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March 17, 2021

Community Partners for Affordable Housing
P.O. Box 23206
Tigard, Oregon 97239
Attention: Jilian Saurage Felton, Housing Development Director

Phone: 503-293-4038
E-mail: jsaurage@cpahoregon.org

Subject: **Geotechnical Investigation Report**
Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon
EEI Report No. 21-023-1

Dear Ms. Saurage Felton:

Earth Engineers, Inc. (EEI) is pleased to provide our attached Geotechnical Investigation Report for the above referenced project. This report includes the results of our field investigation, an evaluation of geotechnical factors that may influence the proposed construction, and geotechnical recommendations for the proposed structure and general site development.

We appreciate the opportunity to perform this geotechnical study and look forward to continued participation during the design and construction phases of this project. If you have any questions pertaining to this report, or if we may be of further service, please contact our office at 360-567-1806.

Sincerely,
Earth Engineers, Inc.

Anita Bauer

Troy Hull, P.E., G.E.
Principal Geotechnical Engineer

Anita Bauer
Geologic Associate

Attachment: Geotechnical Investigation Report

Distribution: Addressee
Rachel Loftin, CPAH (rloftin@cpahoregon.org)
Melissa Soots, Carlton Hart Architecture (Melissa.soots@carltonhart.com)

GEOTECHNICAL INVESTIGATION REPORT

for the

Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Prepared for

Community Partners for Affordable Housing
P.O. Box 23206
Tigard, Oregon 97239

Prepared by

Earth Engineers, Inc.
2411 Southeast 8th Avenue
Camas, Washington 98607
Telephone (360) 567-1806

EEI Report No. 21-023-1

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Anita Bauer

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Geologic Associate

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JULY 15, 1997
TROY M. HULL

EXPIRES: 6/30 21

Troy Hull, P.E., G.E.
Principal Geotechnical Engineer

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1.0 PROJECT INFORMATION

1.1 Project Authorization

Earth Engineers, Inc. (EEI) has completed a geotechnical investigation report for the proposed Basalt Creek affordable housing project to be located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. Our geotechnical services were authorized by Jilian Saurage Felton, Housing Development Director for Community Partners for Affordable Housing (CPAH) on February 3, 2021 by signing EEI Proposal No. 21-P004-R1 dated January 20, 2021.

1.2 Project Description

Our current understanding of the project is based on information Rachel Loftin with CPAH, Melissa Soots with Carleton Hart Architecture (CHA) and Kim Shera with Vega Civil provided to EEI Principal Geotechnical Engineer Troy Hull. The following are the most up-to-date documents provided to us:

- **Undated Preliminary Site Plan, Sheet A0.00, by Carleton Hart Architecture, received by e-mail on February 17, 2021.** This drawing replaced 2 previous drawings by CHA dated May 15, 2020 that shows the locations of test pits and infiltration test locations.

Briefly, we understand the project will consist of demolishing the 2 existing homes on the 2 lots and constructing a multi-family housing complex consisting of the following:

- Three, 3-story residential buildings (A, B, and C) that are anticipated to have floor slabs on grade.
- A community building. We assume this will be 1 or 2 stories and have a floor slabs on grade.
- 3 detached garage buildings
- Paved parking and drive lanes, including some permeable pavement.

We have not been provided any foundation load information. For the purposes of this report, we are assuming maximum foundation loads of 6 kips per linear foot for wall footings, 60 kips for column footings, and 150 psf for floor slabs. Other than underground utilities, we assume there will be no below grade construction. We assume cuts and fills will generally be no greater than about 2 feet. Finally, we have assumed that the buildings will be constructed in accordance with the 2019 Oregon Structural Specialty Code (OSSC), an amendment to the 2018 International Building Code (IBC).

As far as stormwater disposal is concerned, we understand the current plan is to use permeable pavement at the north end of the project (beneath a sport court) and in the parking stalls, and surface infiltration in storm swales along the west edge and middle of the project.

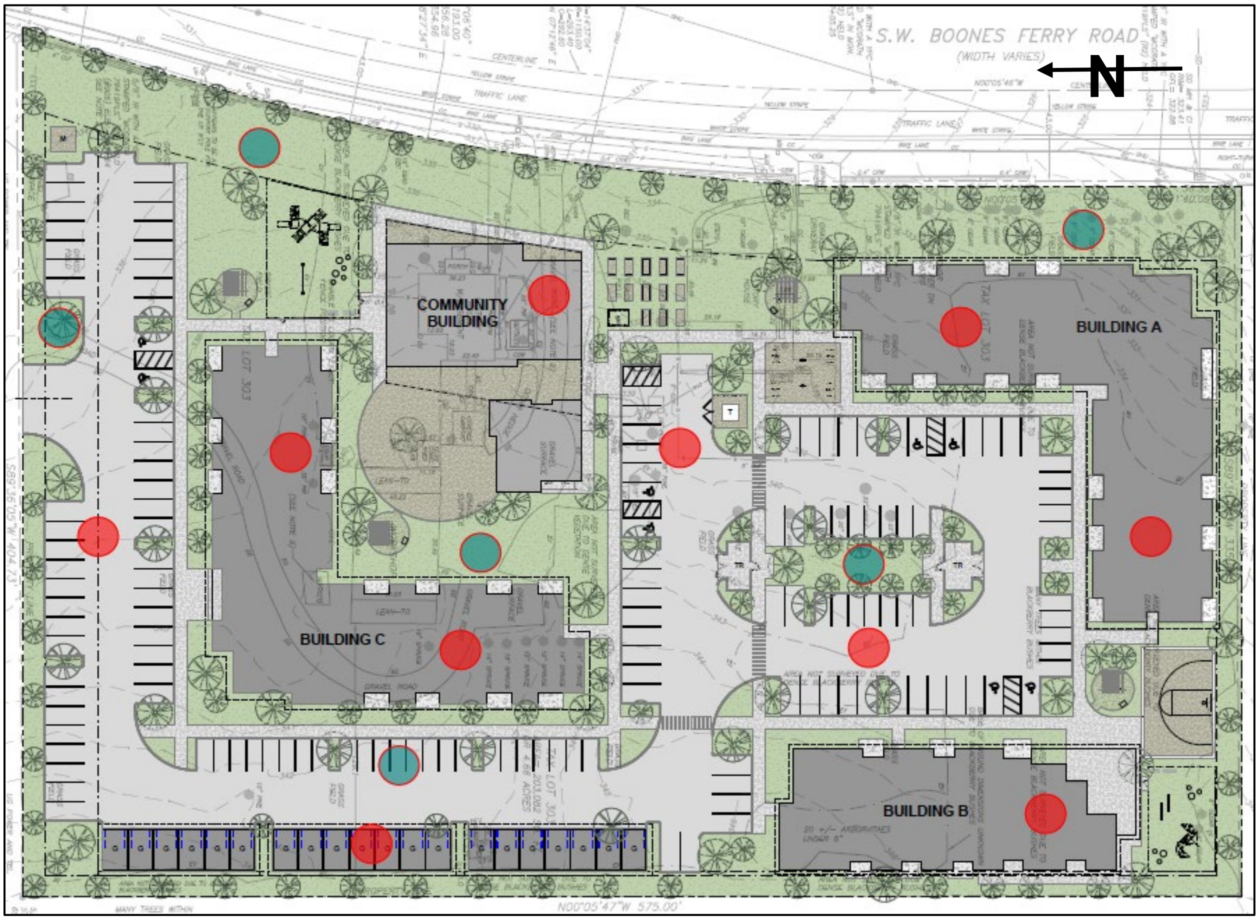

Figure 1: Proposed site plan (source: undated Sheet A0.00 by Carleton Hart Architecture).

1.3 Purpose and Scope of Services

The purpose of our services was to explore the subsurface conditions at the site to better define the existing soil, rock, and groundwater properties in order to provide geotechnical related recommendations for the proposed new building construction. Our site investigation consisted of excavating 10 test pits (TP-1 to TP-10) to depths ranging from 7 to 10 feet below ground surface (bgs) with a Hitachi Zaxis 40U excavator subcontracted from Dan Fischer Excavating. Drive probe testing was performed adjacent to test pits TP-1 through TP-7 to better characterize the soil strength. The approximate test pit locations are shown in Appendix B. Grab soil samples were samples were obtained at the discretion of the Geotechnical Engineer’s field representative and returned to our office for testing.

Our site investigation scope also included infiltration testing in general accordance with Clean Water Services at the locations specified by Vega Civil.

Laboratory testing was performed on select grab samples to determine the material properties for our evaluation and, in general accordance with ASTM procedures. This included moisture content (ASTM D2216), material finer than #200 Sieve - washed (ASTM D1140), Atterberg limits (ASTM D4318), and classification of soils by the Unified Soil Classification System [USCS] (ASTM D2487 and D2488).

This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and presents recommendations regarding the following:

- A discussion of subsurface conditions encountered including pertinent soil and groundwater conditions.
- Seismic design parameters in accordance with the 2019 OSSC and ASCE 7-16.
- Geotechnical related recommendations for foundation design including allowable bearing capacity, minimum footing dimensions and estimated settlements.
- Structural fill recommendations, including an evaluation of whether the in-situ soils can be used as structural fill.
- Grading recommendations, including special considerations for wet weather grading.
- Retaining wall design parameter recommendations, including coefficient of friction and earth pressures.
- Floor slab support recommendations.
- Pavement section thickness recommendations based on an assumed CBR value and assumed traffic loading conditions.
- Results of our infiltration testing to aid the project Civil Engineer in designing the on-site stormwater disposal system.
- Other discussion on geotechnical issues that may impact the project.

2.0 SITE AND SUBSURFACE CONDITIONS

2.1 Site Location and Description

The property is located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. The subject property is bordered by Southwest Boones Ferry Road to the west, an existing residence and New Horizon Church to the east, the driveway access for New Horizon Church to the north, and a large field to the south.

In terms of topography, the subject property mostly is generally level to slightly sloping. There is a large fill mound that is several feet high at the north edge of the property. The property is generally covered with grass, bushes, and young and mature trees. See Photos 1 through 5 below for the site conditions.

Photo 1: Looking west from the east-central portion of the site at an existing barn structure to be demolished.

Photo 2: Looking south from the northwest corner of the project site at an existing house to be demolished.

Photo 3: Looking west at the fill mound at the north end of the site.

Photo 4: Looking north at the west property boundary along Southwest Boones Ferry Road.

Photo 5: Looking northeast at the project site from the southwest corner of the property.

