ECS Mid-Atlantic, LLC

Geotechnical Engineering Report, Rev. 1

NRRWA Water Treatment Plant

289 Kohler Avenue
Austinville, Virginia

ECS Project No. 12:2638-D1

October 12, 2023
Revised January 23, 2024

October 12, 2023
Revised January 23, 2024

Mr. Johnathan McClure, EIT
Peed & Bortz
20 Midway Plaza Drive
Christiansburg, Virginia 24073

ECS Project No. 12:2638-D1

Reference: Geotechnical Engineering Report, Rev. 1
NRRWA Water Treatment Plant
289 Kohler Avenue
Austinville, Virginia

Dear Mr. McClure:

ECS Mid-Atlantic, LLC (ECS) has completed the subsurface exploration, laboratory testing, and geotechnical engineering analyses for the above-referenced project. Our services were performed in general accordance with our agreed to scope of work. This report presents our understanding of the geotechnical aspects of the project along with the results of the field exploration and laboratory testing conducted, and our design and construction recommendations. This report has been revised to include data from the recent supplemental subsurface exploration consisting of additional ERI testing and geotechnical soil borings.

It has been our pleasure to be of service to Peed & Bortz during the design phase of this project. We would appreciate the opportunity to remain involved during the continuation of the design phase, and we would like to provide our services during construction phase operations as well to verify subsurface conditions assumed for this report. Should you have any questions concerning the information contained in this report, or if we can be of further assistance to you, please contact us.

Respectfully submitted,

ECS Mid-Atlantic, LLC

This document has been digitally signed & sealed by Michael D. Venezia, P.E. on 01/23/2024. Printed copies of this document are not considered signed & sealed, and the signature must be verified on electronic copies.

COMMONWEALTH OF VIRGINIA
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EXECUTIVE SUMMARY

This Executive Summary is intended as a very brief overview of the primary geotechnical conditions that are expected to affect design and construction. Information gleaned from the Executive Summary should not be utilized in lieu of reading the entire geotechnical report.

- ECS performed an ER study as shown on the attached Location Diagram. Four (4) ER lines were conducted on the site. Our interpretation of the ER data in the context of the boring data and mapped karst features is portions of the site are underlain by adverse karst conditions that may affect overlying building structures. Siting buildings in areas where potential karst features are identified would be characterized as a moderate to high likelihood of future sinkhole activity.

- ECS recommends the dewatering building and solids shelter be shifted appropriately 25 feet northwest of the current layout and the thickener tanks be rotated 90 degrees to distance the proposed structures from the identified potential karst features observed in our ERI profiles.

- Shifting the footprint of the proposed structures is intended to help lessen future potential karst related concerns. The preponderance of subsurface data indicates that the portion of the site (i.e. the area recommended to re-locate the structure footprints) has a low to moderate risk of sinkhole development thus less extensive karst mitigation measures may be considered (as opposed to the Compaction Grouting recommendations contained within the October 12, 2023 report).

- The proposed thickener tanks, dewatering building, and solids shelter can be supported by conventional shallow foundations consisting of a mat foundation (thickener tanks) or strip/continuous foundations (dewatering building & dry solids shelter) bearing on engineered graded aggregate fill. The thickener tank can be designed for an allowable bearing pressure of 2,500 psf and the dewatering building/dry solids shelter can be designed for an allowable bearing pressure of 2,000 psf.

- ECS should be provided with the opportunity to review our recommendations and complete additional geotechnical exploration and recommendations based on actual loading conditions and final layout.

Refer to the text of the report for site specific design and construction recommendations.

1.0 INTRODUCTION

The purpose of this study was to provide geotechnical information for improvements to the existing NRRWA Water Treatment Plant facility. The recommendations developed for this report are based on project information supplied by you and Russel Jackson of Peed & Bortz, LLC.

Our services were provided in accordance with our Proposal No. 12:15633-PR, dated June 23, 2023, as authorized by you on June 30, 2023, which includes our Terms and Conditions of Service. Our recent supplemental services were also provided in accordance with the Change Order, dated December 12, 2023, as authorized by you on December 12, 2023.

This report contains the procedures and results of our subsurface exploration and laboratory testing programs, review of existing site conditions, engineering analyses, and recommendations for the design and construction of the project.

The report includes the following items.

- A brief review and description of our field and laboratory test procedures and the results of testing conducted
- A review of surface topographical features and site conditions
- A review of area and site geologic conditions
- A review of subsurface soil/rock stratigraphy with pertinent physical properties
- Final soil exploration test boring logs
- Recommendations for site preparation and construction of compacted fills, including an evaluation of on-site soils for use as compacted fills and identification of potentially unsuitable soils and/or soils exhibiting excessive moisture at the time of sampling
- Recommended foundation type(s)
- Recommendations for slab-on-grade construction
- Recommendations for seismic site classification in accordance with the International Building Code (IBC 2018)
- Results and interpretation of Electrical Resistivity Imaging

2.0 PROJECT INFORMATION

2.1 PROJECT LOCATION/CURRENT SITE USE/PAST SITE USE

The site is located at 289 Kohler Avenue in the Austinville area of Wythe County, Virginia. The site is currently developed with several existing structures and infrastructure associated with the currently operating NRRWA Water Treatment Plant. At the time of our visit, the ground surfaces (in the area of the proposed new construction) consisted primarily of grass covered soil and gravel access drives. The overall site is bounded to the north by a densely wooded tree line; to the east and south by Kohler Avenue; and to the west by a residential development.

Figure 2.1.1. Site Location

The northwest portion of the site was generally an open grassy field with a chain link fence running along the westernmost portion of this area. The terrain in this area of the site is relatively flat with elevations ranging from approximately +2122 to +2126 feet, msl. based on topographic information obtained from the conceptual site plan prepared by Peed & Bortz, dated, January 1, 2023.

The southeast portion of the site consisted of a gravel access drive with a chain link fence running along the northwest portion of this area. There is an existing stormwater basin in the southernmost portion of the site with an invert elevation of approximately 2112 feet, msl. With the exception of the stormwater basin, the terrain in this area of the site is relatively flat with elevations ranging from +2115 to +2121 feet, msl.

2.2 PROPOSED CONSTRUCTION

The following information explains our understanding of the planned development including proposed buildings and related infrastructure. The planned improvements include the construction of a 40’ x 40’ Solids Dewatering Building supported with 14’-8” tall CMU walls, a 40’ x 60’ Dry Solids Shelter consisting of a tensioned fabric structure with 6’ tall concrete knee wall foundations, thickener tanks with a common wall or separate bolted glass lined steel alternative, and a sludge pump station wet well, in addition to the associated at-grade asphalt paving, hardscapes, and underground utilities.

SUBJECT	DESIGN INFORMATION / ASSUMPTIONS
Solids Dewatering Building Footprint	Approximately 1,600 square feet in plan view
Dry Solids Shelter Building Footprint	Approximately 2,400 square feet in plan view
# of Stories	1 story above grade
Usage	Water Treatment
Framing	CMU Walls/Tensioned Fabric/Bolted Glass Lined Steel Alternative
Slab Loads*	2 kips per square foot (ksf) maximum
Wall Loads*	2 kips per linear foot (klf) maximum
Lowest Finish Floor Elevation	EL. 2121.5 feet, msl.

*Estimated load are based on approximations of anticipated loading conditions; if final design loads exceed our assumed loads, this report needs to be revised to update our foundation recommendations, bearing capacity, and settlement calculations.

3.0 FIELD EXPLORATION AND LABORATORY TESTING

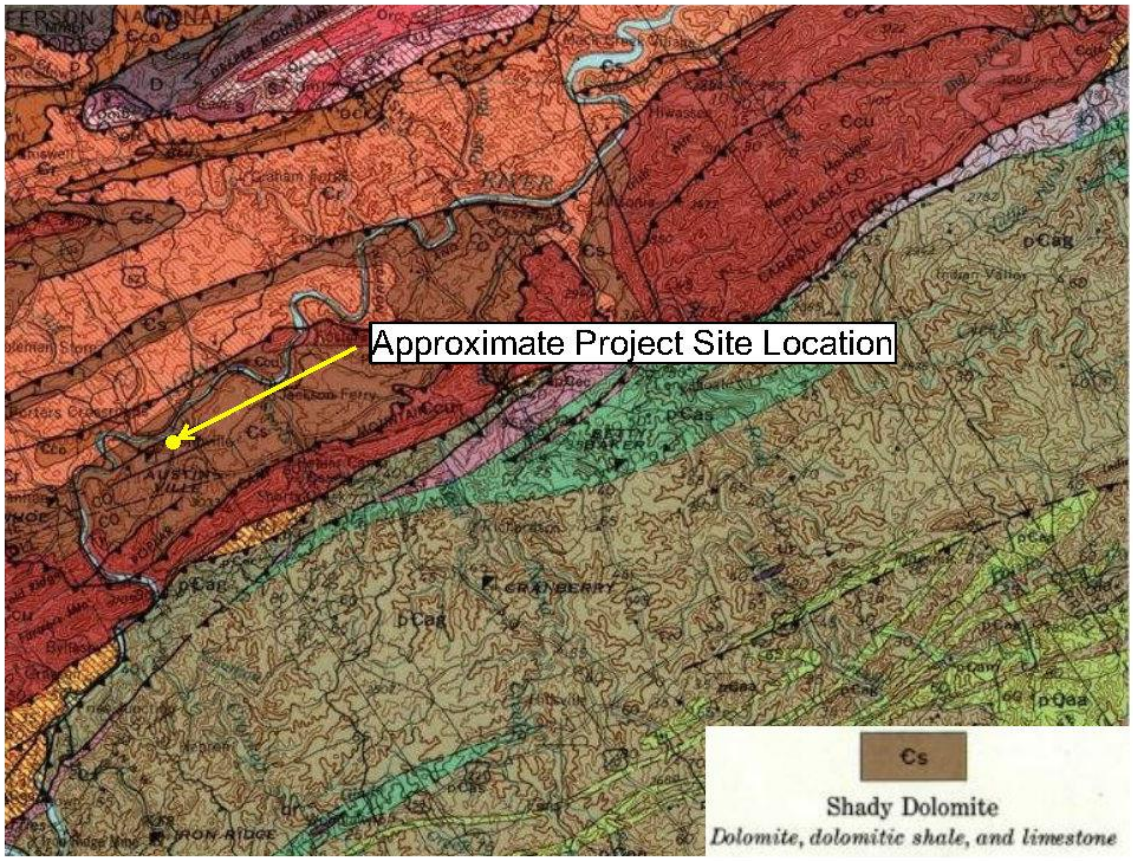
Our exploration procedures are explained in greater detail in Appendix B including the insert titled Subsurface Exploration Procedures. Our scope of work included drilling six (6) borings in July 2023, and six (6) supplemental borings in December 2023. Our borings were located with a handheld GPS unit while referencing Google Earth aerial imaging (showing desired boring locations provided by your office) and estimating angles from existing site features. Their approximate locations are shown on the Boring Location Diagram in Appendix A.

3.1 SITE GEOLOGY

Based on our review of the “Geologic map of the east half of the Winston-Salem quadrangle, North Carolina-Virginia” (U.S. Geological Survey, 1975), the project site is located in the Valley and Ridge Phsiographic and Geologic Province in Southwestern Virginia.

Specifically, geologic mapping indicates that the subject site area is underlain by the Lower Cambrian-aged Shady Dolomite Formation (€s). The Shady Dolomite Formation consists primarily of dolostone with minor limestone and shale divided into three members: Ivanhoe (upper) Member; Austinville (middle) Member, and Patterson (lower) Member. The project site is located in Austinville and therefore characterized by the Austinville Member. The Austinville Member of the Shady Dolostone Formation is known to consist of massive-bedded dolostone with several sequences of interbedded limestone.

The boundary between soil and rock is not sharply defined. A transitional zone termed "weathered rock" is normally found overlying the parent bedrock. Weathered Rock (WR) is defined, for engineering purposes, as residual material with Standard Penetration resistance greater than 60 blows per foot (bpf). Because weathering is facilitated by fractures, joints, and the presence of less resistant rock types, the profile of the WR and hard rock is typically irregular and erratic, even over short horizontal distances. Also, it is not unusual to find lenses and natural floating boulders of hard rock in zones of WR within the soil mantle, well above the general bedrock level.



3.2 KARST FEATURE MAPPING

Based on our review of the *Virginia Energy's Geology and Mineral Resources* map, there are seven (7) mapped karst features on the project site. ECS has overlain the publicly mapped karst features on the proposed development plans as shown on the Karst Feature Location Diagram (2 sheets) included in Appendix A of this report.

3.3 SUBSURFACE CHARACTERIZATION

The subsurface conditions encountered were generally consistent with published geological mapping. The following sections provide generalized characterizations of the soil strata. Please note that the ground surface elevations were not surveyed by a licensed surveyor; these elevations are approximate based on topographic map provided by you, entitled New River Regional Water Authority Water Treatment Plant Expansion, prepared by Peed & Bortz, and dated January 1, 2023; therefore, elevation ranges are approximate. Please refer to the boring logs in Appendix B.

Approximate Depth (ft)	Stratum	Description	Ranges of SPT(1) N-values (bpf)
0-0.42 (Surface cover)	n/a	Topsoil (2 to 5 inches)	N/A
0.33-35	I	Residuum, Very Soft to Very Stiff FAT CLAY (CH) with varying amounts of roots, sand, and gravel, Moist to Wet; Firm to Hard LEAN CLAY (CL) with varying amounts of sand and gravel, Moist; Soft to Firm ELASTIC SILT (MH), trace sand, Moist; Medium Dense CLAYEY SAND (SC) with varying amounts of gravel; Moist; Very Loose to Medium Dense SANDY SILT (ML), trace gravel, Moist; Very Loose to Medium Dense SILTY SAND (SM), Moist	1 to 51
23.5-25	II	Weathered Rock (WR) sampled as SILTY SAND and FAT CLAY, Moist, Very Dense	60+

Notes:
(1) Standard Penetration Testing

A graphical presentation of the subsurface conditions is shown on the Subsurface Cross Section Diagrams (4 sheets) included in Appendix A.

3.4 GROUNDWATER OBSERVATIONS

Groundwater seepage into our borings was not observed during our exploration at the depths explored and prior to borehole backfill. Variations in the long-term water table may occur as a result of changes in precipitation, evaporation, surface water runoff, construction activities, and other factors.

3.5 LABORATORY TESTING

The laboratory testing consisted of selected tests performed on samples obtained during our field exploration operations. Classification and index property tests were performed on representative soil samples. The laboratory testing program included natural moisture content tests (ASTM D2216), grain size analyses tests (ASTM D6913), and Atterberg Limits tests (ASTM D4318). The results of all laboratory testing conducted are included in the Appendix of this report.

Each sample was visually classified on the basis of texture and plasticity in accordance with ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) and including USCS classification symbols, and ASTM D2487 Standard Practice for Classification for Engineering Purposes (Unified Soil Classification System (USCS)). After classification, the samples were grouped in the major zones noted on the boring logs in Appendix B. The group symbols for each soil type are indicated in parentheses along with the soil descriptions. The stratification lines between strata on the logs are approximate; in situ, the transitions may be gradual.

3.6 ELECTRICAL RESISTIVITY (ER) GEOPHYSICS STUDY RESULTS

ECS performed an ER study as shown on the attached Location Diagram. Four (4) ER lines were conducted on the site (2 in July 2023 and 2 in December 2023).

The purpose of an electrical resistivity survey is to estimate the electrical subsurface characteristics through measurements recorded on the ground surface. Based upon the results of the measured electrical properties, estimates of the true resistivities of subsurface features can be made. These estimated values can then be correlated to various geologic parameters including saturated soils, water interfaces, rock, and void spaces.

For this study, the Syscal Kid Automatic Switching resistivity meter with 24 probes was utilized in a dipole-dipole array layout. In this configuration, a constant spacing between electrodes is utilized to measure the apparent resistivities at different depths. The length of the ER lines conducted was 230 feet, with a probe spacing of 10 feet.

Data collected during this study was analyzed utilizing Res2DInv, an electrical resistivity two-dimensional modeling program. The specific modeling method used was a smooth modeling inversion method, which uses a rapid least squares inversion of apparent resistivities to develop a smooth model of the subsurface characteristics.

The results of this study provide subsurface information to an approximate maximum depth of 25 feet below the ground surface. Elevations shown on the attached ER profiles were approximated from the grading plan provided by you.

3.5.1 Observations and Findings

Review of the ER profiles developed during this study show variable subsurface conditions consistent with the potential for the formation of sinkholes or other karst features. Additionally, publicly available resources show several mapped Karst Features near the proposed construction within the bounds of the overall site (reference the Karst Feature Location Diagrams included in Appendix A). Areas of increased risk of development of sinkholes or other adverse karst conditions described below are also identified on the ER Profiles included with this report.

ER Line 1 was generally oriented northwest to southeast as shown on the location diagram included in Appendix D and exhibited no apparent significant karst features within the limits of the exploration. ER Line 2 was generally oriented northwest to southeast and exhibits a potential solution channel from approximately 165 to 190 feet along the profile (in the approximate area between ECS borings B-01 and B-11). ER Line 3 was generally oriented southwest to northeast and exhibited no apparent significant karst features within the limits of the exploration. ER Line 4 was generally oriented west to east and exhibited no apparent significant karst features within the limits of the exploration. The potential solution channel has been annotated on the corresponding ERI profile included in Appendix D.

The potential solution channel may be indicative of areas where an increased risk of sinkhole development may occur.

Attached to this report, please find the ER Location Diagram and annotated copies of the ER Profiles developed during this study.

When reviewing the attached ER Profiles, please consider the following:

1. Low resistive regions are blue on the attached profiles. Low resistivities typically indicate clay soils, saturated soils, or fractured rock that is saturated or includes soil filled seams.
2. Highly resistive regions are red on the attached profiles. High resistivities typically indicate rock, fractured rock, drier soils, or sandy materials.
3. Air-filled voids will typically appear as red bullseyes or other isolated shapes.
4. Water-filled voids will typically appear as blue bullseyes or other isolated shapes.
5. The resistive properties of subsurface materials may vary across sites as it may be affected by several factors such as water content, soil types and distributions, lithology (rock properties) and other factors. As such, there is no direct standardized correlation between the numeric values shown on the ER profiles and geology. Instead, the reviewer must look at the relative variation across a profile, consider the geologic setting that the profile was collected in, review recent weather conditions, and use his experience to help develop an interpretation of the resistivity profiles. It must also be noted that features that are deeper in the profile need to be larger than shallow features to be observed in the data set.
6. Due to the many variables that may influence the measured electrical resistivity of the subsurface, there is no direct correlation between resistivity values and the presence of rock. We have not provided any interpretation regarding potential rock interfaces as we do not have correlative data to support such interpretations.
7. Locations and dimensions described in this report, and noted on the attached images, should be considered approximate.

3.5.2 Opinions and Generalized Recommendations

As indicated on the annotated ER profiles, and as described above, ECS has identified an area where subsurface karst features may be present. This area, described as a solution channel, is a location where there is an increased risk for the formation of sinkholes or related features. While we have identified this potential feature, it is not possible for ECS to predict when or even if these features will eventually develop into surface depressions or open voids. There are however several factors that could increase the likelihood of those features further developing.

The single most significant factor that could contribute to the formation of sinkholes is an influx of water, either from a significant storm event, a change in local surface and/or subsurface water flow patterns, or a water leak due to a broken or distressed utility. Other factors that could contribute to an increased risk for the formation of sinkholes would include soil disturbances due to construction or maintenance activities at the site, or on adjacent properties.

Based upon the information developed during this study, this site appears to be in an area with a risk for the formation of sinkholes or other karst activity. This is supported by both the subsurface data collected during this study and a review of local geologic information.

