S-29-292 (South Plantation Road) Bridge Replacement over Bear Creek

Lancaster County, SC

Geotechnical Subsurface Data Report

August 18, 2023 | SCDOT Project ID: P041170
Terracon Project No.: 7323P100

Prepared for:

HNTB Corporation
343 E. Six Forks Road, Suite 200
Raleigh, NC 27609

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August 18, 2023

HNTB Corporation
343 E. Forks Road, Suite 200
Raleigh, NC 27609

Attn: Mr. Spencer Franklin, PE, Senior Vice President
P: 919-546-8997

Re: Geotechnical Subsurface Data Report
S-29-292 Bridge Replacement over Bear Creek
Lancaster County, South Carolina
SCDOT Project ID.: P041170
Terracon Project No.: 7323P100

Dear Mr. Franklin:

Terracon Consultants Inc. (Terracon) has completed the exploration, testing and limited engineering analysis services (contained in the geotechnical baseline report) for the above referenced project. The services were conducted in general accordance with our Task Order Number 001, dated May 25, 2023.

Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, and laboratory testing for the replacement of the S-29-292 bridge over Bear Creek in Lancaster County, South Carolina. The proposed bridge intends to replace the existing one. This GSDR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and Preconstruction Design Memorandum (PCDM) 11 - Supplemental Design Criteria for Low Volume Bridge Replacement Projects.

Project Description

The project site is located at the S-29-292 (S. Plantation Road) crossing over Bear Creek in Lancaster County, South Carolina. Site location and exploration plans are presented in Appendix A of this report. Based on the conceptual plans by HNTB dated 6/23/2023, the replacement bridge will be constructed on essentially the same alignment as the current bridge. The existing bridge is a multi-span structure supported by deep foundations. The

conceptual plans show that the replacement bridge will also be a multi-span structure supported by deep foundations.

Geotechnical Testing

The geotechnical exploration for this project was performed between June 5 and June 28, 2023. The results of our field work and our associated laboratory testing are included in Appendices A and B.

Field Exploration

Our field exploration consisted of the following:

- Three (3) Standard Penetration Test (SPT) Borings (S-29-292-1, S-29-292-2, and S-29-292-3)
- One (1) offset boring near S-13-292-2 for bulk sample collection
- One (1) Downhole Shear Wave Velocity Test (DHT-1) located in Boring S-29-292-1
- Two (2) Cone Penetration Test soundings (S-29-292-1C and S-29-292-2C)

The tests were performed at the approximate locations as approved by SCDOT. A description of our testing methods and graphical logs outlining the soil conditions at each test location are presented in Appendix A. The test locations were established in the field by Terracon and surveyed by Construction Support Services, LLC after completion.

Laboratory Testing

The following laboratory tests were performed on the soil samples collected at the site.

- Eleven (11) Natural Moisture Content Tests
- Seven (7) Atterberg Limits Tests
- Seven (7) Fines Content Tests
- Five (5) Grain Size Tests with Hydrometer
- One (1) Remolded, Consolidated-Undrained (CU) Triaxial Compression Test with Pore Pressure Readings
- One (1) Standard Proctor Test
- One (1) Corrosivity Suite (pH, chloride content, sulfate content, and resistivity tests)

The general scope of the laboratory testing frequency was determined by the SCDOT. The laboratory testing assignment was performed by our engineers. The laboratory procedures and results of the laboratory tests are presented in Appendix B.

Closure

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Phillip A. Morrison, P.E.
Senior Engineer
SC Registration No. 17275

Abdul Q. Fekrat, PhD, P.E.
Project Engineer
SC Registration No. 38531

Reviewed by Terracon's Authorized Project Reviewer: David J. Corley, P.E.

SOUTH CAROLINA REGISTERED PROFESSIONAL ENGINEER 8/18/2023 No. 17275 PHILLIP A. MORRISON

SOUTH CAROLINA TERRACON CONSULTANTS, INC. No. 2220 CERTIFICATE OF AUTHORIZATION

Appendix A
Field Exploration

Exhibit A-1 – Site Location Map
Exhibit A-2 – Exploration Plan
Exhibit A-3 – Summary of Boring Data
Exhibit A-4 – GeoScoping Form (2 Pages)
Exhibit A-5 – Field Exploration Description (3 Pages)
Exhibit A-6 – Soil/Rock Description Terms (2 Pages)
Exhibit A-7 – Soil/Rock Symbols
Exhibit A-8 – Boring Logs (4 Pages)
Exhibit A-9 – CPT Sounding Logs (2 Pages)
Exhibit A-10 – Geophysical Testing Results
Exhibit A-11 – Grout Logs (4 Pages)
Exhibit A-12 – Rock Core Photograph Logs (4 pages)

Note: All exhibits are one page unless noted above.

Site Location Map – Exhibit A-1
S-29-292 BRO Bear Creek | Lancaster County, SC
Terracon Project No. 7323P100

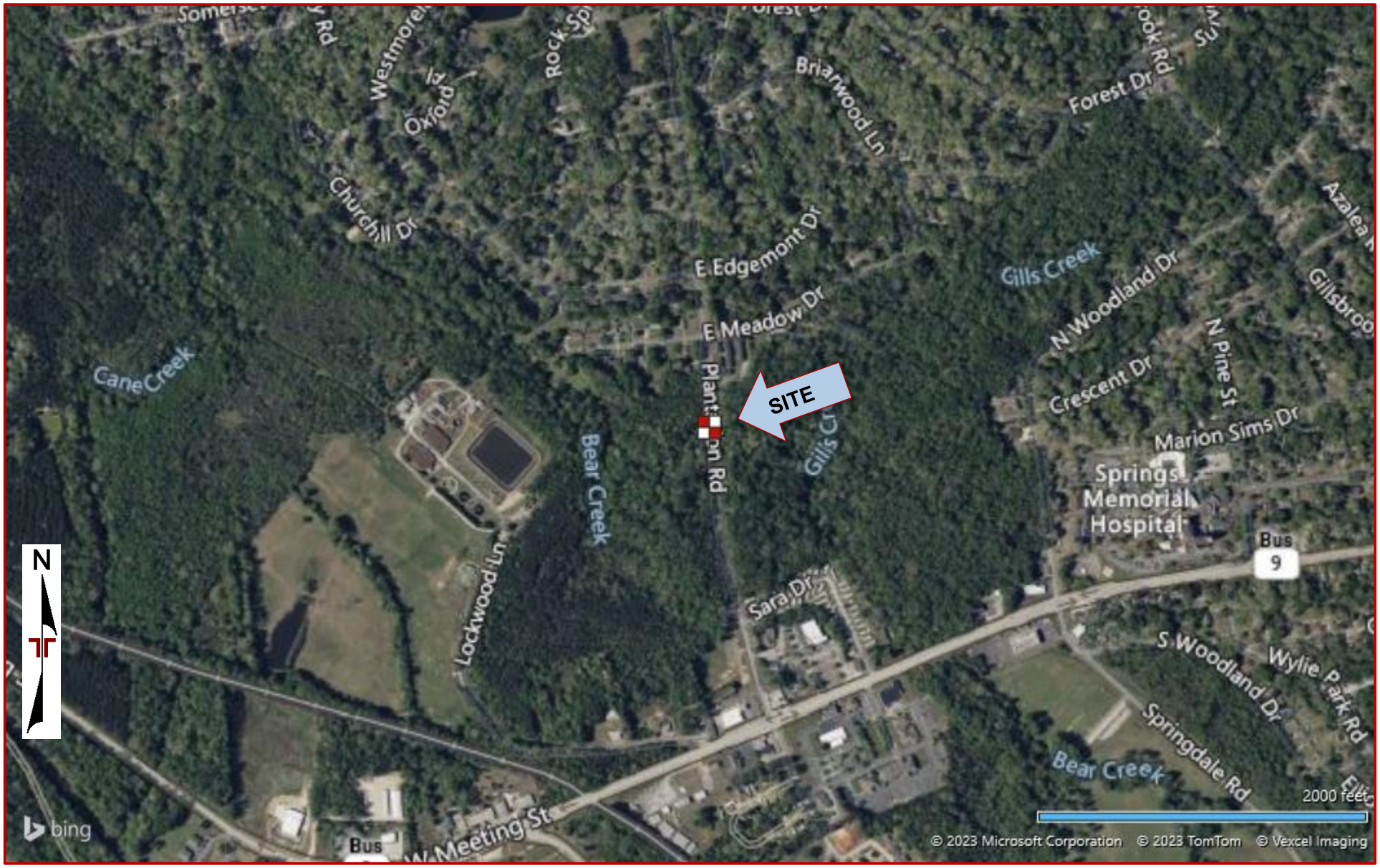


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: HORNSBORO, SC (1/1/1983) and MT CROGHAN, NC (1/1/1983).

Exploration Plan – Exhibit A-2
S-29-292 BRO Bear Creek | Lancaster County, SC
Terracon Project No. 7323P100

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Summary of Boring Data

Boring No.	Ground Elevation ft.	Test Depth ft.	Northing	Easting	Latitude	Longitude	Station	Offset
S-29-292-1	436.7	44.7	1050231.62	2060929.40	34.719628	-80.797245	19+49.76	5.90 L
S-29-292-2	435.8	68.2	1050036.90	2060940.66	34.719093	-80.797209	17+54.72	5.33 L
S-29-292-3	439.2	46.0	1050139.33	2060934.82	34.719374	-80.797228	18+57.31	5.55 L
S-29-292-1C	434.2	15.7	1050332.19	2060962.42	34.719904	-80.797135	20+48.36	32.58 R
S-29-292-2C	435.8	22.4	1050038.77	2060940.39	34.719098	-80.797210	17+56.60	5.50 L

Note: A bulk sample was collected near S-29-292-2.

GeoScoping Form

PROJECT INFORMATION	
Project ID: P041170	Date of Trip: 6/5/2023
County: Lancaster	Location: Lancaster
Rd/Route: S-5/29/292	Local Name: Plantation Road
Attendees: A. Beaty	

EXISTING BRIDGE INFORMATION	
Bridge Length: 180 feet	Bridge Width: 25 Feet
Superstructure Type: Concrete framing and decking	Substructure Type: Timber Piles
Begin Bridge Sta.: 17+60	End Bridge Sta.: 19+40
Begin Bridge Embankment Sta.[1] 16+60	End Bridge Embankment Sta.[1] 20+40
Structure Number: 04157	Posted Weight Limit: N/A
Crossing: Bear Creek	Skew: 10 degrees
Latitude: 34.7192973° N	Longitude: 80.7972087° W
Existing Fill Height: 4 feet	Approximate Existing Slope Angle: 2H:1V

[1]Begin and End Bridge Embankment 100 feet down station or up station from bridge, respectively

EXISTING ROADWAY EMBANKMENT INFORMATION		
Begin Project Sta.: 15+00	Begin Bridge Embankment Sta.[1]: 16+60	
Accessibility Issues: None		
Ground Cover: Asphalt Pavement and sand		
Existing Fill Height: 4 Feet	Approximate Existing Slope Angle: 2H:1V	
Local Development (undeveloped, developed residential, developed commercial, developed industrial, etc.): Developed residential		
Topography (level, flat, rolling, steep, hillside, valley, swamp, gully, etc.): Rolling		
Traffic Control Necessary (Y/N): Yes		
Surface Soil: Clay over silts and sands	Muck (Y/N): No	
Exposed Rock (Y/N): No	In Stream Bed (Y/N): No	In Banks (Y/N): Yes
Wetlands On-Site (Y/N): Yes	Wetlands Adjacent (Y/N): Yes	
Depth FG to Water: 15 Feet	Water Depth: 1 foot	
Depth to Existing Ground: 16 feet		
Scour Condition at EB: None observed	Scour Condition at IB: None Observed	
End Bridge Embankment Sta.[1]: 29+29	End Project Sta.: 33+50	
Accessibility Issues: None		
Ground Cover: Ashphalt Pavement with grassed shoulders		
Existing Fill Height: 4 feet	Approximate Existing Slope Angle: 2H:1V	
Local Development (undeveloped, developed residential, developed commercial, developed industrial, etc.): Developed residential		
Topography (level, flat, rolling, steep, hillside, valley, swamp, gully, etc.): Rolling		
Traffic Control Necessary (Y/N): Yes		
Surface Soil: Clay over silts and sands	Muck (Y/N): No	
Exposed Rock (Y/N): No	In Stream Bed (Y/N): No	In Banks (Y/N): Yes
Wetlands On-Site (Y/N): Yes	Wetlands Adjacent (Y/N): Yes	
Depth FG to Water: 15	Water Depth: 1 Foot	
Depth to Existing Ground: 16 feet		
Scour Condition at EB: None Observed	Scour Condition at IB: None Observed	

GeoScoping Form

UTILITIES INFORMATION
Attached:
Above Ground/ Overhead: None
Underground:

COMMENTS

Instructions:

1. Attach boring location plan for bridge and roadway.
2. Attach all photographs taken, photographs to be labeled as to direction looking in and what is being depicted.
3. Fill out GeoScoping Form as completely as possible, using additional sheets as necessary to describe site conditions.
4. If representative of GEC on site during GeoScoping, include GEC representative's name and contact number in Attendees block.

Field Exploration Description

Overview

The testing locations were proposed to and approved by SCDOT and located in the field by Terracon using measurements from existing structures shown on the provided drawings. The borings were surveyed by Construction Support Services, LLC after testing and drilling was complete. The locations as shown in the Exploration Plan are shown to the scale indicated.

A field log of each test location was prepared by our engineer. The final boring logs included with this report represent the engineer's description of the encountered conditions modified as necessary based on laboratory test results of the individual samples.

Soil Test Borings (STB)

All boring and sampling operations were conducted in general accordance with the following procedures:

- SCDOT Geotechnical Design Manual 2022
- Preconstruction Design Memorandum (PCDM) 11 - Supplemental Design Criteria for Low Volume Bridge Replacement Projects
- ASTM D5783, "Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geo-environmental Exploration"
- ASTM D6151, "Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- ASTM D1586 "Test Method for Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D4220 "Standard Practices for Preserving and Transporting Soil"
- ASTM D2113 "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration"
- ASTM D5079 "Standard Practices for Preserving and Transporting Rock Core Samples"

Each soil test boring was advanced using rotary wash drilling techniques. The initial sampling program is summarized in the following table:

Test ID	Total Depth	Interval of Continuous Sampling
S-29-292-1	100 feet or 15 feet rock coring	0 to 10 feet
S-29-292-2	100 feet or 10 feet rock coring	0 to 40 feet
S-29-292-3	100 feet or 20 feet rock coring	0 to 10 feet
S-29-292-2 Bulk	5 feet	Bulk Sample
S-29-292-1C	60 feet or refusal	CPT - No sampling
S-29-292-2C	60 feet or refusal	CPT - No sampling

Soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel sampler, also known as a standard split-spoon. The sampler is advanced into the soil a total of 18 to 24 inches by striking the drill rod using a 140-pound automatic hammer falling 30 inches. The number of blows required to advance the sampler for each of three to four, 6-inch increments is recorded. The sum of the number of blows for the second and third increments is called the "Standard Penetration Value", or N-value (N_{meas}, blows per foot). The N-value, when properly evaluated, is an index to the soil strength.

Soil classification provides a general guide to the engineering properties of various soil types and enables the engineer to apply his experience to current situations. In our exploration, samples obtained during drilling operations are examined and visually classified by a geotechnical engineer using the procedures outlined in ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System). Laboratory testing was also performed on select split-spoon samples to evaluate index properties for further classification. The soils are described according to color, texture, and relative density or consistency (based on standard penetration resistance). The designations shown on the logs are described in the 2022 SCDOT Geotechnical Design Manual, Chapter 6.

The borings were advanced either to the planned drilling depth at which they were terminated, or to refusal of the drilling equipment. Select borings were continued below this depth using diamond bit rock coring techniques. NQ2 sized cores were recovered from the borehole. The rock recovery ratios (REC, percentage of the total core run), Rock Quality Designation (RQD, percentage of the total core run of pieces greater than 4 inches) were recorded along with a description of the rock. An explanation of the rock descriptions shown on the logs is provided in the SCDOT GDM Chapter 6. Photos of the recovered rock core specimens are provided in the Rock Core Photograph Log.

As practical, groundwater readings were collected from each of the soil test borings after 24 hours. These water levels are indicated on the boring logs. The borings were advanced using mud rotary drilling techniques. As the drilling method introduces water into the borehole, time-of-drilling water levels may not be reliable.

At the conclusion of the work, the boreholes and sounding holes were backfilled with the drill cuttings and clean sand. The upper 20 feet of those in the embankments were grouted with a cement bentonite grout and capped with cold-patch asphalt.

Cone Penetration Test (CPT) Soundings

Cone Penetration Test soundings were conducted in accordance with ASTM D5778 *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils*.

Downhole Shear Wave Velocity Test (DHT)

One downhole seismic test was performed in a cased borehole drilled for this project. After the test boring was completed, the boring was filled with a fluid water/cement/bentonite grout and then a threaded PVC pipe casing (capped at the bottom end) was inserted into the borehole, providing a uniform bond between the soil and pipe exterior.

The downhole seismic test consisted of placing two downhole triaxial geophones at selected depth intervals in the borehole casing. The geophone was connected to a recording device (Seismic Source Daq Link 5 Seismograph) at the surface and clamped to the side of the casing at the selected test depth. The geophones are equipped with a spring-arm that is released at the bottom of the boring. The spring expands and forces the geophone against the casing wall. The interval between each geophone and each test depth was 3 feet for the entire depth of the cased borehole. An instrumented hammer was then used to strike a steel plate with cleats at the bottom (often called a shear wave golf shoe) that penetrated the ground and prevented sliding when struck. The steel plate was oriented to generate horizontal shear waves (SH) at the surface. An additional plate was also struck to better produce compression waves. The horizontal distance was measured and the plate was set exactly 10 feet from the borehole. The recorder was set to record the arrival times of the shear waves at the geophone locations. At least 15 blows (5 in each direction on the golf shoe, and 5 on the steel plate) were struck for each test depth to electronically stack and polarize the observed data, and to increase the signal-to-noise ratio. The data was stored on computer disks for processing and computation. The geophone was raised to the next depth interval and the process was repeated.

Shear Wave Velocity Test Results shows the downhole shear wave velocity and compressive wave velocity test results. The data was evaluated using the Fixed Interval method. S-wave arrival times using the Interval method were picked based on the onset of the signal (first break) as observed in the software package TomTime by GeoTom.

SOIL DESCRIPTION TERMS

Relative Density/Consistency Terms

Relative Density[1]			Consistency[2]		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q_u) (tsf)	SPT Blow Count
Very Loose	0 to 15%	4 and less	Very Soft	0.25 and less	2 and less
Loose	16 to 35%	5 to 10	Soft	0.26 to 0.50	3 to 4
Medium Dense	36 to 65%	11 to 30	Firm	0.51 to 1.00	5 to 8
Dense	66 to 85%	31 to 50	Stiff	1.01 to 2.00	9 to 15
Very Dense	86 to 100%	51 and more	Very Stiff	2.01 to 4.00	16 to 30
			Hard	4.01 and more	31 and more

Moisture Condition

Descriptive Term	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually in coarse-grained soils below the water table

Color

Describe the sample color while sample is still moist.

Angularity[1]

Descriptive Term	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

HCl Reaction[3]

Descriptive Term	Criteria
None Reactive	No visible reaction
Weakly Reactive	Some reaction, with bubbles forming slowly
Strongly Reactive	Violent reaction, with bubbles forming immediately

Cementation[3]

Descriptive Term	Criteria
Weakly Cemented	Crumbles or breaks with handling or little finger pressure Moderately
Cemented	Crumbles or breaks with considerable finger pressure
Strongly Cemented	Will not crumble or break with finger pressure

Particle-Size Range[1]

Gravel	Diameter, mm	Sieve Size	Sand	Diameter, mm	Sieve Size
Fine	4.76 to 19.1	#4 to ¾ inch	Fine	0.074 to 0.42	#200 to #40
Coarse	19.1 to 76.2	¾ inch to 3 inch	Medium	0.42 to 2.00	#40 to #10
			Coarse	4.00 to 4.76	#10 to #4

Primary Soil Type[1, 2]

The primary soil type will be shown in all capital letters.

USCS Soil Designation

Indicate USCS soil designation as defined in ASTM D-2487 and D-2488

AASHTO Soil Designation

Indicate AASHTO soil designation as defined in AASHTO M-145 and ASTM D-3282

[1]Applies to coarse-grained soils (major portion retained on No. 200 sieve)
[2]Applies to fine-grained soils (major portion passing No. 200 sieve)
[3]Use as required

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock[a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

[a]Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designation (RQD)[a]

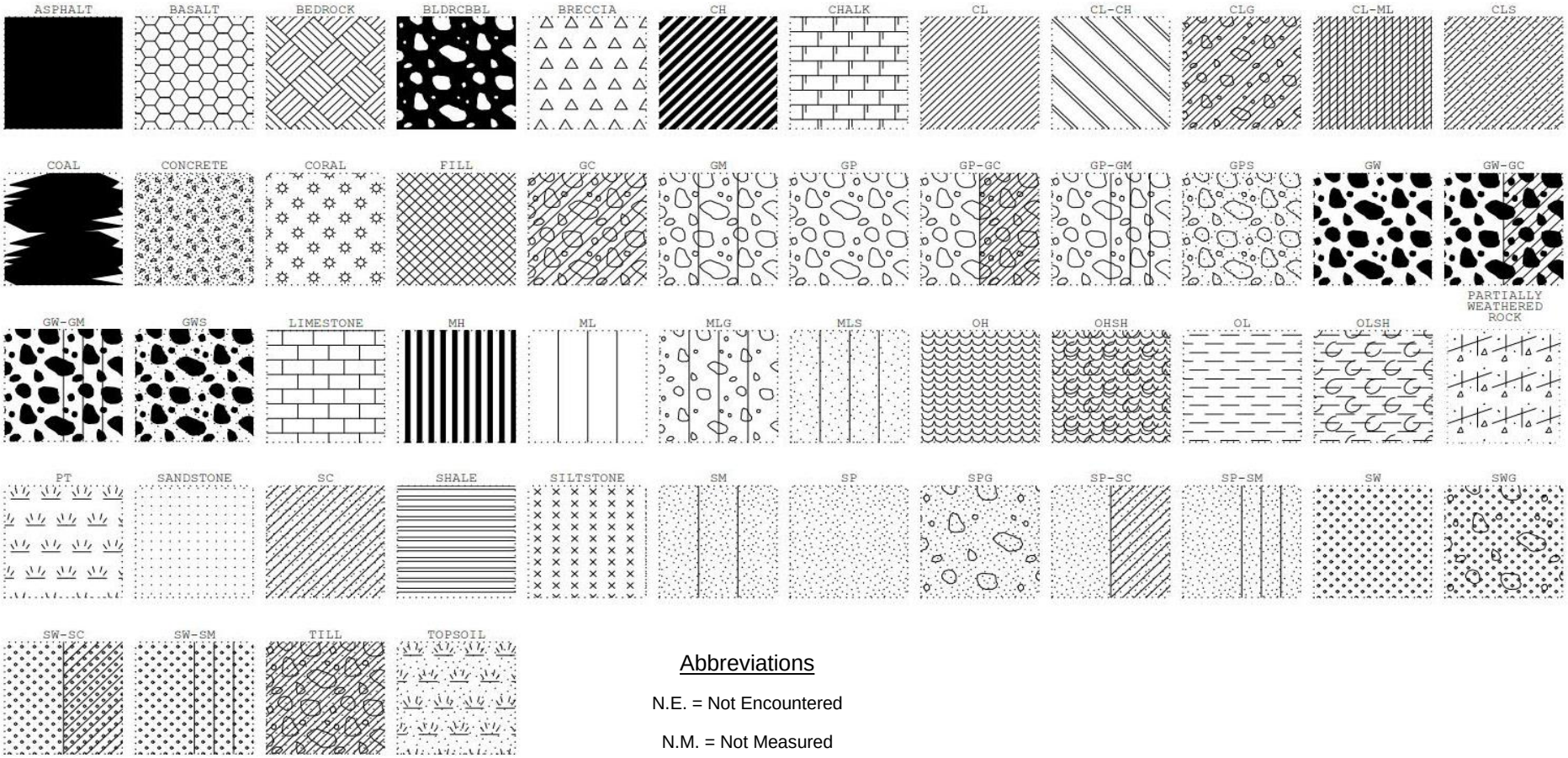
RQD, as a percentage	Diagnostic Description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

[a]RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly open
1/32 to 3/8 in.	Moderately open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

Project Manager: PAM	Project No. 7323P100
Drawn by: KJZ	Scale: N.T.S.
Checked by: PAM	File Name: Soil – Rock – Log
Approved by: DJC	Date: Jul 2023

Terracon
521 Clemson Road Columbia, SC 29229
PH. (803) 741-9000 FAX. (803) 741-9900

SOIL AND ROCK SYMBOLS

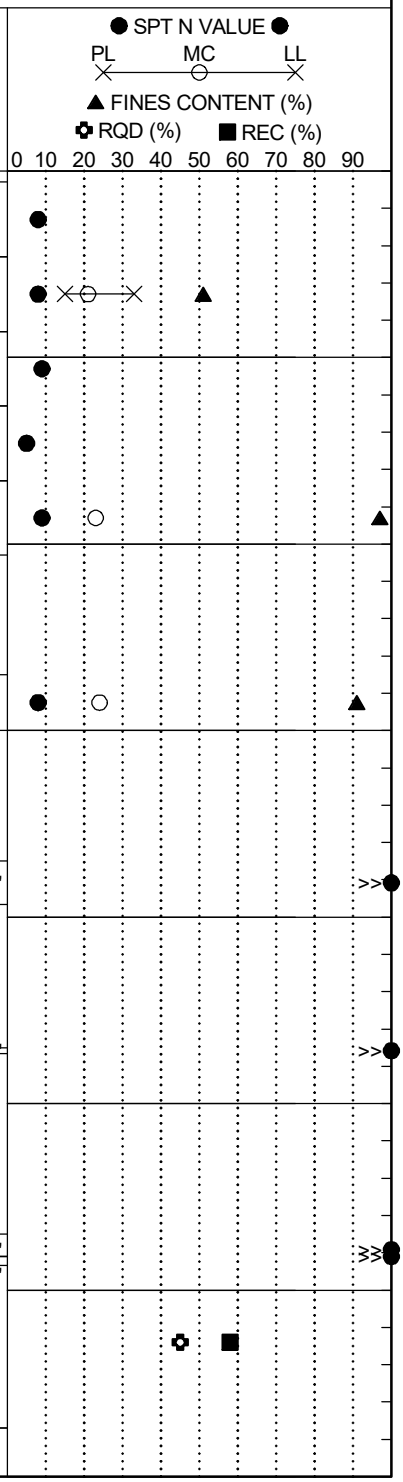
Exhibit A-7

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-1		
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292		
Eng./Geo.:	J. Cerceo	**Boring Location:**	19+49.76	**Offset:**	5.90 L	**Alignment:**	Existing
Elev.:	436.7 ft	**Latitude:**	34.719628	**Longitude:**	-80.797245	**Date Started:**	6/5/2023
Total Depth:	44.7 ft	**Soil Depth:**	29.1 ft	**Core Depth:**	15.6 ft	**Date Completed:**	6/5/2023
Bore Hole Diameter (in):	4	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	DR543	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic	**Energy Ratio:**	93.9%
Core Size:	NQ2	**Driller:**	C. Costner	**Groundwater:**	**TOB** NM	**24HR**	NM

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION
	0.0	Existing Roadway
	0.2	Asphalt (2 inches)
	0.3	Stone Base (1 inch)
		FILL - Firm, moist, dark red, non-reactive, Sandy lean CLAY (CL) (A-6(6)) 10 YR 3/6
	4.3	LL=33, PL=15, PI=18, NMC=20.6, %200=50.7
431.7		
	6.3	Stiff, moist, olive brown, non-reactive, Sandy SILT (ML) (A-4) 2.5 YR 4/4
	8.3	**ALLUVIUM** - Firm, moist, olive brown, non-reactive, Sandy elastic SILT (MH) (A-5) 2.5 YR 4/4
426.7		**RESIDUUM** - Firm to stiff, moist, grayish brown to dark yellowish brown, non-reactive, SILT (ML) (A-4(0)) 2.5 YR 5/2 to 10 YR 4/4
		NMC= 23.3, %200=96.9
		LL=NP, PL=NP, PI=NP, NMC=24.4, %200=91.9
421.7		
	19.0	
416.7		Very dense, moist, light brownish gray, subangular, non-reactive, moderately cemented, fine to coarse, Silty SAND (SM) (A-2-4) 10 YR 6/2 with rock fragments
411.7		
	29.1	
406.7		AUGER REFUSAL AT 29.1 FEET - SET CASING AND BEGIN CORING
		METATUFF, dark bluish gray, fine to medium grained, slightly weathered, weak to strong rock, 60°, Sh, N, Fi, No, Wa, VC, SR, %REC=58, RQD=45, GSI=70, 1.9 min/ft, #8 bit, 350 psi down pressure
		%REC=96, RQD=92, GSI=70, 2.7 min/ft, #8

Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
0.3	SS-1	10	5	3	5	8
2.3	SS-2	3	3	5	6	8
4.3	SS-3	5	3	6	5	9
6.3	SS-4	2	3	2	3	5
8.3	SS-5	1	3	6	9	9
13.5	SS-6	3	4	4		8
18.5	SS-7	4	11	50/2"		50/2"
23.5	SS-8			50/2"		50/2"
28.5						
29.1						50/1"
29.1						50/0"
	NQ-1					
33.7						



LEGEND

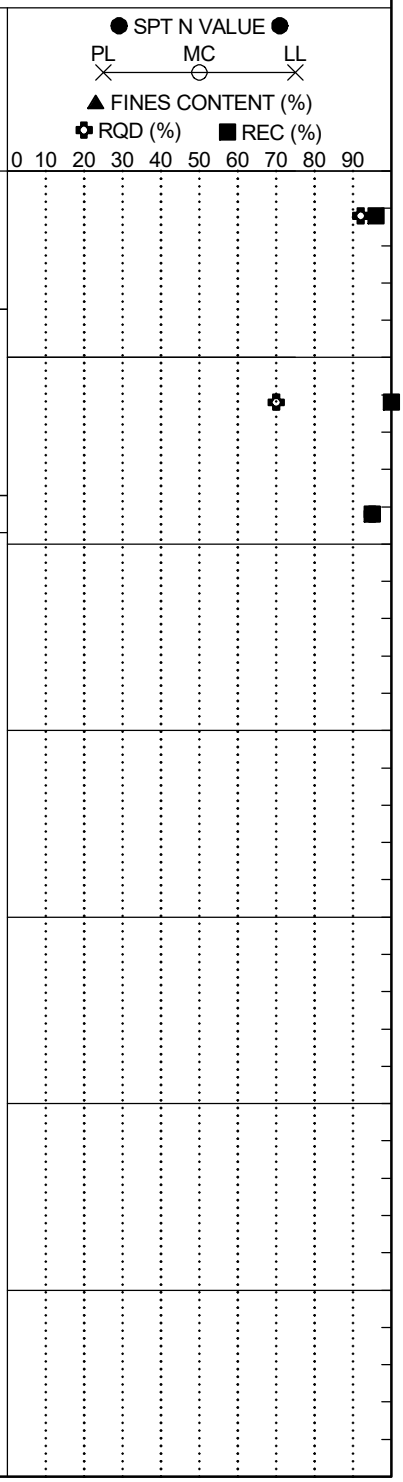
Continued Next Page

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-1
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292
Eng./Geo.:	J. Cerceo	**Boring Location:**	19+49.76	**Offset:**	5.90 L
Alignment:	Existing				
Elev.:	436.7 ft	**Latitude:**	34.719628	**Longitude:**	-80.797245
Date Started:	6/5/2023				
Total Depth:	44.7 ft	**Soil Depth:**	29.1 ft	**Core Depth:**	15.6 ft
Date Completed:	6/5/2023				
Bore Hole Diameter (in):	4	**Sampler Configuration**		**Liner Required:**	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR543	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic
Energy Ratio:	93.9%				
Core Size:	NQ2	**Driller:**	C. Costner	**Groundwater:**	**TOB** NM
24HR	NM				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
		bit, 350 psi down pressure			NQ-2					
	38.7			38.7						
396.7		**METATUFF,** dark greenish gray, fine to medium grained, slightly weathered, strong rock, 60°, Sh, VN, Fi, No, Wa, VC, SR, %REC=100, RQD=70, GSI=70, RMR=57, qc=7,870 psi, 5.4 min/ft, #8 bit, 350 psi down pressure			NQ-3					
				43.7						
	44.7	%REC=95, RQD=95, GSI=70, RMR=69, qc= 17,008 psi, 4.5 min/ft, #8 bit, 350 psi down pressure			NQ-4					
391.7		CORING TERMINATED AT 44.7 FEET, SET DHT CASING								
386.7										
381.7										
376.7										
371.7										



