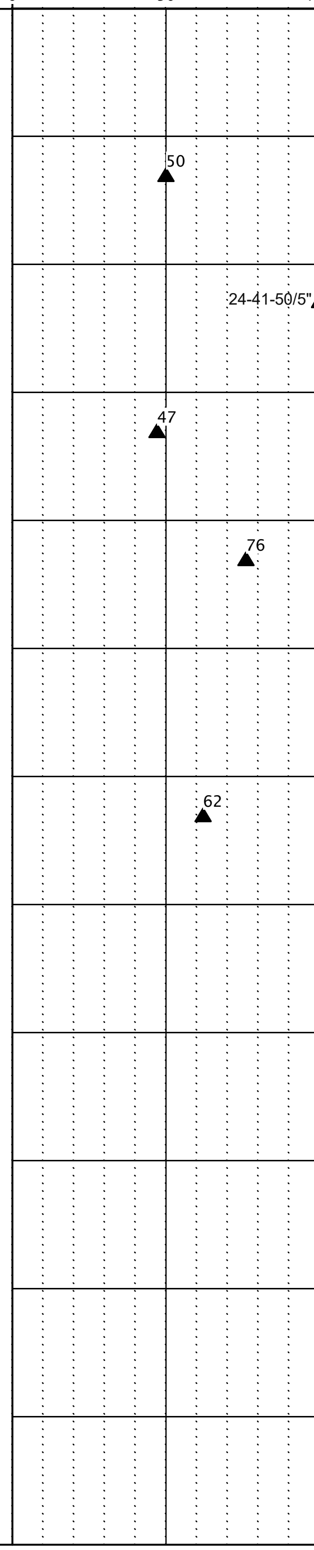
JUNE 2023

BORING B-8

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-8

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Dense to very dense, orange-brown with gray mottled GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse, subrounded, and friable, sand is fine to coarse (decomposed basalt).				
2.5			X	50	Grinding and chatter from 2.0 to 7.0 feet.
4.5	Hard, orange-brown with gray mottled CLAY (CL), minor sand; moist, clay has low plasticity, sand is fine to coarse (decomposed basalt).	4.5			
5.0			X	24-41-50/5"	
7.5	gray with orange mottles at 7.5 feet		X	47	Smoother drilling (no chatter) from 7.0 to 15.0 feet.
10.0	with sand at 10.0 feet		X	76	
15.0	black at 15.0 feet		X	62	
16.5	Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 75.1 percent.	16.5			Surface elevation was not measured at the time of exploration.



DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/13/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5	SHERWOODC-10-02	**BORING B-9**
	JUNE 2023	ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR — **FIGURE A-9**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Dense, gray-brown with orange-brown mottled GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse, subrounded to subangular, and friable, sand is fine to coarse (2-inch-thick root zone; decomposed basalt).					
2.5						33	
		Very stiff, gray-brown CLAY (CL), minor sand and gravel; moist, clay has low plasticity, sand is fine to coarse, gravel is fine and subrounded (decomposed basalt).	4.5				
5.0						24	Driller Comment: Soil is soft at approximately 6.0 feet.
7.5		medium stiff, gray to black at 7.5 feet				17	
10.0		without gravel; sand is fine to medium at 10.0 feet				17	
12.5		hard, dark gray at 13.0 feet					Driller Comment: Soil is more firm at 13.0 feet.
15.0						50/4"	Surface elevation was not measured at the time of exploration.
		Exploration completed at a depth of 15.3 feet.	15.3				
17.5		Hammer efficiency factor is 75.1 percent.					
20.0							
22.5							
25.0							
27.5							
30.0							

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/13/23

BORING METHOD: mud rotary (see document text) BORING BIT DIAMETER: 4 7/8 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-10

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-10

BORING B-11

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	Loose, orange-brown with black mottled, clayey GRAVEL with sand (GC); moist, gravel is fine to coarse, subrounded to subangular, and friable, sand is fine to coarse (decomposed basalt).			
2.5			9	
4.5	Medium dense, orange-brown with black mottled SAND with clay and gravel (SP-SC); moist, sand is fine to coarse, gravel is fine, subangular, and friable (decomposed basalt).	4.5	20	
7.5	very dense, without gravel at 7.5 feet		11-14-50/1"	
10.0	gray with orange-brown mottles; sand is fine to medium at 10.0 feet		31-50/5"	
15.0	dense, dark red-brown; sand is fine to coarse at 15.0 feet		49	
16.5	Exploration completed at a depth of 16.5 feet. Hammer efficiency factor is 75.1 percent.	16.5		Surface elevation was not measured at the time of exploration.

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0–50–100)

DRILLED BY: Western States Soil Conservation, Inc.

LOGGED BY: S. Freeman

COMPLETED: 04/13/23

BORING METHOD: mud rotary (see document text)

BORING BIT DIAMETER: 4 7/8 inches

NV5

SHERWOODC-10-02

JUNE 2023

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-11

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
0.0		Very dense, gray-brown with orange mottled, clayey GRAVEL (GC); moist, gravel is fine to coarse, subangular to angular, and friable, sand is fine to coarse (decomposed basalt).					2.5 feet, during drilling
2.5		wet at 3.0 feet				7-14-50/4"	Switched to mud rotary drilling at 2.5 feet.
5.0						50/1"	
		Very dense, gray-brown, clayey SAND (SC); moist, sand is fine to coarse (decomposed basalt).	6.0				Driller Comment: Softer soil at 6.0 feet.
7.5						50/5"	
		with gravel at 9.5 feet					
10.0		Medium hard (R3), yellow-gray BASALT; moderately weathered, moderately fractured [joint; 0-30°; very narrow; black, yellow, and green clay infill; curved to undulating; rough; not healed], aphanitic, vesicular (<1 mm, approximately 1%) (Columbia River Basalt Group).	10.0				Switched to core drilling at 10.0 feet.
12.5							
15.0		Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 75.1 percent.	15.0				Surface elevation was not measured at the time of exploration.
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/14/23

BORING METHOD: hollow-stem auger, mud rotary, HQ core drilling (see document text) BORING BIT DIAMETER: 6 inches, 4 7/8 inches, and 4 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-12

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-12

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
0.0		Very dense, gray-brown GRAVEL with clay and sand (GP-GC); moist to wet, gravel is fine, angular, and friable, sand is fine to coarse (decomposed basalt).					
2.5						50/4"	
5.0						50/2"	
		Soft to medium hard (R2-R3), gray-yellow BASALT; moderately weathered, moderately to intensely fractured [joint, 0-15° and 80-90°, very narrow, brown clay infill and iron oxide staining, curved to undulating, rough, not healed], aphanitic, vesicular (<1 mm, approximately 5%) (Columbia River Basalt Group). hard (R4), dark gray; slightly fractured [joint, 0-5°, no infill, curved], vesicular (up to 2 mm, approximately 20-30%) at 10.0 feet	6.0				Switched to core drilling at 6.0 feet.
7.5							
10.0							
12.5							
15.0		Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 75.1 percent.	15.0				Surface elevation was not measured at the time of exploration.
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/14/23

BORING METHOD: mud rotary and HQ core drilling (see document text) BORING BIT DIAMETER: 4 7/8 inches and 4 inches

NV5 | SHERWOODC-10-02 | **BORING B-13**

JUNE 2023 | ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR | **FIGURE A-13**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	BLOW COUNT / RQD% / CORE REC%	INSTALLATION AND COMMENTS
0.0	Very dense, orange-brown with gray mottled, clayey GRAVEL with sand (GC); moist, gravel is fine to coarse and subangular to angular (decomposed basalt).			Outcrop, boulders, and cobbles at the surface. Boulder from 1.0 to 2.0 feet.
2.5			13-11-50/3"	Boulder from 3.5 to 4.0 feet.
5.0	Very dense, gray GRAVEL with clay and sand (GP-GC); moist, gravel is fine to coarse and angular (fragments), sand is fine to coarse (decomposed basalt).	5.0	50/3"	
7.5			50/4"	
10.0	Medium hard (R3), dark gray to black BASALT; slightly weathered, moderately to intensely fractured [joint, 0-30°, very narrow to narrow, brown clay infill and iron oxide staining, curved to undulating, rough, not healed], aphanitic, vesicular (up to 4 mm, approximately 5-10%) (Columbia River Basalt Group).	10.0		Switched to core drilling at 10.0 feet.
15.0	Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 75.1 percent.	15.0		Surface elevation was not measured at the time of exploration.

Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0 – 50 – 100)

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

Columns: GRAPHIC LOG, TESTING, SAMPLE

DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Freeman
COMPLETED: 04/14/23

BORING METHOD: mud rotary and HQ core drilling (see document text)
BORING BIT DIAMETER: 4 7/8 inches and 4 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-14

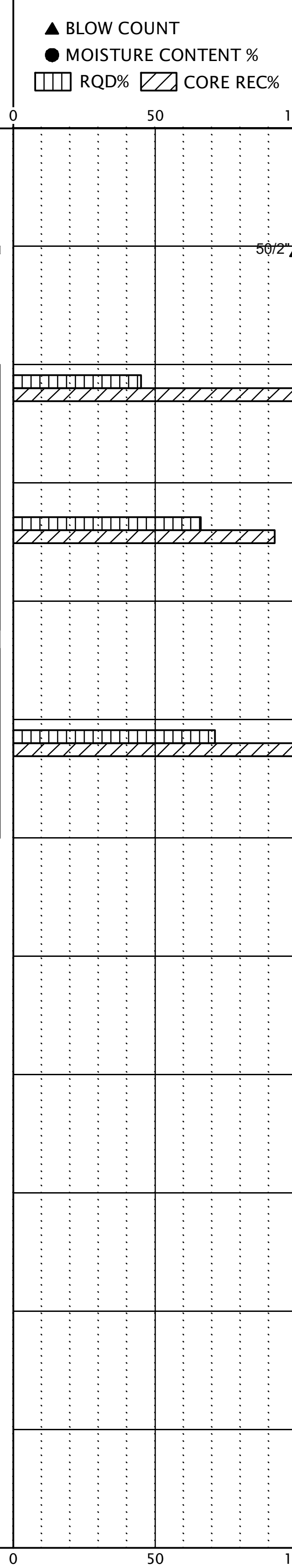
ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-14

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	INSTALLATION AND COMMENTS
0.0	CRUSHED ROCK (6.0 inches) - **FILL**.	0.5	
	Very dense, gray-brown GRAVEL with sand (GP), trace silt (rock chips); moist, gravel is fine to coarse, angular, and friable, sand is fine to medium (decomposed basalt).		
5.0	Medium hard (R3), dark gray-brown to black BASALT; slightly weathered, moderately fractured [joint, 0-10°, narrow, brown clay infill and iron oxide staining, curved to undulating, rough, not healed], aphanitic (Columbia River Basalt Group).	5.0	Switched to core drilling at 5.0 feet.
15.0	Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 75.1 percent.	15.0	Surface elevation was not measured at the time of exploration.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

Columns: GRAPHIC LOG | TESTING | SAMPLE



DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/17/23

BORING METHOD: mud rotary and HQ core drilling (see document text) BORING BIT DIAMETER: 4 7/8 inches and 4 inches

NV5	SHERWOODC-10-02	BORING B-15	
	JUNE 2023	ICE AGE DRIVE FINAL DESIGN SHERWOOD, OR	FIGURE A-15

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
0.0		CRUSHED ROCK (8.0 inches) - **FILL**.					
		Very dense, gray-brown, clayey SAND with gravel (SC); moist, sand is fine to coarse, gravel is fine and angular (decomposed basalt).	0.7			25-50/5"	
5.0		Medium hard to hard (R3-R4), dark gray BASALT; fresh to slightly weathered, slightly fractured [joint, 0-45˚, very narrow, light orange to green staining, curved, smooth to rough, not healed], aphanitic, vesicular (1-3 mm, <5%) (Columbia River Basalt Group).	5.0			50/1"	Switched to core drilling at 5.0 feet.
15.0		Exploration completed at a depth of 15.0 feet. Hammer efficiency factor is 75.1 percent.	15.0				Surface elevation was not measured at the time of exploration.

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 04/17/23

BORING METHOD: mud rotary and HQ core drilling (see document text) BORING BIT DIAMETER: 4 7/8 inches and 4 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-16

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-16

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	INSTALLATION AND COMMENTS
0.0	CRUSHED ROCK (2.0 inches) - **FILL**.	0.2	
	Very dense, orange-brown to gray-brown, clayey GRAVEL (GC), minor sand; moist to wet, gravel is fine to coarse and subangular, sand is fine to coarse (decomposed basalt).		Cuttings below crushed rock are orange-brown likely some weathered basalt.
2.5	(Blow count: 50/3")		Cuttings are dark brown-gray at 3.0 feet.
5.0	Soft (R2), red-brown BASALT; moderately to intensely weathered, moderately to intensely fractured [fracture zone and joint, 0-4°, narrow, green and black clay infill with iron oxide staining, undulating, very rough, partly healed), aphanitic, vesicular (up to 2 cm, approximately 30%) (Columbia River Basalt Group).	5.0	Switched to core drilling at 5.0 feet.
7.5			
10.0	medium hard (R3), gray; slightly weathered, moderately fractured [joint, 0-10°, very narrow, iron oxide staining, curved to undulating, rough, not healed) at 11.0 feet		Vesicle percentage decreases with depth.
12.5			
15.0	vesicular (<1 mm, approximately <1%) at 15.0 feet		
	Exploration completed at a depth of 16.0 feet.	16.0	Surface elevation was not measured at the time of exploration.
17.5	Hammer efficiency factor is 75.1 percent.		
20.0			
22.5			
25.0			
27.5			
30.0			

Columns: GRAPHIC LOG; TESTING; SAMPLE; ▲ BLOW COUNT, ● MOISTURE CONTENT %, RQD%, CORE REC% (scale 0, 50, 100)

DRILLED BY: Western States Soil Conservation, Inc.

LOGGED BY: S. Freeman

COMPLETED: 04/17/23

BORING METHOD: mud rotary and HQ core drilling (see document text)

BORING BIT DIAMETER: 4 7/8 inches and 4 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-17

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-17

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	BLOW COUNT	INSTALLATION AND COMMENTS
0.0	ASPHALT CONCRETE (12.0 inches).					
	AGGREGATE BASE (12.0 inches).	1.0		⊠		
	Medium stiff to stiff, brown SILT (ML), trace sand; moist, silt has low plasticity, sand is fine.	2.0				
2.5				▮	8	
	Stiff, orange-brown with gray mottled, sandy CLAY (CL), minor gravel; moist, clay has low plasticity, sand is fine to coarse, gravel is fine, subangular, and friable (decomposed basalt).	4.5				
5.0				▮	9	
7.5	very stiff, without gravel at 7.5 feet			▮	21	
10.0	hard, dark gray with orange mottles, with gravel; gravel is fine and subangular at 10.0 feet			▮	69	
12.5						
15.0				▮	15-50/4"	
17.5						
	Very dense, orange-brown, clayey GRAVEL with boulders (GC), minor sand; wet, gravel is friable (decomposed basalt).	18.0				Heavy drill chatter at 18.5 feet. Dark black basalt fragments in cuttings.
20.0						
22.5						
	Very stiff, gray with black mottled CLAY (CH), trace sand; wet, clay has high plasticity, sand is fine.	24.0				
25.0				▮	29	
27.5						
30.0						

▲ BLOW COUNT ● MOISTURE CONTENT % ▥ RQD% ▨ CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 05/12/23

BORING METHOD: core drill and mud rotary (see document text) BORING BIT DIAMETER: 5.5 inches and 4 7/8 inches

NV5

SHERWOODC-10-02

JUNE 2023

BORING B-18

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

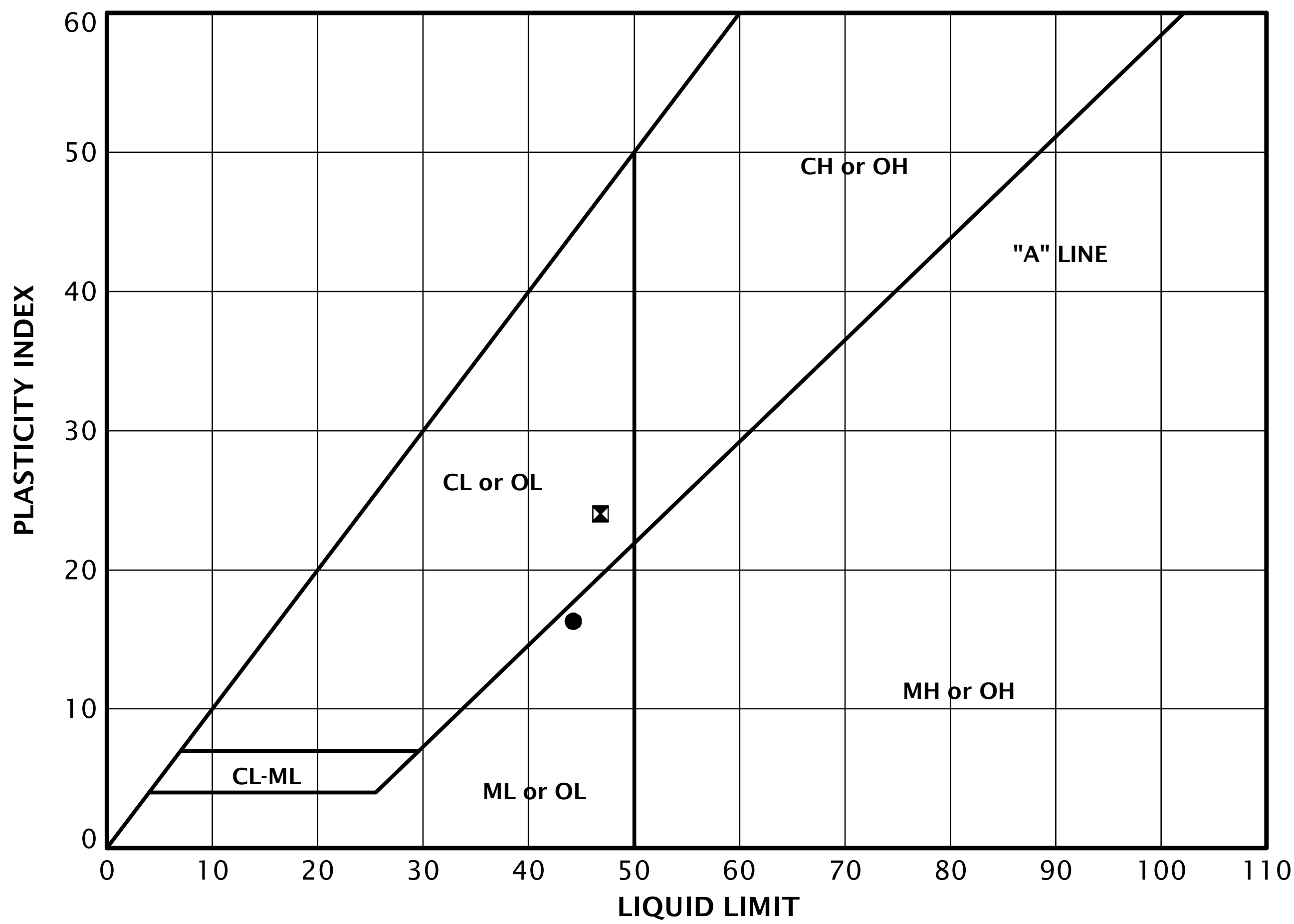
FIGURE A-18

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
30.0		dark blue-gray, with sand; sand is fine to coarse at 30.0 feet				3-50/5"	
		Exploration completed at a depth of 30.9 feet.	30.9				CORE DETAILS: No patch observed. No crack at core.
32.5		Hammer efficiency factor is 77.5 percent.					Surface elevation was not measured at the time of exploration.
35.0							
37.5							
40.0							
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							

