AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Casey Leach, P.E. Project Manager

JJZ CEE

From: Jacob Zhao, EIT., Rotational Engineer, via, Callie Ewald, P.E., Senior Geotechnical Engineer

Date: September 30th, 2026

Subject: Charleston STP CULV(113) – Geotechnical Report

1.0 INTRODUCTION

As requested, we have completed our subsurface investigation and geotechnical analyses of the spread footing foundations for the proposed box culvert and wingwalls as part of the Charleston STP CULV(113) project. The project involves removing and replacing Bridge No. 15, along with associated roadway and channel work, in the town of Charleston, VT. It is located on Vermont Route 5A, where Bridge No. 15 crosses an unnamed tributary of Nutting Brook, approximately 0.14 miles southwest of the intersection with Allen Farm Road. Contained herein are the results of our field sampling and testing, as well as our design parameter recommendations for use in the design of the proposed replacement structure, based on the 2024 AASHTO LRFD Bridge Design Specifications.

2.0 FIELD INVESTIGATION & LABORATORY TESTING

A field investigation was conducted by GZA between May 20th and May 21st, 2024. A summary of the final location of each boring and corresponding ground surface elevation can be found in Table 2.1. The findings of the investigation are detailed in a Geotechnical Report dated July 12th, 2024 to Stephen Madden (attached as **Appendix A**). Refer to this report for a detailed description of the field sampling and testing, laboratory analysis of soil samples, generalized subsurface profile and borings.

Table 2.1 Boring Locations and Elevations.

Boring No.	Northing (ft)	Easting (ft)	Approximate Ground Surface Elevation (ft)
B-101	856677.3	1755510.1	1164.0
B-102	856606.5	1755516.5	1173.0
B-103	856595.8	1755538.3	1173.0

3.0 SHALLOW FOUNDATION ANALYSIS

AASHTO's LRFD Bridge Design Specifications Manual (2024) was used as the reference for settlement and bearing resistance equations. Section 10.6.3.1.2 contains the equation used for bearing resistance. Neither depth factors nor load inclination factors were used in the analysis as they were not considered pertinent due to the designed embedment of the structure, per Section C.10.6.3.1.2a. Hough's Method, used to calculate settlement in normally consolidated cohesionless soils, can be found in Section 10.6.2.4.2.

It is recommended that the bottom of the wingwall footings be at least 4 ft below the ground surface based on frost susceptibility and bearing stratum at the site. Based on the analysis and results, it is recommended to over-excavate a minimum of 12 inches below the bottom of footing elevation and replace with suitable material, such as crushed stone or granular backfill. To account for this, an embedment value of 5 ft was used for the strength limit state analysis, and an embedment value of 1 ft was used for the service limit state analysis, which tends to control the design, to account for potential scour conditions at the design flood elevation per Section 2.6.4.4.2. A conservative groundwater elevation at the bottom of the footing was used in design at the inlet and outlet, respectively.

As per section 10.5.5.1 of the 2020 AASHTO LRFD Bridge Design Specifications, a resistance factor of 1.0 should be applied to the unfactored bearing resistance for use in service limit state design. Service limit state design includes, but is not limited to, settlement and scour. Section 10.5.5.2.2 specifies that a resistance factor of 0.45 should be applied to the unfactored bearing resistance for use in strength limit state design for spread footings on rock and soil. Strength limit state design includes, but is not limited to, checks for bearing resistance, sliding, and constructability. Potential for overturning is limited by controlling the location of the resultant of the reaction forces (eccentricity). Eccentricity, e, shall be limited as follows:

Foundations on soil:	$\|e\| < b/3$
Foundations on rock:	$\|e\| < 0.45b$

Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. All footing widths presented in this report are *effective* footing widths.

3.1 Bearing Resistance & Settlement

The maximum length of wingwalls used in the analysis was 14.0 ft, based on the Box Culvert Detail Sheet provided by Roadway Design, dated July 2026. The sheet also indicated a bottom of footing elevation of 1154.19 ft at the inlet and 1151.3 ft at the outlet, corresponding to Borings B-101 and B-103, respectively. Based on the geometry and elevations shown in the plans, it is anticipated that the footings will bear on the Clay & Silt layer. For the bearing layer, a density (γ) of 100 lb/ft^3 was used with a corresponding friction angle (ϕ) determined through subsequent calculations of 32° and at the inlet and outlet, respectively. The resulting bearing resistances using the 32° friction angle are included here based on the variability in soil stratum elevations and distance from the borings to the walls.

For effective footing widths of 4 ft through 8 ft, the maximum factored bearing resistances for the strength and service limit states are provided in Table 3.1.1. Calculations accounted for 1 foot of additional embedment through inclusion of suitable material, as described above.

Table 3.1.1 Factored Bearing Resistances at Various Effective Footing Widths at the Inlet and Outlet.

Maximum Wingwall Length (ft)	Effective Footing Width (ft)	Factored Bearing Resistance, Strength Limit State (ksf)	Factored Bearing Resistance, Service Limit State (ksf)
14.0	4.0	7.4	5.4
	5.0	7.8	6.1
	6.0	8.3	6.7
	7.0	8.7	7.3
	8.0	9.2	7.8

Soil settlement values were calculated for these footing widths based on the nominal bearing pressure at the service limit state using Hough's Method, as described in Section 3.0. Analyses indicated that 1 inch of settlement at either the inlet or outlet would require loading in excess of anticipated loads; therefore, settlement does not govern the design. Considering the granular nature of the foundation soils, any settlement is expected to occur during or immediately after construction. Appendix B contains graphs detailing the corresponding bearing resistances and settlements for various effective footing widths.

3.2 Culvert Wingwall Stability Analysis

The overall stability of the proposed wingwalls was analyzed using the SLIDE2 limit equilibrium slope stability analysis program developed by Rocscience. The wingwalls at the inlet and outlet of the culvert were analyzed at a critical cross-section representing the full height of the wingwalls. The wingwall geometries and cross sections used were based on the Final Plans dated July 30th, 2026. Per Section 11.6.3.7 of the *AASHTO LRFD Bridge Design Specifications*, a maximum resistance factor of 0.65 is allowable where the geotechnical parameters and subsurface stratigraphy are highly variable or based on limited information and a resistance factor of 0.75 is allowable where the geotechnical parameters and subsurface stratigraphy are well defined. The resistance factor of the slope is the inverse of the factor of safety as determined from the stability analysis.

Computer models were generated using SLIDE2 for Wingwall 3 at Station 56+75 and Wingwall 4 at Station 56+69.10 and were analyzed using the Spencer Method. According to the VTrans Geotechnical Engineering Instruction on Soil Slope Stability Investigation & Evaluation Manual (GEC 14-01), the Spencer Method is recommended to be used for the analysis of failure surfaces of any shape. Soil parameters used in the analysis were equivalent to those developed for the shallow foundation analyses, as described above, and a conservative water table elevation was modeled. The maximum heights of the wingwalls were used based on the geometries shown in the Final Plans, corresponding to a height of 10.81 feet at both the inlet and the outlet.

Based on the analysis it appears that no deep-seated global stability issues will exist given the proposed conditions, and the overall stability of the wingwalls is acceptable. The resistance factors for slip surfaces beneath the wingwalls are less than AASHTO's maximum recommended value of 0.75. Refer to **Appendix C** for outputs of the completed analyses.

4.0 RECOMMENDATIONS

Shallow foundations appear to be feasible for the proposed wingwalls as detailed in correspondence with the project engineers and the Box Culvert Detail Sheet provided by Roadway Design, dated July 2026. Factored bearing resistances for various footing widths were calculated for the wingwalls and can be found in Table 3.1.1. These calculations are based on the geometric and geotechnical assumptions outlined in Section 3.0 of this report. The bearing resistances presented in this report at the service limit state were calculated assuming a conservative scour condition with over-excavation of 1ft (1 ft embedment). Sections 10.5.2 and 10.5.3 of AASHTO outline all design states relevant to spread footing design and their respective resistance factors. Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. Table 4.1 shows the appropriate resistance factors for various design states.

Table 4.1: Summary of Resistance Factors

Design State	Resistance Factor, φ
Settlement	1.0
Scour	1.0
Bearing Resistance	0.45
Sliding*	0.90

* Assumed precast concrete placed on sand

4.1 Plan Notes & Details

- For strength limit state, using a resistance factor of 0.45, the factored bearing resistance is 7.4 ksf
- For service limit state, using a resistance factor of 1.0, the factored bearing resistance is 5.4 ksf

In order to achieve the above bearing resistances, we recommend over excavating a minimum of 12 inches below the bottom of footing elevations and replacing with a suitable material, such as crushed stone or 704.08 Granular backfill for Structures. Material placement should extend a minimum of 12 inches horizontally from the edge of the footing.

4.2 Design Parameters

Table 4.2.1 highlights engineering properties assigned to the in-situ soils as well as the engineering properties of common construction materials. These values should be used when designing any substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into

the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. The design earth pressure coefficients are based on horizontal surfaces (non-sloping backfill) and a vertical wall face.

Table 4.2.1: Engineering Properties of In-Situ and Construction Materials

	703.04 – Granular Borrow	**704.08 – Granular Backfill for Structures**	**Clay & Silt (Inlet/Outlet Bearing Stratum)**
Unit Weight, γ (lbs/ft^3):	130	140	100
Internal Friction Angle, φ (degrees):	32	34	32
Coefficient of Friction, f			
- mass concrete cast against soil:	0.45	0.55	0.34
- soil against precast/formed concrete:	0.40	0.54	0.25
Active Earth Pressure Coef., K_a:	0.31	0.28	0.31
Passive Earth Pressure Coef., K_p:	3.26	3.57	3.26
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.44	0.47

4.3 Construction Considerations

4.3.1 Cofferdams/Temporary Earthwork Support

The Contractor should be reminded that Section 208.06 of VTrans' *2024 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of operations for each cofferdam specified in the Contract. Construction drawings shall be submitted in accordance with Subsection 105.06."

4.3.2 Construction Dewatering

The bottom of footing elevations for the culverts are estimated to be beneath the water table based on where water was encountered during the subsurface investigation therefore temporary construction dewatering will likely be required to construct the foundations. Temporary dewatering will also be necessary to limit disturbance to and maintain the integrity of the bearing surface.

Temporary dewatering can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. Sumps should be provided with filters suitable to prevent pumping of fine-grained soil particles. The water trapped by the temporary dewatering controls should be discharged to settling basins or an approved filter "sock" so that the fine particles suspended in the discharge have adequate time to "settle out" prior to discharge. All effluent water, or discharge, should comply with all applicable permits and regulations.

Sumps and trenches should lie outside a 1V:1H line extending downward and outward from the edge of footing. Installation and operation of the Contractor's dewatering system should be integrated with other earthwork operations and sequence of cutting, filling, foundation construction, and backfilling.

4.3.3 Placement and Compaction of Soils

Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment is used, such as a small vibratory plate compactor, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement. It is also recommended to over-excavate a minimum of 12 inches below the bottom of footing elevation and replace with suitable material, such as crushed stone or granular backfill.

Embankment fills should be compacted to a dry density of no less than 95% of the maximum dry density determined in accordance with AASHTO T-99, Method C. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density equal to 95% of the maximum dry density as determined in accordance with AASHTO T-99.

5.0 CONCLUSION

If you have any questions or would like to discuss this report, please contact the Geotechnical Engineering Section via email.

Reviewed by: Callie Ewald, PE

Enclosures: Appendix A: GZA Report and Boring Logs (27 Pages)
Appendix B: Bearing Resistance and Settlement Graphs (4 Pages)
Appendix C: Slope Stability Outputs (2 Pages)

cc: Project File

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Appendix A

GZA Report and Boring Logs



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5 Commerce Park North
Suite 201
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T: 603.623.3600
F: 603.624.9463
www.gza.com

Via Email

July 12, 2024
File No. 04.0191154.21

Stephen Madden
Vermont Agency of Transportation
Construction and Materials Bureau, Geotechnical Engineering Services
2178 Airport Road, Unit B
Berlin, Vermont 05641

RE: Geotechnical Engineering Data Report
Charleston STP CULV(113)
Charleston, Vermont

Dear Mr. Madden:

This data report presents GZA GeoEnvironmental, Inc.'s (GZA's) geotechnical subsurface investigation for the proposed replacement of Bridge No. 15 carrying Vermont Route 5A (VT 5A) over an unnamed brook in Charleston, Vermont. This study has been conducted in accordance with our Standard Contract for Services, Geotechnical Engineering Services 2020 to the Vermont Agency of Transportation (VTrans) and our proposal dated February 1, 2024. The contents of this report are subject to the *Limitations* set forth in **Appendix A**.

