



# Geotechnical Subsurface Data Report

S-11-56 (Montgomery Dr.) Bridge Replacement  
over Horse Creek

*Cherokee County, SC*  
June 24, 2022



June 24, 2022

Mr. Trapp Harris, PE, DBIA  
Geotechnical Engineer  
Alternative Delivery  
South Carolina Department of Transportation  
955 Park Street  
Columbia, SC 29201

Dear Mr. Harris,

We have completed the Geotechnical Subsurface Data Report for the S-11-56 (Montgomery Dr.) Bridge Replacement over Horse Creek in Cherokee County, SC. Please call at your convenience if you have questions or comments. HDR appreciates the opportunity to provide geotechnical engineering services to the South Carolina Department of Transportation.

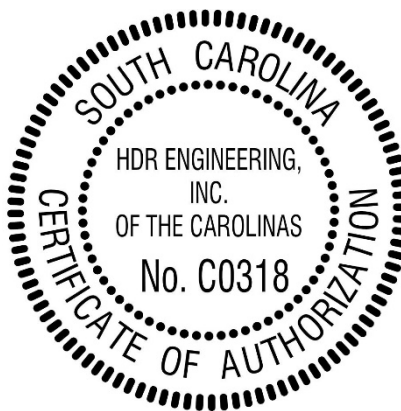
Sincerely,  
HDR

Kiera Hughes, E.I.T.  
*Engineer-in-Training*

Nathan Yacobi, P.G.  
*Professional Geologist*



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- Appendix B. Boring Logs; Rock Core Photos
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# 1 Introduction

This Geotechnical Subsurface Data Report (GSDR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed S-11-56 Bridge Replacement over Horse Creek, in Cherokee County, South Carolina. The proposed bridge intends to replace the existing bridge over Horse Creek on existing alignment.

This Geotechnical Subsurface Data Report was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and PCDM-11 Supplemental Design Criteria for Low Volume Bridge Replacement Projects. Geotechnical data including standard penetration testing (SPT), bulk samples, rock cores, and a variety of laboratory tests are presented herein to provide geological features and site conditions for the design of the proposed bridge. Geotechnical recommendations are not included in this report.

## 1.1 Project Description

The project site is located north of Chesnee, approximately a half mile south of the South Carolina/North Carolina State Line. It is bound to the north by State Road S-42-100 (Old Island Ford Road) and to the south by State Road S-11-76. It is placed within an area experiencing a low volume of traffic. A Site Vicinity Map is included in Appendix A.

The existing bridge over Horse Creek is approximately 30 feet in length and 25 feet wide and will be removed and replaced with a new bridge along the existing alignment. The proposed single span replacement bridge will be approximately 50 feet in length and will accommodate two 11-foot lanes with 6-foot shoulders. Construction is anticipated to be completed with a temporary detour of traffic.

# 2 Investigative Procedures

The geotechnical subsurface exploration at the project site was performed by F&ME Consultants in May 2022. The subsurface investigation consisted of standard penetration test (SPT) borings, rock core samples, and bulk sample soil collection.

A test location plan showing all testing locations is included in Appendix A. The boring logs and rock core photos from the subsurface investigation are included in Appendix B.

## 2.1 Drilling and Sampling

A total of two (2) SPT borings were performed during the subsurface investigation, B-1 and B-2. Auger refusal was encountered in both borings at depths of 28.9 feet and 47.6 feet, respectively. Advancement of the bridge borings B-1 and B-2 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 38.9 feet and 57.6 feet.

The boring logs from the subsurface investigations are included in Appendix B. The borings were advanced by a CME 45B using rotary wash and driven casing drilling

techniques. Soil sampling and penetration testing was performed in general accordance with ASTM D-1586 and ASTM D-1587. SPT's were typically conducted continuously in the top 10 feet of each boring followed by 5-foot intervals thereafter until auger refusal was encountered. SPT's were carried out utilizing a standard 1.4-inch I.D., 2-inch O.D, split barrel, or split-spoon sampler. Blow counts recorded at these intervals were produced from SPT hammer with energy ratio of 81.4%. The hammer energy ratio is identified on each boring log. SPT hammer energy measurements on the CME 45B drill rig were performed with a pile driving analyzer (PDA) and the SPT Hammer Energy Calibration Report is included in Appendix D.

One (1) bulk sample was obtained at boring BS-1 collectively from 5 feet below the existing ground surface from auger cuttings. The collected rock core samples were evaluated in the field and the percentage of core recovery (REC) and Rock Quality Designation (RQD) were recorded.

Recovered SPT, bulk sample, and rock cores were sent to the F&ME laboratory for testing.

## 2.2 Groundwater Conditions

Groundwater levels were recorded at the time of completion of soil drilling and/or rock coring at the boring locations at depths of 9.1 feet and 8.8 feet, respectively. These depths correspond to elevations of 837.1 feet and 836.7 feet.

Stabilized groundwater levels recorded approximately 24 hours after completion of investigation operations indicated groundwater depths of 9.0 feet and 8.6 feet. These depths correspond to elevations of 837.2 feet and 836.9 feet.

These reported groundwater levels are interpreted to be dependent upon seasonal fluctuations, individual event intensity and/or level of the Horse Creek.

## 2.3 Field Testing Summary

The field testing locations and other pertinent information are summarized in Table 2-1 below, and are also plotted on the field test location plan included in Appendix A.

**Table 2-1. Field Soil Testing Summary**

Test Hole No.	Station <sup>a</sup>	Offset (ft)	Latitude	Longitude	Top of Boring Elevation (ft)	Test Type	Total Depth (ft)
B-1	34+52	1 LT	35.17587	-81.86538	846.2	SPT/RC	38.9
B-2	34+07	2 LT	35.17599	-81.86540	845.5	SPT/RC	57.6
BS-1	34+02	2 LT	35.17601	-81.86540	845.5	BULK	5.0

<sup>a</sup> Stations based on latest S-11-56 alignment.

### 3 Laboratory Test Program

Laboratory testing was performed by F&ME Consultants on representative samples collected from the geotechnical borings to obtain index and engineering properties. Geotechnical index property testing included natural moisture content, Atterberg limits, #200 wash, and sieve analysis. Engineering property tests included consolidated undrained (CU) triaxial compression, unconfined compression of rock, Standard Proctor, and corrosion series testing.

Laboratory testing was performed in general accordance with ASTM or AASHTO test procedures. Representative samples were classified in accordance with the AASHTO and Unified Soil Classification System (USCS). Table 3-1 summarizes the testing types and quantity of each test performed. For detailed laboratory information, refer to Appendix C.

**Table 3-1. Laboratory Testing Summary**

Test Type	Quantity
Natural Moisture Content	9
Atterberg Limits	5
Grain Size Analysis with Hydrometer	3
Grain Size Analysis with #200 Wash	6
CU Triaxial	1
Unconfined Compression of Rock	4
Standard Proctor	1
Corrosion Series	1

#### 3.1 Soil and Rock Properties

Split spoon soil samples from the preliminary geotechnical subsurface site exploration for this bridge site were grouped and classified into AASHTO and USCS soil classifications. According to the AASHTO Soil Classification System, the classifications of these samples ranged from A-1-b to A-2-4. According to the Unified Soil Classification System, the classifications of these samples ranged from poorly graded sand with silt (SP-SM) to clayey sand (SC-SM). Tested samples yielded liquid limits ranging from 0 to 29 and plasticity indices ranging from 0 to 7.

Corrosion series test were performed on select split spoon samples. Standard proctor testing and remolded CU triaxial tests were performed on the collected bulk sample. Finally, four (4) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 11,980 psi to 15,880 psi. Results of laboratory testing are included in Appendix C.

## 4 Limitations to Report

This report has been prepared for the exclusive use of the South Carolina Department of Transportation or their agent, for specific application to the proposed S-11-56 Bridge over Horse Creek in Cherokee County, South Carolina in accordance with generally accepted soil and foundation engineering practices. No other warranty expressed or implied is made. The subsurface investigation logs included herein, do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to perform additional subsurface exploration based upon on-site observations of the conditions.

## 5 References

Butler, J.R. (1991). "Metamorphism". In Horton, J.W., Jr., and Zullo, V.A., Eds., the Geology of the Carolinas: Knoxville, University of Tennessee Press: 127.

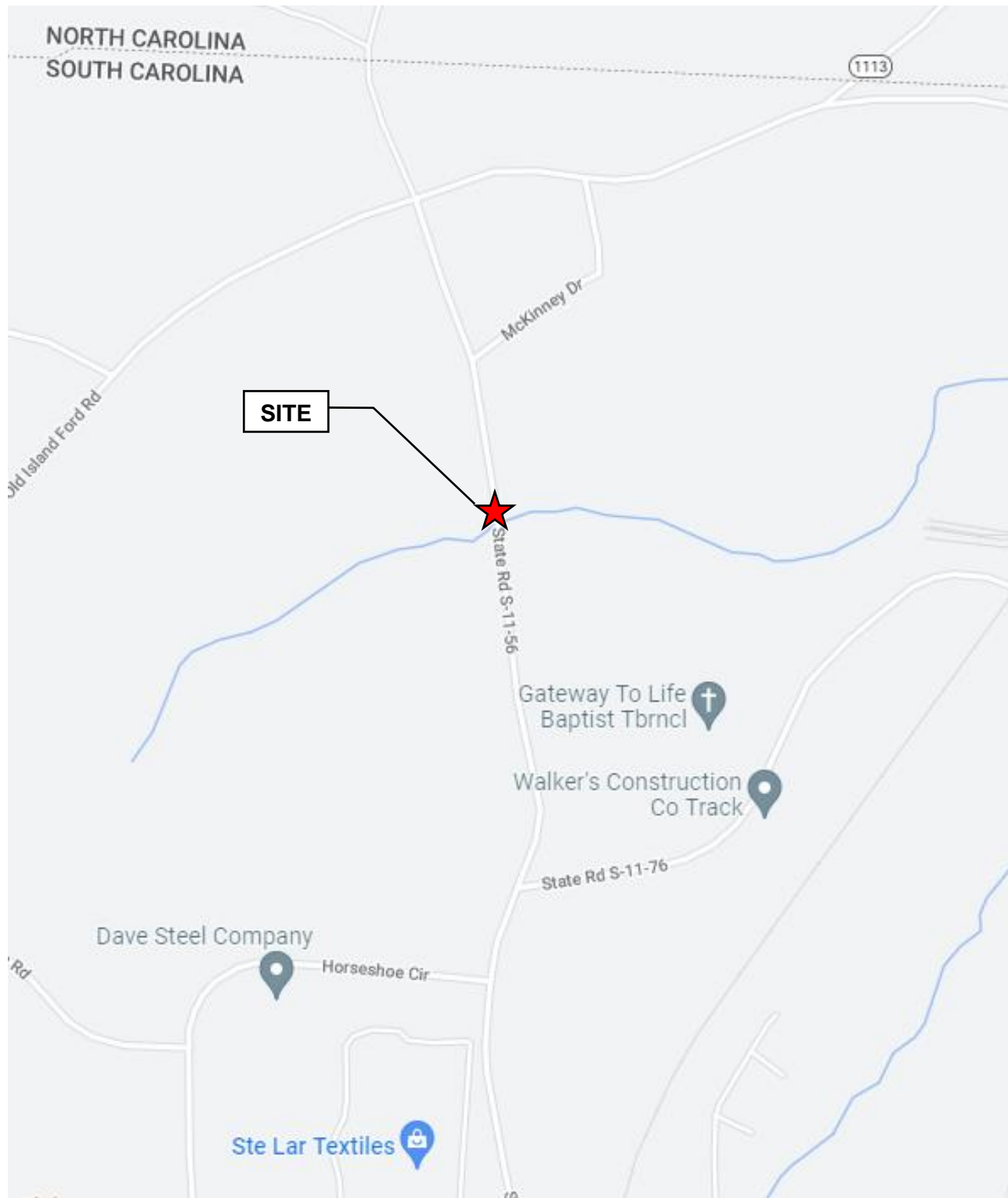
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Kesler, Thomas L. "*Kings Mountain Belt*" Carolina Geological Society Field Trip, October 1956. Foote Mineral Company

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## Appendix A. Site Vicinity Map, Test Location Plan



HDR ENGINEERING INC.  
OF THE CAROLINAS

1201 Main Street, Suite 800  
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### S-11-56 (Montgomery Dr.) over Horse Creek

COUNTY

CHEROKEE

SITE VICINITY MAP

Source: Google Maps



# S-11-56 Montgomery Dr. over Horse Creek

- Legend**
- Bulk Sample
  - SPT Boring

BS-1  
B-2

B-1



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## S-11-56 (Montgomery Dr.) over Horse Creek

COUNTY

CHEROKEE

FIELD TEST LOCATION PLAN

Source: Google Earth



100 ft

## Appendix B. Boring Logs; Rock Core Photos



# SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS  MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS  MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS  (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS  MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS  (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS  MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS  LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS  LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

**SCDOT** Soil Test Log Descriptors

a

-

Relative Density / Consistency Terms

Relative Density <sup>1</sup>			Consistency <sup>2</sup>		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q <sub>u</sub> ) (tsf)	SPT Blow Count
Very Loose	0 to 15%	< 4	Very Soft	<0.25	<2
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	Very Stiff	2.01 to 4.00	16 to 30
			Hard	>4.01	> 31

b

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

c

Color

Describe the sample color while sample is still moist, using Munsell color chart.

d

Angularity<sup>1</sup>

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

e

HCl Reaction<sup>3</sup>

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

f

Cementation<sup>3</sup>

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

g

Particle-Size Range<sup>1</sup>

Gravel		Sand			
mm	Sieve size	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

h

Primary Soil Type<sup>1,2</sup>

The primary soil type will be shown in all capital letters

i

USCS Soil Designation

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

j

AASHTO Soil Designation

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

<sup>1</sup>Applies to coarse-grained soils (major portion retained on No. 200 sieve)<sup>2</sup>Applies to fine-grained soils (major portion passing No. 200 sieve)<sup>3</sup>Use as required**Figure 6-15, SCDOT Soil Test Log Descriptors – Soil**

**SCDOT** Soil Test Log Descriptors

**k** **Rock Type**  
Indicate type of rock encountered (i.e. granite, limestone, shale, slate, etc.)

**l** **Color**  
Describe the sample color while sample is still moist, using Munsell color chart.

**m** **Texture**  
Describe the nonfracture structural features. Stratification is the layering of sedimentary rock and foliation is the layering of metaphoric rock

<u>Descriptive Term</u>	<u>Criteria</u>
Very Thickly Bedded	> 1.0 m
Thickly Bedded	0.5 to 1.0 m
Thinly Bedded	50 to 500 mm
Very Thinly Bedded	10 to 50 mm
Laminated	2.5 to 10 mm
Thinly Laminated	< 2.5 mm

**n** **Grain Size and Shape**  
Describe the size and shape of all visible grains, typically used on sedimentary rock.

<u>Size</u>		<u>Sieve size</u>
<u>Descriptor</u>	<u>mm</u>	
Very coarse grained	> 4.75	Grain sizes greater than popcorn kernels
Coarse grained	2.00 – 4.75	Individual grains easy to distinguish by eye
Medium grained	0.425 – 2.00	Individual grains distinguished by eye
Fine grained	0.075 – 0.425	Individual grains distinguished with difficulty
Very Fine grained	< 0.075	Individual grains cannot be distinguished by unaided eye
<u>Shape</u>		
<u>Descriptive Term</u>	<u>Criteria</u>	
Angular	Shows little wear; edges and corners are sharp	
Subangular	Shows definite effects of wear; edges and corners are slightly rounded off	
Subrounded	Shows considerable wear; edges and corners are rounded to smooth curves	
Rounded	Shows extreme wear; edges and corners are smoother to broad curves	
Well-rounded	Completely worn; edges and corners are not present	

**o** **Weathering / Alteration**  
Weathering is the physical disintegration of the minerals by atmospheric processes. Alteration is disintegration of the minerals by geothermal processes.

<u>Description</u>	<u>Recognition</u>
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered / Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although the original fabric may be intact; material can be granulated by hand
Highly Weathered / Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 1-7/8 inch diameter sample can be easily broken readily by hand across rock fabric
Moderately Weathered / Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 1-7/8 inch diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered / Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh	Rock shows no discoloration, loss of strength, or other effect of weathering / alteration

**Figure 6-16, SCDOT Soil Test Log Descriptors – Rock**

**SCDOT** Soil Test Log Descriptors
**p****Rock Strength**

Provide a qualitative assessment of the rock strength using either a geologic hammer or knife.

Description	Recognition	Approximately Uniaxial Compressive Strength (psi)
Extremely Weak Rock	Can be indented by thumbnail	35 – 150
Very Weak Rock	Can be peeled by pocket knife	150 – 700
Weak Rock	Can be peeled with difficulty by pocket knife	700 – 3,500
Medium Strong Rock	Can be indented 3/16 inch with sharp end of pick	3,500 – 7,200
Strong Rock	Requires one hammer blow to fracture	7,200 – 14,500
Very Strong Rock	Requires many hammer blows to fracture	14,500 – 35,000
Extremely Strong Rock	Can only be chipped with hammer blows	> 35,000

**q****Strike and Dip**

Dip of fracture surface measured relative to horizontal with bearing and direction (i.e. N30°down, etc.)

**r****Discontinuity Type****s****Discontinuity Width (millimeters)****t****Amount of Infilling**

F - Fault	W - Wide (12.5 – 50)	Su - Surface Stain
J - Joint	MW - Moderately Wide (2.5 – 12.5)	Sp - Spotty
Sh - Shear	N - Narrow (1.25 – 2.5)	Pa - Partially Filled
Fo - Foliation	VN - Very Narrow (< 1.25)	Fi - Filled
V - Vein	T - Tight (0)	No - None
B - Bedding		

**u****Type of Infilling****v****Surface Shape of Joint****w****Discontinuity Spacing (feet)**

Cl - Clay	Wa - Wavy	EW - Extremely Wide (> 65)
Ca - Calcite	Pl - Planar	W - Wide (22 – 65)
Ch - Chloride	St - Stepped	M - Moderate (7.5 – 22)
Fe - Iron Oxide	Ir - Irregular	C - Close (2 – 7.5)
Gy - Gypsum/Talc		VC - Very Close (< 2)
H - Healed		
No - None		
Py - Pyrite		
Qz - Quartz		
Sd - Sand		

**x****Roughness of Surface**

Slk - Slickensided (surface has smooth, glassy finish with visual evidence of striations)
S - Smooth (surface appears smooth and feels so to the touch)
SR - Slightly Rough (asperities on the discontinuity surfaces are distinguishable and can be felt)
R - Rough (some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive)
VR - Very Rough (near-vertical steps and ridges occur on the discontinuity surface)

**Figure 6-17, SCDOT Soil Test Log Descriptors – Rock (con't)**

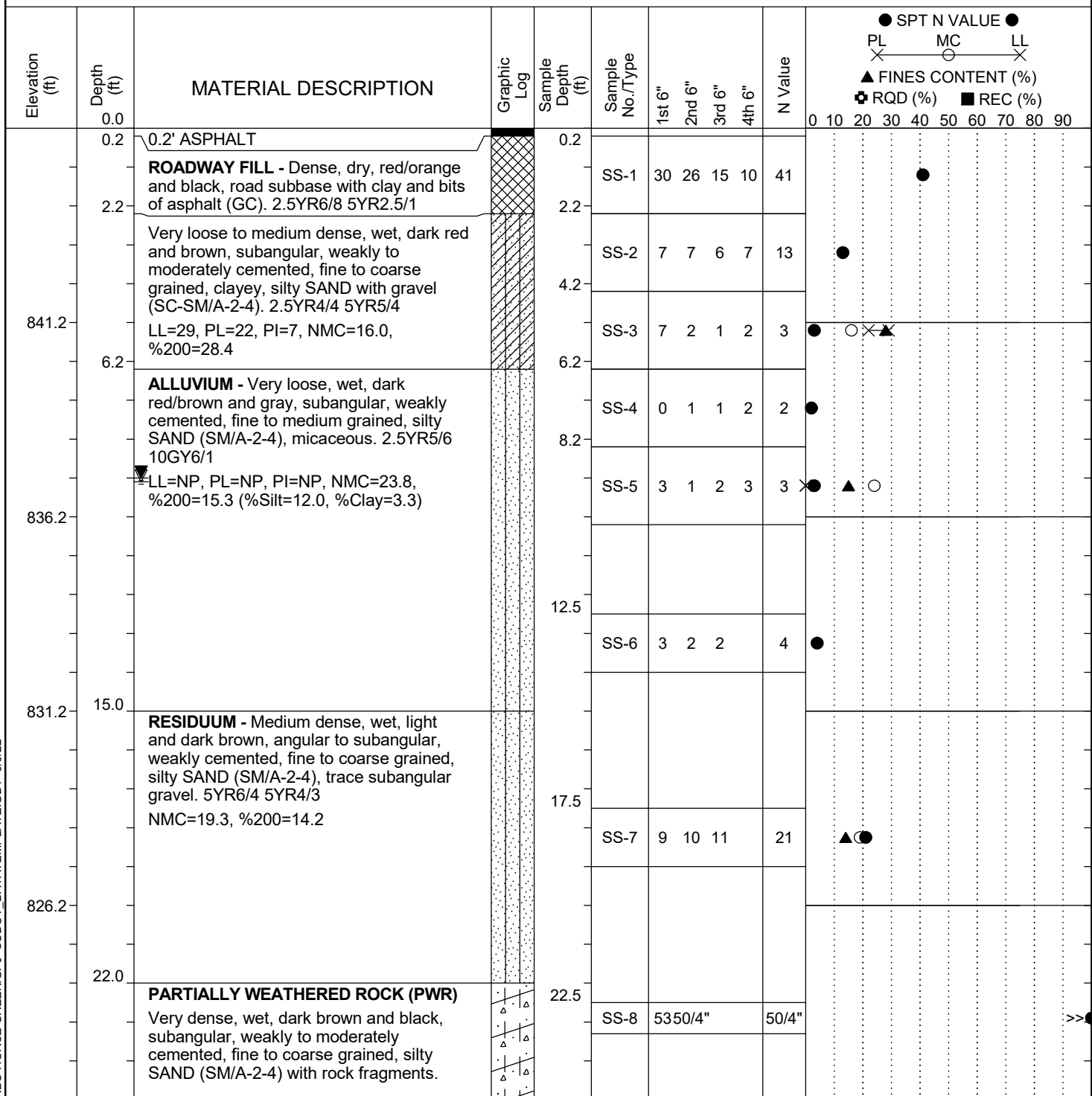


## **Appendix B. Subsurface Investigation**

### **Boring Logs**

# SCDOT Soil Test Log

<b>Project ID:</b>	P041148	<b>County:</b>	Cherokee, SC	<b>Boring No.:</b>	B-1
<b>Site Description:</b>	S-11-56 (Montgomery Dr.) over Horse Creek			<b>Route:</b>	S-11-56
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	34+52	<b>Offset:</b>	1 LT
<b>Elev.:</b>	846.2 ft	<b>Latitude:</b>	35.17587	<b>Longitude:</b>	-81.86538
<b>Total Depth:</b>	38.9 ft	<b>Soil Depth:</b>	28.9 ft	<b>Core Depth:</b>	10.0 ft
<b>Date Started:</b>	5/2/2022				
<b>Date Completed:</b>	5/2/2022				
<b>Bore Hole Diameter (in):</b>	2.97"	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)		<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b>	CME 45B	<b>Drill Method:</b>	RW & RC	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	D. Harris/ F&ME	<b>Groundwater:</b>	TOB 9.1 ft
<b>24HR</b>	9.0 ft				