LEGEND

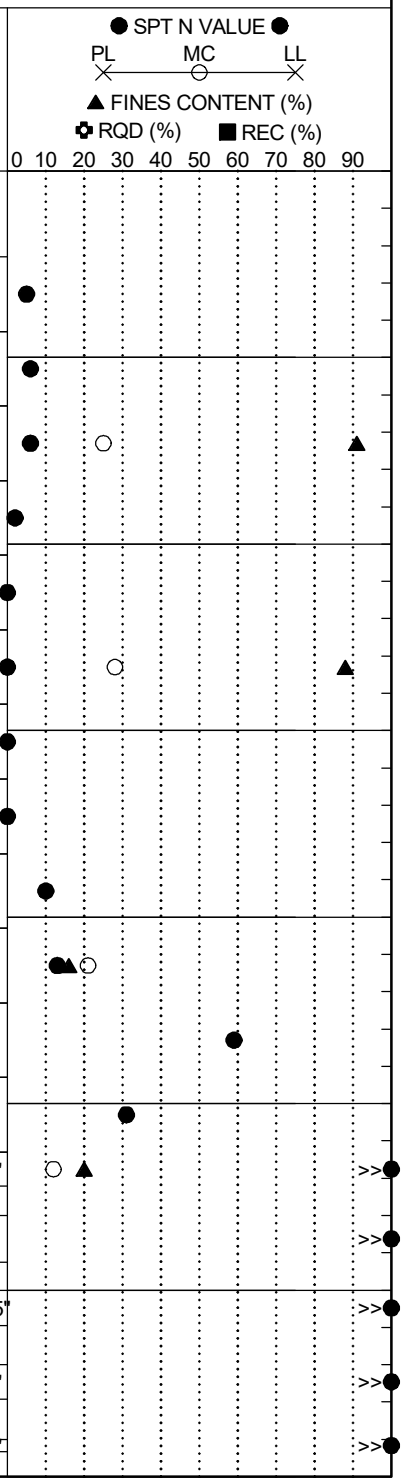
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-2		
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292		
Eng./Geo.:	A. Beaty	**Boring Location:**	17+54.72	**Offset:**	5.33 L	**Alignment:**	Existing
Elev.:	435.8 ft	**Latitude:**	34.719093	**Longitude:**	-80.797209	**Date Started:**	6/5/2023
Total Depth:	68.2 ft	**Soil Depth:**	49.7 ft	**Core Depth:**	18.5 ft	**Date Completed:**	6/6/2023
Bore Hole Diameter (in):	4	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME550X	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic	**Energy Ratio:**	84.4%
Core Size:	NQ2	**Driller:**	J. Cain	**Groundwater:**	**TOB** NM	**24HR**	12'

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION
	0.0	Existing Bridge Deck
	0.8	Asphalt (9 inches)
	2.3	Stone Base (18 inches)
	3.3	**FILL** - Loose, moist, yellowish brown, subrounded, non-reactive, moderately cemented, fine to coarse, Clayey SAND (SC) (A-2-6) 10 YR 5/4
430.8		**ALLUVIUM** - Firm, moist, gray, non-reactive, SILT (ML) (A-4(0)) 5 YR 5/1 LL=NP, PL=NP, PI=NP, NMC=25.3, %200=91.4
	8.3	Very soft, moist, gray to dark gray, non-reactive, SILT (ML) (A-4(0)) 5 YR 5/1 to 7.5 YR 4/1
425.8		LL=NP, PL=NP, PI=NP, NMC=27.5, %200=88
420.8		
	18.3	**RESIDUUM** - Loose to medium dense, moist to wet, gray, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4(0)) 7.5 YR 6/1 LL=NP, PL=NP, PI=NP, NMC=21.3, %200=16
415.8	22.3	Very dense, wet, gray, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4) 7.5 YR 6/1
410.8	24.3	Dense, wet, gray, subrounded, non-reactive, weakly cemented, fine to coarse, Poorly graded SAND with silt (SP-SM) (A-3) 7.5 YR 6/1
	26.3	Very dense, moist, dark greenish gray, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4) GLEY 1 4/5G_/1 NMC=12.3, %200=20.3
405.8	28.0	Hard, moist, very dark grayish green, non-reactive, Sandy SILT (ML) (A-4) GLEY 1 2.5/5G_/2
	32.0	
	34.0	

Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
2.3	SS-1	4	2	3	3	5
4.3	SS-2	2	3	3	4	6
6.3	SS-3	2	3	3	3	6
8.3	SS-4	1	1	1	1	2
10.3	SS-5	WOH/24"				0
12.3	SS-6	WOH/24"				0
14.3	SS-7	WOR/24"				0
16.3	SS-8	WOH/24"				0
18.3	SS-9	1	3	7	4	10
20.3	SS-10	3	4	9	7	13
22.3	SS-11	7	16	43	44	59
24.3	SS-12	6	14	17	20	31
26.3	SS-13	24	50/5"			50/5"
28.0	SS-14	13	29	42	50/3"	71
30.0	SS-15	19	50/5.5"			50/5.5"
32.0	SS-16	31	50/5"			50/5"
34.0	SS-17		50/4"			50/4"



LEGEND

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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-2
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292
Eng./Geo.:	A. Beaty	**Boring Location:**	17+54.72	**Offset:**	5.33 L
Alignment:	Existing				
Elev.:	435.8 ft	**Latitude:**	34.719093	**Longitude:**	-80.797209
Date Started:	6/5/2023	**Date Completed:**	6/6/2023		
Total Depth:	68.2 ft	**Soil Depth:**	49.7 ft	**Core Depth:**	18.5 ft
Bore Hole Diameter (in):	4	**Sampler Configuration**			
Liner Required:	Y (N)	**Liner Used:**	Y (N)		
Drill Machine:	CME550X	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic
Energy Ratio:	84.4%				
Core Size:	NQ2	**Driller:**	J. Cain	**Groundwater:**	**TOB** NM / **24HR** 12'

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION
		Very dense, very dark grayish green, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4) GLEY 1 2.5/5G_/2
395.8		Hard, moist, very dark grayish green, non-reactive, Sandy SILT (ML) (A-4) GLEY 1 2.5/5G_/2
390.8		
385.8	49.7	AUGER REFUSAL AT 49.7 FEET - SET CASING BEGIN CORING
		METATUFF, dark greenish gray, very fine grained, moderately weathered, strong rock, -, J, MW, No, No, Ir, VC, SR, %REC=95, RQD=0, GSI=50, 2.1 min/ft, #8 bit, 350 psi down pressure
380.8		%REC=95, RQD=0, GSI=60, RMR=36, qc=4,602 psi, 2.4 min/ft, #8 bit, 350 psi down pressure
375.8		%REC=95, RQD=28, GSI=70, 2.8 min/ft, #8 bit, 350 psi down pressure
370.8		%REC=95, RQD=0, GSI=50, 2.5 min/ft, #8 bit, 350 psi down pressure
	68.2	CORING TERMINATED AT 68.2 FEET

Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
36.0	SS-18	50/3"				50/3"
38.0	SS-19	50/2"				50/2"
40.0	SS-20	50/1"				50/1"
42.0	SS-21	50/5"				50/5"
44.0	SS-22	50/2"				50/2"
46.0	SS-23	50/1"				50/1"
48.0	SS-24	50/5"				50/5"
49.7	SS-25	50/0"				50/0"
49.7	NQ-1					
53.2	NQ-2					
58.2	NQ-3					
63.2	NQ-4					

● SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%)
0 10 20 30 40 50 60 70 80 90

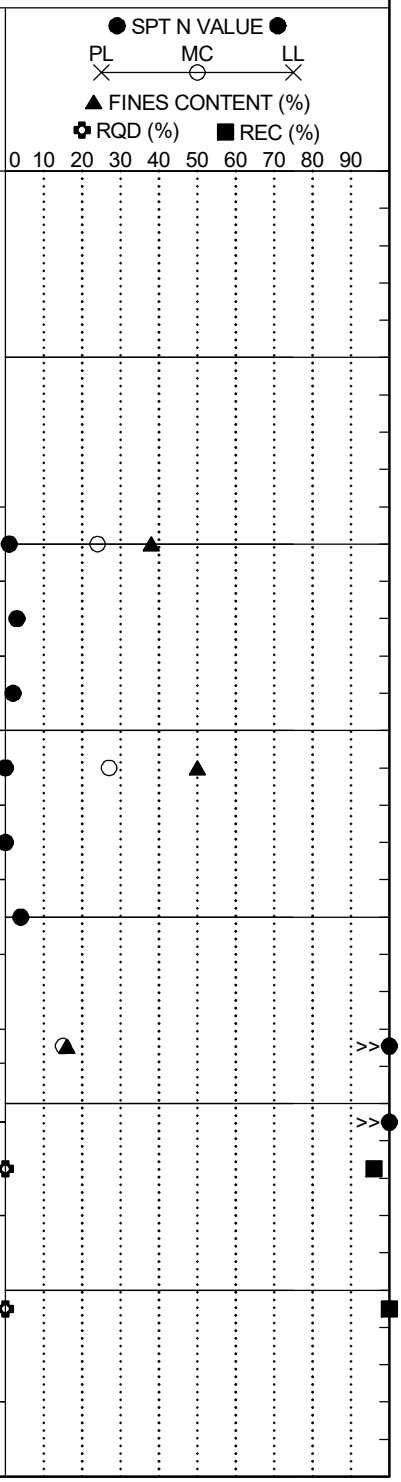
LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-3		
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292		
Eng./Geo.:	A. Beaty	**Boring Location:**	18+57.31	**Offset:**	5.55 L	**Alignment:**	Existing
Elev.:	439.2 ft	**Latitude:**	34.719374	**Longitude:**	-80.797228	**Date Started:**	6/7/2023
Total Depth:	46 ft	**Soil Depth:**	25.5 ft	**Core Depth:**	20.5 ft	**Date Completed:**	6/8/2023
Bore Hole Diameter (in):	4	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME550X	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic	**Energy Ratio:**	84.4%
Core Size:	NQ2	**Driller:**	J. Cain	**Groundwater:**	**TOB** NM	**24HR**	11'

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	Existing Roadway							
	0.3	Asphalt (3.5 inches)							
	1.0	Concrete (8.5 inches)							
		AIR GAP - SET CASING AND BEGIN DRILLING							
434.2									
	9.0		9.0						
429.2		**ALLUVIUM** - Very loose, moist, yellowish red to gray, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-4) 5 YR 4/6 to 10 YR 5/1	11.0	SS-1	WOH/12"		1	1	1
		NMC=24.2, %200=38	13.0	SS-2	2	2	1	1	3
			15.0	SS-3	3	2	WOH/12"		2
424.2		LL=NP, PL=NP, PI=NP, NMC=27.3, %200=49.8	17.0	SS-4		WOH/24"			0
			19.0	SS-5	1	WOH/12"			0
	19.0								
419.2		Very loose, moist, yellowish red to gray, subangular, non-reactive, weakly cemented, fine to coarse, Silty SAND (SM) (A-2-4) 5 YR 4/6 to 10 YR 5/1		SS-6	1	2	2	3	4
	22.0	%200=12.8	23.0	SS-7	23	50/5"			50/5"
414.2	25.5	**RESIDUUM** - Very dense, moist, very dark greenish gray, angular, non-reactive, moderatly cemented, fine to coarse, Silty SAND (SM) (A-2-4) GLEY 1/5G_/1	25.5	SS-8		50/0"			50/0"
		NMC=14.5, %200=15.5	25.5	NQ-1					
		AUGER REFUSAL AT 25.5 FEET SET -CASING AND BEGIN CORING	28.0						
409.2		**METATUFF**, dark greenish gray, very fine grained, slightly to moderately weathered, strong rock, -, J, N, No, No, Ir, VC, SR, %REC=96, RQD=0, GSI=50, 1.8 min/ft, #8 bit, 350 psi down pressure		NQ-2					
		%REC=100, RQD=0, GSI=40, 2.1 min/ft, #8 bit, 350 psi down pressure	33.0						
		%REC=100, RQD=0, GSI=50, 1.4 min/ft, #8							



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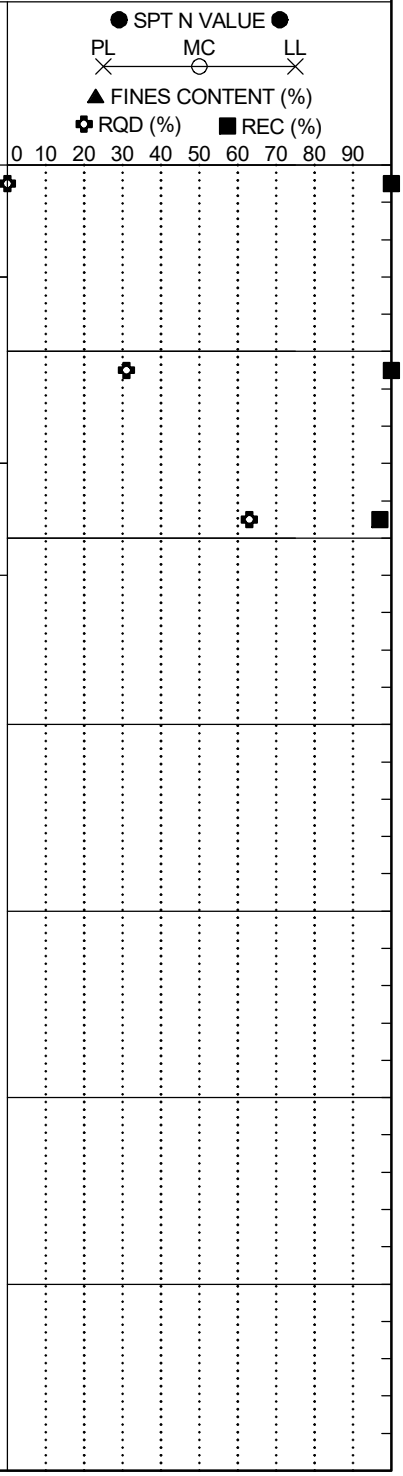
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P041170	**County:**	Lancaster	**Boring No.:**	S-29-292-3
Site Description:	S-29-292 BRO Bear Creek			**Route:**	S-29-292
Eng./Geo.:	A. Beaty	**Boring Location:**	18+57.31	**Offset:**	5.55 L
Alignment:	Existing				
Elev.:	439.2 ft	**Latitude:**	34.719374	**Longitude:**	-80.797228
Date Started:	6/7/2023				
Total Depth:	46 ft	**Soil Depth:**	25.5 ft	**Core Depth:**	20.5 ft
Date Completed:	6/8/2023				
Bore Hole Diameter (in):	4	**Sampler Configuration**		**Liner Required:**	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME550X	**Drill Method:**	RW/RC	**Hammer Type:**	Automatic
Energy Ratio:	84.4%				
Core Size:	NQ2	**Driller:**	J. Cain	**Groundwater:**	**TOB** NM **24HR** 11'

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
		bit, 350 psi down pressure			NQ-3					
				38.0						
		%REC=100, RQD=31, GSI=70, 2.0 min/ft, #8 bit, 350 psi down pressure								
399.2					NQ-4					
				43.0						
		%REC=97, RQD=63, GSI=70, 2.2 min/ft, #8 bit, 350 psi down pressure								
394.2					NQ-5					
	46.0	CORING TERMINATED AT 46 FEET								
389.2										
384.2										
379.2										
374.2										



LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT SCDOT S-29-292 BEAR CREEK.GPJ SCDOT_DATATEMPLATE.GDT 8/18/23

S-29-292 (S Plantation Rd) BRO Bear Creek
SCDOT Project ID: P041170 | Lancaster County, South Carolina
Terracon Project No. EN23P100

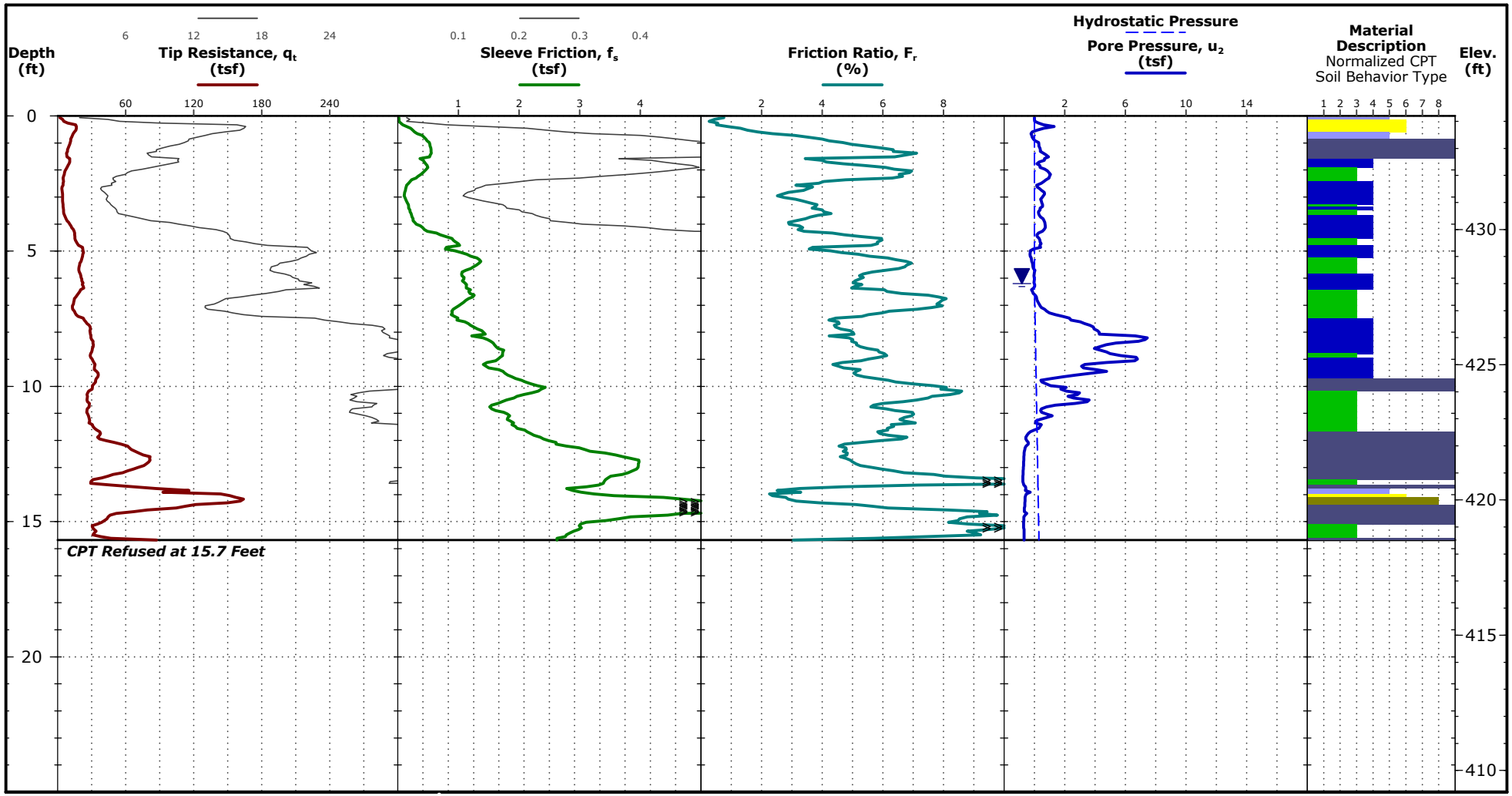
CPT Sounding ID S-29-292-1C

Terracon
1800 Reynolds Ave
North Charleston, SC

Latitude: 34.719904° Longitude: -80.797135°
Station: 20+48.36 Offset: R 32.58

Elevation: 434.2 (ft)

CPT Started: 6/28/2023
CPT Completed: 6/28/2023



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

CPT Equipment

CPT Rig: TG 73-200
Operator: AF/BR
CPT sensor calibration reports available upon request
Probe No. 5617 with net area ratio of 0.84
U_2 pore pressure transducer location
Manufactured by Geotech A.B.- Calibrated 5/31/2023
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 2 in

Water Level Observation

6.2 ft measured water depth
(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

S-29-292 (S Plantation Rd) BRO Bear Creek
SCDOT Project ID: P041170 | Lancaster County, South Carolina
Terracon Project No. EN23P100

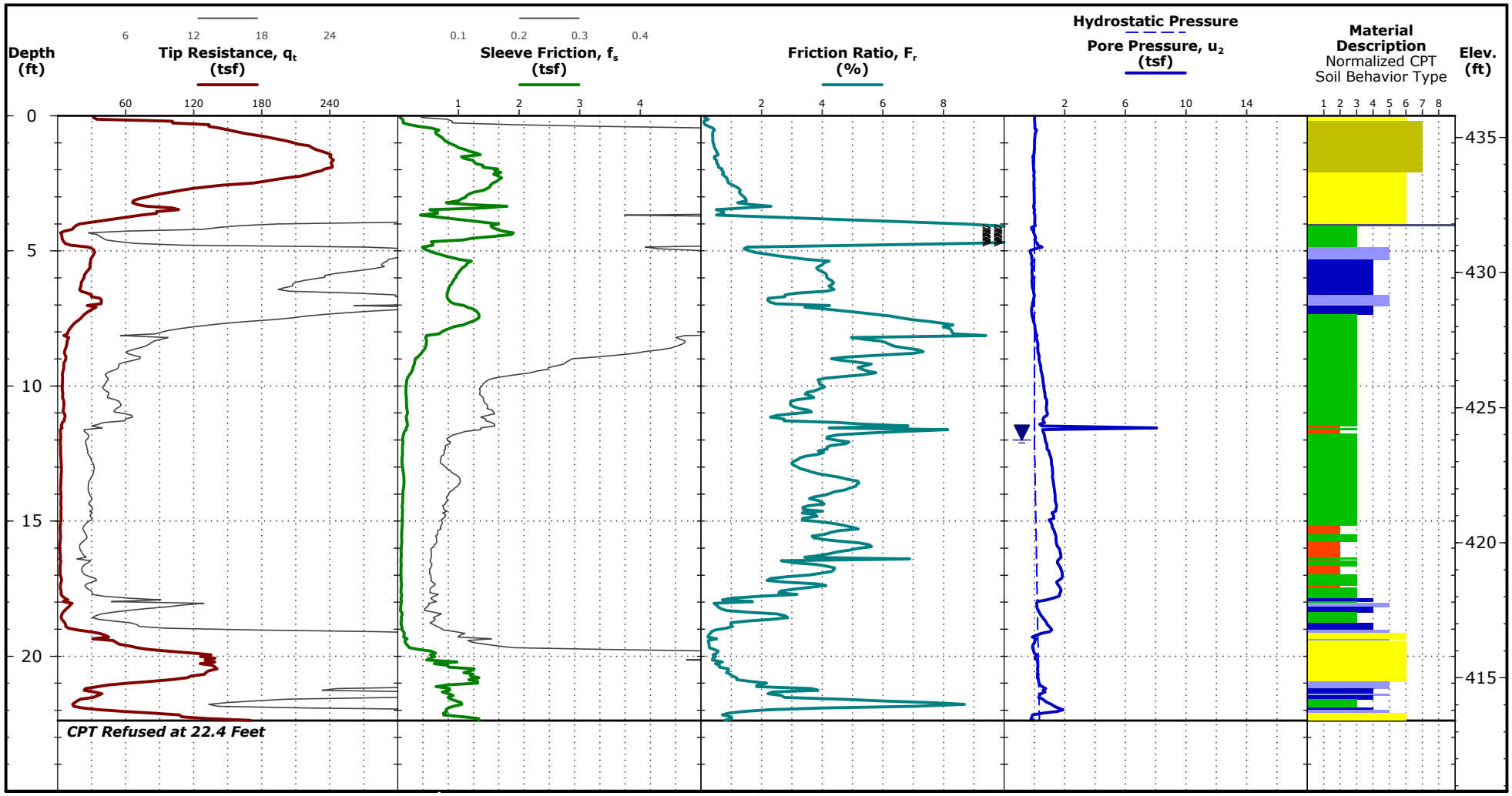
CPT Sounding ID S-29-292-2C

Terracon
1800 Reynolds Ave
North Charleston, SC

Latitude: 34.719098° Longitude: -80.797210°
Station: 17+56.60 Offset: L 5.5

Elevation: 435.8 (ft)

CPT Started: 6/28/2023
CPT Completed: 6/28/2023



See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data, if any.

See Supporting Information for explanation of symbols and abbreviations.

Notes

Test Location: See Exploration Plan

CPT Equipment

CPT Rig: TG 73-200

Operator: AF/BR

CPT sensor calibration reports available upon request

Probe No. 5617 with net area ratio of 0.84

U_2 pore pressure transducer location

Manufactured by Geotech A.B.- Calibrated 5/31/2023

Tip and sleeve areas of 10 cm^2 and 150 cm^2

Ring friction reducer with O.D. of 2 in

Water Level Observation

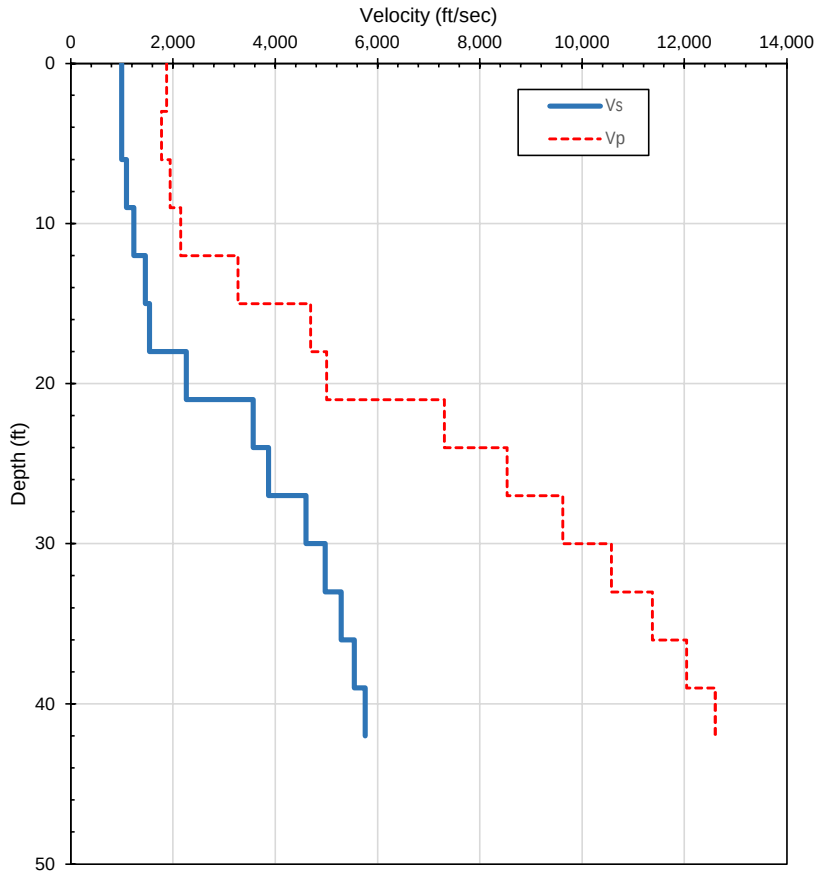
12 ft estimated water depth

(used in normalizations and correlations)

Normalized Soil Behavior Type
(Robertson 1990)

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

Downhole Seismic Velocity Fixed Interval Method



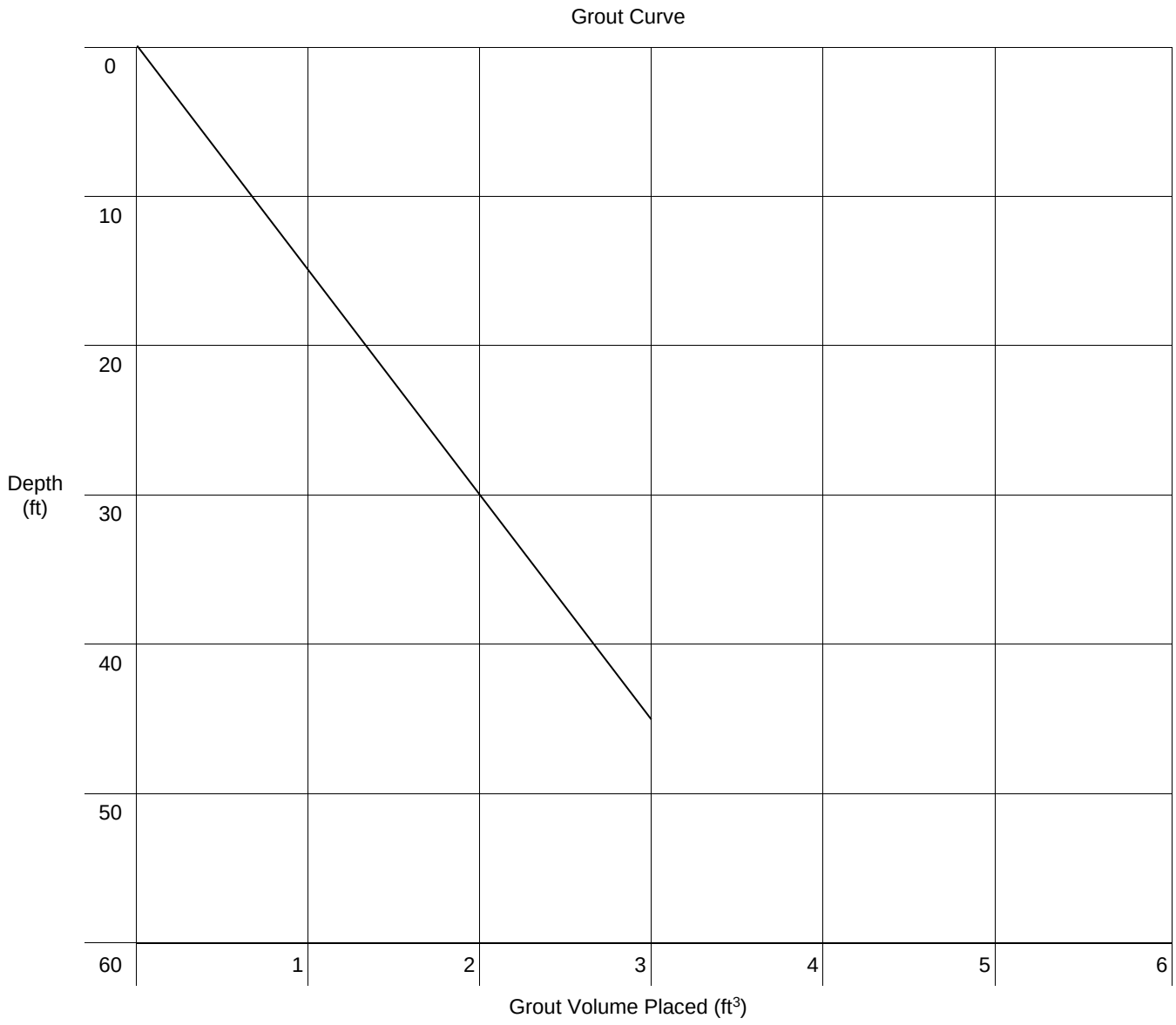
Depth (ft)	Vp (ft/sec)	Vs (ft/sec)	Δi (ft)	Δt (sec)
3	1,874	996	3	0.00301
6	1,772	999	3	0.00300
9	1,944	1,088	3	0.00276
12	2,148	1,233	3	0.00243
15	3,266	1,459	3	0.00206
18	4,690	1,542	3	0.00195
21	5,000	2,264	3	0.00133
24	7,306	3,567	3	0.00084
27	8,528	3,867	3	0.00078
30	9,621	4,600	3	0.00065
33	10,568	4,979	3	0.00060
36	11,371	5,292	3	0.00057
39	12,044	5,549	3	0.00054
42	12,602	5,758	3	0.00052
Sum of Data Over Profile			42	0.02103
Weighted Average Shear Wave Velocity Over Profile			**1,997 ft/sec**	