As previously indicated, ECS is not able to predict when, where, or if a sinkhole will develop on a site. We are able to identify locations where there is an increased risk for the formation of a sinkhole to develop, and to develop an overall risk potential of a specific site.

4.0 DESIGN RECOMMENDATIONS

4.1 KARST RISK COMMENTARY

The subsurface conditions encountered in the soil test borings consist of residual soils of varying strength and moisture. In addition, the soil strength profile encountered in several of the borings decreases severely with depth (i.e., reverse weathering, a karst indicator). These conditions are indicative of residual soils underlain by karst bedrock, which is subject to sinkhole development. Due to data gathered during the initial exploration, ECS remobilized to the site to perform a supplemental exploration consisting of six additional borings and two additional ERI lines.

Based on review of the subsurface data collected during the explorations, ECS recommends relocating the proposed structures away from potential karst features identified in the soil borings and/or ERI profiles. Shifting the footprint of the proposed structures is intended to help lessen future potential karst related concerns. The preponderance of subsurface data indicates that the portion of the site (i.e. the area recommended to re-locate the structure footprints) has a low to moderate risk of sinkhole development thus less extensive karst mitigation measures may be considered (as opposed to the Compaction Grouting recommendations contained within the October 12, 2023 report).

ECS cannot guarantee that future karst activity will not become evident due to the dissolution of bedrock generally being a very slow process that occurs over geologic time.

Based on our review of the *Virginia Energy's Geology and Mineral Resources* map, there are seven (7) mapped karst features on the project site. The local geology includes carbonate rock which is prone to karst activity. As carbonate rock dissolves, the soluble minerals are carried away by the groundwater, leaving behind the insoluble materials (clay minerals and silicates). The process reduces hard rock into soft soil with the consistency of soft paste. The rate of rock solutioning is rapid relative to geologic time (where processes are generally measured in tens of thousands to millions of years), but very slow on a human time scale. Rock solutioning occurs primarily from the surface downward, along the surfaces of fissures (joints, bedding planes, and fracture zones) in the bedrock. The rock fissures are enlarged, creating soil-filled troughs and channels, surrounded by hard rock. The soil filling is often eroded by flowing groundwater and the troughs and channels become open cavities. These cavities can develop and become interconnected to form caves, which in turn, become open conduits for groundwater flow and sediment transport.

As a cavity in the bedrock grows and expands, the tensile stresses in the roof of the cavity increase, and occasionally the roof will spall slabs of rock as the cavity grows upward toward the ground surface. When a cavity in the rock grows to the point that the roof of rock is too thin or weak to span the void and support the overburden, the cavity can collapse and form a depression or sinkhole at the ground surface, similar to that visible just east of the building. This type of sinkhole development is relatively rare because it is a slow process in terms of human time.

The more common mechanism for sinkhole development is through the erosion of soil overburden into cavities in the underlying bedrock. This erosion starts at the soil-rock interface over an opening in the bedrock. As soil is carried into the opening by percolating groundwater, a cavity is formed in the soil. This cavity grows as the result of raveling of soils from the roof, and can eventually collapse, propagating to the surface and causing a sinkhole. Factors that can contribute to or cause such a collapse include: soil overburden weight, new structural loads, vibrations, construction equipment weight, changes in groundwater levels, and changes to surface water infiltration patterns.

Subsurface soil erosion is aggravated by, among others, the following hydrologic factors: increasing the infiltration of water at the ground surface; lowering of the groundwater level so as to increase the vertical flow gradient and erosion potential at the critical rock-soil interface; and alternately, draining and saturating the soil at the critical rock-soil interface by repeatedly fluctuating the groundwater level from above to below the surface.

4.2 FOUNDATIONS

The surficial soils encountered at the site consisted of high and low plasticity clay, sand, and silt residual soils. These fill soils were encountered in depths extending up to 35± feet below existing grades and could vary in unexplored areas. Due to the karst concerns on site, for conventional shallow foundations to be used, ECS recommends that the thickener tanks be rotated 90° and that the dewatering building and dry solids shelter be shifted northwest approximately 25 feet as shown in the diagram included in Appendix A of this report. Please note that the use of shallow foundations provides less protection/mitigation in the event of future karst related activity than a more extensive karst mitigation measure (such as Compaction Grouting). Should karst features such as voids or sinkholes be observed during construction, ECS should be notified, and further mitigation methods may be warranted.

Provided subgrades (including undercutting discussed below) and Structural Fills are prepared as recommended in this report, the proposed structure can be supported by shallow foundations including a mat foundation (thickener tank) and continuous wall/strip footings (dewatering building & dry solids shelter). We recommend the foundation design use the following parameters:

Design Parameter	Mat Footing for Thickener Tanks	Wall/Strip Footings for Dewatering Building and Dry Solids Shelter
Net Allowable Bearing Pressure(1)	2,500 psf	2,000 psf
Acceptable Bearing Soil Material	Engineered Graded Aggregate Fill	Engineered Graded Aggregate Fill
Minimum Width	-	24 inches
Minimum Interior Footing Embedment Depth (below slab or finished grade) (2)	24 inches	24 inches
Minimum Exterior Footing Depth (below final exterior grade)(2)	30 inches	30 inches
Estimated Total Settlement (3)	Less than 1- inch	Less than 1- inch

Notes:

(1) Net allowable bearing pressure is the applied pressure in excess of the surrounding overburden soils above the base of the foundation.
(2) For bearing considerations, frost penetration requirements or expansive soil concerns.
(3) Based on assumed structural loads. If final loads are different, ECS must be contacted to update foundation recommendations and settlement calculations.

Foundation Subgrade Preparation, Undercutting & Fill Placement: Prior to foundation construction, ECS recommends the foundation subgrade soils be undercut a minimum of 3 feet below the planned bottom of foundation elevation for each structure. Following the undercuts, ECS (the GER) should be engaged to observe the excavations for signs of potential karst related conditions/features. Provided that no obvious karst related features are observed during the undercutting operations, the undercuts should be backfilled with a graded stone aggregate (VDOT No. 21-A or GER approved alternative), and compacted to 95% of the maximum dry density. Alternatively, lean concrete/flowable fill may also be used to backfill the undercuts below foundation; however, open graded stone (such as but not limited to No. 57 stone) **shall not** be used for backfill below foundation elements due to drainage considerations.

4.3 SLABS ON GRADE

The proposed floor slabs can be constructed as Ground Supported Slabs (or Slab-On-Grade). The existing fill soils as well as localized natural soils will require thorough proofrolling and localized undercutting and replacement with properly compacted structural fill may be required. The following graphic depicts our soil-supported slab recommendations:

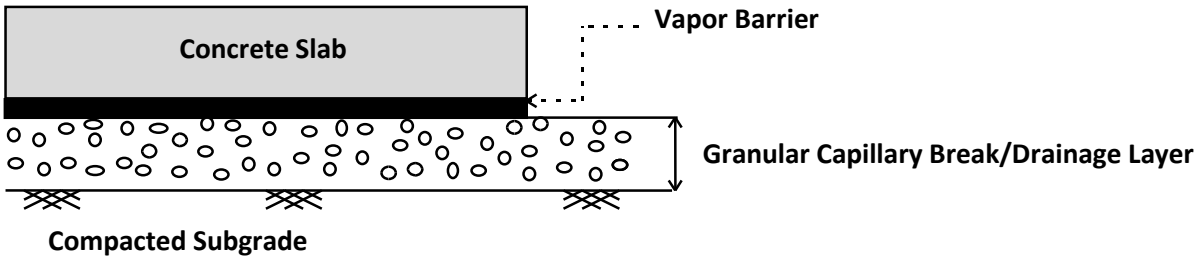


Figure 4.3.1

1. Drainage Layer Thickness: 4 inches
2. Drainage Layer Material: GRAVEL (GP, GW), SAND (SP, SW)

Soft or yielding soils may be encountered in some areas. Those soils should be removed and replaced with compacted Structural Fill in accordance with the recommendations included in this report.

Subgrade Modulus: Provided the Structural Fill and Granular Drainage Layer are constructed in accordance with our recommendations, the slab may be designed assuming a modulus of subgrade reaction, k_1 of 100 pci (lbs./cu. inch). The modulus of subgrade reaction value is based on a 1 foot by 1 foot plate load test basis.

Vapor Barrier: Before the placement of concrete, a vapor barrier may be placed on top of the granular drainage layer to provide additional protection against moisture penetration through the floor slab. When a vapor barrier is used, special attention should be given to surface curing of the slab to reduce the potential for uneven drying, curling and/or cracking of the slab. Depending on proposed flooring material types, the structural engineer and/or the architect may choose to eliminate the vapor barrier.

Slab Isolation: Soil-supported slabs should be isolated from the foundations and foundation-supported elements of the structure so that differential movement between the foundations and slab will not induce excessive shear and bending stresses in the floor slab. Where the structural configuration prevents the use of a free-floating slab such as in a drop down footing/monolithic slab configuration, the slab should be designed with suitable reinforcement and load transfer devices to preclude overstressing of the slab.

4.4 ALTERNATIVE FOUNDATION METHOD – COMPACTION GROUTING

Karst features and the potential for future sinkhole formation cannot be fully mitigated for future overlying proposed structures, but there are techniques commonly employed to reduce your risk of sinkholes adversely affecting your structures. One common technique we suggest is Low Mobility Grouting (LMG) prior to foundation construction.

Compaction grouting involves injecting a very stiff low mobility grout (LMG) mix under high pressure in a pre-designed pattern to displace and compact the soils beneath foundations. This type of soil improvement will densify the soil matrix, which will in turn decrease the raveling of soils from known problematic areas and potentially fill voids. Drilling techniques are suggested to advance the LMG columns deep enough vs. a driven mandrel technique which may reach shallow refusal. Please note that some boulders, float rock, and rock pinnacles may be encountered during drilling and the contractor should account for difficult drilling. The LMG column spacing and depths are determined via a delegated design; however, we envision the LMGs extending to at least the top of highly weathered Dolostone rock.

The design of LMG grouting plans is considered a delegated design but should follow the minimum performance objectives:

1. Support overlying shallow foundations with maximum bearing pressures of 3,000 psf.
2. Result in less than 1 inches of settlement in the event a sinkhole forms in the future.
3. Treat the subgrade beneath the tank/building/structure foundations.
4. LMG treatment areas should extend 10 feet beyond the perimeters of structures.

The LMG delegated design should be reviewed by the Geotechnical Engineer of Record for compliance with the performance objectives.

It should be noted that no amount of compaction grouting will eliminate the potential for sinkhole development; however, completion of grouting program will reduce the potential for adverse impacts to overlying structures in the treated areas. Compaction grouting is not required if the structures are shifted/relocated per our recommendations in **Section 4.2 Foundations.**

4.5 BELOW GRADE WALLS

We recommend that below grade walls be designed to withstand at-rest lateral earth pressures, hydrostatic loading and surcharge loads from adjacent building foundations, and/or streets. These recommendations apply to a “undrained” condition which is where drainage will not be provided behind below grade wet wells.

We recommend that wells that are restrained from movement at the top be designed for a linearly increasing lateral earth pressure. The following figure depicts our recommended at-rest lateral earth pressure condition for an “undrained below-grade wall” with restrained wall top:

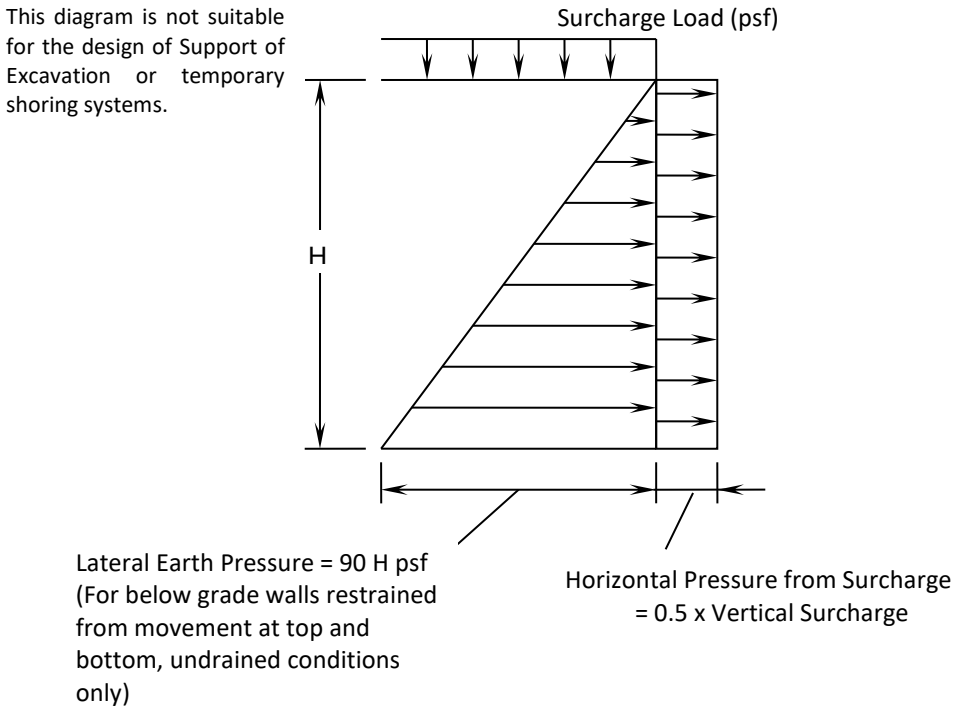


Figure 4.5.1

Surcharge loads imposed within a 45-degree slope from the base of the restrained wall should be considered in the below grade wall design. These surcharge loads should be based on an at-rest pressure coefficient, k_0, of 0.5. Care should be used to avoid the operation of heavy equipment to compact the wall backfill since it may overload and damage the wall; in addition, such loads are not typically considered in the design of below grade walls.

4.6 SEISMIC DESIGN CONSIDERATIONS

Seismic Site Classification: The International Building Code (IBC) 2018 requires site classification for seismic design based on the upper 100 feet of a soil profile. At least two methods are utilized in classifying sites, namely the shear wave velocity (v_s) method and the Standard Penetration Resistance (N-value) method. The second method (N-value) was used in classifying this site.

SEISMIC SITE CLASSIFICATION			
Site Class	**Soil Profile Name**	**Shear Wave Velocity, Vs, (ft./s)**	**N value (bpf)**
A	Hard Rock	Vs > 5,000 fps	N/A
B	Rock	2,500 < Vs ≤ 5,000 fps	N/A
C	Very dense soil and soft rock	1,200 < Vs ≤ 2,500 fps	>50
D	Stiff Soil Profile	600 ≤ Vs ≤ 1,200 fps	15 to 50
E	Soft Soil Profile	Vs < 600 fps	<15

Based upon our interpretation of the subsurface conditions, the appropriate Seismic Site Classification is "D" as shown in the preceding table.

Ground Motion Parameters: In addition to the seismic site classification, ECS has determined the design spectral response acceleration parameters following the IBC methodology. The Mapped Responses were estimated from the USGS website https://www.usgs.gov/natural-hazards/earthquake-hazards/design-ground-motions. The design responses for the short (0.2 sec, S_{DS}) and 1-second period (S_{D1}) are noted in bold at the far right end of the following table.

GROUND MOTION PARAMETERS [IBC 2018/ASCE 7-16 Method]								
Period (sec)	**Mapped Spectral Response Accelerations (g)**		**Values of Site Coefficient for Site Class D**		**Maximum Spectral Response Acceleration Adjusted for Site Class (g)**		**Design Spectral Response Acceleration (g)**	
Reference	Figures 1613.3.1 (1) & (2)		Tables 1613.3.3 (1) & (2)		Eqs. 16-37 & 16-38		Eqs. 16-39 & 16-40	
0.2	S_S	0.248	F_a	1.6	$S_{MS}=F_aS_s$	0.397	$S_{DS}=2/3\ S_{MS}$	0.265
1.0	S_1	0.075	F_v	2.4	$S_{M1}=F_vS_1$	0.179	$S_{D1}=2/3\ S_{M1}$	0.12

The Site Class definition should not be confused with the Seismic Design Category designation which the Structural Engineer typically assesses. If a higher site classification is beneficial to the project, we can provide additional testing methods that may yield more favorable results.

5.0 SITE CONSTRUCTION RECOMMENDATIONS

5.1 SUBGRADE PREPARATION

5.1.1 Stripping and Grubbing

The subgrade preparation should consist of stripping all vegetation, rootmat, topsoil, existing fill, and any soft or unsuitable materials from the 5-foot expanded building and 2-foot expanded pavement limits, and 5 feet beyond the toe of Structural Fills. Borings performed in "undisturbed" areas of the site contained an observed 4 or 5 inches of topsoil. Deeper topsoil or organic laden soils may be present in wet, low-lying, and poorly drained areas. In wooded areas, the root balls may extend as deep as about 2 feet and will require additional localized stripping depth to completely remove the organics. ECS should be retained to verify that topsoil and unsuitable surficial materials have been removed prior to the placement of structural fill or construction of structures.

5.1.2 Proofrolling

Prior to fill placement or other construction on subgrades, the subgrades should be evaluated by an ECS field technician. The exposed subgrade should be thoroughly proofrolled with construction equipment having a minimum axle load of 10 tons [e.g. fully loaded tandem-axle dump truck]. Proofrolling should be traversed in two perpendicular directions with overlapping passes of the vehicle under the observation of an ECS technician. This procedure is intended to assist in identifying any localized yielding materials.

Where proofrolling identifies areas that are unstable or "pumping" subgrade in those areas should be repaired prior to the placement of any subsequent Structural Fill or other construction materials. Methods of stabilization include undercutting, moisture conditioning, or chemical stabilization. The situation should be discussed with ECS to determine the appropriate procedure. Test pits may be excavated to explore the shallow subsurface materials to help in determining the cause of the observed unstable materials, and to assist in the evaluation of appropriate remedial actions to stabilize the subgrade.

5.2 EARTHWORK OPERATIONS

5.2.1 High Plasticity Soils

High plasticity soils are present at the project site. Ideally, such soils would be excluded from reuse as fill and be undercut and replaced in cut subgrades for slabs, pavements, and footings to avoid the potential for moisture-related volume change or instability when wet; however, we anticipate this would not be practical for the subject site. Therefore, it should be recognized that high plasticity soils are moisture sensitive and may be problematic during construction activities. Care should be taken to provide adequate drainage and maintenance of exposed subgrades.

5.2.2 Structural Fill

Prior to placement of Structural Fill, representative bulk samples (about 50 pounds) of on-site and/or off-site borrow should be submitted to ECS for laboratory testing, which will typically include Atterberg limits, natural moisture content, grain-size distribution, and moisture-density relationships (i.e., Proctors) for compaction. Import materials should be tested prior to being hauled to the site to determine if they meet project specifications. Alternatively, Proctor data from other accredited laboratories can be submitted if the test results are within the last 90 days.

Satisfactory Structural Fill Materials: Materials satisfactory for use as Structural Fill should consist of inorganic soils with the following engineering properties and compaction requirements.

STRUCTURAL FILL INDEX PROPERTIES	
Subject	**Property**
Building and Pavement Areas (Borrow Soils)	LL < 50, PI<25
Building and Pavement Areas (On-site Soils)	LL < 60, PI < 30
Max. Particle Size	4 inches
Max. organic content	3% by dry weight

STRUCTURAL FILL COMPACTION REQUIREMENTS	
Subject	**Requirement**
Compaction Standard	Standard Proctor, ASTM D698
Required Compaction	95% of Max. Dry Density
Moisture Content	+/-3 % points of the soil's optimum value
Loose Thickness	8 inches prior to compaction

On-Site Borrow Suitability: Significant natural deposits of soils are present on the site. These occur mostly at relatively shallow depth below the surface where residual soils are most weathered.