2.2 Mapped Soils and Geology

The subject property is regionally located on the east side of Parrett Mountain and the Chehalem Mountain range that separates the sediment filled Tualatin and Northern Willamette Valley drainage basins. The subject property is bordered by the Tualatin Basin to the north, the Northern Willamette Valley Basin to the south, Parrett Mountain to the west and the Portland Hills to the northeast. The Portland Hills, Chehalem Mountain range, and Parrett Mountain are relatively small mountain ranges composed of Miocene aged (23 to 5 million years ago) basalt from the Columbia River Basalt Group (CRBG) that had been folded and uplifted around the Tualatin Basin during the late Neogene (roughly 3 million years ago)[1].

In the vicinity of the subject property, the underlying geology is mapped as the Sentinel Bluffs Member (Tgsb) which is an informal unit of Miocene aged Grande Ronde Basalt and part of the Columbia River Basalt Group. Pleistocene aged (2.6 million to 11,700 years ago) Missoula flood deposits (Qf) are also mapped in the area. The Sentinel Bluffs Member consists of light to dark gray, columnar-jointed basalt with vesicular flow tops. Weathered surfaces are greenish gray to pale gray and the unit thickness typically ranges from about 30 to 75 feet. Missoula flood deposits (Qf) consist of unconsolidated stratified clay, silt, sand and gravel that originated from Lake Missoula, flowed down the Columbia River and flooded the Tualatin and Willamette Valley Basins[2].

The surface soils on the project site are mapped by the US Soil Survey as Unit 28B: Laurelwood silt loam on 3 to 7 percent slopes. This soil is formed on hills and comes from a loess (i.e. wind-blown) parent material. A typical profile for this unit consists of silt loam approximately 0-11 inches bgs, followed by silty clay loam 11-52 inches bgs, and overlying silty clay 52 to 72 inches bgs. This typically well-drained soil has a moderately high transmissivity of water (0.20 to 0.57 inches per hour)[3].

We reviewed the Oregon Department of Geology and Mineral Industries (DOGAMI) Statewide Geohazards Information Database for Oregon (HazVu) website (https://gis.dogami.oregon.gov/hazvu/ to report the applicable hazards for the subject property. This database maps the property within a very strong to sever expected earthquake shaking hazard and very strong Cascadia earthquake expected shaking. In addition, the subject property's proximity to the Canby-Molalla fault is approximately 3.3 miles to the northeast; see Figure 2 below. The Canby-Molalla fault is moderately constrained, late Quaternary (<130,000 years) in age, has a right lateral slip sense

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[1] D.K. McPhee, V.E. Langenheim, R.E. Wells, R.J. Blakely; Tectonic evolution of the Tualatin basin, northwest Oregon, as revealed by inversion of gravity data. *Geosphere* 2014;; 10 (2): 264–275. doi:

[2] Wells, R.E., Haugerud, R.A., Niem, A.R., Niem, W.A., Ma, L., Evarts, R.C., O'Connor, J.E., Madin, I.P., Sherrod, D.R., Beeson, M.H., Tolan, T.L., Wheeler, K.L., Hanson, W.B., and Sawlan, M.G., 2020, Geologic map of the greater Portland metropolitan area and surrounding region, Oregon and Washington: U.S. Geological Survey Scientific Investigations Map 3443, pamphlet 55 p., 2 sheets, scale 1:63,360, https://doi.org/10.3133/sim3443.

[3] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/ accessed 3/16/2021.

with a slip rate of less than 0.2mm/year[4]. The database also maps the subject property within moderate landslide susceptibility on the north end of the property. It should be noted that the surrounding, previously developed properties are also mapped within these same hazards.

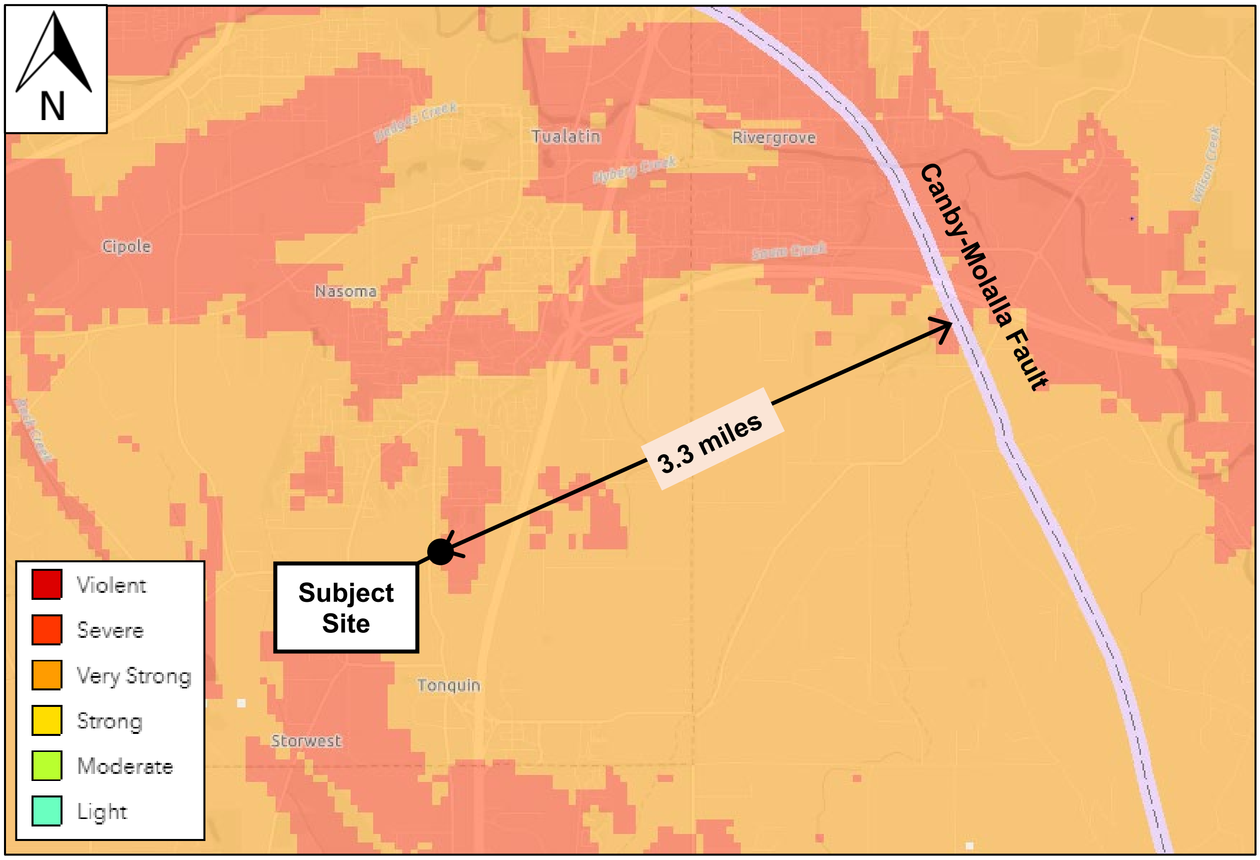

Figure 2: Earthquake hazard map of the subject property and vicinity (base map source: DOGAMI HazVu).

2.3 Subsurface Materials

The subsurface conditions at the site were explored with 10 test pits (TP-1 through TP-10) excavated with a Hitachi Zaxis 40U excavator to depths ranging from 7 to 10 feet bgs. To better characterize the soil strengths, we performed drive probe testing adjacent to test pits TP-1 through TP-7. The drive probe test is based on a “relative density” exploration device used to determine the distribution and to estimate strength of the subsurface soil units. The resistance to penetration is measured in blows-per-½-foot of an 11-pound hammer which free falls roughly 3½ feet driving a 1-inch diameter pipe into the ground. This measure of resistance to penetration can be used to

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[4] United States Geologic Survey, U.S. Quarternary Faults database. Available online at https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf accessed 3/16/21

estimate relative density of soils. For a more detailed description of this geotechnical exploration method, please refer to the Slope Stability Reference Guide for National Forests in the United States, Volume I, USDA, EM-7170-13, August 1994, P 317-321. The drive probe test results are summarized in the test pit logs in Appendix C.

Disturbed “grab” soil samples were obtained in the test pits from each major soil stratum. The soil samples were tested in the laboratory to determine material properties for our evaluation. Laboratory testing was accomplished in accordance with ASTM procedures which included moisture content tests (ASTM D2216), fines content determinations (ASTM D1140), and Atterberg limits (ASTM D4318). The test results have been included on the Exploration Logs in Appendix C.

In general, we encountered topsoil overlying native fine-grained soils (i.e. silt and clay) that graded to decomposed/intensely weathered basalt with increasing depth In a few isolated locations, we encountered existing fill soil. Each of the strata we encountered in our exploration are described individually below:

Topsoil – Topsoil was encountered in all of the test pits, except TP-5 and TP-9, which were located in the fill mound at the north end of the project site. The topsoil generally consisted of dark brown sandy silt with roots, occasional gravels, and ranged in thickness from about 6 inches to 2 feet. It should also be noted we did encounter some old PVC irrigation pipes within the upper 2 feet throughout the site.

Fill – Fill was encountered in test pits TP-5 through TP-10. The fill in TP-5 and TP-9 was from a fill mound (i.e. stockpile). The fill soil in the test pits in general consisted of silt with organics (i.e. roots and rootlets), asphalt chunks, gravel and cobble size rocks, and trace charcoal and brick fragments. The fill in our test pits extended to a depth below the general site grade of 1.5 to 3.5 feet bgs.

Silt (ML) - Below the surficial topsoil and fill layers, we encountered soft to very stiff, brown with some orange and black mottling, silt. Moisture contents of the samples tested ranged from 24 to 31 percent, indicating the soils are generally moist to wet.

Elastic Silt (MH) – Generally below the silt (ML) layer, we encountered a high plasticity silt starting at a depth of 2.5 to 7.5 feet bgs. This soil unit was brown to reddish brown and medium stiff to hard. Moisture contents of the samples tested ranged from 26 to 49 percent, indicating the soils are generally moist to wet. An Atterberg limits test on this material indicated a Liquid Limit (LL) of 54, Plastic Limit (PL) of 23, and a Plasticity Index (PI) of 31. Based on this test result, we consider this soil to be moderately expansive and to have moderate risk of heaving and shrinking due to moisture change. This soil unit graded from decomposed to intensely weathered basalt bedrock with increasing depth. Where the test pits indicate the digging became “hard” at depth, we interpret that to be the less weathered basalt bedrock stratum. That depth generally ranged from about 6.5 to 8.5 feet bgs in our test pits.