Project Mgr: DC	Project No. EN23P100	Terracon Consulting Engineers and Scientists	**GEOPHYSICAL TESTING RESULTS** **DOWNHOLE SEISMIC TEST**	**TEST NO.**
Prepared by: RK			**S-29-292 (S Plantation Rd) Bridge Replacement over Bear Creek** **LANCASTER COUNTY, SOUTH CAROLINA**	**S-29-292-1**
Checked by: AF	Scale: NA			
Approved by:	Date: 7/12/2023	1800 Reynolds Avenue North Charleston, South Carolina Ph: (843) 884-1234 Fax. (843) 884-9234	**P041170**	

EXHIBIT A-10

GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

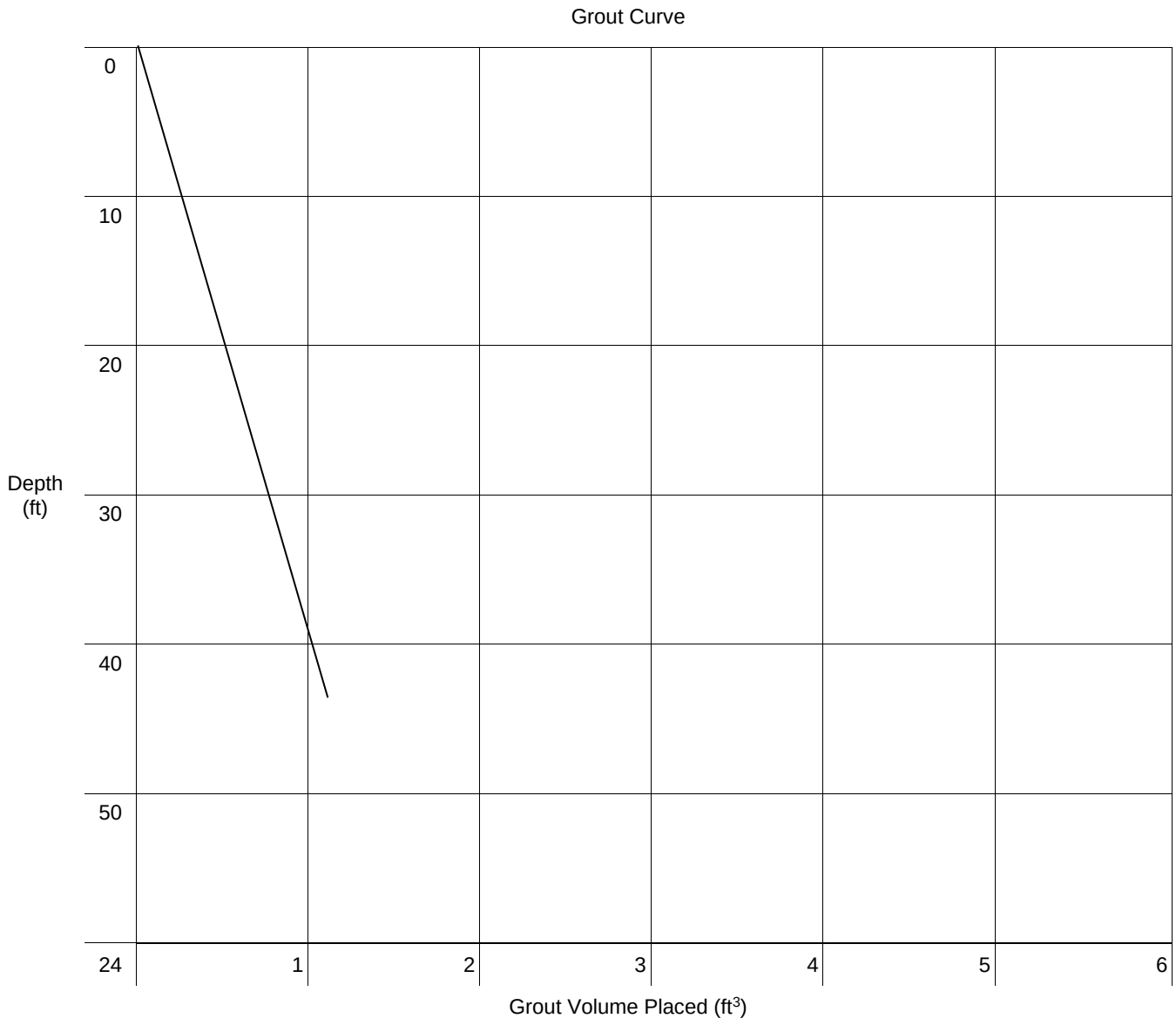
Project Name:	S-29-292 BRO Bear Creek		
Project ID:	P041170	Test Hole No.:	S-29-292-1
Consultant Firm:	Terracon Consultants, Inc.	Station:	19+49.76
Grouted By (Driller's Name):	Costner Date 6/5/23	Offset:	5.90 L
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water		



Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	44.7	ft.
Diameter of Test Hole	0.33	ft.
Area of Test Hole	0.09	ft^2
Volume of Test Hole	3.82	ft^3
Volume of Casing (If applicable)	1.16	ft^3
Theoretical Volume of Test Hole	2.66	ft^3
Number of Bags Used	6	ea.
Volume Placed	3.0	ft^3

GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

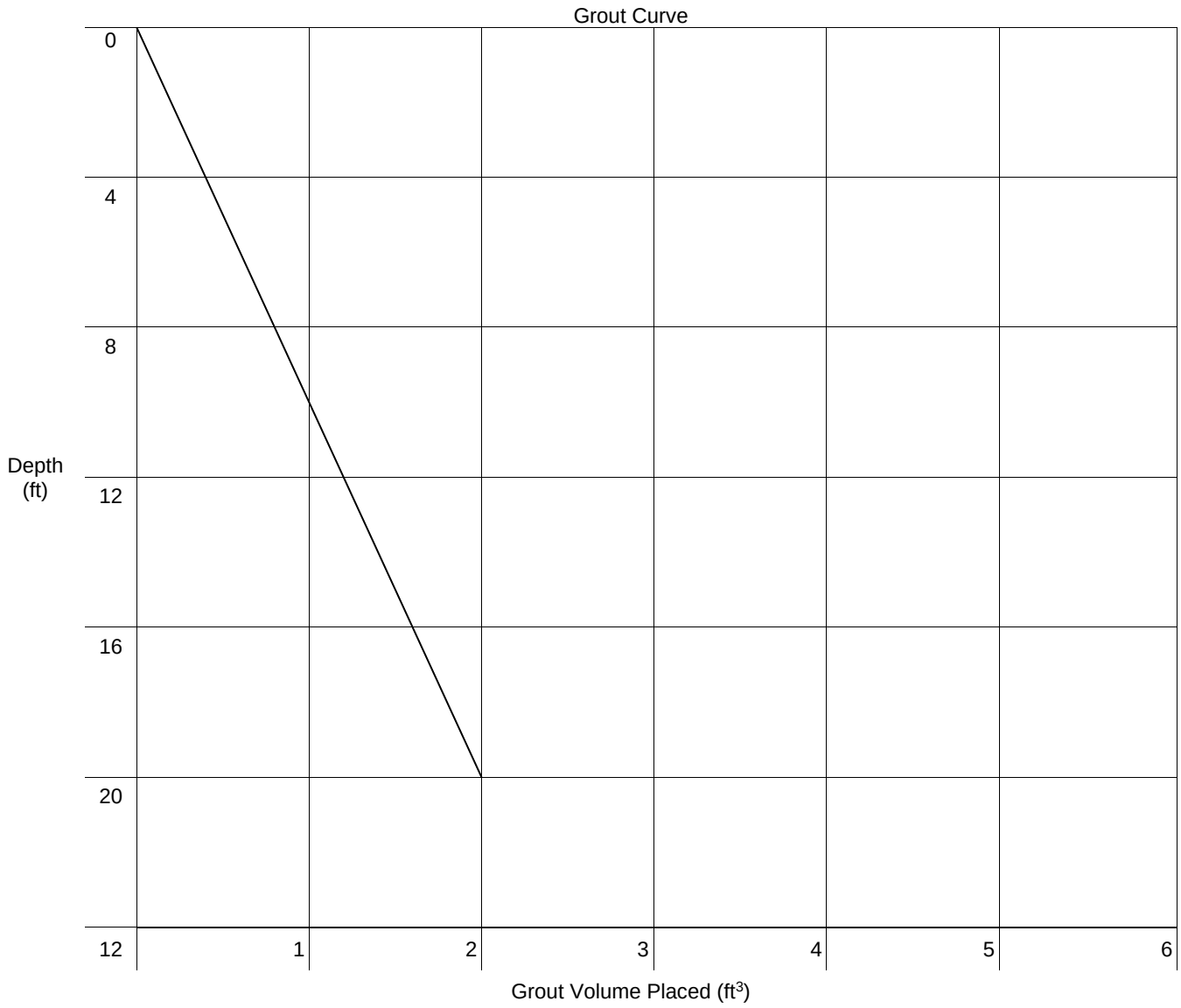
Project Name:	S-29-292 BRO Bear Creek		
Project ID:	P041170	Test Hole No.:	S-29-292-1
Consultant Firm:	Terracon Consultants, Inc.	Station:	19+49.76
Grouted By (Driller's Name):	Truesdale Date 7/15/23	Offset:	5.90 L
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water		



Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	44	ft.
Diameter of Test Hole	0.17	ft.
Area of Test Hole	0.022	ft^2
Volume of Test Hole	0.96	ft^3
Volume of Casing (If applicable)	-	ft^3
Theoretical Volume of Test Hole	0.96	ft^3
Number of Bags Used	1.5	ea.
Volume Placed	1.1	ft^3

GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name:	S-29-292 BRO Bear Creek		
Project ID:	P041170	Test Hole No.:	S-29-292-2
Consultant Firm:	Terracon Consultants, Inc.	Station:	17+54.92
Grouted By (Driller's Name):	Truesdale Date 5.33 L	Offset:	5.33 L
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water		

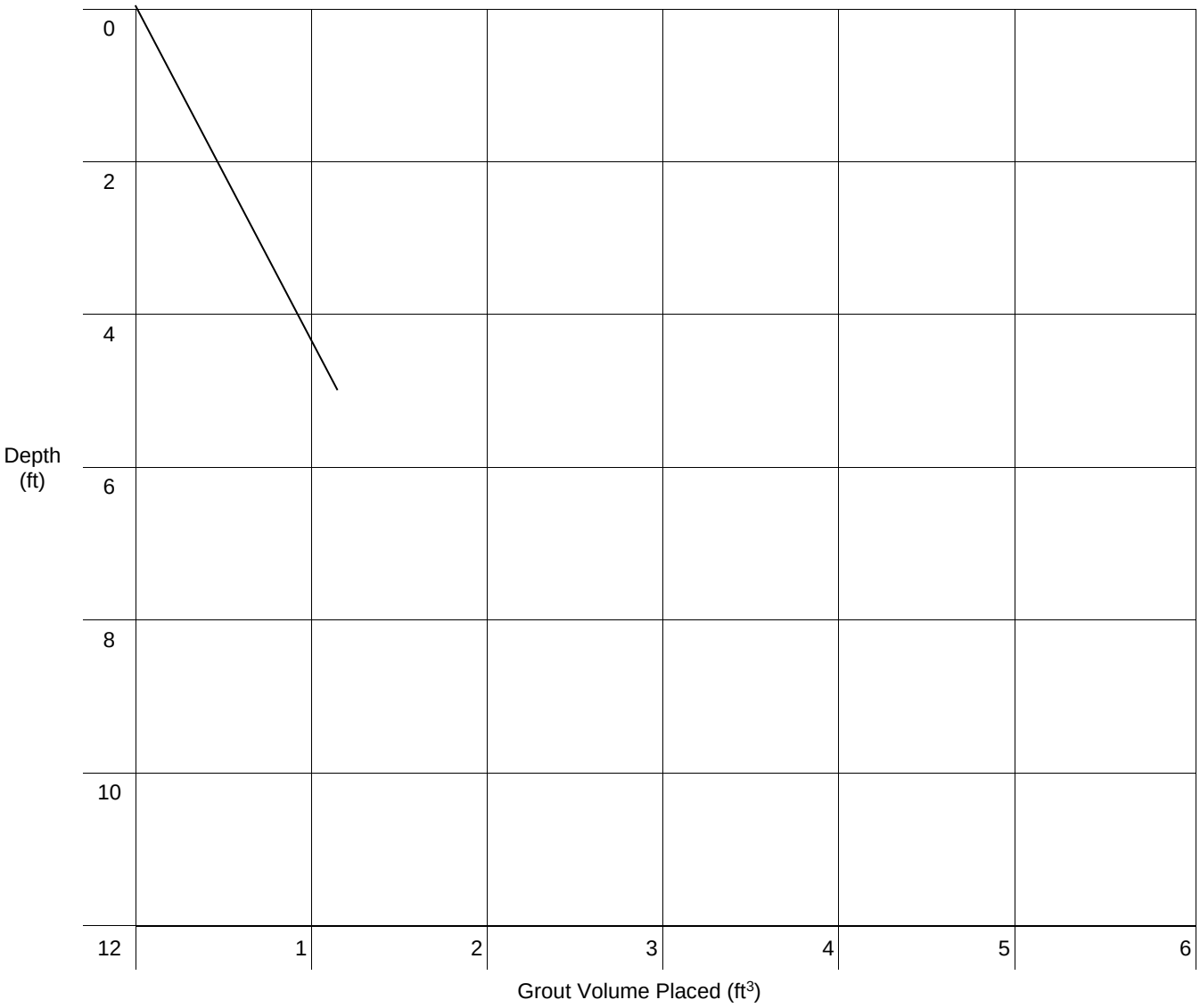


Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	20	ft.
Diameter of Test Hole	0.33	ft.
Area of Test Hole	0.09	ft^2
Volume of Test Hole	1.74	ft^3
Volume of Casing (If applicable)	-	ft^3
Theoretical Volume of Test Hole	1.74	ft^3
Number of Bags Used	2.5	ea.
Volume Placed	2	ft^3

GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

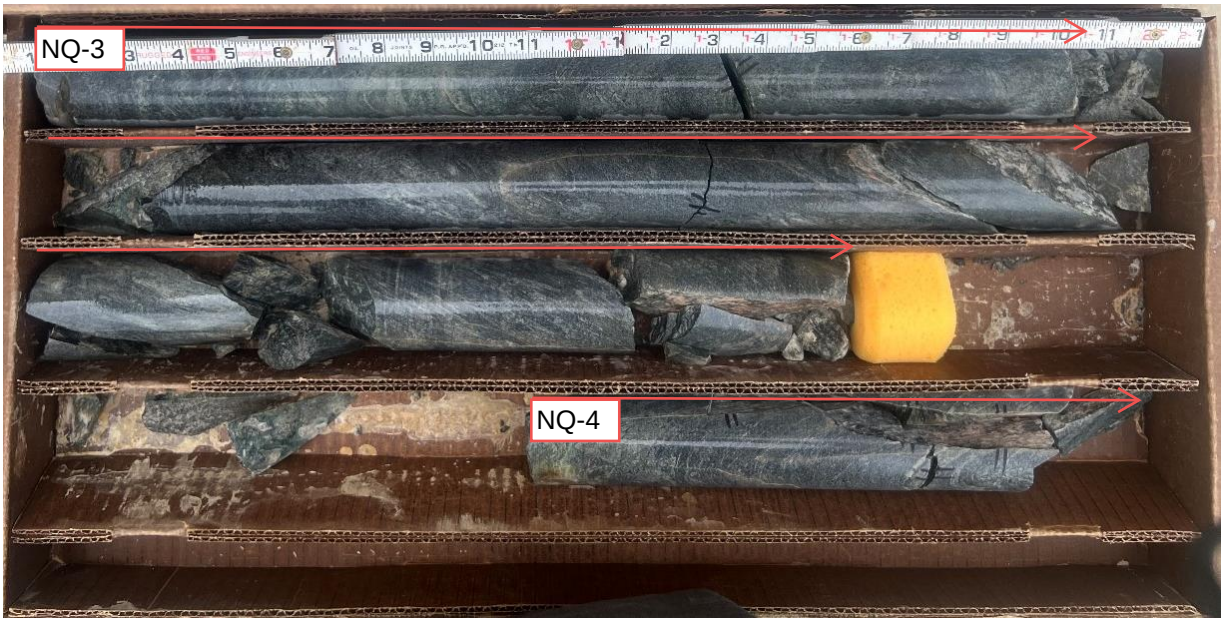
Project Name:	S-29-292 BRO Bear Creek		S-29-292-2
Project ID:	P041170	Test Hole No.:	(Bulk)
Consultant Firm:	Terracon Consultants, Inc.	Station:	17+54.72
Grouted By (Driller's Name):	Truesdale Date 6/6/23	Offset:	5.33 L
Notes:	Mix design: 1 pound cement, 1 pound bentonite, 6 pounds water		

Grout Curve



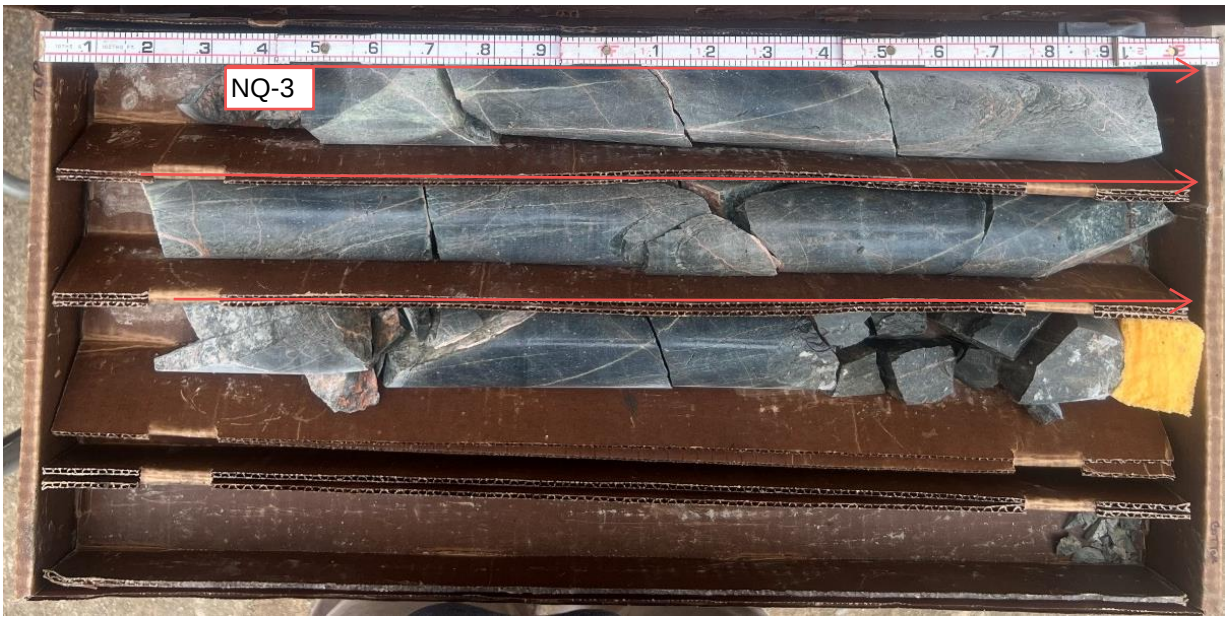
Number of Bags On-Site	20	ea.
Depth of Test Hole Grouted	5	ft.
Diameter of Test Hole	0.5	ft.
Area of Test Hole	0.20	ft^2
Volume of Test Hole	0.99	ft^3
Volume of Casing (If applicable)	-	ft^3
Theoretical Volume of Test Hole	0.99	ft^3
Number of Bags Used	2	ea.
Volume Placed	1.1	ft^3

S-29-292-1, NQ-1 and NQ-2



S-29-292-1 NQ-3 and NQ-4

S-29-292-2, NQ-1 and NQ-2

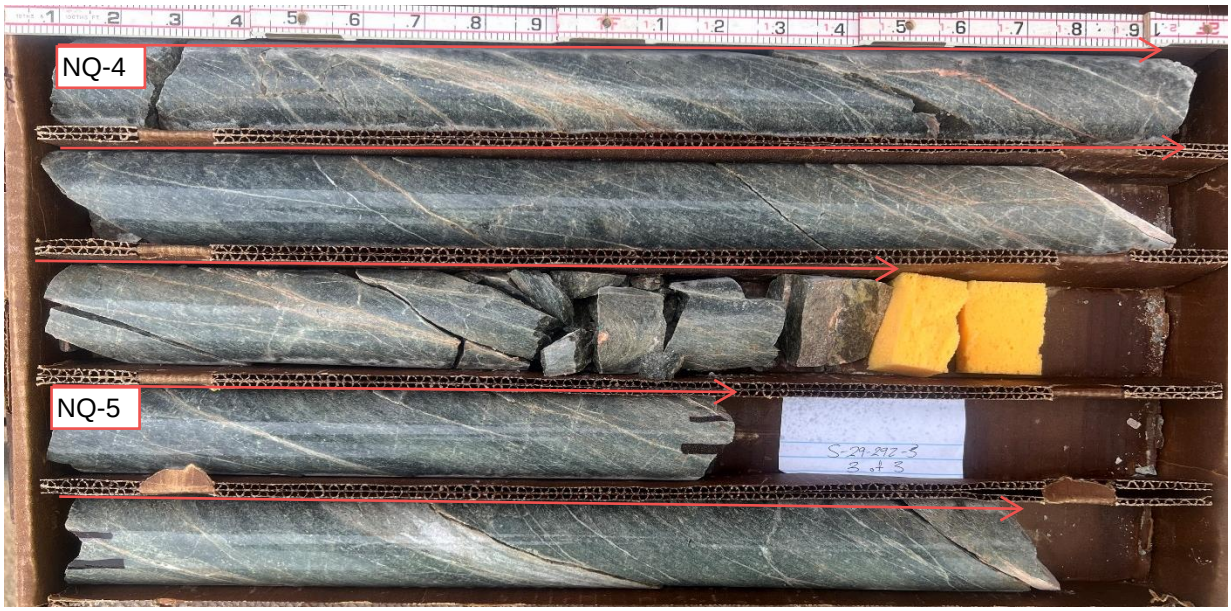


S-29-292-2, NQ-3

S-29-292-2, NQ-4

S-29-292-3, NQ-1 and NQ-2

S-29-292-3, NQ-3



S-29-292-3, NQ-4 and NQ-5

Appendix B
Laboratory Testing

Exhibit B-1 – Laboratory Testing Description
Summary of Laboratory Data
Laboratory Data Sheets (23 Pages)

Note: All exhibits are one page unless noted above.

Laboratory Testing Description

The samples collected during the field exploration were taken to our laboratory for additional testing. The laboratory testing scope was developed by the SCDOT and laboratory assignment was performed by Terracon. The laboratory tests were conducted on selected soil samples from the borings and the bulk samples locations. The test results are presented in this appendix.

The laboratory test results were used to confirm the soil descriptions presented on the boring logs in Appendix A. Laboratory tests were performed in general accordance with the applicable ASTM, AASHTO, SCDOT or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

■ Moisture Content	AASHTO T265/(ASTM D2216)
■ Atterberg Limits	AASHTO T89/T90(ASTM D4318)
■ Wash 200	AASHTO T11/(ASTM D1140)
■ Triaxial Shear CU w/ PP	AASHTO T297/(ASTM D4767)
■ Grain Size Distribution	ASTM D6913
■ Hydrometer	ASTM D7928
■ Corrosion Series	AASHTO D422
	AASHTO T289/ASTM G51
	AASHTO T290/ASTM C1580
	AASHTO T291

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth (Ft.)	Soil Classification USCS & AASHTO	Liquid Limit	Plastic Limit	Plasticity Index	% Fines	% Gravel	% Sand	% Silt	% Clay	Water Content (%)
S-29-292-2 Bulk	0-5	LEAN CLAY with SAND(CL) / A-4 (5)	30	21	9	71.8					7.9
S-29-292-1	2.3-4.3	SANDY LEAN CLAY(CL) / A-6 (6)	33	15	18	50.7					20.6
S-29-292-1	8.3-10.3					96.9	0.0	3.1	66.2	30.7	23.3
S-29-292-1	13	SILT(ML) / A-4 (0)	NP	NP	NP	91.9					24.4
S-29-292-2	6.3-8.3	SILT(ML) / A-4 (0)	NP	NP	NP	91.4					25.3
S-29-292-2	12.3-14.3	SILT(ML) / A-4 (0)	NP	NP	NP	88.0	0.0	12.0	66.8	21.1	27.5
S-29-292-2	20.3-22.3	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	16.0					21.3
S-29-292-2	26					20.3					12.3
S-29-292-3	9-11					38.0	0.5	61.5	27.7	10.4	24.2
S-29-292-3	15-17	SILTY SAND(SM) / A-4 (0)	NP	NP	NP	49.8	0.0	50.2	30.8	19.0	27.3
S-29-292-3	19-21					12.8	26.0	61.2	9.0	3.8	
S-29-292-3	23-24.5					15.5					14.5

PROJECT: S-29-292 BRO Bear Creek

SITE: Lancaster County, SC

Terracon
521 Clemson Rd
Columbia, SC
PH. 803-741-9000 FAX. 803-741-9900

PROJECT NUMBER: 7323P100

CLIENT: NHTB

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART LAB SUMMARY-LANDSCAPE_A S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23

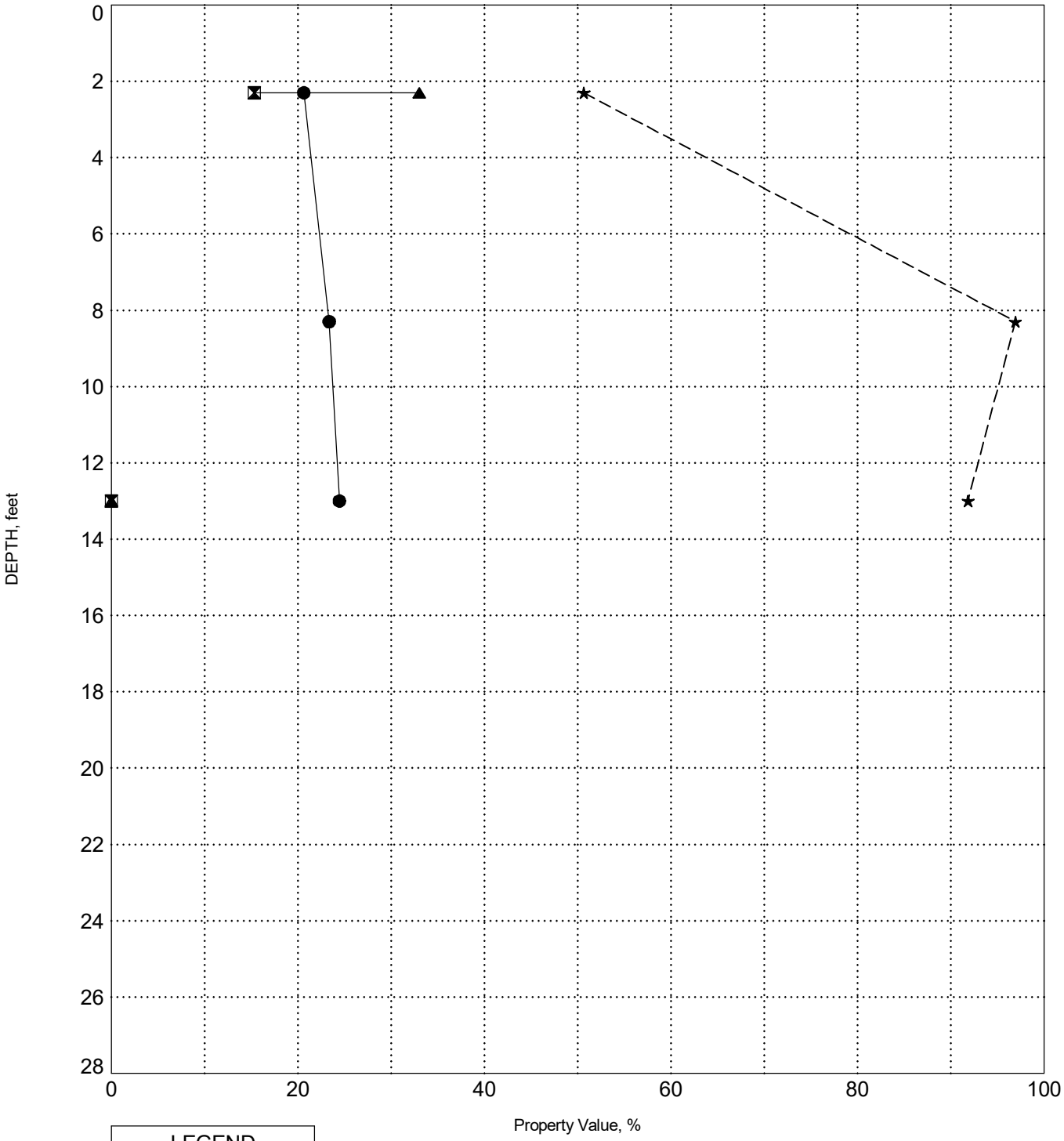
INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041170 **PROJECT NAME** S-29-292 BRO Bear Creek

PROJECT COUNTY Lancaster

BORING S-29-292-1

SURFACE ELEVATION: 436.7



LEGEND
● Water Content
⊠ Plastic Limit
▲ Liquid Limit
★ Fines

INDEX PROPS SCDOT S-29-292 BEAR CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/18/23

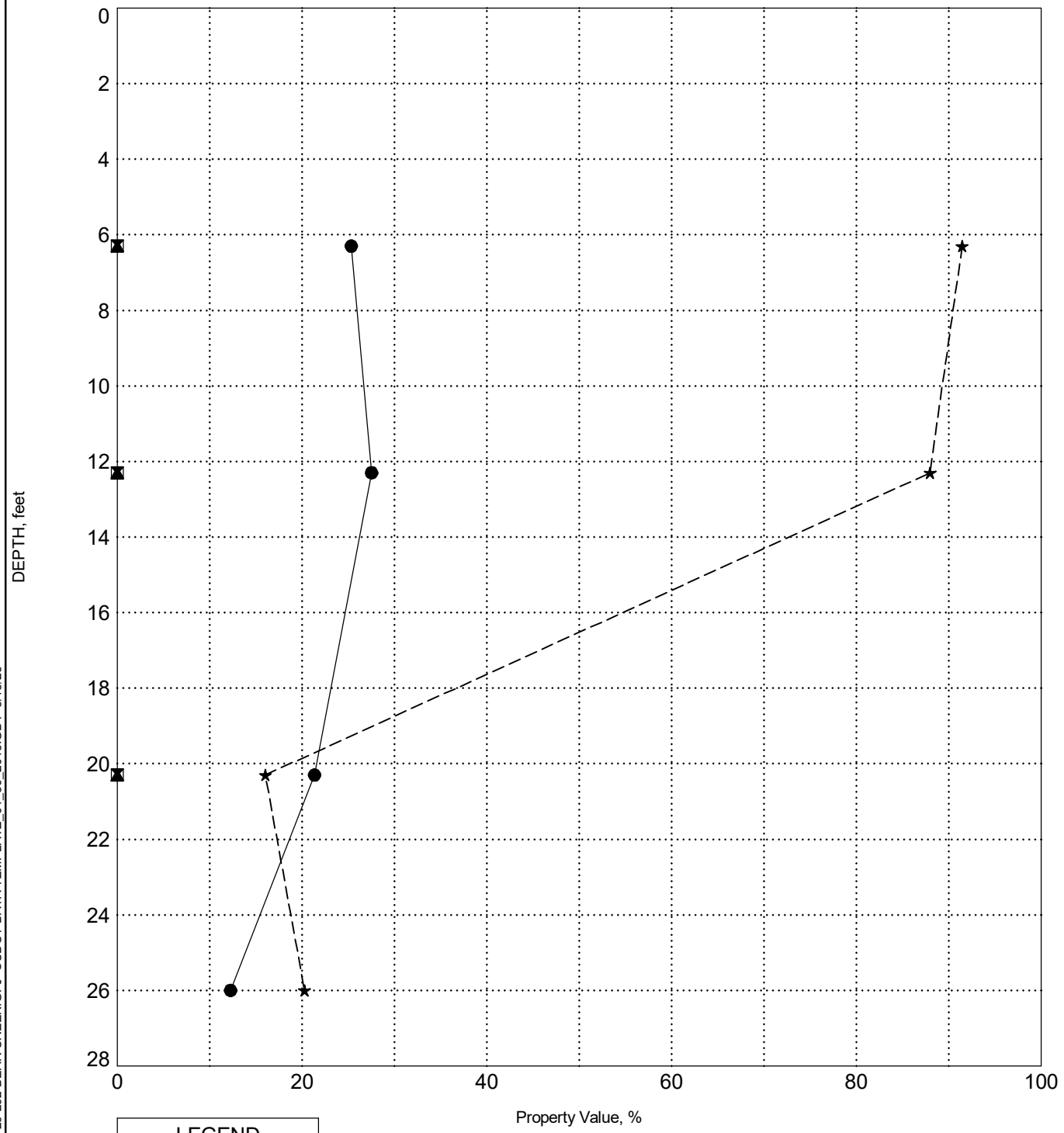
INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041170 **PROJECT NAME** S-29-292 BRO Bear Creek