Fill Placement: Fill materials should not be placed on frozen soils, on frost-heaved soils, and/or on excessively wet soils. Borrow fill materials should not contain frozen materials at the time of placement, and all frozen or frost-heaved soils should be removed prior to placement of Structural Fill or other fill soils and aggregates. Excessively wet soils or aggregates should be scarified, aerated, and moisture conditioned.

5.2.3 Fills Supporting Foundations

Fills supporting foundation elements have a more stringent material specification than Structural Fills noted in Section 5.2.2. The planned undercuts below foundations should be backfilled with a graded stone aggregate (VDOT No. 21-A or GER approved alternative), and compacted to 95% of the maximum dry density. These fill should be placed in maximum 8-inch thick loose lifts, at moisture content of +/-2 percentage points of the material's optimum value. Alternatively, lean concrete/flowable fill may also be used to backfill the undercuts below foundation; however, open graded stone (such as but not limited to No. 57 stone) **shall not** be used for backfill below foundation elements due to drainage considerations.

5.3 FOUNDATION AND SLAB OBSERVATIONS

Protection of Foundation Excavations: Exposure to the environment may weaken the soils at the footing bearing level if the foundation excavations remain open for too long a time. Therefore, foundation concrete should be placed the same day that excavations are made. If the bearing soils are softened by surface water intrusion or exposure, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete. If the excavation must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, a 1 to 3-inch thick "mud mat" of "lean" concrete should be placed on the bearing soils before the placement of reinforcing steel.

Footing Subgrade Observations: Prior to foundation construction, ECS recommends the foundation subgrade soils be undercut a minimum of 3 feet below the planned bottom of foundation elevation for each structure. Following the undercuts, ECS (the GER) should be engaged to observe the excavations for signs of potential karst related conditions/features. It is important to have ECS observe the foundation subgrade prior to placing foundation concrete, to confirm the bearing soils are what was anticipated.

Slab Subgrade Verification: Prior to placement of a drainage layer, the subgrade should be prepared in accordance with the recommendations found in **Section 5.1.2 Proofrolling**.

5.4 UTILITY INSTALLATIONS

Utility Subgrades: The soils encountered in our exploration are expected to be generally suitable for support of utility pipes. The pipe subgrades should be observed and probed for stability by ECS. Any loose or unsuitable materials encountered should be removed and replaced with suitable compacted Structural Fill, or pipe stone bedding material.

Utility Backfilling: The granular bedding material (VDOT No. 21A stone) should be at least 4 inches thick, but not less than that specified by the civil engineer's project drawings and specifications. We recommend that the bedding materials be placed up to the springline of the pipe. Fill placed for support of the utilities, as well as backfill over the utilities, should satisfy the requirements for Structural Fill and Fill Placement.

Excavation Safety: All excavations and slopes should be constructed and maintained in accordance with OSHA excavation safety standards. The contractor is solely responsible for designing, constructing, and maintaining stable temporary excavations and slopes. 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. ECS is providing this information solely as a service to our client. ECS is not assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

6.0 CLOSING

ECS has prepared this report to guide the geotechnical-related design and construction aspects of the project. We performed these services in accordance with the standard of care expected of professionals in the industry performing similar services on projects of like size and complexity at this time in the region. No other representation, expressed or implied, and no warranty or guarantee is included or intended in this report.

The description of the proposed project is based on information provided to ECS by our client. If any of this information is inaccurate or changes, either because of our interpretation of the documents provided or site or design changes that may occur later, ECS should be contacted so we can review our recommendations and provide additional or alternate recommendations that reflect the proposed construction.

We recommend that ECS review the project plans and specifications so we can confirm that those plans/specifications are in accordance with the recommendations of this geotechnical report.

Field observations, and quality assurance testing during earthwork and foundation installation are an extension of, and integral to, the geotechnical design. We recommend that ECS be retained to apply our expertise throughout the geotechnical phases of construction, and to provide consultation and recommendation should issues arise.

ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

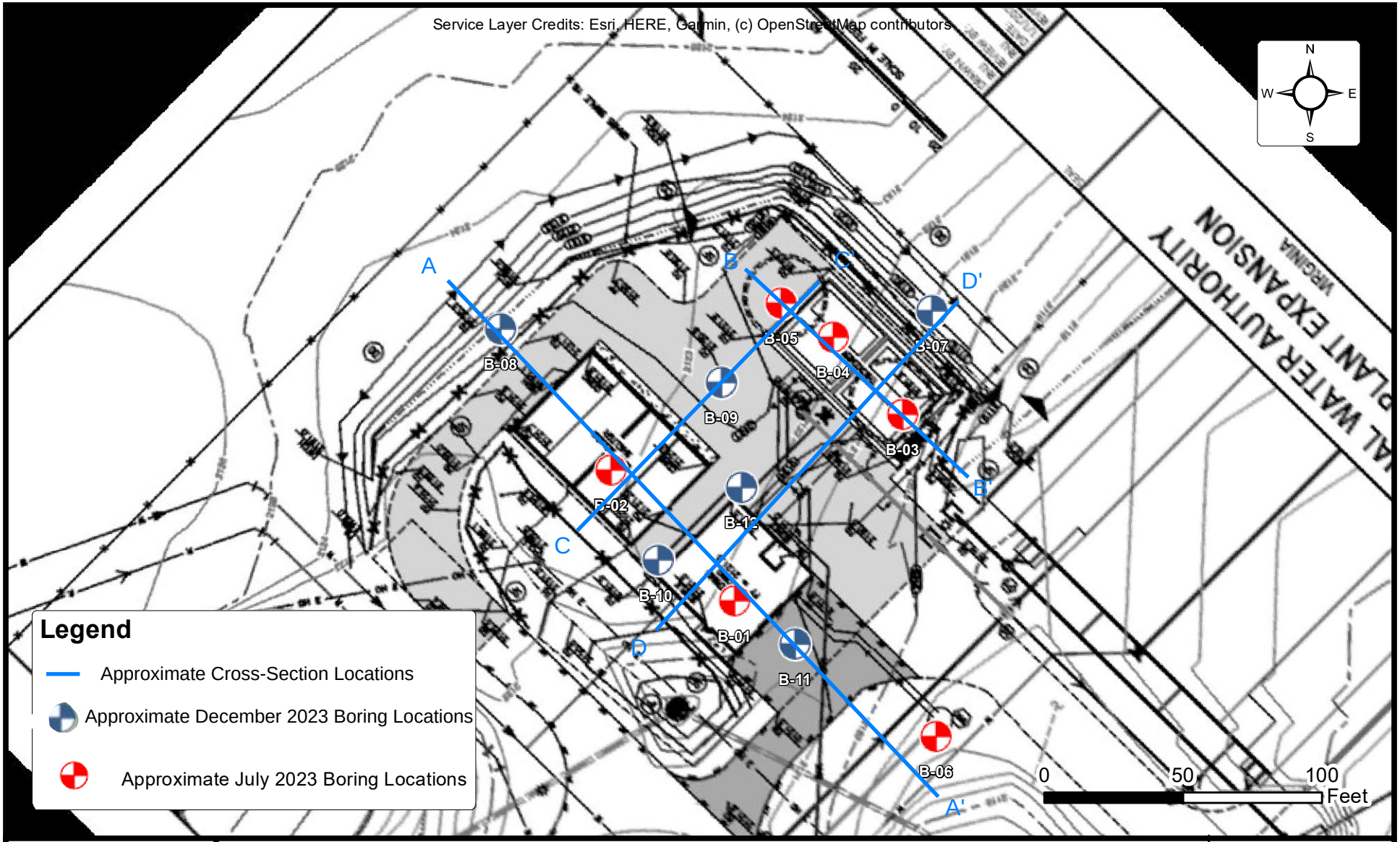
APPENDIX A – Diagrams & Reports

Site Location Diagram
Boring Location Diagram
Structure Shift Diagram
Karst Feature Location Diagrams
Subsurface Cross-Section

SITE LOCATION DIAGRAM
NRRWA WATER TREATMENT PLANT

289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

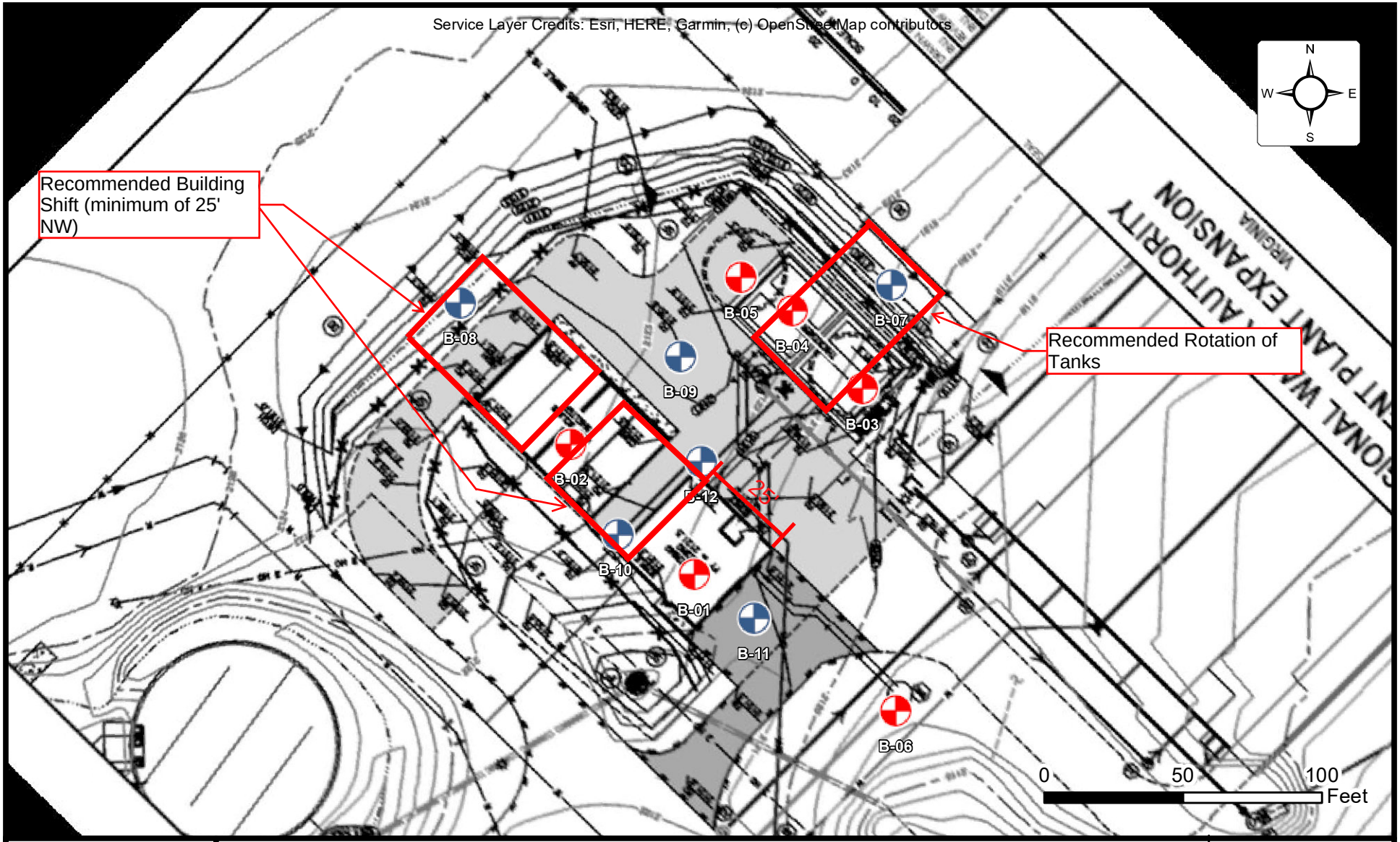
ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	7/31/2023



BORING LOCATION DIAGRAM
NRRWA WATER TREATMENT PLANT

289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

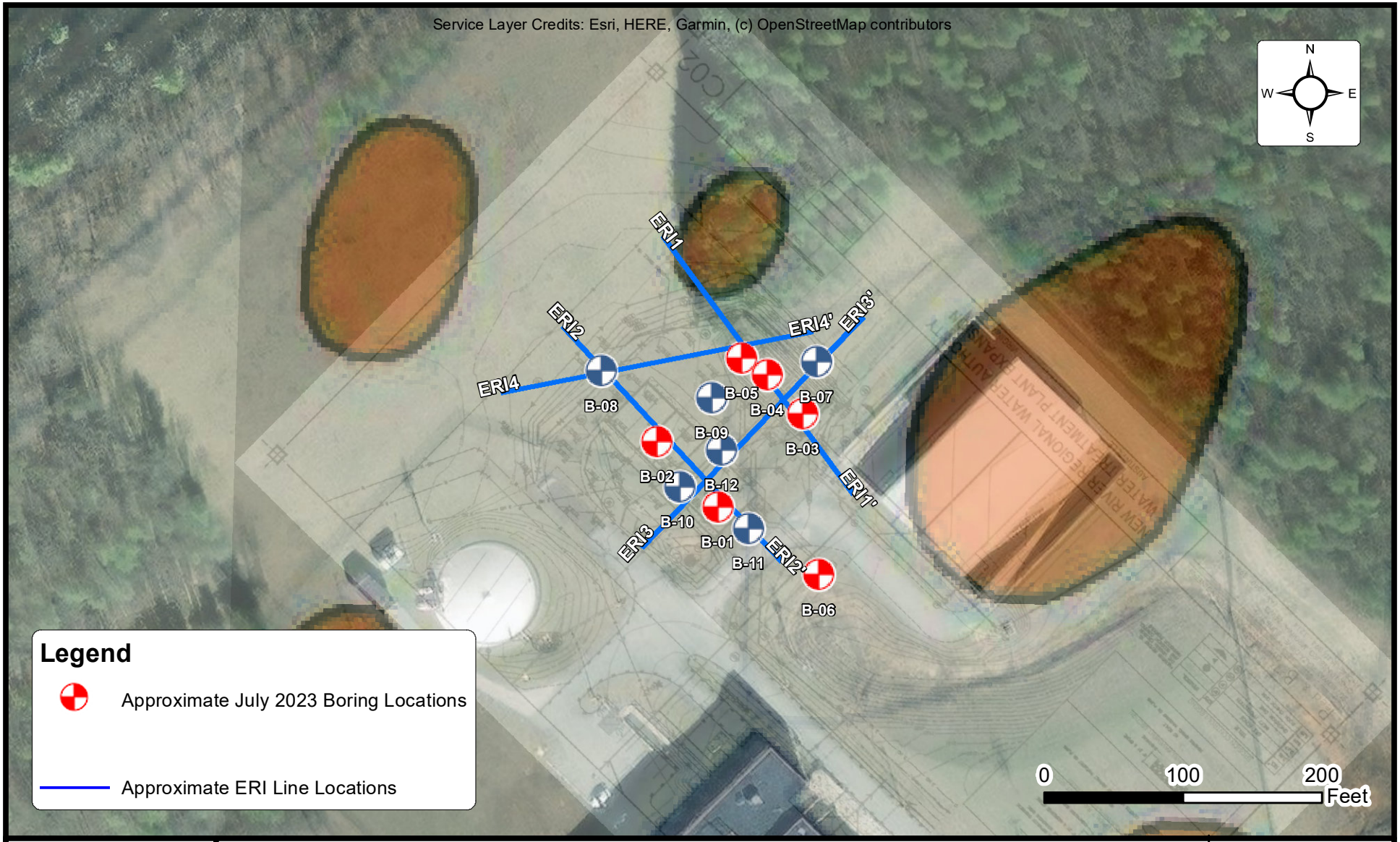
ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	1/3/2024



STRUCTURE SHIFT DIAGRAM
NRRWA WATER TREATMENT PLANT

289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	1/10/2024



KARST FEATURE LOCATION DIAGRAM
NRRWA WATER TREATMENT PLANT

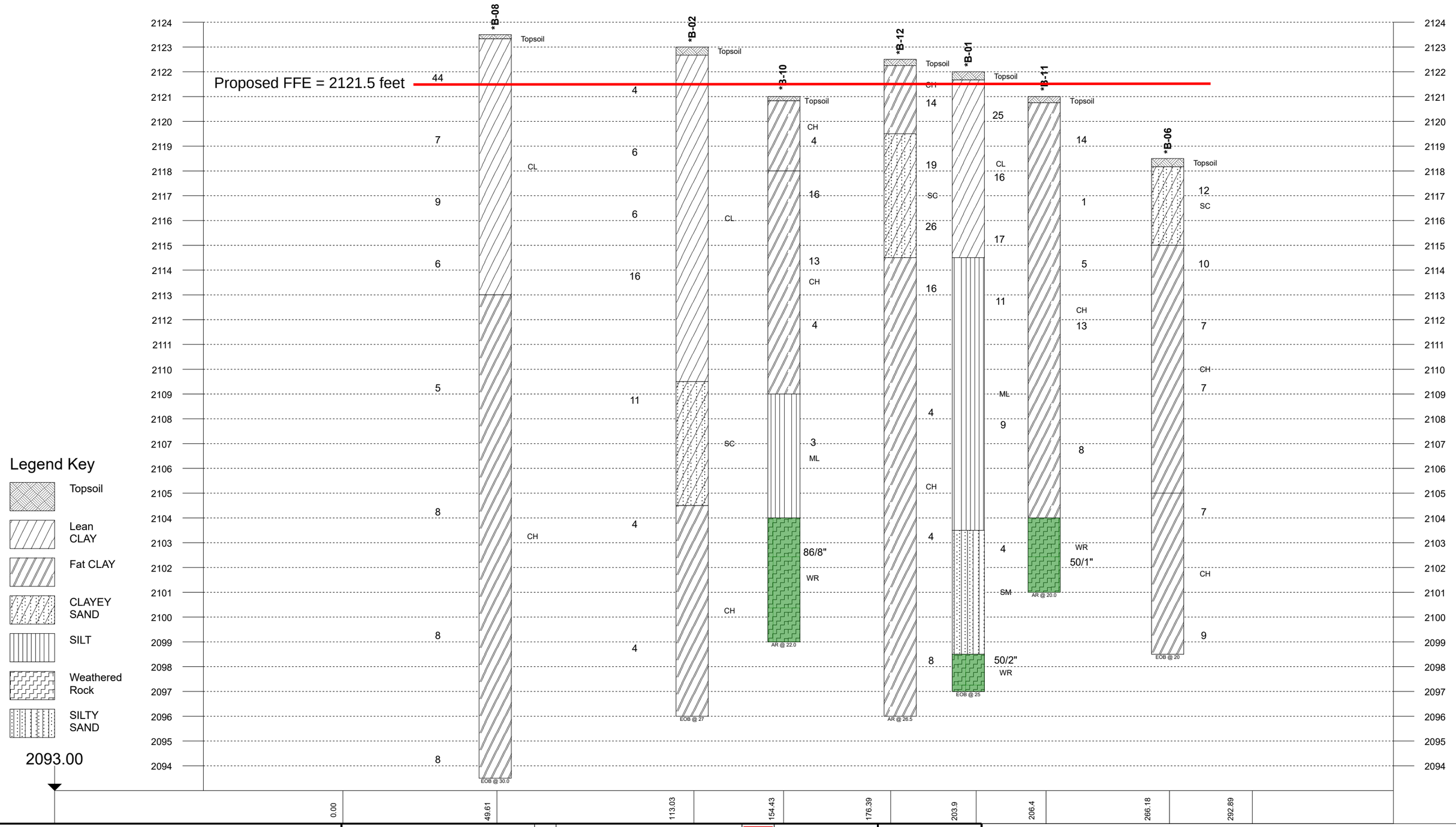
289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	1/3/2024