GZA's understanding of the project is based on discussions with VTrans and the VTrans Work Order Request (WOR) for Geotechnical Engineering Services dated December 12, 2023, including the Geotechnical Services Request Form dated June 30, 2023.

BACKGROUND AND EXISTING CONDITIONS

The existing culvert, located at mile marker 1.08 on VT 5A, consists of a 48-inch-diameter corrugated metal pipe that carries the roadway over an unnamed brook in Charleston, Vermont, as shown in **Figure 1, Locus Plan.** It is GZA's understanding that the project involves the removal of the existing corrugated metal pipe and replacement with a four-sided precast concrete box culvert and associated headwalls/wingwalls. The new culvert is expected to have external dimensions of approximately 7.5 feet wide and 7.5 feet tall.

OBJECTIVES AND SCOPE OF SERVICES

The objectives of our work were to evaluate the subsurface conditions with respect to the proposed construction, conduct geotechnical laboratory testing, perform

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geotechnical engineering analyses, and provide VTrans with this geotechnical data report. To meet these objectives, GZA completed the following Scope of Services:

- Conducted a site visit to observe surficial conditions, traffic, and boring access;
- Coordinated and observed a subsurface exploration program consisting of three test borings to evaluate subsurface conditions;
- Conducted a laboratory testing program consisting of six soil gradation analyses on select samples to evaluate the engineering properties of the soil encountered in the test borings;
- Completed geotechnical engineering evaluations and developed recommendations for engineering properties of the soils encountered for use in design and construction; and
- Prepared this report summarizing our findings and recommendations.

SUBSURFACE EXPLORATIONS

GZA completed the requested subsurface exploration program consisting of three test borings (designated B-101 through B-103). One test boring was drilled on either side of the existing culvert within the roadway limits of VT 5A. An additional boring was drilled on the west side of the road near the inlet of the proposed culvert structure. The approximate as-drilled boring locations were located by GZA personnel using a handheld GPS and are shown on **Figure 2, Subsurface Exploration Location Plan**. Ground surface elevations at each boring location, accurate to approximately 1 foot, were provided by VTrans.

The borings were drilled to depths of approximately 20.0 to 42.0 feet below ground surface (bgs), as summarized on **Table 1, Summary of GZA Test Borings**. Borings were drilled using a track-mounted drill rig and 4-inch-diameter flush-jointed casing and drive-and-wash drilling techniques. Standard penetration testing (SPT) and split-spoon sampling were generally performed continuously in the borings. The borings were backfilled with drill cuttings and clean sand. Boring B-103 was finished with asphalt cold patch of approximately the same thickness as the existing pavement.

New England Boring Contractors (NEBC) of Derry, New Hampshire coordinated Dig Safe® utility clearance and provided drilling services and traffic control. The drilling was completed on May 20 and May 21, 2024. GZA personnel observed the drilling and prepared logs of each boring. Soil samples were visually classified according to the Modified Burmister classification system with the AASHTO classification indicated in parentheses. Test boring logs prepared by GZA are included in **Appendix B**.

LABORATORY TESTING

GZA conducted a geotechnical laboratory testing program consisting of six soil gradation analyses on representative soil samples recovered from the subsurface explorations. The tests were used to confirm visual-manual field classifications and for use in our engineering analyses. The laboratory gradation testing was performed by Thielsch Engineering of Cranston, Rhode Island. The results of the geotechnical laboratory testing are included in **Appendix C**.

SUBSURFACE CONDITIONS

SURFICIAL AND BEDROCK GEOLOGY

From a review of available literature, including the USGS 1970 Surficial Geologic Map of Vermont, surficial geologic units identified in the culvert area are identified as glaciolacustrine sand, alluvium, and glacial till underlain by bedrock.

According to the USGS 2011 Bedrock Geologic Map of Vermont, bedrock in the vicinity of the site consists of gray to light gray, graphitic slate, phyllite, or schist of the Quartzite and Metapelite Member of the Gile Mountain Formation.

SUBSURFACE PROFILE

Four soil units were encountered in the test borings: Silt, Sand, Clay & Silt, and Glacial Till. Approximately six inches of asphalt pavement was encountered at the ground surface in test boring B-103. Approximately two inches of topsoil were encountered at the ground surface in test borings B-101 and B-102. The approximate thicknesses and generalized descriptions of the subsurface units are presented in the following table, in descending order from existing ground surface. Detailed descriptions of the materials encountered at specific locations are provided in the boring logs in **Appendix B**.

GENERALIZED SUBSURFACE CONDITIONS		
Subsurface Unit	**Approx. Thickness (ft)**	**Generalized Description**
Silt	3.8	Very loose, brown, SILT, some fine to coarse Sand. (A-4) Encountered in test boring B-101.
Sand	5.8 to 11.5	Loose to medium dense, brown, fine to coarse SAND, some to trace Gravel, some to little Silt. (A-1-b, A-2-4) Encountered in test borings B-102 and B-103.
Clay & Silt	7.0 to 11.5	Soft to very stiff, brown to gray, CLAY & SILT, and to some fine to coarse Sand, trace Gravel. (A-4) Encountered in test borings B-101 through B-103.
Glacial Till	>7.5 to >27.0	Dense to very dense, brown to gray, fine to coarse SAND, and to little Gravel, some to trace Clay &Silt TO hard, brown to gray, Clayey SILT, little fine to coarse Sand, trace Gravel. (A-1-a, A-2-4, A-4). Zones of cobbles from approximately 0.5 to 2.5 feet thick were encountered within the Glacial Till. Encountered in test borings B-101 through B-103.

BEDROCK

Bedrock was not encountered during the subsurface investigation to a maximum depth of 42.0 feet bgs.

GROUNDWATER

The drive-and-wash cased drilling method used introduces large quantities of water during drilling. Therefore, groundwater levels observed in the test borings may not represent stabilized groundwater levels. Groundwater was observed at the completion of drilling at depths ranging from 3.9 to 12.9 feet bgs. Stabilization times ranged from 15 to 30 minutes.

Groundwater observations were made at the times and under the conditions stated on the boring logs. Fluctuations in groundwater levels will occur due to variations in season, precipitation, brook level and other factors. Consequently, water levels during and after construction are likely to vary from those encountered in the borings at the time the observations were made.

GENERAL GEOTECHNICAL DESIGN RECOMMENATIONS

Recommended geotechnical design parameters for foundation design are provided the following sections.

GEOTECHNICAL ENGINEERING EVALUATIONS AND RECOMMENDATIONS

GZA conducted our geotechnical engineering evaluations in general accordance with the 2020 American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LFRD) Bridge Design Specifications, 9th Edition.

SEISMIC CONSIDERATIONS

Evaluation of the seismic site class for the project site was based on the N-bar approach in accordance with AASHTO Table C3.10.3.1-1. N-bar is defined as the average, corrected SPT value for the upper 100 feet of the soil profile. For the Charleston culvert replacement site, N-bar was between 15 and 50 blows per foot; therefore, the site should be assigned to Site Class D.

Based on the site location, the recommended AASHTO Response Spectrum (Site Class D) for a 7 percent probability of exceedance in 75 years are summarized as follows:

SITE CLASS D SEISMIC DESIGN PARAMETERS	
Parameter	**Design Value**
PGA	0.08 g
S_s	0.18 g
S_1	0.045 g
F_{pga}	1.6
F_a	1.6
F_v	2.4
A_s (Period = 0.0 sec)	0.13 g
S_{DS} (Period = 0.2 sec)	0.29 g
S_{D1} (Period = 1.0 sec)	0.11 g

The site was also evaluated for liquefaction potential during an earthquake. The term "liquefaction" describes a phenomenon in which cohesionless soil experiences a substantial reduction in effective stress during an earthquake and acquires a degree of temporary mobility sufficient to permit substantial settlement and/or loss of bearing capacity. Based on the relative density of the soils and their gradation, it is GZA's opinion that site soils are not liquefiable.

INTERPRETATION OF SOIL ENGINEERING PROPERTIES

Based on the laboratory and in-situ testing results and our experience with similar deposits in the area, GZA has provided the following soil properties for each encountered strata at the replacement culvert site, as outlined in the following tables.

ESTIMATED ENGINEERING PROPERTIES OF SOIL				
	Total Unit Weight, φ (pcf)	Effective Submerged Unit Weight, φ' (pcf)	Friction Angle, ϕ (deg.)	Undrained Shear Strength Cohesion, s_u (psf)
Silt	90	28	27	-
Sand	110	48	32	-
Clay & Silt	100	38	-	750
Glacial Till	130	68	34	-

CLOSING

We appreciate the opportunity to work with you on this project, and we would be pleased to work with you through design and construction. In the meantime, if you have any questions regarding the recommendations contained in this report or require additional information, please contact us.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Jennifer R. Baron
Senior Project Manager

Dave G. Lamothe, P.E.
Associate Principal

Jay L. Hodkinson, P.E.
Consultant/Reviewer

JRB/DGL/JLH:jrb
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Attachments: Table 1 – Summary of GZA Test Borings
Figure 1 – Locus Plan
Figure 2 – Subsurface Exploration Location Plan
Appendix A – Limitations
Appendix B – Test Boring Logs
Appendix C – Laboratory Test Results

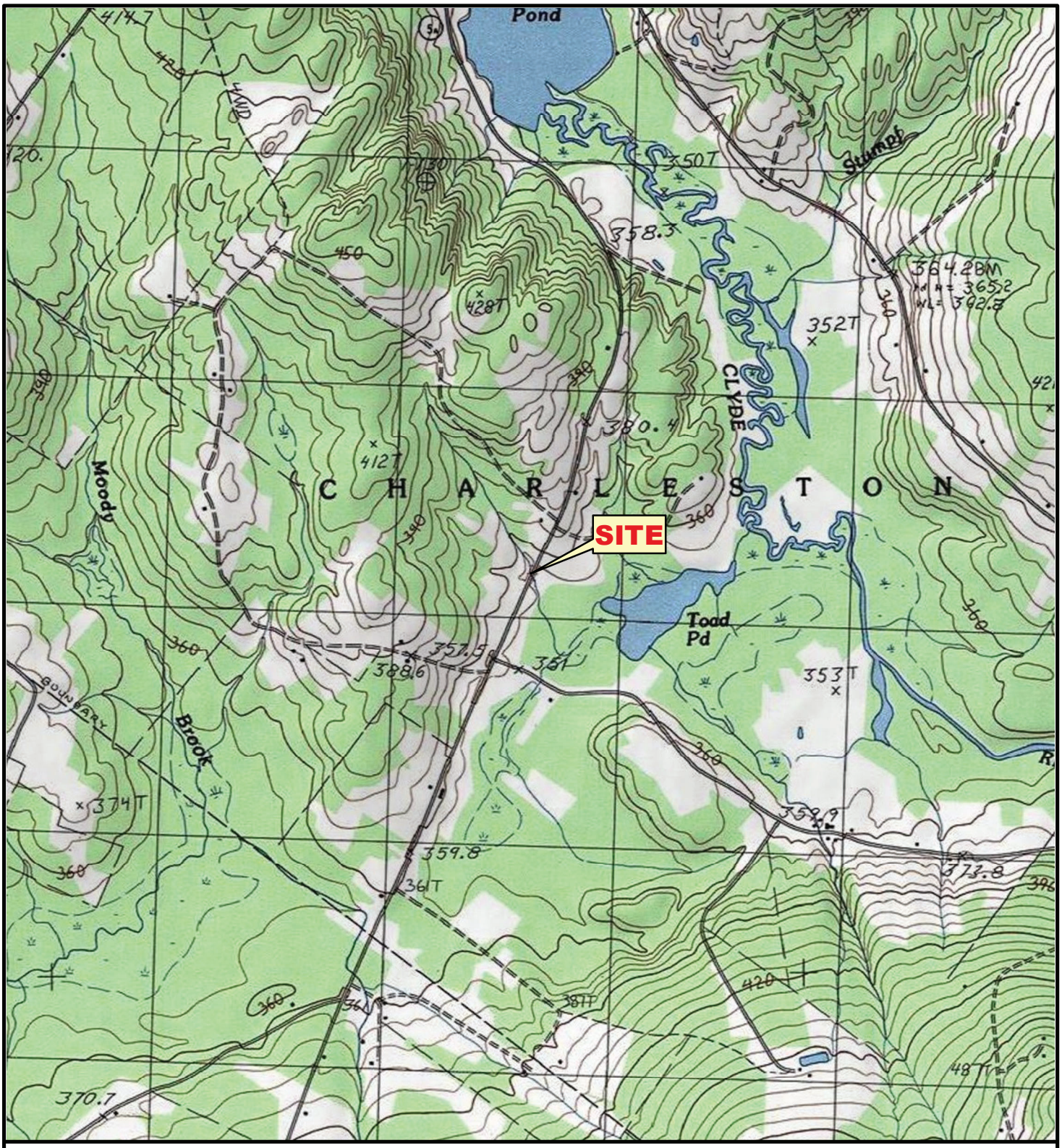
Table

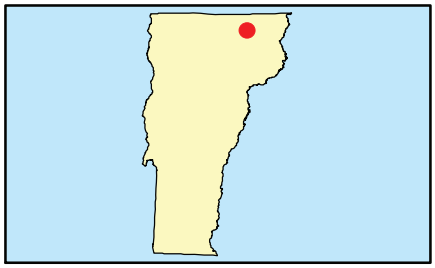
TABLE 1
SUMMARY OF GZA TEST BORINGS
Charleston STP Culv(113)
Charleston,Vermont