0 50 100

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: S. Freeman COMPLETED: 05/12/23

BORING METHOD: core drill and mud rotary (see document text) BORING BIT DIAMETER: 5.5 inches and 4 7/8 inches



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-1	2.5	31	44	28	16
⊠	B-4	7.5	36	47	23	24

_ATTERBERG_LIMITS 7 SHERWOODC-10-02-B1_18.GPJ GEODESIGN.GDT PRINT DATE: 6/7/23:KT

NV5

SHERWOODC-10-02

JUNE 2023

ATTERBERG LIMITS TEST RESULTS

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-19

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	2.5		31					44	28	16
B-1	5.0		25							
B-2	2.5		34							
B-2	7.5		22							
B-4	2.5		25							
B-4	5.0		27				34			
B-4	7.5		36					47	23	24
B-6	2.5		24							
B-6	7.5		31							
B-10	2.5		17							
B-11	2.5		38							
B-11	7.5		33							

LAB SUMMARY - GDI-NV5 SHERWOODC-10-02-B1_18.GPJ GDI_NV5.GDT PRINT DATE: 6/7/23:KT

NV5

SHERWOODC-10-02

JUNE 2023

SUMMARY OF LABORATORY DATA

ICE AGE DRIVE FINAL DESIGN
SHERWOOD, OR

FIGURE A-20

Summary of SPT Test Results

Project: WSSC-8-06, Test Date: 12/23/2021

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
60.00	**9-12-11**	**23**	**28**	36	12.5	48.5	265	75.6
60.00	**10-11-13**	**24**	**30**	35	12.5	48.8	260	74.2
60.00	**7-15-18**	**33**	**41**	32	12.3	52.4	251	71.8
60.00	**7-12-15**	**27**	**33**	37	11.9	49.5	271	77.5
60.00	**10-14-14**	**28**	**35**	37	11.3	51.9	269	76.9
			Overall Average Values:	35	12.1	50.4	263	75.1
			Standard Deviation:	6	2.2	5.6	46	13.2
			Overall Maximum Value:	39	14.3	86.5	285	81.6
			Overall Minimum Value:	0	0.7	30.4	0	0.0

Summary of SPT Test Results

Project: WSSC-8-06, Test Date: 12/23/2021

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
60.00	**4-6-15**	**21**	**27**	40	13.0	51.6	267	76.4
60.00	**5-11-8**	**19**	**24**	41	13.0	58.5	288	82.4
60.00	**7-14-15**	**29**	**37**	41	13.0	57.0	274	78.2
60.00	**7-12-18**	**30**	**38**	40	13.0	49.9	266	76.0
60.00	**4-19-19**	**38**	**49**	40	12.5	51.7	267	76.2
			Overall Average Values:	41	12.9	53.3	271	77.5
			Standard Deviation:	1	0.6	3.4	9	2.7
			Overall Maximum Value:	43	15.1	58.9	296	84.5
			Overall Minimum Value:	37	11.8	38.1	251	71.7

APPENDIX B

APPENDIX B

PRIOR EXPLORATION AT THE SITE

The exploration log and laboratory testing results for boring B-1 (NV5, 2022a) are presented in this appendix.

DRAFT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		CRUSHED ROCK - **FILL**.					
		Very dense, gray to red-brown GRAVEL with silt and sand (GP-GM); moist, gravel is angular, sand is fine to coarse - **FILL**.	1.0				
2.5				SIEV		8-50/3"	Driller Comment: Very dense/hard rock (likely a boulder) at approximately 3.5 feet. Auger pulled. Boring restarted approximately 2 feet away.
5.0		Hard, pale brown to orange-brown, sandy SILT with gravel (ML); dry to moist, silt has low plasticity, sand is fine to coarse, gravel is angular (decomposed basalt).	5.0	Oth		48	Infiltration test at 5.0 feet. Oth = RES: 87.0 ohms-m Auger grinding on dense rock from approximately 6.5 to 7.0 feet. ▽ 6.0 feet, during drilling
7.5		with boulders, trace gravel; dry at 7.5 feet				39	
10.0		with gravel; moist at 10.0 feet				68	After collecting SPT at 10.0 feet, observed water in boring. Let the boring sit idle for approximately 10 minutes and the water rose up to 6.0 feet.
12.5		pale gray-brown with orange mottles at 12.5 feet				11-50/4"	
		Medium hard (R3), gray to brown BASALT; slightly to moderately weathered, moderately to intensely fractured [joint, 0-40˚, extremely narrow to very narrow, irregular, rough, surface oxidation, not healed], aphanitic.	13.0				
15.0							
17.5		[fracture zone] from 17.0 to 17.6 feet					
		Exploration completed at a depth of 18.0 feet. Hammer efficiency factor is 81.4 percent.	18.0				Surface elevation was not measured at the time of exploration.
20.0							

DRILLED BY: Western States Soil Conservation, Inc.   LOGGED BY: S. Freeman   COMPLETED: 05/06/22

BORING METHOD: hollow-stem auger and HQ core drilling (see document text)   BORING BIT DIAMETER: 4 1/4 inches and 4 inches

NV5

SHERWOODC-10-01

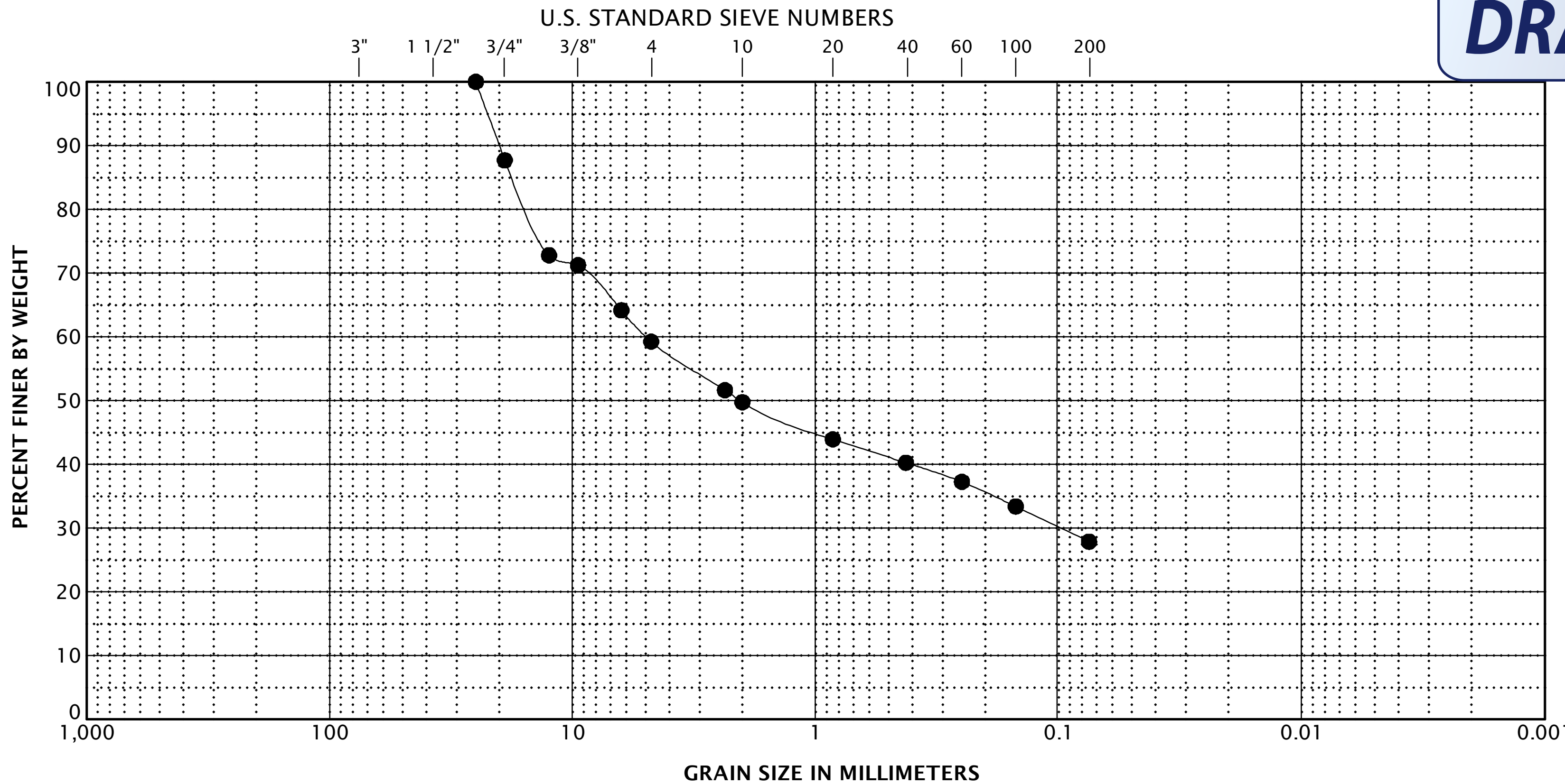
JULY 2022

BORING B-1

ICE AGE DRIVE EXTENSION
SHERWOOD, OR

FIGURE A-1

DRAFT



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	D60	D50	D30	D10	D5	GRAVEL (PERCENT)	SAND (PERCENT)	SILT (PERCENT)	CLAY (PERCENT)
●	B-1	2.5	16	4.96	2.05	0.10			41	31	28	