KARST FEATURE LOCATION DIAGRAM
NRRWA WATER TREATMENT PLANT

289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	1/10/2024



Legend Key

- Topsoil
- Lean CLAY
- Fat CLAY
- CLAYEY SAND
- SILT
- Weathered Rock
- SILTY SAND

2093.00

Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit
X———●———△
[FINES CONTENT %]
BOTTOM OF CASING
100 LOSS OF CIRCULATION
CALIBRATED PENETROMETER

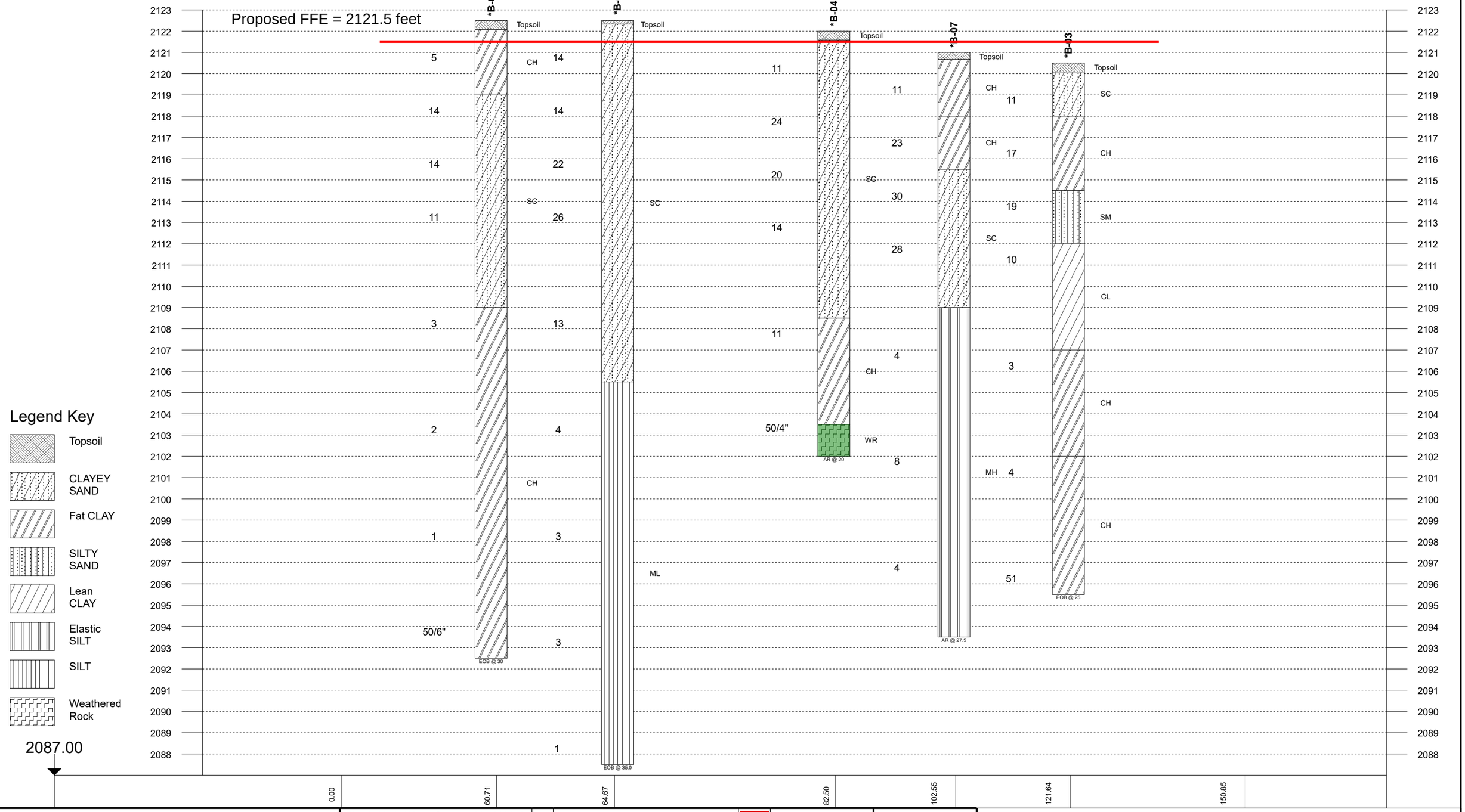
WL (First Encountered)
WL (Completion)
WL (Estimated Seasonal High Water)
WL (Stabilized)

Fill
Possible Fill
Probable Fill
Rock

GENERALIZED SUBSURFACE PROFILE

Cross-Section A-A'
NRRWA Water Treatment Plant
Peed & Bortz
289 Kohler Avenue, Austinville, Virginia, 24312

Project No: 12:2638-D Date: 01/03/2024



Legend Key

- Topsoil
- CLAYEY SAND
- Fat CLAY
- SILTY SAND
- Lean CLAY
- Elastic SILT
- SILT
- Weathered Rock

Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit X—●—△	WL (First Encountered)
[FINES CONTENT %]	WL (Completion)
BOTTOM OF CASING	WL (Estimated Seasonal High Water)
LOSS OF CIRCULATION	WL (Stabilized)
CALIBRATED PENETROMETER	

Fill	
Possible Fill	
Probable Fill	
Rock	

ECS

GENERALIZED SUBSURFACE PROFILE

Cross-Section B-B'

NRRWA Water Treatment Plant

Peed & Bortz

289 Kohler Avenue, Austinville, Virginia, 24312

Project No: 12:2638-D Date: 01/15/2024

Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit X——●——△			
[FINES CONTENT %]			
BOTTOM OF CASING	WL (First Encountered)	Fill	
LOSS OF CIRCULATION	WL (Completion)	Possible Fill	
CALIBRATED PENETROMETER	WL (Estimated Seasonal High Water)	Probable Fill	
	WL (Stabilized)	Rock	

GENERALIZED SUBSURFACE PROFILE

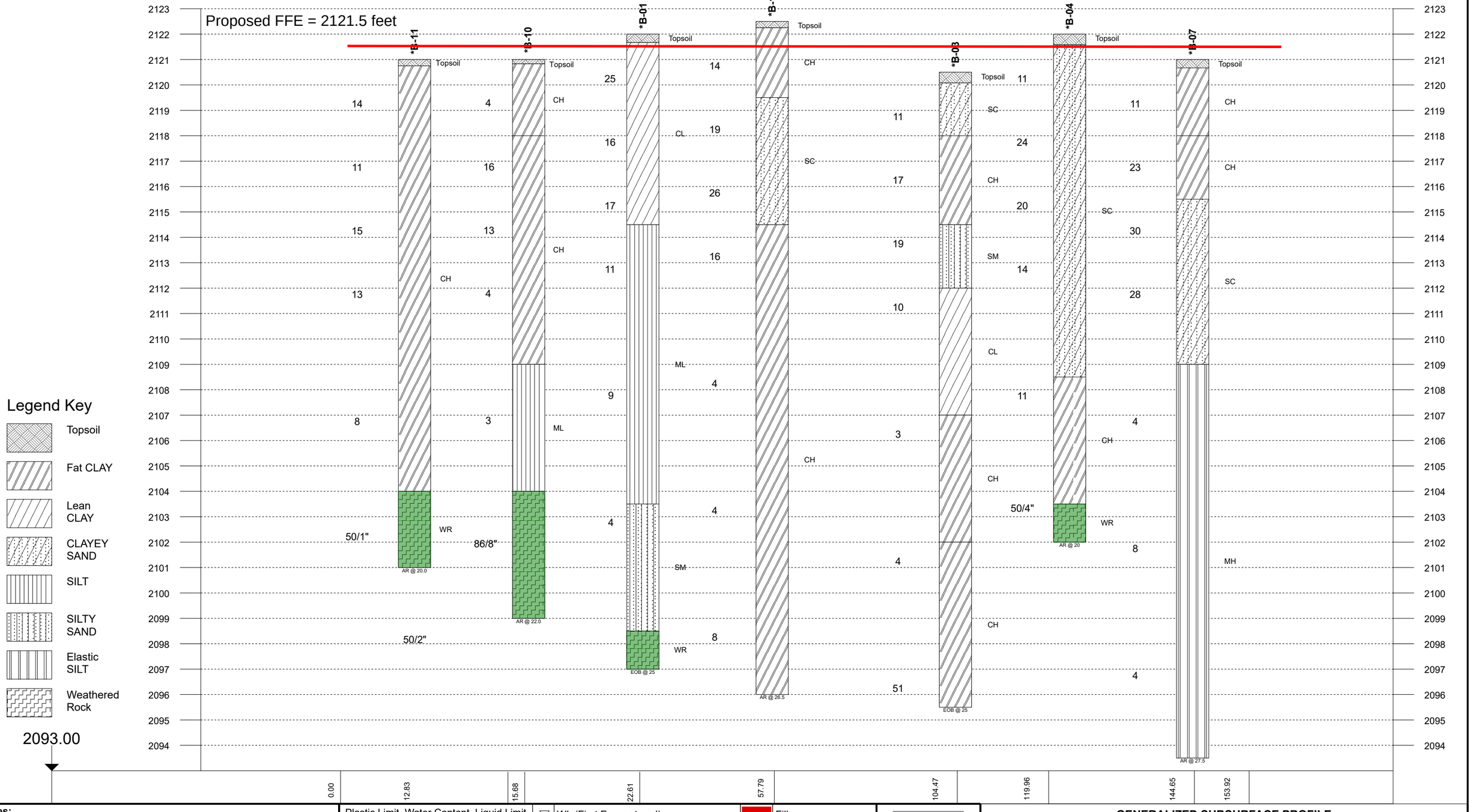
Cross-Section C-C'

NRRWA Water Treatment Plant

Peed & Bortz

289 Kohler Avenue, Austinville, Virginia, 24312

Project No: 12:2638-D Date: 01/15/2024



Legend Key

- Topsoil
- Fat CLAY
- Lean CLAY
- CLAYEY SAND
- SILT
- SILTY SAND
- Elastic SILT
- Weathered Rock

2093.00

Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit
X———●———△
[FINES CONTENT %]
BOTTOM OF CASING
100 LOSS OF CIRCULATION
CALIBRATED PENETROMETER

WL (First Encountered)
WL (Completion)
WL (Estimated Seasonal High Water)
WL (Stabilized)

Fill
Possible Fill
Probable Fill
Rock

ECS

GENERALIZED SUBSURFACE PROFILE

Cross-Section D-D'

NRRWA Water Treatment Plant

Peed & Bortz

289 Kohler Avenue, Austinville, Virginia, 24312

Project No: 12:2638-D Date: 01/15/2024

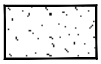
APPENDIX B – Field Operations

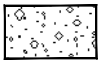
Reference Notes for Boring Logs
Subsurface Exploration Procedure: Standard Penetration Testing (SPT)
Boring Logs B-01 through B-12

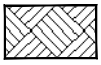
REFERENCE NOTES FOR BORING LOGS

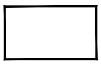
MATERIAL[1,2]

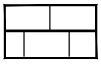

ASPHALT


CONCRETE


GRAVEL

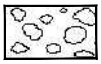

TOPSOIL

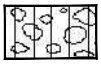

VOID


BRICK

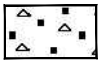

AGGREGATE BASE COURSE

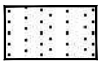

GW **WELL-GRADED GRAVEL**
gravel-sand mixtures, little or no fines

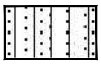

GP **POORLY-GRADED GRAVEL**
gravel-sand mixtures, little or no fines


GM **SILTY GRAVEL**
gravel-sand-silt mixtures

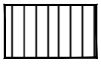

GC **CLAYEY GRAVEL**
gravel-sand-clay mixtures

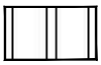

SW **WELL-GRADED SAND**
gravelly sand, little or no fines

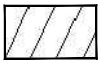

SP **POORLY-GRADED SAND**
gravelly sand, little or no fines


SM **SILTY SAND**
sand-silt mixtures

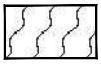

SC **CLAYEY SAND**
sand-clay mixtures

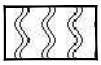

ML **SILT**
non-plastic to medium plasticity

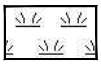

MH **ELASTIC SILT**
high plasticity


CL **LEAN CLAY**
low to medium plasticity


CH **FAT CLAY**
high plasticity


OL **ORGANIC SILT or CLAY**
non-plastic to low plasticity


OH **ORGANIC SILT or CLAY**
high plasticity


PT **PEAT**
highly organic soils

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS

SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation %
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION

DESIGNATION		PARTICLE SIZES
Boulders		12 inches (300 mm) or larger
Cobbles		3 inches to 12 inches (75 mm to 300 mm)
Gravel:	Coarse	¾ inch to 3 inches (19 mm to 75 mm)
	Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand:	Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
	Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
	Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS

UNCONFINED COMPRESSIVE STRENGTH, Q_P[4]	SPT[5] (BPF)	CONSISTENCY[7] (COHESIVE)
<0.25	<2	Very Soft
0.25 - <0.50	2 - 4	Soft
0.50 - <1.00	5 - 8	Firm
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

GRAVELS, SANDS & NON-COHESIVE SILTS

SPT[5]	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

RELATIVE AMOUNT[7]	COARSE GRAINED (%)[8]	FINE GRAINED (%)[8]
Trace	≤5	≤5
With	10 - 20	10 - 25
Adjective *(ex: "Silty")*	25 - 45	30 - 45

WATER LEVELS[6]

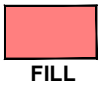

WL (First Encountered)


WL (Completion)


WL (Seasonal High Water)


WL (Stabilized)

FILL AND ROCK


FILL


POSSIBLE FILL


PROBABLE FILL


ROCK

[1]Classifications and symbols per ASTM D 2488-17 (Visual-Manual Procedure) unless noted otherwise.

[2]To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.

[3]Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-FILL)].

[4]Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).

[5]Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf). SPT correlations per 7.4.2 Method B and need to be corrected if using an auto hammer.

[6]The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.

[7]Minor deviation from ASTM D 2488-17 Note 14.

[8]Percentages are estimated to the nearest 5% per ASTM D 2488-17.

SUBSURFACE EXPLORATION PROCEDURE: STANDARD PENETRATION TESTING (SPT) ASTM D 1586 Split-Barrel Sampling

Standard Penetration Testing, or **SPT**, is the most frequently used subsurface exploration test performed worldwide. This test provides samples for identification purposes, as well as a measure of penetration resistance, or N-value. The N-Value, or blow counts, when corrected and correlated, can approximate engineering properties of soils used for geotechnical design and engineering purposes.

SPT Procedure:

- Involves driving a hollow tube (split-spoon) into the ground by dropping a 140-lb hammer a height of 30-inches at desired depth
- Recording the number of hammer blows required to drive split-spoon a distance of 18-24 inches (in 3 or 4 Increments of 6 inches each)

- Auger is advanced* and an additional SPT is performed
- One SPT typically performed for every two to five feet. An approximate 1.5 inch diameter soil sample is recovered.

**Drilling Methods May Vary*— The predominant drilling methods used for SPT are open hole fluid rotary drilling and hollow-stem auger drilling.

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-01**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.853886	**-80.910661**		**2122**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[4.00"]			
	S-1	SS	18	16	(CL) Residuum, SANDY LEAN CLAY WITH GRAVEL, orangish brown, moist, very stiff			4-11-14 (25)
	S-2	SS	18	15				3-7-9 (16)
5							2117	
	S-3	SS	18	17				3-7-10 (17)
					(ML) SANDY SILT, trace clay, trace gravel, reddish brown, moist, loose to medium dense			
	S-4	SS	18	16				2-5-6 (11)
10							2112	
	S-5	SS	18	17				3-4-5 (9)
15							2107	
	S-6	SS	18	18	(SM) SILTY SAND, dark brown, moist, very loose			WOH-1-3 (4)
20							2102	
	S-7	SS	8	6	(WR) WEATHERED ROCK SAMPLED AS SILTY SAND, light tan, moist, very dense			40-50/2" (50/2")
25					**END OF BORING AT 25 FT**		2097	
30							2092	

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Jul 17 2023**	CAVE IN DEPTH:	**13.50**
WL (Completion)	**Dry**	BORING COMPLETED:	**Jul 17 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4**
WL (Stabilized)		**CME 45**	**EAH1**		

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-02**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854012	**-80.910812**		**2123**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[4.00"]			
	S-1	SS	18	16	(CL) Residuum, LEAN CLAY WITH SAND, contains slight roots, trace gravel, reddish dark brown, moist, soft to very stiff			1-2-2 (4)
	S-2	SS	18	3				3-3-3 (6)
5							2118	
	S-3	SS	18	16				2-2-4 (6)
	S-4	SS	18	18				4-7-9 (16)
10							2113	
	S-5	SS	18	17	(SC) CLAYEY SAND, orangish brown, moist, medium dense			2-3-8 (11)
15							2108	
	S-6	SS	18	16	(CH) FAT CLAY, trace sand, reddish brown, wet, very soft			3-2-2 (4)
20							2103	
	S-7	SS	18	18				1-2-2 (4)
25							2098	
					END OF BORING AT 27 FT			
30							2093	

STANDARD PENETRATION BLOWS/FT (20 40 60 80 100)

ROCK QUALITY DESIGNATION & RECOVERY — RQD — REC

LIQUID LIMIT △ PLASTIC LIMIT ×

CALIBRATED PENETROMETER TSF (1 2 3 4 5) ○

WATER CONTENT % ● [FINES CONTENT] % (10 20 30 40 50)

18 — 23.1 — 44 — [75.7%]

28.9

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**	BORING STARTED: **Jul 17 2023**		CAVE IN DEPTH: **3.40**
▼ WL (Completion)	**Dry**	BORING COMPLETED: **Jul 17 2023**		HAMMER TYPE: **Auto**
▼ WL (Seasonal High Water)		EQUIPMENT: **CME 45**	LOGGED BY: **EAH1**	DRILLING METHOD: **2 1/4**
▽ WL (Stabilized)				

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-03**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854065	**-80.910460**		**2120.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[5.00"]			
	S-1	SS	18	16	(SC) Residuum, CLAYEY SAND, trace gravel, dark reddish brown, moist, medium dense			4-5-6 (11)
	S-2	SS	18	17	(CH) SANDY FAT CLAY, orange brown, moist, very stiff		2116	5-6-11 (17)
5	S-3	SS	18	15	(SM) SILTY SAND, light orangish brown, moist, medium dense			4-8-11 (19)
	S-4	SS	18	16	(CL) LEAN CLAY WITH SAND, orangish brown, moist, stiff		2111	2-4-6 (10)
10								
	S-5	SS	18	5	(CH) SANDY FAT CLAY, reddish brown, moist, soft		2106	2-1-2 (3)
15								
	S-6	SS	18	3	(CH) FAT CLAY WITH SAND, dark brown to tan, wet to moist, soft to very hard		2101	5-2-2 (4)
20								
	S-7	SS	18	1			2096	37-30-21 (51)
25					**END OF BORING AT 25 FT**			
30							2091	

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

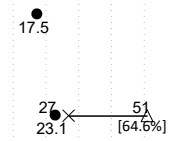
ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED: **Jul 17 2023**	CAVE IN DEPTH:	**7.80**
WL (Completion)	**Dry**	BORING COMPLETED: **Jul 17 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT: **CME 45**	LOGGED BY: **EAH1**	DRILLING METHOD: **2 1/4**
WL (Stabilized)				

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-04**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:
36.854140	**-80.910556**		**2122**

BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[5.00"]			
	S-1	SS	18	17	(SC) Residuum, CLAYEY SAND, trace gravel, reddish brown, moist, medium dense			2-4-7 (11)
	S-2	SS	18	17				4-11-13 (24)
5							2117	
	S-3	SS	18	17				4-9-11 (20)
	S-4	SS	18	16				2-5-9 (14)
10							2112	
	S-5	SS	18	16	(CH) SANDY FAT CLAY, trace gravel, tan to dark brown, moist, stiff			3-7-4 (11)
15							2107	
	S-6	SS	4	2	(WR) WEATHERED ROCK SAMPLED AS FAT CLAY, trace sand, tan to dark brown, moist, very hard			50/4" (50/4")
20					**AUGER REFUSAL AT 20 FT**		2102	
25							2097	
30							2092	