Boring Number	Boring Depth (ft)	Depth to Groundwater[1] (ft)	Approx. Thickness of Deposit (ft)					
			Asphalt	Topsoil	Silt	Sand	Clay & Silt	Glacial Till
B-101	20.0	3.9	NE	0.2	3.8	NE	8.5	>7.5
B-102	40.0	12.7	NE	0.2	NE	5.8	7.0	>27.0
B-103	42.0	12.9	0.5	NE	NE	11.5	11.5	>18.5

NOTES:
1. Refer to Appendix B for test boring logs.
2. Groundwater measurements recorded in the table were obtained during the drilling process and should not be considered stabilized.
3. "NE" indicates not encountered.
   ">" indicates the bottom of the deposit was not encountered within the boring.

Figures





SOURCE : USGS TOPOGRAPHIC QUADRANGLES SCANNED BY
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Data Supplied by : esri

0 1,000 2,000 4,000 6,000
SCALE IN FEET

N
W E
S

GZA

PROJ. MGR.: JRB
DESIGNED BY: JRB
REVIEWED BY: DGL
OPERATOR: KLS

DATE: 05-08-2024

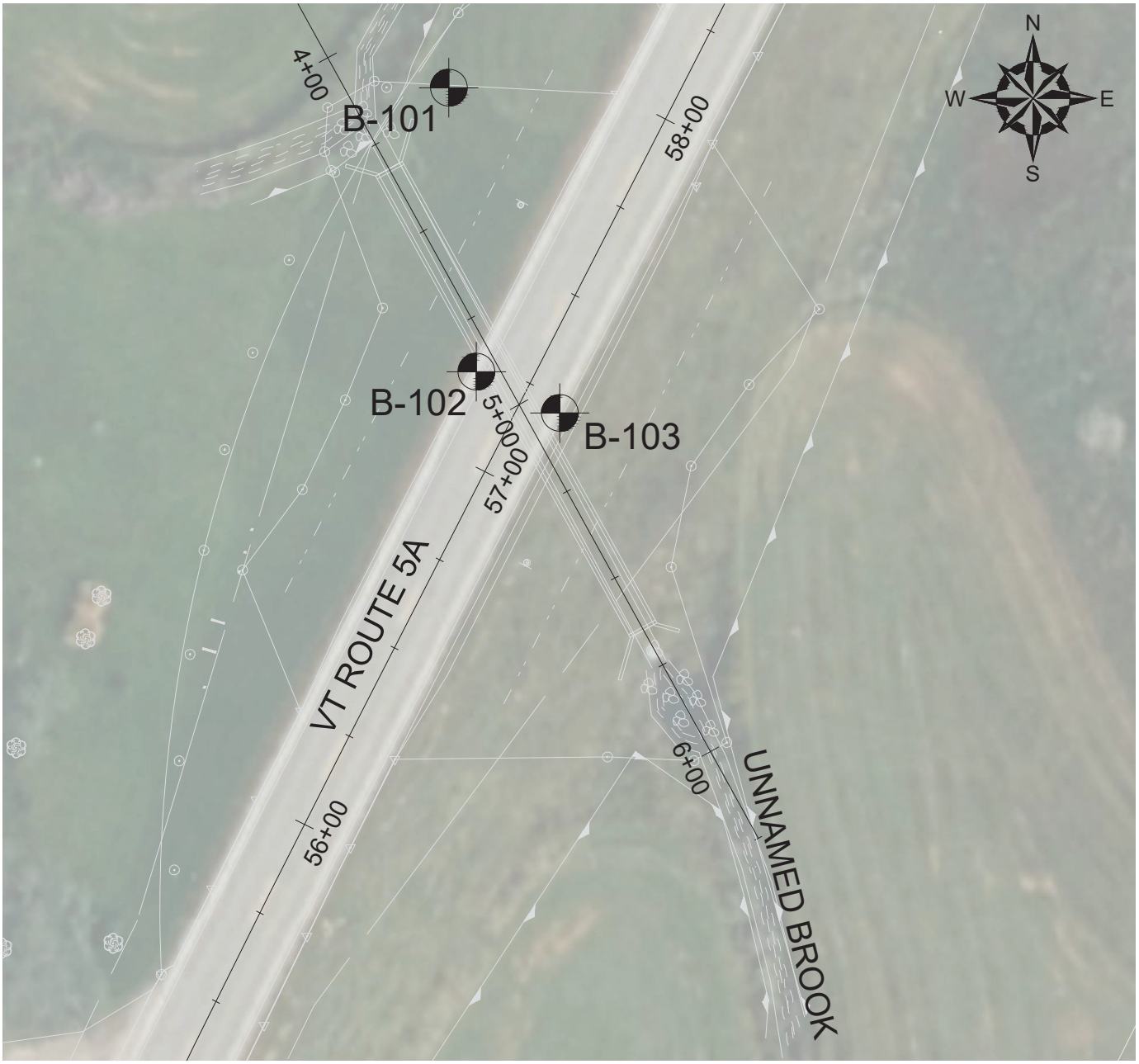
LOCUS PLAN

CHARLESTON STP CULV(113)
CHARLESTON, VERMONT

JOB NO.
04.0191154.21

FIGURE NO.
1

© 2024 - GZA GeoEnvironmental, Inc., \\GZABedford\Jobs\04Jobs\0191100s\04.0191154.00-Vtrans PS08451\04.0191154.21 - Charleston STP Culv(113)\Figures\GIS\MXD\FIG_1_LOCUS PLAN_04_0191154_21.mxd, 5/8/2024, 8:37:59 AM, automap



0 20' 40' 80'

SCALE IN FEET 1" = 40'

LEGEND

GZ-1 APPROXIMATE AS DRILLED LOCATION OF TEST BORING

NOTES:

1. BASE PLAN WAS DEVELOPED FROM A PDF FILE ENTITLED "PROPOSED IMPROVEMENT TOWN OF CHARLESTON COUNTY OF ORLEANS VT ROUTE 5A (MINOR ARTERIAL)" PREPARED BY THE STATE OF VERMONT AGENCY OF TRANSPORTATION DATED 05/31/2023.
2. GZA TEST BORINGS WERE DRILLED BY NEW ENGLAND BORING CONTRACTORS OF DERRY, NEW HAMPSHIRE BETWEEN MAY 20 AND 21, 2024 AND WERE OBSERVED BY GZA PERSONNEL.
3. LOCATIONS OF TEST BORINGS WERE DETERMINED VIA A HANDHELD GPS. THIS DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

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NO.	ISSUE/DESCRIPTION	BY	DATE

CHARLESTON STP CULV(113)
CHARLESTON, VERMONT

SUBSURFACE EXPLORATION
LOCATION PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
VERMONT AGENCY OF TRANSPORTATION

PROJ MGR: JRB	REVIEWED BY: DGL	CHECKED BY: DGL	FIGURE 2
DESIGNED BY: JRB	DRAWN BY: KLS	SCALE: 1:40	
DATE: JUNE 2024	PROJECT NO. 04.0191154.21	REVISION NO. -	SHEET NO. 1 OF 1

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GZA-P:\04Jobs\01911\00s\04.0191154.00-Vtrans PS08451\04.0191154.21 - Charleston STP Culv(113)\Figures\DRAFT Figure 2.dwg [FIGURE 2] June 20, 2024 - 11:05am Haley.Puntin

Appendix A – Limitations

GEOTECHNICAL LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in GZA's Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs.

5. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

6. Water level readings have been made in test holes (as described in the Report) at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

7. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.

8. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

Compliance with Codes and Regulations

9. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

Cost Estimates

10. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

11. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B – Test Boring Logs

STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Charleston STP Culv(113)
Bridge No. 15, VT Route 5A
Charleston, VT

Boring No.: **B101**
Page No.: 1 of 1
Pin No.: 22d243
Checked By: J. Baron

Boring Crew: W. Hockele, K. Stevenson (GZA)
Date Started: 5/21/24 Date Finished: 5/21/24
VTSPG NAD83: N 856677.30 ft E 1755510.05 ft
Station: 4+22.00 Offset: LT23
Ground Elevation: 1164.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	2 in
Hammer Wt:	300 lb	140 lb
Hammer Fall:	24 in	30 in
Hammer/Rod Type:	Auto/AWJ	
Rig: MOBILE B53 TRACK	C_E = 1.3	

Groundwater Observations

Date	Depth (ft)	Notes
05/21/24	3.9	Stab. time =0.5 hrs.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Visual Description, 2 inches of Topsoil, TOPSOIL					
		Visual Description, (Modified Burmister), S-1 (0.0 ft - 2.0 ft): Very loose, brown, SILT, some fine Sand (A-4). Moist, Rec. = 1.3 ft, SILT	1/24" (1)				
		Visual Description, (Modified Burmister), S-2 (2.0 ft - 4.0 ft): Very loose, brown, SILT, some fine to coarse Sand (A-4). Moist, Rec. = 1.1 ft, SILT	1/24" (1)				
5		Classification:, (Modified Burmister), S-3 (4.0 ft - 6.0 ft): Medium stiff, dark brown, CLAY & SILT, little fine Sand, trace Gravel (A-4). Wet, Rec. = 1.0 ft, CLAY & SILT	2-2-4-7 (6)		1.3	18.4	80.3
		Visual Description, (Modified Burmister), S-4 (6.0 ft - 8.0 ft): Medium stiff, brown to dark gray, Clayey SILT, some fine Sand (A-4). Wet, Rec. = 1.6 ft, CLAY & SILT	4-3-2-2 (5)				
		Visual Description, (Modified Burmister), S-5 (8.0 ft - 10.0 ft): Medium stiff, brown to dark gray, CLAY & SILT, little fine to medium Sand, trace Gravel (A-4). Moist to wet, Rec. = 1.7 ft, CLAY & SILT	2-2-2-15 (4)				
10		Visual Description, CLAY & SILT					
		Visual Description, GLACIAL TILL					
15		Classification:, (Modified Burmister), S-6 (14.0 ft - 16.0 ft): Very dense, dark brown, fine to medium SAND, some Silt & Clay, some Gravel (A-2-4)., Rec. = 1.4 ft, GLACIAL TILL	42-42-37-36 (79)		40.4	27.5	32.1
		Visual Description, GLACIAL TILL					
20		Visual Description, (Modified Burmister), S-7 (19.0 ft - 21.0 ft): Very dense, brown to gray, fine to medium SAND, little Silt, trace Gravel (A-2-4)., Rec. = 1.7 ft, GLACIAL TILL	15-30-70-70 (100)				
		Hole stopped @ 20.0 ft					
25							

Remarks:
1. Strata changes based on collected samples, cuttings, and drilling action.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Charleston STP Culv(113)
Bridge No. 15, VT Route 5A
Charleston, VT