The classifications noted above were made in general accordance with the USCS as shown in Appendix D. The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The exploration logs included in the Appendix should be reviewed for specific information at specific locations. These records include soil descriptions, stratifications, and locations of the samples. The stratifications shown on the logs represent the conditions only at the actual exploration locations.

The fill extent at each boring location was estimated based on an examination of the soil samples, the presence of foreign materials, field measurements, and the subsurface data. The explorations performed are not adequate to accurately identify the full extent of existing fill across the site. Consequently, the actual fill extent may be much greater than that shown on the exploration logs and discussed herein.

Soil variations may occur and should be expected between locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these logs. The samples that were not altered by laboratory testing will be retained for 90 days from the date of this report and then will be discarded.

2.4 Groundwater Information

Groundwater was encountered in all of our test pits except TP-8 and TP-9. The depth of groundwater ranged from 4 to 7.5 feet bgs. We do anticipate that the relatively shallow depth to groundwater could potentially impact the proposed construction. It should be noted that groundwater elevations can fluctuate annually and seasonally, especially during periods of extended wet or dry weather, or from changes in land use.

2.5 Seismicity

In accordance with Section 1613.2.2 of the 2019 OSSC and Table 20.3-1 of ASCE 7-16, we recommend a Site Class D (stiff soil profile with an average standard penetration resistance of between 15 and 50 blows per foot) when considering the average of the upper 100 feet of bearing material beneath the proposed foundations. This recommendation is based on our observations in the test pits, our drive probe test data, as well as our local knowledge of the area geology. Inputting our recommended Site Class as well as the site latitude and longitude into the Structural Engineers Association of California (SEAOC) – OSHPD Seismic Design Maps website (http://seismicmaps.org) which is based on the United States Geological Survey, we obtained the seismic design parameters shown in Table 1 below.

Table 1: Seismic Design Parameter Recommendations (ASCE 7-16)

PARAMETER	RECOMMENDATION
Site Class	D
S_s	0.830g
S_1	0.386g
F_a	1.168
F_v	Null – See Section 11.4.8
S_{MS} (= S_s x F_a)	0.970g
S_{M1} (= S_1 x F_v)	Null – See Section 11.4.8
S_{DS} (=2/3 x S_s x F_a)	0.646g
Design PGA (= S_{DS} / 2.5)	0.258g
MCE_G PGA	0.378g
F_{PGA}	1.222
PGA_M (MCE_G PGA * F_{PGA})	0.462g

Note: Site latitude = Latitude 45.3502154, longitude = Longitude -122.77435

The return interval for the ground motions reported in the table above is 2 percent probability of exceedance in 50 years.

Per Section 11.4.8 of ASCE 7-16 a site-specific seismic site response is required for structures on Site Class D and E sites with S_1 greater than or equal to 0.2g. The S_1 value for this site is greater than 0.2g as shown in Table 1 above. Therefore a site response analysis is required as part of the design phase. However, Section 11.4.8 does provide an exception for not requiring a site response analysis (reference Sections 11.4.8.1, 11.4.8.2 and 11.4.8.3). The project Structural Engineer should determine if the proposed buildings will meet any of the exceptions—if the buildings do not meet the exception requirements then EEI should be retained to perform a site-specific site response analysis.

We understand a Supplement 1 dated December 12, 2018 has been issued for ASCE 7-16 to correct some issues in the original publication. One of the corrections in the Supplement pertains to Table 11.4-2 (see table below) for determining the value of the Long-Period Site Coefficient, F_V, which is then used to calculate the value of T_S. The T_S value is needed for one of the exceptions in Section 11.4.8. Without the correction in Supplement 1, it would not be possible to determine F_V and calculate T_s. Based on Supplement 1, the F_V value may be determined from the following corrected table.

Table 2: Long-Period Site Coefficient, F_V (corrected Table 11.4-2 in ASCE 7-16).

	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period					
Site Class	S_1<=0.1	S_1<=0.2	S_1<=0.3	S_1<=0.4	S_1<=0.5	S_1>=0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	**2.2**[a]	**2.0**[a]	**1.9**[a]	**1.8**[a]	**1.7**[a]
E	4.2	**3.3**[a]	**2.8**[a]	**2.4**[a]	**2.2**[a]	**2.0**[a]
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: use linear interpolation for intermediate values of S_1.

[a] See requirements for site-specific ground motions in Section 11.4.8. These values of F_V shall be used only for calculation of T_S.

2.6 Infiltration Testing

The infiltration testing was conducted in general accordance with the Clean Water Services requirements for the single ring, falling head test procedure. As requested, a total of 5 test locations (IT-1 through IT-5) were completed. Three separate trials (i.e. standpipes) were performed at each of the 5 test locations. Each test location was cased with a 6-inch diameter PVC pipe and seated at least 4-inches into the bottom of the test pit. Approximately 2-inches of clean gravel was placed in the bottom of the pipes to prevent scouring. 12-inches of water was then placed into the pipes and allowed to drain. Because the 12 inches of water did not drain away in 10 minutes or less, a 4-hour minimum presoak was required for all of the tests performed. After the 4-hour presoak period, we took repeated 30-minute readings with six inches of water in the standpipe until a consistent rate was observed. The location of the infiltration testing can be seen in Appendix B. Disturbed grab samples were taken at the bottom of each test location and soil samples were returned to our laboratory for testing (i.e. moisture content and wash #200).

The results of our lab testing and infiltration tests are shown in Table 3 below. The infiltration test results should be considered ultimate values and do not include a factor of safety. Clean Water Services recommends a factor of safety of 2. We recommend that during construction, field verification testing be performed to confirm the actual infiltration rates are consistent with the values in Table 3 below.

Photo 6: Setting the 3 standpipes in the test pit trench at one of the infiltration test locations.

Photo 7: Backfilling around the 3 standpipes in the test pit trench at one of the infiltration test locations prior to conducting the infiltration testing.

Table 3: Summary of Infiltration Test Results.

Test #	Test Depth, bgs (inches)	Soil Description	% Fines	% Moisture	Tested Infiltration Rate (inches/hour)*
IT-1a	24	Silt	90	28	0.5
IT-1b	30		76	28	2.0
IT-1c	30		92	28	5.2
IT-2a	28	Silt	89	26	8.2
IT-2b	30		88	27	6.0
IT-2c	24		91	22	2.2
IT-3a	24	Silt	94	28	1.0
IT-3b	36		94	29	5.5
IT-3c	36		94	30	19.3
IT-4a	24	Silt	91	29	40.5
IT-4b	36		91	27	22.0
IT-4c	39		91	27	9.2
IT-5a	24	Silt	92	26	6.8
IT-5b	33		92	27	1.7
IT-5c	30		92	28	7.2

*No safety factors have been applied to the test rates above.

3.0 EVALUATION AND FOUNDATION RECOMMENDATIONS

3.1 Geotechnical Discussion

It is our professional opinion that the following factors may influence the proposed construction:

1. **Presence of existing fill soils** – We encountered fill soils below existing grade generally throughout the property, as well as at a large fill mound at the north end of the project. At least some of the fill encountered below existing grade appears to be grading for the driveways and home developments. The fill mound at the north end of the property appears to be stockpiled soil. Some of the fill appeared firm and well compacted, while some was very soft and poorly compacted. In general, the fill closer to the ground surface was more firm, presumably from past vehicular traffic driving over it. Excluding the fill mound, the fill was generally 1.5 to 3.5 feet deep. However, it should be assumed that the fill soils could be variable across the property.

   Because of the variability in strength (i.e. compaction), we recommend structures not be supported directly on the existing fill soils. One mitigation option would be recompact all of the existing fill beneath all building structures (i.e. footings and slabs). Another option would be to limit the overexcavation to the native soils just beneath footing areas and only do a partial overexcavation beneath floor slabs to reduce the risk of future floor slab settlement. This second option carries more risk of settlement cracking for the floor slab areas, but reduces the construction cost.

   The fill mound material appears generally suitable for use as fill. Ideally, it would be limited to landscape fill areas because it contains some organics. However, it could be used for structural fill provided the organic material is removed. Some minor (i.e. less than 5 percent) organics (i.e. rootlets) would be acceptable in the structural fill, but larger quantities of organics would need to be removed. Note that we only performed 2 test pits in the fill mound area so there is a large percentage of the mound that we did not investigate. If the contractor will rely on using the fill mound material in their construction cost, we recommend they consider further investigating the contents of the mound.

2. **Presence of soft native soils** – The near-surface native silt soils in our test pits were generally soft. They are appropriate for supporting the proposed buildings, but will have a relatively low allowable soil bearing pressure (i.e. 1,500 pounds per square foot). Firmer (stiff) silt soils were encountered at a depth of 5 to 6 feet below grade. If a higher allowable soil bearing pressure (i.e. 2,500 psf) is desired, the footings could be overexcavated to this stiff soil stratum and then backfilled up to bottom of footing grade. Or rammed aggregate piers designed and installed by a geotechnical specialty contractor could also be used to achieve the same thing and also provide for a much higher allowable bearing capacity (i.e. on the order of 5,000 to 6,000 psf). One consideration with the overexcavation option is that groundwater may be encountered in the footing

overexcavations depending upon the time of year. We anticipate that during the summer months, the risk of groundwater interfering with footing overexcavations will be less.

3. **Presence of potentially expansive soils** – Based on our Atterberg limits testing, the clayey silt (MH) soils first encountered below a depth of about 2.5 to 7.5 feet bgs in our test pits are moderately expansive. It will be acceptable to support the proposed structures on this soil. The only mitigation recommendation we are providing is to not let this soil dry out if exposed. If it is exposed during excavation during the warmer months of the year, it should be covered the same day so it is not allowed to dry out.

4. **Shallow groundwater** – As discussed above, we did encounter shallow groundwater in our test pits—generally 4 to 7.5 feet bgs. Deep excavations (i.e. for trenches, etc.) may require dewatering.

5. **Existing buildings to be demolished** – The existing residences and associated improvements will need to be demolished before the proposed construction can begin. It will be important to remove all the construction debris from the site and to backfill any voids with properly compacted structural fill that is approved by a representative of the Geotechnical Engineer.

6. **Moisture sensitive soils** – This project will likely involve a significant amount of earthwork. The fine-grained site soils are sensitive to wet weather conditions. While not required, earthwork is expected to be easier and less expensive if conducted during the dry summer and early fall months.