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

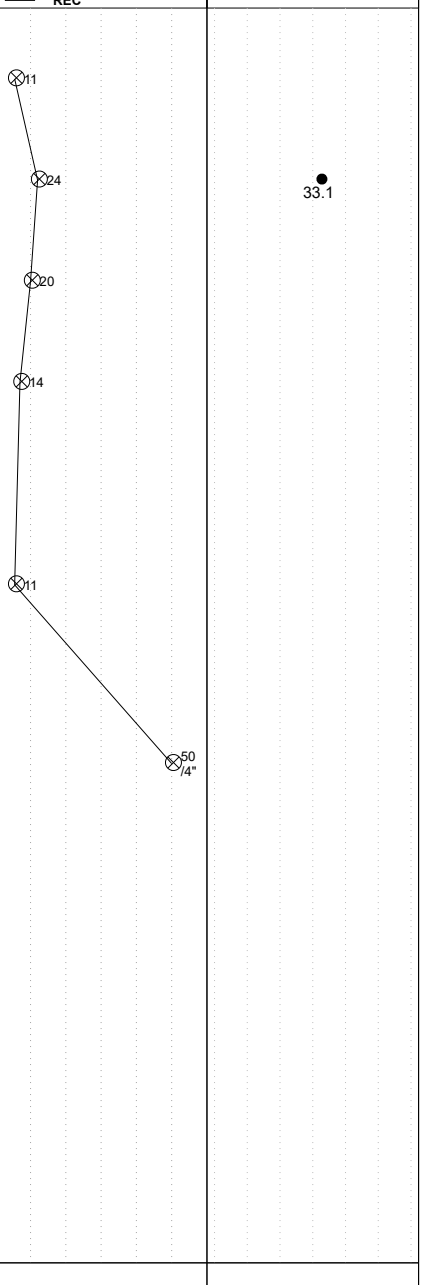
ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Jul 17 2023**	CAVE IN DEPTH:	**2.90**
WL (Completion)	**Dry**	BORING COMPLETED:	**Jul 17 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4**
WL (Stabilized)		**CME 45**	**EAH1**		

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-05**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854175	**-80.910617**		**2122.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[5.00"]			
	S-1	SS	18	16	(CH) Residuum, SANDY FAT CLAY, trace gravel, red brown, moist, firm			2-2-3 (5)
	S-2	SS	18	17	(SC) CLAYEY SAND, red brown, moist, medium dense		2118	2-6-8 (14)
5	S-3	SS	18	18				3-6-8 (14)
	S-4	SS	18	18			2113	2-4-7 (11)
10								
	S-5	SS	18	16	(CH) SANDY FAT CLAY, reddish brown to dark brown, moist to wet, very soft to hard		2108	1-1-2 (3)
15								
	S-6	SS	18	18			2103	1-1-1 (2)
20								
	S-7	SS	18	18			2098	WOH-0-1 (1)
25								
	S-8	SS	6	4			2093	50/6" (50/6")
30					**END OF BORING AT 30 FT**			

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

39.7

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered) **Dry**	BORING STARTED: **Jul 17 2023**	CAVE IN DEPTH: **11.70**	
WL (Completion) **Dry**	BORING COMPLETED: **Jul 17 2023**	HAMMER TYPE: **Auto**	
WL (Seasonal High Water)	EQUIPMENT: **CME 45**	LOGGED BY: **ARP4**	DRILLING METHOD: **2 1/4**
WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

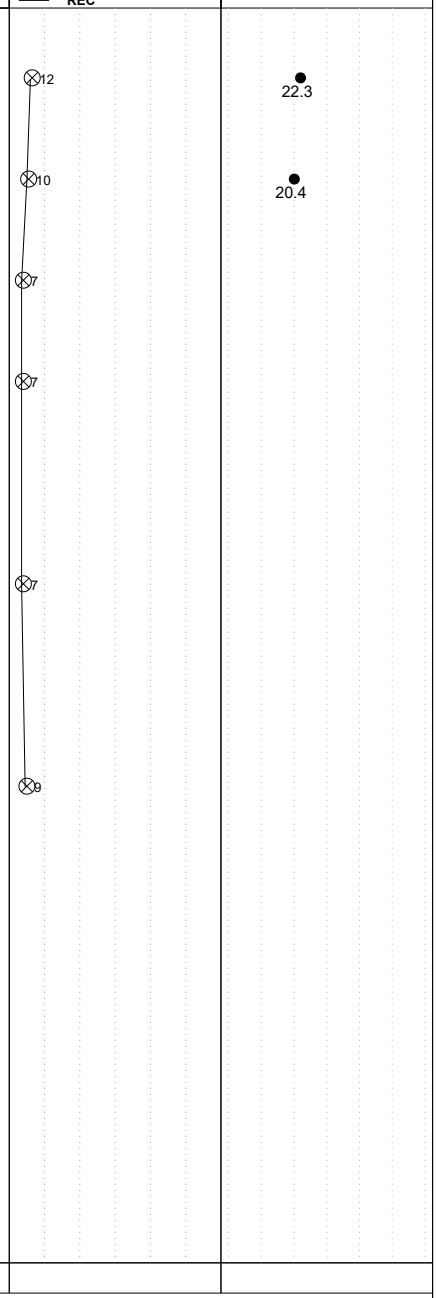
CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-06**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION:	LOSS OF CIRCULATION
289 Kohler Avenue, Austinville, Virginia, 24312	

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.853754	**-80.910398**		**2118.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[4.00"]			
	S-1	SS	18	17	(SC) Residuum, CLAYEY SAND, trace gravel, dark brown, moist, medium dense			3-6-6 (12)
	S-2	SS	18	18	(CH) FAT CLAY, dark reddish brown, moist, stiff to firm		2114	3-5-5 (10)
5	S-3	SS	18	18				2-3-4 (7)
	S-4	SS	18	16			2109	2-3-4 (7)
10								
	S-5	SS	18	18	(CH) SANDY FAT CLAY, dark reddish brown, moist, firm to stiff		2104	2-2-5 (7)
15								
	S-6	SS	18	18			2099	2-4-5 (9)
20					**END OF BORING AT 20 FT**			
25							2094	
30							2089	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**Dry**	BORING STARTED:	**Jul 17 2023**	CAVE IN DEPTH:	**2.40**
▼ WL (Completion)	**Dry**	BORING COMPLETED:	**Jul 17 2023**	HAMMER TYPE:	**Auto**
▼ WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4**
▽ WL (Stabilized)		**CME 45**	**ARP4**		

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-07**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854173	**-80.910427**		**2121**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[4.00"]			
	S-01	SS	18	15	(CH) Residuum, FAT CLAY WITH SAND, dark red brown, moist, stiff			4-5-6 (11)
	S-02	SS	18	16	(CH) SANDY FAT CLAY, trace gravel, dark red brown, moist, very stiff			4-8-15 (23)
5	S-03	SS	18	16	(SC) CLAYEY SAND, trace gravel, orange brown, moist, medium dense		2116	7-15-15 (30)
	S-04	SS	18	17				8-12-16 (28)
10							2111	
					(MH) ELASTIC SILT, trace sand, dark red to tan, moist, soft to firm			
	S-05	SS	18	17				WOH-2-2 (4)
15							2106	
	S-06	SS	18	13				2-3-5 (8)
20							2101	
	S-07	SS	18	15				1-2-2 (4)
25							2096	
					AUGER REFUSAL AT 27.5 FT			
30							2091	

STANDARD PENETRATION BLOWS/FT (20 40 60 80 100)

ROCK QUALITY DESIGNATION & RECOVERY — RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF (1 2 3 4 5)

WATER CONTENT % [FINES CONTENT] % (10 20 30 40 50)

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Dec 21 2023**	CAVE IN DEPTH:	**21.60**
WL (Completion)	**Dry**	BORING COMPLETED:	**Dec 21 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT: **CME45c**	LOGGED BY: **ARP4**	DRILLING METHOD:	**2 1/4"**
WL (Stabilized)					

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-08**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854143	**-80.910958**		**2123.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[2.00"]			
	S-01	SS	18	10	(CL) Residuum, LEAN CLAY WITH SAND, trace gravel, dark brown, moist, hard to firm			26-28-16 (44)
	S-02	SS	18	14			2119	3-3-4 (7)
5	S-03	SS	18	12				2-4-5 (9)
	S-04	SS	18	0			2114	3-3-3 (6)
10					(CH) SANDY FAT CLAY, trace gravel, dark red brown, moist, firm			
	S-05	SS	18	17			2109	2-2-3 (5)
15								
	S-06	SS	18	18			2104	2-3-5 (8)
20								
	S-07	SS	18	17			2099	3-3-5 (8)
25								
	S-08	SS	18	18			2094	2-3-5 (8)
30					**END OF BORING AT 30.0 FT**			

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Dec 21 2023**	CAVE IN DEPTH:	**24.00**
WL (Completion)	**Dry**	BORING COMPLETED:	**Dec 21 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4"**
WL (Stabilized)		**CME45c**	**ARP4**		

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-09**	**1 of 2**
PROJECT NAME:	DRILLER/CONTRACTOR:		
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**		
SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**			LOSS OF CIRCULATION
LATITUDE: **36.854097**	LONGITUDE: **-80.910686**	STATION:	SURFACE ELEVATION: **2122.5**
			BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[2.00"]			
	S-01	SS	18	16	(SC) Residuum, CLAYEY SAND, trace gravel, dark brown and dark red brown, moist, medium dense			2-6-8 (14)
	S-02	SS	18	16			2118	2-6-8 (14)
5	S-03	SS	18	17				6-9-13 (22)
	S-04	SS	18	18			2113	6-11-15 (26)
10								
	S-05	SS	18	16			2108	5-5-8 (13)
15					(ML) SILT WITH SAND, trace gravel, red brown to dark brown, moist, soft to very soft			
	S-06	SS	18	18			2103	WOH-2-2 (4)
20								
	S-07	SS	18	18			2098	1-1-2 (3)
25								
	S-08	SS	18	18			2093	1-1-2 (3)
30								

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100
ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC
LIQUID LIMIT
PLASTIC LIMIT
CALIBRATED PENETROMETER TSF: 1 2 3 4 5
WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

CONTINUED ON NEXT PAGE

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered) **Dry**	BORING STARTED: **Dec 21 2023**	CAVE IN DEPTH: **3.30**	
WL (Completion) **Dry**	BORING COMPLETED: **Dec 21 2023**	HAMMER TYPE: **Auto**	
WL (Seasonal High Water)	EQUIPMENT: **CME45c**	LOGGED BY: **ARP4**	DRILLING METHOD: **2 1/4"**
WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-09**	**2 of 2**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.854097	**-80.910686**		**2122.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
35	S-09	SS	18	6	(ML) SILT WITH SAND, trace gravel, red brown to dark brown, moist, soft to very soft		2088	WOH-WOH-1 (1)
					END OF BORING AT 35.0 FT			
40							2083	
45							2078	
50							2073	
55							2068	
60							2063	

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Dec 21 2023**	CAVE IN DEPTH:	**3.30**
WL (Completion)	**Dry**	BORING COMPLETED:	**Dec 21 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4"**
WL (Stabilized)		**CME45c**	**ARP4**		

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-10**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.853842	**-80.910584**		**2121**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[2.00"]			
	S-01	SS	18	8	(CH) Residuum, FAT CLAY WITH SAND, red brown, moist, soft			1-2-2 (4)
	S-02	SS	18	12	(CH) SANDY FAT CLAY, trace gravel, red brown, moist, very stiff to soft		2116	4-6-10 (16)
5	S-03	SS	18	18				3-5-8 (13)
	S-04	SS	18	18			2111	1-2-2 (4)
10								
	S-05	SS	18	16	(ML) SILT WITH SAND, red brown and tan, moist, soft		2106	1-2-1 (3)
15								
	S-06	SS	14	13	(WR) WEATHERED ROCK SAMPLED AS, SANDY FAT CLAY, dark brown and tan, moist, very hard		2101	8-36-50/2" (86/8")
20								
					AUGER REFUSAL AT 22.0 FT			
25							2096	
30							2091	

STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT

PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered) **Dry**	BORING STARTED: **Dec 21 2023**	CAVE IN DEPTH: **4.30**	
WL (Completion) **Dry**	BORING COMPLETED: **Dec 21 2023**	HAMMER TYPE: **Auto**	
WL (Seasonal High Water)	EQUIPMENT: **CME45c**	LOGGED BY: **ARP4**	DRILLING METHOD: **2 1/4"**
WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-11**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.853833	**-80.910582**		**2121**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
					Topsoil Thickness[3.00"]			
	S-01	SS	18	15	(CH) Residuum, SANDY FAT CLAY, trace gravel, dark red brown, moist, stiff to firm			4-8-6 (14)
	S-02	SS	18	16				2-4-7 (11)
5							2116	
	S-03	SS	18	16				4-6-9 (15)
	S-04	SS	18	17				3-5-8 (13)
10							2111	
	S-05	SS	18	16				2-4-4 (8)
15							2106	
	S-06	SS	7	4	(WR) WEATHERED ROCK SAMPLED AS, SANDY FAT CLAY, dark red brown and tan, moist, very hard			36-50/1" (50/1")
20					**AUGER REFUSAL AT 20.0 FT**		2101	
25							2096	
30							2091	

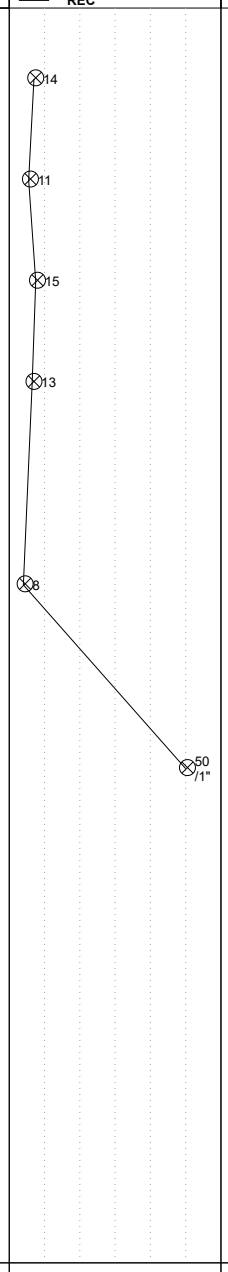
STANDARD PENETRATION BLOWS/FT: 20 40 60 80 100

ROCK QUALITY DESIGNATION & RECOVERY: RQD, REC

LIQUID LIMIT, PLASTIC LIMIT

CALIBRATED PENETROMETER TSF: 1 2 3 4 5

WATER CONTENT % [FINES CONTENT] %: 10 20 30 40 50



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Dec 21 2023**	CAVE IN DEPTH:	**6.30**
WL (Completion)	**Dry**	BORING COMPLETED:	**Dec 21 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT: **CME45c**	LOGGED BY: **ARP4**	DRILLING METHOD:	**2 1/4"**
WL (Stabilized)					

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Peed & Bortz	**12:2638-D**	**B-12**	**1 of 1**

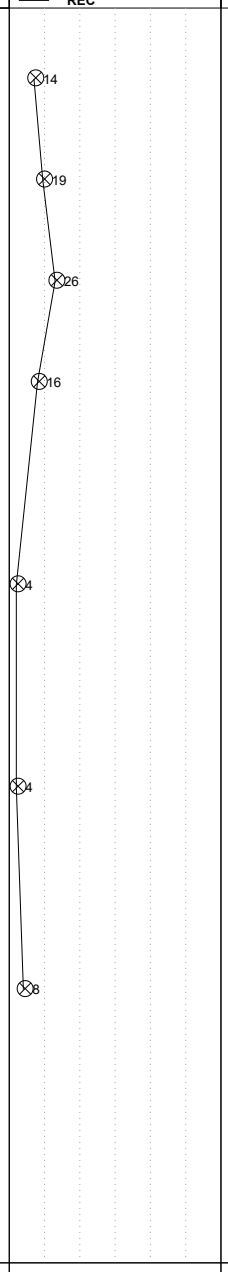
PROJECT NAME:	DRILLER/CONTRACTOR:
NRRWA Water Treatment Plant	**Blue Ridge Drilling, Inc.**

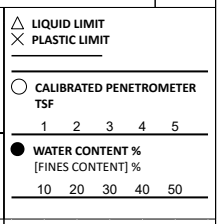
SITE LOCATION: **289 Kohler Avenue, Austinville, Virginia, 24312**

LOSS OF CIRCULATION

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:	BOTTOM OF CASING
36.853987	**-80.910653**		**2122.5**	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (N - Value)
0					Topsoil Thickness[3.00"]			
	S-01	SS	18	16	(CH) Residuum, SANDY FAT CLAY, trace gravel, contains roots, red brown, moist, stiff			3-7-7 (14)
	S-02	SS	18	16	(SC) CLAYEY SAND, trace gravel, red brown and tan, moist, medium dense		2118	5-7-12 (19)
5	S-03	SS	18	18				5-9-17 (26)
	S-04	SS	18	18	(CH) SANDY FAT CLAY, red brown, black, and tan, moist, very stiff to soft		2113	4-6-10 (16)
10								
	S-05	SS	18	16			2108	1-2-2 (4)
15								
	S-06	SS	18	10			2103	1-1-3 (4)
20								
	S-07	SS	18	16			2098	3-4-4 (8)
25					**AUGER REFUSAL AT 26.5 FT**			
30							2093	





THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**Dry**	BORING STARTED:	**Dec 21 2023**	CAVE IN DEPTH:	**20.20**
WL (Completion)	**Dry**	BORING COMPLETED:	**Dec 21 2023**	HAMMER TYPE:	**Auto**
WL (Seasonal High Water)		EQUIPMENT:	LOGGED BY:	DRILLING METHOD:	**2 1/4"**
WL (Stabilized)		**CME45c**	**ARP4**		

GEOTECHNICAL BOREHOLE LOG

APPENDIX C – Laboratory Testing

Laboratory Test Results Summary
Plasticity Chart
Grain Size Analyses

Laboratory Testing Summary

Sample Location	Sample Number	Depth ()	^MC (%)	Soil Type	Atterberg Limits			**Percent Passing No. 200 Sieve	Moisture - Density		CBR (%)		#Organic Content (%)
					LL	PL	PI		<Maximum Density (pcf)	<Optimum Moisture (%)	0.1 in.	0.2 in.	
B-01	S-2	3.5-5.0	21.1	CL	45	21	24	66.5					
B-01	S-4	8.5-10.0	44.9										
B-02	S-3	6.0-7.5	23.1	CL	44	18	26	75.7					
B-02	S-4	8.5-10.0	28.9										
B-03	S-1	1.0-2.5	17.5										
B-03	S-2	3.5-5.0	23.1	CH	51	27	24	64.6					
B-04	S-2	3.5-5.0	33.1										
B-05	S-3	6.0-7.5	39.7										
B-06	S-1	1.0-2.5	22.3										

Notes: See test reports for test method, ^ASTM D2216-19, *ASTM D2488, **ASTM D1140-17, #ASTM D2974-20e1 < See test report for D4718 corrected values

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content

Project: NRRWA Water Treatment Plant
Client: Peed & Bortz

Project No.: 12:2638-D
Date Reported: 7/31/2023

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received
JGeil	JMurphy	JMurphy	7/26/2023