NIV5

SHERWOODC-10-01

JULY 2022

GRAIN-SIZE TEST RESULTS

ICE AGE DRIVE EXTENSION
SHERWOOD, OR

FIGURE A-2

DRAFT

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
B-1	2.5		16		41	31	28			
B-1	7.5		31							
B-1	10.0		27							
B-1	12.5		28							

NV5	SHERWOODC-10-01	SUMMARY OF LABORATORY DATA	
	JULY 2022	ICE AGE DRIVE EXTENSION SHERWOOD, OR	FIGURE A-3

Summary of SPT Test Results

Project: WSSC-8-06, Test Date: 12/23/2021

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
60.00	**3-3-6**	**9**	**12**	41	12.1	52.9	249	71.0
60.00	**3-5-6**	**11**	**14**	43	13.2	51.0	282	80.6
60.00	**7-10-12**	**22**	**29**	44	13.3	51.0	271	77.4
60.00	**3-11-12**	**23**	**31**	43	13.1	51.0	275	78.5
60.00	**7-11-14**	**25**	**33**	44	13.8	50.9	321	91.8
			Overall Average Values:	43	13.2	51.1	285	81.4
			Standard Deviation:	3	0.9	1.8	32	9.0
			Overall Maximum Value:	46	14.6	67.8	333	95.1
			Overall Minimum Value:	21	6.3	50.7	68	19.5

APPENDIX C

APPENDIX C

PRIOR EXPLORATIONS IN THE AREA

The exploration logs and laboratory testing results for explorations completed for the SW Dahlke Development (NV5, 2022b), WWSP project (McMillen Jacobs, 2020), SCC project (GeoDesign, Inc., 2020), and GRI project (GRI, 2016) are presented in this appendix.

FOR LAND USE PERMITTING (EXHIBIT B)

Project: WWSP_WTP_1.0
Project Location: Sherwood, OR
Project Number: 5887.0

Log of Boring WTP_1.0-B-04

Date(s) Drilled	**Feb 05 2019**	Client	**CDM Smith**	Logged By **A Havekost**	Checked By **K Elliott**
Drilling Method/ Rig Type	**HQ Wireline/CME 850 Track Mounted**	Drilling Contractor	**Western States Soil Conservation, Inc.**	Total Depth of Borehole	**15.0 ft.**
Hole Diameter	**5.00 in.**	Hammer Weight/Drop (lb/in.)/Type		Ground Surface Elevation/Datum	**269.0 ft.**
Location	**Sherwood, OR**	Coordinates	**45.363887 -122.808435**	Hammer Efficiency (%)	

Column headings: Elevation (ft.) | Water Level (ft.) | Depth (ft.) | **Material Description** | Graphic | Sample Type | Sample No. | Backfill Information | ▭ Recovery (%) ▭ RQD (%); ▲ Penetration Resistance, N (blows/ft); ■ Percent Fines (< 0.075 mm); ● Percent Water Content; ├┤ Plastic Limit - Liquid Limit (scale 0, 20, 40, 60, 80, 100) | N Value | **Remarks and Tests**

Depth (ft.)	Elevation (ft.)	Material Description	Sample No.	Remarks and Tests
0–3		Very wet, brown-black ORGANIC SILT (OL), with roots; grades to Residual Soil. [Top Soil/Residual Soil]		Red-brown drill water and roots returned.
3–15	264 (at 5 ft), 259 (at 10 ft), 254 (at 15 ft)	BASALT, very strong, fresh to slightly weathered, moderately fractured, gray, vesicular; iron-stained joints, scattered plagioclase phenocrysts up to 0.8 in. long. [Columbia River Basalt] *From 3 to 10 ft bgs, highly to intensely fractured; joints range from 35° to 45°, undulating and rough; and, ~75°, heavily iron-oxide stained.* *After 10 ft bgs, joints range from 20° to 30°; planar, undulating, smooth, iron-oxide stained.* *At 10.5 ft bgs, becomes fresh, moderately fractured, gray; diktytaxitic.*	RC1 (3–6 ft) RC2 (6–11 ft) RC3 (11–15 ft)	Rod chatter, gray-brown water and basalt chips. From 10.5-11 ft bgs, dropped core was recovered in Run 3. From 13.5-15 ft, core was stuck in casing, driller hammered and broke core.
15				Borehole completed at 15ft. below ground surface (bgs).

Depth scale: 1–25 ft. Elevation marks: 264, 259, 254, 249.

Log of Test Pit WTP_1.0-TP-03

	Test Pit Depth: 4.0 feet **Completed: 12/27/2018**	**Equipment: Hitachi 210LC** **Contractor: Richter Logging Co.** **Logged by: K. Elliott**
Depth (feet, bgs)	**Material Description**	
0.0 to 1.0	Very soft, moist, dark brown ORGANIC SILT (OL); low plasticity, numerous fine roots, estimate 60% coarse angular gravel- to cobble-size basalt rock fragments. (Possible Roadbed Fill)	
1.0 to 2.0	Soft, moist, slightly orange-brown SILTY GRAVEL with Cobbles (GM); angular coarse gravel- to cobble-size fragments of highly to completely weathered basalt in a low plasticity silt matrix. (Residual Soil)	
2.0 to 4.0	BASALT; moderately strong, highly weathered, moderately to highly fractured, joint apertures are moderately wide to wide and filled with orange-brown fines, iron oxide stains on the joint surfaces penetrate throughout fragments smaller than boulders, boulder-sizes up to at least 3 feet of apparent strong and relatively fresh rock were pulled from the excavation. Between 2.0 and 2.5 feet an intact portion of rock was observed in the west side wall; interlocking, sharp, angular, fracture-bound, cobble-sized clasts were observed and photographed; fracture apertures were filled with low plasticity fines. Practical refusal of the equipment was reached at a depth of 4.0 feet when the excavator was no longer able to pull the bottom of the test pit. (Columbia River Basalt)	

Log of Test Pit WTP_1.0-TP-04

	Test Pit Depth: 4.0 feet **Completed: 12/27/2018**	**Contractor: Richter Logging Co.** **Equipment: Hitachi 210LC** **Logged by: K. Elliott**
Depth (feet, bgs)	**Material Description**	
0.0 to 0.8	Very soft, moist, dark brown ORGANIC SILT (OL); numerous fine roots, trace angular fine to coarse gravel-size rock fragments, low plasticity. (Top Soil)	
0.8 to 4.0	Soft, slightly yellow-brown, moist, GRAVELLY SILT with Cobbles and Boulders (ML); subangular to subrounded coarse gravel- to boulder-sizes scattered in low plasticity fines. Groundwater began to seep into the excavation at 3.5 feet bgs; quickly filled the test pit to a level approximately 3.0 feet bgs; sidewalls unstable, cannot support the larger clasts; sidewalls slough; bottom of the test pit obscured by water, but a hard rock surface is present at 4.0 feet bgs.	

5887.0
Willamette Water Supply Program
Water Treatment Plant 1.0

McMILLEN JACOBS ASSOCIATES

Probe Hole Exploration Points - Summary Field Logs

Probe Hole P-7

Depth From	Depth To	Observations: Driller Log	Observations: MJA Log	Interpretation
0	1	Dirt	Yellow-brown Soil	Top Soil
1	2			
2	3			Fine-grained Missoula Flood Deposits
3	4			
4	5			
5	6			
6	7			
7	8			
8	9		Light Brown Soil	Residual Soil
9	10			
10	11			
11	12	Brown-gray mix		
12	13			
13	14			
14	15			
15	16			
16	17		Boulders or blocky-jointed rock?	Moderately weathered and highly fractured rock
17	18			
18	19			
19	20			
20	21			
21	22			
22	23			
23	24		Dark brown	Highly weathered; possible interflow zone
24	25			
25	26		Orange-brown	
26	27			
27	28			
28	29			
29	30			
30	31		Boulders or blocky-jointed rock	Moderately weathered; blocky-jointed rock
31	32			
32	33			
33	34	Gray		
34	35			

Probe Hole P-8

Depth From	Depth To	Observations: Driller Log	Observations: MJA Log	Interpretation
0	1	Dirt	Brown soil, moist	Top Soil grading to Missoula Flood Deposits grading to Residual Soil
1	2			
2	3			
3	4			
4	5		Gray rock	
5	6			
6	7			
7	8			
8	9			
9	10	Brown-gray mix		Moderately weathered rock
10	11			
11	12			
12	13	Gray-brown		
13	14			
14	15			
15	16	Dirt		Highly weathered zone; possible flow contact
16	17			
17	18			
18	19			
19	20	Brown-gray		
20	21	Dirt	Dark red-brown	
21	22			
22	23		Gray rock	
23	24			
24	25			
25	26	Brown; bit plugged w/ soil at 32 ft.		Highly weathered and intensely fractured rock
26	27			
27	28			
28	29			
29	30			
30	31		Dark brown	
31	32			