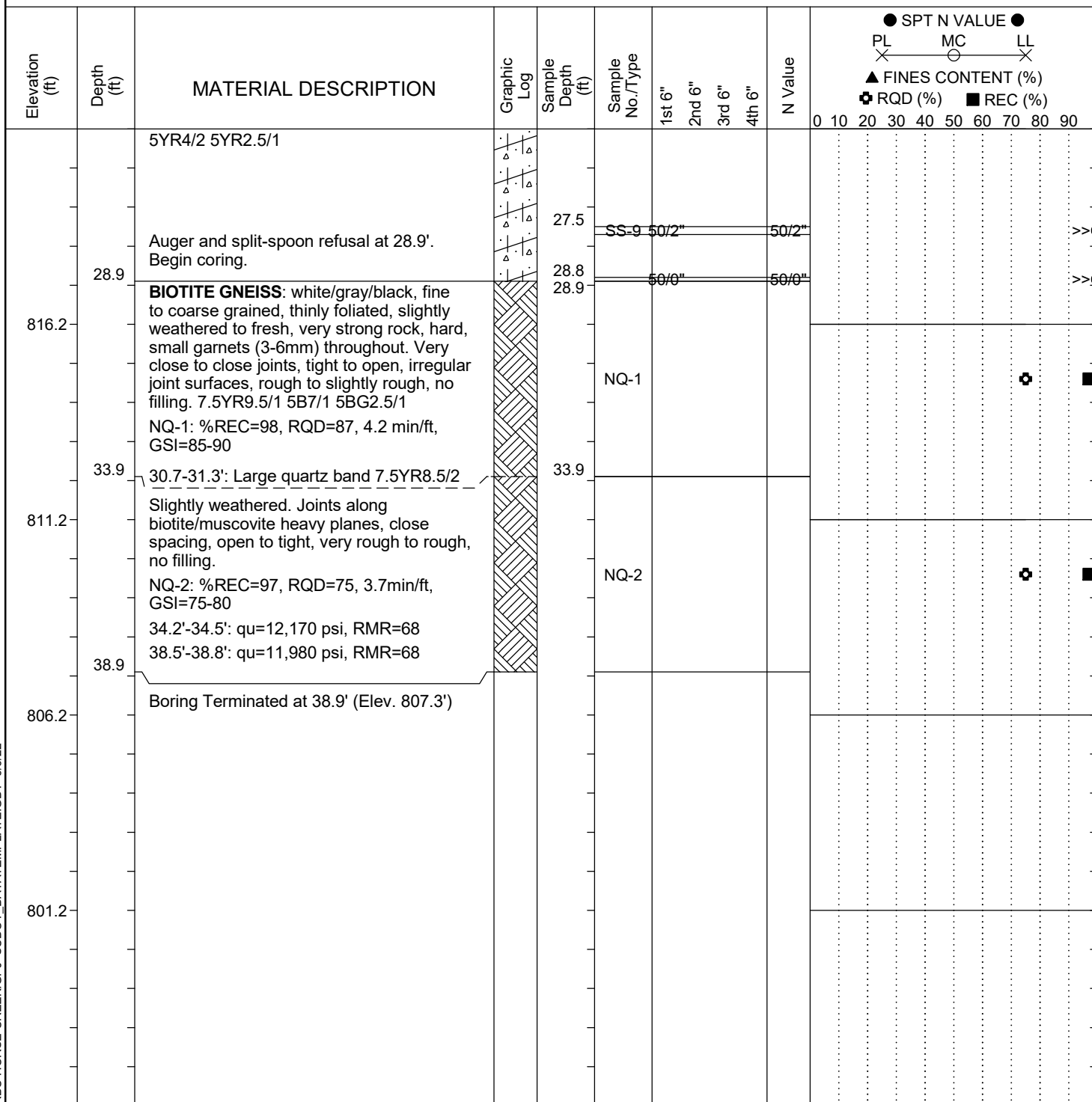
## LEGEND

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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

<b>Project ID:</b>	P041148	<b>County:</b>	Cherokee, SC	<b>Boring No.:</b>	B-1
<b>Site Description:</b>	S-11-56 (Montgomery Dr.) over Horse Creek			<b>Route:</b>	S-11-56
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	34+52	<b>Offset:</b>	1 LT
<b>Elev.:</b>	846.2 ft	<b>Latitude:</b>	35.17587	<b>Longitude:</b>	-81.86538
<b>Date Started:</b>	5/2/2022				
<b>Total Depth:</b>	38.9 ft	<b>Soil Depth:</b>	28.9 ft	<b>Core Depth:</b>	10.0 ft
<b>Date Completed:</b>	5/2/2022				
<b>Bore Hole Diameter (in):</b>	2.97"	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)		<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b>	CME 45B	<b>Drill Method:</b>	RW & RC	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	D. Harris/ F&ME	<b>Groundwater:</b>	TOB 9.1 ft
<b>24HR</b>	9.0 ft				



## LEGEND

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

# Rock Core Photos

B-1

Box 1 of 1 (28.9' to 38.9')





# SCDOT Soil Test Log

<b>Project ID:</b>	P041148	<b>County:</b>	Cherokee, SC	<b>Boring No.:</b>	B-2
<b>Site Description:</b>	S-11-56 (Montgomery Dr.) over Horse Creek			<b>Route:</b>	S-11-56
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	34+07	<b>Offset:</b>	2 LT
<b>Elev.:</b>	845.5 ft	<b>Latitude:</b>	35.17599	<b>Longitude:</b>	-81.8654
<b>Date Started:</b>	5/3/2022				
<b>Total Depth:</b>	57.6 ft	<b>Soil Depth:</b>	47.6 ft	<b>Core Depth:</b>	10.0 ft
<b>Date Completed:</b>	5/3/2022				
<b>Bore Hole Diameter (in):</b>	2.97"	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)		<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b>	CME 45B	<b>Drill Method:</b>	RW & RC	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	D. Harris/ F&ME	<b>Groundwater:</b>	TOB 8.8 ft
<b>24HR</b>	8.6 ft				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL X MC X LL X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
	0.0										0 10 20 30 40 50 60 70 80 90
	0.6	0.6' ASPHALT		0.6							
		ROADWAY FILL - Medium dense to loose, wet, dark red, subangular, weakly cemented, fine to coarse grained, silty, clayey SAND (SC-SM/A-2-4). 10R 3/4			SS-1	10	14	11	13	25	
	2.6			2.6							
					SS-2	4	5	3	3	8	
	4.6			4.6							
					SS-3	4	2	3	2	5	
	6.6			6.6							
		ALLUVIUM - Very loose to loose, wet, brown to light gray, subangular to subrounded, weakly cemented, fine to coarse grained, poorly graded SAND with Silt (SP-SM/A-1-b). 5YR5/3 5YR6/1			SS-4	2	1	1	2	2	
	8.6	LL=NP, PL=NP, PI=NP, NMC=24.1, %200=8.2 (%Silt=6.6, %Clay=1.6)		8.6							
					SS-5	2	3	1	2	4	
	11.7			11.7							
		RESIDUUM - Very loose to loose, wet, light gray, subrounded to rounded, weakly cemented, fine to coarse grained, Silty SAND (SM/A-2-4), micaceous. 5YR7/1									
	13.3	LL=NP, PL=NP, PI=NP, NMC=70.2, %200=27.6 (%Silt=23.3, %Clay=4.3)		13.3							
					SS-6	1	2	1		3	
	18.3			18.3							
					SS-7	3	6	4		10	
	23.3			23.3							
		NMC=51.7, %200=32.9			SS-8	1	2	4		6	

## 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

<b>Project ID:</b>	P041148	<b>County:</b>	Cherokee, SC	<b>Boring No.:</b>	B-2
<b>Site Description:</b>	S-11-56 (Montgomery Dr.) over Horse Creek			<b>Route:</b>	S-11-56
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	34+07	<b>Offset:</b>	2 LT
<b>Elev.:</b>	845.5 ft	<b>Latitude:</b>	35.17599	<b>Longitude:</b>	-81.8654
<b>Date Started:</b>	5/3/2022				
<b>Total Depth:</b>	57.6 ft	<b>Soil Depth:</b>	47.6 ft	<b>Core Depth:</b>	10.0 ft
<b>Date Completed:</b>	5/3/2022				
<b>Bore Hole Diameter (in):</b>	2.97"	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)		<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b>	CME 45B	<b>Drill Method:</b>	RW & RC	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	D. Harris/ F&ME	<b>Groundwater:</b>	TOB 8.8 ft
<b>24HR</b>	8.6 ft				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	<div> ● SPT N VALUE ●  PL — MC — LL  X — X — X  ▲ FINES CONTENT (%)  + RQD (%) ■ REC (%) </div>
815.5	25.8	Medium dense, wet, gray and brown, subangular to subrounded, weakly cemented, fine to coarse grained, silty SAND (SM/A-2-4). 5YR5/1 5YR5/3									
				28.3	SS-9	3	5	6		11	●
810.5		NMC=15.3, %200=14.9 includes gravel		33.3	SS-10	18	15	8		23	▲ ●
805.5				38.3	SS-11	10	9	7		16	●
800.5		NMC=21.5, %200=21.3		43.3	SS-12	12	14	12		26	▲ ●
	47.6	Auger and split-spoon refusal at 47.6'. Begin coring.		47.5							
		BIOTITE GNEISS: white/gray/black, fine to coarse grained, thin to very thin foliations, slightly weathered to fresh, very strong rock, very hard, small garnets		47.6		50/1"			50/1"		>>●

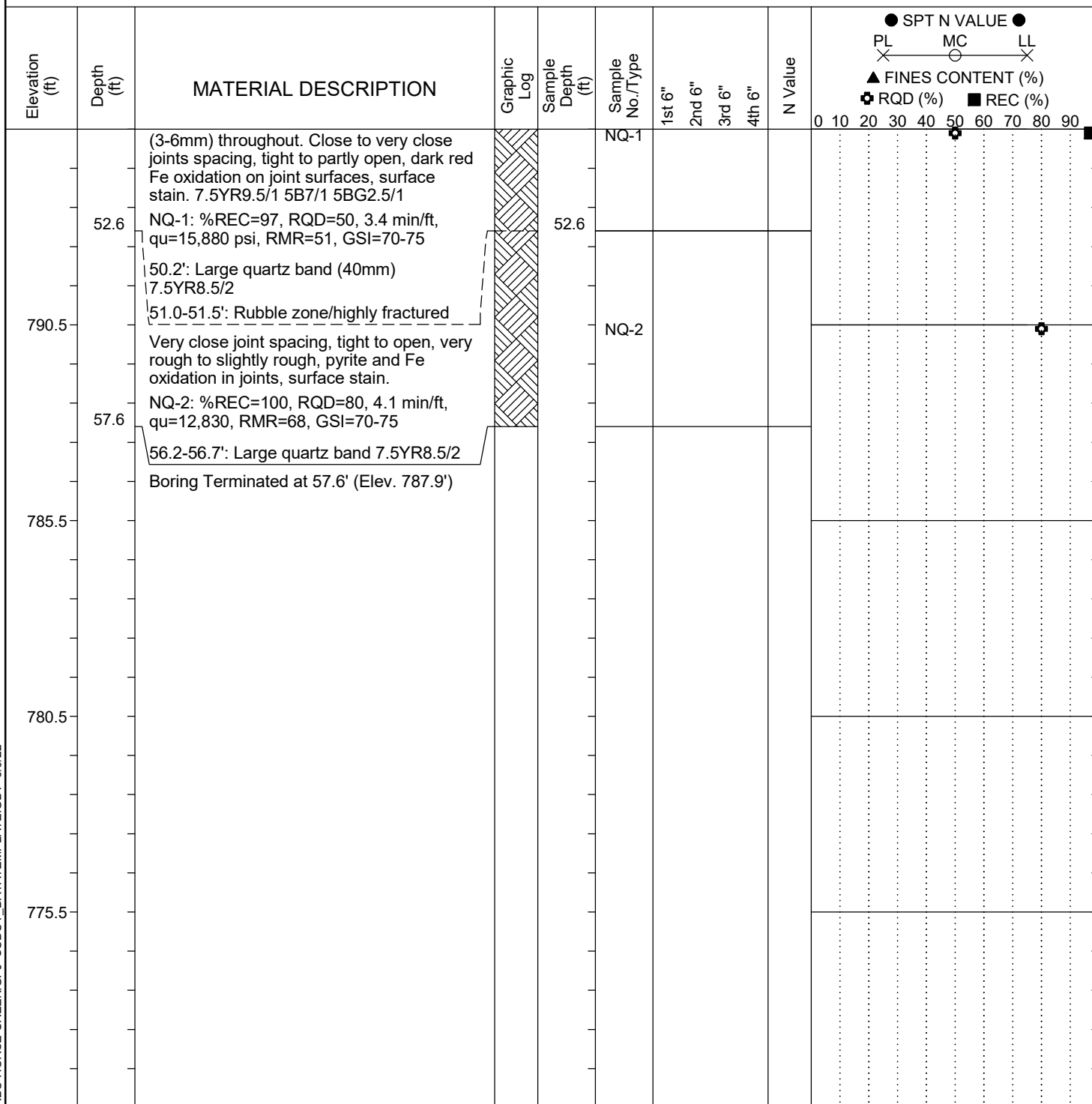
## LEGEND

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

<b>Project ID:</b>	P041148	<b>County:</b>	Cherokee, SC	<b>Boring No.:</b>	B-2
<b>Site Description:</b>	S-11-56 (Montgomery Dr.) over Horse Creek			<b>Route:</b>	S-11-56
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	34+07	<b>Offset:</b>	2 LT
<b>Elev.:</b>	845.5 ft	<b>Latitude:</b>	35.17599	<b>Longitude:</b>	-81.8654
<b>Total Depth:</b>	57.6 ft	<b>Soil Depth:</b>	47.6 ft	<b>Core Depth:</b>	10.0 ft
<b>Date Started:</b>	5/3/2022				
<b>Date Completed:</b>	5/3/2022				
<b>Bore Hole Diameter (in):</b>	2.97"	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)		<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b>	CME 45B	<b>Drill Method:</b>	RW & RC	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	D. Harris/ F&ME	<b>Groundwater:</b>	TOB 8.8 ft
<b>24HR</b>	8.6 ft				



## 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 S-11-56 RBO HORSE CREEK.GPJ SCDOT\_DATATEMPLATE.GDT 6/6/22

# Rock Core Photos

B-2

Box 1 of 1 (47.6' to 57.6')



15,880 psi

12,830 psi

## Appendix C. Laboratory Testing



# SUMMARY OF LABORATORY RESULTS

PAGE 1 OF 1

PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-1	4.2	29	22	7	0.075	28	SC-SM	16.0			
B-1	8.2	NP	NP	NP	0.075	15	SM	23.8			
B-2	8.6	NP	NP	NP	0.075	8	SP-SM	24.1			
B-2	13.3	NP	NP	NP	0.075	28	SM	70.2			

# Rock Coring Summary

PAGE 1 OF 1



PROJECT ID P041148

PROJECT NAME S-11-56 (Montgomery Dr.) over Horse Creek

PROJECT COUNTY Cherokee, SC

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q <sub>u</sub> (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
B-1	NQ-1	28.9	98	87						88
B-1	NQ-2.1	33.9	97	75	12170	0.20	5490	174	68	78
B-1	NQ-2.2	33.9	97	75	11980	0.36	5000	176	68	78
B-2	NQ-1	47.6	97	50	15880	0.01	2620	168	51	73
B-2	NQ-2	52.6	100	80	12830	0.02	4620	173	68	73



# INDEX PROPERTIES VERSUS DEPTH

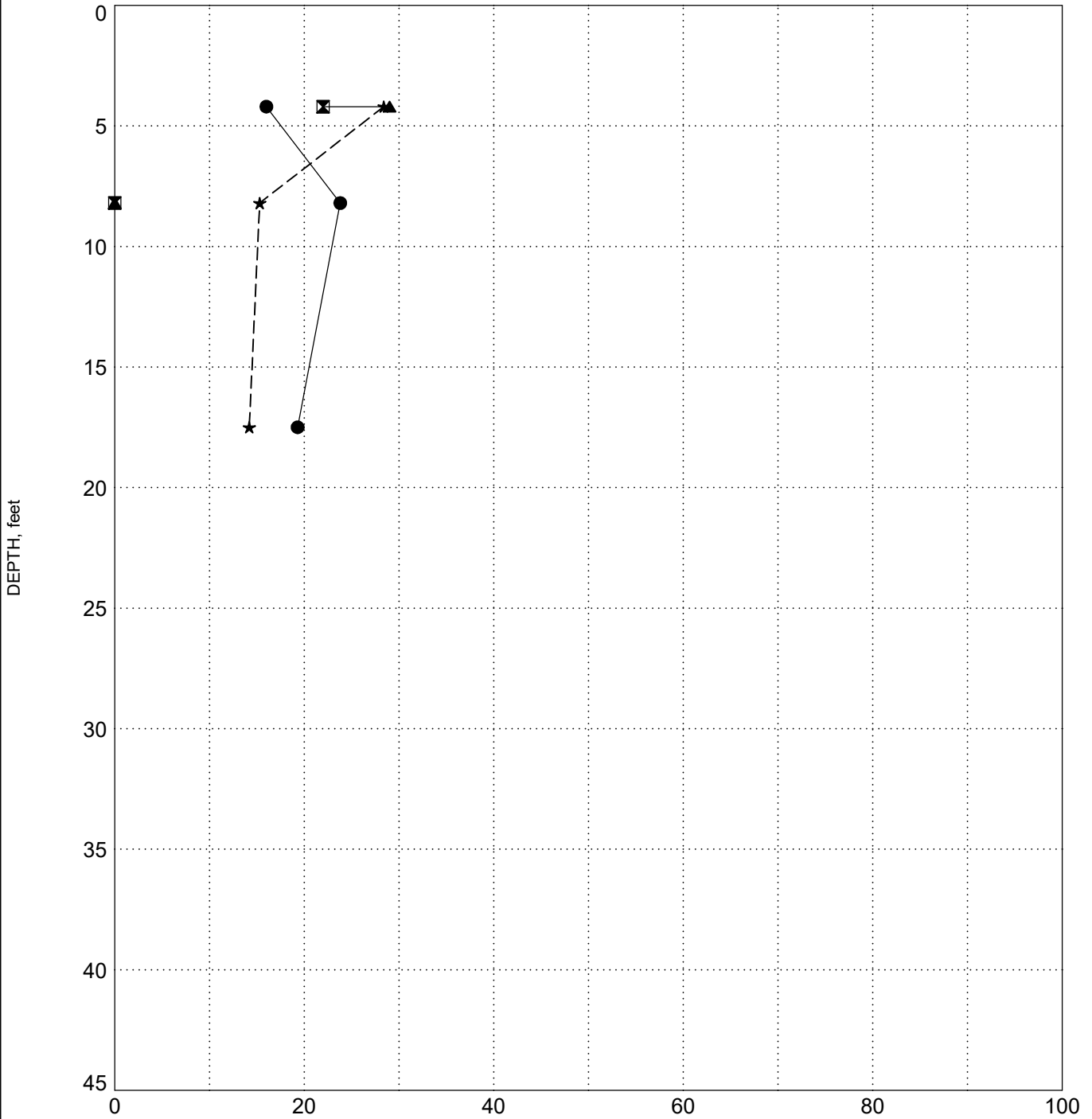
PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC

SURFACE ELEVATION: 846.2

## BORING B-1



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





# INDEX PROPERTIES VERSUS DEPTH

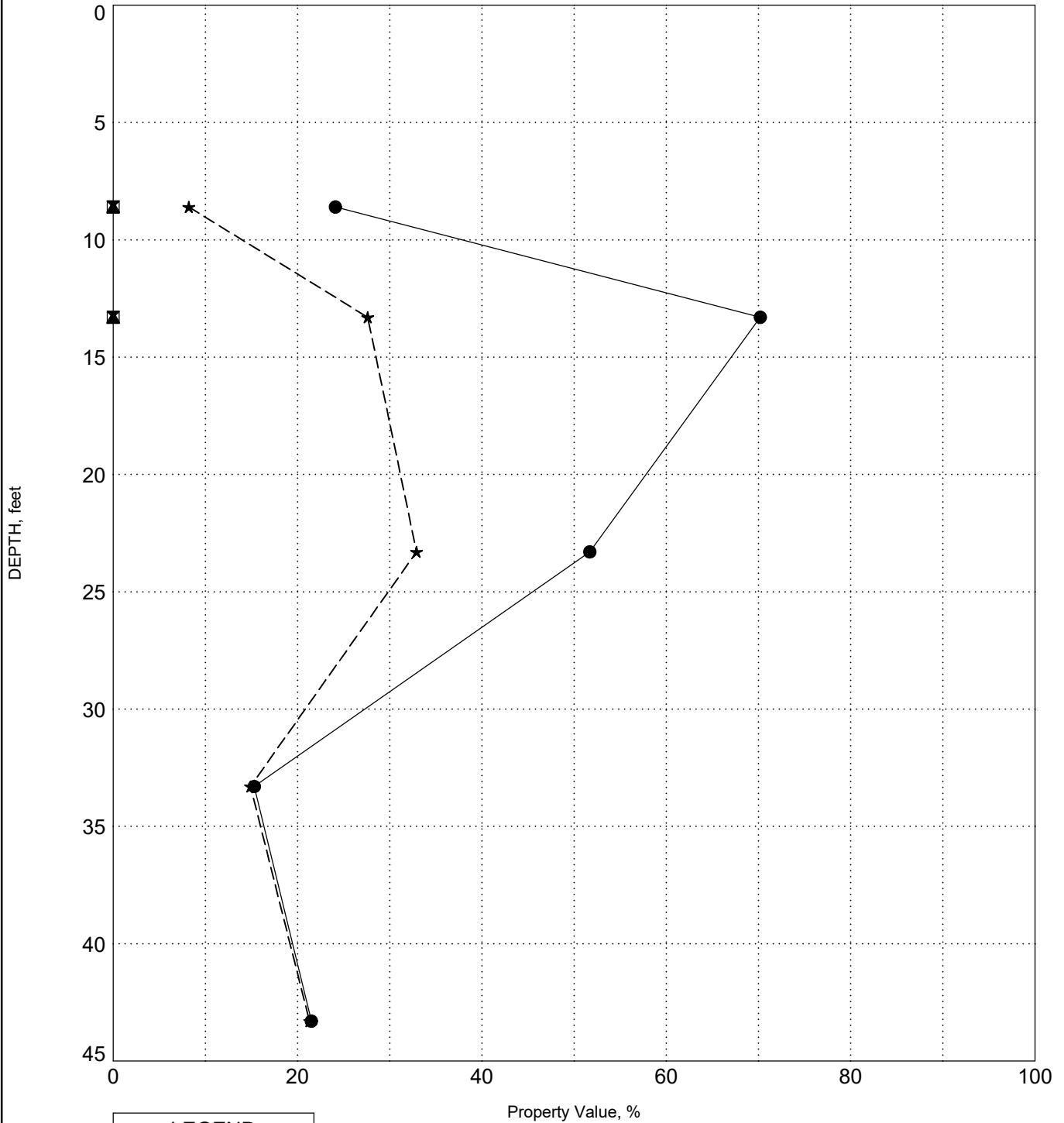
PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC

SURFACE ELEVATION: 845.5

## BORING B-2



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



## **Laboratory Testing Procedures**

### **Grain Size Distribution**

Wash #200 Testing has been conducted following ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than 75- $\mu\text{m}$  (No. 200) Sieve in Soils by Washing. Full grain size analysis was conducted on select samples following ASTM D6913 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

### **Hydrometer**

Hydrometer grain size analysis for soils was conducted following ASTM D7928 Standard Test Method for Particle Size Analysis of Soils.

### **Atterberg Limits**

Atterberg limits testing have been conducted following ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

### **Moisture Content**

Moisture content testing has been conducted following ASTM D2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

### **Standard Proctor**

Standard Proctor testing has been conducted following ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600kN-m/m<sup>3</sup>)).

### **Consolidated-Undrained Triaxial Test**

CU testing allows the soil specimen to be consolidated under a confining pressure prior to shear and has been conducted following ASTM D4767 Standard Test Method for Consolidated-Undrained Triaxial Compression Test for Cohesive Soils. The soil specimens in this case were bulk samples that were remolded and compacted to 95% of the Standard Proctor.

**Corrosion Series**

Corrosion series testing has been conducted including pH, chloride content, sulfate content, and resistivity. PH testing was conducted AASHTO T289 Standard Method of Test for Determining pH of Soil for Use in Corrosion Testing. Chloride content testing was conducted following AASHTO T291 Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil. Sulfate content testing was conducted following AASHTO T290 Standard Method of Test for Determining Water-Soluble Sulfate Content in Soil. Resistivity testing was conducted following AASHTO T288 Standard Method of Test for Determining Minimum Laboratory Soil Resistivity.

**Compressive Strength of Rock Cores**

Compressive strength of rock cores has been conducted following ASTM D7012 Standard Test for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.



## **Appendix C. Laboratory Testing**

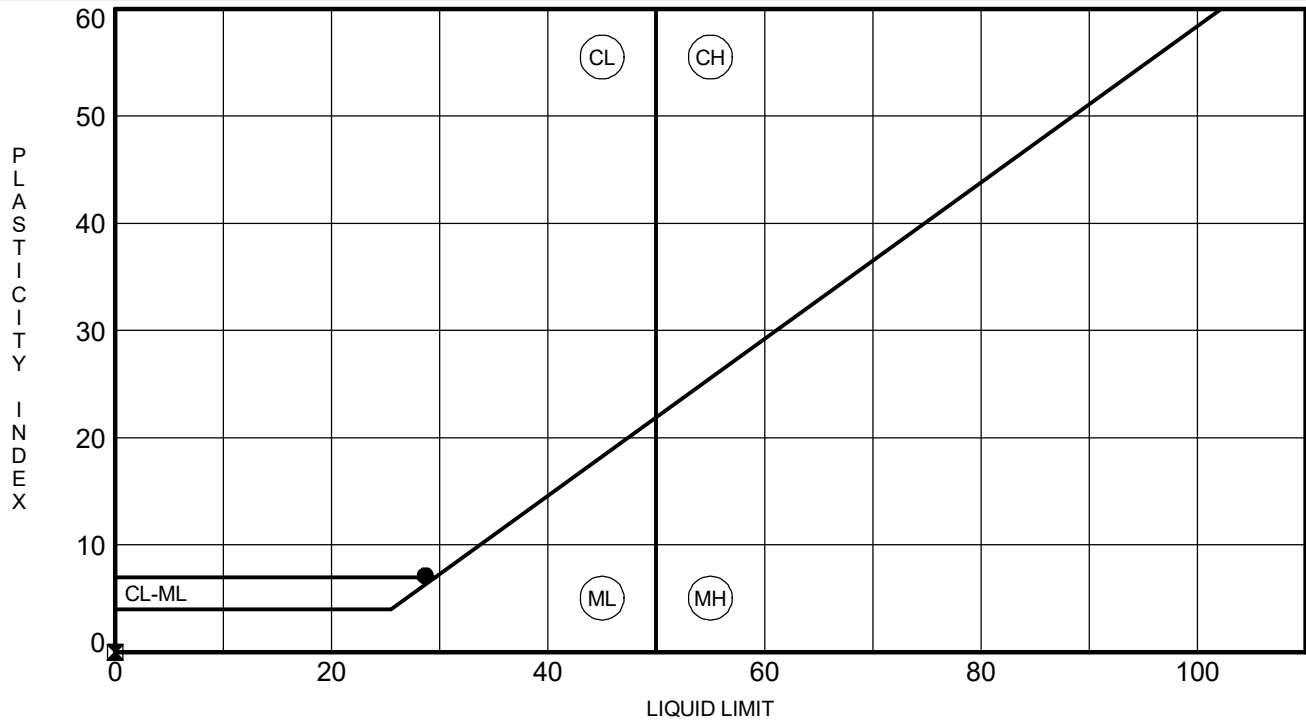
### **Split Spoon Samples**

## ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041148

**PROJECT NAME** S-11-56 RBO Horse Creek

**PROJECT COUNTY** Cherokee, SC

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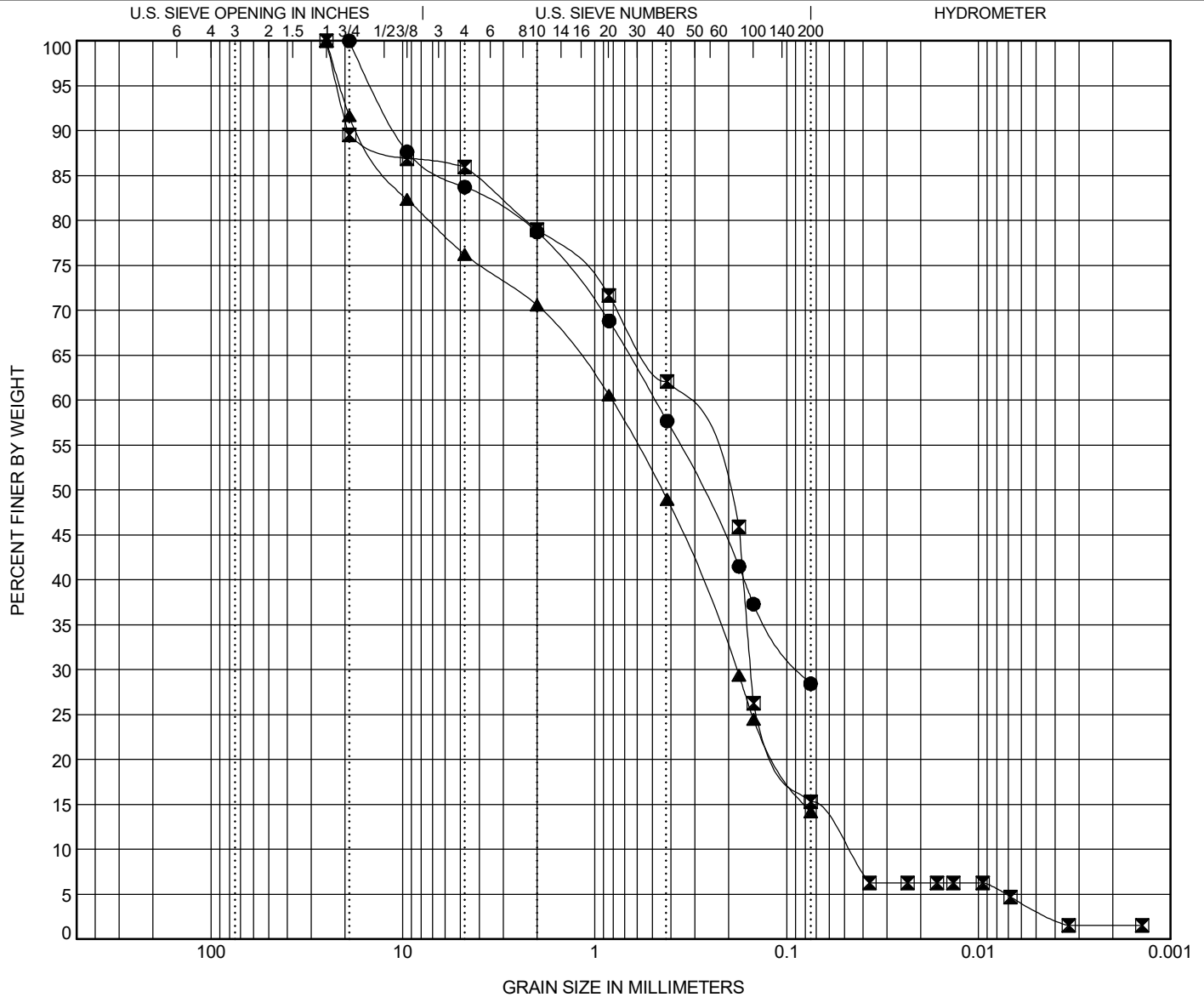


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-1	6.2	Silty, Clayey SAND (SC-SM/A-2-4) with Gravel					29	22	7		
■ B-1	10.2	Silty SAND (SM/A-2-4)					NP	NP	NP	1.28	7.60
▲ B-1	19.0	Silty SAND (SM/A-2-4)									
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-1	6.2	19	0.485	0.085		16.3	55.3	28.4			
■ B-1	10.2	25	0.375	0.154	0.049	14.0	70.6	12.0		3.3	
▲ B-1	19.0	25	0.812	0.182		23.8	62.0	14.2			

# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-11-56 RBO Horse Creek **SCDOT PROJECT ID:** P041148  
**SAMPLE NUMBER:** 22-1395 **DATE SAMPLE RECEIVED:** 5/9/2022  
**DESCRIPTION OF SOIL:** Various  
**TESTED BY:** A. Abernethy **DATE SETUP:** 5/9/2022  
**WEIGHED BY:** T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	B-1	B-1	B-1		
SAMPLE NO.	SS-3	SS-5	SS-7		
SAMPLE DEPTH (FT.)	4.2 - 6.2	8.2 - 10.2	17.5 - 19.0		
WATER CONTENT, W%	16.0	23.8	19.3		

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



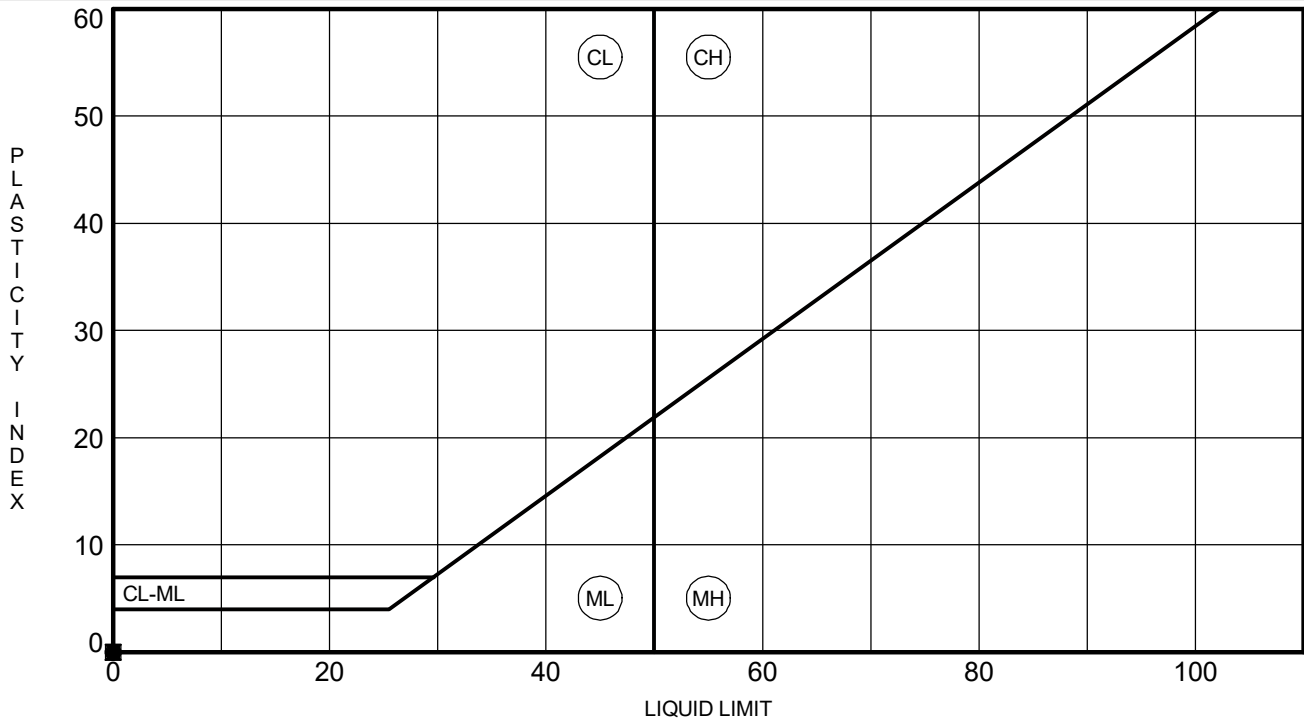
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## ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041148

**PROJECT NAME** S-11-56 RBO Horse Creek

**PROJECT COUNTY** Cherokee, SC

[illegible]



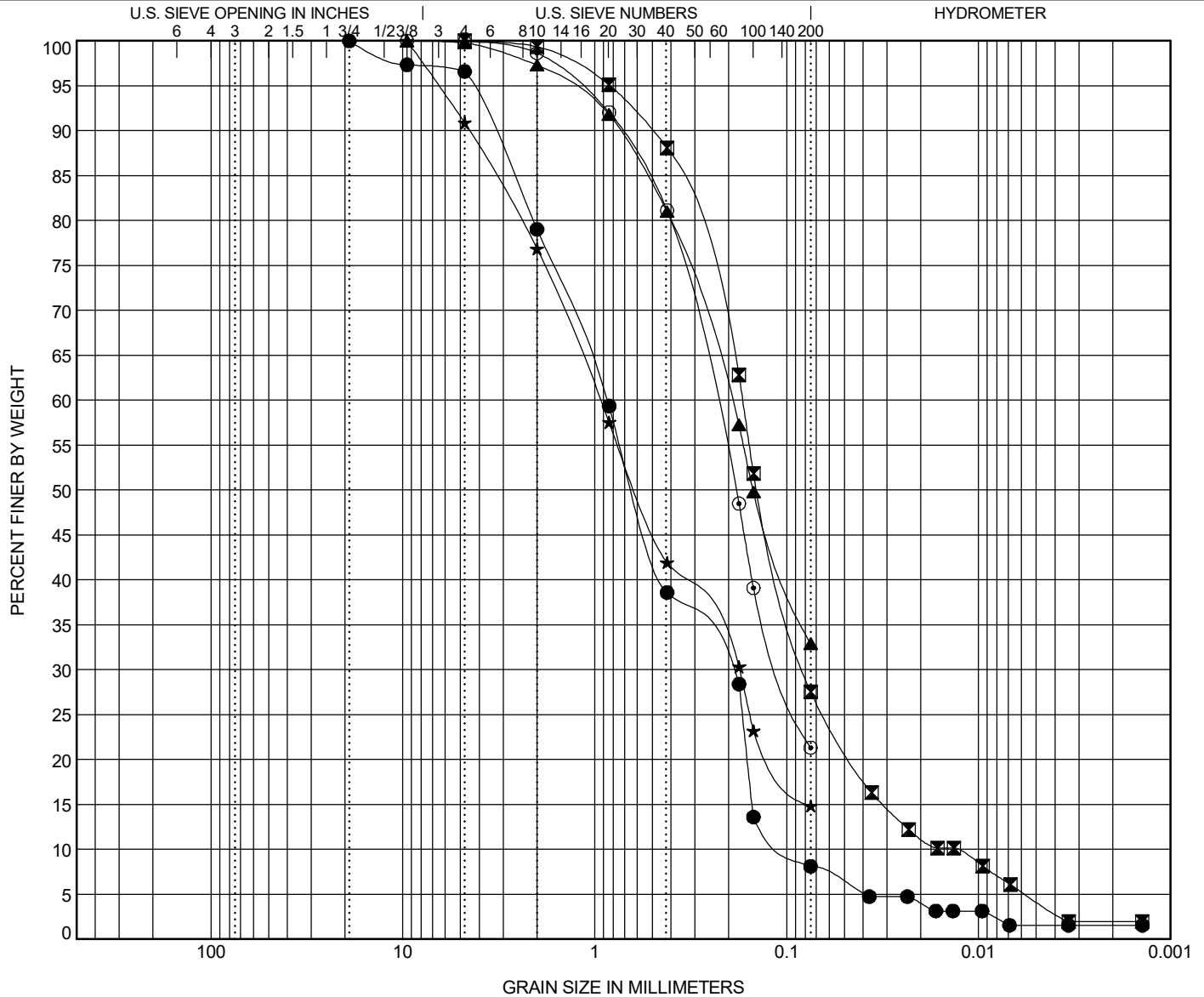


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-2	10.6	Poory Graded <u>SAND (SP-SM/A-1-b)</u> with Silt					NP	NP	NP	0.50	9.12
▣ B-2	14.8	Silty <u>SAND (SM/A-2-4)</u>					NP	NP	NP	2.93	13.01
▲ B-2	24.8	Silty <u>SAND (SM/A-2-4)</u>									
★ B-2	34.8	Silty <u>SAND (SM/A-2-4)</u>									
⊙ B-2	44.8	Silty <u>SAND (SM/A-2-4)</u>									
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-2	10.6	19	0.865	0.203	0.095	3.4	88.4	6.6		1.6	
▣ B-2	14.8	4.76	0.169	0.08	0.013	0.0	72.4	23.3		4.3	
▲ B-2	24.8	9.51	0.196			0.2	66.9	32.9			
★ B-2	34.8	9.51	0.939	0.176		9.1	76.0	14.9			
⊙ B-2	44.8	9.51	0.24	0.105		0.1	78.6	21.3			

# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-11-56 RBO Horse Creek **SCDOT PROJECT ID:** P041148  
**SAMPLE NUMBER:** 22-1396 **DATE SAMPLE RECEIVED:** 5/9/2022  
**DESCRIPTION OF SOIL:** Various  
**TESTED BY:** A. Abernethy **DATE SETUP:** 5/9/2022  
**WEIGHED BY:** T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	B-2	B-2	B-2	B-2	B-2
SAMPLE NO.	SS-5	SS-6	SS-8	SS-10	SS-12
SAMPLE DEPTH (FT.)	8.6 - 10.6	13.3 - 14.8	23.3 - 24.8	33.3 - 34.8	43.3 - 44.8
WATER CONTENT, W%	24.1	70.2	51.7	15.3	21.5

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



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Client:	F&ME Consultants
Project Name:	S-56 Bridge Replacement over Horse Creek
Project Location:	Cherokee County, South Carolina
GTX #:	315488
Test Date:	5/18/2022
Tested By:	mgh
Checked By:	jm

## pH by AASHTO T 289

Boring ID	Sample ID	Depth, ft	Description	pH
B-2	---	6.6-10.6	Poorly Graded SAND (SP-SM/A-1-b) with Silt	6.6

Notes:



Client:	F&ME Consultants
Project:	S-56 Bridge Replacement over Horse Creek
Location:	Cherokee County, South Carolina
GTX#:	315488
Test Date:	05/23/22
Tested By:	mgh
Checked By:	jm

## Minimum Laboratory Soil Resistivity by AASHTO T 288

Boring ID	Sample ID	Depth, ft.	Sample Description	Minimum Soil Resistivity, ohm-cm
B-2	---	6.6-10.6	Poorly Graded SAND (SP-SM/A-1-b) with Silt	5,301

Notes: Test Equipment: Nilsson Model 400 Soil Resistance Meter, MC Miller Soil Box  
Test conducted in standard laboratory atmosphere: 68-73 F



PO Box 572455 / Salt Lake City UT 84157-2455 / USA  
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|||||  
GEOTESTING EXPRESS INCORPORATED  
2358 PERIMETER PARK DRIVE  
SUITE 320  
ATLANTA GA 30341-1315  
USA

Analysis No. TS-A2210296  
Report Date 18 May 2022  
Date Sampled 16 May 2022  
Date Received 17 May 2022  
Where Sampled Atlanta, GA USA  
Sampled By Client

This is to attest that we have examined: Soil: Project: S-56 Bridge Replacement over Horse Creek; Site Location: Cherokee County, SC; Job Number: GTX-315488

When examined to the applicable requirements of:

AASHTO T-291-18 "Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil" Method B

AASHTO T 290-20 "Standard Method of Test for Determining Water-Soluble Sulfate Ion Content in Soil"

Results:

AASHTO T 291 - Chloride Method B

Sample		Results		Detection Limit
		ppm (mg/kg)	% <sup>1</sup>	
B-2		< 10.	< 0.0010	10.
---	6.6 – 10.6'			

NOTE: <sup>1</sup>Percent by weight after drying and prepared as per the Standard.