Laboratory Testing Summary

Sample Location	Sample Number	Depth ()	^MC (%)	Soil Type	Atterberg Limits			**Percent Passing No. 200 Sieve	Moisture - Density		CBR (%)		#Organic Content (%)
					LL	PL	PI		<Maximum Density (pcf)	<Optimum Moisture (%)	0.1 in.	0.2 in.	
B-06	S-2	3.5-5.0	20.4										

Notes: See test reports for test method, ^ASTM D2216-19, *ASTM D2488, **ASTM D1140-17, #ASTM D2974-20e1 < See test report for D4718 corrected values

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content

Project: NRRWA Water Treatment Plant
Client: Peed & Bortz

Project No.: 12:2638-D
Date Reported: 7/31/2023

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received
JGeil	JMurphy	JMurphy	7/26/2023

Laboratory Testing Summary

Sample Location	Sample Number	Depth (ft)	^MC (%)	Soil Type	Atterberg Limits			**Percent Passing No. 200 Sieve	Moisture - Density		CBR (%)		#Organic Content (%)
					LL	PL	PI		<Maximum Density (pcf)	<Optimum Moisture (%)	0.1 in.	0.2 in.	
B-07	S-05	13.5-15.0	44.2	MH	58	39	19	89.3					
B-07	S-07	23.5-25.0	30.5										
B-08	S-05	13.5-15.0	17.8										
B-09	S-06	18.5-20.0	33.1	ML	48	28	20	82.4					
B-09	S-09	33.5-35.0	37.4										
B-10	S-04	8.5-10.0	43.2										
B-12	S-05	13.5-15.0	35.9										
B-12	S-06	18.5-20.0	8.9										

Notes: See test reports for test method, ^ASTM D2216-19, *ASTM D2488, **ASTM D1140-17, #ASTM D2974-20e1 < See test report for D4718 corrected values

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content

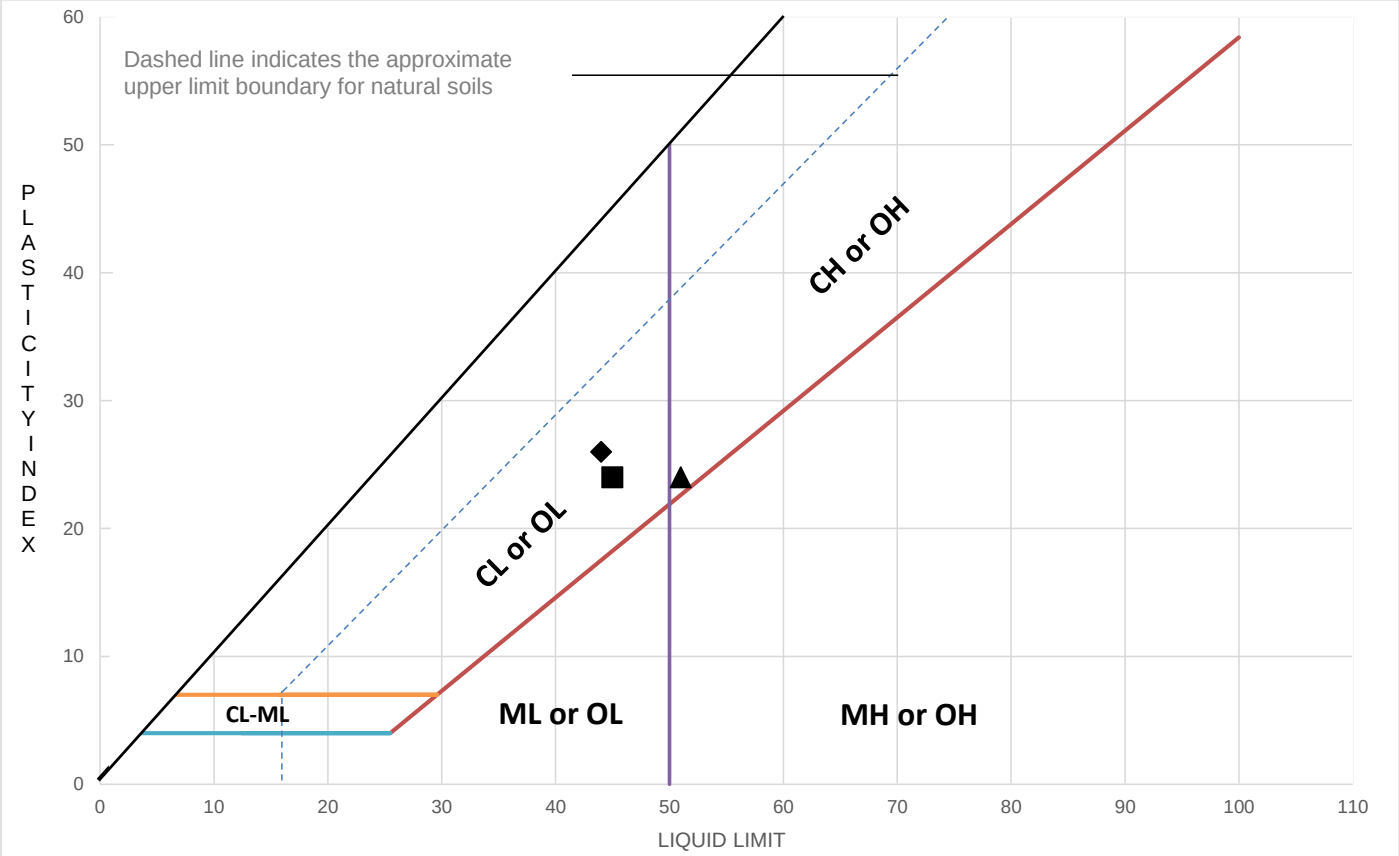
Project: NRRWA Water Treatment Plant Extension
Client: Peed & Bortz

Project No.: 12:2638-D1
Date Reported: 1/15/2024

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received
JGeil	JMurphy	JMurphy	1/3/2024

LIQUID AND PLASTIC LIMITS TEST REPORT



TEST RESULTS (ASTM D4318-10 (MULTIPOINT TEST))

	Sample Location	Sample Number	Sample Depth (ft)	LL	PL	PI	%<#40	%<#200	AASHTO	USCS	Material Description
■	B-01	S-2	3.50-5.00	45	21	24	96.8	66.5	A-7-6	CL	Light Orange Brown SANDY LEAN CLAY
◆	B-02	S-3	6.00-7.50	44	18	26	90.4	75.7	A-7-6	CL	Red Brown LEAN CLAY with Sand
▲	B-03	S-2	3.50-5.00	51	27	24	91.7	64.6	A-7-6	CH	Red Orange SANDY FAT CLAY

Project: NRRWA Water Treatment Plant
Client: Peed & Bortz

Project No.: 12:2638-D
Date Reported: 7/31/2023

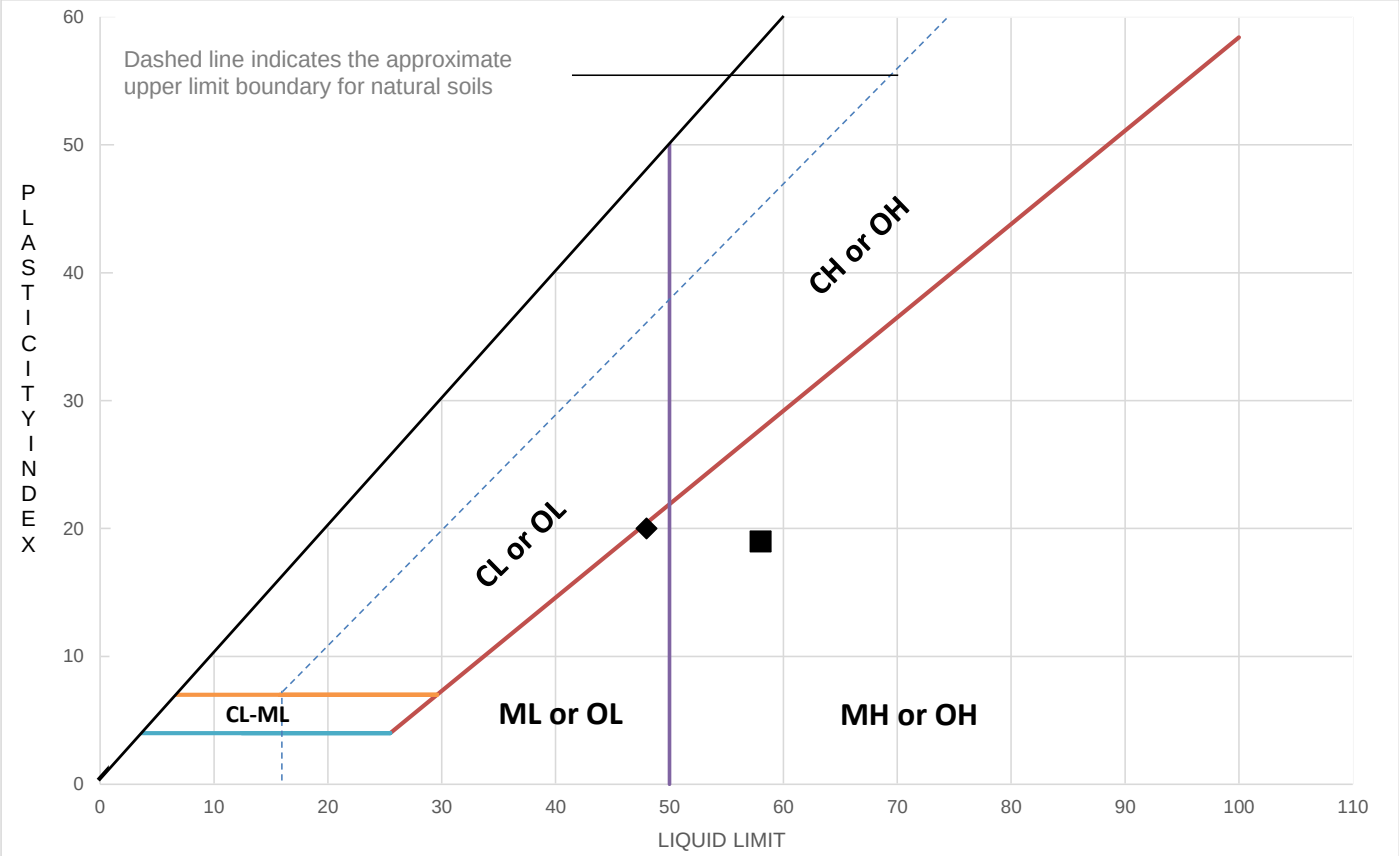
Office / Lab: ECS Mid-Atlantic LLC - Roanoke

Address: 7670 Enon Drive, Suite 101, Roanoke, VA 24019

Office Number / Fax: (540)362-2000, (540)362-1202

Tested by	Checked by	Approved by	Date Received
JGeil	JMurphy	JMurphy	7/26/2023

LIQUID AND PLASTIC LIMITS TEST REPORT



TEST RESULTS ()

	Sample Location	Sample Number	Sample Depth ()	LL	PL	PI	%<#40	%<#200	AASHTO	USCS	Material Description
■	B-07	S-05	13.50-15.00	58	39	19	94.6	89.3	A-7-5	MH	Dark Red ELASTIC SILT
◆	B-09	S-06	18.50-20.00	48	28	20	90.6	82.4	A-7-6	ML	Dark Brown/Purple SILT with Sand

Project: NRRWA Water Treatment Plant Extension
Client: Peed & Bortz

Project No.: 12:2638-D1
Date Reported: 1/15/2024

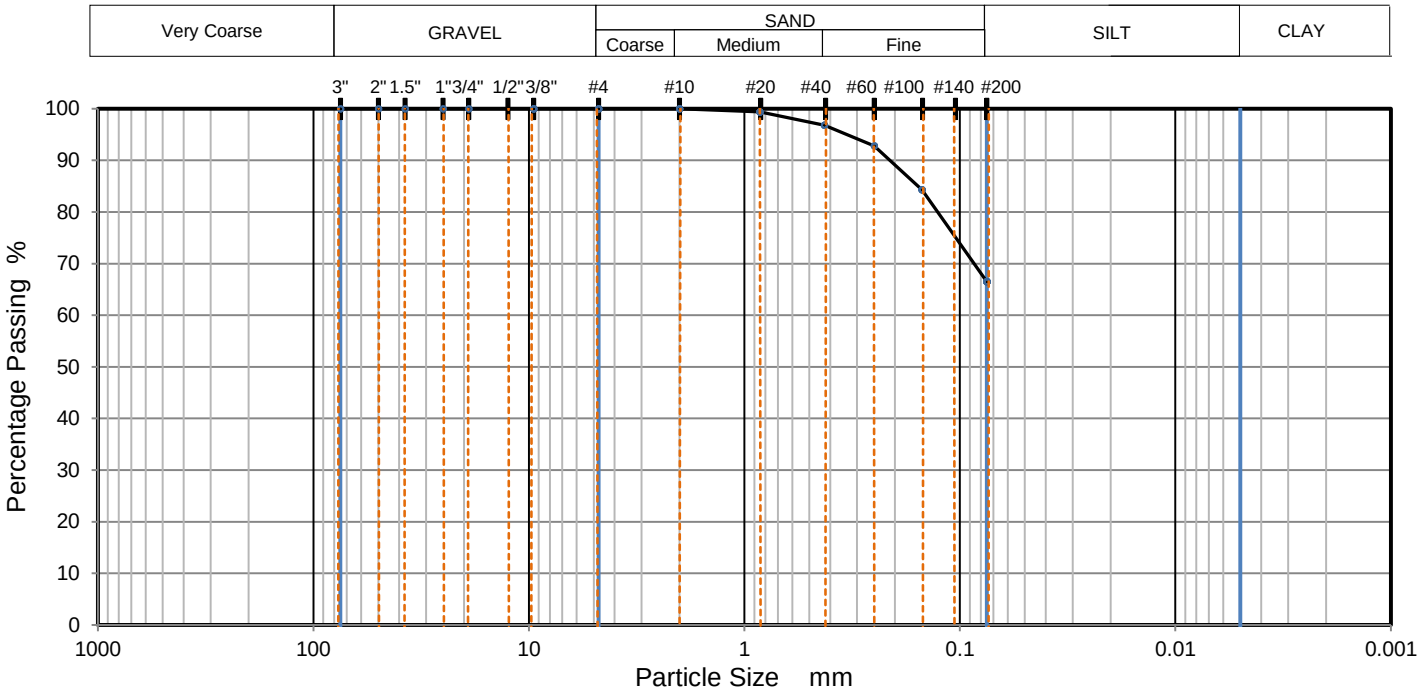
Office / Lab: ECS Mid-Atlantic LLC - Roanoke

Address: 7670 Enon Drive, Suite 101, Roanoke, VA 24019

Office Number / Fax: (540)362-2000, (540)362-1202

Tested by	Checked by	Approved by	Date Received
JGeil	JMurphy	JMurphy	1/3/2024

PARTICLE SIZE DISTRIBUTION



TEST RESULTS (ASTM D6913M-17-METHOD A)

Sieving		Hydrometer Sedimentation	
Particle Size	% Passing	Particle Size mm	% Passing
3"	100		
2"	100		
1 1/2"	100		
1"	100		
3/4"	100		
3/8"	100		
#4	100		
#10	100		
#20	99		
#40	97		
#60	93		
#100	84		
#200	67		

Dry Mass of sample, g	24.9

Sample Proportions	% dry mass
Very coarse, >3" sieve	0
Gravel, 3" to # 4 sieve	0
Coarse Sand, #4 to #10 sieve	0
Medium Sand, #10 to #40	3
Fine Sand, #40 to #200	30
Fines <#200	67

USCS	CL	Liquid Limit	45	D90	0.211	D50		D10	
AASHTO	A-7-6	Plastic Limit	21	D85	0.156	D30		Cu	
USCS Group Name	Sandy lean clay	Plasticity Index	24	D60		D15		Cc	

Project: NRRWA Water Treatment Plant
Client: Peed & Bortz
Sample Description: Light Orange Brown SANDY LEAN CLAY
Sample Source: B-01

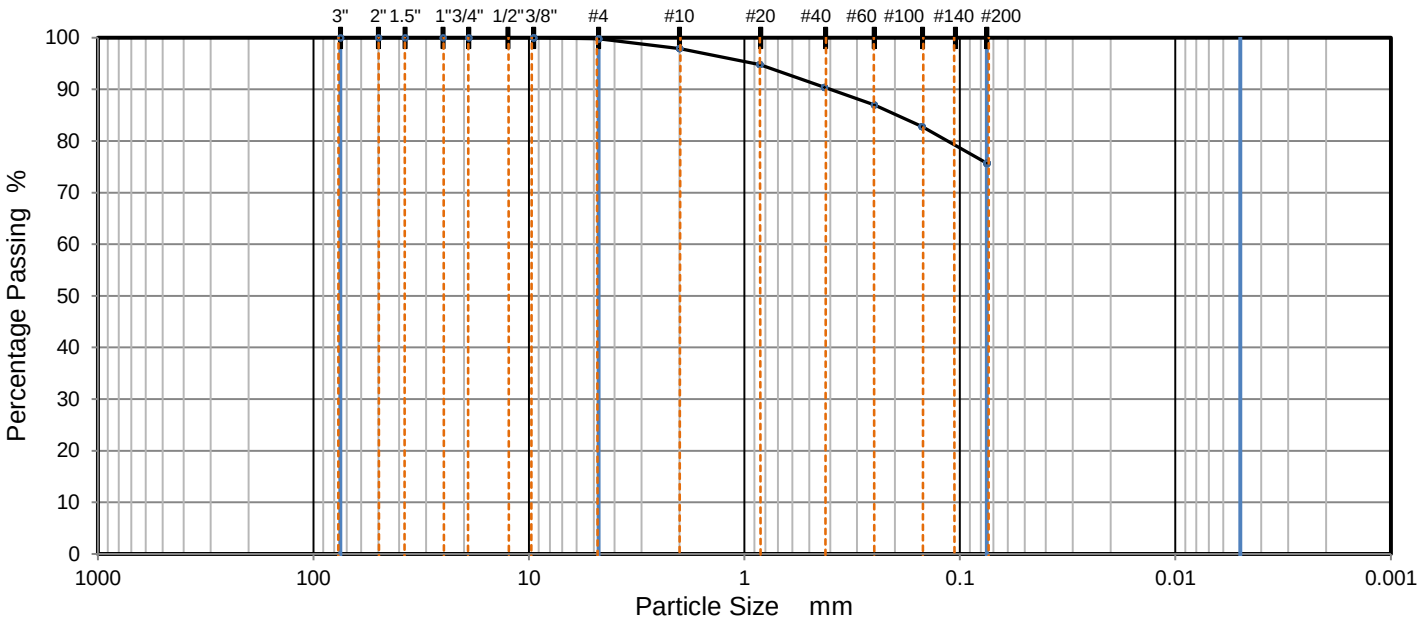
Project No.: 12:2638-D
Depth (ft): 3.5 - 5.0
Sample No.: S-2
Date Reported: 7/31/2023

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received	Remarks
JGeil	JMurphy	JMurphy	7/26/2023	

PARTICLE SIZE DISTRIBUTION

Very Coarse	GRAVEL	SAND			SILT	CLAY
		Coarse	Medium	Fine		



TEST RESULTS (ASTM D6913M-17-METHOD A)

Sieving		Hydrometer Sedimentation	
Particle Size	% Passing	Particle Size mm	% Passing
3"	100		
2"	100		
1 1/2"	100		
1"	100		
3/4"	100		
3/8"	100		
#4	100		
#10	98		
#20	95		
#40	90		
#60	87		
#100	83		
#200	76		

Dry Mass of sample, g	63.7

Sample Proportions	% dry mass
Very coarse, >3" sieve	0
Gravel, 3" to # 4 sieve	0
Coarse Sand, #4 to #10 sieve	2
Medium Sand, #10 to #40	8
Fine Sand, #40 to #200	15
Fines <#200	76