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Probe Hole Exploration Points - Summary Field Logs

Probe Hole P-9

Depth From	Depth To	Observations: Driller Log	Observations: MJA Log	Interpretation
0	1	Dirt	Slightly red-brown soil	Top Soil grading to Residual Soil
1	2			
2	3			
3	4			
4	5	Medium gray		
5	6			
6	7		Brown	Residual Soil
7	8		Gray rock	Slightly to moderately weathered rock
8	9			
9	10			
10	11			
11	12			
12	13			
13	14			
14	15	Brown-gray		
15	16			
16	17		Brown soil with brown rock;	Moderate to highly weathering
17	18			
18	19			
19	20			
20	21			
21	22			
22	23			
23	24			
24	25			
25	26		Bit plugged w/brown silt at 30 ft.	
26	27			
27	28			
28	29			
29	30	Soft, gray		
30	31		Dark gray, fine rock cuttings	Chilled zone?
31	32			
32	33			
33	34			
34	35			

Probe Hole P-10

Depth From	Depth To	Observations: Driller Log	Observations: MJA Log	Interpretation
0	1	Dirt	Red-brown Soil	Top Soil grading to Residual Soil
1	2			
2	3			
3	4			
4	5		Gray	Residual Soil
5	6			
6	7	Medium gray	Light gray rock	Slightly weathered rock
7	8			
8	9			
9	10			
10	11			
11	12		Brown rock	Increased weathering
12	13			
13	14			
14	15			
15	16			
16	17			
17	18			
18	19		Light gray rock chips	Moderately weathered rock
19	20			
20	21			
21	22			
22	23			
23	24		Slightly red-brown	Highly weathered
24	25			
25	26		Dark gray rock chips with soil	Highly weathered rock; chilled zone?
26	27			
27	28	Soft gray mix		
28	29			
29	30			
30	31			
31	32			
32	33			
33	34			
34	35			

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Water Treatment Plant 1.0

Probe Hole Exploration Points - Summary Field Logs

Probe Hole P-11

Depth		Observations		Interpretation
From	To	Driller Log	MJA Log	
0	1	Dirt		Slightly to moderately weathered rock with thin highly weathered zones
1	2			
2	3	Medium gray		
3	4			
4	5			
5	6	Brown		
6	7	Medium gray		
7	8			
8	9		Light gray rock chips; no soil cover	
9	10			
10	11			
11	12			
12	13			
13	14			
14	15			
15	16			
16	17			
17	18			
18	19			
19	20			
20	21		Bit plugged at 23 ft., but drilled consistent and uniformly to 35 ft.	
21	22			
22	23			
23	24			
24	25			
25	26			
26	27			
27	28			
28	29			
29	30			
30	31			
31	32			
32	33			
33	34	Soft, black		Possible flow contact
34	35			

Probe Hole P-12

Depth		Observations		Interpretation
From	To	Driller Log	MJA Log	
0	1	Dirt	Brown soil w/ broken gray rock	Residual Soil
1	2			
2	3			
3	4	Medium gray	Gray rock	Moderately weathered rock
4	5			
5	6			
6	7		Brown rock	Increased weathering
7	8			
8	9			
9	10			
10	11			
11	12			
12	13			
13	14		Orange-brown	Significant iron-stained jointing
14	15			
15	16			
16	17			
17	18			
18	19		Dark gray	Moderately weathered rock
19	20	Brown		
20	21	Medium gray		
21	22			
22	23			
23	24			
24	25			
25	26			
26	27			
27	28			
28	29			
29	30	Soft, black		Chilled basal contact?
30	31			
31	32			
32	33			
33	34			
34	35			

5887.0
Willamette Water Supply Program
Water Treatment Plant 1.0

Probe Hole Exploration Points - Summary Field Logs

Probe Hole P-13

Depth		Observations		Interpretation
From	To	Driller Log	MJA Log	
0	1	Dirt	Brown soil & broken rock	Residual Soil
1	2			
2	3		Light gray rock Bit plugged at 21 ft.	Slightly to moderately weathered rock
3	4			
4	5			
5	6	Brown		
6	7			
7	8			
8	9			
9	10			
10	11			
11	12			
12	13			
13	14			
14	15			
15	16			
16	17			
17	18			
18	19			
19	20			
20	21			Moderately to highly weathered rock
21	22			
22	23			
23	24		Dark brown soil; soft	
24	25			
25	26			
26	27		Light brown, soft	
27	28			
28	29			
29	30			
30	31			
31	32			
32	33			
33	34	Medium gray	Gray, soft	
34	35			

Probe Hole P-14

Depth		Observations		Interpretation
From	To	Driller Log	MJA Log	
0	1	Dirt	Brown soil, broken rock	Top Soil grading to Residual Soil
1	2			
2	3			
3	4			
4	5	Brown		
5	6			
6	7		Light gray rock; hard	Moderately weathered rock
7	8			
8	9			
9	10			
10	11			
11	12			
12	13			
13	14			
14	15			
15	16			
16	17	Medium gray		Slightly weathered Rock
17	18			
18	19			
19	20			
20	21			
21	22			
22	23			
23	24	Brown-gray mix	Brown, soft	Moderate to highly weathered rock
24	25			
25	26			
26	27			
27	28			
28	29			
29	30			
30	31		Orange-brown	Increased jointing with iron stains
31	32			
32	33			
33	34			
34	35			

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	COMMENTS
0.0	FOREST DUFF (wood chips, wood debris) (4.0 to 6.0 inches).	213.0			
	Medium stiff, brown SILT (ML), minor clay and sand, trace organics (roots, rootlets); moist (topsoil/tilled zone to 22.0 inches, 6-inch-thick root zone).	212.5 / 0.5	PP	☒	PP = 2.25 tsf
	Medium stiff to stiff, red-brown SILT (ML), minor clay and sand; moist, silt has medium plasticity.	211.1 / 1.9	PP		PP = 1.5 tsf
2.5			PP	☒	PP = 1.75 tsf
	Medium dense, red-brown, clayey GRAVEL (GC), minor sand; moist, gravel is subrounded.	210.0 / 3.0			
5.0	with cobbles; cobbles are approximately 15% at 5.0 feet			☒	
7.5					
	light gray-brown, with sand and cobbles; gravel is fine and subrounded, cobbles are approximately 5 to 10% at 9.0 feet				Minor caving observed from 9.0 to 16.5 feet.
10.0				☒	
12.5	gravel is coarse, cobbles are approximately 10 to 20% at 12.0 feet				
15.0					
	Exploration completed at a depth of 16.5 feet.	196.5 / 16.5			No groundwater seepage observed to the depth explored. Surface elevation estimated from site survey.
17.5					
20.0					

MOISTURE CONTENT % (0, 50, 100)

EXCAVATED BY: Northwest Earthmovers, Inc. LOGGED BY: J. Hook COMPLETED: 08/08/19

EXCAVATION METHOD: mini excavator (see document text)

GEODESIGN INC — AN NV5 COMPANY

HARSCHINV-23-01	TEST PIT TP-2	
MARCH 2020	SHERWOOD COMMERCE CENTER WASHINGTON COUNTY, OR	FIGURE A-2

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	COMMENTS
0.0	FOREST DUFF (wood, chips) (2.0 inches).	220.5 / 220.3 / 0.2			
	Medium stiff, brown SILT (ML), minor clay and sand, trace gravel and organics (roots, rootlets); moist (topsoil to 14.0 inches, 6-inch-thick root zone).	219.3 / 1.2	PP		PP = 1.75 tsf
2.5	Stiff, light red-brown CLAY with cobbles and boulders (CL), minor sand, trace organics (rootlets); moist, clay has low plasticity, cobbles are approximately 10%, boulders are approximately 5%.	218.0 / 2.5	PP PP	☒	PP = 2.5 tsf PP = 3.0 tsf
5.0	Medium dense to dense, red-brown, clayey GRAVEL with sand, cobbles, and boulders (GC); moist, gravel is subrounded to subangular, cobbles are approximately 20%, boulders are approximately 5 to 10%.			☒	
7.5	without boulders; gravel is fine and subrounded, cobbles are approximately 5% at 7.5 feet	212.0 / 8.5			Moderate caving observed at 8.5 feet.
10.0	Stiff, red-brown CLAY (CL), minor sand, trace silt; moist, clay has medium plasticity.	209.5 / 11.0	PP	☒	PP = 2.0 tsf Approximately 70% of rocks broken by hand.
12.5	Medium dense, red-brown, clayey GRAVEL (GC), minor sand; moist, gravel is angular (decomposed basalt).	206.5 / 14.0		☒	
15.0	Exploration completed at a depth of 14.0 feet.				No groundwater seepage observed to the depth explored. Surface elevation estimated from site survey.
17.5					
20.0					

● MOISTURE CONTENT % (scale 0 – 50 – 100)

EXCAVATED BY: Northwest Earthmovers, Inc. LOGGED BY: J. Hook COMPLETED: 08/08/19

EXCAVATION METHOD: mini excavator (see document text)