AASHTO T 290 – Sulfates (Soluble)

Sample		Results		Detection Limit
		ppm (mg/kg)	% <sup>1</sup>	
B-2		14.	0.0014	10.
---	6.6 – 10.6'			

NOTE: <sup>1</sup>Percent by weight after drying and prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee P.E. – Engineer in Charge

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## **Appendix C. Laboratory Testing**

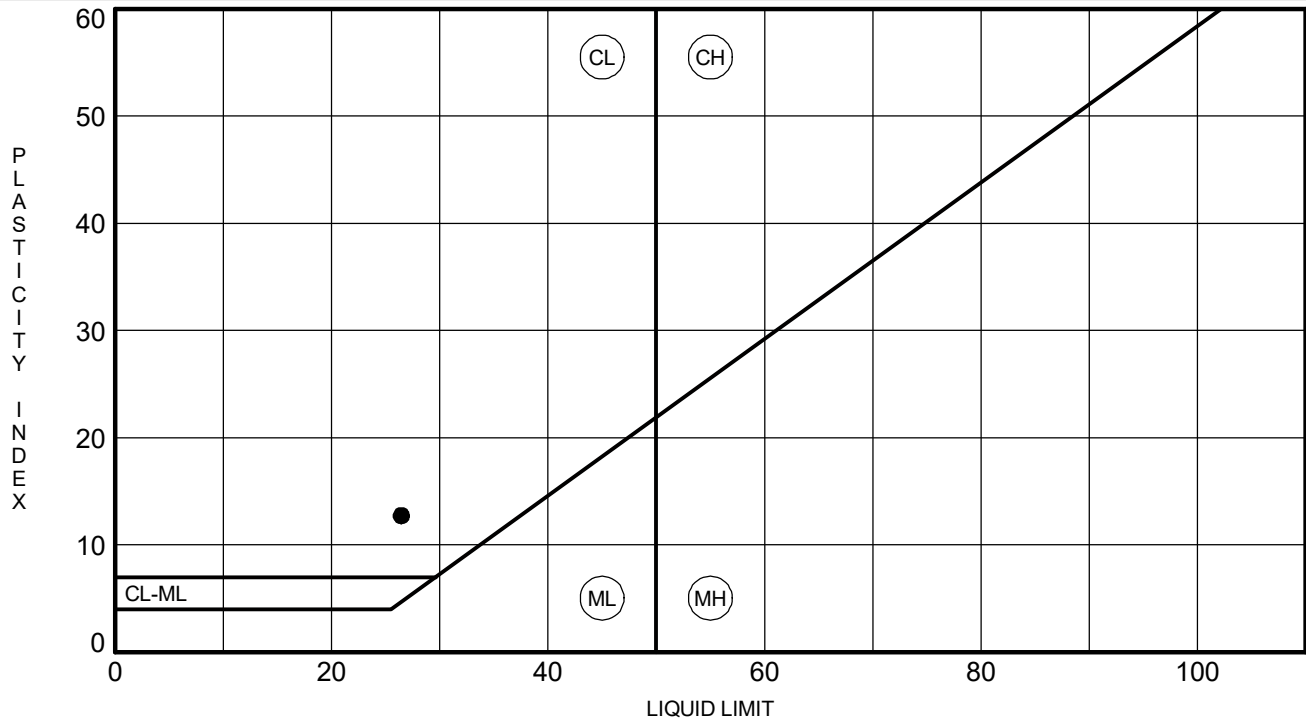
### **Bulk Samples**

## ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041148

**PROJECT NAME** S-11-56 RBO Horse Creek

**PROJECT COUNTY** Cherokee, SC

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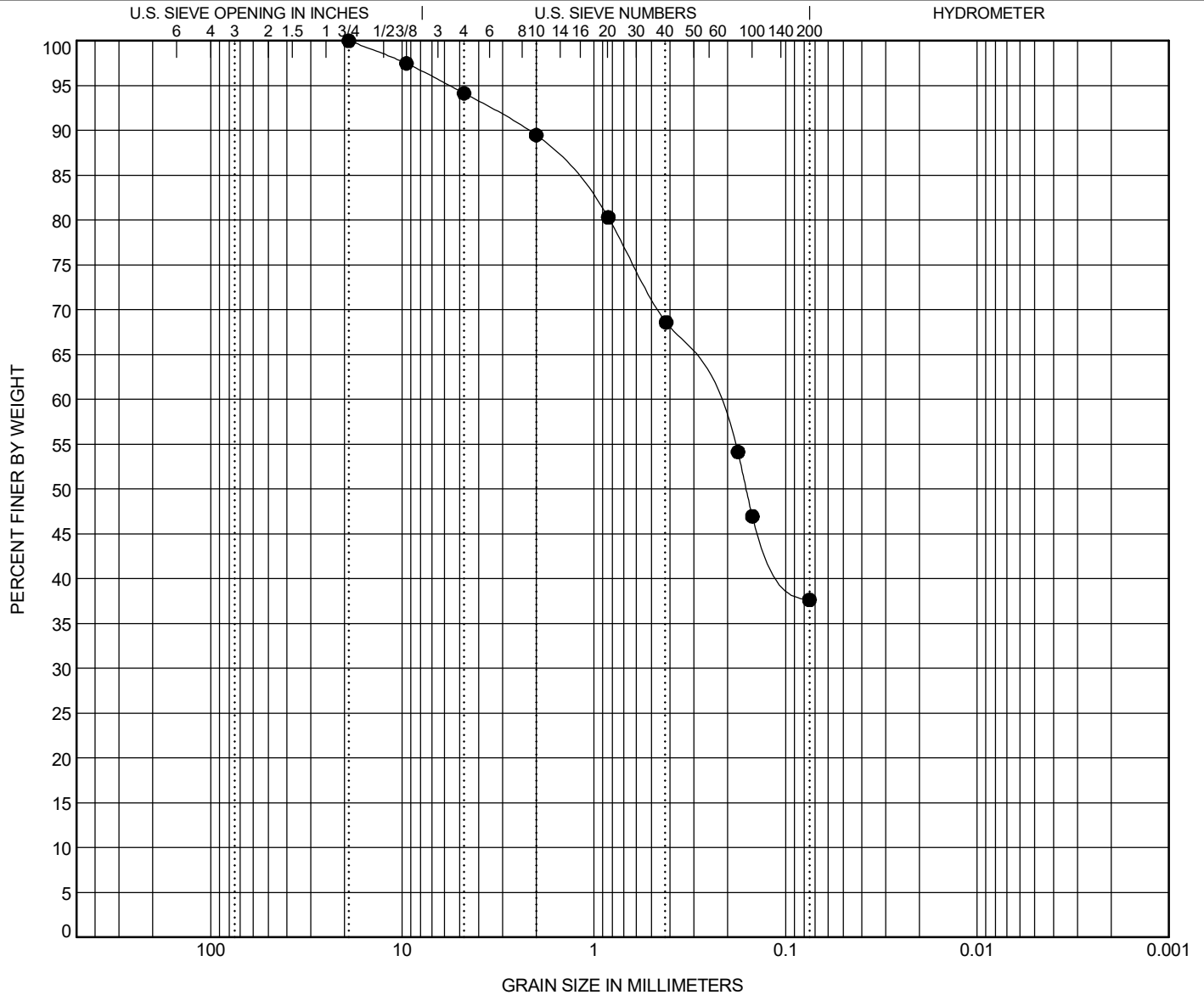


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● BS-1	5.0	Clayey SAND (SC/A-6)					26	14	12		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BS-1	5.0	19	0.251			5.9	56.5	37.6			



# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-11-56 RBO Horse Creek **SCDOT PROJECT ID:** P041148  
**SAMPLE NUMBER:** 22-1396 **DATE SAMPLE RECEIVED:** 5/9/2022  
**DESCRIPTION OF SOIL:** Clayey SAND (SC/A-6)  
**TESTED BY:** A. Abernethy **DATE SETUP:** 5/9/2022  
**WEIGHED BY:** T. Peterson **DATE OF WEIGHING:** 5/10/2022

BORING NO.	BS-1				
SAMPLE NO.	--				
SAMPLE DEPTH (FT.)	0.0 - 5.0				
WATER CONTENT, W%	12.1				

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					

BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



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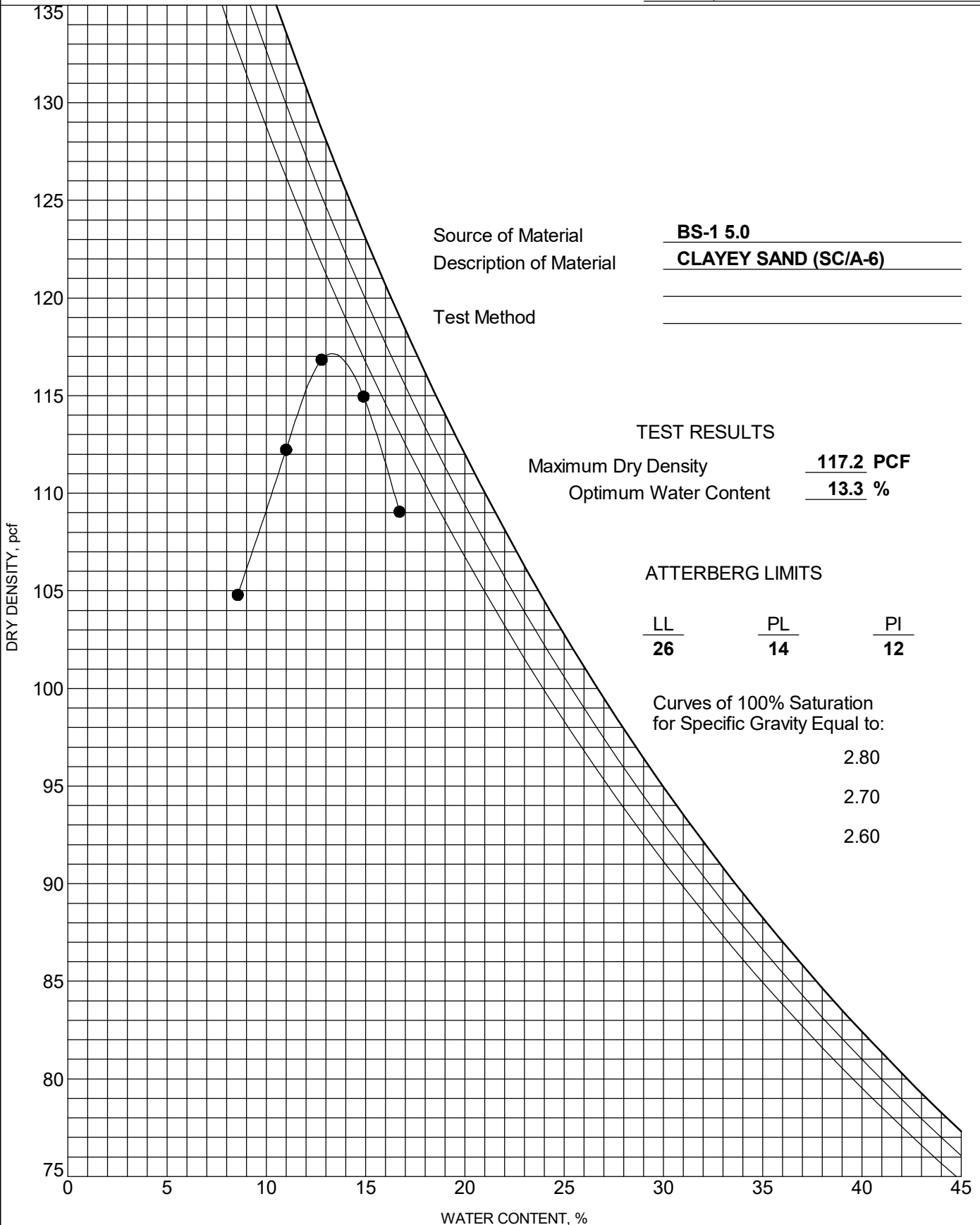


# MOISTURE-DENSITY RELATIONSHIP

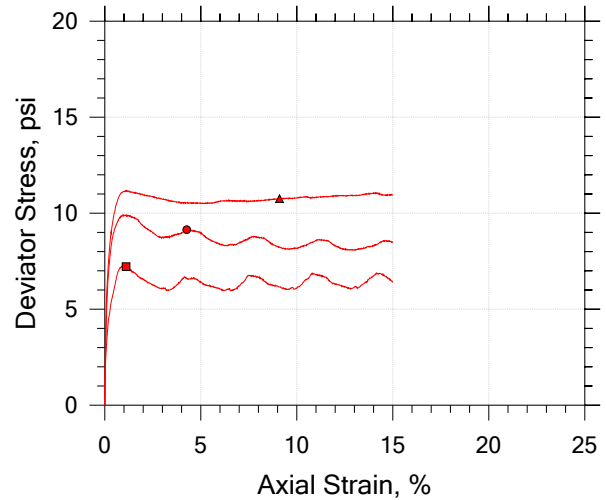
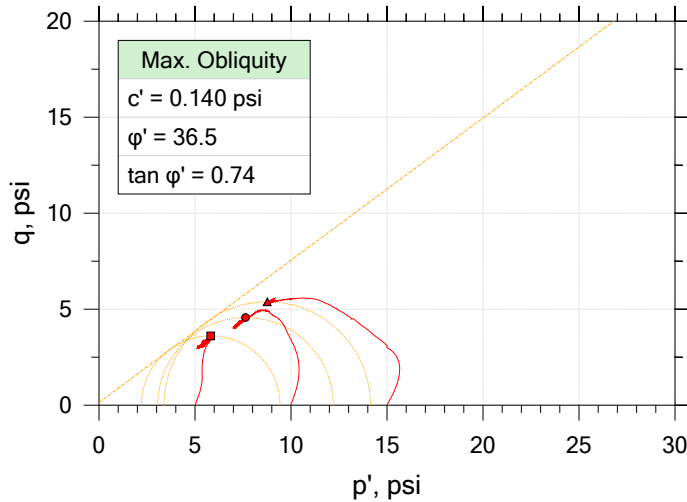
PROJECT ID P041148

PROJECT NAME S-11-56 RBO Horse Creek

PROJECT COUNTY Cherokee, SC



## Consolidated Undrained by AASHTO T297

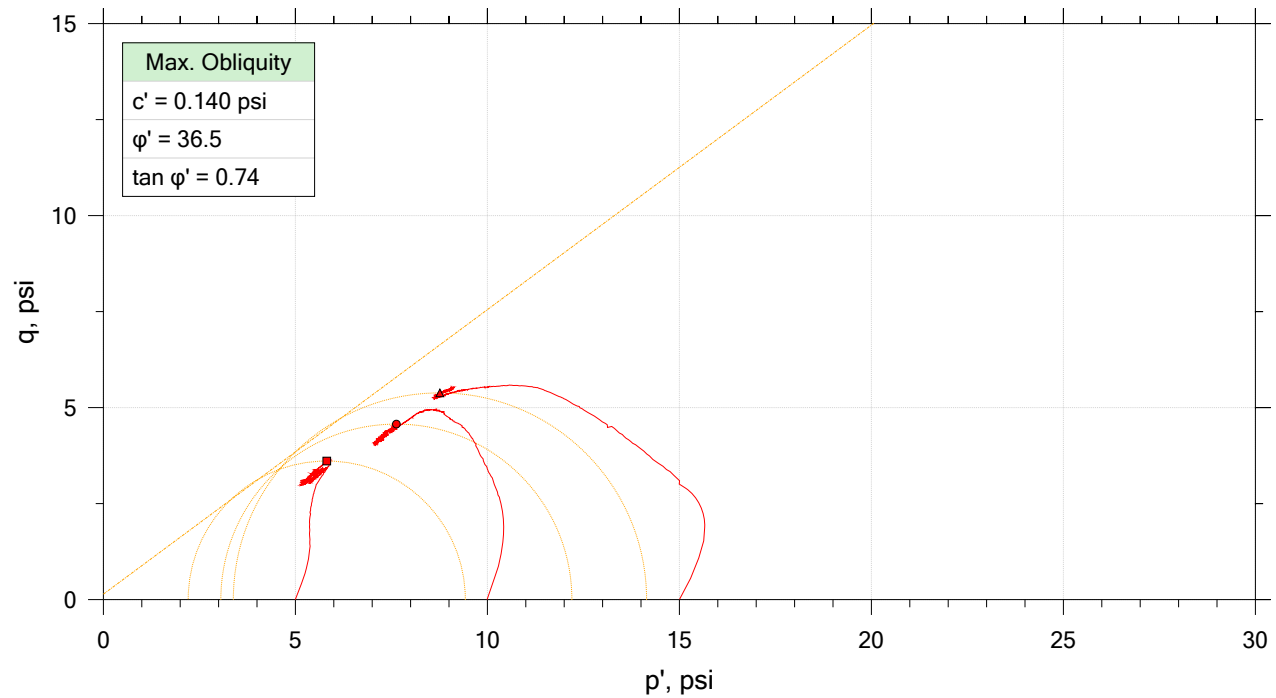
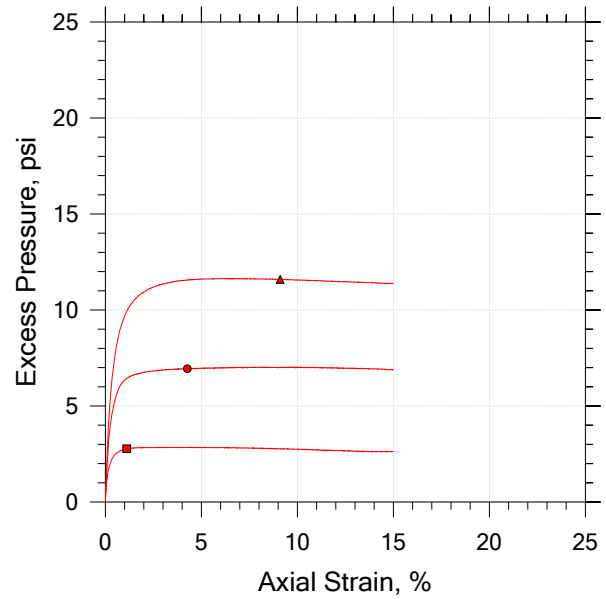
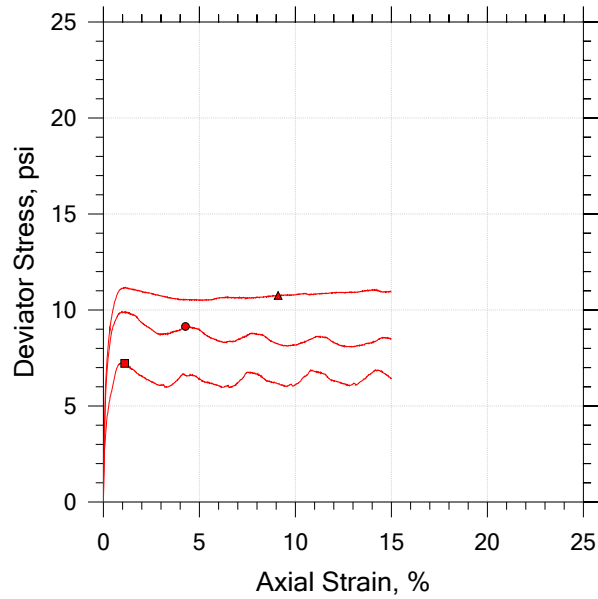


Symbol	■	●	▲	
Sample ID	22-1397	22-1397	22-1400	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0 - 5.0	
Test Number	ABC	B2	C2	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	13.3	12.9	12.9	
Dry Density, pcf	111.	112.	112.	
Saturation (Wet Method), %	70.6	70.6	70.6	
Void Ratio	0.503	0.488	0.488	
Final				
Moisture Content, %	18.2	17.1	16.1	
Dry Density, pcf	113.	115.	117.	
Cross-Sectional Area (Method A), in <sup>2</sup>	6.102	6.064	5.979	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.487	0.459	0.431	
Back Pressure, psi	91.99	94.99	98.00	
Vertical Effective Consolidation Stress, psi	4.980	9.966	14.96	
Horizontal Effective Consolidation Stress, psi	4.999	9.995	15.00	
Vertical Strain after Consolidation, %	0.1623	0.4164	0.7564	
Volumetric Strain after Consolidation, %	1.029	1.901	3.263	
Time to 50% Consolidation, min	0.4000	0.3800	0.3500	
Shear Strength, psi	3.608	4.571	5.382	
Strain at Failure, %	1.11	4.27	9.10	
Strain Rate, %/min	0.05000	0.05000	0.05000	
Deviator Stress at Failure, psi	7.216	9.142	10.76	
Effective Minor Principal Stress at Failure, psi	2.209	3.059	3.382	
Effective Major Principal Stress at Failure, psi	9.425	12.20	14.14	
B-Value	0.96	0.95	0.95	


Notes:  
 - Before Shear Saturation set to 100% for phase calculation.  
 - Moisture Content determined by ASTM D2216.  
 - Atterberg Limits determined by ASTM D4318.  
 - Deviator Stress includes membrane correction.  
 - Values for  $c$  and  $\phi$  determined from best-fit straight line for the specific test conditions.  
 Actual strength parameters may vary and should be determined by an engineer for site conditions.