In summary, it is acceptable to construct the proposed development on this property provided the recommendations in this report are followed.

3.2 General Site Preparation

Prior to the start of grading, we recommend our test pits performed for this report be located, excavated to their bottoms, and backfilled with properly compacted granular structural fill under the observation of a representative of the Geotechnical Engineer.

Existing pavement and structures will need to be demolished and completely removed from the site. Any topsoil, vegetation, roots, organic laden soils, debris, and any other deleterious soils should also be removed from building areas. It should be expected that the depth of these materials may vary across the site. Topsoil in our test pits ranged from about 6 to 24 inches thick. A representative of the Geotechnical Engineer should determine the depth of removal at the time of construction.

Existing utilities will need to be located and rerouted as necessary and any abandoned pipes or utility conduits should be removed or properly capped off to inhibit the potential for subsurface soil erosion. Utility trench excavations should be backfilled with properly compacted structural fill that is constructed as outlined in Section 3.3 of this report.

After stripping and excavating to the proposed subgrade level, as required, building subgrade areas should be observed by a representative of the Geotechnical Engineer and proofrolled with a fully loaded tandem axle dump truck**.** If the subgrade cannot be accessed with a dump truck to perform a proofroll, then the subgrade will need to be evaluated by a representative of the Geotechnical Engineer by soil probing. Structural fill, as described in Section 3.3 below, should be placed on the prepared subgrade after it has been proofrolled or soil probed. Soils that are observed to be soft or are otherwise judged to be unsuitable should be undercut and replaced with properly compacted structural fill.

As noted in Section 3.1, the brown to red brown clayey silt soils encountered in our test pits at depths of 2.5 to 7.5 feet bgs are moderately potentially expansive. We recommend they be covered the same day if they are exposed during excavation so that they don’t dry out.

3.3 Structural Fill

Any structural fill to be placed should be free of organics or other deleterious materials, have a maximum particle size less than 3 inches, be relatively well graded, and have a liquid limit less than 45 and plasticity index less than 25. In our professional opinion the onsite native low plasticity silt (ML) soils are appropriate for use as structural fill, however they may be difficult to compact without first adjusting the moisture content. As such, it may be more practical to import granular structural fill. Structural fill should be moisture conditioned to within 3 percentage points below and 2 percentage points above optimum moisture as determined by ASTM D1557 (Modified Proctor).

Fill should be placed in relatively uniform horizontal lifts on the prepared subgrade which has been stripped of deleterious materials and approved by the Geotechnical Engineer or their representative. If loose soils exist on the prepared subgrades, they should be re-compacted. Each loose lift should be about 1-foot thick. The type of compaction equipment used will ultimately determine the maximum lift thickness. Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D1557. Each lift of compacted engineered fill should be tested by a representative of the Geotechnical Engineer prior to placement of subsequent lifts.

To reiterate, each 12-inch thick lift of structural fill should be tested for compaction by a representative of the Geotechnical Engineer prior to placement of subsequent lifts.

3.4 Foundation Recommendations

Once the site has been properly prepared as discussed above, the proposed buildings can be supported on a conventional shallow foundation system. Spread footings for isolated columns and continuous bearing walls supported on the medium stiff silt soils or on granular structural fill overly the medium stiff silt stratum can be designed for an allowable soil bearing pressure of up to 1,500 psf. The medium stiff silt was generally encountered immediately beneath the existing fill and topsoil.

If the footings will be overexcavated to the stiff silt soil generally encountered 5 to 6 feet below existing grade, then the footings may be designed for an allowable soil bearing pressure for up to 2,500 psf when bearing on the stiff silt or granular structural fill overlying the stiff silt. Note that the actual depth to the stiff silt stratum may be variable, but we expect that the average depth is 5 to 6 feet across the project site.

To be clear, we do not recommend the footings be supported on the existing fill soils as they were variable in strength and could lead to greater than normal settlement.

Our recommended allowable bearing capacity is based on dead load plus design live load, and can be increased by one-third when including short-term wind or seismic loads. Minimum footing dimensions should be 18 inches for continuous wall footings and 24 inches for isolated pad footings.

Lateral frictional resistance between the base of footings and the subgrade can be expressed as the applied vertical load multiplied by a coefficient of friction of 0.32 for concrete foundations bearing directly on the native silt soils or 0.42 when bearing on at least 12 inches of granular structural fill. In addition, lateral loads may be resisted by passive earth pressures based on an equivalent fluid pressure of 300 pounds per cubic foot (pcf) for footings poured “neat” against the dense to medium dense native soils, or properly backfilled structural fill. These are ultimate values—we recommend a factor of safety of 1.5 be applied to the equivalent fluid pressure, which is appropriate due to the amount of movement required to develop full passive resistance. To be clear, no safety factor has been applied to the friction coefficient discussed above.

Exterior footings and foundations in unheated areas should be located at a depth of at least 18 inches below the final exterior grade to provide adequate frost protection. If the additions are to be constructed during the winter months or if the foundation soils will likely be subjected to freezing temperatures after foundation construction, then the foundation soils should be adequately protected from freezing. Otherwise, interior foundations can be located at nominal depths compatible with architectural and structural considerations.

The foundation excavations should be observed by a representative of the Geotechnical Engineer prior to steel or concrete placement to assess that the foundation materials are capable of supporting the design loads and are consistent with the materials discussed in this report. Unsuitable soil zones encountered at the bottom of the foundation excavations should be removed to the level of suitable soils or properly compacted structural fill as directed by the Geotechnical Engineer.

After opening, foundation excavations should be observed and concrete placed as quickly as possible to avoid exposure of the excavation bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If possible, the foundation concrete should be placed during the same day the excavation is made. If the soils will be exposed for more than 2 days, consideration should be given to placing a thin layer of rock atop the exposed subgrade to protect it from the elements.

Based on the known subsurface conditions and site geology, laboratory testing and past experience, we anticipate that properly designed and constructed foundations supported on the recommended materials should not exceed maximum total and differential settlements of 1-inch and ½-inch between 25-foot column spans, respectively.

3.5 Floor Slab Recommendations

Given the presence of existing, variable strength fill soils, there is some risk of future floor slab settlement if the floor slabs are supported on the existing fill in its existing condition. To completely mitigate the settlement risk, the fill soils would be removed and replaced with properly compacted structural fill. However, given the thickness of the existing fill soils, that approach may not be economical. A more limited approach would be to partially overexcavate the existing fill soil at least 12 inches, recompact the exposed fill surface, and then replace with well-graded crushed rock gravel structural fill (subbase). Partial overexcavation carries a little more risk, but it’s our opinion that risk is relatively low and would primarily result in some settlement cracking of slabs.

For the purposes of this report, we have assumed that maximum floor slab loads will not exceed 150 psf. Based on the existing soil conditions, the design of slabs-on-grade can be based on a subgrade modulus (k) of 125 pci. This subgrade modulus value represents an anticipated value which would be obtained in a standard in-situ plate test with a 1-foot square plate. Use of this subgrade modulus for design or other on-grade structural elements should include appropriate modification based on dimensions as necessary.

Concrete floor slabs-on-grade should be supported on a base course consisting of at least 6 inches of properly compacted, crushed rock gravel structural fill. The floor slabs should have an adequate number of joints to reduce cracking resulting from any differential movement and shrinkage.

Prior to placing the structural fill, the exposed subgrade surface should be prepared as discussed in Section 3.2 the subgrade will need to be visually evaluated by a representative of the Geotechnical Engineer by soil probing. If fill is required, the structural fill should be placed on the prepared subgrade after it has been approved by the Geotechnical Engineer.

The 6-inch thick crushed rock structural fill should provide a capillary break to limit migration of moisture through the slab. If additional protection against moisture vapor is desired, a moisture vapor retarding membrane may also be incorporated into the design. Factors such as cost, special considerations for construction, and the floor coverings suggest that decisions on the use of vapor retarding membranes be made by the project design team, the contractor and the owner.

3.6 Retaining Wall Recommendations

We are not aware of any retaining walls being planned for the project. As such, we are providing general retaining wall recommendations for preliminary use and should be provided retaining wall design specifics once they are known.

Retaining wall footings should be designed in general accordance with the recommendations contained in Section 3.4 above. Lateral earth pressures on walls, which are not restrained at the top, may be calculated on the basis of an “active” equivalent fluid pressure of 40 pcf for level backfill, and 65 pcf for sloping backfill with a maximum 2H:1V slope. Lateral earth pressures on walls that are restrained from yielding at the top may be calculated on the basis of an “at-rest” equivalent fluid pressure of 60 pcf for level backfill, and 95 pcf for sloping backfill with a maximum 2H:1V slope. The stated equivalent fluid pressures do not include surcharge loads, such as foundation, vehicle, equipment, etc., adjacent to walls, hydrostatic pressure buildup, or earthquake loading.

Lateral frictional resistance between the base of footings and the subgrade can be expressed as the applied vertical load multiplied by a coefficient of friction of 0.32 for concrete foundations bearing directly on native fine-grained soils or 0.42 for concrete foundations bearing on at least 12 inches of granular structural fill. In addition, lateral loads may be resisted by passive earth pressures based on an equivalent fluid density of 300 pounds per cubic foot (pcf) for footings poured "neat" against in-situ soils, or properly backfilled with structural fill. These are ultimate values - we recommend a factor of safety of 1.5 be applied to the equivalent fluid pressure, which is appropriate due to the amount of movement required to develop full passive resistance.

We recommend that retaining walls be designed for an earth pressure determined using the Mononobe-Okabe method to mitigate future seismic forces. Our calculations were based on one-half of the Design Peak Ground Acceleration (PGA) value of 0.278g, which was obtained from Table 2 above. For seismic loading on retaining walls with level backfill, new research indicates that the seismic load is to be applied at 1/3 H of the wall instead of 2/3 H, where H is the height of the wall[5]. We recommend that a Mononobe-Okabe earthquake thrust per linear foot of 7.5 psf * H^2 be applied at 1/3 H from the base of the wall, where H is the height of the wall measured in

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[5] Lew, M., et al (2010). “Seismic Earth Pressures on Deep Building Basements,” SEAOC 2010 Convention Proceedings, Indian Wells, CA.

feet. Note that the recommended earthquake thrust value is appropriate for slopes behind the retaining wall of up to 10 degrees.

All backfill for retaining walls should be select granular material, such as sand or crushed rock with a maximum particle size between ¾ and 1½ inches, having less than five percent material passing the No. 200 sieve. Because of the fines content, the soil on site **will not** meet this requirement, and it will be necessary to import specified material to the project for structural drainage backfill behind retaining walls. Silty soils can be used for the last 18 to 24 inches of backfill, thus acting as a seal to the granular backfill.