Boring No.: **B102**
Page No.: 1 of 2
Pin No.: 22d243
Checked By: J. Baron

Boring Crew: W. Hockele, K. Stevenson (GZA)
Date Started: 5/21/24 Date Finished: 5/21/24
VTSPG NAD83: N 856606.51 ft E 1755516.54 ft
Station: 4+87.00 Offset: RT06
Ground Elevation: 1173.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	2 in
Hammer Wt:	300 lb	140 lb
Hammer Fall:	24 in	30 in
Hammer/Rod Type:	Auto/AWJ	
Rig: MOBILE B53 TRACK	C_E = 1.3	

Groundwater Observations

Date	Depth (ft)	Notes
05/21/24	9.7	Stab. time = 0.3 hrs
05/21/24	12.7	Stab. time = 0.5 hrs

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Visual Description, 2 inches of Topsoil, TOPSOIL					
		Classification:, (Modified Burmister), S-1 (0.0 ft - 2.0 ft): Medium dense, brown, fine to coarse SAND, some Gravel, little Silt (A-1-b). Moist, Rec. = 1.2 ft, SAND	3-6-5-5 (11)		34.6	49.1	16.3
		Visual Description, (Modified Burmister), S-2 (2.0 - 4.0 ft): Medium dense, brown, fine to coarse SAND, some Gravel, little Silt (A-1-b). Moist, Rec. = 0.9 ft, SAND	6-10-9-7 (19)				
5		Visual Description, (Modified Burmister), S-3 (4.0 - 6.0 ft): Medium dense, brown, fine to coarse SAND, some Gravel, little Silt (A-1-b). Moist, Rec. = 0.7 ft, SAND	18-10-13-8 (23)				
		Visual Description, (Modified Burmister), S-4 (6.0 ft - 8.0 ft): Stiff, brown, CLAY & SILT, some fine to coarse Sand, trace Gravel (A-4). Moist, Rec. = 1.1 ft, CLAY & SILT	10-5-4-4 (9)				
		Classification:, (Modified Burmister), S-5 (8.0 ft - 10.0 ft): Medium stiff, brown, CLAY & SILT, some fine to medium Sand, trace Gravel, trace wood (A-4). Moist to wet, Rec. = 1.1 ft, CLAY & SILT	2-4-2-2 (6)		13.0	32.5	54.5
10		Visual Description, CLAY & SILT					
		Visual Description, GLACIAL TILL					
		Visual Description, (Modified Burmister), S-6 (14.0 ft - 16.0 ft): No recovery, Rec. = 0.0 ft, GLACIAL TILL	45-23-9-6 (32)				
15		Visual Description, (Modified Burmister), S-7 (16.0 ft - 18.0 ft): Dense, brown, GRAVEL, some fine to coarse Sand, little Silt (A-1-b), Rec. = 0.5 ft, GLACIAL TILL	8-13-27-14 (40)				
		Visual Description, GLACIAL TILL					
		Visual Description, 18.5 ft - 19.5 ft, COBBLES					
20		Visual Description:, GLACIAL TILL					
		Visual Description, (Modified Burmister), S-8 (19.7 ft - 21.7 ft): Very dense, gray, GRAVEL, little fine to coarse Sand, little Clayey Silt (A-2-4), Rec. = 0.8 ft, GLACIAL TILL	13-25-50-50/5" (75)				
		Visual Description, 21.7 ft - 23.5 ft, COBBLES					
		Visual Description, GLACIAL TILL					
25		Visual Description, (Modified Burmister), S-9 (24.3 ft - 26.3 ft): Hard, brown to gray, Clayey SILT, little fine to coarse Sand, trace Gravel (A-4). Iron oxidation, Rec. = 1.5 ft, GLACIAL TILL	10-17-45-38 (62)				
		Visual Description, GLACIAL TILL					
		Visual Description, (Modified Burmister), S-10 (29.0 ft - 29.3 ft): Very dense, brown to gray, fine to coarse SAND, some Clayey Silt (A-2-4), Rec. = 0.2 ft, GLACIAL TILL	50/3" (R)				

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Charleston STP Culv(113)
Bridge No. 15, VT Route 5A
Charleston, VT

Boring No.: **B102**
Page No.: 2 of 2
Pin No.: 22d243
Checked By: J. Baron

Boring Crew: W. Hockele, K. Stevenson (GZA)
Date Started: 5/21/24 Date Finished: 5/21/24
VTSPG NAD83: N 856606.51 ft E 1755516.54 ft
Station: 4+87.00 Offset: RT06
Ground Elevation: 1173.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	2 in
Hammer Wt:	300 lb	140 lb
Hammer Fall:	24 in	30 in
Hammer/Rod Type:	Auto/AWJ	
Rig: MOBILE B53 TRACK	C_E = 1.3	

Groundwater Observations

Date	Depth (ft)	Notes
05/21/24	9.7	Stab. time = 0.3 hrs
05/21/24	12.7	Stab. time = 0.5 hrs

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Visual Description, GLACIAL TILL					
35		Visual Description, (Modified Burmister), S-11 (34.0 ft - 34.2 ft): Very dense, gray, SILT, little fine to coarse Sand (A-4), Rec. = 0.2 ft, GLACIAL TILL	100/2" (R)				
		Visual Description, GLACIAL TILL					
40		Visual Description, (Modified Burmister), S-12 (39.0 ft - 40.0 ft): Very dense, dark brown, fine to coarse SAND, some Silt, trace Gravel (A-2-4), Rec. = 0.8 ft, GLACIAL TILL	25-39-50/0" (R)				
		Hole stopped @ 40.0 ft					
45							
50							
55							

Remarks:
1. Initial groundwater reading measured prior to drive and wash method of drilling. Final groundwater reading measured after completion of boring.
2. Strata changes based on collected samples, cuttings, and drilling action.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Charleston STP Culv(113)
Bridge No. 15, VT Route 5A
Charleston, VT

Boring No.: **B103**
Page No.: 1 of 2
Pin No.: 22d243
Checked By: J. Baron

Boring Crew: W. Hockele, K. Stevenson (GZA)
Date Started: 5/20/24 Date Finished: 5/20/24
VTSPG NAD83: N 856595.75 ft E 1755538.31 ft
Station: 5+07.00 Offset: LT08
Ground Elevation: 1173.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	2 in
Hammer Wt:	300 lb	140 lb
Hammer Fall:	24 in	30 in
Hammer/Rod Type:	Auto/AWJ	
Rig: MOBILE B53 TRACK	C_E = 1.3	

Groundwater Observations

Date	Depth (ft)	Notes
05/20/24	12.9	Stab. time = 0.5 hrs.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Visual Description, 6 inches of asphalt pavement, ASPHALT					
		Visual Description, (Modified Burmister), S-1 (0.5 ft - 2.0 ft): Medium dense, brown, fine to coarse SAND, little Gravel, trace Silt (A-1-a). Moist, Rec. = 0.9 ft, SAND	6-8-8 (16)				
		Visual Description, (Modified Burmister), S-2 (2.0 ft - 4.0 ft): Loose, brown, fine to coarse SAND, little Silt, trace Gravel (A-1-b). Moist, Rec. = 0.9 ft, SAND	7-5-4-6 (9)				
5		Classification:, (Modified Burmister), S-3 (4.0 ft - 6.0 ft): Medium dense, brown, fine to medium SAND, some Silt, trace Gravel (A-2-4). Moist, Rec. = 0.5 ft, SAND	5-8-5-3 (13)		14.3	58.1	27.6
		Visual Description, (Modified Burmister), S-4 (6.0 - 8.0 ft): Medium dense, brown, fine to coarse SAND, little Silt (A-1-b). Moist, Rec. = 0.3 ft, SAND	5-7-3-3 (10)				
		Visual Description, (Modified Burmister), S-5 (8.0 ft - 10.0 ft): Medium dense, brown, fine to coarse SAND, little Clayey Silt, trace Gravel (A-2-4). Moist, Rec. = 0.9 ft, SAND	5-14-5-3 (19)				
10		Visual Description, SAND					
		Visual Description, SILT & CLAY					
		Classification:, (Modified Burmister), S-6 (14.0 ft - 16.0 ft): Soft, brown, SILT & CLAY and fine Sand, trace wood (A-4), Rec. = 1.3 ft, SILT & CLAY	8-2-2-2 (4)		0.9	47.7	51.4
15		Visual Description, SILT & CLAY					
		Visual Description, (Modified Burmister), S-7 (19.0 ft - 21.0 ft): Very stiff, brown to gray, SILT & CLAY, some fine to coarse Sand, trace Gravel (A-4), Rec. = 1.0 ft, SILT & CLAY	17-11-6-4 (17)				
20		Visual Description, SILT & CLAY					
		Visual Description, 23.5 ft - 24.0 ft, COBBLES					
		Visual Description, (Modified Burmister), S-8 (24.0 ft - 26.0 ft): No recovery, Rec. = 0.0 ft, GLACIAL TILL	50/0" (R)				
25		Visual Description, 26.0 ft - 28.0 ft, COBBLES					
		Visual Description, GLACIAL TILL					
		Visual Description, (Modified Burmister), S-9 (29.0 ft - 31.0 ft): Very dense, brown to gray, fine to coarse SAND, some Clayey Silt, trace Gravel (A-2-4), Rec. = 1.6 ft, GLACIAL TILL	32-42-41-42				

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
CONSTRUCTION AND
MATERIALS BUREAU
CENTRAL LABORATORY

BORING LOG

Charleston STP Culv(113)
Bridge No. 15, VT Route 5A
Charleston, VT

Boring No.: **B103**
Page No.: 2 of 2
Pin No.: 22d243
Checked By: J. Baron

Boring Crew: W. Hockele, K. Stevenson (GZA)
Date Started: 5/20/24 Date Finished: 5/20/24
VTSPG NAD83: N 856595.75 ft E 1755538.31 ft
Station: 5+07.00 Offset: LT08
Ground Elevation: 1173.0 ft

	Casing	Sampler
Type:	WASH BORE	SS
I.D.:	3 in	2 in
Hammer Wt:	300 lb	140 lb
Hammer Fall:	24 in	30 in
Hammer/Rod Type:	Auto/AWJ	
Rig: MOBILE B53 TRACK	C_E = 1.3	

Groundwater Observations

Date	Depth (ft)	Notes
05/20/24	12.9	Stab. time = 0.5 hrs.

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %
		Visual Description, GLACIAL TILL	(83)				
35		Visual Description, (Modified Burmister), S-10 (34.0 ft - 35.4 ft): Very dense, gray, fine to coarse SAND, some Clayey Silt, trace Gravel (A-2-4), Rec. = 1.4 ft, GLACIAL TILL	42-48-50/5" (R)				
		Visual Description, GLACIAL TILL					
		Visual Description, 38.5 ft - 41.0 ft, COBBLES					
40		Visual Description, (Modified Burmister), S-11 (39.0 ft - 39.1 ft): No recovery, Rec. = 0.0 ft, COBBLES	50/1" (R)				
		Visual Description, GLACIAL TILL					
		Hole stopped @ 42.0 ft					
45		Remarks: 1. Strata changes based on collected samples, cuttings, and drilling action.					
50							
55							

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

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Appendix C – Laboratory Test Results

Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:
GZA GeoEnvironmental, Inc.
Bedford, NH
Project Manager: Jen Baron
Assigned By: Jen Baron
Collected By: Keely Stevenson

Project Information:
Charleston STP Culv(113)
Charleston, VT
Project Number: 04.0191154.21
Summary Page: 1 of 1
Report Date: 05.31.24