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
	Remarks: Max Dry Density=117.2 pcf, OMC=13.3%, Samples Molded at 95% of Max Dry Density		

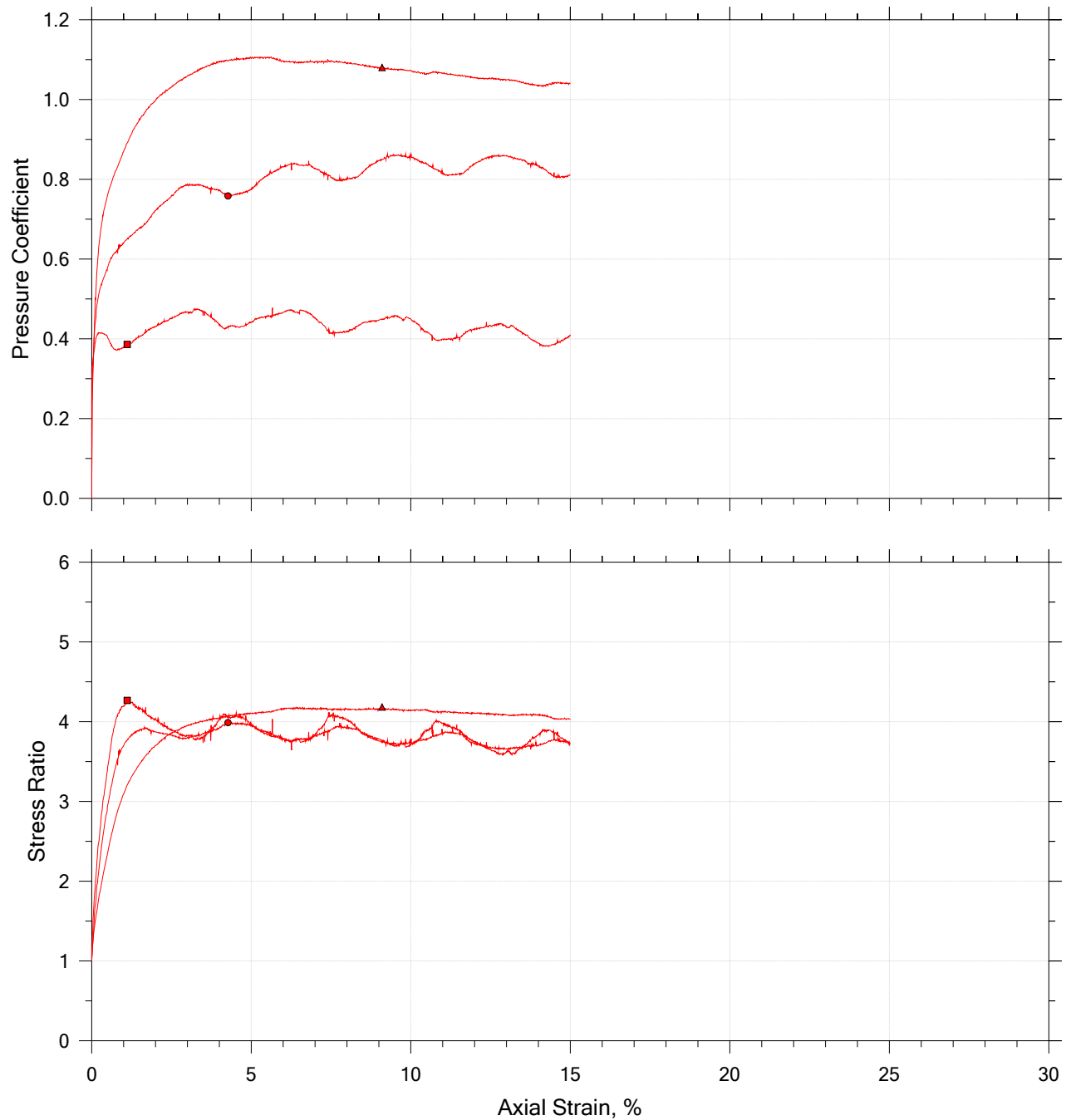
## Consolidated Undrained by AASHTO T297




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1397	ABC	0.0' - 5.0'	WAP/RMC	5/19/2022	WAP/ WJG		BS-1.A.dat
●	22-1397	B2	0.0' - 5.0'	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.B2.dat
▲	22-1400	C2	0.0' - 5.0'	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.C2.dat

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
	Remarks: Max Dry Density=117.2 pcf, OMC=13.3%, Samples Molded at 95% of Max Dry Density		

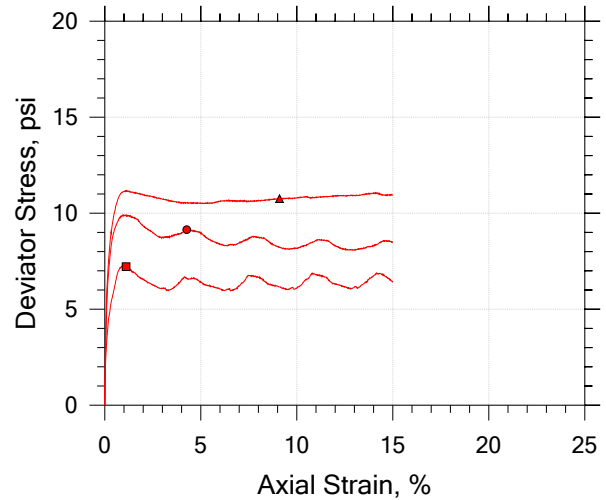
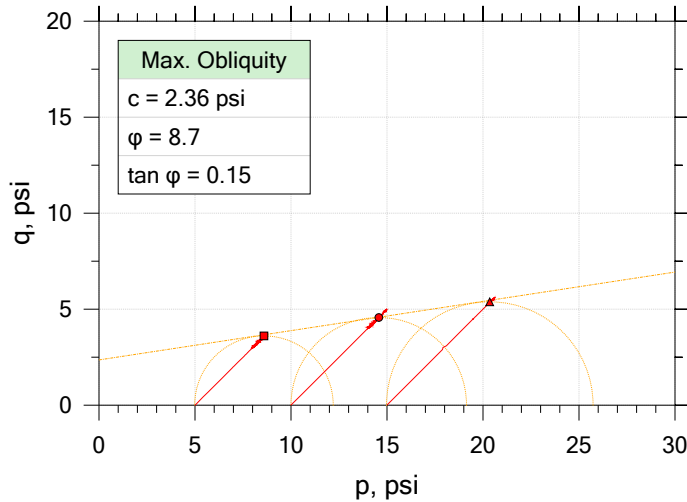
## Consolidated Undrained by AASHTO T297



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1397	ABC	0.0' - 5.0'	WAP/RMC	5/19/2022	WAP/ WJG		BS-1.A.dat
●	22-1397	B2	0.0' - 5.0'	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.B2.dat
▲	22-1400	C2	0.0 - 5.0	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.C2.dat

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
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## Consolidated Undrained by AASHTO T297

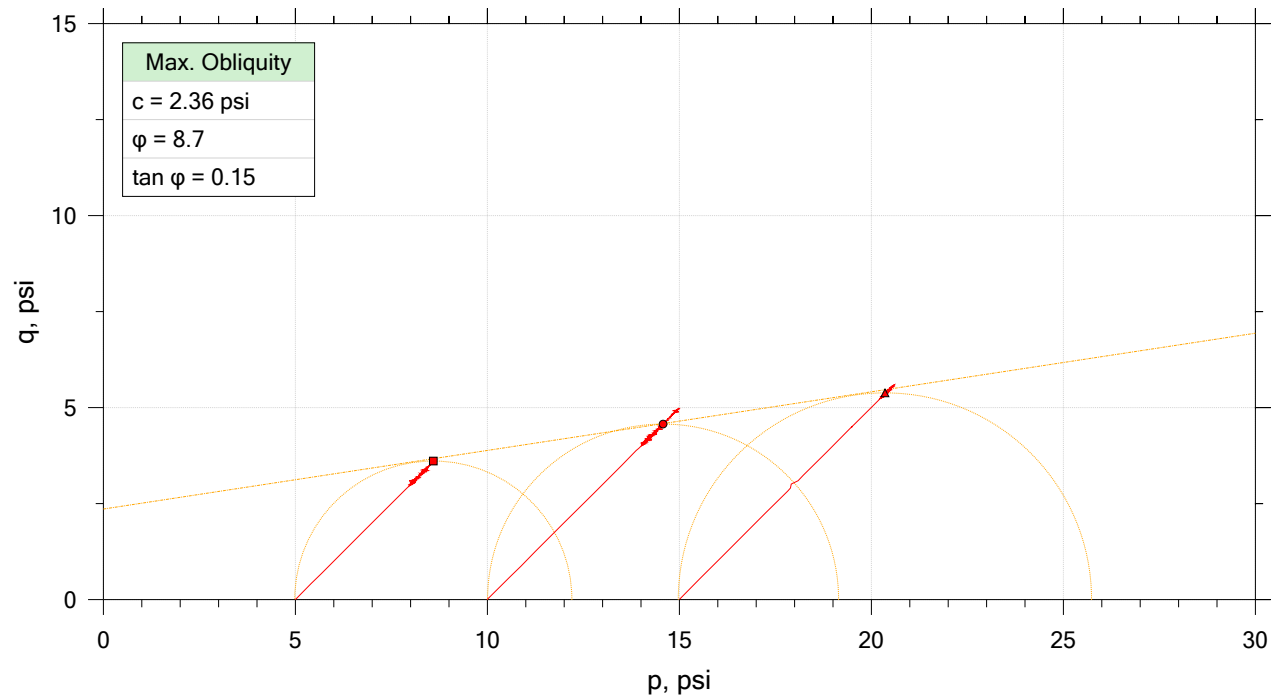
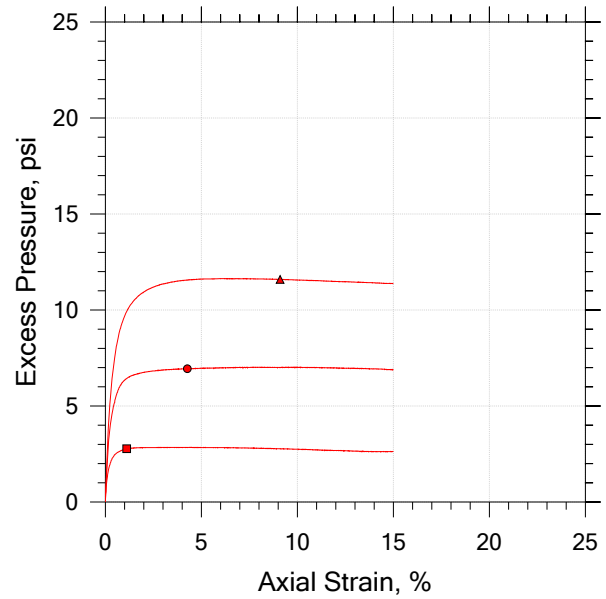
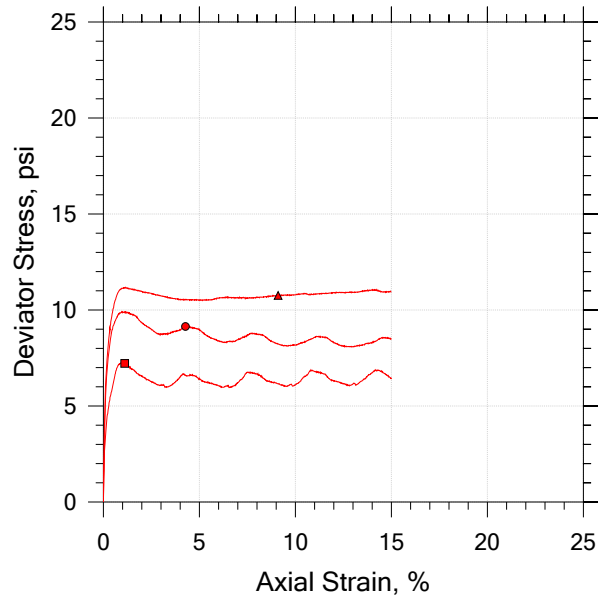


Symbol	■	●	▲	
Sample ID	22-1397	22-1397	22-1400	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0 - 5.0	
Test Number	ABC	B2	C2	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	13.3	12.9	12.9	
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Moisture Content, %	18.2	17.1	16.1	
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Shear Strength, psi	3.608	4.571	5.382	
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Effective Minor Principal Stress at Failure, psi	2.209	3.059	3.382	
Effective Major Principal Stress at Failure, psi	9.425	12.20	14.14	
B-Value	0.96	0.95	0.95	


Notes:  
 - Before Shear Saturation set to 100% for phase calculation.  
 - Moisture Content determined by ASTM D2216.  
 - Atterberg Limits determined by ASTM D4318.  
 - Deviator Stress includes membrane correction.  
 - Values for  $c$  and  $\phi$  determined from best-fit straight line for the specific test conditions.  
 Actual strength parameters may vary and should be determined by an engineer for site conditions.

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
	Remarks: Max Dry Density=117.2 pcf, OMC=13.3%, Samples Molded at 95% of Max Dry Density		

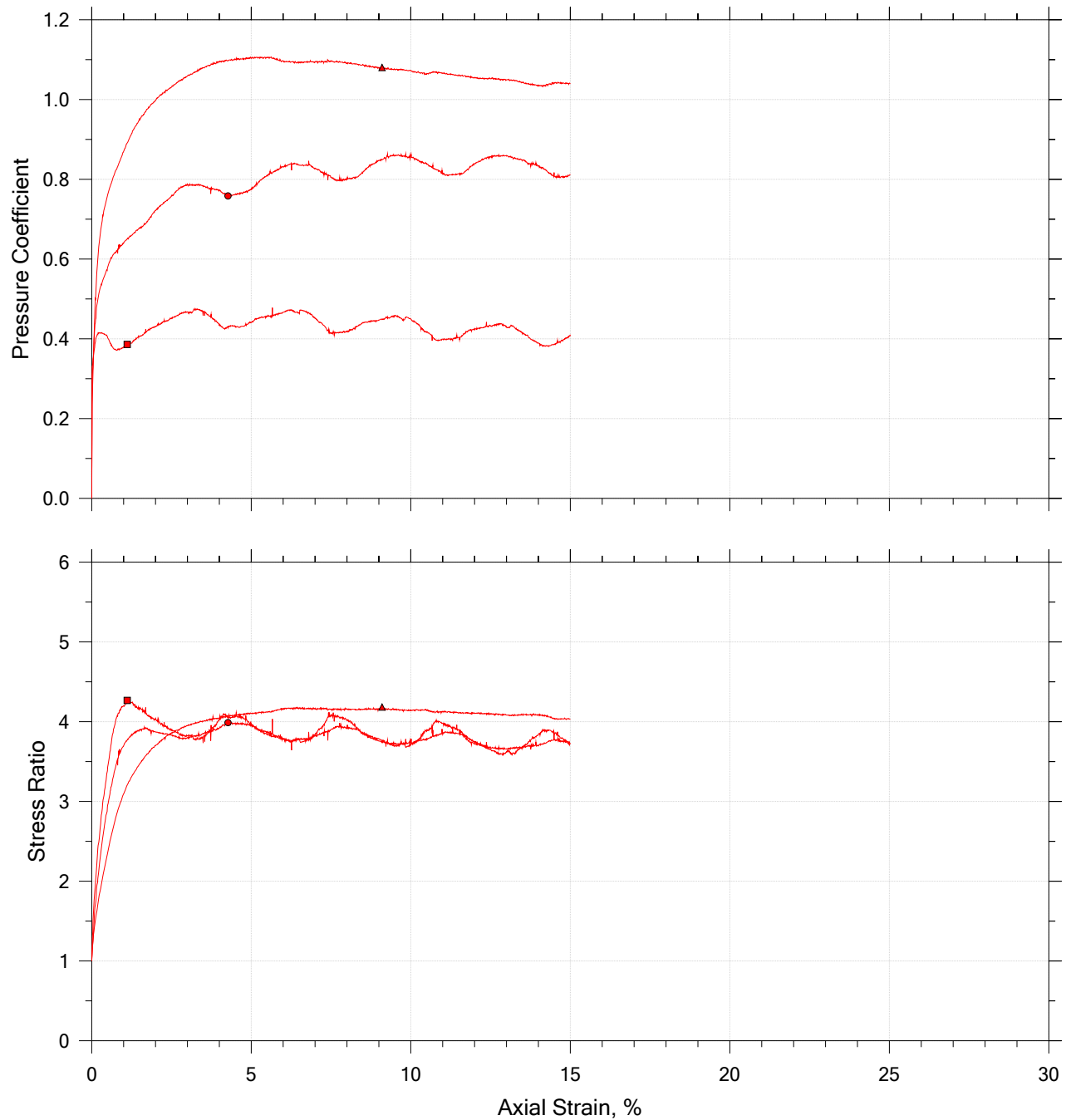
## Consolidated Undrained by AASHTO T297




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1397	ABC	0.0' - 5.0'	WAP/RMC	5/19/2022	WAP/ WJG		BS-1.A.dat
●	22-1397	B2	0.0' - 5.0'	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.B2.dat
▲	22-1400	C2	0.0 - 5.0	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.C2.dat

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
	Remarks: Max Dry Density=117.2 pcf, OMC=13.3%, Samples Molded at 95% of Max Dry Density		

## Consolidated Undrained by AASHTO T297



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-1397	ABC	0.0' - 5.0'	WAP/RMC	5/19/2022	WAP/ WJG		BS-1.A.dat
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▲	22-1400	C2	0.0 - 5.0	WAP/RMC	5/24/2022	WAP/ WJG		BS-1.C2.dat

	Project Name: CLRB Replacements 2022 - pkg 14	Location: S-56 RBO Horse Creek	Project Number: G6655.001
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-1397	Test Date: 5/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Clayey SAND (SC/A-6) LL=26, PL=14, PI=12, %200=37.6		
	Remarks: Max Dry Density=117.2 pcf, OMC=13.3%, Samples Molded at 95% of Max Dry Density		





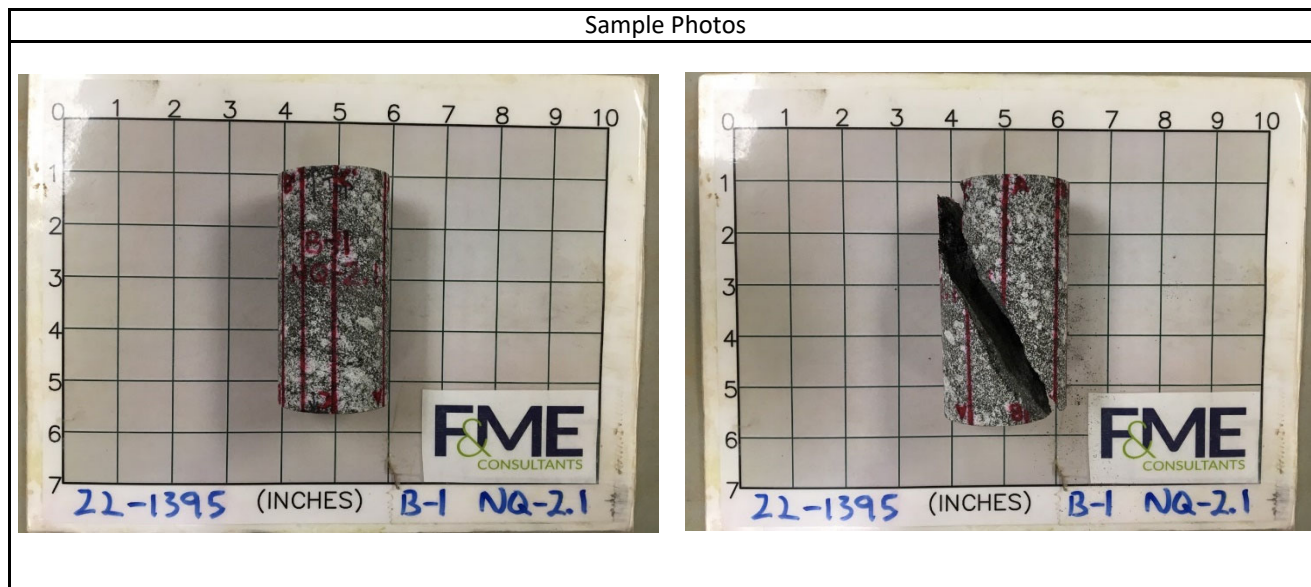
## **Appendix C. Laboratory Testing**

### **Rock Cores**

Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.869	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	3.96	Reviewed By	WJG
Boring	B-1	Unit Weight (pcf)	173.8	Core Size	NQ
Sample No.	NQ-2.1 / 22-1395A	L/D Ratio	2.12	Recovery	97%
Depth	34.2' - 34.5'	Load Rate (psi/sec)	20	RQD	75%
Description	White/Gray/Black Biotite Gneiss				