All backfill behind retaining walls should be moisture conditioned to within +/- 2 percent of optimum moisture content and compacted to a minimum of 90 percent of the material's maximum dry density as determined in accordance with ASTM D1557. This recommendation applies to all backfill located within a horizontal distance equal to 75 percent of the wall height, but should be no less than 4 feet.

An adequate subsurface drain system will need to be designed and installed behind retaining walls to prevent hydrostatic buildup. A waterproofing system should be designed to mitigate against moisture intrusion.

3.7 Pavement Recommendations

After pavement subgrades have been stripped, the exposed pavement subgrade soil should be proofrolled with a fully loaded dual axle dump truck before the placement of any imported granular fill base rock. Areas found to be soft or yielding under the weight of the dump truck should be overexcavated as recommended by an EEI representative and replaced with properly compacted granular structural fill. Given the presence of existing, variably compacted fill soils, we expect that there could be some overexcavation recommended during construction.

The recommended pavement section thicknesses presented below should be considered typical and minimum for the assumed traffic loading parameters and assumed California Bearing Ratio (CBR) value of 6 for fine-grained soils. Using the ASSHTO method of flexible pavement design, the following design parameters have been assumed:

- Pavement design life of 20 years.
- Terminal serviceability (P_t) of 2 (i.e. poor condition).
- A regional factor (R) of 3.0 (generally moderate weather conditions).
- 18,000-pound equivalent single axle load (ESAL) of 5 per day for parking and 20 ESALs per day for driveways.

The project Civil Engineer should review our assumptions to confirm they are appropriate for the anticipated traffic loading. Using the above assumptions, we recommend the following typical "standard" pavement section for the proposed development of the property. The tables below summarize our recommendations for asphaltic concrete and concrete pavement sections, and pervious concrete base course, respectively.

Table 4: Asphaltic Concrete Section Recommended Minimum Thicknesses

PAVEMENT MATERIAL	CAR PARKING	DRIVEWAY
Asphaltic Concrete (inches)	2.5	3
Crushed Aggregate Base Course (inches) underlain by Mirafi 500X or equivalent	7	9

Asphalt pavement base course material should consist of a well-graded 1½-inch or ¾-inch-minus crushed rock having less than 5 percent material passing the No. 200 sieve. The base course and asphaltic concrete materials should conform to the requirements set forth in the latest edition of the State of Oregon Standard Specifications for Highway Construction. Base course material should be moisture conditioned to within ± 2 percent of optimum moisture content, and compacted to a minimum of 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor). Fill materials should be placed in layers that, when compacted, do not exceed about 8 inches. Asphaltic concrete material should be compacted to at least 91 percent of the material's theoretical maximum density as determined in accordance ASTM D2041 (Rice Specific Gravity).

As requested, we are also providing a gravel section thickness for permeable pavement to support traffic loading. Our recommendations in Table 5 below do not include any strength contribution from the permeable pavement section (i.e. we are relying entirely on the gravel.

Table 5: Permeable Pavement Section Recommended Minimum Thicknesses

PAVEMENT MATERIAL	CAR PARKING	DRIVEWAY
Crushed Aggregate Base Course (inches) underlain by Mirafi 500X or equivalent	14	18

A representative of the Geotechnical Engineer should approve any selected granular fill material before importing it to the site. Each lift of compacted engineered fill should be evaluated by a representative of the Geotechnical Engineer prior to placement of subsequent lifts. The base course fill should extend horizontally outward beyond the exterior perimeter of the pavement at least three feet, prior to sloping.

In order to achieve the assumed 20-year design life, pavement does need regular maintenance to protect the underlying subgrade from being damaged. The primary concern is subgrade saturation which can cause it to weaken. Proper site drainage should be maintained to protect pavement areas. In addition, cracks that develop in the pavement should be sealed on a regular basis.

4.0 CONSTRUCTION CONSIDERATIONS

EEI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. EEI cannot accept any responsibility for any conditions that deviate from those described in this report, nor for the performance of the foundations if not engaged to also provide construction observation for this project.

4.1 Moisture Sensitive Soils/Weather Related Concerns

The soils encountered at this site are expected to be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

4.2 Drainage and Groundwater Considerations

Water should not be allowed to collect in the foundation excavations or on prepared subgrades for the slabs during construction. Positive site drainage should be maintained throughout construction activities. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, groundwater, or surface runoff.

The site grading plan should be developed to provide rapid drainage of surface water away from the building areas and to inhibit infiltration of surface water around the perimeter of the proposed structure. The grades should be sloped away from the construction area to prevent saturation of the foundation/slab subgrades which could lead to softening of the soils and excessive settlement.

4.3 Excavations

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document and subsequent updates were issued to better insure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavations or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

We are providing this information solely as a service to our client. EEI does not assume responsibility for construction site safety or the contractor's compliance with local, state, and federal safety or other regulations.

5.0 REPORT LIMITATIONS

As is standard practice in the geotechnical industry, the conclusions contained in our report are considered preliminary because they are based on assumptions made about the soil, rock, and groundwater conditions exposed at the site during our subsurface investigation. A more complete extent of the actual subsurface conditions can only be identified when they are exposed during construction. Therefore, EEI should be retained as your consultant during construction to observe the actual conditions and to provide our final conclusions. If a different geotechnical consultant is retained to perform geotechnical inspection during construction then they should be relied upon to provide final design conclusions and recommendations, and should assume the role of geotechnical engineer of record.

The geotechnical recommendations presented in this report are based on the available project information, and the subsurface materials described in this report. If any of the noted information is incorrect, please inform EEI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. EEI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

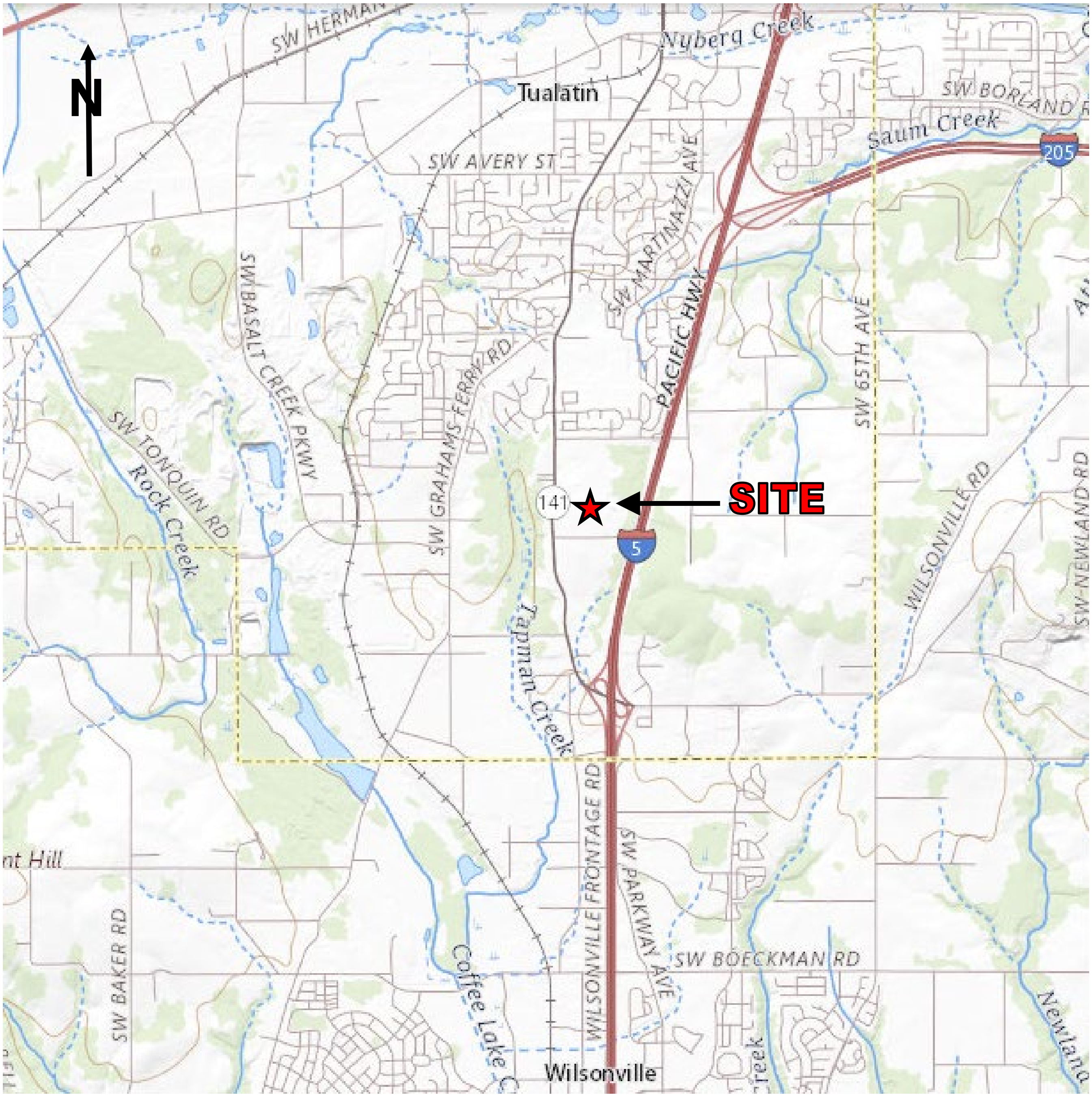
Once construction plans are finalized and a grading plan has been prepared, EEI should be retained to review those plans, and modify our existing recommendations related to the proposed construction, if determined to be necessary.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

This report has been prepared for the exclusive use of Community Partners for Affordable Housing for the specific application to the proposed Basalt Creek Affordable Housing development to be located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. EEI does not authorize the use of the advice herein nor the reliance upon the report by third parties without prior written authorization by EEI.

APPENDICES

APPENDIX A – SITE LOCATION PLAN



Base map source: https://apps.nationalmap.gov/viewer/.