LABORATORY TESTING DATA SHEET, Report No.: 24E222

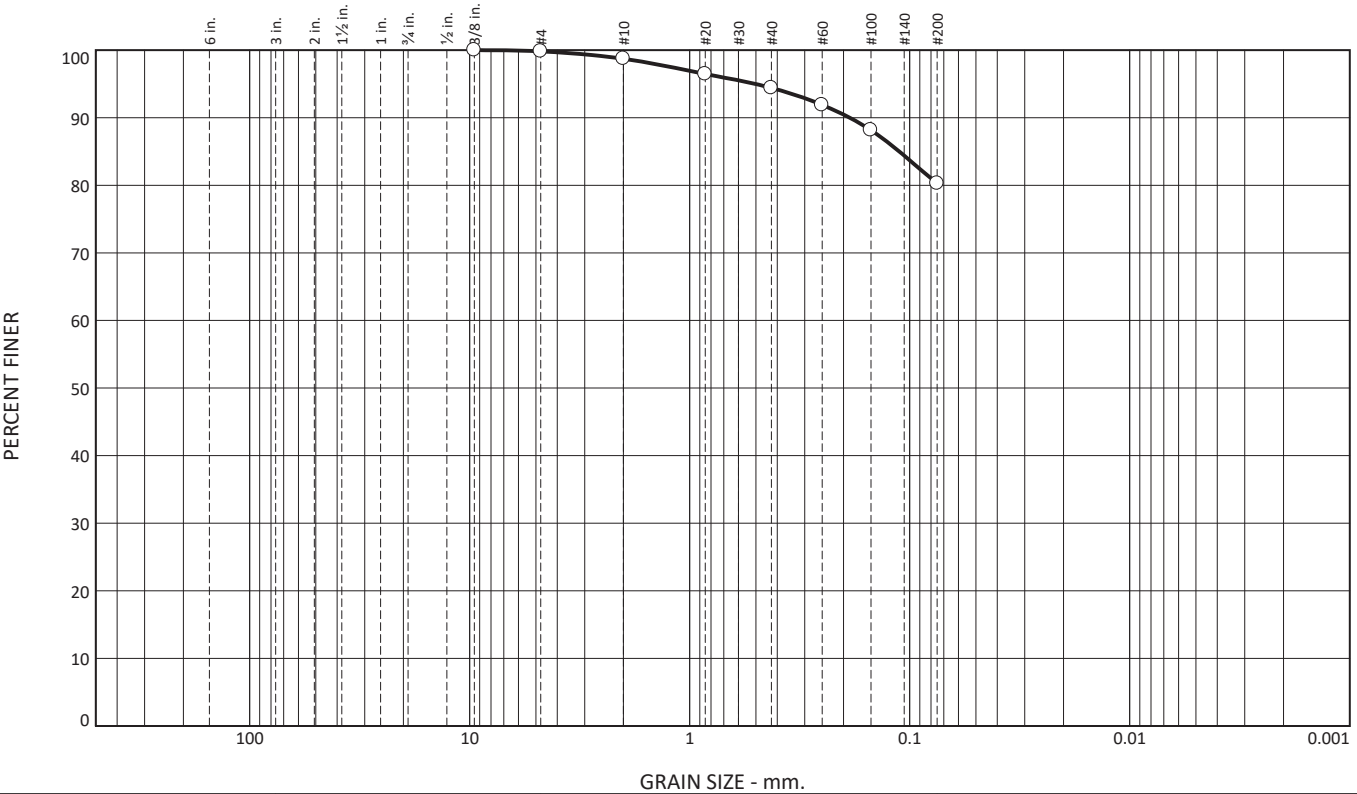
Boring No.	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Proctor / Thermal Resistivity							Laboratory Log and Soil Description
				As Rcvd Water Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	g_d MAX (pcf) W_{opt} (%)	g_d MAX (pcf) W_{opt} (%) (Corr.)	Dry unit wt. (pcf)	Test Water Content %	Target Test Setup as % of Proctor	Thermal Resistivity Optimum (°C*cm/W)	Thermal Resistivity Oven Dried (°C*cm/W)	
				D2216	D4318		D6913			D2974	D854	D1557					D5334		
B101	S-4	4-6	24-S-2021				0.2	19.5	80.3										Dark Brown CLAY & SILT, little fine Sand, trace fine Gravel
B101	S-6	14-16	24-S-2022				31.5	36.4	32.1										Dark Brown f-m SAND, some Silt & Clay, some f-c Gravel
B102	S-1	0-2	24-S-2023				24.3	59.4	16.3										Brown f-c SAND, some f-c Gravel, little Silt
B102	S-5	8-10	24-S-2024				9.3	36.2	54.5										Brown CLAY & SILT, some f-m Sand, trace fine Gravel
B103	S-3	4-6	24-S-2025				6.0	66.4	27.6										Brown f-m SAND, some Silt, trace fine Gravel
B103	S-6	14-16	24-S-2026				0.0	48.6	51.4										Brown SILT & CLAY and fine SAND

Date Received: **05.24.24** Reviewed By: Date Reviewed: **06.03.24**

This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.
This report shall not be reporduced, except in full, without prior written approval from the Agency, as defined in ASTM E329.

Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.2	1.1	4.3	14.1	80.3	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
3/8"	100.0			
#4	99.8			
#10	98.7			
#20	96.5			
#40	94.4			
#60	91.9			
#100	88.2			
#200	80.3			

* (no specification provided)

Material Description

Dark Brown CLAY & SILT, little fine Sand, trace fine Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.1876 D_{85}= 0.1117 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Test Remarks

Sample visually classified as plastic. Sample rolled below 1/8".

Source of Sample: Boring **Depth:** 4-6'
Sample Number: B101 / S-4 **Sample Date:** 05.30.24

Thielsch Engineering Inc.

Cranston, RI

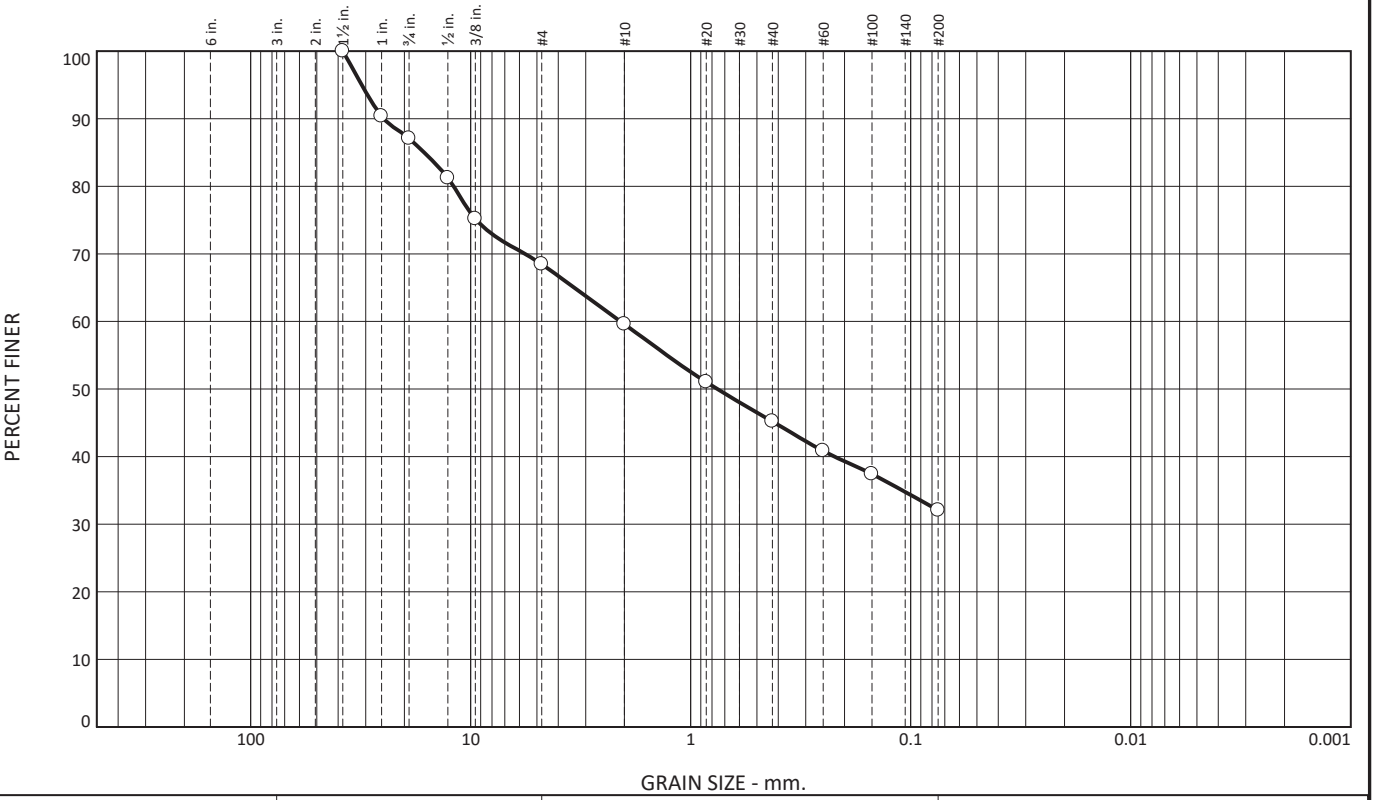
Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2021

Tested By: MCS **Checked By:** Andrew Vanasse

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	12.9	18.6	8.9	14.4	13.1	32.1	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
1 1/2"	100.0			
1"	90.4			
3/4"	87.1			
1/2"	81.2			
3/8"	75.2			
#4	68.5			
#10	59.6			
#20	51.0			
#40	45.2			
#60	40.8			
#100	37.4			
#200	32.1			

* (no specification provided)

Material Description

Dark Brown f-m SAND, some Silt & Clay, some f-c Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 24.8408 D_{85}= 16.2629 D_{60}= 2.0840
D_{50}= 0.7584 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

Test Remarks

Sample visually classified as plastic. Sample rolled to 1/8".

Source of Sample: Boring **Depth:** 14-16'
Sample Number: B101 / S-6 **Sample Date:** 05.30.24

Thielsch Engineering Inc.

Cranston, RI

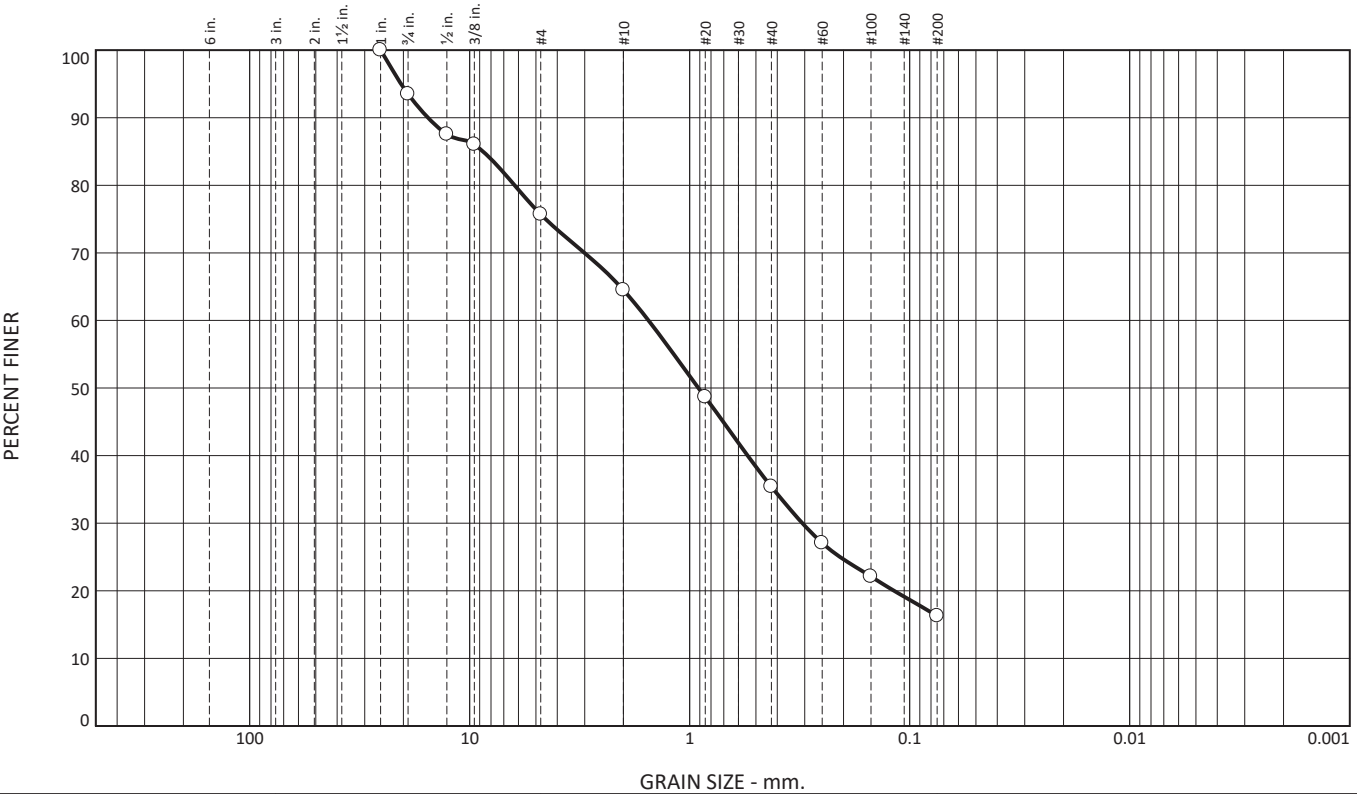
Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2022