USCS	CL	Liquid Limit	44	D90	0.399	D50		D10	
AASHTO	A-7-6	Plastic Limit	18	D85	0.196	D30		Cu	
USCS Group Name	Lean clay with sand	Plasticity Index	26	D60		D15		Cc	

Project: NRRWA Water Treatment Plant
Client: Peed & Bortz
Sample Description: Red Brown LEAN CLAY with Sand
Sample Source: B-02

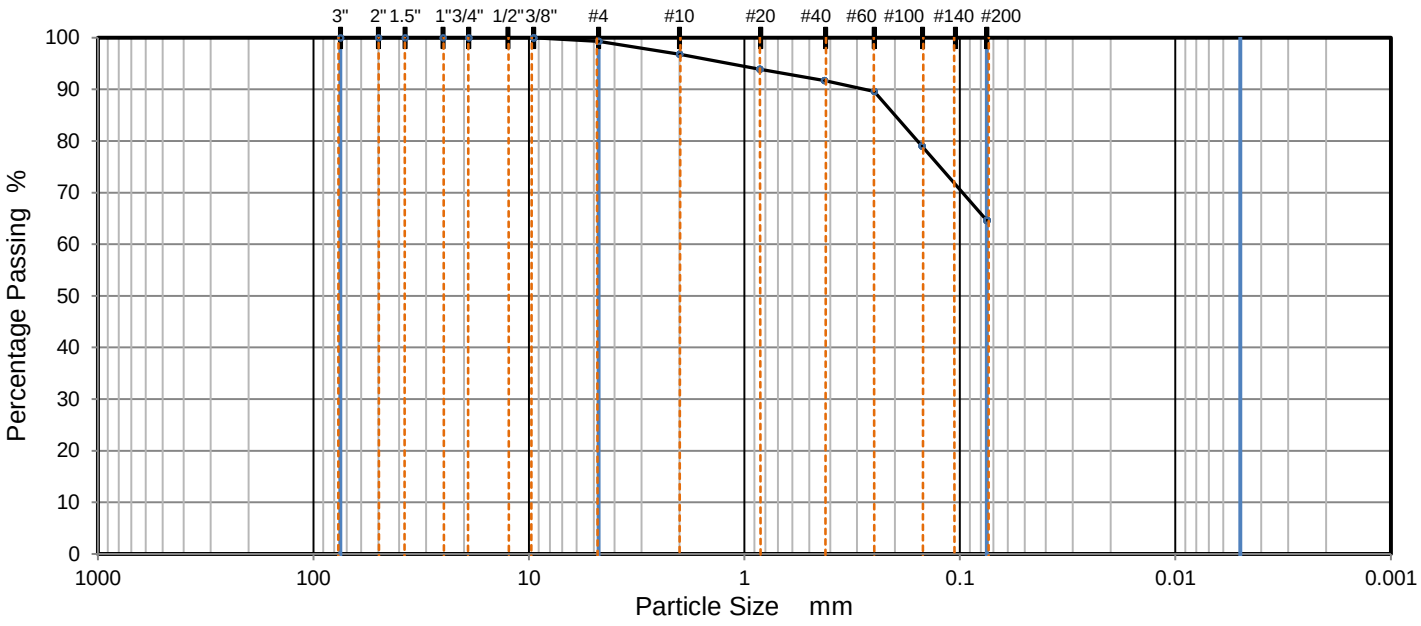
Project No.: 12:2638-D
Depth (ft): 6.0 - 7.5
Sample No.: S-3
Date Reported: 7/31/2023

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received	Remarks
JGeil	JMurphy	JMurphy	7/26/2023	

PARTICLE SIZE DISTRIBUTION

Very Coarse	GRAVEL	SAND			SILT	CLAY
		Coarse	Medium	Fine		



TEST RESULTS (ASTM D6913M-17-METHOD A)

Sieving		Hydrometer Sedimentation	
Particle Size	% Passing	Particle Size mm	% Passing
3"	100		
2"	100		
1 1/2"	100		
1"	100		
3/4"	100		
3/8"	100		
#4	99		
#10	97		
#20	94		
#40	92		
#60	90		
#100	79		
#200	65		

Dry Mass of sample, g	54.5

Sample Proportions	% dry mass
Very coarse, >3" sieve	0
Gravel, 3" to # 4 sieve	1
Coarse Sand, #4 to #10 sieve	3
Medium Sand, #10 to #40	5
Fine Sand, #40 to #200	27
Fines <#200	65

USCS	CH	Liquid Limit	51	D90	0.277	D50		D10	
AASHTO	A-7-6	Plastic Limit	27	D85	0.200	D30		Cu	
USCS Group Name	Sandy fat clay	Plasticity Index	24	D60		D15		Cc	

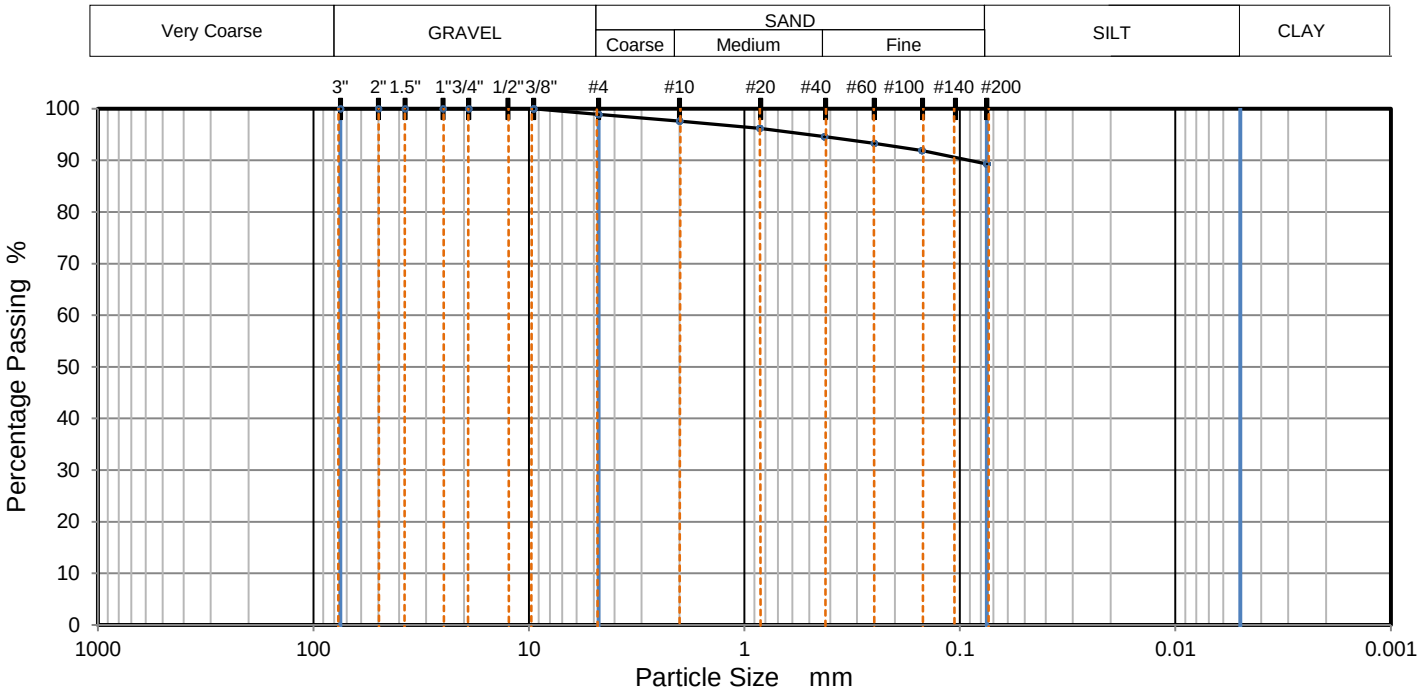
Project: NRRWA Water Treatment Plant
Client: Peed & Bortz
Sample Description: Red Orange SANDY FAT CLAY
Sample Source: B-03

Project No.: 12:2638-D
Depth (ft): 3.5 - 5.0
Sample No.: S-2
Date Reported: 7/31/2023

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received	Remarks
JGeil	JMurphy	JMurphy	7/26/2023	

PARTICLE SIZE DISTRIBUTION



TEST RESULTS (ASTM D6913M-17-METHOD A)

Sieving		Hydrometer Sedimentation	
Particle Size	% Passing	Particle Size mm	% Passing
3"	100		
2"	100		
1 1/2"	100		
1"	100		
3/4"	100		
3/8"	100		
#4	99		
#10	98		
#20	96		
#40	95		
#60	93		
#100	92		
#200	89		

Dry Mass of sample, g: 67.7

Sample Proportions	% dry mass
Very coarse, >3" sieve	0
Gravel, 3" to # 4 sieve	1
Coarse Sand, #4 to #10 sieve	1
Medium Sand, #10 to #40	3
Fine Sand, #40 to #200	5
Fines <#200	89

USCS	MH	Liquid Limit	58	D90	0.090	D50		D10	
AASHTO	A-7-5	Plastic Limit	39	D85		D30		Cu	
USCS Group Name	Elastic silt	Plasticity Index	19	D60		D15		Cc	

Project: NRRWA Water Treatment Plant Extension
Client: Peed & Bortz
Sample Description: Dark Red ELASTIC SILT
Sample Source: B-07

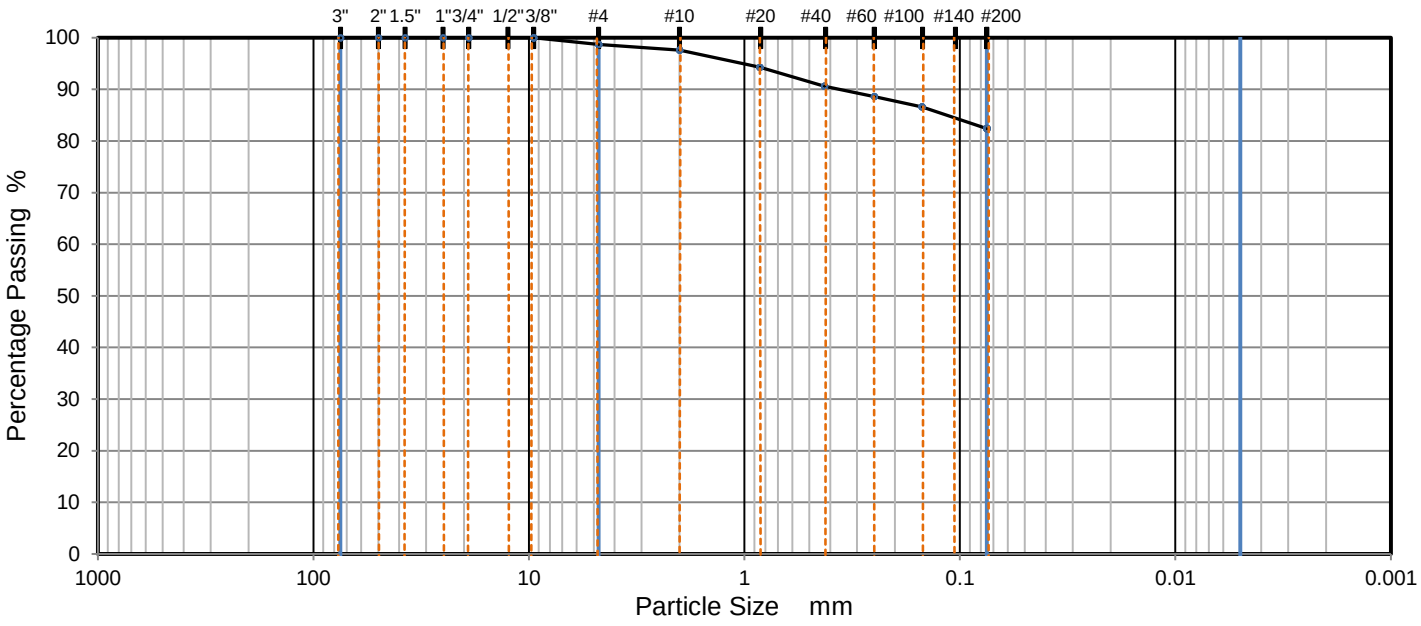
Project No.: 12:2638-D1
Depth (ft): 13.5 - 15.0
Sample No.: S-05
Date Reported: 1/15/2024

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received	Remarks
JGeil	JMurphy	JMurphy	1/3/2024	

PARTICLE SIZE DISTRIBUTION

Very Coarse	GRAVEL	SAND			SILT	CLAY
		Coarse	Medium	Fine		



TEST RESULTS (ASTM D6913M-17-METHOD A)

Sieving		Hydrometer Sedimentation	
Particle Size	% Passing	Particle Size mm	% Passing
3"	100		
2"	100		
1 1/2"	100		
1"	100		
3/4"	100		
3/8"	100		
#4	99		
#10	98		
#20	94		
#40	91		
#60	89		
#100	87		
#200	82		

Dry Mass of sample, g	64.7

Sample Proportions	% dry mass
Very coarse, >3" sieve	0
Gravel, 3" to # 4 sieve	1
Coarse Sand, #4 to #10 sieve	1
Medium Sand, #10 to #40	7
Fine Sand, #40 to #200	8
Fines <#200	82

USCS	ML	Liquid Limit	48	D90	0.363	D50		D10	
AASHTO	A-7-6	Plastic Limit	28	D85	0.115	D30		Cu	
USCS Group Name	Silt with sand	Plasticity Index	20	D60		D15		Cc	

Project: NRRWA Water Treatment Plant Extension
Client: Peed & Bortz
Sample Description: Dark Brown/Purple SILT with Sand
Sample Source: B-09

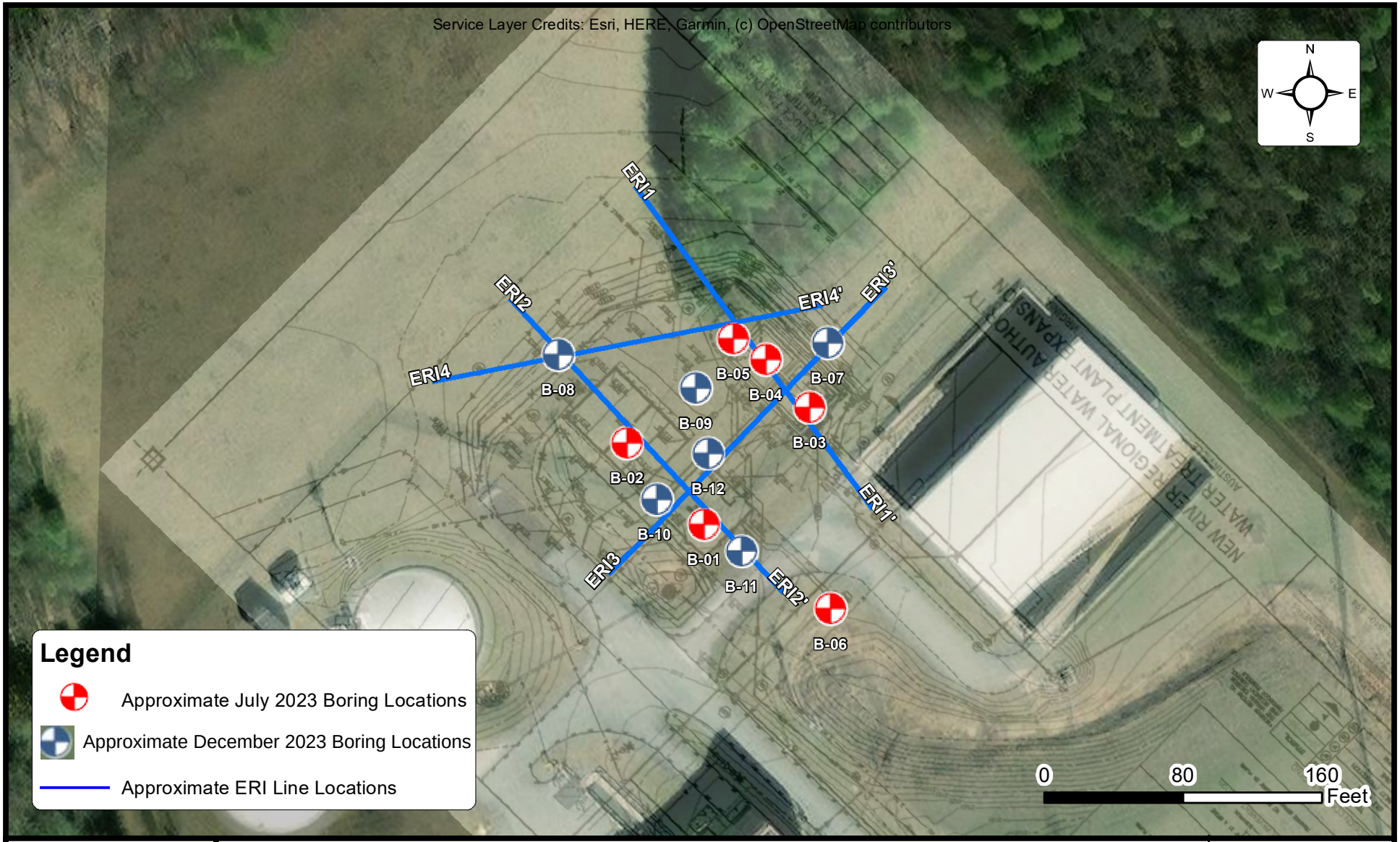
Project No.: 12:2638-D1
Depth (ft): 18.5 - 20.0
Sample No.: S-06
Date Reported: 1/15/2024

Office / Lab	Address	Office Number / Fax
ECS Mid-Atlantic LLC - Roanoke	7670 Enon Drive Suite 101 Roanoke, VA 24019	(540)362-2000 (540)362-1202

Tested by	Checked by	Approved by	Date Received	Remarks
JGeil	JMurphy	JMurphy	1/3/2024	

APPENDIX D – Electrical Resistivity Imaging

Electrical Resistivity Location Diagram
Electrical Resistivity Profiles



ERI LOCATION DIAGRAM
NRRWA WATER TREATMENT PLANT

289 KOHLER AVENUE, AUSTINVILLE, VIRGINIA
PEED & BORTZ

ENGINEER	DOS
SCALE	AS NOTED
PROJECT NO.	12:2638-D
FIGURE	1 OF 1
DATE	1/10/2024

SOIL CLASSIFICATION LEGEND

ST - SHELBY TUBE RC - ROCK CORE PM - PRESSURE METER EOB - END OF BORING AR - AUGER REFUSAL SR - SAMPLE REFUSAL [FINES CONTENT%]

- FILL
- POSSIBLE FILL
- PROBABLE FILL
- GW - WELL GRADED GRAVEL
- GM - SILTY GRAVEL
- GP - POORLY GRADED GRAVEL
- GC - CLAYEY GRAVEL
- SW - WELL GRADED SAND
- ML - LOW PLASTICITY SILT
- CL - LOW PLASTICITY CLAY
- MH - HIGH PLASTICITY SILT
- SM - SILTY SAND
- SP - POORLY GRADED SAND
- SC - CLAYEY SAND
- CH - HIGH PLASTICITY CLAY
- OH - HIGH PLASTICITY ORGANIC SILTS AND CLAYS
- OL - LOW PLASTICITY ORGANIC SILTS AND CLAY
- PT - PEAT
- WR - WEATHERED ROCK

Notes: 1- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE. 2- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION. 3- PENETRATION TEST RESISTANCE IN BLOWS PER FOOT (ASTM D1586).