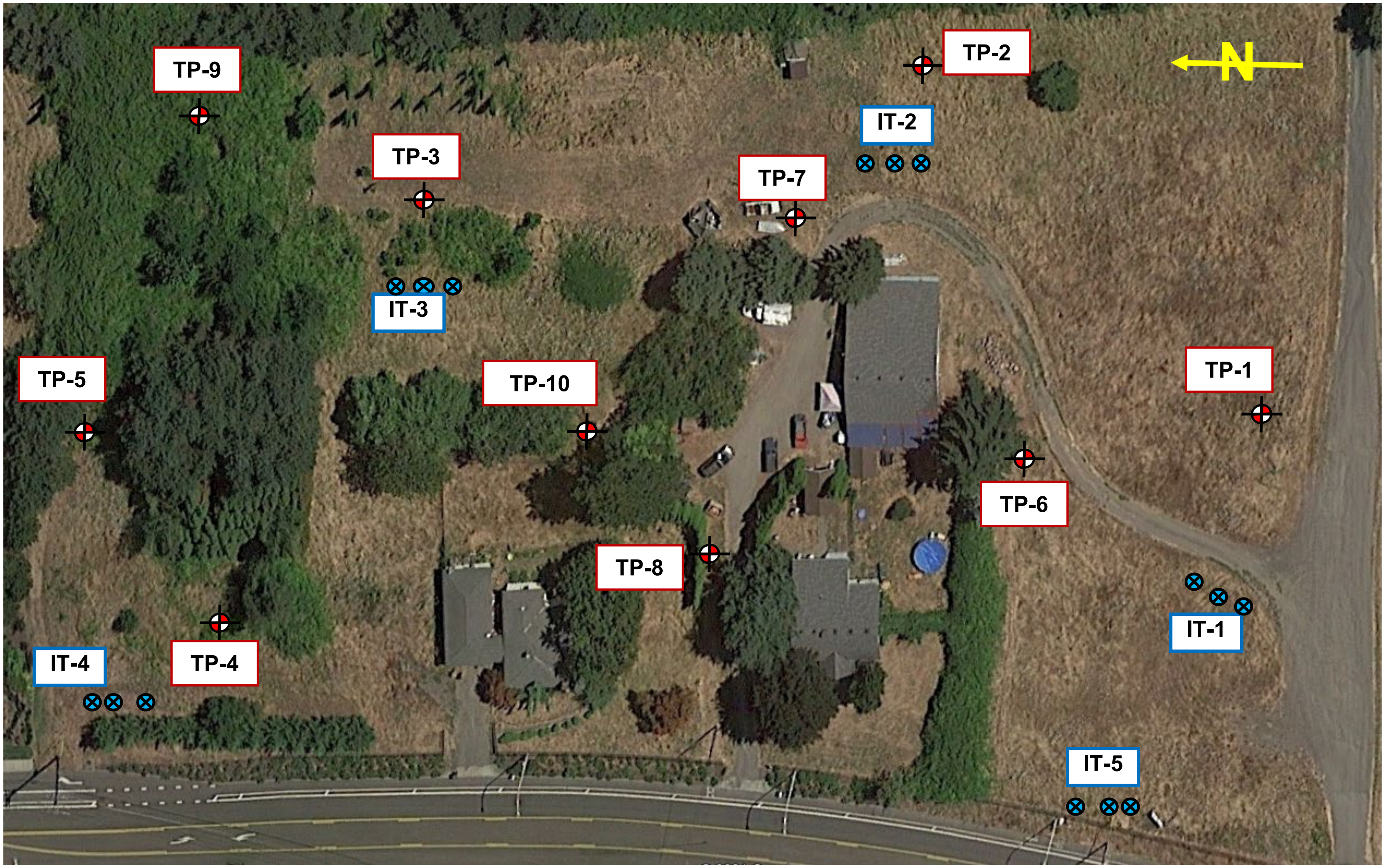
Earth
Engineers,
Inc.

Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Report No.
21-023-1

March 17, 2021

APPENDIX B – EXPLORATION LOCATION PLAN



Base drawing source: “Preliminary” drawing A0.00 by Carlton Hart Architecture, undated.

Earth Engineers, Inc.

Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Report No.
20-023-1

March 17, 2021

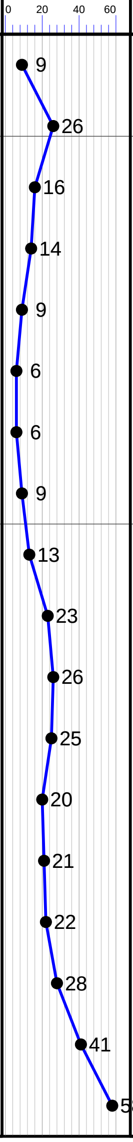
Earth
Engineers,
Inc.

Appendix C: Test Pit TP-1

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 347
Date of Exploration: March 1, 2021



		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Easy	9						
						26						
1			Silt (ML) - brown silt with orange and black mottling, very stiff to medium stiff, moist to wet			16						
				GRAB 1		14	3	24	89			
2						9						
						6						
3				GRAB 2		6	0.75	31	92	38	25	
	▼					9						
4			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet			13						
						23						
5						26						
						25						
6				GRAB 3		20		29				
						21						
7						22						
						28						
8						41						
				GRAB 4	Hard	58		31				
9												
9												
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 4 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

Appendix C: Test Pit TP-2

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 353
Date of Exploration: March 1, 2021

		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches (0 20 40 60)	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with roots, and rootlets, moist		Easy	3						
						4						
1			Silt (ML) - brown silt with orange and black mottling, soft to medium stiff, moist	GRAB 1		4	0.75	31				
						4						
2						4						Hit a white PCV pipe
						7						
3						8						
	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 2		12	2.5	31				
4						14						
						17						
5						17						
						16						
6						18						
						18						
7						27						
				GRAB 3		32		49				
8						30						
					Hard	42						
9						55						
				GRAB 4				47				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 10 feet bgs. Drive probe terminated at a depth of approximately 9.5 feet bgs. Groundwater seepage was encountered at depth of about 4 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

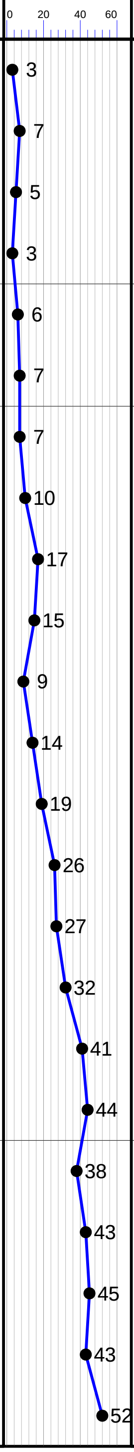
Appendix C: Test Pit TP-3

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 354
Date of Exploration: March 1, 2021

Depth (ft)	Water Level	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0		Topsoil - dark brown sandy silt with roots and rootlets, moist		Easy	3 7 5 3						Hit a white PCV pipe
2		Silt (ML) - brown silt with orange and black mottling, medium stiff, moist			6 7	0.5					
3	▼	Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 1 GRAB 2 GRAB 3	Hard	7 10 17 15 9 14 19 26 27 32 41 44	1.5	31 27 33				
9					38 43 45 43 52						



Depth (ft): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 11.5 feet bgs. Groundwater seepage was encountered at depth of about 6.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

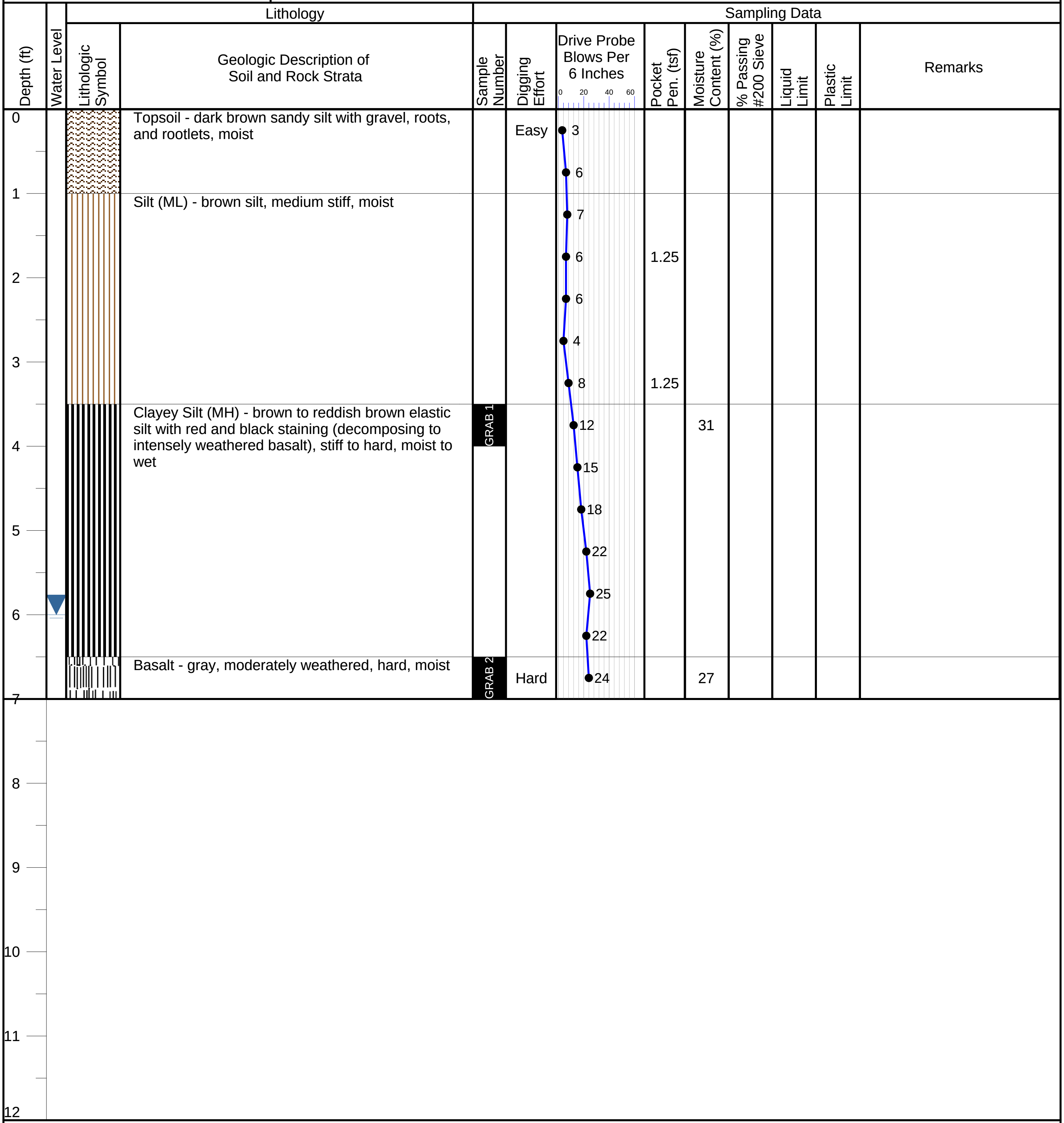
Earth Engineers, Inc.