Tested By: MCS **Checked By:** Andrew Vanasse

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.5	17.8	11.2	29.1	19.1	16.3	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
1"	100.0			
3/4"	93.5			
1/2"	87.5			
3/8"	86.0			
#4	75.7			
#10	64.5			
#20	48.7			
#40	35.4			
#60	27.1			
#100	22.1			
#200	16.3			

* (no specification provided)

Material Description

Brown f-c SAND, some f-c Gravel, little Silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 15.4827 D_{85}= 8.6845 D_{60}= 1.5375
D_{50}= 0.9126 D_{30}= 0.3075 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Test Remarks

Source of Sample: Boring **Depth:** 0-2'
Sample Number: B102 / S-1 **Sample Date:** 05.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2023

Tested By: MCS / SL **Checked By:** Andrew Vanasse

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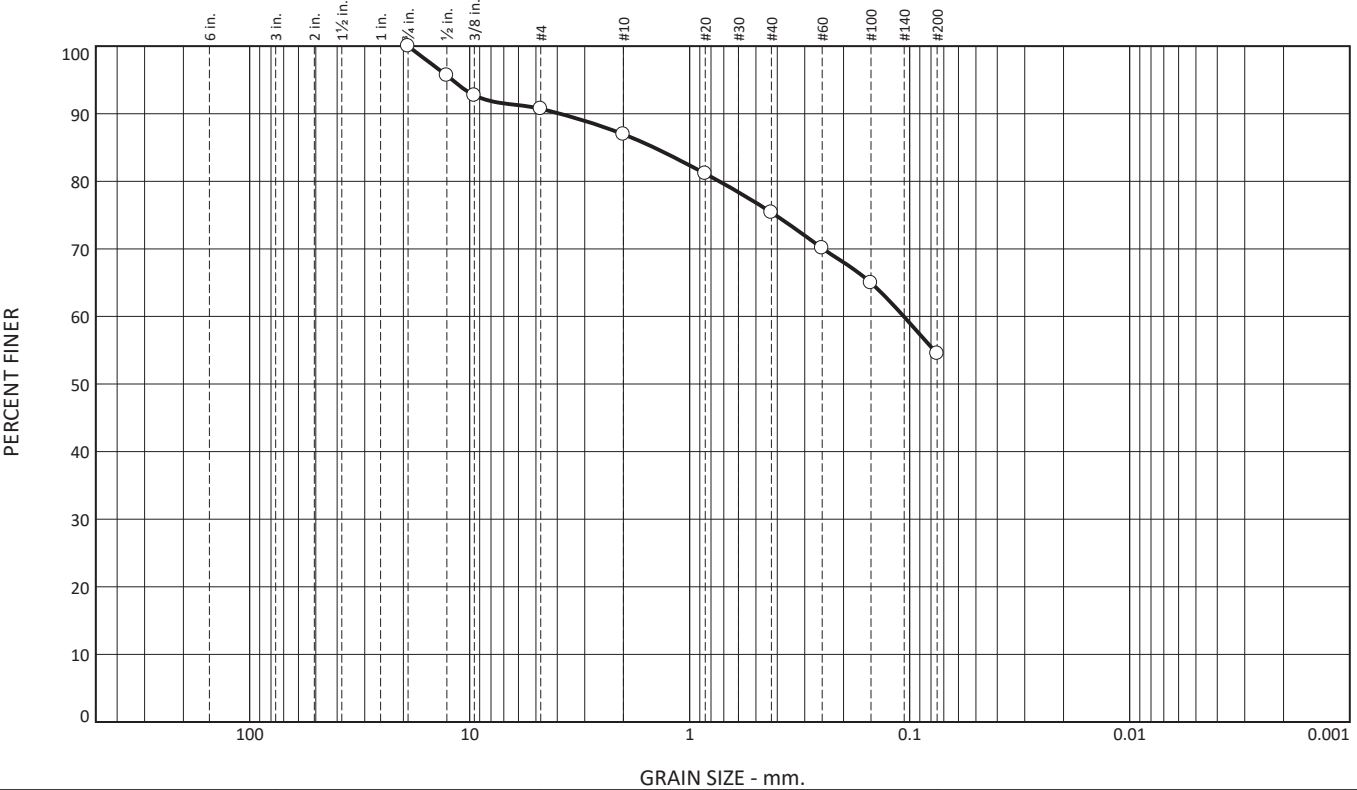
Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.3	3.7	11.6	20.9	54.5	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
3/4"	100.0			
1/2"	95.7			
3/8"	92.7			
#4	90.7			
#10	87.0			
#20	81.1			
#40	75.4			
#60	70.1			
#100	65.0			
#200	54.5			

* (no specification provided)

Material Description

Brown CLAY & SILT, some f-m Sand, trace fine Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 3.9069 D_{85}= 1.4555 D_{60}= 0.1064
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Test Remarks

Sample visually classified as plastic. Sample rolled below 1/8".

Source of Sample: Boring **Depth:** 8-10'
Sample Number: B102 / S-5 **Sample Date:** 05.31.24

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2024

Tested By: MCS / SL **Checked By:** Andrew Vanasse

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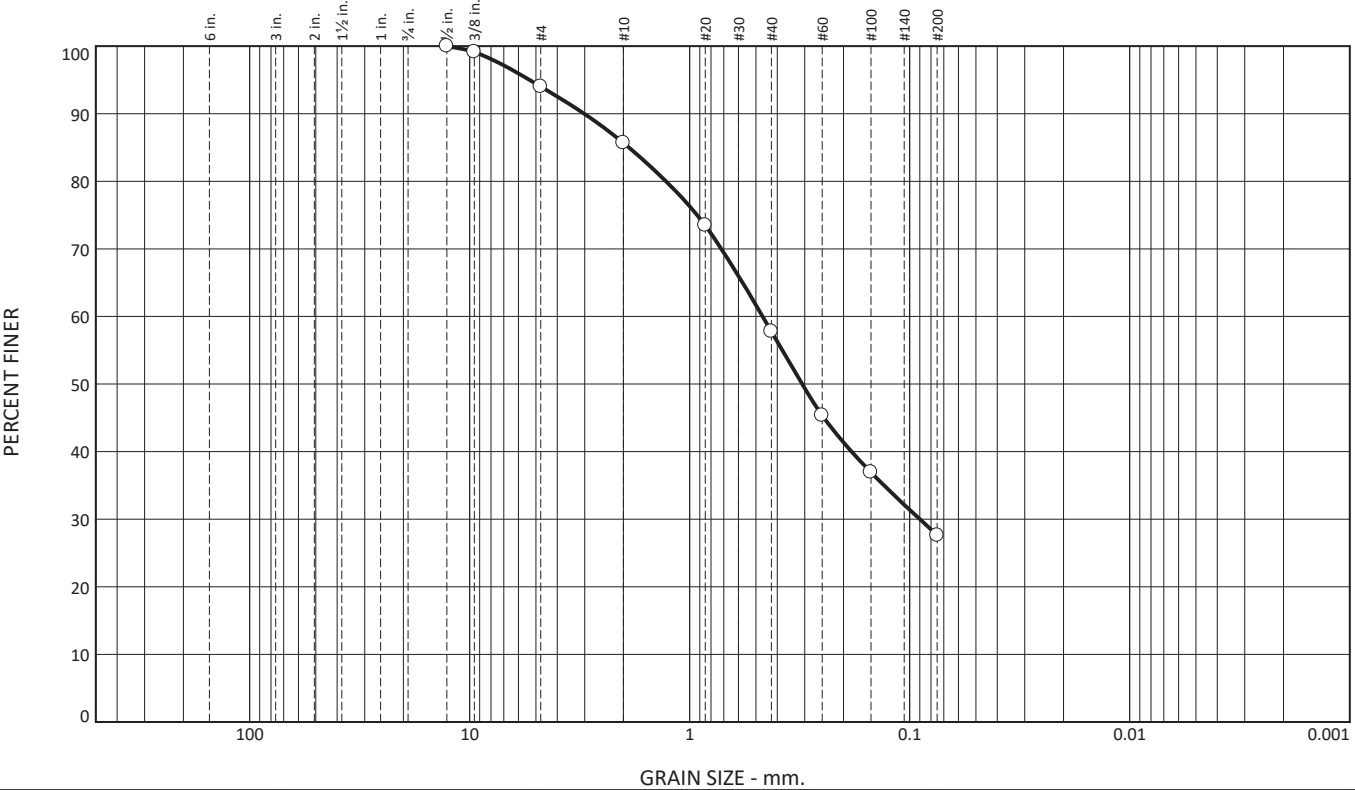
Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	6.0	8.3	27.9	30.2	27.6	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
1/2"	100.0			
3/8"	99.1			
#4	94.0			
#10	85.7			
#20	73.5			
#40	57.8			
#60	45.3			
#100	37.0			
#200	27.6			

* (no specification provided)

Material Description

Brown f-m SAND, some Silt, trace fine Gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 3.0151 D_{85}= 1.8923 D_{60}= 0.4670
D_{50}= 0.3081 D_{30}= 0.0899 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

Test Remarks

Source of Sample: Boring **Depth:** 4-6'
Sample Number: B103 / S-3 **Sample Date:** 05.31.24

Thielsch Engineering Inc.

Cranston, RI

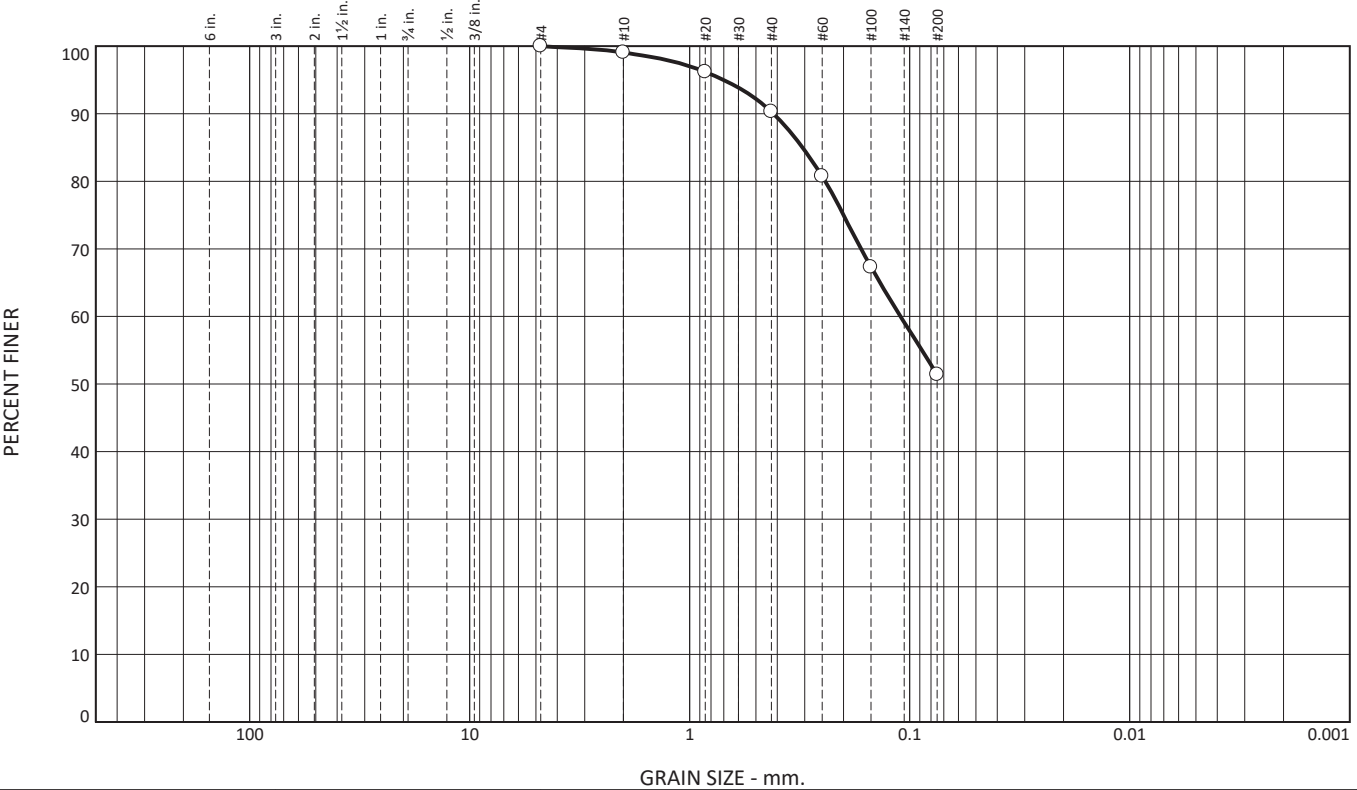
Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2025

Tested By: MCS / SL **Checked By:** Andrew Vanasse

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report

ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.9	8.8	38.9	51.4	

Test Results (ASTM D6913)

Sieve Size or Diam. (mm.)	Finer (%)	Spec.* (%)	Out of Spec. (%)	Pct. of Fines
#4	100.0			
#10	99.1			
#20	96.2			
#40	90.3			
#60	80.7			
#100	67.3			
#200	51.4			

* (no specification provided)

Material Description

Brown SILT & CLAY and fine SAND

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.4162 D_{85}= 0.3072 D_{60}= 0.1099
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Test Remarks

Sample visually classified as plastic. Sample rolled to 1/8".