GEODESIGN INC — AN NV5 COMPANY

HARSCHINV-23-01

MARCH 2020

TEST PIT TP-3

SHERWOOD COMMERCE CENTER
WASHINGTON COUNTY, OR

FIGURE A-3

DRAFT

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	COMMENTS
0.0	FOREST DUFF (wood debris) (3.0 inches).	228.0			Moderate to severe caving observed from 0.0 to 6.0 feet.
	Medium stiff, brown SILT (ML), minor sand, gravel, and clay, trace organics (roots, rootlets); moist (topsoil to 15.0 inches, 4-inch-thick root zone).	227.7 / 0.3	PP		PP = 2.25 tsf
2.5	Medium dense, red-brown, clayey GRAVEL with cobbles and boulders (GC), minor sand; moist, cobbles are approximately 15%, boulders are approximately 10%.	226.7 / 1.3		☒	
5.0					
7.5					
10.0	Medium stiff, light brown SILT (ML), trace to minor sand, trace clay; moist, silt has low plasticity.	219.5 / 8.5	PP	☒	PP = 1.0 tsf
12.5					
15.0	Medium dense, gray with red and brown mottled, clayey GRAVEL (GC), minor sand; moist.	214.0 / 14.0			
17.5	Exploration completed at a depth of 16.0 feet.	212.0 / 16.0			No groundwater seepage observed to the depth explored. Surface elevation estimated from site survey.
20.0					

MOISTURE CONTENT % (0, 50, 100)

EXCAVATED BY: Northwest Earthmovers, Inc. LOGGED BY: J. Hook COMPLETED: 08/08/19

EXCAVATION METHOD: mini excavator (see document text)

GEODESIGN INC — AN NV5 COMPANY	HARSCHINV-23-01	**TEST PIT TP-4**
	MARCH 2020	SHERWOOD COMMERCE CENTER WASHINGTON COUNTY, OR — **FIGURE A-4**

DRAFT

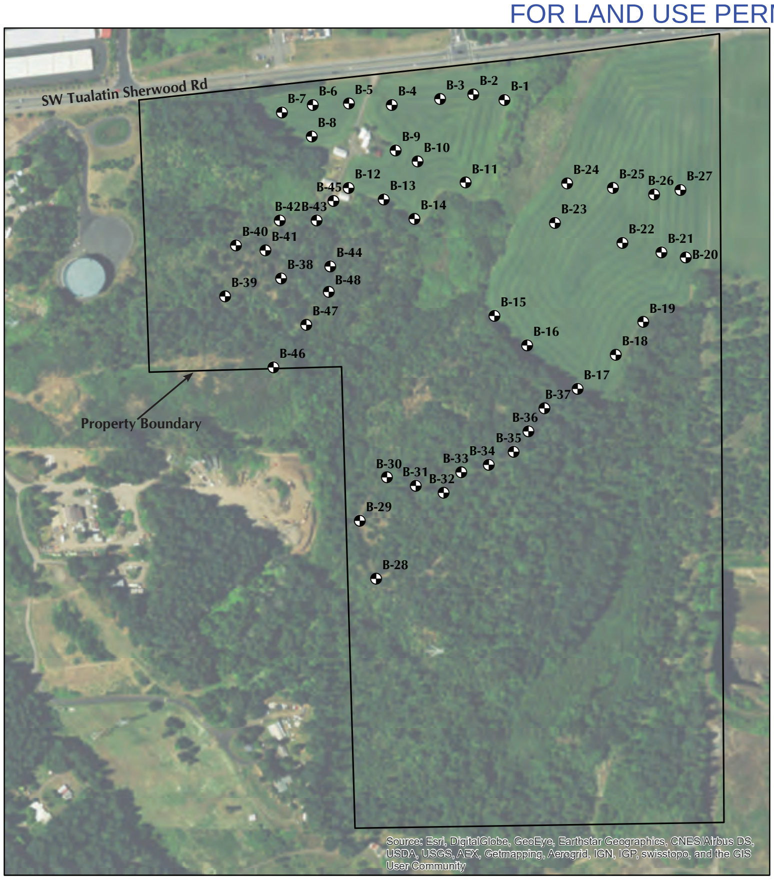
DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		FOREST DUFF (woody debris) (4.0 inches).	230.0 229.7 / 0.3				Moderate to severe caving observed from 0.0 to 7.5 feet. PP = 1.25 tsf
		Medium stiff, dark brown SILT (ML), minor organics (roots, rootlets, woody debris), minor clay, trace to minor sand and gravel; moist (topsoil to 18.0 inches, 8-inch-thick-root zone).	228.5 / 1.5	PP	☒		
2.5		Medium dense, red-brown, clayey GRAVEL with cobbles and boulders (GC), minor sand; moist, cobbles are approximately 20%, boulders are approximately 15%.			☒		
5.0		cobbles are approximately 10%, boulders are approximately 5% at 5.0 feet					Moderate caving observed from 7.5 to 15.0 feet. Gravel after 7.5 feet is angular and moderately weathered. Approximately 10% of rocks broken by hand.
7.5		Very dense, red-brown with gray mottled GRAVEL with clay (GP-GC), minor sand; moist (weathered basalt).	222.5 / 7.5		☒		
10.0							
12.5		cobbles are approximately 20%, boulders are approximately 5% at 12.0 feet					
		cobbles are approximately 40%, boulders are approximately 10% at 14.0 feet			☒		Slow groundwater seepage observed at 14.5 feet.
15.0		Exploration completed at a depth of 15.0 feet.	215.0 / 15.0				Surface elevation estimated from site survey.
17.5							
20.0							

EXCAVATED BY: Northwest Earthmovers, Inc. LOGGED BY: J. Hook COMPLETED: 08/08/19

EXCAVATION METHOD: mini excavator (see document text)

GEODESIGN INC — AN NV5 COMPANY	HARSCHINV-23-01	**TEST PIT TP-5**	
	MARCH 2020	SHERWOOD COMMERCE CENTER WASHINGTON COUNTY, OR	**FIGURE A-5**

FOR LAND USE PERMITTING (EXHIBIT B)



Boring	Latitude[5]	Longitude[5]	Ground Surface Elev. (ft)[6]	Total Depth (ft)	Depth to Very Soft (R1) to Medium Hard (R3), Moderately Weathered to Predominantly Decomposed Basalt (ft)	Depth to Soft (R2) to hard (R4), Slightly Weathered to Fresh Basalt (ft)	Depth to Groundwater (ft)
B-1	45.36863	-122.80848	195.1	15	>15	>15	3
B-2	45.36867	-122.80890	194.3	15	>15	>15	N/A
B-3	45.36862	-122.80935	195.3	15	>15	>15	N/A
B-4	45.36855	-122.81000	197.1	15	>15	>15	2.5
B-5	45.36855	-122.81058	200.1	15	9	>15	7
B-6	45.36853	-122.81107	203.4	15	8	>15	>15
B-7	45.36845	-122.81148	205.7	15	5	12	>15
B-8	45.36823	-122.81107	209.3	15	N/A	13	9.7
B-9	45.36812	-122.80993	202.6	15	>15	>15	N/A
B-10	45.36802	-122.80963	201.0	15	>15	>15	N/A
B-11	45.36783	-122.80897	199.6	15	>15	>15	N/A
B-12	45.36775	-122.81055	215.6	20	7	12	10.8
B-13	45.36765	-122.81007	214.2	20	6	11	18.2
B-14	45.36747	-122.80965	215.6	20	18	5[2]	14.8
B-15	45.36657	-122.80853	227.0	20	5	9	19.1
B-16	45.36630	-122.80808	232.8	20	5[4]	9	10.9
B-17	45.36590	-122.80738	241.1	20	N/A	6	15.9
B-18	45.36623	-122.80688	234.1	20	4	>20	16
B-19	45.36655	-122.80652	228.5	20	7	>20	8.3
B-20	45.36718	-122.80597	213.8	20	>20[3]	>20	N/A
B-21	45.36722	-122.80630	215.1	20	>20	>20	6.8
B-22	45.36730	-122.80683	214.6	20	12	>20	7.7
B-23	45.36747	-122.80775	204.4	20	12	>20	N/A
B-24	45.36785	-122.80760	200.1	15	>15	>15	2.2
B-25	45.36782	-122.80698	203.5	15	>15	>15	N/A
B-26	45.36777	-122.80642	205.1	15	>15	>15	0.4
B-27	45.36782	-122.80607	204.3	15	>15	>15	1.1
B-28	45.36403	-122.81003	256.8	23	21	0[2]	18.6
B-29	45.36458	-122.81027	249.2	23	N/A	0	>23
B-30	45.36500	-122.80992	246.6	23	2	7	7.9
B-31	45.36493	-122.80953	257.7	30	N/A	0	6.2
B-32	45.36487	-122.80915	264.7	30	2	18	9.5
B-33	45.36507	-122.80892	266.1	30	0	10	15.5
B-34	45.36515	-122.80855	267.1	30	N/A	1.5	26.3
B-35	45.36528	-122.80822	265.6	30	N/A	0	11
B-36	45.36548	-122.80803	260.1	23	N/A	3	4.9
B-37	45.36570	-122.80782	254.3	23	N/A	0.5	10.2
B-38	45.36687	-122.81143	244.5	30	N/A	2	1.9
B-39	45.36668	-122.81218	243.5	30	N/A	0	15.9
B-40	45.36717	-122.81205	248.1	30	N/A	3	1.9
B-41	45.36713	-122.81165	244.7	30	N/A	2	27.7
B-42	45.36742	-122.81147	235.6	30	N/A	1	14.7
B-43	45.36743	-122.81097	231.8	30	4	10	28.6
B-44	45.36700	-122.81077	243.5	30	N/A	3	22.4
B-45	45.36762	-122.81075	222.8	30	6	11	29.5
B-46	45.36602	-122.81150	228.7	30	6[1]	2[2]	18
B-47	45.36643	-122.81107	233.3	30	20[1]	2[2]	22
B-48	45.36675	-122.81078	242.6	30	N/A	1	>30

Notes:

1. Clay seams were observed in B-46 and B-47 at a depth of about 20 ft.
2. Zones of moderately weathered to predominantly decomposed basalt beneath fresh to slightly weathered basalt in B-14, B-28, B-46, and B-47.
3. Boulder encountered between 8 and 14 ft in boring B-20.
4. Very soft (R1) to Medium hard (R3) basalt encountered below 18 ft in boring B-16.
5. Geographic Coordinate System: North American Datum of 1983 (NAD 83). Accuracy within 15 ft horizontal for hand held unit.
6. Elevation Datum: North American Vertical Datum of 1988 (NAD 88). Accuracy within 1 ft vertical for GIS lidar.