PROJECT COUNTY Lancaster

BORING S-29-292-2

SURFACE ELEVATION: 435.8



LEGEND
● Water Content
⧗ Plastic Limit
▲ Liquid Limit
★ Fines

INDEX PROPS SCDOT S-29-292 BEAR CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/18/23

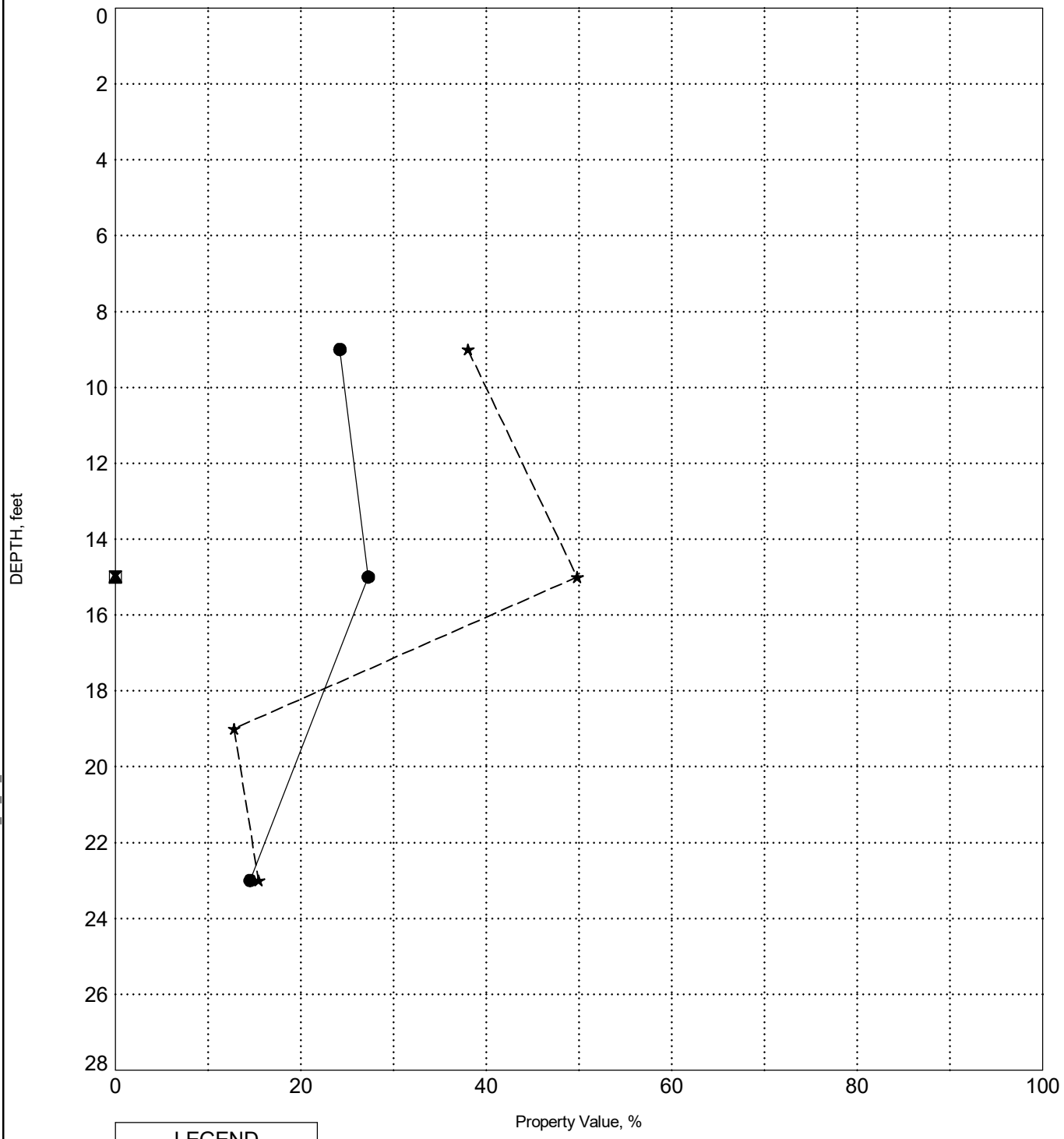
INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041170 **PROJECT NAME** S-29-292 BRO Bear Creek

PROJECT COUNTY Lancaster

BORING S-29-292-3

SURFACE ELEVATION: 439.2

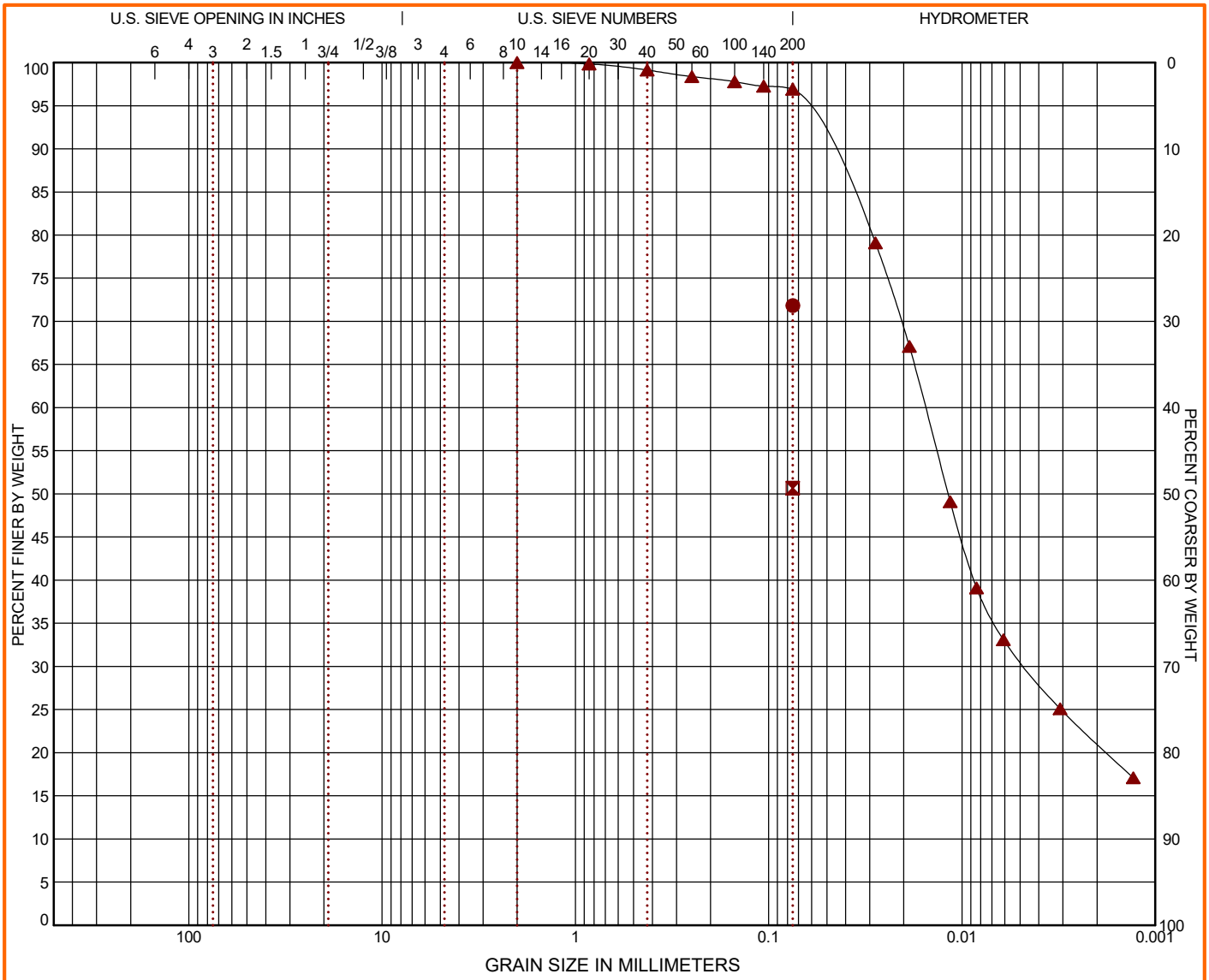


LEGEND
● Water Content
⊠ Plastic Limit
▲ Liquid Limit
★ Fines

INDEX PROPS SCDOT S-29-292 BEAR CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/18/23

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	S-29-292-2 Bulk	0 - 5					71.8		CL
⊠	S-29-292-1	2.3 - 4.3					50.7		CL
▲	S-29-292-1	8.3 - 10.3	0.0	0.0	3.1	66.2		30.7	

GRAIN SIZE	●	⊠	▲
D_{60}			0.015
D_{30}			0.005
D_{10}			

COEFFICIENTS	●	⊠	▲
C_C			
C_U			

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
#200	71.83	#200	50.66	#10	100.0
				#20	99.84
				#40	99.13
				#60	98.36
				#100	97.78
				#140	97.27
				#200	96.93

	SOIL DESCRIPTION
●	A-4 (5)
⊠	A-6 (6)
▲	

	REMARKS
●	
⊠	
▲	

PROJECT: S-29-292 BRO Bear Creek

PROJECT NUMBER: 7323P100

SITE: Lancaster County, SC

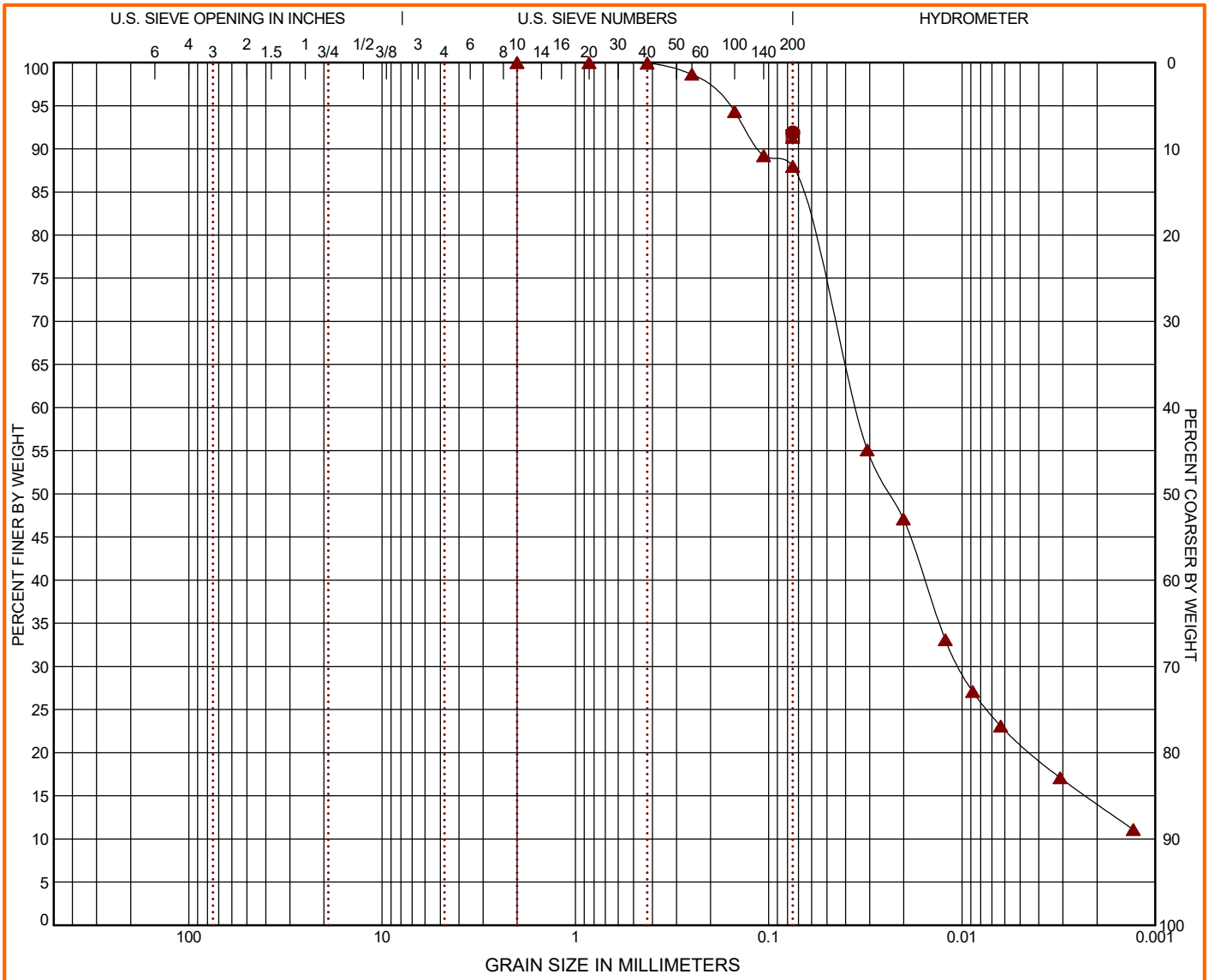
Terracon
521 Clemson Rd
Columbia, SC

CLIENT: NHTB

GRAIN SIZE: AASHTO DESC-1 S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	S-29-292-1	13					91.9		ML
⊠	S-29-292-2	6.3 - 8.3					91.4		ML
▲	S-29-292-2	12.3 - 14.3	0.0	0.0	12.0	66.8		21.1	ML

GRAIN SIZE

	●	⊠	▲
D_{60}			0.035
D_{30}			0.01
D_{10}			

COEFFICIENTS

	●	⊠	▲
C_C			
C_U			

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#200	91.85	#200	91.44	#10	100.0
				#20	99.98
				#40	99.94
				#60	98.65
				#100	94.31
				#140	89.21
				#200	87.96

SOIL DESCRIPTION

●	A-4 (0)
⊠	A-4 (0)
▲	A-4 (0)

REMARKS

●	
⊠	
▲	

PROJECT: S-29-292 BRO Bear Creek

PROJECT NUMBER: 7323P100

SITE: Lancaster County, SC

CLIENT: NHTB

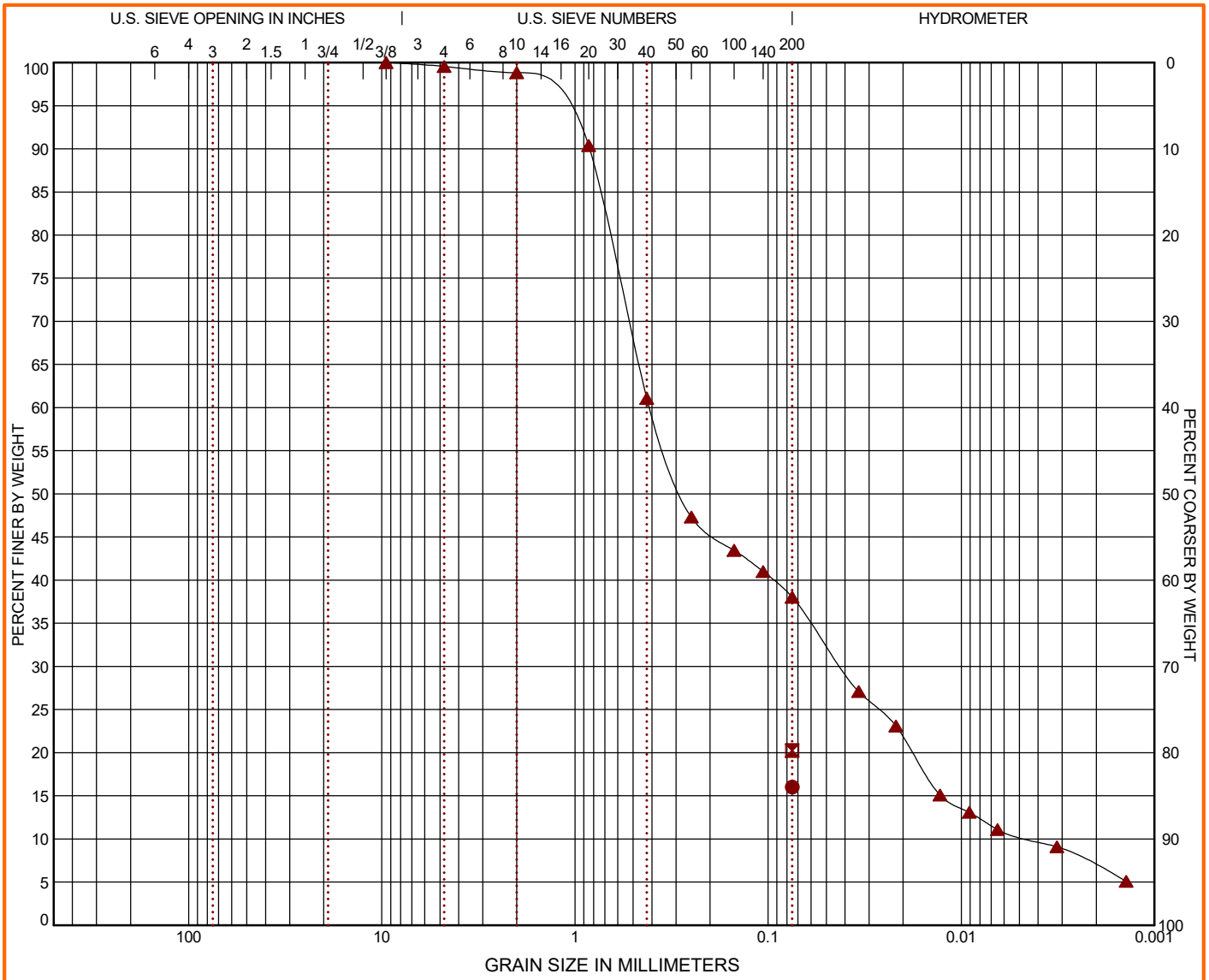
Terracon
521 Clemson Rd
Columbia, SC

GRAIN SIZE: AASHTO DESC-1 S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	S-29-292-2	20.3 - 22.3					16.0		SM
⊠	S-29-292-2	26					20.3		
▲	S-29-292-3	9 - 11	0.0	0.5	61.5	27.7		10.4	

GRAIN SIZE

	●	⊠	▲
D_{60}			0.408
D_{30}			0.042
D_{10}			0.004

COEFFICIENTS

	●	⊠	▲
C_C			0.98
C_U			92.49

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
#200	16.02	#200	20.25	3/8"	100.0
				#4	99.54
				#10	98.82
				#20	90.38
				#40	61.06
				#60	47.31
				#100	43.46
				#140	40.99
				#200	38.03

SOIL DESCRIPTION

●	A-2-4 (0)
⊠	
▲	

REMARKS

●	
⊠	
▲	

PROJECT: S-29-292 BRO Bear Creek

PROJECT NUMBER: 7323P100

SITE: Lancaster County, SC

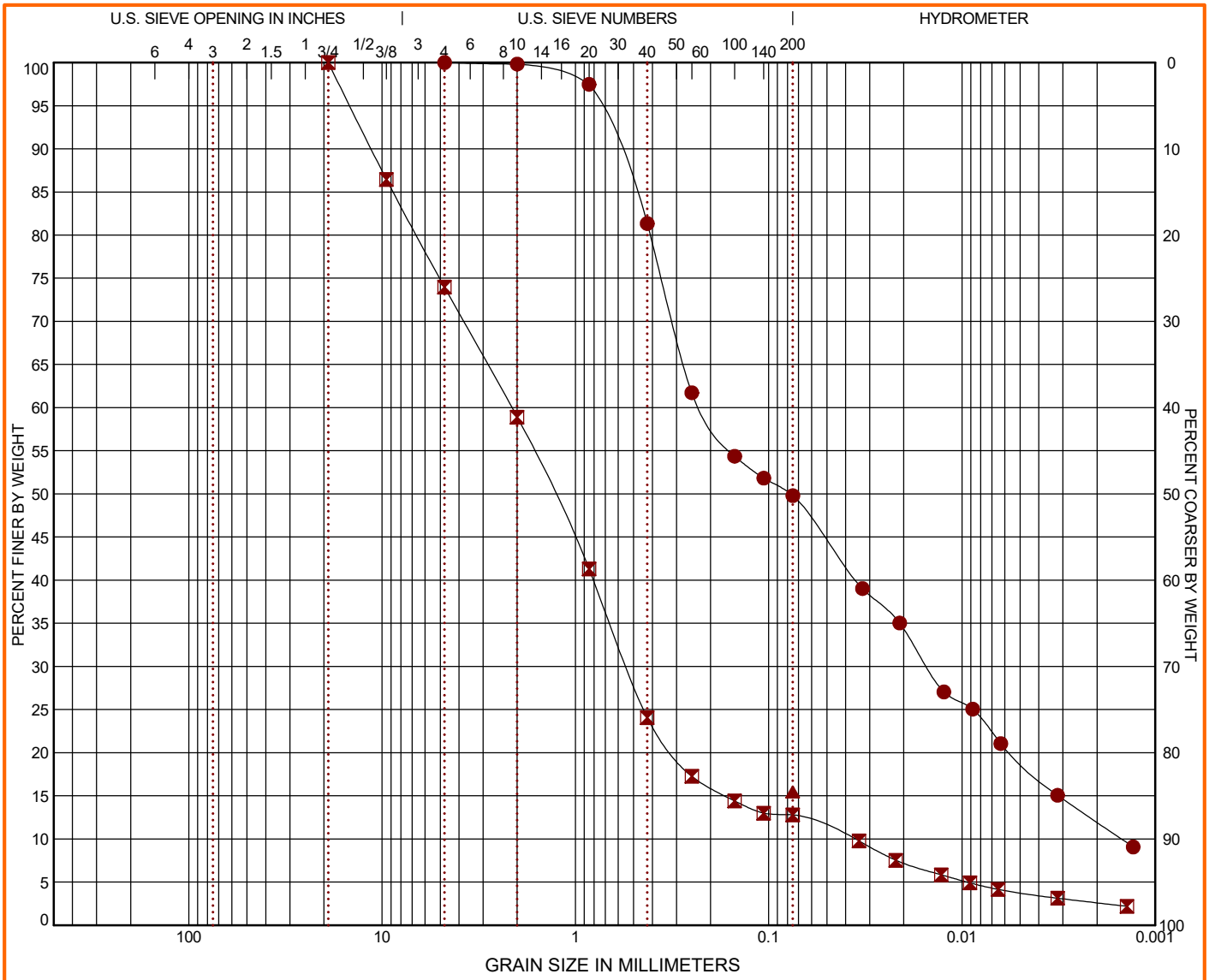
CLIENT: NHTB

Terracon
521 Clemson Rd
Columbia, SC

GRAIN SIZE: AASHTO DESC-1 S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	S-29-292-3	15 - 17	0.0	0.0	50.2	30.8		19.0	SM
⊠	S-29-292-3	19 - 21	0.0	26.0	61.2	9.0		3.8	
▲	S-29-292-3	23 - 24.5					15.5		

GRAIN SIZE

	●	⊠	▲
D_{60}	0.222	2.13	
D_{30}	0.015	0.539	
D_{10}	0.001	0.036	

COEFFICIENTS

	●	⊠	▲
C_C	0.69	3.79	
C_U	148.54	59.10	

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#4	100.0	3/4"	100.0	#200	15.45
#10	99.82	3/8"	86.45		
#20	97.47	#4	73.96		
#40	81.34	#10	58.9		
#60	61.72	#20	41.3		
#100	54.36	#40	24.07		
#140	51.83	#60	17.27		
#200	49.8	#100	14.41		
		#140	13.0		
		#200	12.79		

SOIL DESCRIPTION

●	A-4 (0)
⊠	
▲	

REMARKS

●	
⊠	
▲	

PROJECT: S-29-292 BRO Bear Creek

PROJECT NUMBER: 7323P100

SITE: Lancaster County, SC

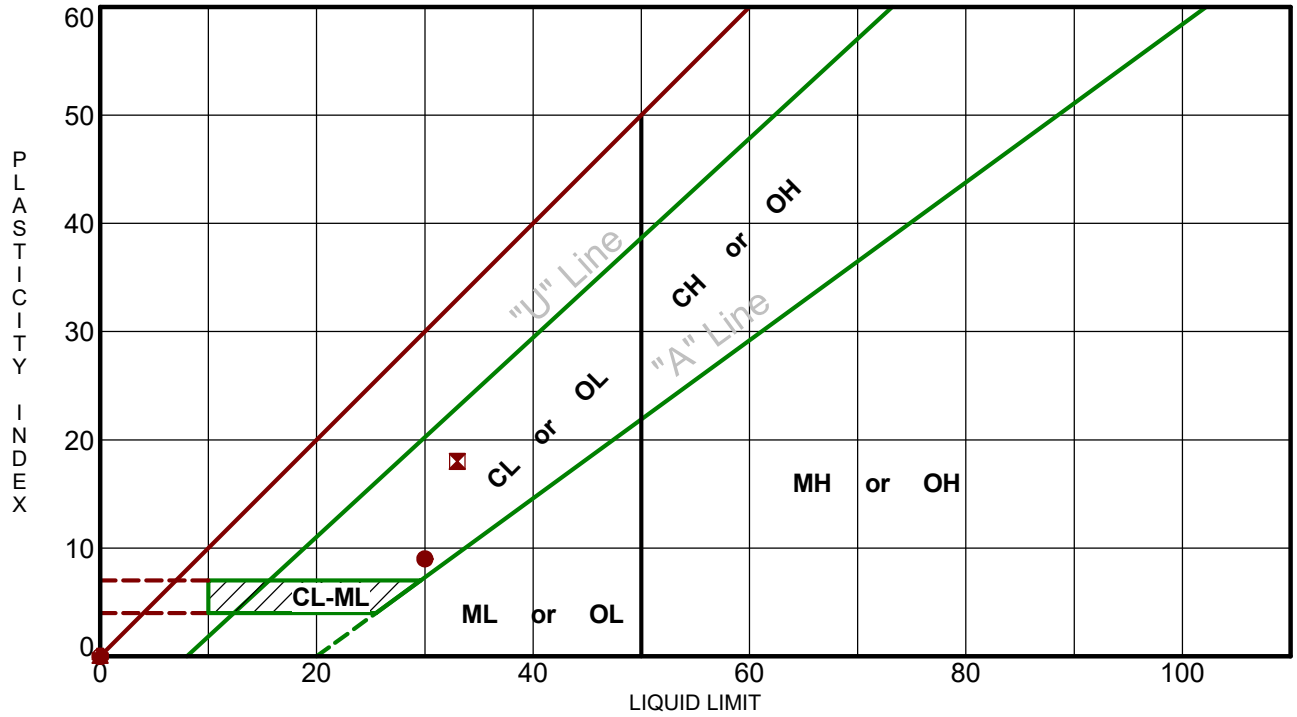
Terracon
521 Clemson Rd
Columbia, SC

CLIENT: NHTB

GRAIN SIZE: AASHTO DESC-1 S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	AASHTO	Description
●	S-29-292-2 Bulk	0 - 5	30	21	9	71.8	A-4 (5)	LEAN CLAY with SAND (CL)
⊠	S-29-292-1	2.3 - 4.3	33	15	18	50.7	A-6 (6)	SANDY LEAN CLAY (CL)
▲	S-29-292-1	13	NP	NP	NP	91.9	A-4 (0)	SILT (ML)
★	S-29-292-2	6.3 - 8.3	NP	NP	NP	91.4	A-4 (0)	SILT (ML)
⊙	S-29-292-2	12.3 - 14.3	NP	NP	NP	88.0	A-4 (0)	SILT (ML)
✿	S-29-292-2	20.3 - 22.3	NP	NP	NP	16.0	A-2-4 (0)	SILTY SAND (SM)
○	S-29-292-3	15 - 17	NP	NP	NP	49.8	A-4 (0)	SILTY SAND (SM)

PROJECT: S-29-292 BRO Bear Creek

SITE: Lancaster County, SC

Terracon
521 Clemson Rd
Columbia, SC

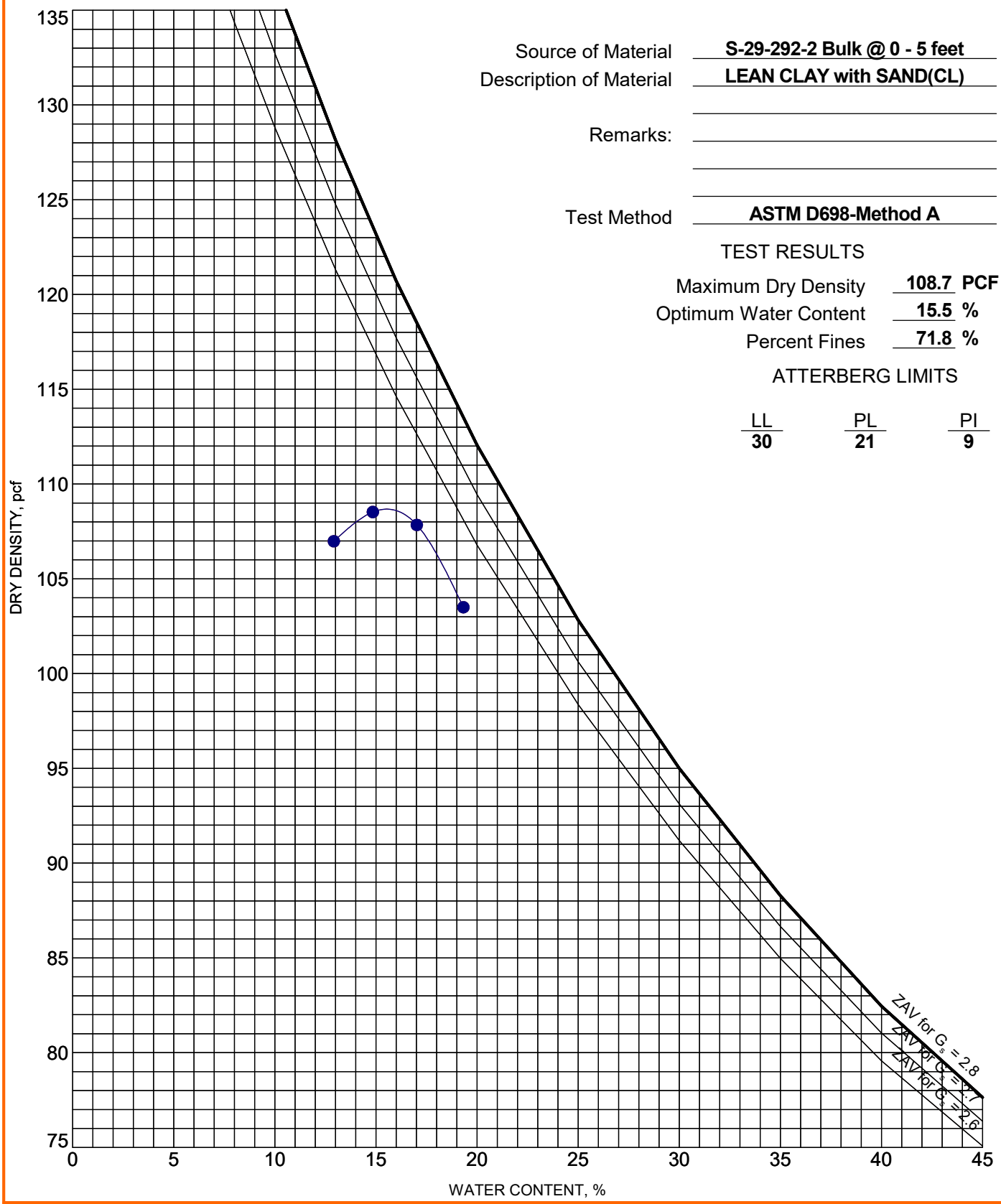
PROJECT NUMBER: 7323P100

CLIENT: NHTB

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS-AASHTO S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**S-29-292-2 Bulk @ 0 - 5 feet**
Description of Material	**LEAN CLAY with SAND(CL)**
Remarks:	
Test Method	**ASTM D698-Method A**