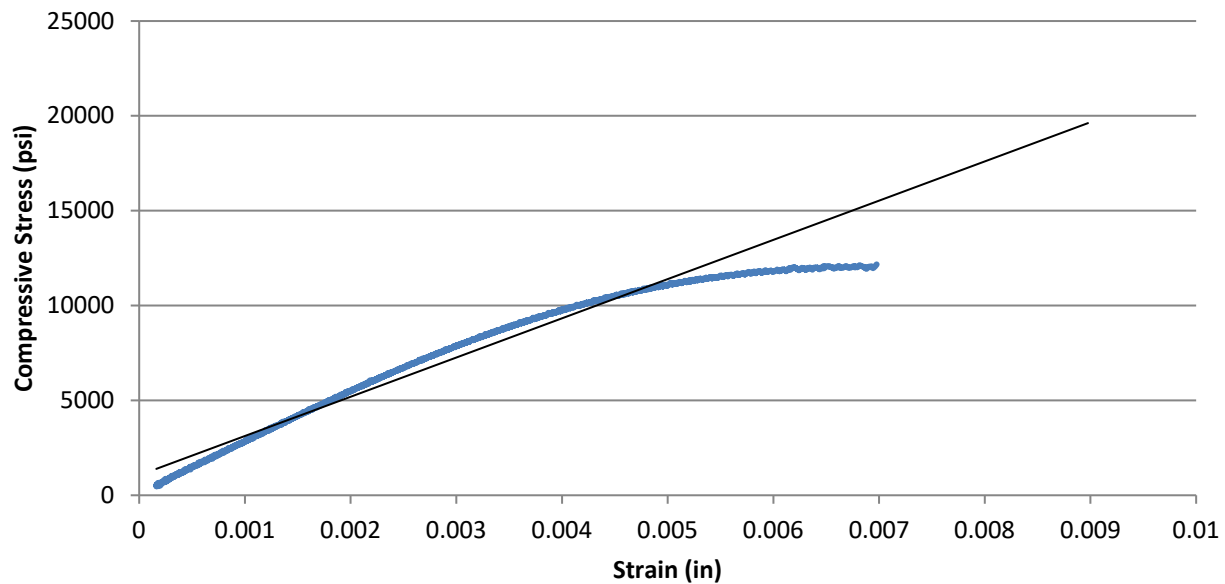
Test Data						
Percent of Failure Load	Strain ( $10^{-6}$ )		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-407	25	3,327	1,213	5.97	0.06
20%	-850	110	6,679	2,434	5.73	0.13
30%	-1293	211	10,006	3,647	5.64	0.16
40%	-1753	332	13,335	4,860	5.55	0.19
50%	-2231	489	16,669	6,076	5.45	0.22
60%	-2750	660	20,049	7,308	5.31	0.24
70%	-3317	791	23,362	8,515	5.13	0.24
80%	-3977	794	26,708	9,735	4.90	0.20
90%	-4872	437	30,044	10,951	4.50	0.09
100%	-6977	-978	33,384	12,168		



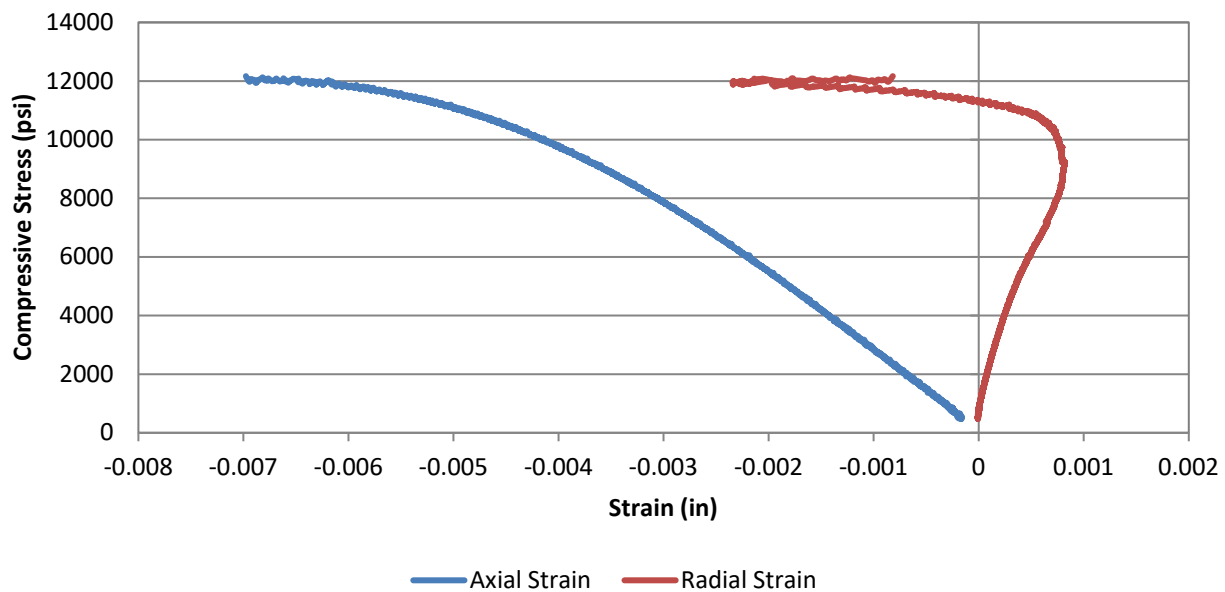
Test Results			
Unconfined Compressive Strength (psi)	<b>12,170</b>	Elastic Modulus (psi)	5.49E+06
		Poisson's Ratio in Elastic Range	0.20
Comments	Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.869	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	3.96	Reviewed By	WJG
Boring	B-1	Unit Weight (pcf)	173.8	Core Size	NQ
Sample No.	NQ-2.1 / 22-1395A	L/D Ratio	2.12	Recovery	97%
Depth	34.2' - 34.5'	Load Rate (psi/sec)	20	RQD	75%
Description	White/Gray/Black Biotite Gneiss				

**Axial Stress vs. Strain**



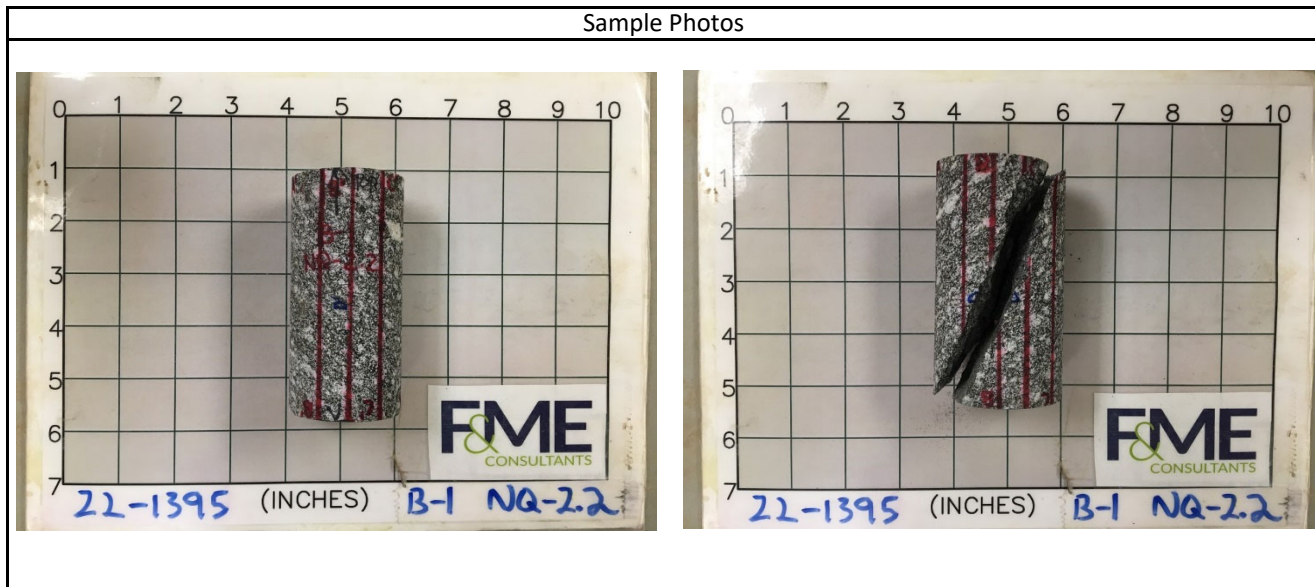
**Stress vs. Strain**



Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	4.006	Reviewed By	WJG
Boring	B-1	Unit Weight (pcf)	175.7	Core Size	NQ
Sample No.	NQ-2.2 / 22-1395B	L/D Ratio	2.14	Recovery	97%
Depth	38.5' - 38.8'	Load Rate (psi/sec)	20	RQD	75%
Description	White/Gray/Black Biotite Gneiss				

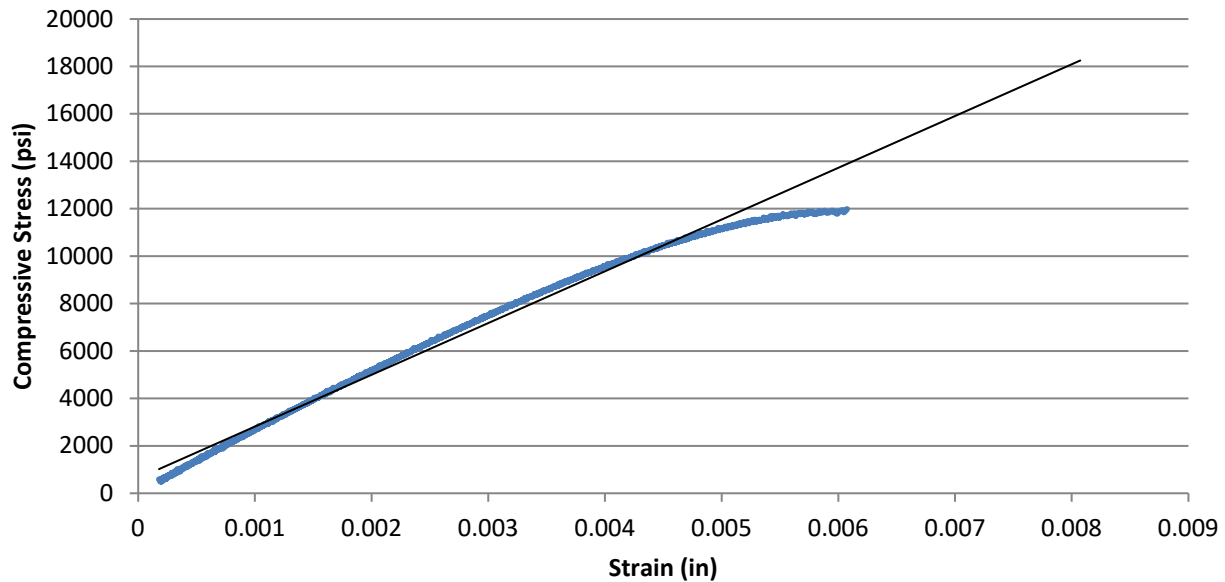
Test Data						
Percent of Failure Load	Strain ( $10^{-6}$ )		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-436	472	3,297	1,203	5.51	1.08
20%	-887	593	6,552	2,391	5.39	0.67
30%	-1361	687	9,849	3,594	5.28	0.51
40%	-1843	782	13,158	4,801	5.21	0.42
50%	-2336	882	16,418	5,991	5.13	0.38
60%	-2854	1005	19,707	7,191	5.04	0.35
70%	-3416	1178	22,993	8,390	4.91	0.34
80%	-4009	1288	26,298	9,596	4.79	0.32
90%	-4731	1537	29,555	10,784	4.56	0.32
100%	-6074	3228	32,846	11,985		



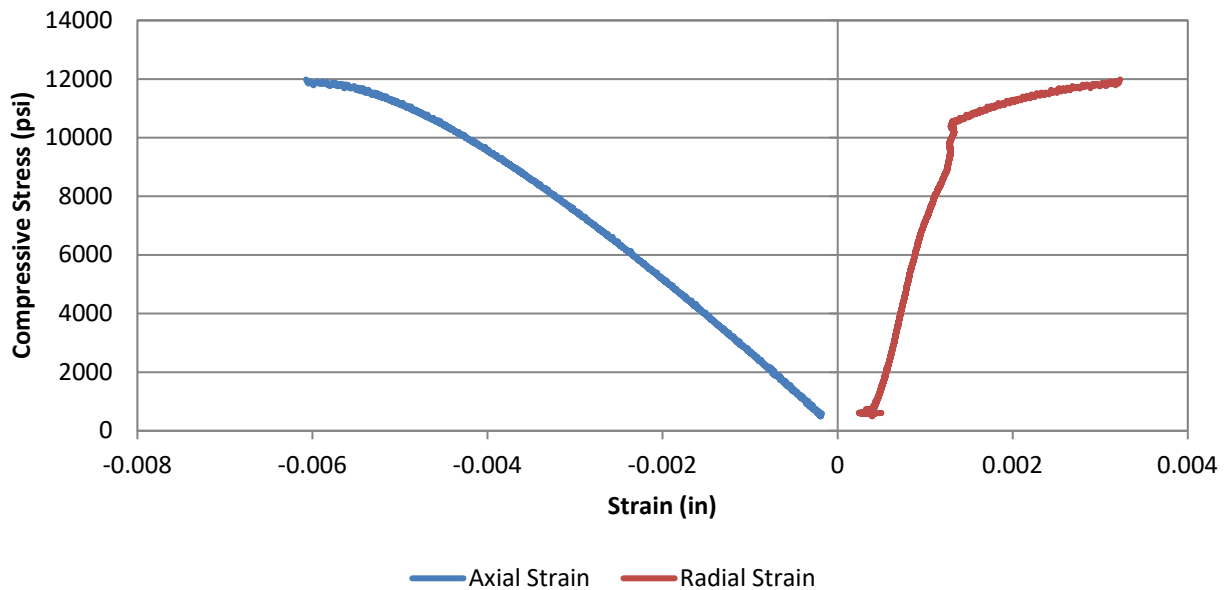
Test Results			
Unconfined Compressive Strength (psi)	<b>11,980</b>	Elastic Modulus (psi)	5.00E+06
		Poisson's Ratio in Elastic Range	0.36
Comments	Elastic range was taken as between 0.002 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	4.006	Reviewed By	WJG
Boring	B-1	Unit Weight (pcf)	175.7	Core Size	NQ
Sample No.	NQ-2.2 / 22-1395B	L/D Ratio	2.14	Recovery	97%
Depth	38.5' - 38.8'	Load Rate (psi/sec)	20	RQD	75%
Description	White/Gray/Black Biotite Gneiss				

**Axial Stress vs. Strain**



**Stress vs. Strain**

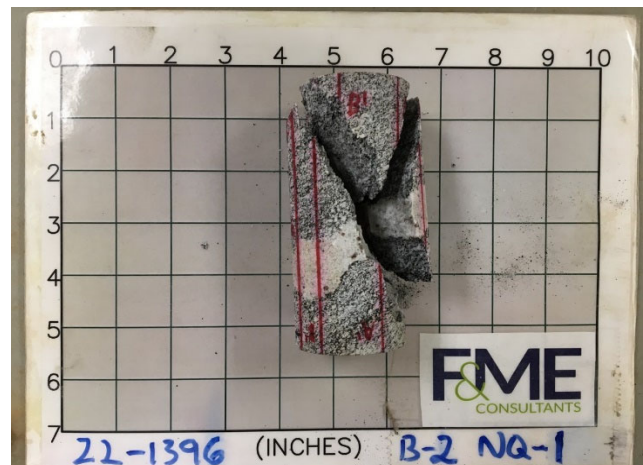
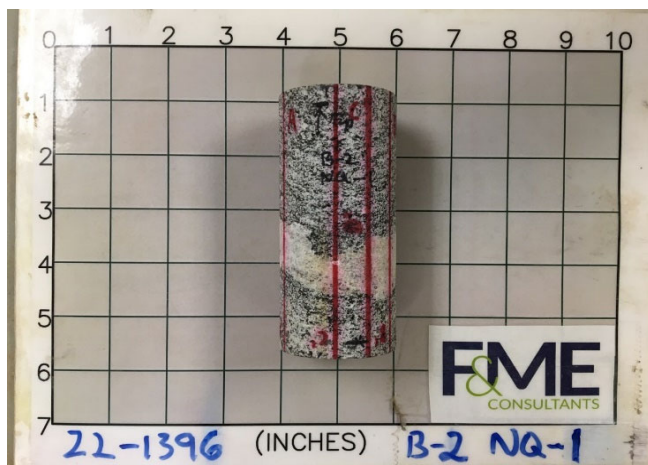


Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	4.18	Reviewed By	WJG
Boring	B-2	Unit Weight (pcf)	168.3	Core Size	NQ
Sample No.	NQ-1 / 22-1396A	L/D Ratio	2.23	Recovery	97%
Depth	49.6' - 49.9'	Load Rate (psi/sec)	20	RQD	50%
Description	White/Gray/Black Biotite Gneiss				

Test Data						
Percent of Failure Load	Strain ( $10^{-6}$ )		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-2188	58	4,381	1,593	1.46	0.03
20%	-3349	7	8,724	3,173	1.90	0.00
30%	-4206	10	13,093	4,762	2.26	0.00
40%	-4921	28	17,416	6,335	2.57	0.01
50%	-5566	121	21,823	7,937	2.85	0.02
60%	-6172	350	26,165	9,517	3.08	0.06
70%	-6775	563	30,487	11,089	3.27	0.08
80%	-7405	774	34,949	12,711	3.43	0.10
90%	-8055	1013	39,266	14,282	3.55	0.13
100%	-8610	1264	43,662	15,881		

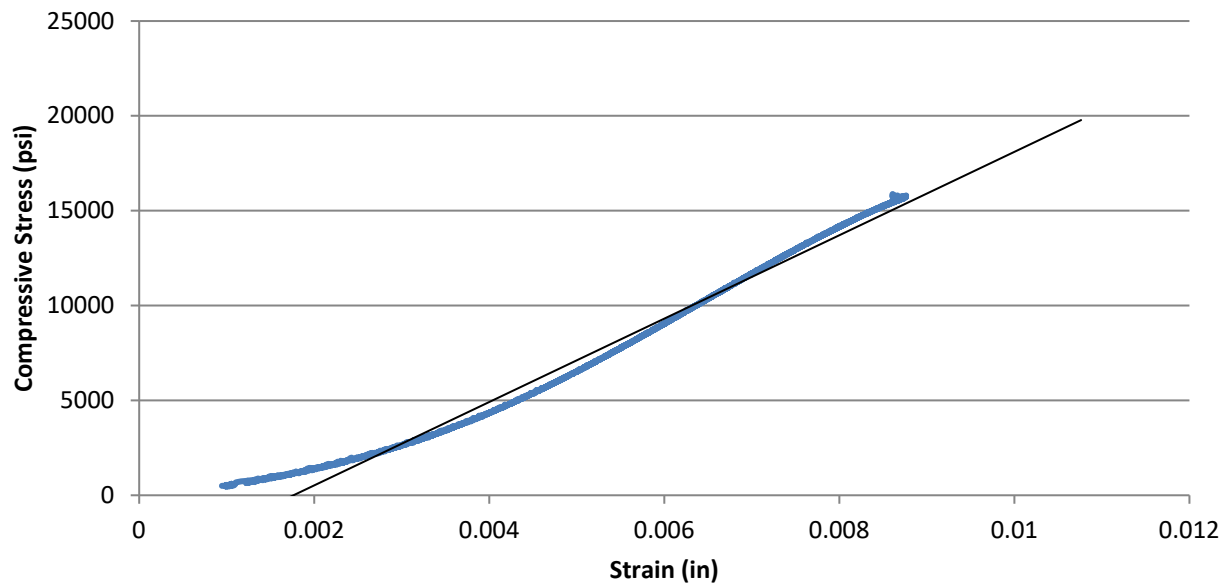
Sample Photos



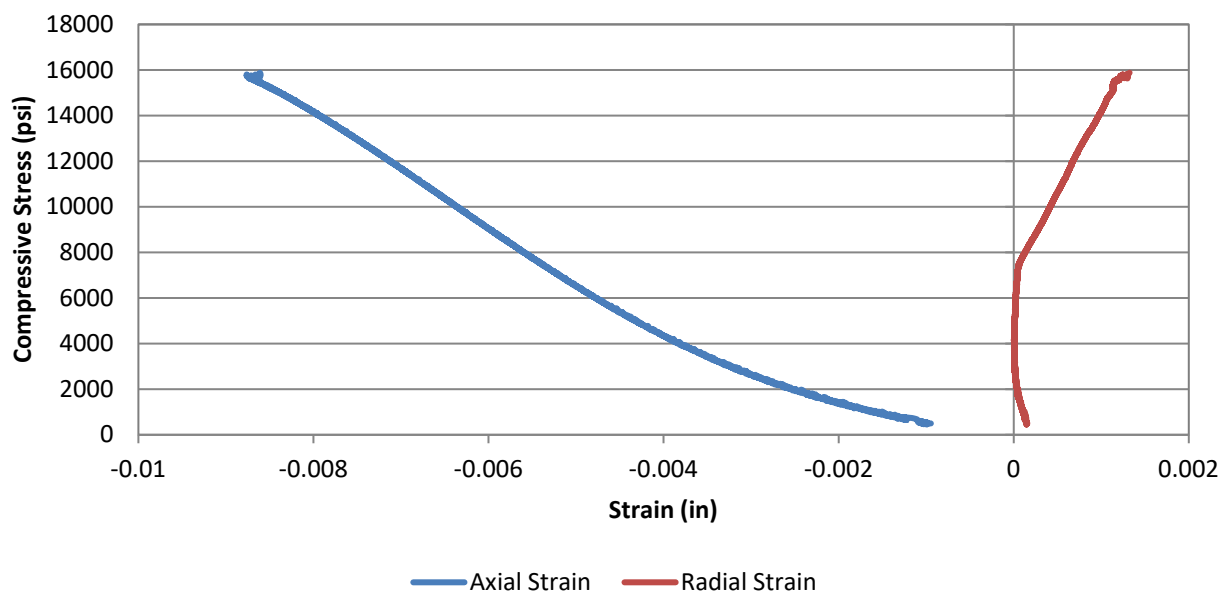
Test Results			
Unconfined Compressive Strength (psi)		15,880	Elastic Modulus (psi)
			2.62E+06
			Poisson's Ratio in Elastic Range
			0.01
Comments	<p>Elastic range was taken as between 0.004 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.</p> <p>Poisson's Modulus data indicates that the radial displacement gauge may have moved during testing. The engineer should evaluate this value before using for design.</p>		