Appendix C: Test Pit TP-4

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 344
Date of Exploration: March 1, 2021



Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Easy	3 6						
1			Silt (ML) - brown silt, medium stiff, moist			7 6 6 4 8	1.25 1.25					
	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet	GRAB 1		12 15 18 22 25 22		31				
			Basalt - gray, moderately weathered, hard, moist	GRAB 2	Hard	24		27				

Notes: Test pit terminated at a depth of approximately 7 feet bgs due to practical digging refusal. Drive probe terminated at a depth of approximately 7 feet bgs due to refusal. Groundwater seepage was encountered at depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

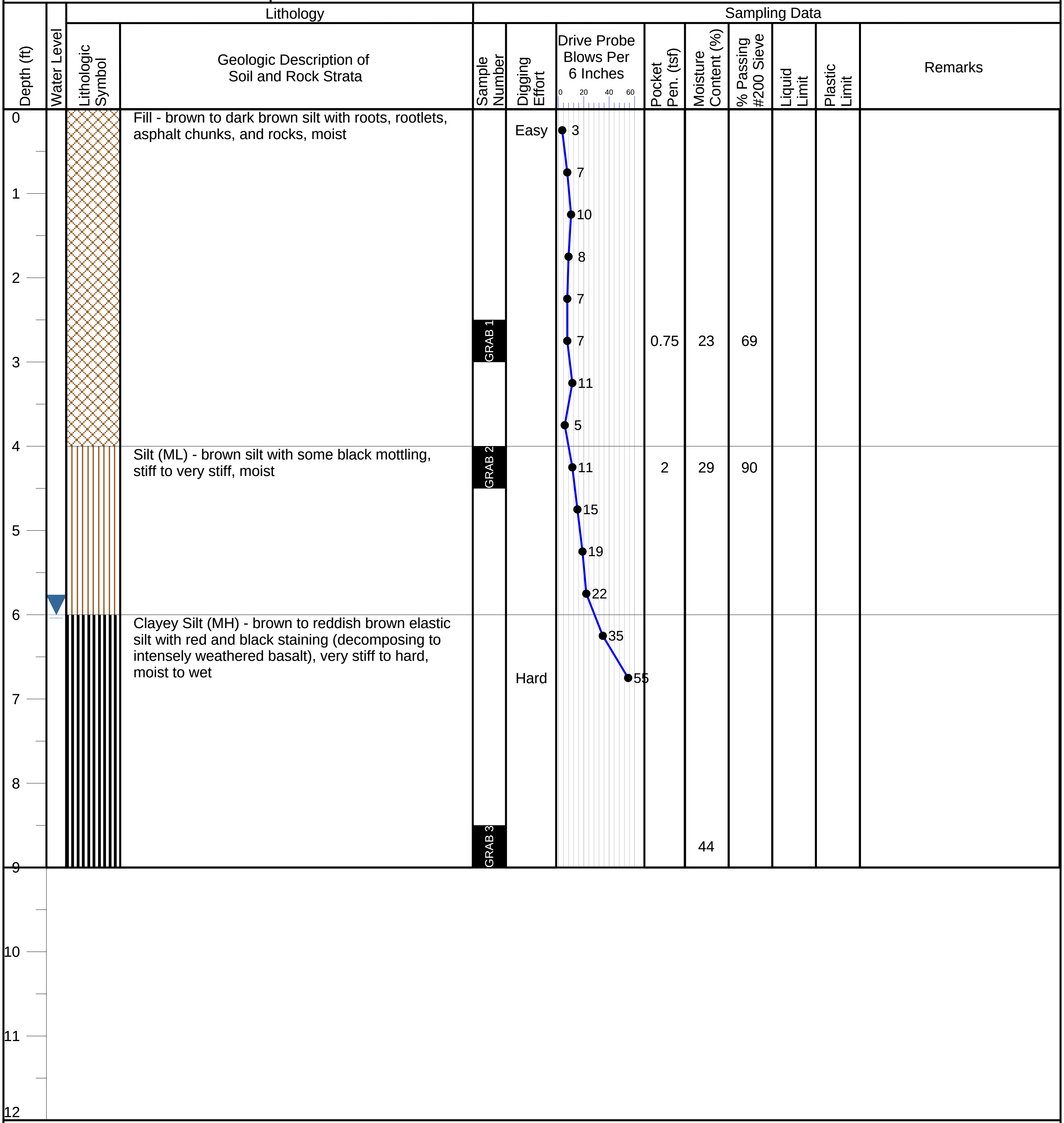
Earth Engineers, Inc.

Appendix C: Test Pit TP-5

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 346
Date of Exploration: March 1, 2021



Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Fill - brown to dark brown silt with roots, rootlets, asphalt chunks, and rocks, moist	GRAB 1	Easy	0.75	23	69			
4			Silt (ML) - brown silt with some black mottling, stiff to very stiff, moist	GRAB 2		2	29	90			
6	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist to wet	GRAB 3	Hard		44				

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 7 feet bgs due to refusal. Groundwater seepage was encountered at depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

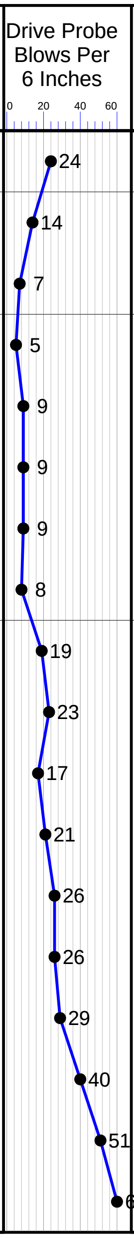
Earth Engineers, Inc.

Appendix C: Test Pit TP-6

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 348
Date of Exploration: March 2, 2021



Depth (ft)	Water Level	Lithology: Lithologic Symbol	Lithology: Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Mod.	24						
1			Fill - dark borwn silt with gravel and some charcoal and brick fragments, moist	GRAB 1		14 7	2.25	26				
2 3			Silt (ML) - brown silt with orange and black mottling, medium stiff to stiff, moist to wet	GRAB 2	Easy	5 9 9 9 8	1.25	24				
4 5 6 7 8 9	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist to wet	GRAB 3 GRAB 4	Hard	19 23 17 21 26 26 29 40 51 60		26 28				

9
10
11
12

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 7.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

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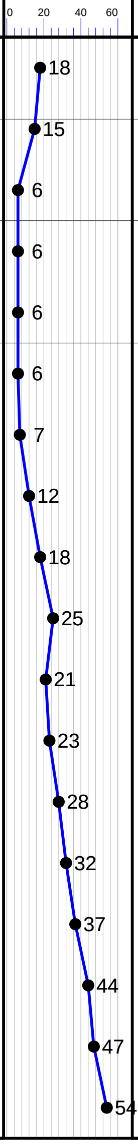
Appendix C: Test Pit TP-7

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 352
Date of Exploration: March 2, 2021



		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Mod.	18						
1			Fill - dark borwn silt with gravel and some charcoal and brick fragments	GRAB 1		15 6	0.5	25				
2			Silt (ML) - brown silt with orange and black mottling, medium stiff, moist		Easy	6 6						
3 4 5 6 7 8 9	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 2 GRAB 3 GRAB 4	Hard	6 7 12 18 25 21 23 28 32 37 44 47 54	1.5 2	28 29 31	92	54	23	
10 11 12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 4.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

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Appendix C: Test Pit TP-8

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 348
Date of Exploration: March 2, 2021

Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches (0 20 40 60)	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil- dark brown sandy silt with roots and rootlets, moist		Mod.							
1			Fill - brown clayey silt with gravel, charcoal, and bricks, moist	GRAB 1			2	24				Hit a steel water line
3			Silt (ML) - brown silt, very stiff to medium stiff to very stiff, moist to wet	GRAB 2	Easy		0.5	26				
6			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist	GRAB 3				28				
				GRAB 4	Hard			28				
9												
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe testing not attempted at this location. Groundwater was not encountered at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

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Appendix C: Test Pit TP-9

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 354
Date of Exploration: March 2, 2021

		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches (0 20 40 60)	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0		▨	Fill - brown to dark brown silt with roots, rootlets, charcoal, and rocks, moist									
1					Easy							
2												
3				GRAB 1			1	24				
4												
5												
6												
6.5		▥	Silt (ML) - brown silt, medium stiff to stiff, moist									Becomes Stiff
7				GRAB 2				26				
7.5		▥	Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing basalt), stiff									
8												
9				GRAB 3				28				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9.5 feet bgs. Drive probe testing not attempted at this location. Groundwater was not encountered at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

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Appendix C: Test Pit TP-10

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 349
Date of Exploration: March 2, 2021

Depth (ft)	Water Level	Lithology		Sampling Data								
		Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches 0 20 40 60	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil- dark brown sandy silt with roots and rootlets, moist		Mod.							
				GRAB 1				30				
1			Fill - brown to reddish brown silt with bricks and charcoal, moist									
2				GRAB 2			1	28				
3												
			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet	GRAB 3			2	30	94			
4												
5												
	▼			GRAB 4				28				
6												
7												
8												
				GRAB 5	Hard			27				
9												
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe testing not attempted at this location. Groundwater seepage was encountered at a depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

APPENDIX D: SOIL CLASSIFICATION LEGEND

APPARENT CONSISTENCY OF COHESIVE SOILS (PECK, HANSON & THORNBURN 1974, AASHTO 1988)

Descriptor	SPT N_{60} (blows/foot)*	Pocket Penetrometer, Qp (tsf)	Torvane (tsf)	Field Approximation
Very Soft	< 2	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	2 – 4	0.25 – 0.50	0.12 – 0.25	Easily penetrated several inches by thumb
Medium Stiff	5 – 8	0.50 – 1.0	0.25 – 0.50	Penetrated several inches by thumb w/moderate effort
Stiff	9 – 15	1.0 – 2.0	0.50 – 1.0	Readily indented by thumbnail
Very Stiff	16 – 30	2.0 – 4.0	1.0 – 2.0	Indented by thumb but penetrated only with great effort
Hard	> 30	> 4.0	> 2.0	Indented by thumbnail with difficulty

* Using SPT N_{60} is considered a crude approximation for cohesive soils.