TEST RESULTS

Maximum Dry Density	**108.7**	**PCF**
Optimum Water Content	**15.5**	**%**
Percent Fines	**71.8**	**%**

ATTERBERG LIMITS

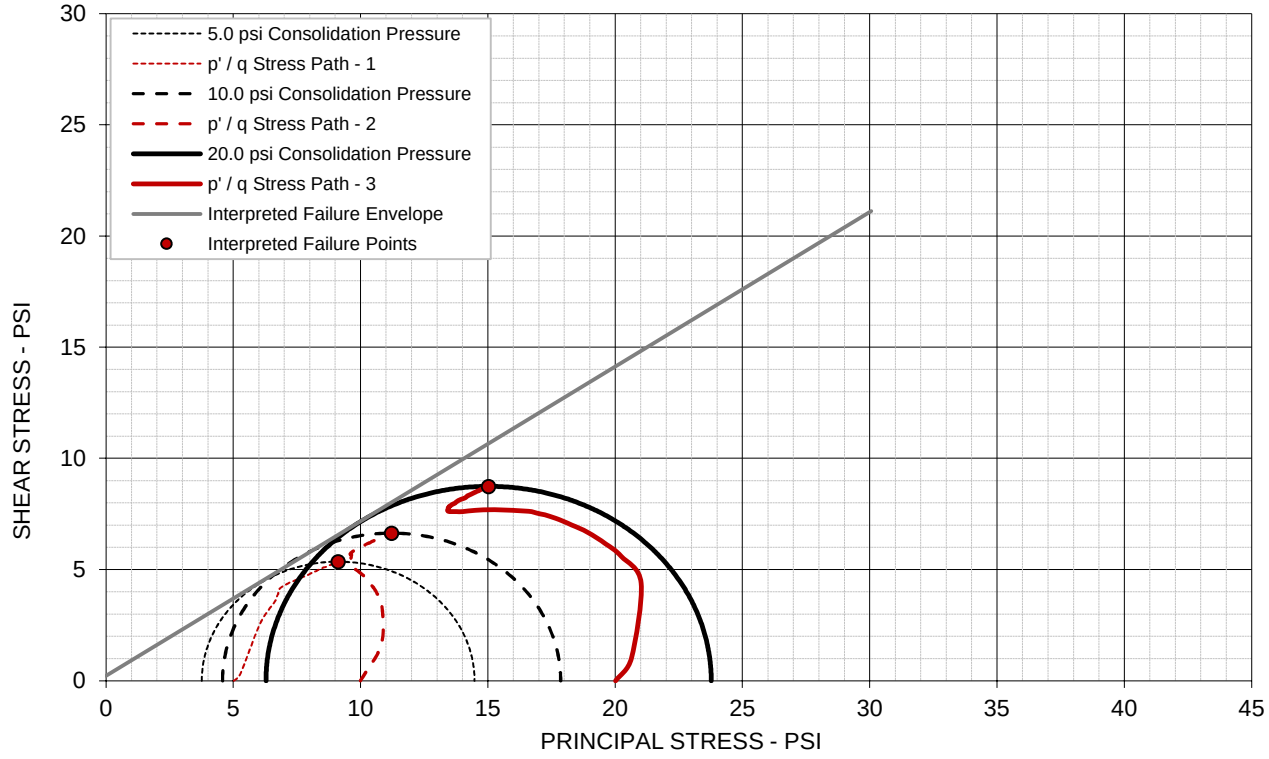
LL	PL	PI
30	**21**	**9**

PROJECT: S-29-292 BRO Bear Creek	Terracon 521 Clemson Rd Columbia, SC	PROJECT NUMBER: 7323P100
SITE: Lancaster County, SC		CLIENT: NHTB

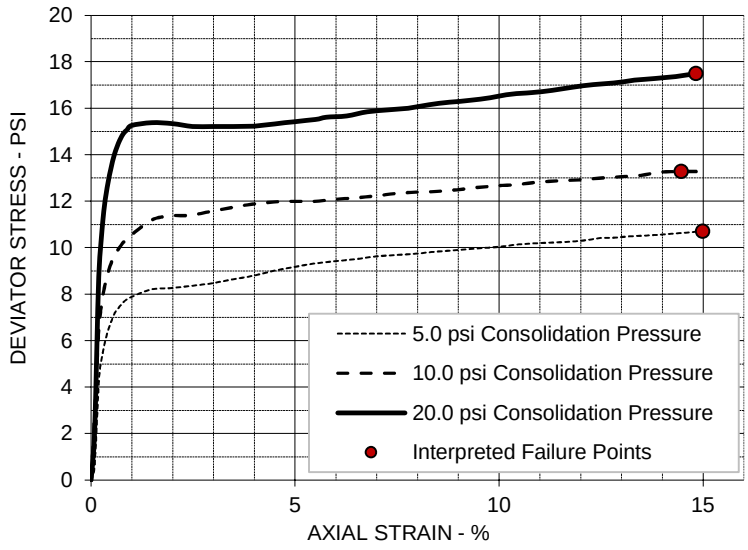
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 S-29-292 BEAR CREEK.GPJ TERRACON_DATATEMPLATE.GDT 8/16/23

ICU TRIAXIAL COMPRESSION TEST
ASTM D4767 / AASHTO T297

Failure Criteria: Max Deviator Stress



EFFECTIVE STRESS PARAMETERS	ϕ' = 34.8 deg	c' = 0.2 psi



SPECIMEN NO.	1	2	3
INITIAL			
Moisture Content - %	15.6	15.6	15.6
Dry Density - pcf	103.3	103.3	103.2
Diameter - inches	2.86	2.86	2.86
Height - inches	6.00	6.00	6.00
AT TEST			
Final Moisture - %	22.1	21.5	20.8
Dry Density - pcf	103.4	103.9	105.5
Calculated Diameter (in.)	2.85	2.84	2.84
Height - inches	5.97	5.96	5.95
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	10.71	13.28	17.49
Total Pore Pressure - psi	81.3	85.4	93.7
Strain Rate - %/min.	0.0333	0.0332	0.0335
Failure Strain - %	15.0	14.5	14.8
σ_1' Failure - psi	14.47	17.86	23.77
σ_3' Failure - psi	3.76	4.58	6.28

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)

SAMPLE ID: S-29-292-2 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 30 PL: 21 PI: 9 Percent -200: 71.8%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-29-292 Bear Creek

LOCATION: Lancaster County, SC

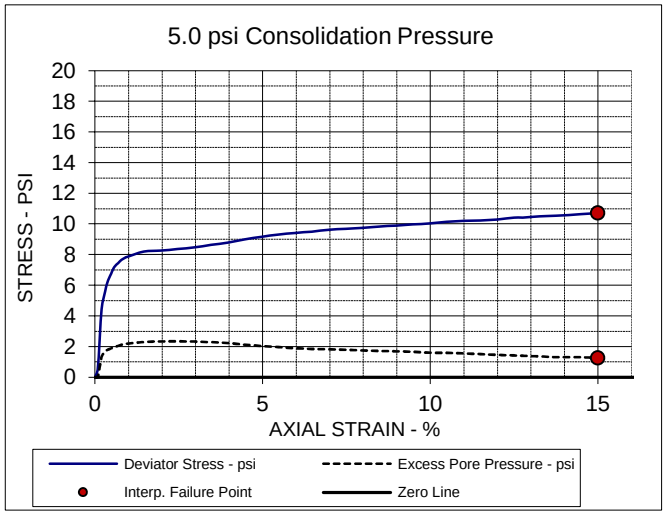
PROJECT #: 7323P100

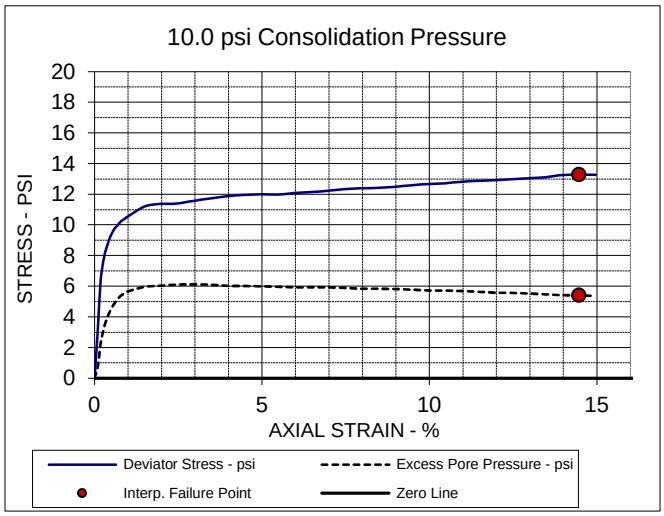
CLIENT: SCDOT

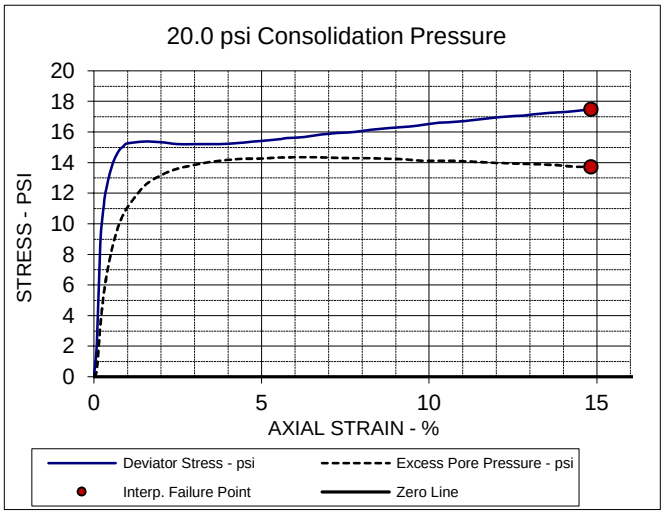
DATE: 06/16/23

521 Clemson Road
Columbia, SC

Terracon

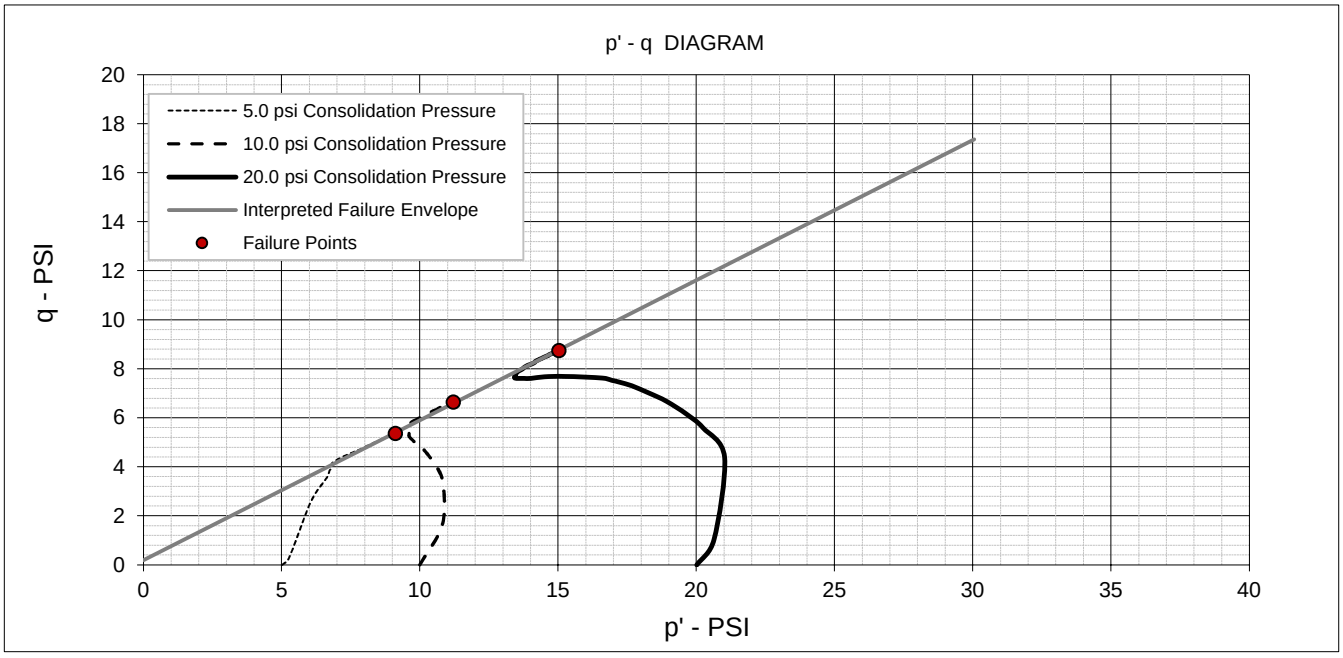






SPECIMEN FAILURE ILLUSTRATIONS

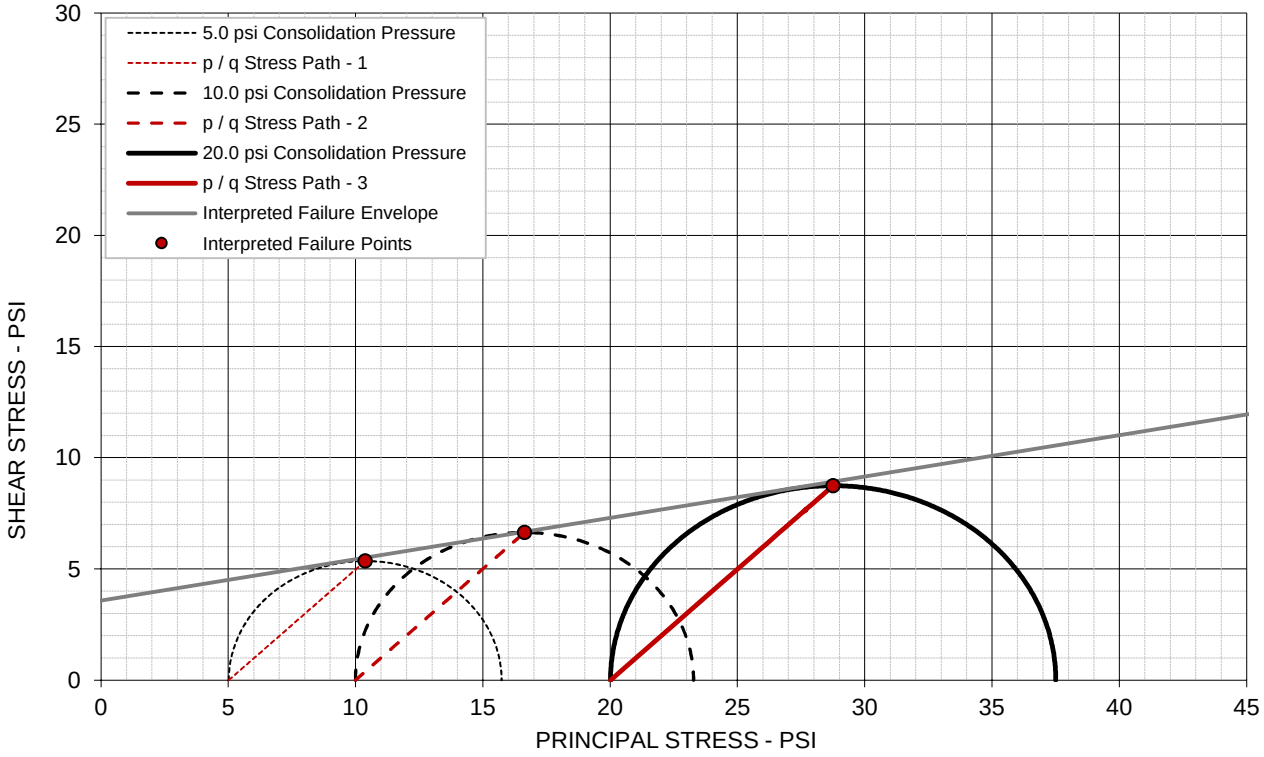
1 2 3



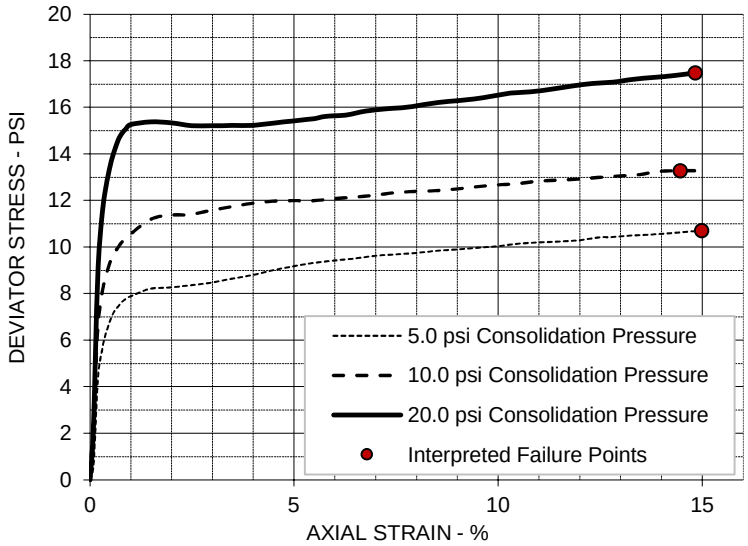
EFFECTIVE STRESS PARAMETERS R^2 = 1.00	α = 29.7 deg	a = 0.2 psi
PROJECT: S-29-292 Bear Creek	ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST	
LOCATION: Lancaster County, SC	CLIENT: SCDOT	
SAMPLE ID: S-29-292-2 Bulk 0-5' DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)	**521 Clemson Road** **Columbia, SC**	Terracon

ICU TRIAXIAL COMPRESSION TEST
ASTM D4767 / AASHTO T297

Failure Criteria: Max Deviator Stress



TOTAL STRESS PARAMETERS	ϕ = 10.5 deg	c = 3.6 psi



SPECIMEN NO.	1	2	3
INITIAL			
Moisture Content - %	15.6	15.6	15.6
Dry Density - pcf	103.3	103.3	103.2
Diameter - inches	2.86	2.86	2.86
Height - inches	6.00	6.00	6.00
AT TEST			
Final Moisture - %	22.1	21.5	20.8
Dry Density - pcf	103.4	103.9	105.5
Calculated Diameter (in.)	2.85	2.84	2.84
Height - inches	5.97	5.96	5.95
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	10.71	13.28	17.49
Total Pore Pressure - psi	81.3	85.4	93.7
Strain Rate - %/min.	0.0333	0.0332	0.0335
Failure Strain - %	15.0	14.5	14.8
σ_1 Failure - psi	15.73	23.27	37.50
σ_3 Failure - psi	5.02	9.99	20.01

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)

SAMPLE ID: S-29-292-2 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 30 PL: 21 PI: 9 Percent -200: 71.8%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-29-292 Bear Creek

LOCATION: Lancaster County, SC

PROJECT #: 7323P100

CLIENT: SCDOT

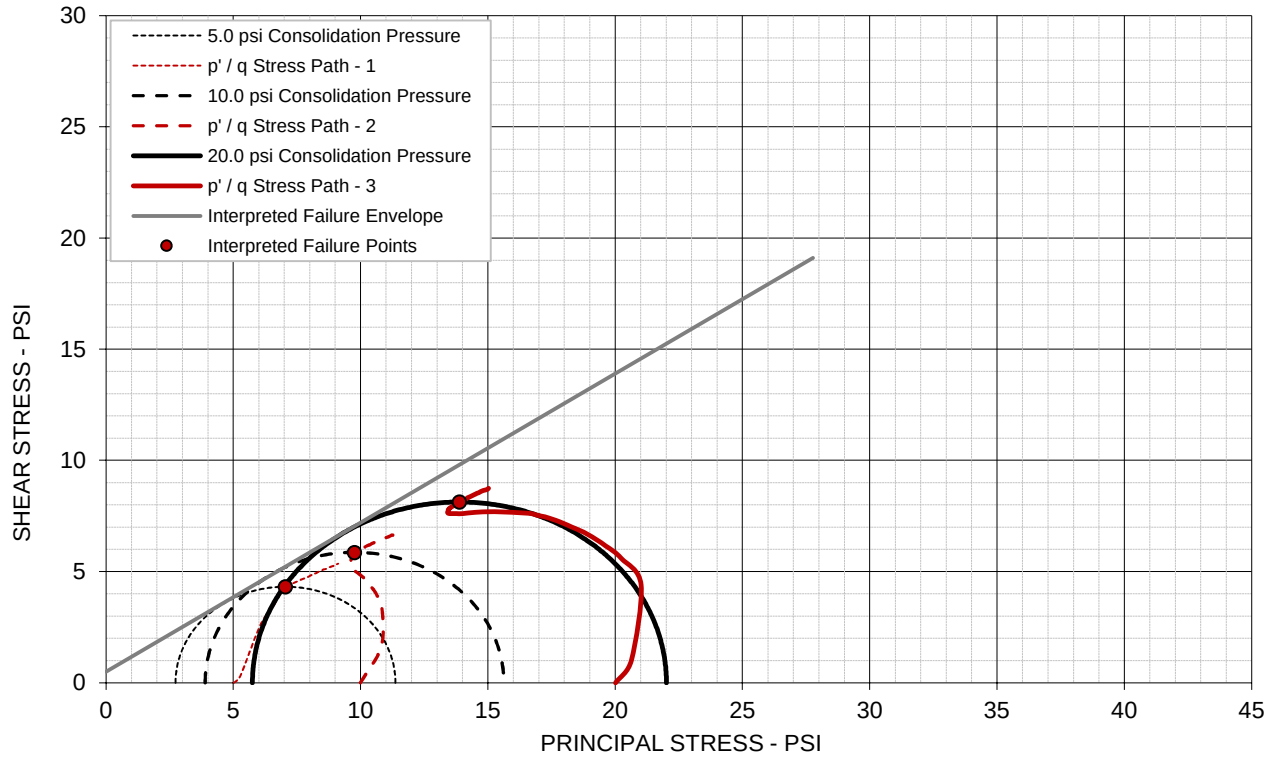
DATE: 06/16/23

521 Clemson Road
Columbia, SC

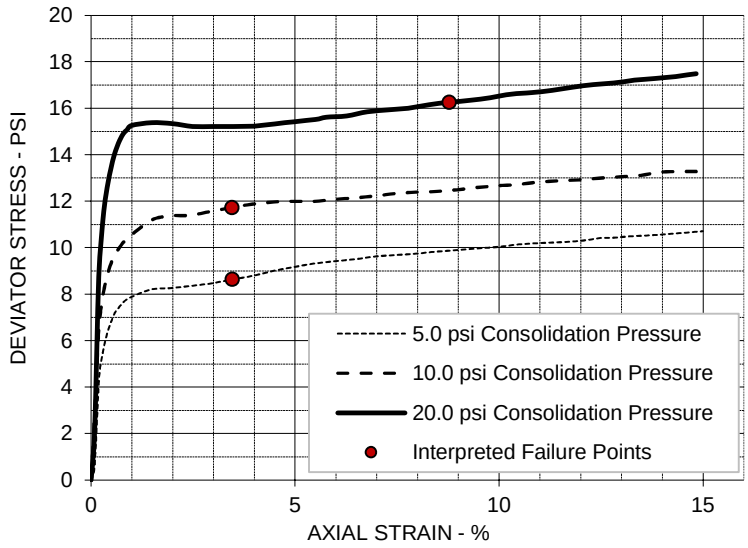
Terracon

ICU TRIAXIAL COMPRESSION TEST
ASTM D4767 / AASHTO T297

Failure Criteria: Max Obliquity (s1': s3')



EFFECTIVE STRESS PARAMETERS	ϕ' = 33.8 deg	c' = 0.5 psi



SPECIMEN NO.	1	2	3
INITIAL			
Moisture Content - %	15.6	15.6	15.6
Dry Density - pcf	103.3	103.3	103.2
Diameter - inches	2.86	2.86	2.86
Height - inches	6.00	6.00	6.00
AT TEST			
Final Moisture - %	22.1	21.5	20.8
Dry Density - pcf	103.4	103.9	105.5
Calculated Diameter (in.)	2.85	2.84	2.84
Height - inches	5.97	5.96	5.95
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	8.64	11.73	16.26
Total Pore Pressure - psi	82.3	86.1	94.3
Strain Rate - %/min.	0.0333	0.0332	0.0335
Failure Strain - %	3.5	3.5	8.8
σ_1' Failure - psi	11.37	15.62	22.01
σ_3' Failure - psi	2.73	3.89	5.75

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)

SAMPLE ID: S-29-292-2 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 30 PL: 21 PI: 9 Percent -200: 71.8%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-29-292 Bear Creek

LOCATION: Lancaster County, SC

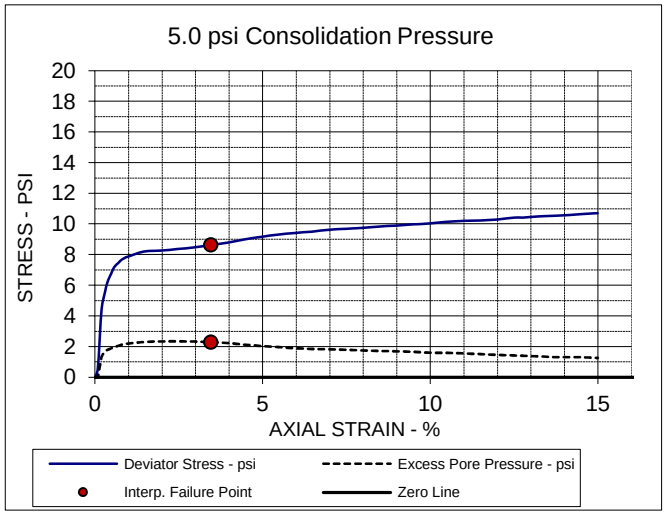
PROJECT #: 7323P100

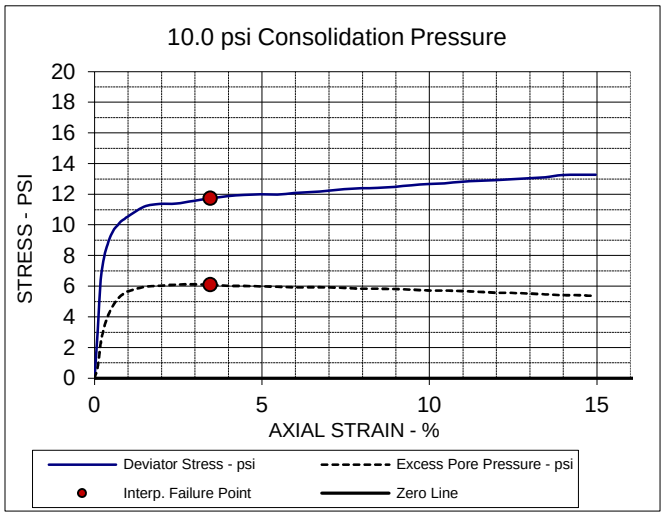
CLIENT: SCDOT

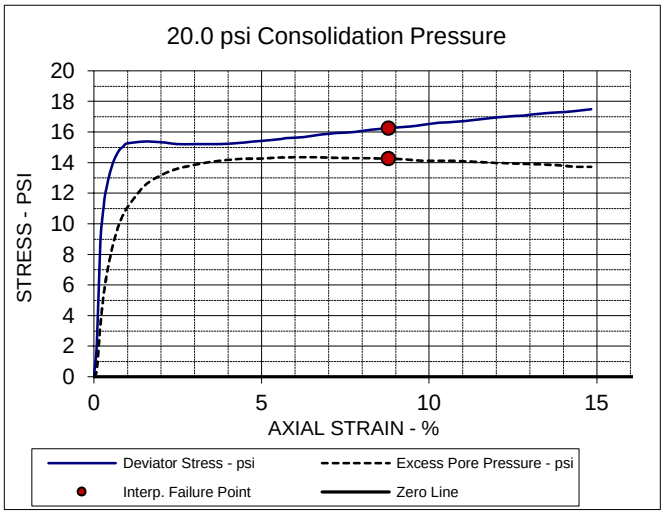
DATE: 06/16/23

521 Clemson Road
Columbia, SC

Terracon

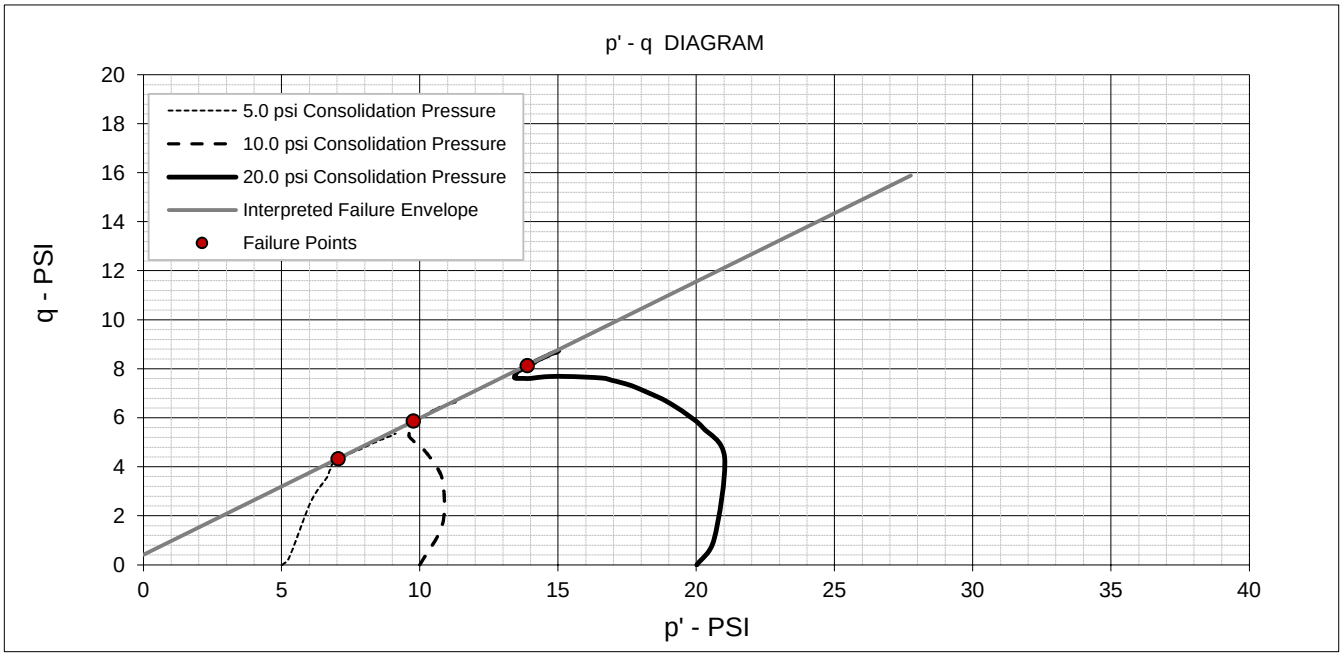






SPECIMEN FAILURE ILLUSTRATIONS

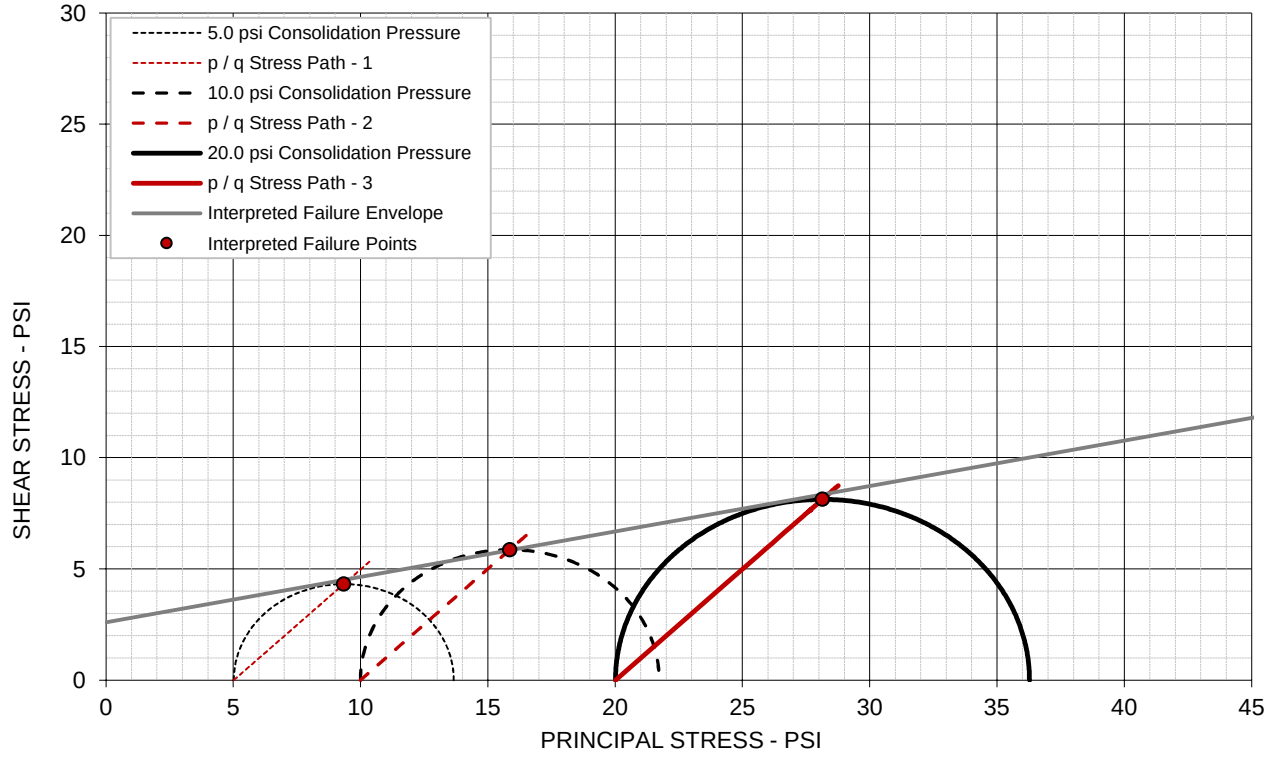
1 2 3



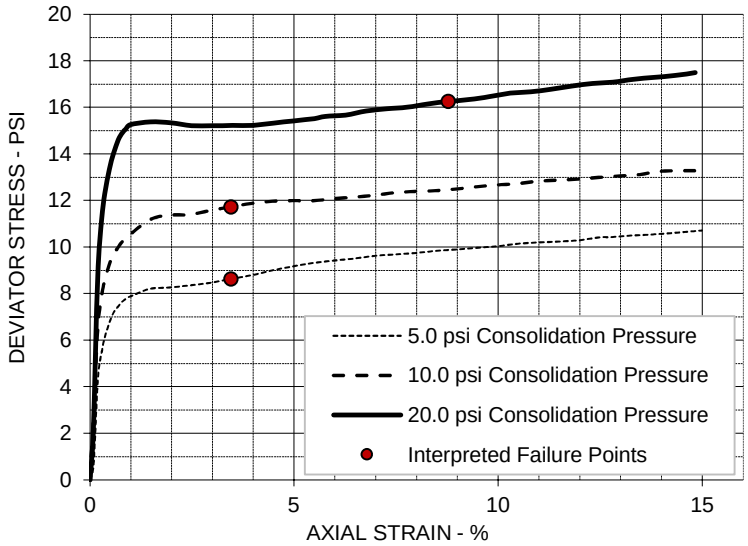
EFFECTIVE STRESS PARAMETERS R^2 = 1.00	α = 29.1 deg	a = 0.4 psi
PROJECT: S-29-292 Bear Creek	ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION TEST	
LOCATION: Lancaster County, SC	CLIENT: SCDOT	
SAMPLE ID: S-29-292-2 Bulk 0-5' DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)	**521 Clemson Road** **Columbia, SC**	Terracon