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.871	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	4.18	Reviewed By	WJG
Boring	B-2	Unit Weight (pcf)	168.3	Core Size	NQ
Sample No.	NQ-1 / 22-1396A	L/D Ratio	2.23	Recovery	97%
Depth	49.6' - 49.9'	Load Rate (psi/sec)	20	RQD	50%
Description	White/Gray/Black Biotite Gneiss				

**Axial Stress vs. Strain**



**Stress vs. Strain**

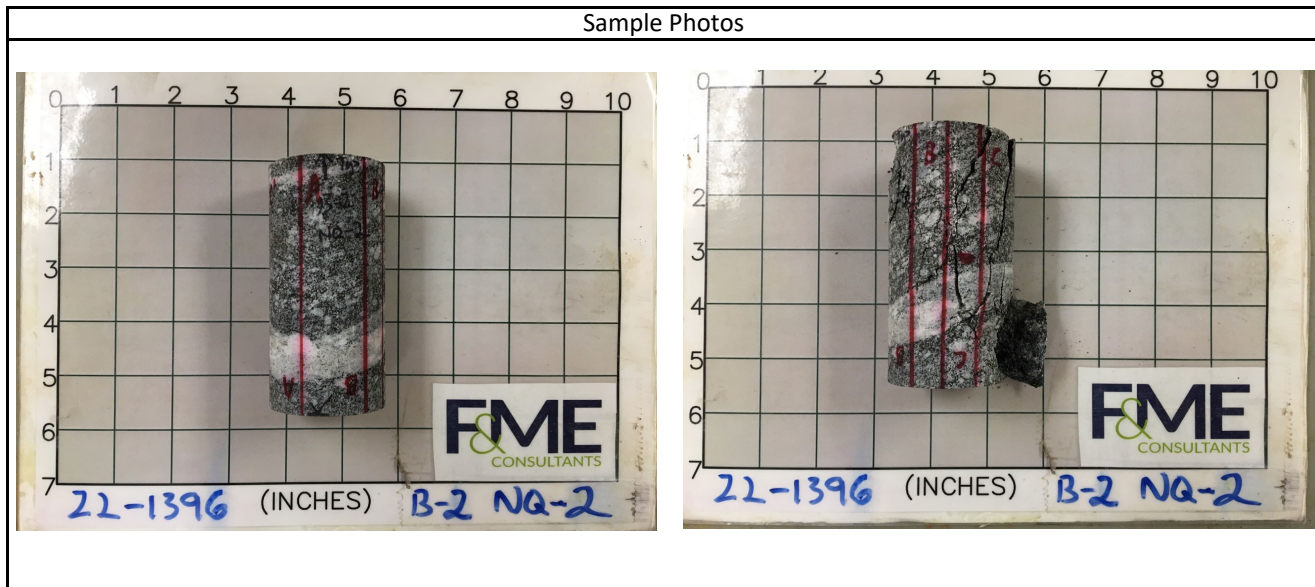




Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	3.998	Reviewed By	WJG
Boring	B-2	Unit Weight (pcf)	172.7	Core Size	NQ
Sample No.	NQ-2 / 22-1396B	L/D Ratio	2.14	Recovery	100%
Depth	56.8' - 57.1'	Load Rate (psi/sec)	20	RQD	80%
Description	White/Gray/Black Biotite Gneiss				

Test Data						
Percent of Failure Load	Strain ( $10^{-6}$ )		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-579	52	3,518	1,281	4.43	0.09
20%	-1131	12	7,038	2,563	4.53	0.01
30%	-1690	2	10,571	3,849	4.55	0.00
40%	-2212	11	14,037	5,111	4.62	0.01
50%	-2739	41	17,624	6,417	4.69	0.01
60%	-3294	97	21,177	7,711	4.68	0.03
70%	-3840	182	24,629	8,968	4.67	0.05
80%	-4450	334	28,184	10,262	4.61	0.08
90%	-5158	614	31,758	11,563	4.48	0.12
100%	-7995	3566	35,234	12,829		

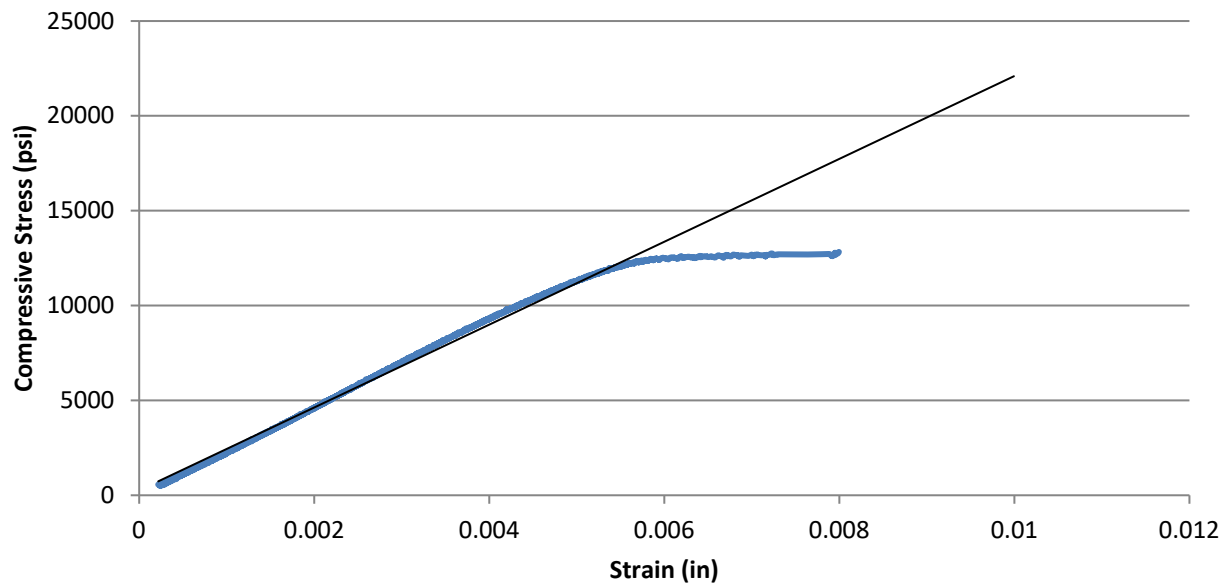


Test Results			
Unconfined Compressive Strength (psi)		<b>12,830</b>	Elastic Modulus (psi)
			4.62E+06
			Poisson's Ratio in Elastic Range
			0.02
Comments	<p>Elastic range was taken as between 0.001 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.</p> <p>Poisson's Modulus data indicates that the radial displacement gauge may have moved during testing. The engineer should evaluate this value before using for design.</p>		

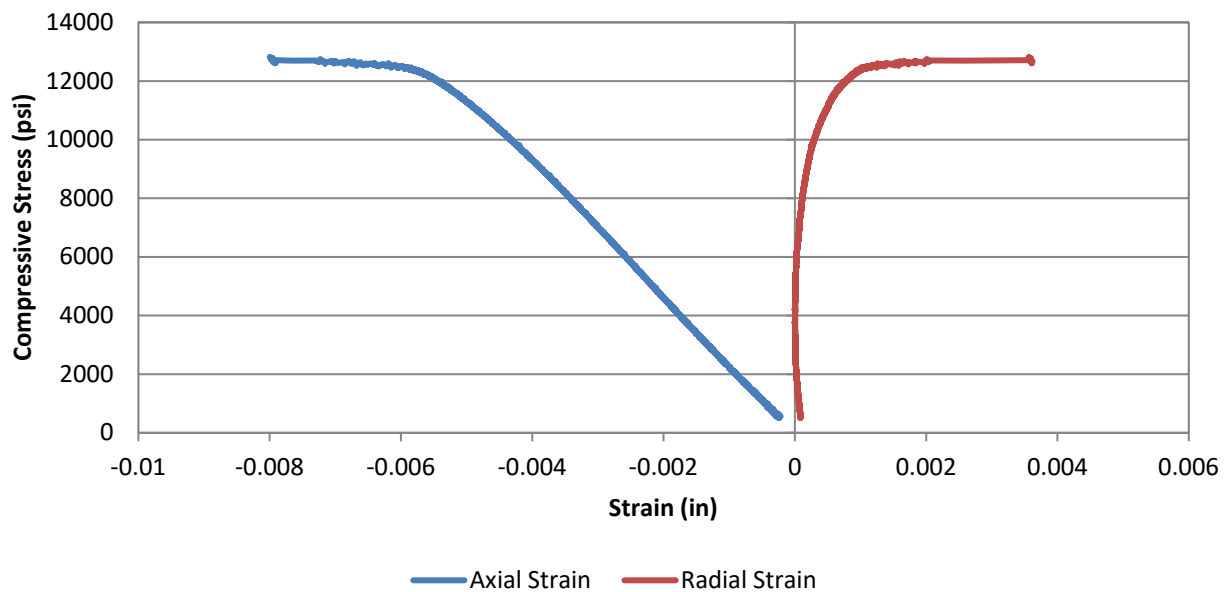


Project	S-11-56 RBO Horse Creek			Date	5/25/2022
Project No.	G6655.001	Sample Diameter (in.)	1.87	Tested By	WAP
SCDOT ID	P041148	Sample Length (in.)	3.998	Reviewed By	WJG
Boring	B-2	Unit Weight (pcf)	172.7	Core Size	NQ
Sample No.	NQ-2 / 22-1396B	L/D Ratio	2.14	Recovery	100%
Depth	56.8' - 57.1'	Load Rate (psi/sec)	20	RQD	80%
Description	White/Gray/Black Biotite Gneiss				

**Axial Stress vs. Strain**



**Stress vs. Strain**



## Appendix D. SPT Hammer Energy Calibration Report

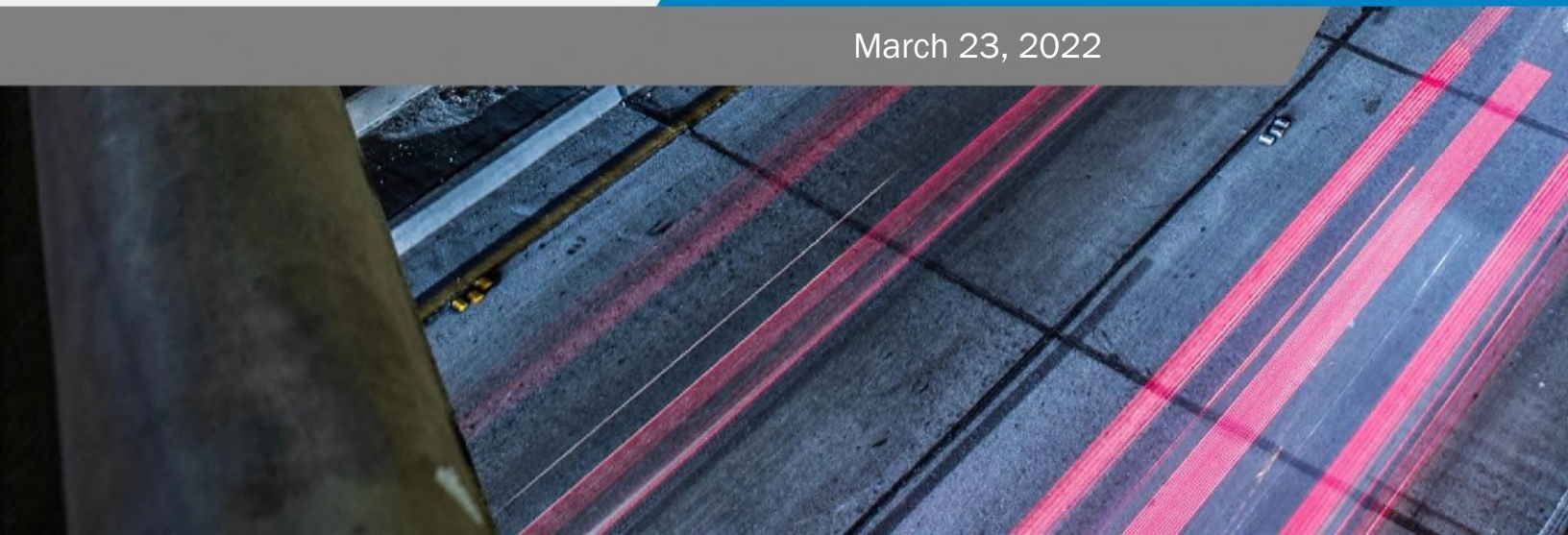


**CAROLINAS  
GEOTECHNICAL  
GROUP**

## **Report of SPT Hammer Energy**

Prepared for:  
Breccia Construction, LLC  
620-B Industrial Way  
Chester, South Carolina 29706

March 23, 2022







2400 Crownpoint Executive Drive  
Suite 800  
Charlotte, NC 28227



(980) 339-8684



contact@carolinasgeotech.com



www.carolinasgeotech.com

March 23, 2022

Mr. Jarod S. Ford  
Breccia Construction, LLC  
620-B Industrial Way  
Chester, South Carolina 29706

SUBJECT: **Report of SPT Hammer Energy**  
Breccia Construction, LLC CME 45B Trailer Rig (SN 303304)  
Chester, South Carolina  
CG2 Project No.: 240021095

Dear Mr. Ford:

Carolinas Geotechnical Group, PLLC (CG2) has completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer mounted on a Breccia Construction, LLC (Breccia) CME 45B trailer-mounted drill rig with a serial number of 303304, see attached Drill Rig Photo Log. This service was performed by Mr. Robert E. Kral, PE on March 11, 2022. SPT energy testing was performed in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation (NCDOT), Geotechnical Engineering Unit's requirements. The testing procedures, equipment used during testing, and detailed results are presented in this report.

CG2 recommends Breccia submit this Report of SPT Hammer Energy to the NCDOT Geotechnical Engineering Unit for review and approval no later than April 8, 2022.

#### DYNAMIC TESTING METHODOLOGY

Testing was performed using a model SPT (Serial No. 4549 TB) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K11957 and K10959) bolted to a 2-foot long AWJ drill rod (SN 528AWJ) internally instrumented with two strain transducers. The instrumented AWJ drill rod has a cross-sectional area of 1.19 square inches, an outside diameter of approximately 1.75 inches, and an inside diameter of 1.25 inches at the gauge location. The accelerometers and strain gauges, which are mounted on opposing axis 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. Calibration sheets for the PDA, accelerometers, and the instrumented rod are included in the Appendix III.

Report of SPT Hammer Energy  
Chester, South Carolina  
CG2 Project No.: 240021095

### TESTING AND OBSERVATIONS

CG2 personnel was on site March 11, 2022 to observe and perform high-strain dynamic testing during SPT sampling on the CME 45B trailer-mounted drill rig operated by D. Harris of Breccia. The measurements were taken during drilling operations at 1817 Lowrys Highway in Chester, South Carolina (Chester County). The approximate coordinates (not professionally surveyed) for the test location are 34.770585, -81.245517. No Soil Test Boring Log was maintained. SPT energy measurements were recorded during three intervals at depths of approximately 28½, 33½, and 38½ feet below the existing ground surface. The information presented in the table below summarizes the equipment tested and tooling used during the SPT energy measurements.

**Table 1: SPT Field Data**

Drill Rig Information	
Manufacturer	CME
Model	45B
Serial Number	303304
Operator	D. Harris
Carrier	Trailer
Hammer Information	
Model / Type	CME / Auto
Serial Number	N/A
Anvil Height (inches)	11.5
Anvil Diameter (inches)	2.5
Drop Height (inches)	30
Ram Weight (pounds)	140
Ram Serial Number	N/A
Drilling and Instrumented Rod Information	
Drill Rod Type	AWJ
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in <sup>2</sup> )	1.19
Typical Lengths (feet)	5
Instrumented Rod Type	AWJ (SN 528)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in <sup>2</sup> )	1.19
Total Instrumented Rod Length (feet)	2.00
Length Below Gages (feet)	0.70
Split-Spoon Length (feet)	2.85

Report of SPT Hammer Energy  
Chester, South Carolina  
CG2 Project No.: 240021095

## DYNAMIC TESTING RESULTS

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.6 feet to the required drill rod length at each sample depth. Based on the test data, the automatic hammer on the CME 45B Trailer-mounted drill rig operated at a rate of about 53.2 to 61.4 blows per minute (BPM) during dynamic testing. The measured transferred hammer energy (EFV) ranged from 273.5 to 298.0 foot-pounds, which corresponds to Energy Transfer Ratio (ETR) values of 78.2 to 85.1%, respectively.

The SPT Energy Measurement Data Summary tables in the Appendix present the test data from every hammer blow at each sampling interval along with representative force and velocity traces for each test interval. The reported blow counts, obtained by the drill rig personnel, and a summary of the test data and average computed hammer energy and transfer ratio values are provided in Table 2. Plots and tables of the following are also included in the Appendix and present the test data with depth for each test interval:

- Penetration vs. BLC
- Penetration vs. CSX
- Average ETR vs. Rod Length
- Penetration vs. FMX
- Penetration vs. VMX
- ETR vs. Rod Length
- Penetration vs. EFV
- Penetration vs. ETR

**Table 2: 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	28½ - 30	30	33.6	4-6-7 / 13	SA SILT	53.4	277.5	79.3
2	33½ - 35	35	38.6	3-5-6 / 11	SA SILT	58.3	291.4	83.3
3	38½ - 40	40	43.6	4-6-9 / 15	SA SILT	55.5	286.8	81.9
<b>Overall Average</b>						<b>55.6</b>	<b>285.0</b>	<b>81.4</b>

The average hammer rate, transferred energy, and transfer ratio were calculated for each depth interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e., the blows that determine the N-value) were included when computing the average values shown in Table 2. The overall average transferred hammer energy for the automatic hammer on the CME 45B trailer-mounted drill rig (for all the depth intervals tested) was 285.0 foot-pounds, with an average ETR of 81.4%.

Report of SPT Hammer Energy  
Chester, South Carolina  
CG2 Project No.: 240021095

### LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The information 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.

### CLOSING

CG2 is pleased to have the opportunity to provide these services to you. If you have questions concerning the content of this report, or if CG2 can be of further service, please contact CG2 at (980) 339-8684.

Sincerely,  
**Carolinas Geotechnical Group, PLLC**

DocuSigned by:  
  
386129C0A4C1462...  
D. Matthew Brewer, PE  
Senior Project Engineer

DocuSigned by:  
  
8AD703B2A8484F4...  
Robert E. Kral, PE  
Senior Project Engineer  
NC Registration No. 042642



### Appendices:

- Appendix I - CME 45B Trailer Rig (SN 303304) SPT Energy Measurements Summary Plots and Tables
- Appendix II - SPT Hammer Energy Field Form (Field Log) and Drill Rig Photo Log
- Appendix III - Instrumented Rod and Accelerometer Calibration Sheets
- Appendix IV - Certificate of Proficiency



# APPENDIX I

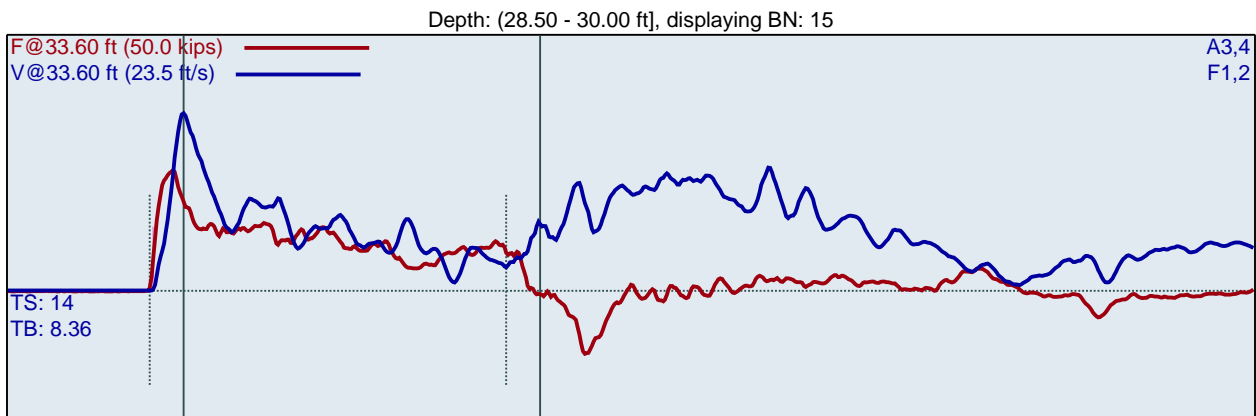


CME 45B (SN 303304)  
REK  
B-1

B-1  
Interval start: 3/11/2022

AR: 1.19 in<sup>2</sup>  
LE: 33.60 ft  
WS: 16807.9 ft/s

SP: 0.492 k/ft<sup>3</sup>  
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1  
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1  
A4 (PR): [K10959] 417.27 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

LP	BL#	BC	BPM	FMX	VMX	DMX	CSX	DFN	EFV	ETR
ft		/6"	bpm	kips	ft/s	in	ksi	in	ft-lb	%
28.63	1	4	1.9	23.8	15.1	2.0	20.0	1.5	258.9	74.0
28.75	2	4	52.7	25.1	15.4	1.6	21.1	1.5	269.5	77.0
28.88	3	4	53.1	25.1	15.7	1.6	21.1	1.5	272.5	77.8
29.00	4	4	53.5	24.6	15.4	1.5	20.7	1.5	269.5	77.0
29.08	5	6	53.4	25.0	15.6	1.2	21.0	1.0	273.5	78.2
29.17	6	6	53.3	24.8	15.7	1.1	20.8	1.0	274.5	78.4
29.25	7	6	53.4	24.6	15.7	1.1	20.7	1.0	277.2	79.2
29.33	8	6	53.3	24.7	16.0	1.1	20.8	1.0	274.8	78.5
29.42	9	6	53.4	24.6	16.0	1.1	20.6	1.0	275.4	78.7
29.50	10	6	53.7	24.3	15.9	1.1	20.4	1.0	276.7	79.1
29.57	11	7	53.3	24.6	16.3	1.0	20.7	0.9	281.6	80.4
29.64	12	7	53.3	24.1	16.2	1.1	20.2	0.9	279.6	79.9
29.71	13	7	53.5	23.8	16.1	1.1	20.0	0.9	280.2	80.0
29.79	14	7	53.7	23.7	16.5	1.0	19.9	0.9	278.2	79.5
29.86	15	7	53.2	23.6	16.3	1.0	19.8	0.9	277.1	79.2
29.93	16	7	53.4	23.3	15.7	0.9	19.6	0.9	278.7	79.6
30.00	17	7	53.5	23.2	17.1	0.9	19.5	0.9	280.6	80.2
Average			53.4	24.2	16.1	1.1	20.3	0.9	277.5	79.3
Std Dev			0.1	0.6	0.4	0.1	0.5	0.1	2.4	0.7
Maximum			53.7	25.0	17.1	1.2	21.0	1.0	281.6	80.4
Minimum			53.2	23.2	15.6	0.9	19.5	0.9	273.5	78.2

N-value: 13

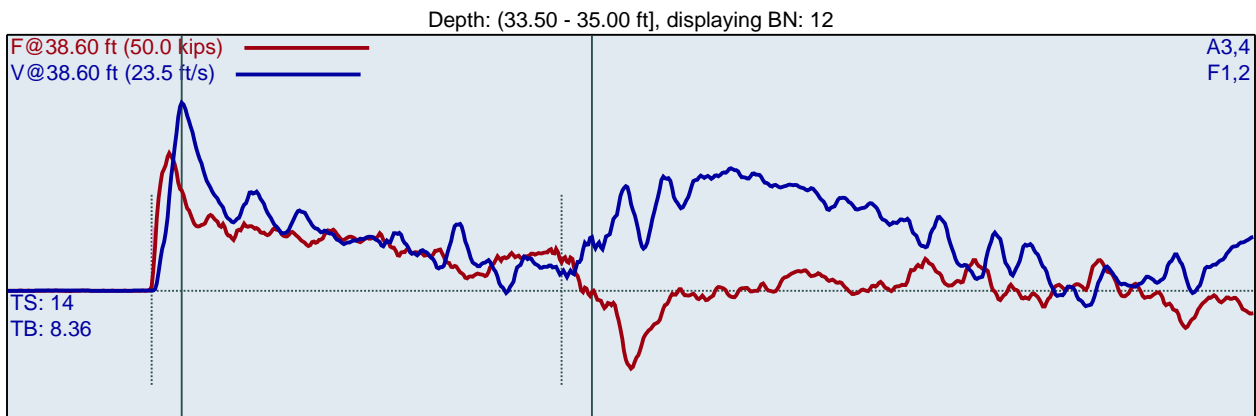
Sample Interval Time: 17.92 seconds.