BORING COMPLETED BY GRI
(MARCH 28 - 29, 2016)

North

0 300 600 FT

GRI

KEN LEAHY CONSTRUCTION
90-ACRE SITE

SITE MAP

APR. 2016 | JOB NO. 5838 | FIG. 1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0–50–100)	COMMENTS
0.0		Very soft, red-brown CLAY (CL), trace to minor sand, trace organics; moist to wet, sand is fine to medium (topsoil to 12 inches, 3- to 4-inch-thick root zone).		P200 PP	☒	●	P200 = 80% PP = 0.0 tsf
		with cobbles and boulders; cobbles are approximately 10 to 15%, boulders are approximately 5 to 7% at 1.5 feet					
2.5		Dense, brown, clayey GRAVEL with sand, cobbles, and boulders (GP-GC); wet, sand is fine to coarse, cobbles are subangular to angular and approximately 20%, boulders are subangular to angular and approximately 7 to 10% (decomposed basalt).	2.5		☒	●	Moderate to rapid groundwater seepage observed at 3.5 feet. Moderate to severe caving observed at 5.0 feet.
5.0							
		Exploration terminated at a depth of 6.0 feet due to refusal on weathered basalt.	6.0				Surface elevation was not measured at the time of exploration.
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.   LOGGED BY: H. Herinckx   COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5	SHERWOODC-12-01	**TEST PIT TP-1**	
	DECEMBER 2022	SW DAHLKE DEVELOPMENT SHERWOOD, OR	**FIGURE A-1**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Very stiff, red-brown CLAY with gravel, cobbles, and boulders (CL), minor sand, trace organics; moist, gravel is subrounded to subangular, cobbles are approximately 1 to 2%, boulders are approximately 1 to 2%, sand is fine to medium (topsoil to 12 inches, 3-inch-thick root zone).		PP	☒	●	PP = 2.75 tsf
		Dense, brown GRAVEL with clay, sand, cobbles, and boulders (GP-GC); moist, gravel is subrounded to subangular, sand is fine to coarse, cobbles are approximately 30%, boulders are approximately 2 to 5%.	1.5		☒		
5.0		Very dense, brown-gray BOULDERS with cobbles, minor gravel, trace clay; moist, boulders are subangular, cobbles are approximately 1 to 2%.	5.5				
7.5		Dense, brown with orange mottled GRAVEL with clay, sand, cobbles, and boulders (GP-GC); moist, gravel is subangular to angular, cobbles are approximately 10%, boulders are approximately 5%.	7.5				Moderate groundwater seepage observed at 8.0 feet.
10.0		Stiff to very stiff, light brown with yellow and black mottled SILT (ML), minor sand; moist, sand is fine (decomposed siltstone).	11.0	P200	☒	●	P200 = 92%
12.5		Medium dense, black with orange and brown mottled GRAVEL with clay, cobbles, and boulders (GP-GC); wet, gravel is subangular to angular, cobbles are approximately 5%, boulders are approximately 1 to 2% (decomposed basalt).	12.0		☒		
15.0		Exploration completed at a depth of 15.5 feet.	15.5				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: H. Herinckx

COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5

SHERWOODC-12-01

DECEMBER 2022

TEST PIT TP-2

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-2

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Very dense, brown and gray BOULDERS with cobbles, gravel, sand, and clay; moist, boulders are subrounded to subangular and up to approximately 4 feet in diameter, cobbles are approximately 15%, sand is fine to coarse (2- to 3-inch-thick root zone).					
2.5					☒		
		Exploration terminated at a depth of 3.5 feet due to refusal.	3.5				No groundwater seepage observed to the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: H. Herinckx COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5	SHERWOODC-12-01	TEST PIT TP-3	
	DECEMBER 2022	SW DAHLKE DEVELOPMENT SHERWOOD, OR	FIGURE A-3

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Soft to medium stiff, dark brown CLAY with gravel, boulders, and cobbles (CL), minor sand, trace organics; wet, gravel is subrounded to subangular, boulders are approximately 15%, cobbles are approximately 5%, sand is fine to medium (topsoil to 18 inches, 3-inch-thick root zone).	1.5		☒		Moderate to severe caving observed at 1.0 foot. Rapid groundwater seepage observed at 1.5 feet.
2.5		Dense, brown GRAVEL with clay, cobbles, and boulders (GP-GC), minor sand; wet, gravel is subrounded to subangular, cobbles are approximately 20%, boulders are approximately 20%, sand is fine to coarse.	3.0		☒	●	Surface elevation was not measured at the time of exploration.
5.0		Exploration terminated at a depth of 3.0 feet due to rapid groundwater seepage.					
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: H. Herinckx

COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5

SHERWOODC-12-01

DECEMBER 2022

TEST PIT TP-4

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-4

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Stiff, red-brown CLAY (CL), minor sand, trace organics; moist, sand is fine to medium (12- to 14-inch-thick tilled zone, 3-inch-thick root zone). very stiff at 1.0 foot with sand, trace to minor gravel at 1.5 feet		PP PP PP	☒ ☒		PP = 1.25 tsf PP = 3.25 tsf PP = 4.5 tsf
2.5		Dense, brown and gray with orange mottled GRAVEL with clay, sand, and cobbles (GP-GC); moist, gravel is subangular to angular, sand is fine to coarse, cobbles are approximately 10 to 15% (decomposed basalt).	3.0				
5.0		Exploration terminated at a depth of 5.0 feet due to refusal on weathered basalt.	5.0		☒	●	No groundwater seepage observed to the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
7.5							
10.0							
12.5							
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: H. Herinckx COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5

SHERWOODC-12-01

DECEMBER 2022

TEST PIT TP-5

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Stiff, red-brown CLAY (CL), minor sand, trace organics; moist, sand is fine (14-inch-thick tilled zone, 3-inch-thick root zone).		PP PP	X		PP = 1.25 tsf PP = 0.25 tsf
		very soft to soft at 1.0 foot			X	●	
		stiff at 2.0 feet		PP			PP = 1.5 tsf
2.5		with gravel at 3.0 feet		P200 ATT	X	●	P200 = 75% LL = 32% PL = 22%
		Medium dense, brown, clayey GRAVEL with sand and cobbles (GC); moist, gravel is subangular to angular, cobbles are approximately 15 to 20% (decomposed basalt).	4.0 4.5		X		Slow groundwater seepage observed at 5.0 feet.
5.0		Dense, brown GRAVEL with clay, sand, and cobbles (GP-GC); moist, gravel is subangular to angular, sand is fine to coarse, cobbles are approximately 20 to 25% (decomposed basalt).	5.0				No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
7.5		Exploration terminated at a depth of 5.0 feet due to refusal on weathered basalt.					
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: H. Herinckx COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5

SHERWOODC-12-01

DECEMBER 2022

TEST PIT TP-6

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-6

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Medium dense, dark brown, clayey GRAVEL with cobbles and boulders (GC), minor sand, trace organics; moist, gravel is subrounded to subangular, cobbles are approximately 30%, boulders are approximately 25 to 30% and up to 2 feet in diameter, sand is fine to coarse (topsoil to 12 to 16 inches, 3-inch-thick root zone). red-brown, with sand at 1.5 feet	2.0		☒		Minor to moderate caving observed from 1.0 foot to 2.0 feet.
2.5		Medium dense to dense, red-brown GRAVEL with clay, sand, cobbles, and boulders (GP-GC), trace organics; moist, gravel is subrounded to subangular, cobbles are approximately 30%, boulders are approximately 25 to 30% and up to 2 feet in diameter, sand is fine to coarse (decomposed basalt). dry to moist (weathered bedrock) at 4.0 feet	6.5		☒	●	No groundwater seepage observed to the depth explored. Surface elevation was not measured at the time of exploration.
7.5		Exploration terminated at a depth of 6.5 feet due to refusal on intact rock.					
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: H. Herinckx COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5	SHERWOODC-12-01	**TEST PIT TP-7**
	DECEMBER 2022	SW DAHLKE DEVELOPMENT SHERWOOD, OR — **FIGURE A-7**

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 – 50 – 100)	COMMENTS
0.0		Very dense, red and brown BOULDERS with clay, gravel, and cobbles, minor sand, trace organics; moist, boulders are subrounded to subangular and greater than 4 feet in diameter, cobbles are approximately 20%, sand is fine to coarse (topsoil to 6 to 12 inches, 2- to 3-inch-thick root zone).			☒		
2.5		brown, with sand (decomposed basalt) at 3.5 feet			☒	●	
5.0		dry to moist at 5.5 feet					
		Exploration terminated at a depth of 6.5 feet due to refusal on weathered basalt.	6.5				No groundwater seepage observed to the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc. LOGGED BY: H. Herinckx COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5	SHERWOODC-12-01	TEST PIT TP-8	
	DECEMBER 2022	SW DAHLKE DEVELOPMENT SHERWOOD, OR	FIGURE A-8

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0		Very soft to soft, dark brown CLAY with boulders and cobbles (CL), minor to with sand, trace organics; moist, boulders are approximately 20 to 30% and up to 2 feet in diameter, cobbles are subangular and approximately 1 to 2%, sand is fine to medium (topsoil to 6 to 12 inches, 2- to 3-inch-thick root zone).		PP	☒	●	PP = 0.25 tsf
				PP			PP = 0.25 tsf
2.5		Dense, brown GRAVEL with clay, sand, and cobbles (GP-GC); moist, gravel is subangular to angular, sand is fine to coarse, cobbles are approximately 15% (decomposed basalt). dry to moist at 3.5 feet with boulders; boulders are approximately 15% and greater than 2 feet in diameter (weathered bedrock) at 4.0 feet very dense; boulders are approximately 30% at 5.0 feet	2.5				
5.0							
7.5		Exploration terminated at a depth of 7.5 feet due to refusal on intact rock.	7.5				No groundwater seepage observed to the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.
10.0							
12.5							
15.0							
17.5							
20.0							

EXCAVATED BY: Dan J. Fischer Excavating, Inc.