Source of Sample: Boring **Depth:** 14-16'
Sample Number: B103 / S-6 **Sample Date:** 05.31.24

Thielsch Engineering Inc.

Cranston, RI

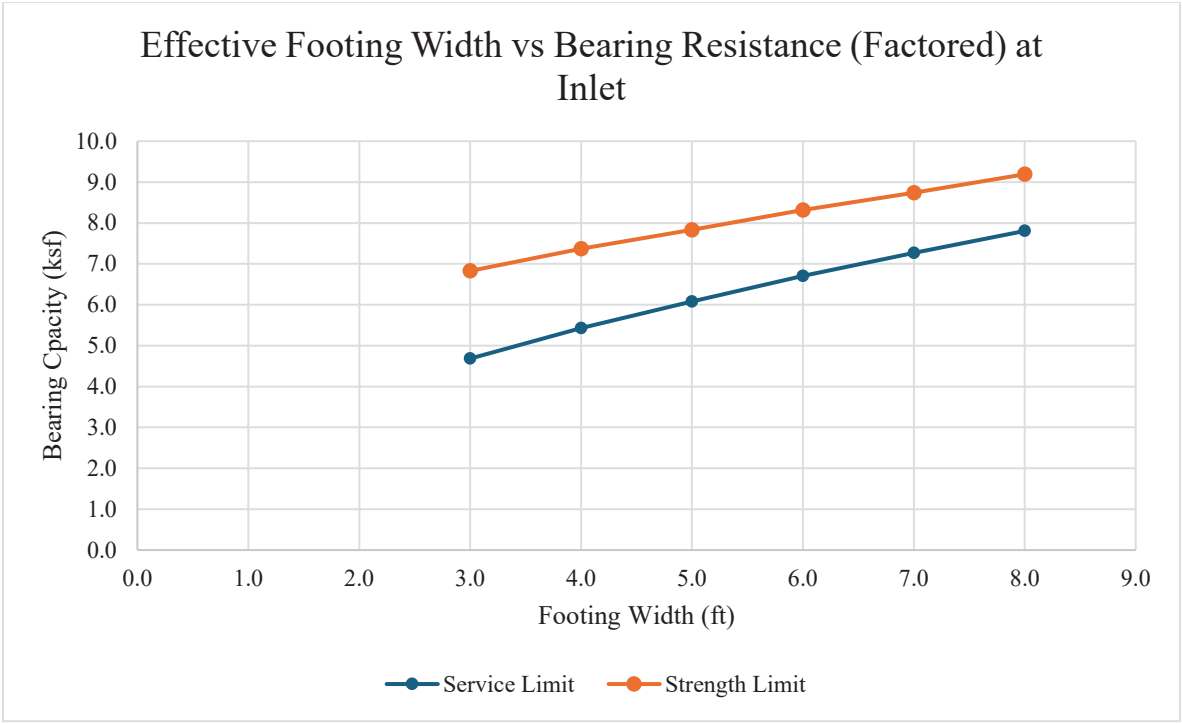
Client: GZA GeoEnvironmental, Inc.
Project: Charleston STP Culv(113)
Charleston, VT
Project No: 04.0191154.21 **Figure** 24-S-2026

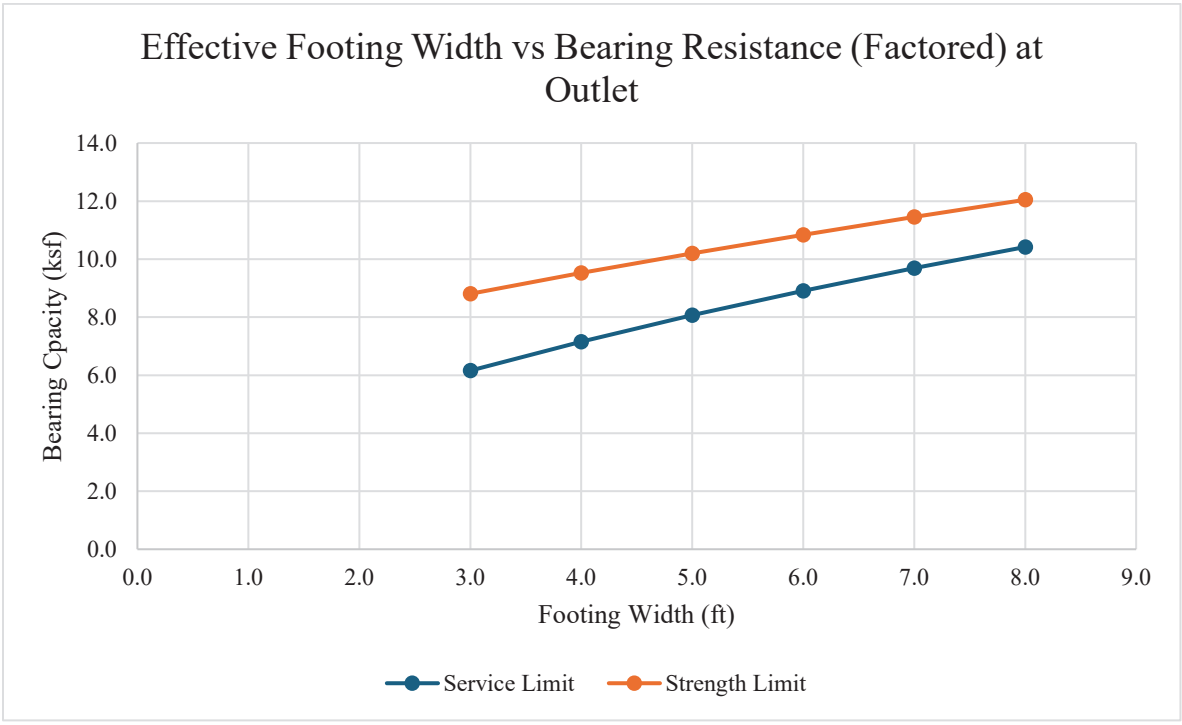
Tested By: MCS / SL **Checked By:** Andrew Vanasse

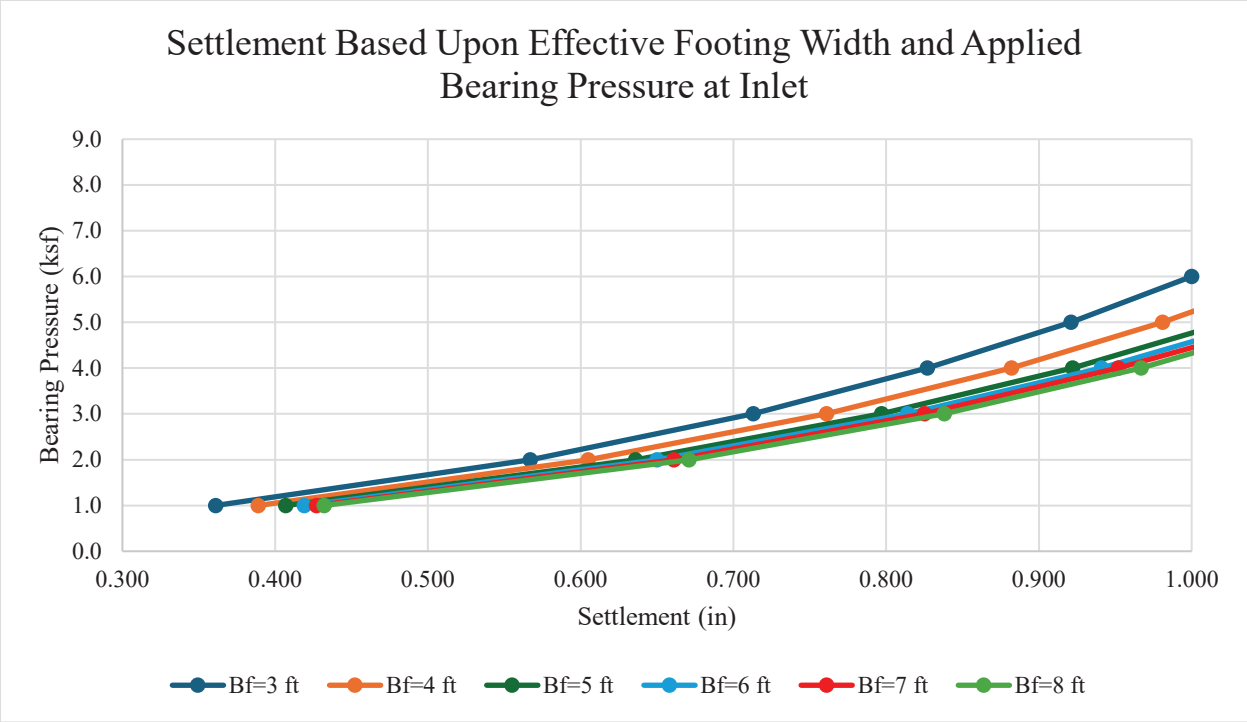
These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

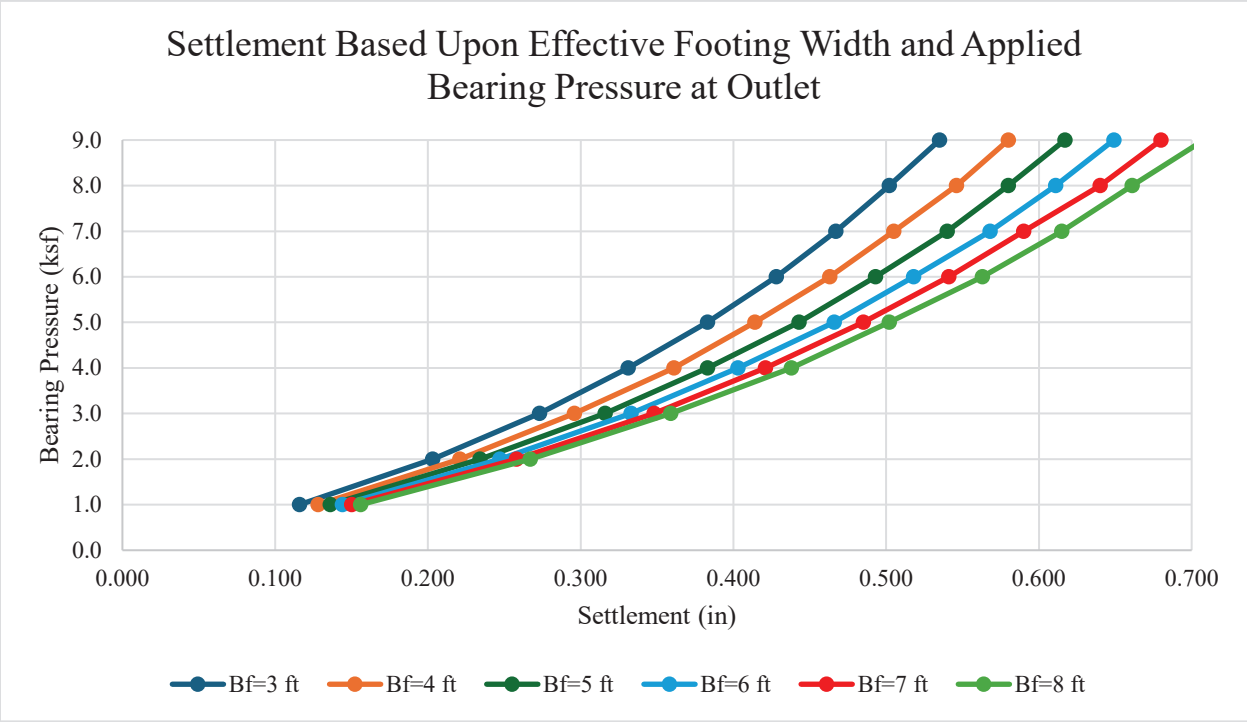
Appendix B

Bearing Resistance and Settlement Graphs


Effective Footing Width vs Bearing Resistance (Factored) at Inlet
Bearing Cpacity (ksf)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Footing Width (ft)
Service Limit
Strength Limit