APPARENT DENSITY OF COHESIONLESS SOILS (AASHTO 1988)

Descriptor	SPT N_{60} Value (blows/foot)
Very Loose	0 – 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	> 50

MOISTURE (ASTM D2488-06)

Descriptor	Criteria
Dry	Absence of moisture, dusty, dry to the touch, well below optimum moisture content (per ASTM D698 or D1557)
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table, well above optimum moisture content (per ASTM D698 or D1557)

PERCENT OR PROPORTION OF SOILS (ASTM D2488-06)

Descriptor	Criteria
Trace	Particles are present but estimated < 5%
Few	5 – 10%
Little	15 – 25%
Some	30 – 45%
Mostly	50 – 100%
Percentages are estimated to nearest 5% in the field. Use "about" unless percentages are based on laboratory testing.	

SOIL PARTICLE SIZE (ASTM D2488-06)

Descriptor	Size
Boulder	> 12 inches
Cobble	3 to 12 inches
Gravel - Coarse Fine	¾ inch to 3 inches No. 4 sieve to ¾ inch
Sand - Coarse Medium Fine	No. 10 to No. 4 sieve (4.75mm) No. 40 to No. 10 sieve (2mm) No. 200 to No. 40 sieve (.425mm)
Silt and Clay ("fines")	Passing No. 200 sieve (0.075mm)

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2488)

Major Division			Group Symbol	Description
Coarse Grained Soils (more than 50% retained on #200 sieve)	**Gravel** (50% or more retained on No. 4 sieve)	Clean Gravel	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravel with fines	GM	Silty gravels and gravel-sand-silt mixtures
			GC	Clayey gravels and gravel-sand-clay mixtures
	Sand (> 50% passing No. 4 sieve)	Clean sand	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly-graded sands and gravelly sands, little or no fines
		Sand with fines	SM	Silty sands and sand-silt mixtures
			SC	Clayey sands and sand-clay mixtures
Fine Grained Soils (50% or more passing #200 sieve)	**Silt and Clay** (liquid limit < 50)		ML	Inorganic silts, rock flour and clayey silts
			CL	Inorganic clays of low-medium plasticity, gravelly, sandy & lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silt and Clay (liquid limit > 50)		MH	Inorganic silts and clayey silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

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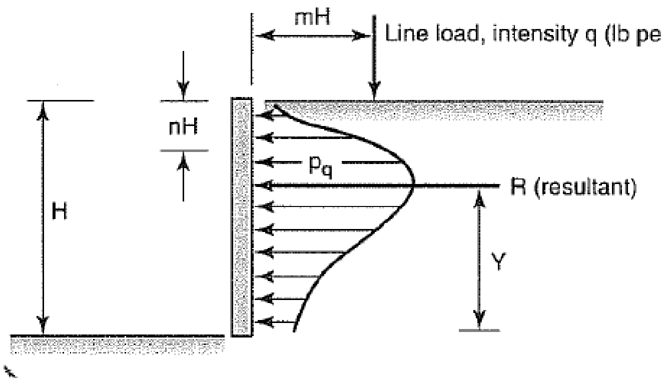
GRAPHIC SYMBOL LEGEND

GRAB	☒	Grab sample
SPT	■	Standard Penetration Test (2" OD), ASTM D1586
ST	▨	Shelby Tube, ASTM D1587 (pushed)
DM	▤	Dames and Moore ring sampler (3.25" OD and 140-pound hammer)
CORE	▥	Rock coring

APPENDIX E: SURCHARGE-INDUCED LATERAL EARTH PRESSURES FOR WALL DESIGN

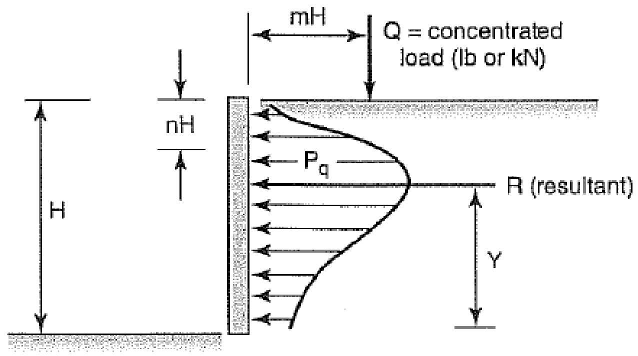
LINE LOAD (applicable for retaining walls not exceeding 20 feet in height):



m	R	Y
0.2	0.55q	0.60 H
0.4	0.55q	0.58 H
0.6	$\frac{0.64q}{m^2+1}$	0.52 H

Figure 16-28 Pressure distribution against vertical wall resulting from line load of intensity *q*.

CONCENTRATED POINT LOAD (applicable for retaining walls not exceeding 20 feet in height):



m	R	Y
0.2	$0.78\frac{Q}{H}$	0.59 H
0.4	$0.78\frac{Q}{H}$	0.59 H
0.6	$0.48\frac{Q}{H}$	0.48 H

Figure 16-27 Pressure distribution against vertical wall resulting from point load, *Q*.

AREAL LOAD:

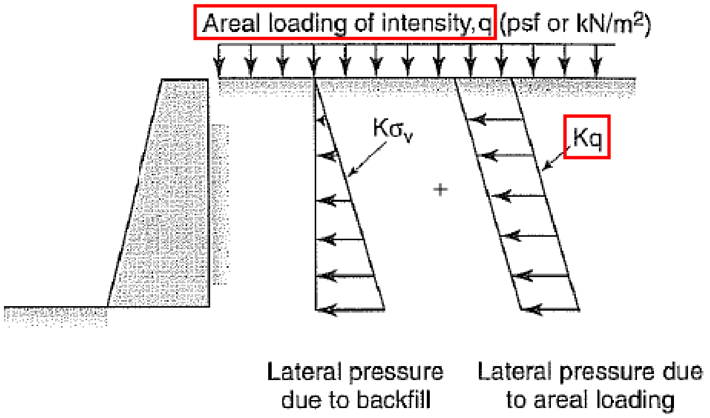
Figure 16-26 Influence of areal loading on wall pressures.

use K=0.4 for active condition (i.e. top of wall allowed to deflect laterally)

use K=0.9 for at-rest condition (i.e. top of wall not allowed to deflect laterally)

Resultant, R = K * q * H

Where H = wall height (feet)



Source of Figures: McCarthy, D.F., 1998, “Essentials of Soil Mechanics and foundations, Basic Geotechnics, Fifth Edition.”

Earth
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Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Report No. 21-023-1

March 17, 2021

Earth
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Inc.

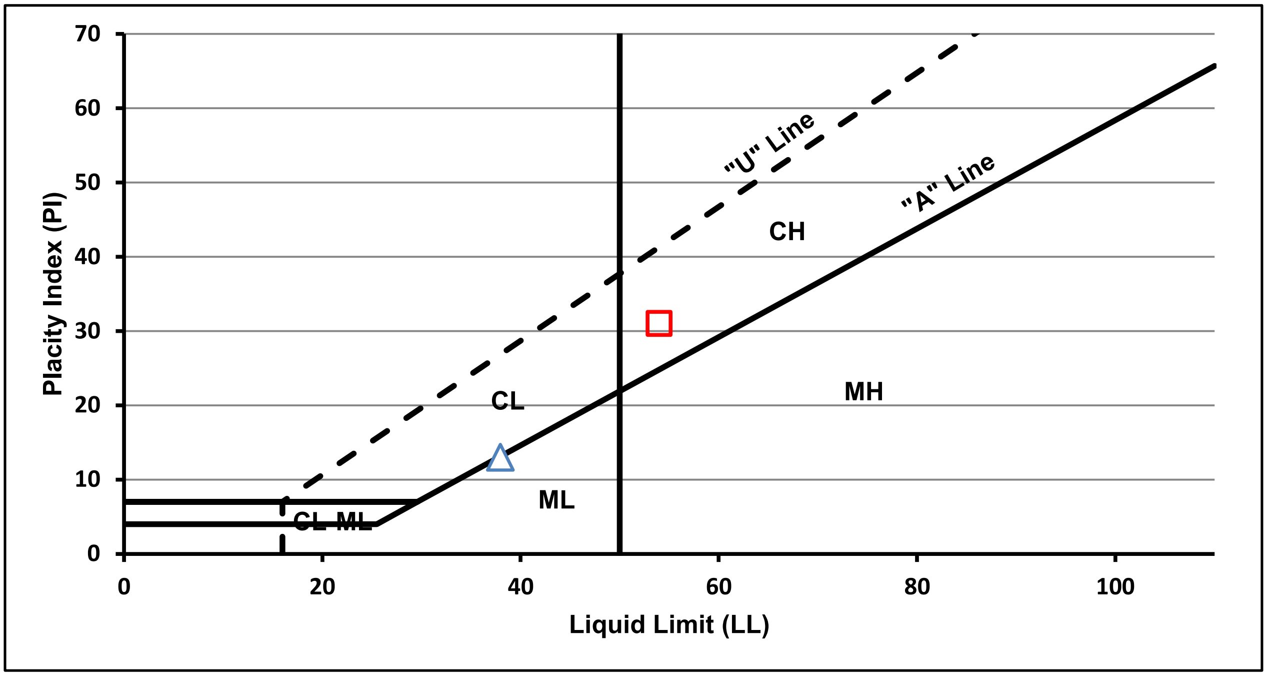
APPENDIX F: LAB TEST RESULTS
REPORT OF ATTERBERG LIMITS
ASTM D 4318

TESTED FOR: Community Partners for Affordable Housing
P.O. Box 23206
Tigard, Oregon 97239
Attention: Jilian Saurage Felton

PROJECT: Basalt Creek Affordable Housing
23500 and 23550 Southwest
Boones Ferry Road
Tualatin, Washington County, OR

DATE: 3/12/2021 REPORT NO.: 21-023-1

TEST DATA



Location	Depth (feet)	Description (USCS)	Moisture Content, %	% Passing #200 Sieve	Atterberg Limits		
					LL	PL	PI
△ TP-1	3	Silt (ML)	31	92	38	25	13
□ TP-7	2.5	Elastic Silt (MH)	28	92	54	23	31

Remarks:
Lab Technician: Anita B.

USCS Classification per ASTM D 2487
Moisture Content per ASTM D 2216
Percent Passing #200 Sieve per ASTM D 1140
Atterberg Limits per ASTM D 4318

Respectfully Submitted,
Earth Engineers, Inc.

Troy Hull, P.E., G.E.

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