LOGGED BY: H. Herinckx

COMPLETED: 12/02/22

EXCAVATION METHOD: backhoe (see document text)

NV5

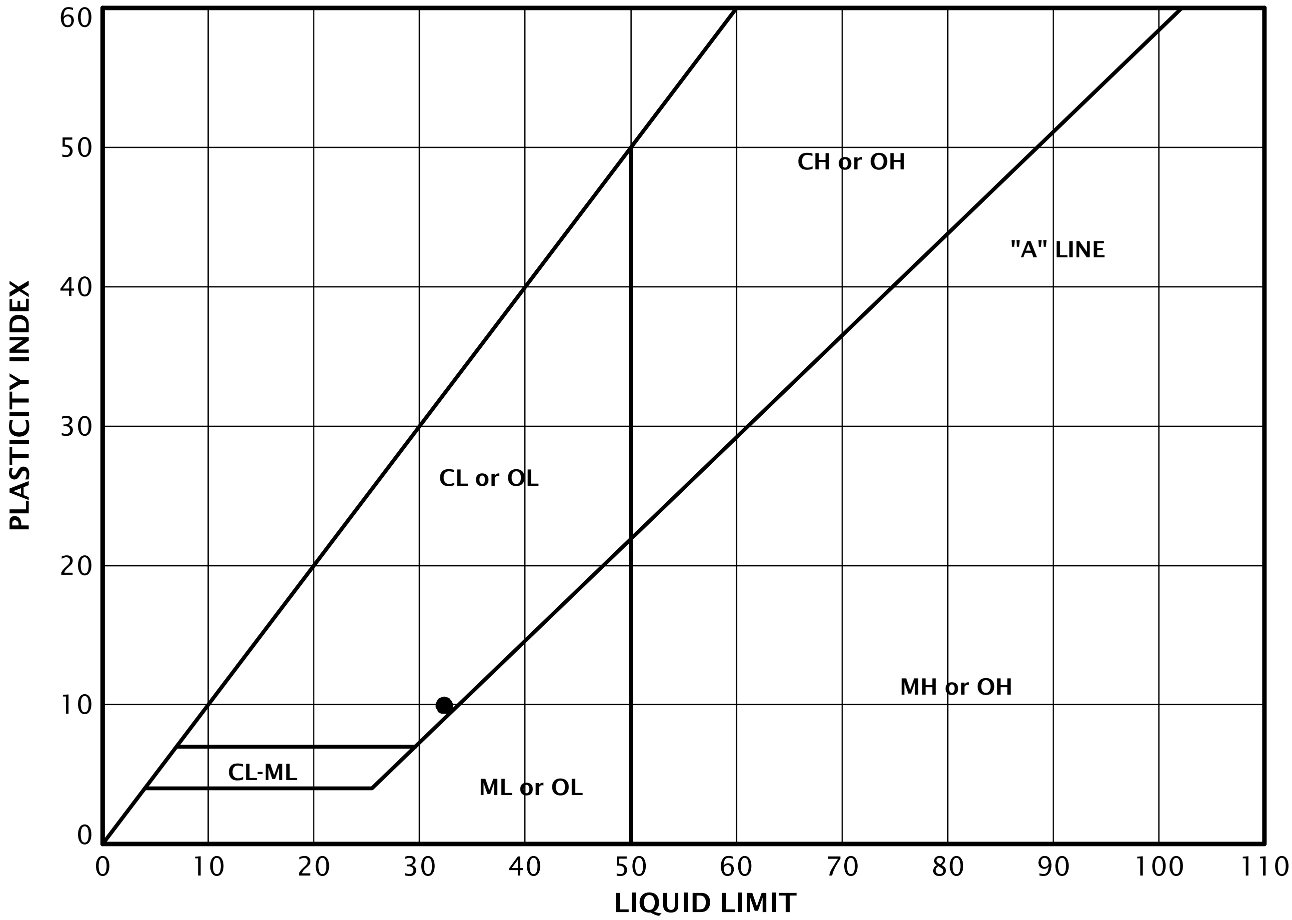
SHERWOODC-12-01

DECEMBER 2022

TEST PIT TP-9

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-9



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	TP-6	3.0	26	32	22	10

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
TP-1	1.0		33				80			
TP-1	2.5		30							
TP-2	1.0		31							
TP-2	11.0		73				92			
TP-4	2.5		34							
TP-5	5.0		26							
TP-6	1.5		25							
TP-6	3.0		26				75	32	22	10
TP-7	6.5		14							
TP-8	3.5		33							
TP-9	1.0		28							

LAB SUMMARY - GDI-NV5 SHERWOODC-12-01-TP1_9.GPJ GDI_NV5.GDT PRINT DATE: 12/19/22:SN

NV5

SHERWOODC-12-01

DECEMBER 2022

SUMMARY OF LABORATORY DATA

SW DAHLKE DEVELOPMENT
SHERWOOD, OR

FIGURE A-11

APPENDIX D

APPENDIX D

ESAL CALCULATIONS

TABLE D-1
ESAL Calculation: Ice Age Drive
Traffic volumes according to information provided by Kittelson & Associates, Inc.

Year of Traffic Count	2022	**Pavement Type**	Flexible
Average Daily Traffic	5,000	**Construction Year[1]**	2023
One-way or Two-way	Two-way	**Lane Distribution Factor**	100
Compound Growth Rate (%)	1.50	**Percent Heavy Trucks**	3.7

[1]Assumes pavement put into service in the following year

FHWA Classification	Average Daily Traffic by Classification in 2022	Conversion Factor[2]	ESALs in 2022
4	7.0	135.3	946
5	129.1	57.2	7,387
6	23.8	156.2	3,714
7	0.5	416.4	194
8	21.9	139.2	3,049
9	1.9	256.3	478
10	0.9	308.6	288
11	0.0	331.7	0
12	0.0	300.3	0
13	1.4	570.4	798
[2]Directional Factor = 55 percent		Total ESALs in 2022	16,855
		ESALs in Construction Year (2023)	17,107

Year	ESALs	Cumulative ESALs[3]	Year	ESALs	Cumulative ESALs[3]
2024 (1)	17,364	34,472	2049 (26)	25,194	564,319
2025 (2)	17,625	52,096	2050 (27)	25,572	589,891
2026 (3)	17,889	69,985	2051 (28)	25,956	615,847
2027 (4)	18,157	88,142	2052 (29)	26,345	642,192
2028 (5)	18,430	106,572	2053 (30)	26,740	668,932
2029 (6)	18,706	125,278	2054 (31)	27,141	696,074
2030 (7)	18,987	144,265	2055 (32)	27,549	723,622
2031 (8)	19,271	163,536	2056 (33)	27,962	751,584
2032 (9)	19,561	183,096	2057 (34)	28,381	779,965
2033 (10)	19,854	202,950	2058 (35)	28,807	808,772
2034 (11)	20,152	223,102	2059 (36)	29,239	838,011
2035 (12)	20,454	243,556	2060 (37)	29,678	867,689
2036 (13)	20,761	264,317	2061 (38)	30,123	897,812
2037 (14)	21,072	285,389	2062 (39)	30,575	928,386
2038 (15)	21,388	306,777	2063 (40)	31,033	959,420
2039 (16)	21,709	328,487	2064 (41)	31,499	990,918
2040 (17)	22,035	350,521	2065 (42)	31,971	1,022,890
2041 (18)	22,365	372,887	2066 (43)	32,451	1,055,340
2042 (19)	22,701	395,587	2067 (44)	32,938	1,088,278
2043 (20)	23,041	418,629	2068 (45)	33,432	1,121,710
2044 (21)	23,387	442,016	2069 (46)	33,933	1,155,643
2045 (22)	23,738	465,753	2070 (47)	34,442	1,190,085
2046 (23)	24,094	489,847	2071 (48)	34,959	1,225,044
2047 (24)	24,455	514,302	2072 (49)	35,483	1,260,527
2048 (25)	24,822	539,124	2073 (50)	36,015	1,296,542

[3]Includes ESALs in construction year as per method in ODOT Pavement Design Guide

2-Year ESALs	15-Year ESALs	20-Year ESALs	30-Year ESALs	40-Year ESALs	50-Year ESALs
35,000	290,000	402,000	652,000	942,000	1,279,000

NV5

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