Effective Footing Width vs Bearing Resistance (Factored) at Outlet
Bearing Cpacity (ksf)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Footing Width (ft)
Service Limit
Strength Limit

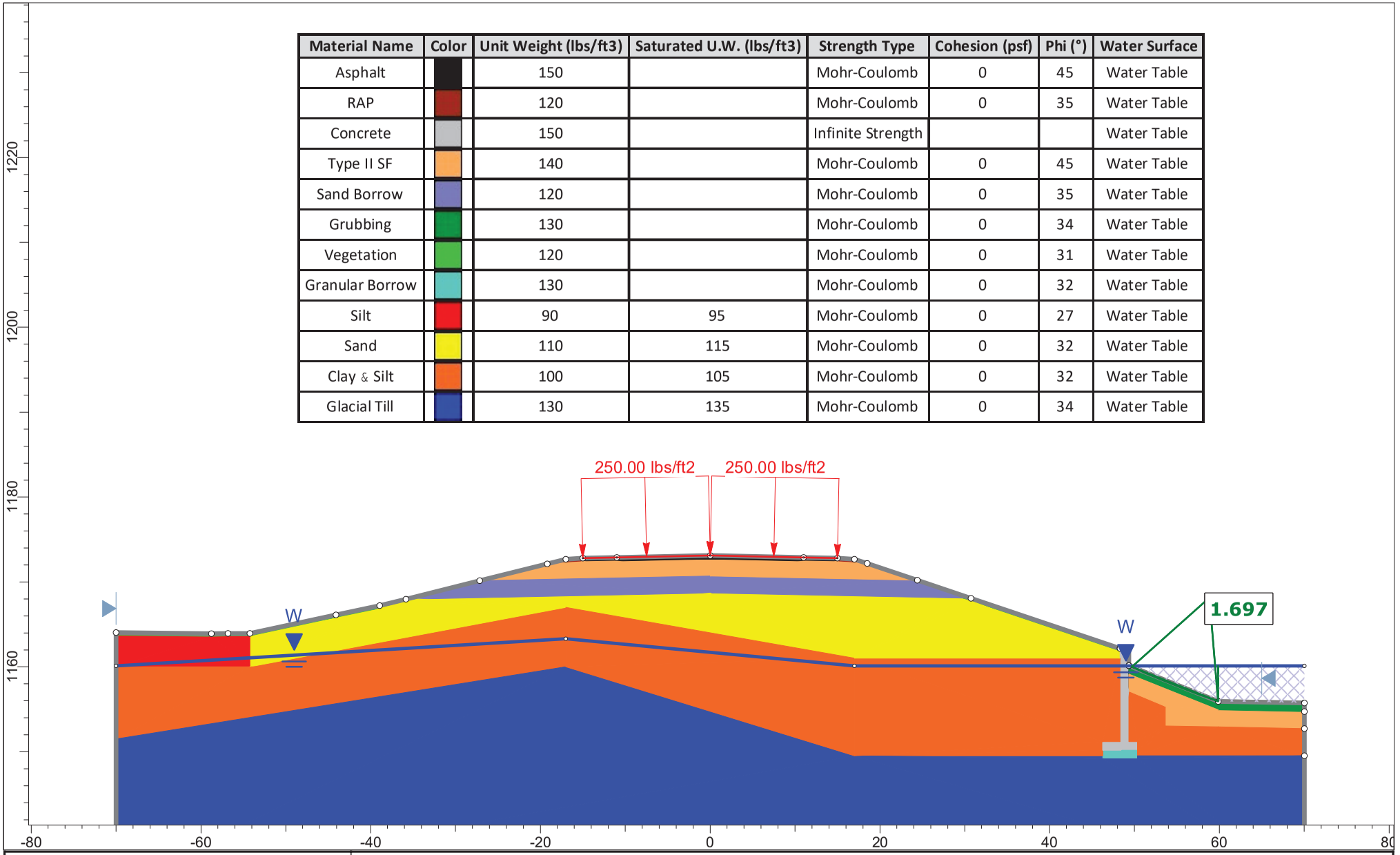

Settlement Based Upon Effective Footing Width and Applied Bearing Pressure at Inlet
Bearing Pressure (ksf)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
Settlement (in)
Bf=3 ft
Bf=4 ft
Bf=5 ft
Bf=6 ft
Bf=7 ft
Bf=8 ft


Settlement Based Upon Effective Footing Width and Applied Bearing Pressure at Outlet
Bearing Pressure (ksf)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
Settlement (in)
Bf=3 ft
Bf=4 ft
Bf=5 ft
Bf=6 ft
Bf=7 ft
Bf=8 ft

Appendix C

Slope Stability Outputs

Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Water Surface
Asphalt		150		Mohr-Coulomb	0	45	Water Table
RAP		120		Mohr-Coulomb	0	35	Water Table
Concrete		150		Infinite Strength			Water Table
Type II SF		140		Mohr-Coulomb	0	45	Water Table
Sand Borrow		120		Mohr-Coulomb	0	35	Water Table
Grubbing		130		Mohr-Coulomb	0	34	Water Table
Vegetation		120		Mohr-Coulomb	0	31	Water Table
Granular Borrow		130		Mohr-Coulomb	0	32	Water Table
Silt		90	95	Mohr-Coulomb	0	27	Water Table
Sand		110	115	Mohr-Coulomb	0	32	Water Table
Clay & Silt		100	105	Mohr-Coulomb	0	32	Water Table
Glacial Till		130	135	Mohr-Coulomb	0	34	Water Table

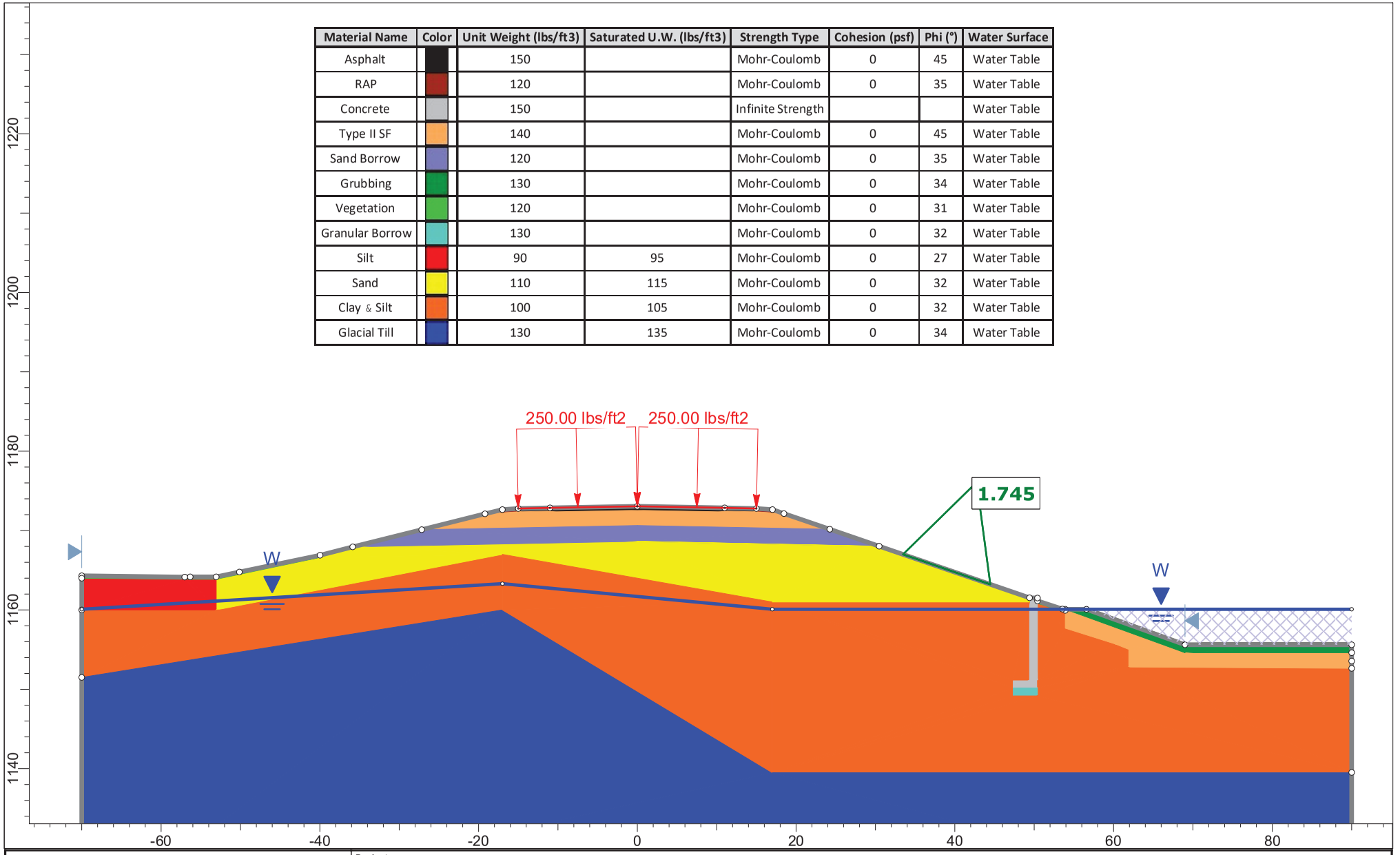


ROCSCIENCE

SLIDEINTERPRET 9.044

Project	Charleston STP CULV (113)			
Analysis Description	STA 56+75 Wingwall 3 GS Analysis			
Drawn By	JJZ	Scale	1:187	Company: VTrans Geotechnical Engineering Section
Date	9/23/2026, 11:02:53 AM			File Name: WW3 56+75.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Water Surface
Asphalt		150		Mohr-Coulomb	0	45	Water Table
RAP		120		Mohr-Coulomb	0	35	Water Table
Concrete		150		Infinite Strength			Water Table
Type II SF		140		Mohr-Coulomb	0	45	Water Table
Sand Borrow		120		Mohr-Coulomb	0	35	Water Table
Grubbing		130		Mohr-Coulomb	0	34	Water Table
Vegetation		120		Mohr-Coulomb	0	31	Water Table
Granular Borrow		130		Mohr-Coulomb	0	32	Water Table
Silt		90	95	Mohr-Coulomb	0	27	Water Table
Sand		110	115	Mohr-Coulomb	0	32	Water Table
Clay & Silt		100	105	Mohr-Coulomb	0	32	Water Table
Glacial Till		130	135	Mohr-Coulomb	0	34	Water Table



ROCSCIENCE

SLIDEINTERPRET 9.044

Project	Charleston STP CULV (113)			
Analysis Description	STA 56+69.10 Wingwall 4 GS Analysis			
Drawn By	JJZ	Scale	1:200	Company VTrans Geotechnical Engineering Section
Date	9/22/2026, 7:48:06 AM			File Name WW4.slmd