ICU TRIAXIAL COMPRESSION TEST
ASTM D4767 / AASHTO T297

Failure Criteria: Max Obliquity (s1': s3')



TOTAL STRESS PARAMETERS	ϕ = 11.6 deg	c = 2.6 psi



SPECIMEN NO.	1	2	3
INITIAL			
Moisture Content - %	15.6	15.6	15.6
Dry Density - pcf	103.3	103.3	103.2
Diameter - inches	2.86	2.86	2.86
Height - inches	6.00	6.00	6.00
AT TEST			
Final Moisture - %	22.1	21.5	20.8
Dry Density - pcf	103.4	103.9	105.5
Calculated Diameter (in.)	2.85	2.84	2.84
Height - inches	5.97	5.96	5.95
Effect. Consol. Stress - psi	5.0	10.0	20.0
Failure Stress - psi	8.64	11.73	16.26
Total Pore Pressure - psi	82.3	86.1	94.3
Strain Rate - %/min.	0.0333	0.0332	0.0335
Failure Strain - %	3.5	3.5	8.8
σ_1 Failure - psi	13.66	21.72	36.27
σ_3 Failure - psi	5.02	9.99	20.01

TEST DESCRIPTION

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL COMPRESSION

SAMPLE TYPE: Remolded

DESCRIPTION: Lean Clay with Sand (CL) / A-4 (5)

SAMPLE ID: S-29-292-2 Bulk 0-5'

SPECIFIC GRAVITY: 2.65

LL: 30 PL: 21 PI: 9 Percent -200: 71.8%

Remarks: Remolded to 95% of the Standard Proctor

PROJECT INFORMATION

PROJECT: S-29-292 Bear Creek

LOCATION: Lancaster County, SC

PROJECT #: 7323P100

CLIENT: SCDOT

DATE: 06/16/23

521 Clemson Road
Columbia, SC

Terracon

Client	Project
HNTB North Carolina PC	S-29-292 RBO Bear Creek
Raleigh, NC	7323P100

Date Received: 6/27/2023

Results from Corrosion Testing

Sample Location	S-29-292-2
Sample Depth (ft.)	0'-10'
pH Analysis, ASTM G 51	6.39
Water Soluble Sulfate (SO4), ASTM D516-07 (mg/kg)	29
Chlorides, APHA 4500-Cl^- E, (mg/kg)	28
Resistivity (Saturated), ASTM G 57, (ohm-cm)	5000

Analyzed By: Kyle Lemcke
Laboratory Manager

The tests were performed in general accordance with applicable ASTM and AWWA test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

Rock Coring Summary

PROJECT ID P041170 **PROJECT NAME** S-29-292 BRO Bear Creek

PROJECT COUNTY Lancaster

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q_u (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
S-29-292-1	NQ-1	29.1	58	45						70
S-29-292-1	NQ-2	33.7	96	92						70
S-29-292-1	NQ-3	38.7	100	70	7870	0.02	1166	172	57	70
S-29-292-1	NQ-4	43.7	95	95	17008	0.24	1359	173	69	70
S-29-292-2	NQ-1	49.7	95	0						50
S-29-292-2	NQ-2	53.2	95	0	4602	1.05	745	166	36	60
S-29-292-2	NQ-3	58.2	95	28						70
S-29-292-2	NQ-4	63.2	95	0						50
S-29-292-3	NQ-1	25.5	96	0						50
S-29-292-3	NQ-2	28.0	100	0						40
S-29-292-3	NQ-3	33.0	100	0						50
S-29-292-3	NQ-4	38.0	100	31						70
S-29-292-3	NQ-5	43.0	97	63						70

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

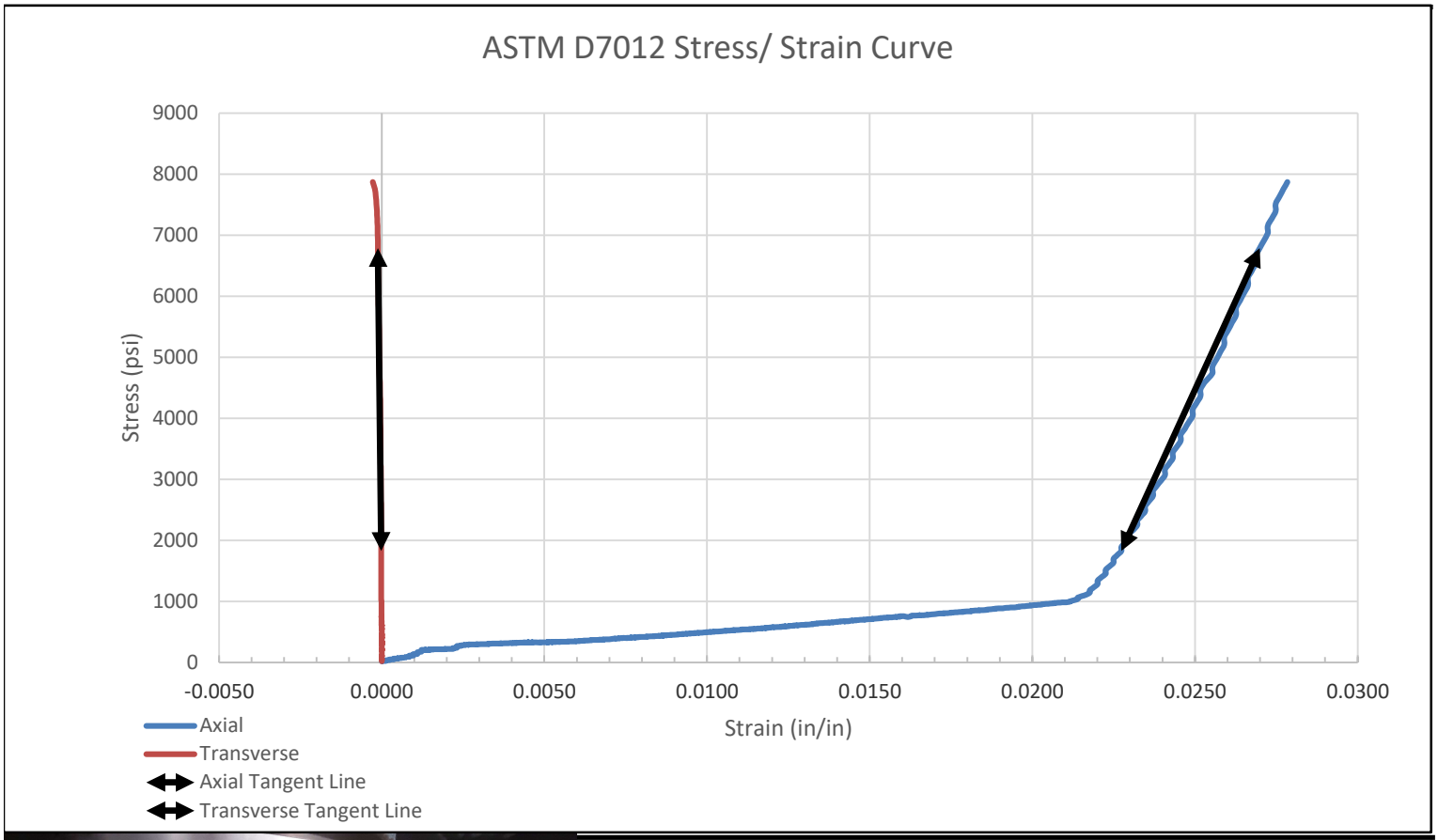
Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100



SAMPLE LOCATION

Site:	S-29-292		
Rock Type:	Metatuff		
Boring:	S-29-292-1	Depth (feet):	38.7

SPECIMEN INFORMATION

Sample No.:	L-4085 (NQ -3)	Mass (g):	567.37
Length (in.):	4.1335	Diameter (in.):	1.97
L/D Ratio:	2.1	Density (pcf):	172.254

TEST RESULTS

Failure Load (lbs):	23892
Failure Strain (%):	2.78
Unconfined Compressive Strength (psi):	7,870
Elastic Modulus, E, (ksi):	1166
Poisson's Ratio, u:	0.023
Time of Failure (min):	02:29
Rate of Loading (psi/sec):	52.822
Moisture Content Post-break:	0.3%

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100

ASTM D4543 Test Results:

Parameter	Data
Side Straightness:	0.0053
Perpendicularity Deviation:	
Diameter 1a:	0.0018
Diameter 1b:	0.0032
Diameter 2a:	0.0024
Diameter 2b:	0.0036
Max Deviation from Flatness:	0.0011
Parallelism Deviation:	
Diameter a:	0.04
Diameter b:	0.43

Equipment:	TICCS ID:
Calipers:	W-44049
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

Samples were prepared and tested in general accordance with ASTM D4543 and D7012.

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

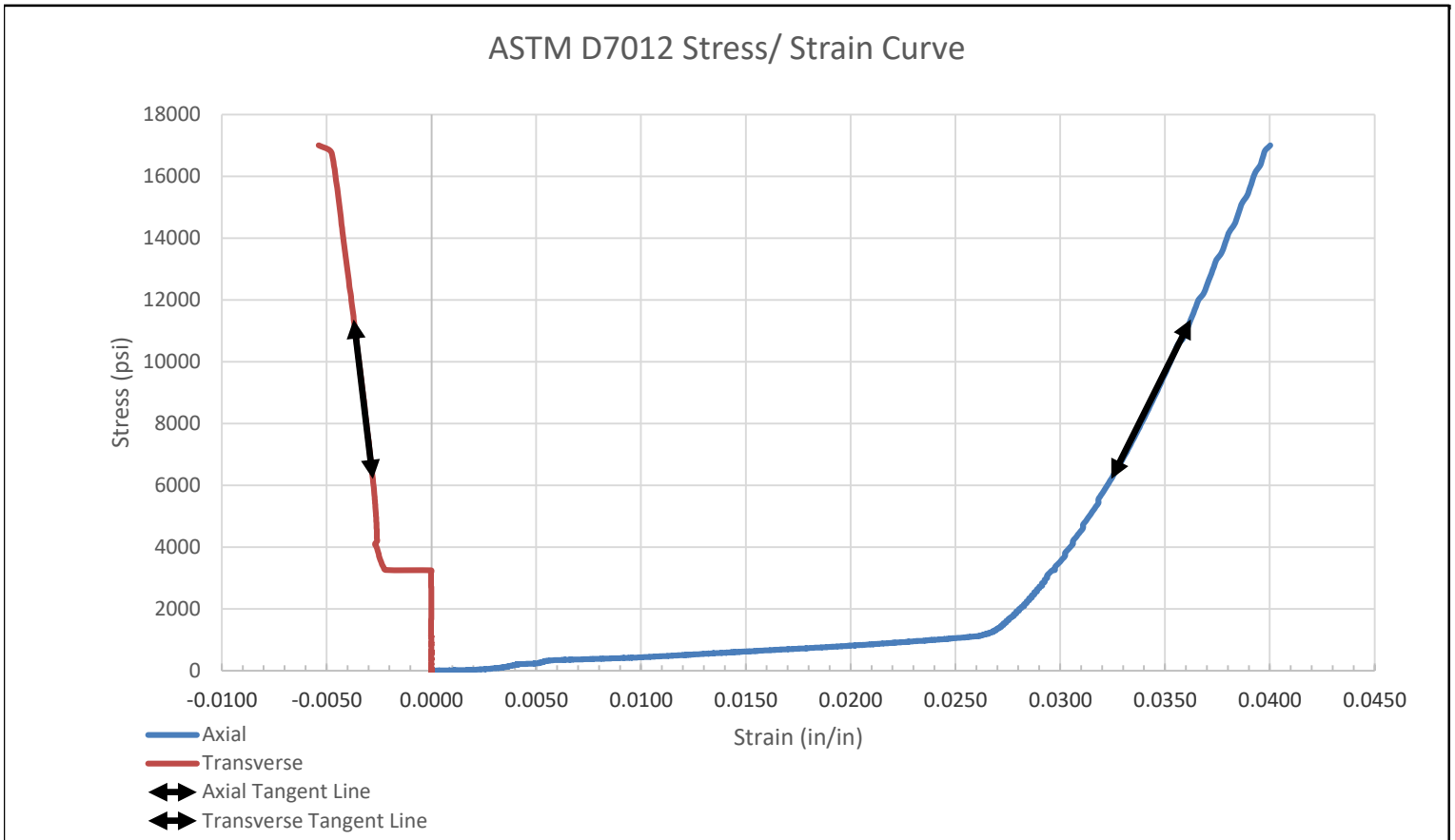
Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100



SAMPLE LOCATION

Site:	S-29-292		
Rock Type:	Metatuff		
Boring:	S-29-292-1	Depth (feet):	43.7

SPECIMEN INFORMATION

Sample No.:	L-4086 (NQ -4)	Mass (g):	571.13
Length (in.):	4.106	Diameter (in.):	1.97
L/D Ratio:	2.1	Density (pcf):	173.320

TEST RESULTS

Failure Load (lbs):	52000
Failure Strain (%):	4.00
Unconfined Compressive Strength (psi):	17,008
Elastic Modulus, E, (ksi):	1359
Poisson's Ratio, u:	0.239
Time of Failure (min):	03:24
Rate of Loading (psi/sec):	83.293
Moisture Content Post-break:	0.1%

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100

ASTM D4543 Test Results:

Parameter	Data
Side Straightness:	0.0024
Perpendicularity Deviation:	
Diameter 1a:	0.0024
Diameter 1b:	0.0011
Diameter 2a:	0.0022
Diameter 2b:	0.0026
Max Deviation from Flatness:	0.0029
Parallelism Deviation:	
Diameter a:	0.02
Diameter b:	0.11

Equipment:	TICCS ID:
Calipers:	W-44049
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

Samples were prepared and tested in general accordance with ASTM D4543 and D7012.

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

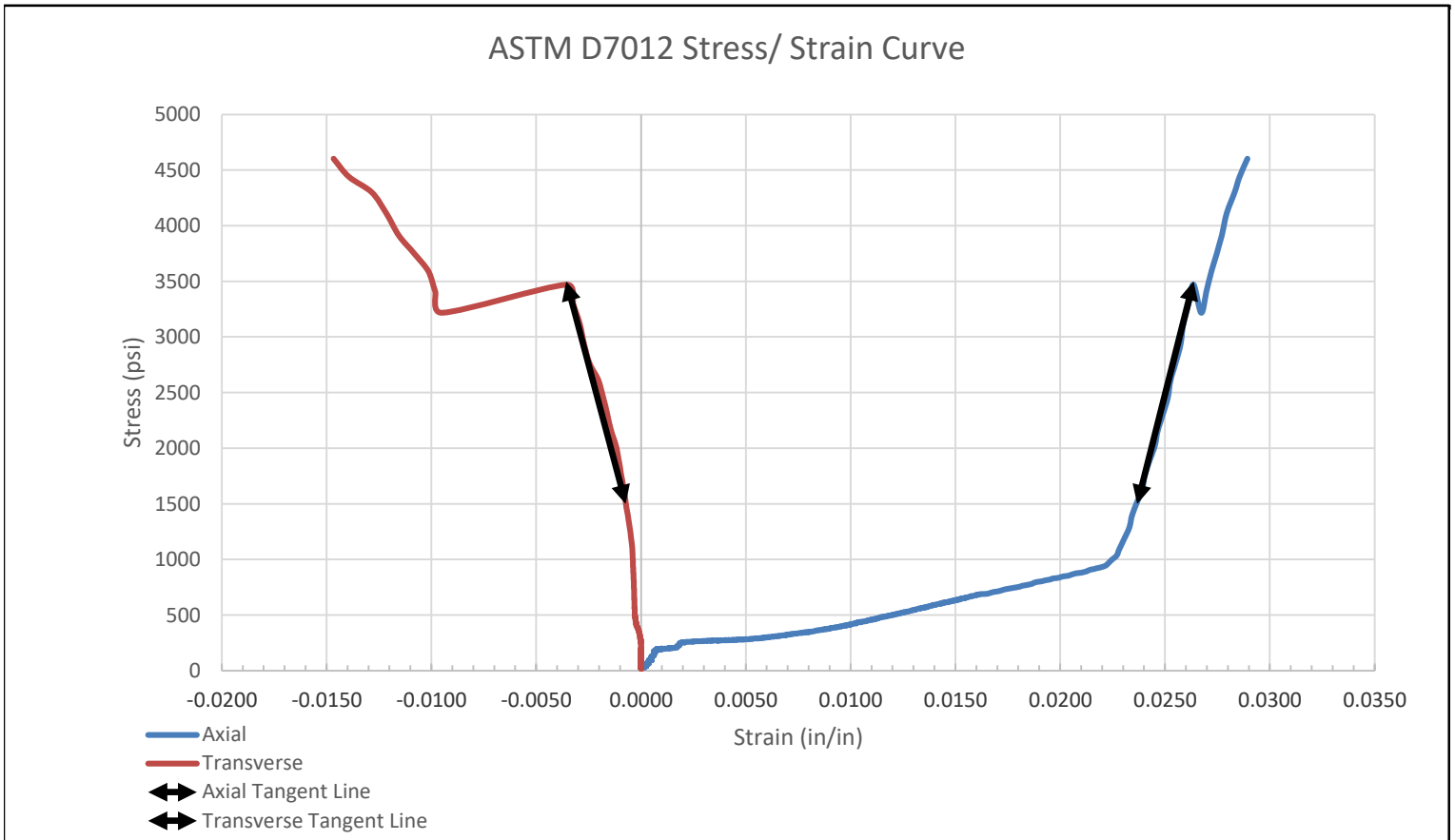
Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100



SAMPLE LOCATION

Site:	S-29-292		
Rock Type:	Metatuff		
Boring:	S-29-292-2	Depth (feet):	53.2

SPECIMEN INFORMATION

Sample No.:	L-4087 (NQ -2)	Mass (g):	553.06
Length (in.):	4.118	Diameter (in.):	1.98
L/D Ratio:	2.1	Density (pcf):	165.748

TEST RESULTS

Failure Load (lbs):	14213
Failure Strain (%):	3.03
Unconfined Compressive Strength (psi):	4,602
Elastic Modulus, E, (ksi):	745
Poisson's Ratio, u:	1.054
Time of Failure (min):	03:47
Rate of Loading (psi/sec):	20.238
Moisture Content Post-break:	0.6%

Report Number: 7323P100
Service Date: 06/02/23
Report Date: 07/10/23

Client

HNTB North Carolina PC
Attn: Spencer Franklin
343 E Six Forks Rd Ste 200
Raleigh, NC 27609

Project

SCDOT Bridge Package 20

Project No. 7323P100

ASTM D4543 Test Results:

Parameter	Data
Side Straightness:	0.0275
Perpendicularity Deviation:	
Diameter 1a:	0.0196
Diameter 1b:	0.0283
Diameter 2a:	0.0206
Diameter 2b:	0.0284
Max Deviation from Flatness:	0.0035
Parallelism Deviation:	
Diameter a:	0.09
Diameter b:	3.61

Equipment:	TICCS ID:
Calipers:	W-44049
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

Samples were prepared and tested in general accordance with ASTM D4543 and D7012.

Appendix C
Supporting Documents

3-Point Acceleration Design Response Spectrum by SCDOT

Rig Calibration Report (14 Pages)

Note: All exhibits are one page unless noted above.

3-Point Acceleration Design Response Spectrum

SCDOT v3.2 - 06/01/2023

Project ID:	P041170			Latitude:	34.7196
Route:	S-29-292	County:	29 - Lancaster	Longitude:	80.7972
Project:	Bridge Replacement over Bear Creek (South Plantation Road)				

Designer:	N. Harman - Support
Date:	7/20/2023

Design EQ	PGA	S_{DS}	S_{D1}	M_W	R	PGV	D_{a5-95}	T'_o
	g	g	g	-	km	inches/sec	sec	sec
FEE	0.03	0.05	0.01	7.30	154.87	0.40	42.29	0.17
SEE	0.05	0.11	0.03	7.30	140.90	0.96	40.20	0.16

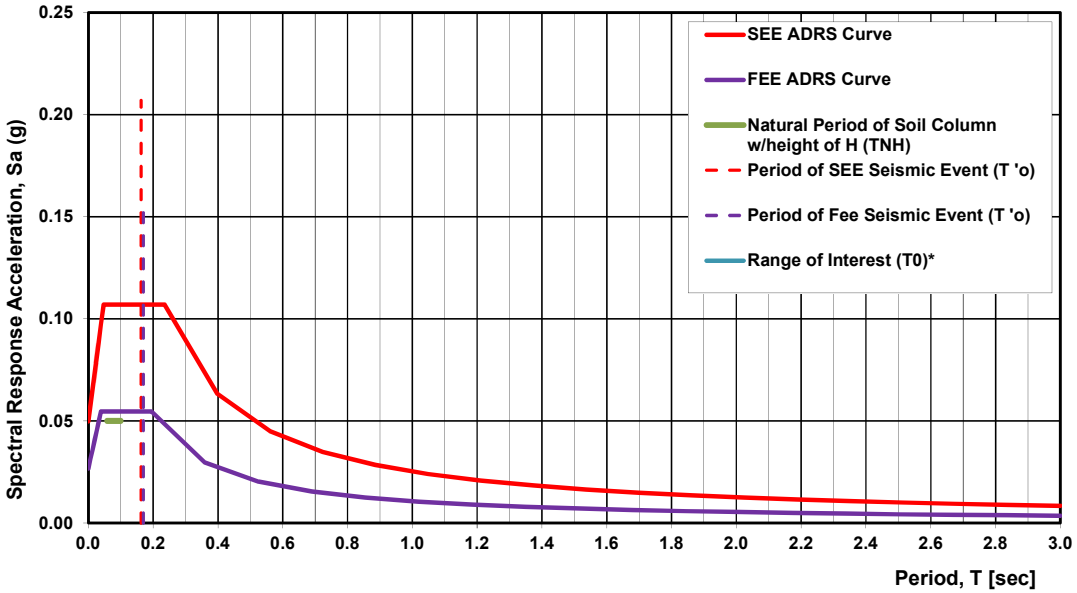
Fundamental Period of Structure, T_0^*	Range of Interest		$V^*_{s,H}$	H	T_{NH}	
	sec				sec	
sec	$0.5*T_0$	$2.0*T_0$	ft/sec	ft	$(4*H)/V^*_{s,H}$	$(6*H)/V^*_{s,H}$
0.00	0.00	0.00	1270.24	21.00	0.06	0.10
0.00	0.00	0.00		H = B-C Boundary		

Damping:	5%
Geologic Condition:	Geologically Realistic (Q = 100)*
	SCP
ADRS Location within Soil Column:	At Ground Surface

South Carolina Piedmont

*Same Geologic Condition as used in SCENARIO_PC (2006)

SC Seismic ADRS Curve



	FEE Data			SEE Data	
	T	S_a		T	S_a
	0.00	0.027		0.00	0.050
	0.01	0.031		0.01	0.059
	0.01	0.036		0.02	0.069
	0.02	0.041		0.02	0.078
	0.03	0.045		0.03	0.088
	0.03	0.050		0.04	0.097
To	0.04	0.055	To	0.05	0.107
	0.05	0.055		0.06	0.107
	0.06	0.055		0.08	0.107
	0.08	0.055		0.09	0.107
	0.09	0.055		0.11	0.107
	0.10	0.055		0.13	0.107
	0.12	0.055		0.14	0.107
	0.13	0.055		0.16	0.107
	0.14	0.055		0.17	0.107
	0.16	0.055		0.19	0.107
	0.17	0.055		0.20	0.107
	0.18	0.055		0.22	0.107
Ts	0.19	0.055	Ts	0.24	0.107
	0.36	0.030		0.40	0.063
	0.52	0.020		0.56	0.045
	0.69	0.015		0.72	0.035
	0.85	0.012		0.89	0.028
	1.02	0.010		1.05	0.024
	1.18	0.009		1.21	0.021
	1.35	0.008		1.37	0.018
	1.51	0.007		1.54	0.016
	1.68	0.006		1.70	0.015
	1.84	0.006		1.86	0.014
	2.01	0.005		2.02	0.012
	2.17	0.005		2.19	0.012
	2.34	0.005		2.35	0.011
	2.50	0.004		2.51	0.010
	2.67	0.004		2.67	0.009
	2.83	0.004		2.84	0.009
	3.00	0.004		3.00	0.008

SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: CME 45C
Serial Number: 406484
Terracon Drill Rig Asset Number: DR#543
July 29, 2022

Prepared for:
Terracon Consultants, Inc.
Columbia Exploration Services

Prepared by:
Terracon Consultants, Inc.
Exploration Services Group

July 29, 2022

Terracon Consultants, Inc.
521 Clemson Rd,
Columbia, SC 29229

Attn: Mr. Phillip Morris
E: phillip.morrison@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report
Terracon Drill Rig DR#543; CME 45C
Terracon Project Number: DUXX0500

Dear Mr. Phillip Morrison:

This report provides the Energy Transfer Ratio (ETR) for the SPT automatic hammer found on drill rig model CME 45C; Terracon Drill Rig Asset Number DR#543 (Serial Number: 406484).

Table 1: Hammer Measurement Summary

Drill Rig Model	Serial No.	Drill Rig Year	Drill Rig No.	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (C_E)
CME 45C	406484	2018	DR#543	93.5% ± 4.5%	1.56

If you have any questions concerning this summary, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Smith, James P
Digitally signed by Smith, James P
DN: cn=Smith, James P, ou=Legal Hold Users, email=Jim.Smith2@terracon.com
Research I attest to the accuracy and integrity of this document
Date: 2022.08.30 07:46:38 -04'00'

James Smith
National Exploration Manager

Jerry Salsgiver, P.E.
Assistant National Manager

Attachments:
Exhibit A: Measurement Information
Exhibit B: PDA SPT Analyzer Results

Exhibit A
Measurement Information

MEASUREMENT INFORMATION

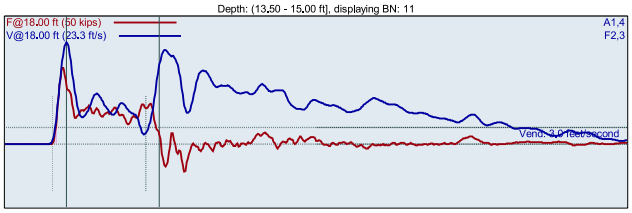
ITEM	DESCRIPTION
Drill Rig Identification	Drill Rig Model: CME 45C Drill Rig Year: 2018 Terracon Drill Rig Asset No.: DR#543; Serial No. 406484
Drill Rig Owner	Terracon Consultants, Inc. – Columbia, SC
Drill Rig Operator	Aaron Bowen; Columbia Exploration
Testing Date	07/28/2022
Testing Location	Columbia, SC
Boring Identification	B-1
Hammer Type	140 pounds (automatic)
Boring Method	Rotary Wash
Drill Rods	■ AWJ ■ 1 3/4" outside diameter ■ 3/16" wall thickness
Testing Equipment	■ 2-foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers ■ Model SPT Analyzer™ (PDA)
ASTM Methods Used	**ASTM D1586**, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils **ASTM D4633-16**, Standard Method for Energy Measurement for Dynamic Penetrometers
Personnel	Jim Smith – National Exploration Manager - Terracon Consultants, Inc.

Responsive ■ Resourceful ■ Reliable

Exhibit B
PDA SPT ANALYZER RESULTS

DU-543-406484 — 13.5-15_1
Jim Smith — Test date: 7/28/2022
AR: 1.20 in^2 — SP: 0.492 k/ft3
LE: 18.00 ft — EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (13.50 - 15.00 ft], displaying BN: 11



F2 : [648AWJ1] 226.21 PDICAL (1) FF1
F3 : [648AWJ2] 225.58 PDICAL (1) FF1
A1 (PR): [K4484] 353.907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410.187 mv/6.4v/5000g (1) VF1

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

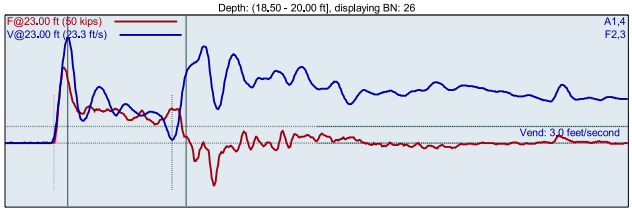
BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
1	2	28	18.4	1.9	279	79.8
2	2	30	18.4	51.6	276	78.9
3	2	31	18.9	51.6	305	87.1
4	2	30	18.3	51.6	309	88.2
5	9	30	18.4	51.7	319	91.2
6	9	29	19.0	51.5	318	91.0
7	9	29	18.5	51.3	305	87.0
8	9	29	18.4	51.2	313	89.3
9	9	30	18.0	51.0	317	90.5
10	9	29	18.6	51.1	317	90.5
11	9	30	18.5	51.0	302	86.1
12	9	30	19.3	51.0	312	89.1
13	9	30	18.8	51.0	321	91.6
	Average	30	18.6	51.3	312	89.2
	Std Dev	1	0.3	0.3	6	1.8
	Maximum	31	19.3	51.7	321	91.6
	Minimum	29	18.0	51.0	302	86.1

N-value: 11

Sample Interval Time: 14.02 seconds.