SURFACE MATERIALS

- TOPSOIL
- ASPHALT
- GRAVEL
- CONCRETE
- VOID

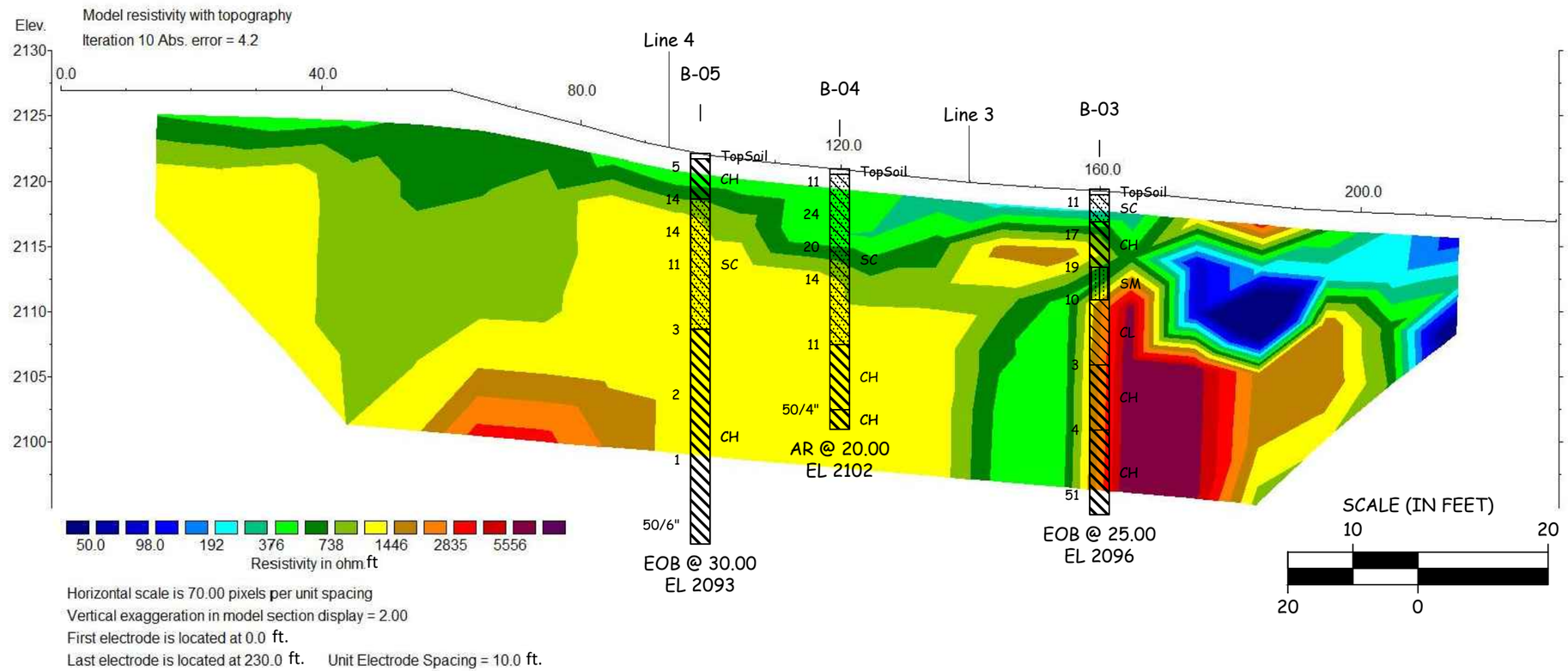
ROCK TYPES

- IGNEOUS
- METAMORPHIC
- SEDIMENTARY

SYMBOL LEGEND

WATER LEVELS
- FIRST ENCOUNTERED
- COMPLETED
- SEASONAL HIGH WATER
- STABILIZED

- BOTTOM OF CASING
- LOSS OF CIRCULATION
- CALIBRATED PENETROMETER TONS/FT.^{2}
- PLASTIC LIMIT %
- WATER CONTENT %
- LIQUID LIMIT %



Horizontal scale is 70.00 pixels per unit spacing
Vertical exaggeration in model section display = 2.00
First electrode is located at 0.0 ft.
Last electrode is located at 230.0 ft. Unit Electrode Spacing = 10.0 ft.

NRRWA WATER TREATMENT PLANT

AUSTINVILLE, VA

ER PROFILES
LINE 1
PEED & BORTZ

ECS REVISIONS
12/20/23
01/08/2024

ENGINEER	DRAFTING
JPP	AMH

SCALE: AS NOTED

PROJECT NO.: 12:2638-D

SHEET: 1 OF 2

DATE: 08/22/2023

SOIL CLASSIFICATION LEGEND

ST - SHELBY TUBE RC - ROCK CORE PM - PRESSURE METER EOB - END OF BORING AR - AUGER REFUSAL SR - SAMPLE REFUSAL [FINES CONTENT%]

- FILL
- POSSIBLE FILL
- PROBABLE FILL
- GW - WELL GRADED GRAVEL
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- GP - POORLY GRADED GRAVEL
- GC - CLAYEY GRAVEL
- SW - WELL GRADED SAND
- ML - LOW PLASTICITY SILT
- CL - LOW PLASTICITY CLAY
- MH - HIGH PLASTICITY SILT
- SM - SILTY SAND
- SP - POORLY GRADED SAND
- SC - CLAYEY SAND
- CH - HIGH PLASTICITY CLAY
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SURFACE MATERIALS

- TOPSOIL
- ASPHALT
- GRAVEL
- CONCRETE
- VOID

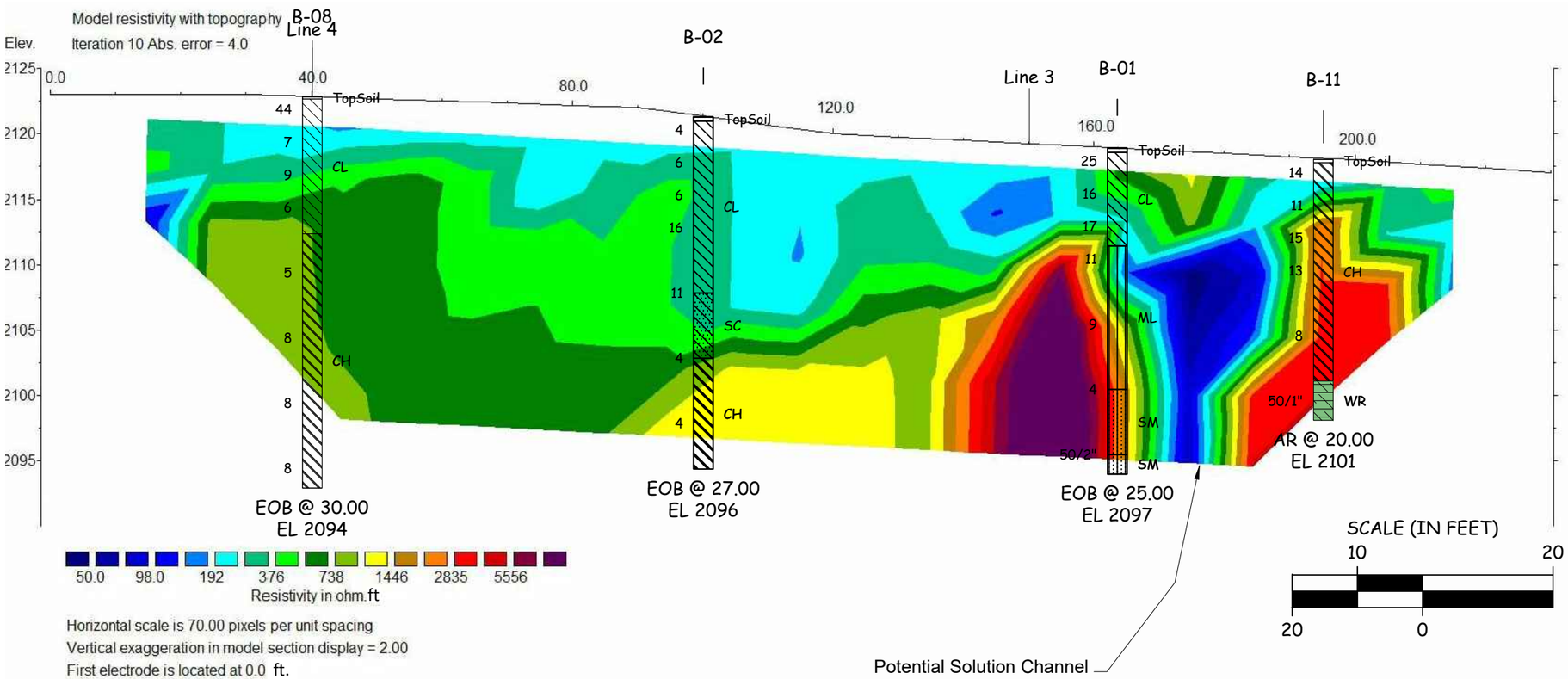
ROCK TYPES

- IGNEOUS
- METAMORPHIC
- SEDIMENTARY

SYMBOL LEGEND

WATER LEVELS
- FIRST ENCOUNTERED
- COMPLETED
- SEASONAL HIGH WATER
- STABILIZED

- BOTTOM OF CASING
- LOSS OF CIRCULATION
- CALIBRATED PENETROMETER TONS/FT.^{2}
- PLASTIC LIMIT %
- WATER CONTENT %
- LIQUID LIMIT %



NRRWA WATER TREATMENT PLANT

AUSTINVILLE, VA

ER PROFILES LINE 2

PEED & BORTZ

ECS REVISIONS
12/20/23
01/08/2024

ENGINEER	DRAFTING
JPP	AMH

SCALE: AS NOTED

PROJECT NO.: 12:2638-D

SHEET: 2 OF 2

DATE: 08/22/2023

SOIL CLASSIFICATION LEGEND

ST - SHELBY TUBE RC - ROCK CORE PM - PRESSURE METER EOB - END OF BORING AR - AUGER REFUSAL SR - SAMPLE REFUSAL [FINES CONTENT%]

- FILL
- POSSIBLE FILL
- PROBABLE FILL
- GW - WELL GRADED GRAVEL
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- GP - POORLY GRADED GRAVEL
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- SW - WELL GRADED SAND
- ML - LOW PLASTICITY SILT
- CL - LOW PLASTICITY CLAY
- MH - HIGH PLASTICITY SILT
- SM - SILTY SAND
- SP - POORLY GRADED SAND
- SC - CLAYEY SAND
- CH - HIGH PLASTICITY CLAY
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- OL - LOW PLASTICITY ORGANIC SILTS AND CLAY
- PT - PEAT
- WR - WEATHERED ROCK

Notes: 1- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE. 2- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION. 3- PENETRATION TEST RESISTANCE IN BLOWS PER FOOT (ASTM D1586).

SURFACE MATERIALS

- TOPSOIL
- CONCRETE
- ASPHALT
- VOID
- GRAVEL

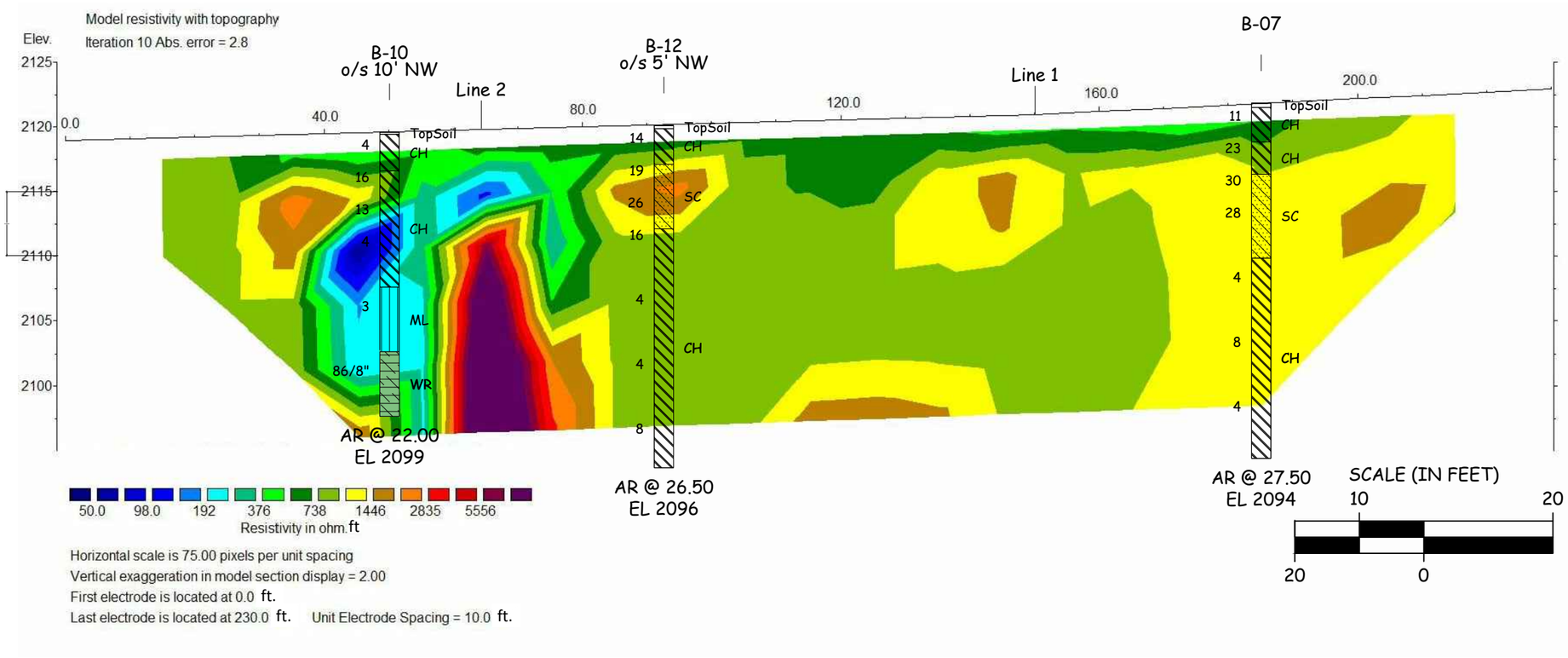
ROCK TYPES

- IGNEOUS
- METAMORPHIC
- SEDIMENTARY

SYMBOL LEGEND

WATER LEVELS
- FIRST ENCOUNTERED
- COMPLETED
- SEASONAL HIGH WATER
- STABILIZED

- BOTTOM OF CASING
- LOSS OF CIRCULATION
- CALIBRATED PENETROMETER TONS/FT.²
- PLASTIC LIMIT %
- WATER CONTENT %
- LIQUID LIMIT %



NRRWA WATER TREATMENT PLANT EXTENSION

AUSTINVILLE, VA

ECS

ER PROFILES LINE 3

PEED & BORTZ

ECS REVISIONS

01/08/2024

ENGINEER	DRAFTING
JPP	AMH

SCALE: AS NOTED

PROJECT NO.: 12:2638-D1

SHEET: 1 OF 2

DATE: 12/20/2023

SOIL CLASSIFICATION LEGEND

ST - SHELBY TUBE RC - ROCK CORE PM - PRESSURE METER EOB - END OF BORING AR - AUGER REFUSAL SR - SAMPLE REFUSAL [FINES CONTENT%]

- FILL
- POSSIBLE FILL
- PROBABLE FILL
- GW - WELL GRADED GRAVEL
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- GP - POORLY GRADED GRAVEL
- GC - CLAYEY GRAVEL
- SW - WELL GRADED SAND
- ML - LOW PLASTICITY SILT
- CL - LOW PLASTICITY CLAY
- MH - HIGH PLASTICITY SILT
- SM - SILTY SAND
- SP - POORLY GRADED SAND
- SC - CLAYEY SAND
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- OH - HIGH PLASTICITY ORGANIC SILTS AND CLAYS
- OL - LOW PLASTICITY ORGANIC SILTS AND CLAY
- PT - PEAT
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Notes: 1- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE. 2- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION. 3- PENETRATION TEST RESISTANCE IN BLOWS PER FOOT (ASTM D1586).

SURFACE MATERIALS

- TOPSOIL
- ASPHALT
- GRAVEL
- CONCRETE
- VOID

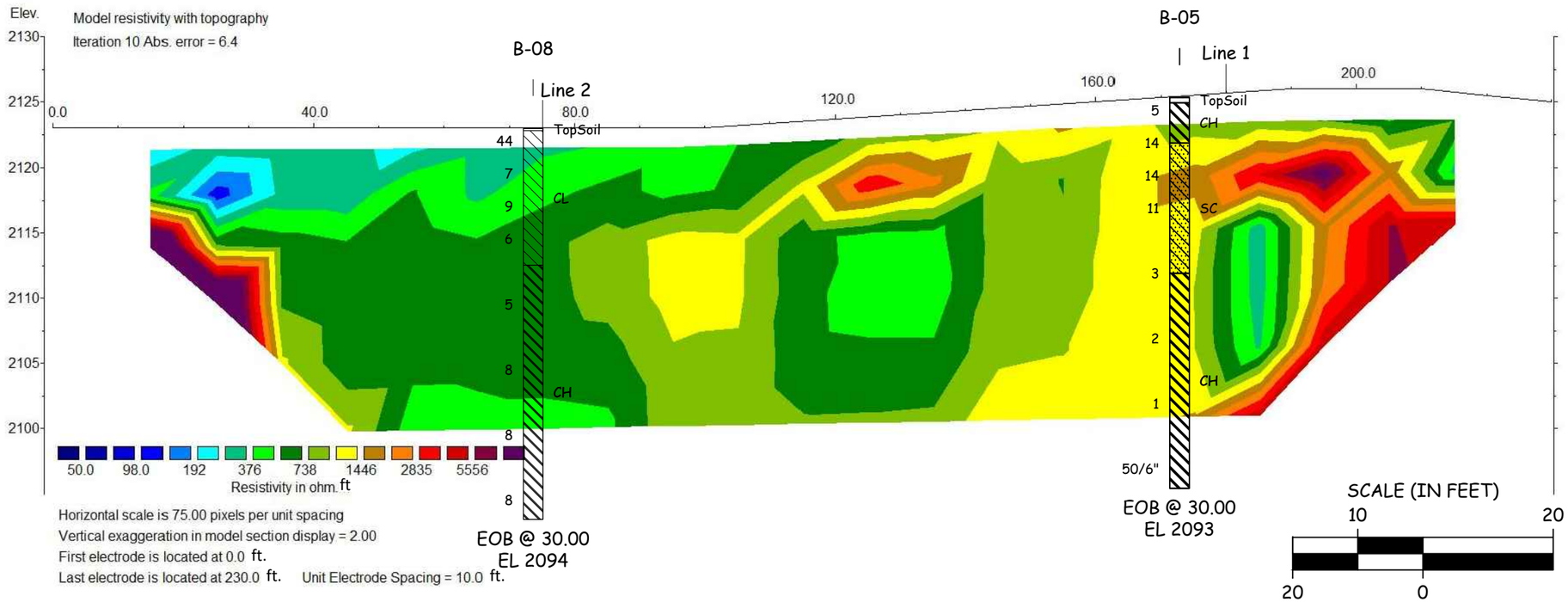
ROCK TYPES

- IGNEOUS
- METAMORPHIC
- SEDIMENTARY

SYMBOL LEGEND

WATER LEVELS
- FIRST ENCOUNTERED
- COMPLETED
- SEASONAL HIGH WATER
- STABILIZED

- BOTTOM OF CASING
- LOSS OF CIRCULATION
- CALIBRATED PENETROMETER TONS/FT.²
- PLASTIC LIMIT %
- WATER CONTENT %
- LIQUID LIMIT %



NRRWA WATER TREATMENT PLANT EXTENSION

AUSTINVILLE, VA

ER PROFILES LINE 4 PEED & BORTZ

ECS REVISIONS
01/08/2024

ENGINEER	DRAFTING
JPP	AMH

SCALE: AS NOTED

PROJECT NO.: 12:2638-D1

SHEET: 2 OF 2

DATE: 12/20/2023