DU-543-406484 — 13.5-15_1
Jim Smith — Test date: 7/28/2022
AR: 1.20 in^2 — SP: 0.492 k/ft3
LE: 23.00 ft — EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (18.50 - 20.00 ft], displaying BN: 26



F2 : [648AWJ1] 226.21 PDICAL (1) FF1
F3 : [648AWJ2] 225.58 PDICAL (1) FF1
A1 (PR): [K4484] 353.907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410.187 mv/6.4v/5000g (1) VF1

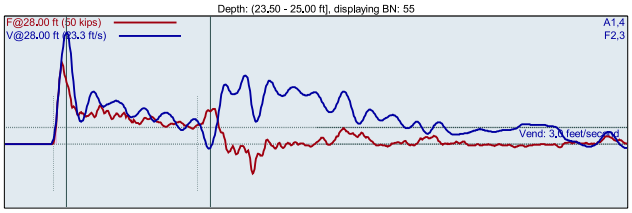
BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
14	5	29	18.1	1.9	322	91.9
15	5	29	19.0	55.9	320	91.3
16	5	30	18.7	55.3	315	89.9
17	5	30	19.2	55.4	334	95.6
18	5	29	19.5	55.7	317	90.6
19	5	29	19.0	55.8	316	90.3
20	5	29	19.4	55.1	320	91.3
21	5	29	18.8	55.9	320	91.5
22	5	30	19.3	55.2	324	92.5
23	5	29	19.2	55.5	320	91.6
24	5	29	19.0	55.6	314	89.7
25	5	30	18.7	55.4	330	94.2
26	5	29	19.2	55.0	310	88.5
27	5	29	18.5	55.2	301	86.0
28	5	30	18.4	54.6	311	88.8
	Average	29	19.0	55.3	317	90.4
	Std Dev	0	0.3	0.4	8	2.2
	Maximum	30	19.4	55.9	330	94.2
	Minimum	29	18.4	54.6	301	86.0

N-value: 10

Sample Interval Time: 15.13 seconds.

DU-543-406484 — 13.5-15_1
Jim Smith — Test date: 7/28/2022
AR: 1.20 in^2 — SP: 0.492 k/ft3
LE: 28.00 ft — EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (23.50 - 25.00 ft], displaying BN: 55



F2 : [648AWJ1] 226.21 PDICAL (1) FF1
F3 : [648AWJ2] 225.58 PDICAL (1) FF1
A1 (PR): [K4484] 353.907 mv/6.4v/5000g (1) VF1
A4 (PR): [K4483] 410.187 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
29	12	1	0.4	1.9	3	0.9
30	12	30	19.1	63.1	340	97.2
31	12	29	20.1	55.5	357	101.9
32	12	29	20.1	55.2	364	104.0
33	12	10	7.3	78.6	55	15.7
34	12	31	20.4	41.0	361	103.2
35	12	31	19.8	57.1	346	98.8
36	12	31	20.0	55.3	342	97.6
37	12	30	19.6	55.6	342	97.8
38	12	31	19.9	55.6	332	94.8
39	12	31	19.8	55.5	337	96.3
40	12	31	19.9	55.5	336	95.9
41	9	31	19.6	55.6	345	98.4
42	9	31	20.1	55.2	335	95.6
43	9	31	19.6	55.6	341	97.4
44	9	31	20.2	55.4	341	97.3
45	9	32	19.5	55.4	341	97.5
46	9	31	19.9	55.5	349	99.7
47	9	31	19.8	55.3	344	98.1
48	9	31	19.9	55.5	346	98.9
49	9	31	19.9	55.6	341	97.6
50	8	31	19.9	55.2	347	99.2
51	8	31	20.0	55.6	338	96.6
52	8	31	20.1	55.2	341	97.4
53	8	32	20.1	55.4	352	100.7
54	8	32	19.8	55.8	348	99.3
55	8	32	20.3	55.1	345	98.5
56	8	32	20.0	55.6	347	99.2
57	8	31	20.0	55.5	340	97.1

Average	31	19.9	55.4	344	98.1
Std Dev	0	0.2	0.2	4	1.2
Maximum	32	20.3	55.8	352	100.7
Minimum	31	19.5	55.1	335	95.6

N-value: 17

Sample Interval Time: 30.24 seconds.

Summary of SPT Test Results

Project: DU-543-406484, Test Date: 7/28/2022

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

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	N Value	N60 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
18.00	**2-2-9**	**11**	**17**	30	18.6	51.3	312	89.2
23.00	**5-5-5**	**10**	**15**	29	19.0	55.3	317	90.4
28.00	**12-9-8**	**17**	**26**	31	19.9	55.4	344	98.1
			Overall Average Values:	30	19.3	54.2	327	93.5
			Standard Deviation:	1	0.7	1.9	16	4.5
			Overall Maximum Value:	32	20.3	55.9	352	100.7
			Overall Minimum Value:	29	18.0	51.0	301	86.0

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model SPT

Serial Number 4535 TB

was calibrated on 8 December 2021

using a PDA Calibration Box whose output was calibrated with test equipment traceable to NIST.

This certificate is valid for 2 years from above date.

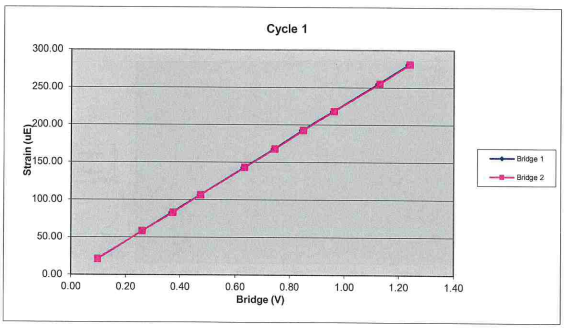
Tested by

Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

648AWJ		Cycle 1		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	799.99	21.12	0.10	0.10
3	2111.63	58.22	0.26	0.26
4	2997.39	82.70	0.37	0.37
5	3848.07	106.26	0.47	0.47
6	5131.83	143.07	0.63	0.63
7	6017.79	167.81	0.74	0.75
8	6872.07	192.74	0.85	0.85
9	7783.57	218.15	0.96	0.96
10	9136.93	255.02	1.12	1.13
11	10026.70	280.73	1.24	1.24

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**8120.30**	**Force Calibration (lb/V)**	**8089.75**
Offset	-4.24	Offset	-2.24
Correlation	0.999998	Correlation	0.999995
Strain Calibration (µE/V)	**228.56**	**Strain Calibration (µE/V)**	**227.70**
Offset	-1.57	Offset	-1.51
Correlation	0.999991	Correlation	0.999983

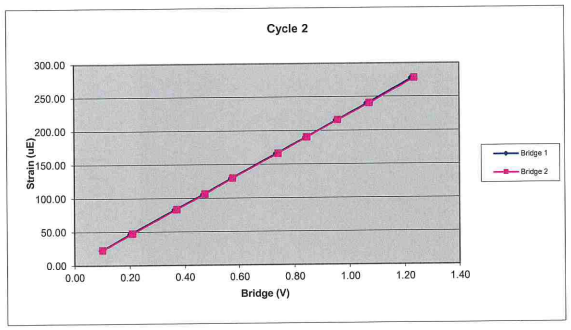
Force Strain Calibration	
EA (Kips)	**35527.98**
Offset	51.69
Correlation	0.999986



648AWJ		Cycle 2		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	805.54	22.23	0.10	0.10
3	1679.81	47.04	0.20	0.21
4	2989.11	83.03	0.37	0.37
5	3830.62	105.81	0.47	0.47
6	4658.00	129.50	0.57	0.58
7	5984.74	165.81	0.74	0.74
8	6848.87	189.76	0.84	0.84
9	7747.90	215.15	0.95	0.96
10	8674.21	240.08	1.07	1.07
11	9994.82	277.48	1.23	1.24

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**8127.14**	**Force Calibration (lb/V)**	**8103.79**
Offset	**10.37**	Offset	**-14.59**
Correlation	**0.999997**	Correlation	**0.999997**
Strain Calibration (µE/V)	**225.29**	**Strain Calibration (µE/V)**	**224.64**
Offset	**0.36**	Offset	**-0.33**
Correlation	**0.999990**	Correlation	**0.999992**

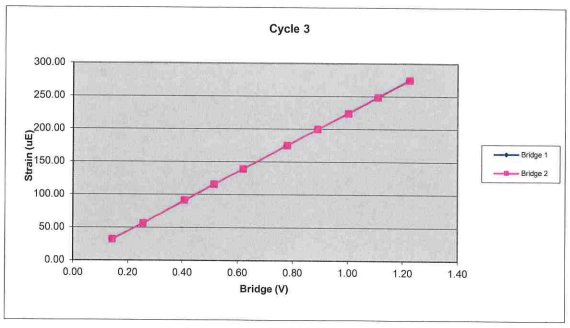
Force Strain Calibration	
EA (Kips)	**36073.41**
Offset	**-2.66**
Correlation	**0.999993**



648AWJ		Cycle 3		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	1153.24	31.90	0.14	0.14
3	2056.55	56.28	0.26	0.26
4	3310.19	91.18	0.41	0.41
5	4155.51	115.51	0.51	0.51
6	5035.81	139.16	0.62	0.62
7	6303.78	175.10	0.78	0.78
8	7221.91	199.87	0.89	0.89
9	8120.94	223.92	1.00	1.00
10	9001.15	248.68	1.11	1.11
11	9931.66	274.33	1.22	1.23

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**8132.32**	**Force Calibration (lb/V)**	**8118.57**
Offset	**-20.37**	Offset	**-15.36**
Correlation	**0.999998**	Correlation	**0.999997**
Strain Calibration (µE/V)	**224.79**	**Strain Calibration (µE/V)**	**224.41**
Offset	**-0.57**	Offset	**-0.43**
Correlation	**0.999984**	Correlation	**0.999985**

Force Strain Calibration	
EA (Kips)	**36175.62**
Offset	**0.42**
Correlation	**0.999984**



Bridge Excitation (V) 5
Shunt Resitor (ohm) 60.4k

Calibration Factors	**648AWJ**		
Bridge 1 (µE/V)	**226.21**	**Bridge 2 (µE/V)**	**225.58**
EA Factor (Kips)	**35925.67**	**Area (in^2)**	**1.20**

Calibrated by: _____
Calibrated Date: 3/3/2022

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on 26Oct2021

Serial No: K4483 **Temperature:** 22.1 °C

Model: PR **Humidity:** 45%

Calibrated on: Channel 3 on 8G 5161 LE

Ref Acc 1: 69096! 978 g's/volt **Cal on:** 27Jan2021

Ref Acc 2: 69132! 960 g's/volt **Cal on:** 09Feb2021

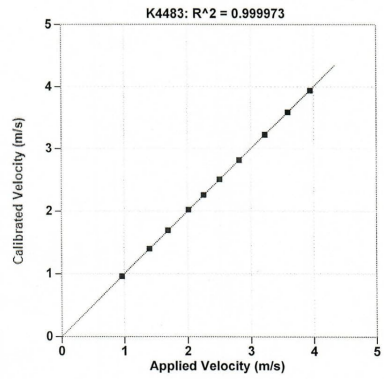
PDA CALIBRATION FACTOR

410.2 mv/5000g
(82.0 µv/g)
R^2: 0.999973 [Chip programmed]

Operator: William Johnson

Signed

Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Reference Velocity m/s	**S/N K4483 Velocity m/s**
0.964	0.962
1.399	1.401
1.691	1.700
2.014	2.022
2.254	2.257
2.507	2.508
2.815	2.814
3.226	3.220
3.590	3.591
3.947	3.941

Maximum Acceleration: 874 g's

Date printed: 26Oct2021, version: 2020.30.170 0.57

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on 25Jan2022

Serial No:	K4484	**Temperature:**	19.3 °C
Model:	PR	**Humidity:**	30%
Calibrated on:	Channel 4 on 8G 5161 LE		
Ref Acc 1:	69132! 960 g's/volt	**Cal on:**	09Feb2021
Ref Acc 2:	69096! 978 g's/volt	**Cal on:**	27Jan2021

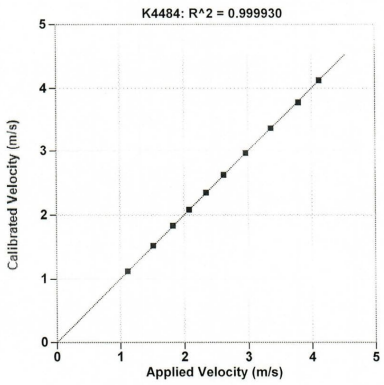
PDA CALIBRATION FACTOR

353.9 mv/5000g
(70.8 µv/g)
R^2: 0.999930 [Chip programmed]

Operator: William Johnson

Signed

Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



Reference Velocity m/s	S/N K4484 Velocity m/s
1.117	1.124
1.518	1.523
1.823	1.835
2.078	2.080
2.344	2.349
2.616	2.624
2.963	2.962
3.360	3.357
3.794	3.778
4.121	4.122

Maximum Acceleration: 916 g's

Date printed: 25Jan2022, version: 2020.30.170 -0.22

Report of SPT Energy Measurements
HPC CME-550X ATV (Serial No. 308513)
Charlotte, North Carolina
S&ME Project No. 22350319

PREPARED FOR:

North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699

c/o HPC Land Services
490 South First Street
PO Box 155
Albemarle, North Carolina 28002

PREPARED BY:

S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, North Carolina 28273

April 22, 2022

April 22, 2022

North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699

c/o HPC Land Services
490 South First Street
PO Box 155
Albemarle, North Carolina 28002

Attention: Shunyi (Chris) Chen, Ph.D., P.E.

Cc: Ms. Cheryl A. Youngblood, L.G.
Ms. Christina M. Bruinsma, L.G.

Reference: **Report of SPT Energy Measurements**
HPC CME-550X ATV (Serial No. 308513)
Charlotte, North Carolina
S&ME Project No. 22350319
NC PE Firm License No. F-0176

Dear Dr. Chen:

We have completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer used with HPC Land Services' (HPC) CME-550X ATV-mounted drill rig (Serial No. 308513). This service was performed by Mr. Alex Rodriguez, E.I. of our firm on April 19, 2022, in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation (NCDOT) Geotechnical Engineering Unit's requirements. Review of the data quality and analyses was performed by Mr. Joseph Williamson, P.E. Copies of the Certificates of Proficiency issued by Pile Dynamics based on the Dynamic Measurement and Analysis Proficiency Test for Mr. Rodriguez and Mr. Williamson are included in Appendix I. The testing procedures, equipment used during testing, and detailed results are presented in this report.

1.0 Dynamic Testing Methodology

Testing was performed using a model PAX (Serial No. 3733L) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K4644 and K4665) bolted to a 2.0-foot-long AWJ drill rod (Serial No. 203) internally instrumented with two strain transducers. Calibration sheets for the accelerometers and the instrumented rod are included in Appendix II. The instrumented AWJ drill rod has a cross-sectional area of 1.19 square inches and an outside diameter of approximately 1.75 inches. Therefore, we calculate the inside diameter to be approximately 1.25 inches at the gauge location. The accelerometers and strain gauges, which are diametrically opposed near the middle of the instrumented rod, monitor acceleration and strain for each hammer blow. The analyzer converts the data to velocities and forces and computes the maximum transferred hammer energies with the "EFV" method described in ASTM D4633. Preliminary results are recorded and displayed in real time for each blow.

2.0 Testing and Observations

S&ME personnel were on site April 19, 2022, to observe and perform high-strain dynamic testing during SPT sampling on the CME-550X ATV-mounted drill rig operated by Zack Kiker of HPC. The measurements were taken during drilling and sampling of test hole at an HPC project site in Charlotte, North Carolina. SPT energy measurements were recorded during five sampling intervals at depths of approximately 33.5, 38.5, 43.5, 48.5, and 53.5 ft below the ground surface. The 38.5 ft sample interval did not meet the NCDOT required blow count criteria and was not considered in the analysis. The information presented in the tables below summarizes the equipment and tooling used during the SPT energy measurements.

Table 2-1: Drill Rig Information

Manufacturer	CME
Model	550X
Serial Number	308513
Operator	Z. Kiker
Carrier	ATV

Table 2-2: Hammer Information

Model / Type	CME / Auto
Serial Number	308513
Typical Drop Height (inches)	30
Typical Ram Weight (pounds)	140

Table 2-3: Drilling and Instrumented Rod Information

Drill Rod Type	AWJ
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in^2)	1.19
Typical Lengths (feet)	5
Instrumented Rod Type	AWJ (Serial No. 203)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in^2)	1.19
Total Instrumented Rod Length (feet)	2.0
Length Below Gages (feet)	0.8
Split-Spoon Length (feet)	2.85

3.0 Dynamic Testing Results

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.65 ft to the drill rod length at each sample depth. The SPT Energy Measurement Data Summary tables in Appendix III present the test data from every hammer blow at each sampling interval, along with representative force and velocity traces for each test interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e. the blows that determine the N-value) are considered when computing the average measurement values of each test interval.

The reported blow counts obtained by the drill rig personnel, a summary of the test data, and average computed hammer energy and transfer ratio values are provided in Table 3-1. Based on the test data, the automatic hammer on the CME-550X operated at an average rate of about 55 blows per minute (bpm) during dynamic testing. The measured average transferred hammer energy (EFV) of the four sample intervals ranged from 292 to 297 ft-lbs, which corresponds to Energy Transfer Ratio (ETR) values of 83.5 to 85.0%, respectively. Plots and tables of the following are also included in Appendix III and present the test data with depth for each test interval:

- Penetration vs. BLC[1]
- Penetration vs. FMX[2]
- Penetration vs. EFV[3]
- Penetration vs. CSX[4]
- Penetration vs. VMX[5]
- Penetration vs. ETR[6]
- ETR vs. Rod Length
- Average ETR vs. Rod Length

Table 3-1: Summary of Dynamic Testing Results

Data Set ID	Sample Depth (ft)	Drill Rod Length (ft)	Instrumentation to Sampler Tip Length (ft)	Blows per 6" Increment / N-value	Soil Sample Description (Piedmont Residual)	Avg. BPM	Avg. EFV (ft-lbs)	Avg. ETR (%)
1	33.5 – 35	35	38.65	3-5-8 / 13	Sandy Silt	55	297	84.8
2	43.5 – 45	45	48.65	12-20-24 / 44	Sandy Silt	55	297	85.0
3	48.5 - 50	50	53.65	10-22-26 / 48	Sandy Silt	55	295	84.4
4	53.5 - 55	55	58.65	7-14-20 / 34	Sandy Silt	55	292	83.5
					Overall Average	**55**	**295**	**84.4**

The overall average transferred hammer energy for the automatic hammer on the CME-550X ATV-mounted drill rig was 295 foot-pounds, with an average ETR of 84.4%.

[1] BLC - Blow Count per 6-in. increment
[2] FMX - Maximum Compressive Force
[3] EFV – Maximum Transferred Energy
[4] CSX – Maximum Compressive Stress
[5] VMX – Maximum Velocity
[6] ETR – Energy Transfer Ratio – Ratio of Calculated Energy to Theoretical Energy of 140 lb hammer falling 30 inches

4.0 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions contained in this report were based on the applicable standards of our profession in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

5.0 Closing

S&ME appreciates the opportunity to provide this report to the North Carolina Department of Transportation, Geotechnical Engineering Unit. Please let us know if you have any questions concerning this report.

Sincerely,

S&ME, Inc.

Alex M. Rodriguez, E.I.
Staff Professional

Joseph R. Williamson, P.E.
Apr 22 2022

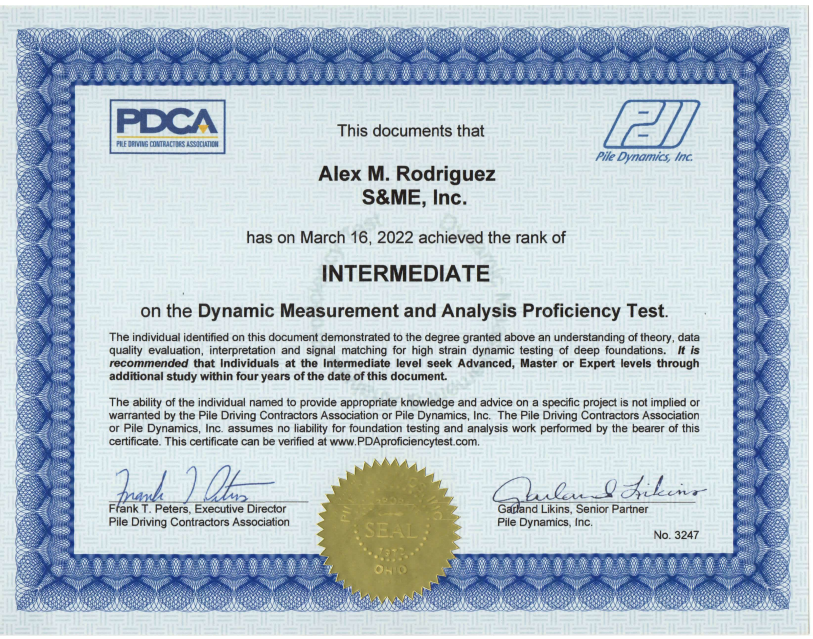
Joseph R. Williamson, P.E.
Project Manager
N.C. Registration No. 42168

Senior Reviewed by: Gregory J. Canivan, P.E.

Appendices:

- Appendix I – Certificates of Proficiency
- Appendix II – Instrumented Rod and Accelerometer Calibration Sheets
- Appendix III – SPT Energy Evaluation Form
- Appendix IV – CME-550X ATV (SN 308513) SPT Energy Measurements Summary Plots and Tables

Appendix I – Certificates of Proficiency



PDCA PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Alex M. Rodriguez
S&ME, Inc.

has on March 16, 2022 achieved the rank of

INTERMEDIATE

on the **Dynamic Measurement and Analysis Proficiency Test**.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended* that Individuals at the Intermediate level seek Advanced, Master or Expert levels through additional study within four years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate. This certificate can be verified at www.PDAproficiencytest.com.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

SEAL OHIO

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3247

PDCA PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Joseph Williamson
S&ME, Inc.

has on March 16, 2022 achieved the rank of

MASTER

on the **Dynamic Measurement and Analysis Proficiency Test**.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended* that individuals at the Master level seek to attain Expert level through additional study within eight years of the date of this document**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate. This certificate can be verified at www.PDAproficiencytest.com.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

SEAL OHIO

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3251

Appendix II – Calibration Sheets

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI Accelerometer Calibration

Model PR-K Serial # K4664

Cal Date: OCT 16, 2021 Cal Due : OCT 15, 2023

Temperature: 72 deg. F Humidity 65 %

Calibrated at
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, OH 44139

Manufactured by Pile Dynamics, Inc.

Procedure used: PDA Accelerometer Calibration Procedure 2016-6, Revision 20160422

Equipment was found to be

X in tolerance As Received _____ out of tolerance As Received

X in tolerance As Returned _____ out of tolerance As Returned

PDI Calibration: 380 mv/5000g

Calibration Standards Utilized
Hopkinson Bar Force Calibration F2, verified on July 28, 2021

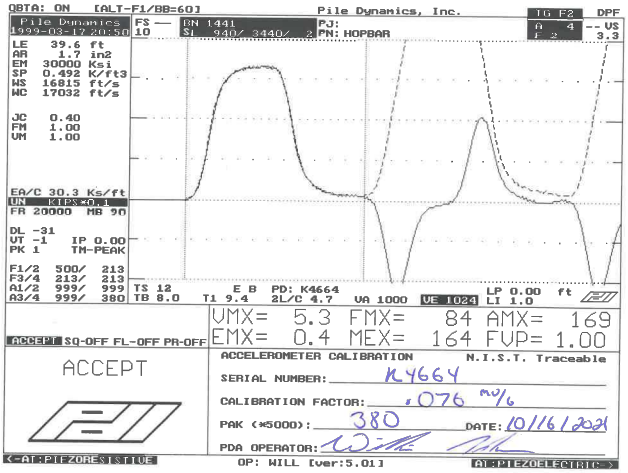
PDI HopBar DOS PAK, serial number 1273K, verified on July 19, 2021

Calibration performed by: _____
William johnson, Technician

Reviewed by: _____
Robert Sprenger, Production Manager

Accelerometer CC-5 Issued 20160426

30725 Aurora Road • Cleveland, Ohio 44139 USA • +1-216-831-6131 • Fax +1-216-831-0916
E-mail: info@pile.com • www.pile.com



Smart Sensor

Programmed By: WJ CRC Value 4898

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI Accelerometer Calibration

Model PR-K Serial # K4665

Cal Date: AUG 10, 2021 Cal Due : AUG 9, 2023

Temperature: 72 deg. F Humidity 70 %

Calibrated at
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, OH 44139

Manufactured by Pile Dynamics, Inc.

Procedure used: PDA Accelerometer Calibration Procedure 2016-6, Revision 20160422

Equipment was found to be

X in tolerance As Received _____ out of tolerance As Received

X in tolerance As Returned _____ out of tolerance As Returned

PDI Calibration: 365 mv/5000g

Calibration Standards Utilized
Hopkinson Bar Force Calibration F2, verified on July 28, 2021

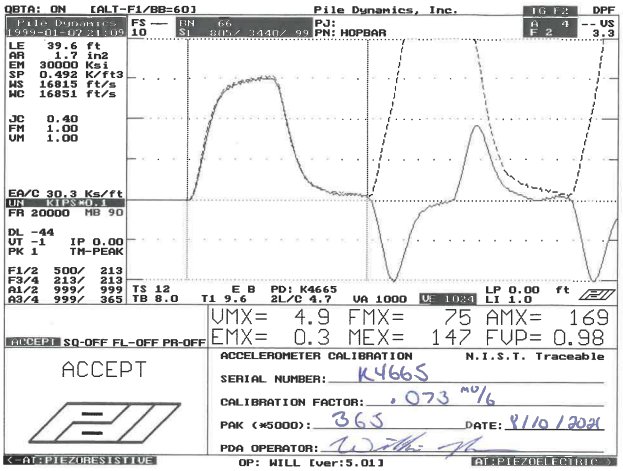
PDI HopBar DOS PAK, serial number 1273K, verified on July 19, 2021

Calibration performed by: _____
William Johnson, Technician

Reviewed by: _____
Bob Sprenger, production Manager

Accelerometer CC-5 Issued 20160426

30725 Aurora Road • Cleveland, Ohio 44139 USA • +1-216-831-6131 • Fax +1-216-831-0916
E-mail: info@pile.com • www.pile.com



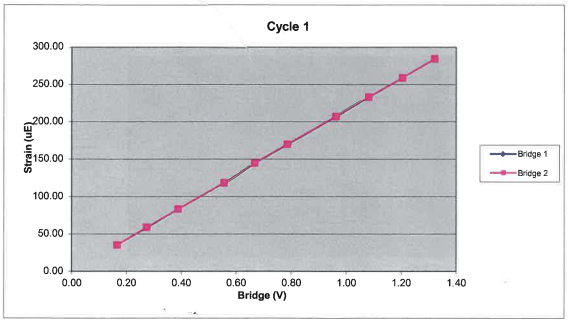
Smart Sensor

Programmed By: WJ CRC Value C59F

203AWJ		Cycle 1		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	1246.03	34.91	0.17	0.17
3	2081.11	58.65	0.28	0.27
4	2941.63	83.02	0.39	0.39
5	4214.76	118.53	0.56	0.56
6	5056.27	144.80	0.67	0.67
7	5965.04	170.09	0.79	0.79
8	7294.42	207.16	0.96	0.96
9	8206.79	233.22	1.08	1.08
10	9138.76	259.03	1.21	1.20
11	10040.70	284.32	1.32	1.32

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7599.69**	**Force Calibration (lb/V)**	**7601.86**
Offset	-24.15	Offset	-17.41
Correlation	0.999998	Correlation	0.999998
Strain Calibration (µE/V)	**215.94**	**Strain Calibration (µE/V)**	**216.00**
Offset	-0.96	Offset	-0.77
Correlation	0.999977	Correlation	0.999970

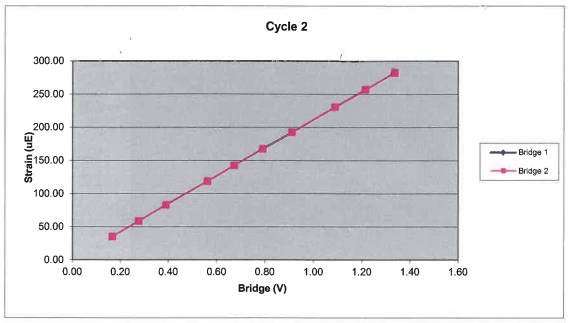
Force Strain Calibration	
EA (Kips)	**35191.11**
Offset	10.07
Correlation	0.999966



203AWJ		Cycle 2		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	1258.51	34.91	0.17	0.17
3	2095.24	58.34	0.28	0.28
4	2959.17	82.77	0.39	0.39
5	4259.41	118.34	0.56	0.56
6	5099.16	142.25	0.67	0.67
7	6003.44	167.19	0.79	0.79
8	6914.94	192.10	0.91	0.91
9	8280.29	230.44	1.09	1.09
10	9224.63	256.64	1.22	1.21
11	10143.64	281.95	1.33	1.34

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7599.73**	**Force Calibration (lb/V)**	**7596.59**
Offset	**-6.06**	Offset	**-5.65**
Correlation	**0.999998**	Correlation	**0.999998**
Strain Calibration (µE/V)	**211.24**	**Strain Calibration (µE/V)**	**211.15**
Offset	**0.01**	Offset	**0.02**
Correlation	**0.999992**	Correlation	**0.999991**

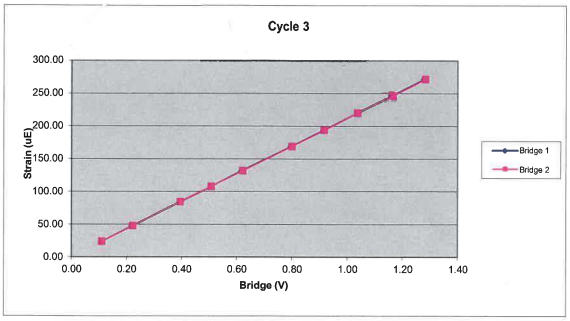
Force Strain Calibration	
EA (Kips)	**35976.99**
Offset	**-6.36**
Correlation	**0.999996**



203AWJ		Cycle 3		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	846.19	23.53	0.11	0.11
3	1695.30	47.55	0.22	0.22
4	3007.23	84.21	0.40	0.40
5	3855.56	107.72	0.51	0.51
6	4714.72	131.93	0.62	0.62
7	6082.40	169.34	0.80	0.80
8	6969.72	194.06	0.92	0.92
9	7881.90	220.26	1.04	1.04
10	8834.83	246.28	1.16	1.17
11	9750.91	271.69	1.28	1.28

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7615.81**	**Force Calibration (lb/V)**	**7596.50**
Offset	**-9.63**	Offset	**-6.69**
Correlation	**0.999996**	Correlation	**0.999998**
Strain Calibration (µE/V)	**212.11**	**Strain Calibration (µE/V)**	**211.57**
Offset	**0.00**	Offset	**0.08**
Correlation	**0.999995**	Correlation	**0.999995**

Force Strain Calibration	
EA (Kips)	**35905.21**
Offset	**-9.52**
Correlation	**0.999994**



Bridge Excitation (V) 5
Shunt Resitor (ohm) 60.4k

Calibration Factors	203AWJ		
Bridge 1 (μE/V)	213.10	Bridge 2 (μE/V)	212.91
EA Factor (Kips)	35691.10	Area (in^2)	1.19

Calibrated by: _____
Calibrated Date: 3/25/2021

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Appendix III - SPT Energy Evaluation Form

SPT Energy Evaluation Form

Project: HPC SPT Energy Testing
Project No.: 22350319
Boring No.: Test Hole
Date: 4/19/2022
Weather: Sunny 60°
Drill Rod Type: AWJ 5' LONG

On-site Personnel

Drilling Company: HPC
Rig Operator: Zack Kiker
Engr/Geologist: -
Client Rep.: -
Analyzer Oper.: Alex Rodriguez

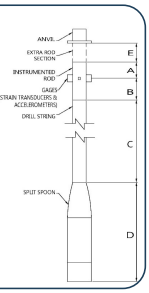
Rig/Hammer Info

Drill Rig Make/Model: CME 550X
Carrier Type: ATV
Rig Serial No.: 308513
Hammer Type/Model: CME 550X
Hammer Serial No.: N/A
Hammer Drop System: Automatic
Lubrication Condition: Per Manufacturer

Operation Rate (bpm): 50 - 55
Typical Drop Height (in.): 30
Typical Hammer Weight (lbs): 140
Anvil Dimension (in.): 12
Drilling Method: 2 1/4" HSA
Drop Height in Tolerance (y/n) Y

Rod Info

(A) + ***(B)*** Instr. Rod Length: 2.0 ft
(B) Instr. Rod Length below Gages: 0.8 ft
(D) Spoon Length: 2.85 ft
(E) Rod Length Above Instr. Rod (if applicable): - ft
(B)+(C)+(D) (LE) - Length Below Gauges **(C)** + 3.65 ft
Instr. Rod S/N: 203AWJ
Instr. Rod Outside Dia.: 1.75 in.
Instr. Rod Area: 1.19 in^2
PDA Make/Model: PDI/PAX
PDA Serial No.: 3733L
Calib. Pulse Test (y/n): Y



Gage Info

Gage		Serial No.	Calibration No.
Accel.	A3	K4664	380
	A4	K4665	365
Strain	F3	AWJ203-1	213.1
	F4	AWJ203-2	212.91

Date of Test	Test Depth Increment	Test Time Start / Stop	Length of Drill String (ft)	(LE) Length below Gages (ft)	Avg. Meas. Hammer Rate	SPT Blow Counts						AASHTO / USCS Classification
	(ft to ft)	(military)	***(C)***	***(B) + (C) + (D)***	(BPM)	Total Blows by PDA	6"	12"	18"	N-Value	Extra Blows	
4/19/2022	33.5 - 35.0	8:50	35	38.65	55	16	**3**	**5**	**8**	**13**	0	A-4/ML
	38.5 - 40.0	8:56	40	43.65	55	78	**20**	**28**	**30**	**58**	0	A-4/ML
	43.5 - 45.0	9:03	45	48.65	55	56	**12**	**20**	**24**	**44**	0	A-4/ML
	48.5 - 50.0	9:10	50	53.65	55	58	**10**	**22**	**26**	**48**	0	A-4/ML
	53.5 - 55.0	9:20	55	58.65	55	41	**7**	**14**	**20**	**34**	0	A-4/ML

Notes:

NOTE: (1) Note any unusual hammer operating conditions that affect the hammer performance, or changes in operating conditions (e.g. veritcality, weather, or lubrication between trials). (2) Note any changes in rod diameter along drill string and record locations of short rod sections.

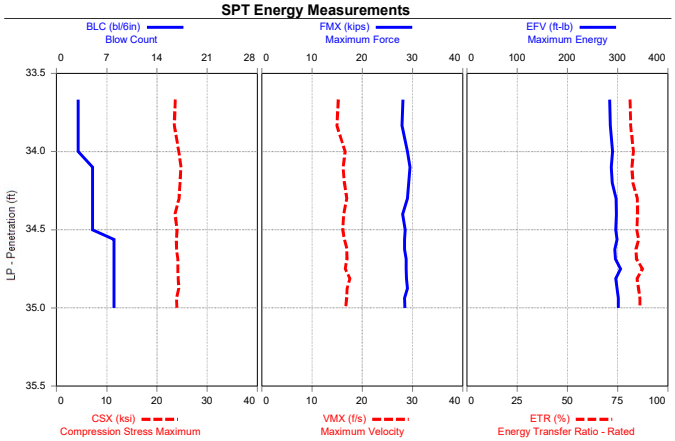
Alex Rodriguez
Prepared By (print/signature)

4/19/2022
Date

Appendix IV - SPT Energy Measurements Plots and Tables

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results
Printed: 19-April-2022 Test started: 19-April-2022

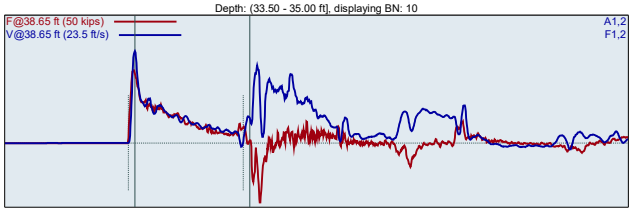
CME 550X (SN308513) - 33.5 - 35.0 Feet
SPT Energy Measurements



CME 550X (SN308513)
AMR
TEST HOLE
AR: 1.19 in^2
LE: 38.65 ft
WS: 16807.9 ft/s

SPT Energy Measurements
Test date: 4/19/2022
SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (33.50 - 35.00 ft], displaying BN: 10



F1 : [203 AWJ-1] 213.1 PDICAL (1) FF1
F2 : [203 AWJ-2] 212.91 PDICAL (1) FF1

A1 (PR): [K4664] 380 mv/6.4v/5000g (1) VF1
A2 (PR): [K4665] 365 mv/6.4v/5000g (1) VF1

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

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

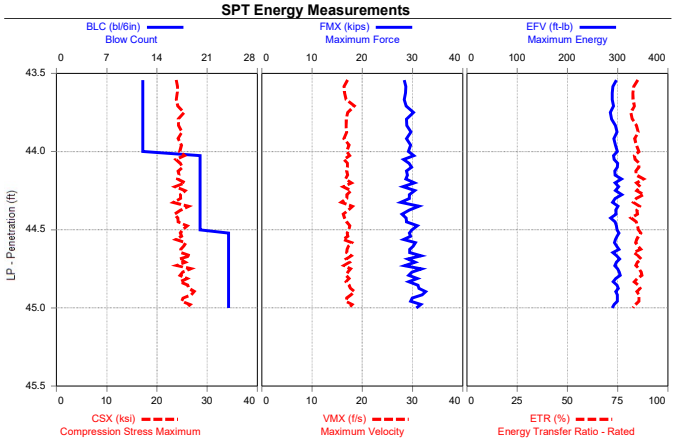
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
1	33.67	3	1.9	28	15.2	2.10	23.6	2.00	284	81.2
2	33.83	3	55.3	28	15.0	2.00	23.4	2.00	285	81.5
3	34.00	3	55.1	29	16.6	2.00	24.3	2.00	290	82.8
4	34.10	5	55.1	29	16.2	1.68	24.8	1.20	287	82.1
5	34.20	5	54.9	29	16.4	1.48	24.6	1.20	289	82.6
6	34.30	5	55.1	29	16.9	1.32	24.4	1.20	297	84.8
7	34.40	5	54.8	28	16.3	1.26	23.6	1.20	297	84.9
8	34.50	5	54.9	29	16.1	1.20	24.0	1.20	296	84.6
9	34.56	8	55.0	28	16.4	0.94	23.9	0.75	299	85.4
10	34.63	8	54.9	28	16.9	0.89	23.9	0.75	294	84.1
11	34.69	8	54.9	29	17.0	0.91	24.1	0.75	295	84.4
12	34.75	8	54.9	29	16.6	0.91	24.1	0.75	306	87.3
13	34.81	8	54.9	29	17.5	0.75	24.2	0.75	296	84.7
14	34.88	8	54.9	29	17.0	0.78	24.3	0.75	299	85.4
15	34.94	8	55.0	28	16.9	0.75	23.9	0.75	301	86.1
16	35.00	8	55.1	29	16.7	0.82	24.0	0.75	301	86.0
	Average		55.0	29	16.7	1.05	24.1	0.92	297	84.8
	Std Dev		0.1	0	0.4	0.29	0.3	0.22	5	1.3
	Maximum		55.1	29	17.5	1.68	24.8	1.20	306	87.3
	Minimum		54.8	28	16.1	0.75	23.6	0.75	287	82.1

N-value: 13

Sample Interval Time: 16.34 seconds.

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results
Printed: 19-April-2022 Test started: 19-April-2022

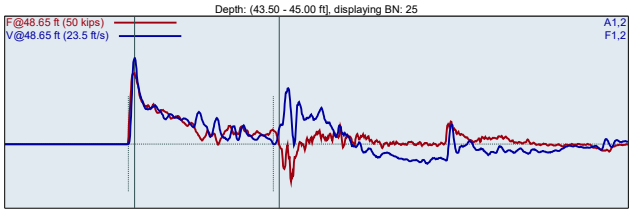
CME 550X (SN308513) - 43.5 - 45.0 Feet
SPT Energy Measurements



CME 550X (SN308513)
AMR
TEST HOLE
AR: 1.19 in^2
LE: 48.65 ft
WS: 16807.9 ft/s

SPT Energy Measurements
Test date: 4/19/2022
SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (43.50 - 45.00 ft], displaying BN: 25



F1 : [203 AWJ-1] 213.1 PDICAL (1) FF1
F2 : [203 AWJ-2] 212.91 PDICAL (1) FF1

A1 (PR): [K4664] 380 mv/6.4v/5000g (1) VF1
A2 (PR): [K4665] 365 mv/6.4v/5000g (1) VF1

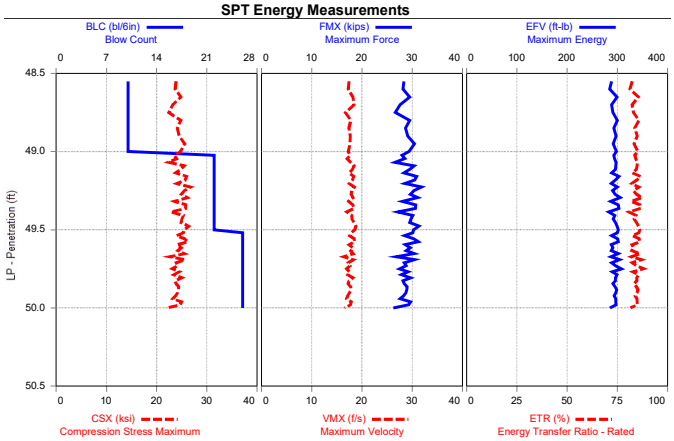
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
1	43.54	12	1.9	28	17.1	0.85	23.8	0.50	298	85.1
2	43.58	12	57.5	29	16.4	0.71	24.1	0.50	291	83.0
3	43.63	12	55.0	29	16.5	0.68	24.0	0.50	289	82.6
4	43.67	12	55.2	28	16.8	0.61	23.8	0.50	289	82.7
5	43.71	12	55.1	29	18.4	0.56	24.1	0.50	292	83.4
6	43.75	12	54.8	30	17.1	0.51	25.4	0.50	285	81.5
7	43.79	12	55.1	29	16.8	0.53	24.2	0.50	288	82.3
8	43.83	12	55.2	29	16.8	0.55	24.3	0.50	295	84.4
9	43.88	12	55.0	30	16.9	0.54	25.0	0.50	299	85.3
10	43.92	12	54.9	29	16.4	0.53	24.2	0.50	292	83.5
11	43.96	12	55.0	30	17.4	0.51	24.9	0.50	295	84.4
12	44.00	12	55.1	29	16.9	0.55	24.5	0.50	299	85.5
13	44.03	20	55.1	30	17.5	0.49	25.5	0.30	292	83.3
14	44.05	20	55.1	28	16.3	0.50	23.8	0.30	293	83.7
15	44.08	20	54.9	29	17.1	0.49	24.7	0.30	300	85.7
16	44.10	20	55.2	30	17.0	0.49	25.1	0.30	299	85.5
17	44.13	20	54.9	29	16.9	0.47	24.2	0.30	294	84.1
18	44.15	20	54.8	29	17.1	0.47	24.4	0.30	295	84.3
19	44.18	20	54.9	29	16.7	0.50	24.1	0.30	308	87.9
20	44.20	20	54.8	30	17.9	0.44	25.5	0.30	295	84.3
21	44.23	20	55.0	28	16.2	0.48	23.6	0.30	302	86.2
22	44.25	20	54.8	30	17.8	0.43	25.6	0.30	296	84.4
23	44.28	20	54.8	29	17.0	0.48	24.7	0.30	308	88.1
24	44.30	20	54.8	29	16.9	0.44	24.7	0.30	295	84.2
25	44.33	20	55.6	28	15.8	0.44	23.3	0.30	290	82.8
26	44.35	20	53.9	31	18.1	0.43	26.3	0.30	301	85.9
27	44.38	20	55.3	29	17.2	0.43	24.7	0.30	296	84.6
28	44.40	20	54.7	28	16.2	0.45	23.5	0.30	297	84.9
29	44.43	20	55.0	29	16.5	0.41	24.1	0.30	286	81.7
30	44.45	20	54.8	29	16.9	0.41	24.2	0.30	295	84.3
31	44.48	20	54.9	31	17.6	0.42	26.0	0.30	297	84.9

32	44.50	20	55.1	30	17.3	0.42	25.1	0.30	298	85.2
33	44.52	24	54.5	29	17.0	0.43	24.7	0.25	303	86.5
34	44.54	24	55.2	30	17.1	0.42	24.9	0.25	299	85.4
35	44.56	24	54.8	28	16.2	0.42	23.7	0.25	296	84.5
36	44.58	24	55.1	31	17.9	0.39	25.7	0.25	294	83.9
37	44.60	24	55.3	30	17.3	0.41	25.3	0.25	298	85.1
38	44.63	24	54.3	29	17.0	0.43	24.7	0.25	303	86.5
39	44.65	24	55.2	29	16.9	0.42	24.7	0.25	291	83.0
40	44.67	24	55.1	32	17.8	0.42	26.7	0.25	298	85.1
41	44.69	24	54.4	29	16.8	0.44	24.5	0.25	304	86.8
42	44.71	24	55.4	31	17.5	0.42	25.7	0.25	297	84.9
43	44.73	24	54.5	28	16.3	0.41	23.9	0.25	294	84.0
44	44.75	24	55.1	32	17.7	0.42	26.7	0.25	300	85.7
45	44.77	24	54.7	30	17.1	0.42	25.1	0.25	303	86.6
46	44.79	24	55.0	29	16.8	0.43	24.6	0.25	305	87.1
47	44.81	24	54.6	31	17.4	0.39	26.0	0.25	297	84.7
48	44.83	24	55.2	29	16.8	0.38	24.6	0.25	291	83.2
49	44.85	24	54.7	31	17.4	0.39	26.1	0.25	298	85.2
50	44.88	24	54.7	31	17.7	0.39	26.3	0.25	301	86.1
51	44.90	24	55.1	33	18.4	0.36	27.4	0.25	296	84.6
52	44.92	24	55.0	32	17.8	0.37	26.8	0.25	300	85.6
53	44.94	24	55.1	30	16.9	0.36	25.2	0.25	299	85.6
54	44.96	24	54.8	30	16.8	0.37	24.9	0.25	300	85.6
55	44.98	24	54.9	32	18.0	0.34	26.6	0.25	293	83.8
56	45.00	24	54.6	31	17.3	0.35	25.9	0.25	289	82.6
		Average	54.9	30	17.1	0.42	25.1	0.27	297	85.0
		Std Dev	0.3	1	0.6	0.04	1.0	0.02	5	1.3
		Maximum	55.6	33	18.4	0.50	27.4	0.30	308	88.1
		Minimum	53.9	28	15.8	0.34	23.3	0.25	286	81.7

N-value: 44

Sample Interval Time: 59.93 seconds.

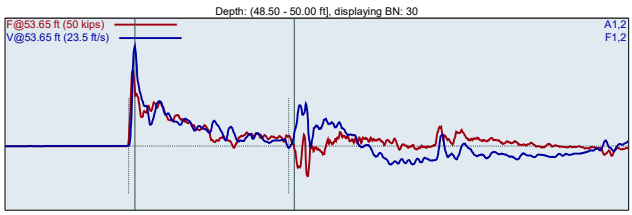
CME 550X (SN308513) - 48.5 - 50.0 Feet
SPT Energy Measurements



CME 550X (SN308513)
AMR
TEST HOLE
AR: 1.19 in^2
LE: 53.65 ft
WS: 16807.9 ft/s

SPT Energy Measurements
Test date: 4/19/2022
SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (48.50 - 50.00 ft], displaying BN: 30



F1 : [203 AWJ-1] 213.1 PDICAL (1) FF1
F2 : [203 AWJ-2] 212.91 PDICAL (1) FF1

A1 (PR): [K4664] 380 mv/6.4v/5000g (1) VF1
A2 (PR): [K4665] 365 mv/6.4v/5000g (1) VF1

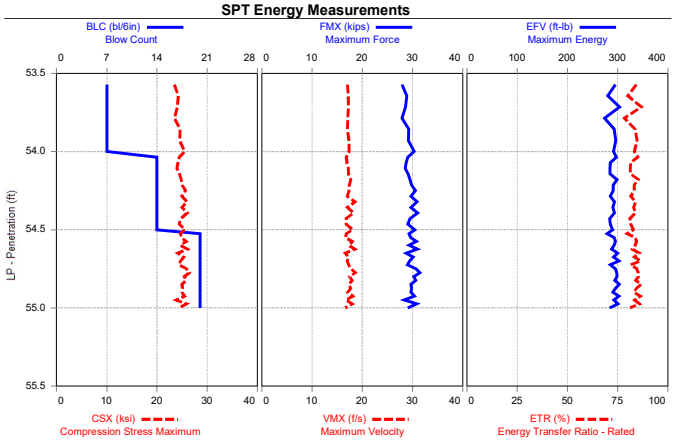
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
1	48.55	10	1.9	28	17.4	1.01	23.9	0.60	289	82.5
2	48.60	10	57.4	28	17.3	0.96	23.7	0.60	285	81.3
3	48.65	10	55.2	30	18.2	0.78	24.8	0.60	299	85.5
4	48.70	10	56.0	28	18.4	0.62	23.2	0.60	288	82.4
5	48.75	10	55.2	27	16.7	0.60	22.4	0.60	291	83.1
6	48.80	10	56.0	30	17.8	0.62	24.8	0.60	300	85.7
7	48.85	10	55.1	29	17.4	0.60	24.1	0.60	293	83.6
8	48.90	10	55.6	29	17.7	0.60	24.5	0.60	297	84.9
9	48.95	10	55.7	30	17.6	0.62	25.6	0.60	292	83.3
10	49.00	10	55.7	29	17.3	0.64	24.7	0.60	298	85.2
11	49.02	22	55.4	28	17.6	0.49	23.5	0.27	293	83.6
12	49.05	22	55.4	29	17.1	0.51	24.0	0.27	295	84.2
13	49.07	22	55.5	27	17.7	0.49	22.3	0.27	297	85.0
14	49.09	22	55.4	30	18.4	0.47	25.5	0.27	297	84.8
15	49.11	22	55.7	30	18.1	0.47	24.8	0.27	296	84.6
16	49.14	22	55.3	28	17.4	0.47	23.8	0.27	288	82.4
17	49.16	22	55.4	31	18.4	0.49	26.0	0.27	303	86.6
18	49.18	22	55.5	31	18.1	0.46	25.7	0.27	296	84.7
19	49.20	22	55.7	29	17.5	0.44	24.0	0.27	288	82.1
20	49.23	22	55.2	32	18.5	0.46	26.8	0.27	300	85.8
21	49.25	22	55.6	30	18.0	0.44	25.5	0.27	291	83.0
22	49.27	22	55.2	30	17.8	0.43	24.9	0.27	296	84.4
23	49.30	22	55.5	31	18.2	0.47	26.1	0.27	306	87.3
24	49.32	22	55.5	28	17.3	0.43	23.6	0.27	286	81.8
25	49.34	22	55.3	31	18.2	0.44	25.8	0.27	302	86.3
26	49.36	22	55.5	31	18.4	0.43	25.8	0.27	303	86.7
27	49.39	22	55.8	27	17.0	0.40	22.8	0.27	283	80.8
28	49.41	22	55.9	30	18.0	0.41	25.3	0.27	295	84.3
29	49.43	22	55.1	30	18.0	0.42	25.0	0.27	292	83.3
30	49.45	22	55.2	30	18.4	0.42	24.8	0.27	296	84.5
31	49.48	22	55.4	31	18.8	0.41	26.4	0.27	299	85.6

32	49.50	22	55.5	30	18.6	0.42	25.5	0.27	302	86.2
33	49.52	26	55.5	30	17.9	0.42	25.3	0.23	300	85.7
34	49.54	26	55.8	29	17.5	0.41	24.0	0.23	289	82.4
35	49.56	26	55.2	30	18.5	0.42	25.5	0.23	300	85.9
36	49.58	26	55.4	31	18.6	0.41	26.2	0.23	302	86.2
37	49.60	26	55.8	29	17.4	0.40	24.1	0.23	288	82.3
38	49.62	26	55.0	30	18.2	0.38	24.9	0.23	291	83.2
39	49.63	26	55.7	29	17.7	0.38	24.2	0.23	288	82.1
40	49.65	26	55.1	30	18.3	0.41	25.5	0.23	302	86.3
41	49.67	26	55.7	27	16.4	0.40	22.6	0.23	287	82.1
42	49.69	26	55.4	31	18.3	0.42	25.6	0.23	304	87.0
43	49.71	26	55.4	28	17.2	0.40	23.9	0.23	288	82.4
44	49.73	26	55.7	29	17.6	0.44	24.2	0.23	296	84.5
45	49.75	26	55.2	27	16.9	0.44	23.1	0.23	308	88.1
46	49.77	26	55.7	29	17.6	0.39	24.5	0.23	290	82.7
47	49.79	26	55.0	28	17.2	0.41	23.4	0.23	299	85.5
48	49.81	26	55.9	30	18.2	0.40	25.0	0.23	296	84.6
49	49.83	26	55.5	28	17.4	0.40	23.7	0.23	296	84.7
50	49.85	26	55.5	28	17.2	0.37	23.9	0.23	291	83.2
51	49.87	26	55.1	29	17.8	0.38	24.4	0.23	296	84.5
52	49.88	26	55.5	29	17.8	0.38	24.3	0.23	299	85.3
53	49.90	26	55.5	29	17.5	0.38	24.2	0.23	297	84.8
54	49.92	26	55.2	28	17.2	0.36	23.8	0.23	294	83.9
55	49.94	26	55.4	28	16.9	0.37	23.2	0.23	297	84.8
56	49.96	26	55.4	30	17.9	0.37	25.0	0.23	297	84.8
57	49.98	26	55.5	29	17.7	0.36	24.6	0.23	298	85.0
58	50.00	26	55.4	26	16.5	0.35	22.1	0.23	285	81.6
		Average	55.4	29	17.8	0.42	24.6	0.25	295	84.4
		Std Dev	0.2	1	0.6	0.04	1.1	0.02	6	1.7
		Maximum	55.9	32	18.8	0.51	26.8	0.27	308	88.1
		Minimum	55.0	26	16.4	0.35	22.1	0.23	283	80.8

N-value: 48

Sample Interval Time: 61.53 seconds.

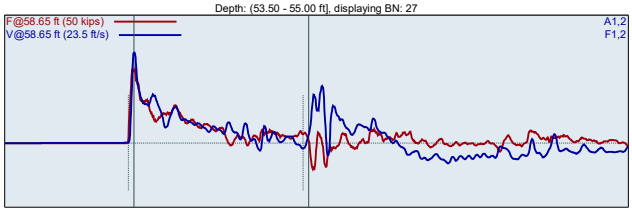
CME 550X (SN308513) - 53.5 - 55.0 Feet
SPT Energy Measurements



CME 550X (SN308513)
AMR
TEST HOLE
AR: 1.19 in^2
LE: 58.65 ft
WS: 16807.9 ft/s

SPT Energy Measurements
Test date: 4/19/2022
SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (53.50 - 55.00 ft], displaying BN: 27



F1 : [203 AWJ-1] 213.1 PDICAL (1) FF1
F2 : [203 AWJ-2] 212.91 PDICAL (1) FF1
A1 (PR): [K4664] 380 mv/6.4v/5000g (1) VF1
A2 (PR): [K4665] 365 mv/6.4v/5000g (1) VF1

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
1	53.57	7	1.9	28	17.1	1.38	23.5	0.86	295	84.3
2	53.64	7	58.2	29	17.2	1.01	24.2	0.86	280	80.0
3	53.71	7	54.6	29	17.2	0.95	24.1	0.86	304	86.8
4	53.79	7	56.2	28	17.1	0.86	23.5	0.86	274	78.3
5	53.86	7	55.5	29	17.1	0.86	24.6	0.86	293	83.8
6	53.93	7	55.0	29	17.3	0.86	24.5	0.86	296	84.7
7	54.00	7	55.8	30	17.4	0.86	25.5	0.86	292	83.3
8	54.04	14	55.2	29	16.8	0.56	24.5	0.43	298	85.1
9	54.07	14	55.4	29	17.0	0.53	24.2	0.43	285	81.5
10	54.11	14	55.4	29	17.2	0.52	24.0	0.43	285	81.3
11	54.14	14	55.7	29	17.2	0.50	24.5	0.43	285	81.4
12	54.18	14	55.2	30	17.7	0.50	24.8	0.43	298	85.3
13	54.21	14	55.1	30	17.4	0.50	25.1	0.43	291	83.2
14	54.25	14	55.6	31	17.4	0.49	25.7	0.43	291	83.3
15	54.29	14	55.4	30	17.0	0.49	25.0	0.43	285	81.5
16	54.32	14	55.0	31	18.6	0.45	26.0	0.43	294	83.9
17	54.36	14	55.7	30	17.0	0.51	25.0	0.43	290	83.0
18	54.39	14	55.4	31	18.3	0.45	26.1	0.43	294	83.9
19	54.43	14	55.1	29	16.8	0.47	24.8	0.43	284	81.1
20	54.46	14	55.9	29	16.8	0.43	24.4	0.43	285	81.4
21	54.50	14	54.9	30	18.1	0.43	25.6	0.43	290	82.8
22	54.53	20	55.7	29	16.8	0.43	24.6	0.30	279	79.7
23	54.55	20	55.1	30	16.6	0.45	24.9	0.30	293	83.8
24	54.58	20	55.3	31	18.0	0.43	25.9	0.30	295	84.4
25	54.60	20	55.0	29	17.3	0.45	24.7	0.30	293	83.7
26	54.63	20	55.4	31	18.6	0.38	26.0	0.30	288	82.3
27	54.65	20	55.1	29	16.6	0.44	24.1	0.30	300	85.7
28	54.68	20	55.1	30	17.2	0.45	25.3	0.30	292	83.4
29	54.70	20	55.8	29	17.0	0.46	24.7	0.30	303	86.4
30	54.73	20	55.0	29	17.3	0.39	24.4	0.30	285	81.5
31	54.75	20	55.2	31	17.7	0.41	25.8	0.30	295	84.4

32	54.78	20	55.2	31	18.7	0.39	26.4	0.30	298	85.2
33	54.80	20	55.1	30	17.5	0.41	25.4	0.30	299	85.3
34	54.83	20	55.5	31	18.0	0.40	25.8	0.30	294	84.0
35	54.85	20	55.1	30	17.3	0.42	25.0	0.30	303	86.7
36	54.88	20	55.4	30	17.7	0.40	25.1	0.30	295	84.3
37	54.90	20	55.1	30	17.1	0.39	25.0	0.30	291	83.1
38	54.93	20	55.4	30	18.1	0.38	25.5	0.30	302	86.4
39	54.95	20	55.0	28	16.7	0.38	23.8	0.30	292	83.4
40	54.98	20	55.7	31	18.0	0.38	25.9	0.30	301	85.9
41	55.00	20	55.2	29	16.6	0.36	24.4	0.30	284	81.1
		Average	55.3	30	17.4	0.44	25.1	0.35	292	83.5
		Std Dev	0.3	1	0.6	0.05	0.7	0.06	6	1.8
		Maximum	55.9	31	18.7	0.56	26.4	0.43	303	86.7
		Minimum	54.9	28	16.6	0.36	23.8	0.30	279	79.7

N-value: 34

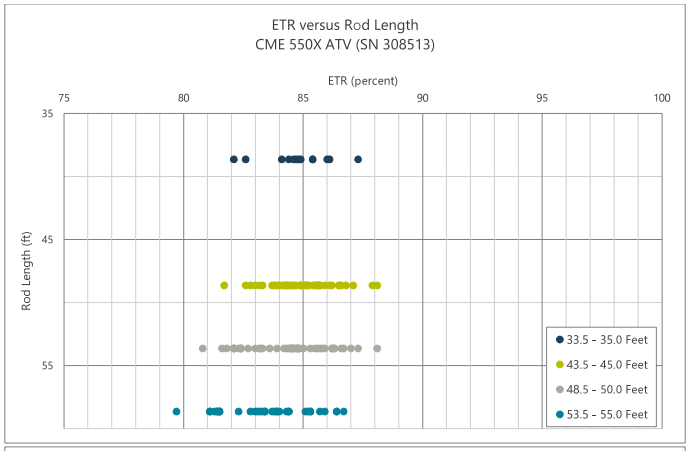
Sample Interval Time: 43.27 seconds.

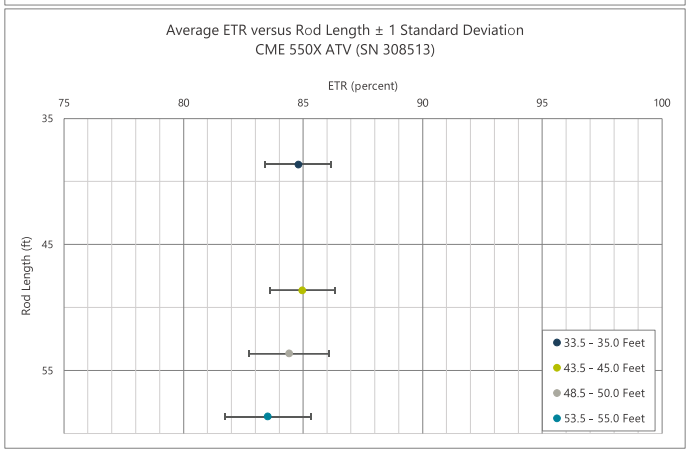
Summary of SPT Test Results

Project: CME 550X (SN308513), Test Date: 4/19/2022

BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement
CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	N Value	N60 Value	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR %
38.65	33.50	35.00	**3-5-8**	**13**	**18**	55.0	29	16.7	1.05	24.1	0.92	297	84.8
48.65	43.50	45.00	**12-20-24**	**44**	**61**	54.9	30	17.1	0.42	25.1	0.27	297	85.0
53.65	48.50	50.00	**10-22-26**	**48**	**67**	55.4	29	17.8	0.42	24.6	0.25	295	84.4
58.65	53.50	55.00	**7-14-20**	**34**	**47**	55.3	30	17.4	0.44	25.1	0.35	292	83.5
					Overall Average Values:	55.2	30	17.4	0.49	24.8	0.35	295	84.4
					Standard Deviation:	0.3	1	0.7	0.21	1.0	0.20	6	1.7
					Overall Maximum Value:	55.9	33	18.8	1.68	27.4	1.20	308	88.1
					Overall Minimum Value:	53.9	26	15.8	0.34	22.1	0.23	279	79.7


ETR versus Rod Length
CME 550X ATV (SN 308513)
ETR (percent)
75
80
85
90
95
100
Rod Length (ft)
35
45
55
33.5 - 35.0 Feet
43.5 - 45.0 Feet
48.5 - 50.0 Feet
53.5 - 55.0 Feet


Average ETR versus Rod Length ± 1 Standard Deviation
CME 550X ATV (SN 308513)
ETR (percent)
75
80
85
90
95
100
Rod Length (ft)
35
45
55
33.5 - 35.0 Feet
43.5 - 45.0 Feet
48.5 - 50.0 Feet
53.5 - 55.0 Feet