CME 45B (SN 303304)  
REK  
B-1

B-1  
Interval start: 3/11/2022

AR: 1.19 in<sup>2</sup>  
LE: 38.60 ft  
WS: 16807.9 ft/s

SP: 0.492 k/ft<sup>3</sup>  
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1  
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1  
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

LP ft	BL#	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
33.67	1	3	1.9	27.2	16.3	2.3	22.8	2.0	290.7	83.0
33.83	2	3	60.1	27.7	17.1	2.0	23.2	2.0	300.3	85.8
34.00	3	3	60.9	27.7	17.1	2.0	23.3	2.0	302.3	86.4
34.10	4	5	61.4	27.6	16.8	1.3	23.2	1.2	293.7	83.9
34.20	5	5	58.8	27.3	16.7	1.3	22.9	1.2	286.9	82.0
34.30	6	5	57.9	27.1	16.9	1.2	22.8	1.2	288.5	82.4
34.40	7	5	57.7	27.5	17.0	1.2	23.2	1.2	288.2	82.3
34.50	8	5	57.9	26.7	16.8	1.2	22.5	1.2	292.5	83.6
34.58	9	6	57.8	26.6	17.0	1.1	22.4	1.0	290.0	82.9
34.67	10	6	58.1	26.9	17.0	1.0	22.6	1.0	287.6	82.2
34.75	11	6	58.1	26.6	17.1	1.0	22.4	1.0	288.5	82.4
34.83	12	6	57.8	26.9	17.3	1.0	22.6	1.0	298.0	85.1
34.92	13	6	58.1	26.5	17.2	1.0	22.3	1.0	295.9	84.6
35.00	14	6	58.2	26.2	17.0	1.0	22.0	1.0	295.4	84.4
Average			58.3	26.9	17.0	1.1	22.6	1.1	291.4	83.3
Std Dev			1.0	0.4	0.2	0.1	0.4	0.1	3.7	1.1
Maximum			61.4	27.6	17.3	1.3	23.2	1.2	298.0	85.1
Minimum			57.7	26.2	16.7	1.0	22.0	1.0	286.9	82.0

N-value: 11

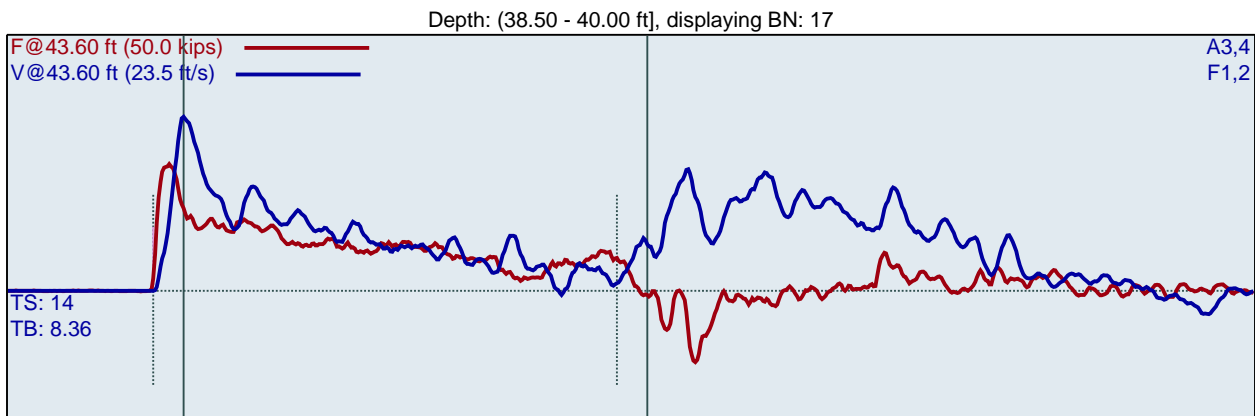
Sample Interval Time: 13.30 seconds.

CME 45B (SN 303304)  
REK  
B-1

B-1  
Interval start: 3/11/2022

AR: 1.19 in<sup>2</sup>  
LE: 43.60 ft  
WS: 16807.9 ft/s

SP: 0.492 k/ft<sup>3</sup>  
EM: 30000 ksi



F1 : [528AWJ1] 205.26 PDICAL (1) FF1  
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1  
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

LP ft	BL#	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR %
38.63	1	4	1.9	26.6	16.9	2.2	22.3	1.5	303.5	86.7
38.75	2	4	59.6	25.2	16.8	1.8	21.2	1.5	301.7	86.2
38.88	3	4	59.9	25.2	16.3	1.5	21.2	1.5	295.2	84.3
39.00	4	4	56.8	24.6	16.3	1.5	20.7	1.5	291.6	83.3
39.08	5	6	55.7	24.9	16.0	1.2	20.9	1.0	290.3	82.9
39.17	6	6	55.5	24.9	16.0	1.2	21.0	1.0	290.4	83.0
39.25	7	6	56.0	24.7	16.2	1.2	20.8	1.0	288.0	82.3
39.33	8	6	55.4	25.2	16.2	1.1	21.2	1.0	287.7	82.2
39.42	9	6	55.7	25.1	15.8	1.0	21.1	1.0	283.1	80.9
39.50	10	6	55.3	24.9	15.8	1.0	21.0	1.0	288.5	82.4
39.56	11	9	55.5	24.5	16.0	0.8	20.6	0.7	286.8	82.0
39.61	12	9	55.7	24.6	16.0	0.8	20.7	0.7	284.4	81.3
39.67	13	9	55.4	24.4	16.2	0.8	20.5	0.7	289.2	82.6
39.72	14	9	55.4	24.4	15.9	0.8	20.5	0.7	283.6	81.0
39.78	15	9	55.3	24.7	15.9	0.8	20.7	0.7	287.0	82.0
39.83	16	9	55.5	24.0	15.6	0.8	20.2	0.7	284.1	81.2
39.89	17	9	55.6	24.8	16.0	0.7	20.8	0.7	283.9	81.1
39.94	18	9	55.6	24.4	15.7	0.7	20.5	0.7	284.9	81.4
40.00	19	9	55.4	24.2	16.2	0.8	20.3	0.7	289.6	82.7
Average			55.5	24.7	16.0	0.9	20.7	0.8	286.8	81.9
Std Dev			0.2	0.3	0.2	0.2	0.3	0.2	2.5	0.7
Maximum			56.0	25.2	16.2	1.2	21.2	1.0	290.4	83.0
Minimum			55.3	24.0	15.6	0.7	20.2	0.7	283.1	80.9

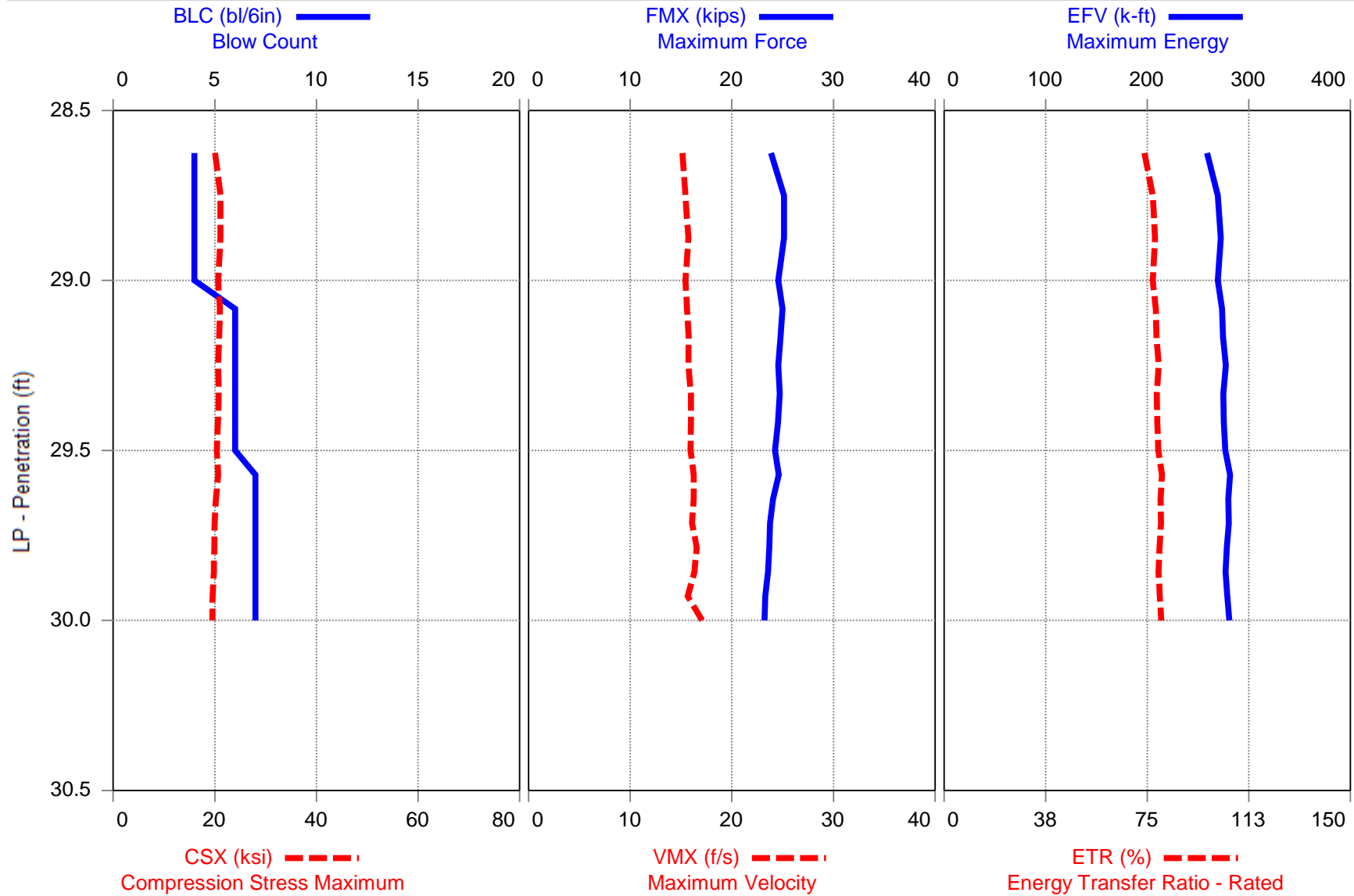
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Sample Interval Time: 19.28 seconds.

**Summary of SPT Test Results**

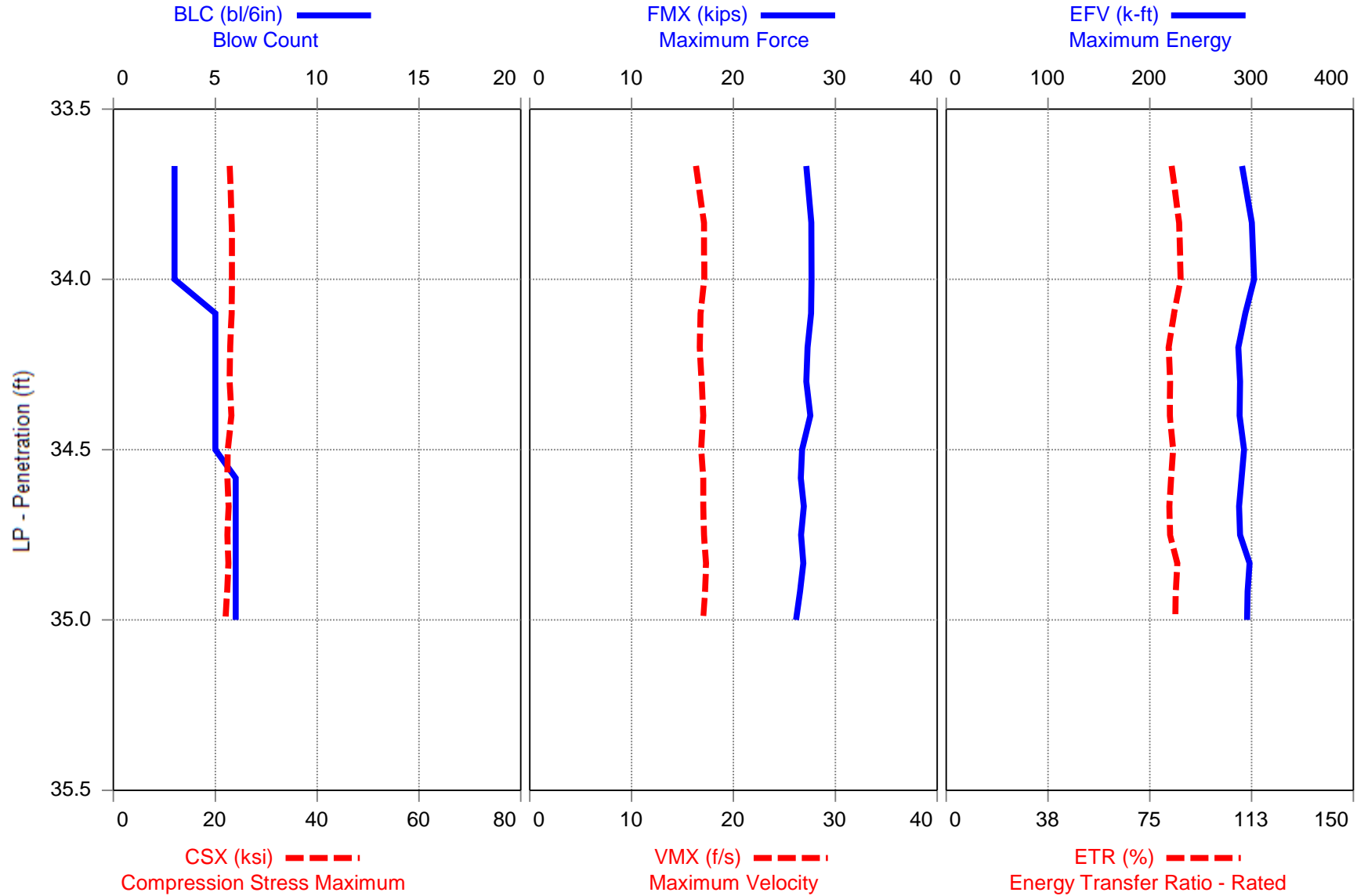
Project: CME 45B (SN 303304), Test Date: 3/11/2022

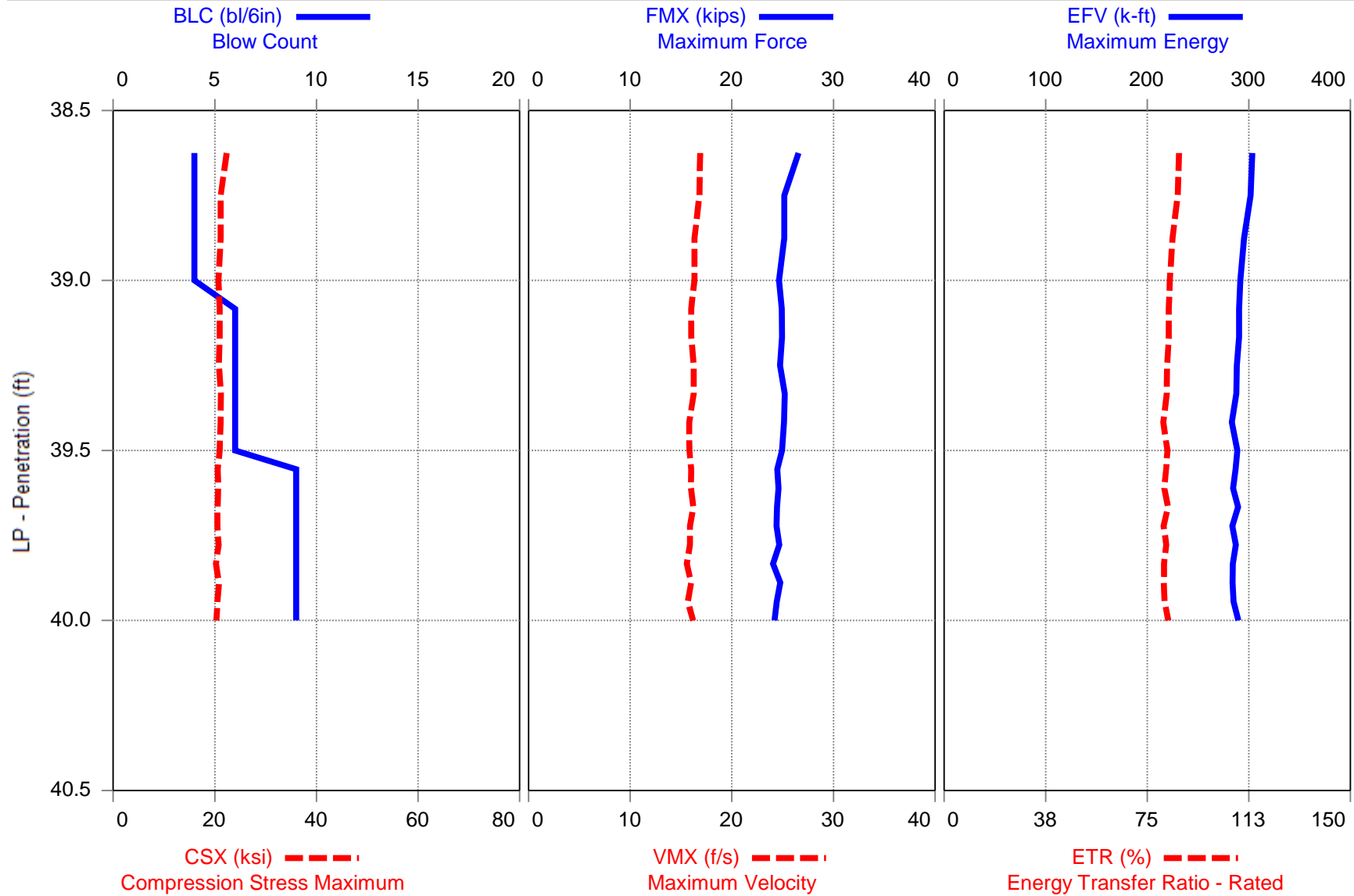
BPM: Blows/Minute											CSX: Compression Stress Maximum		
FMX: Maximum Force											DFN: Final Displacement		
VMX: Maximum Velocity											EFV: Maximum Energy		
DMX: Maximum Displacement											ETR: Energy Transfer Ratio - Rated		
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /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 %
33.60	28.50	30.00	4-6-7	13	17	53.4	24.2	16.1	1.1	20.3	0.9	277.5	79.3
38.60	33.50	35.00	3-5-6	11	14	58.3	26.9	17.0	1.1	22.6	1.1	291.4	83.3
43.60	38.50	40.00	4-6-9	15	20	55.5	24.7	16.0	0.9	20.7	0.8	286.8	81.9
Overall Average Values:						55.6	25.1	16.3	1.0	21.1	0.9	285.0	81.4
Standard Deviation:						2.0	1.2	0.5	0.2	1.0	0.2	6.3	1.8
Overall Maximum Value:						61.4	27.6	17.3	1.3	23.2	1.2	298.0	85.1
Overall Minimum Value:						53.2	23.2	15.6	0.7	19.5	0.7	273.5	78.2



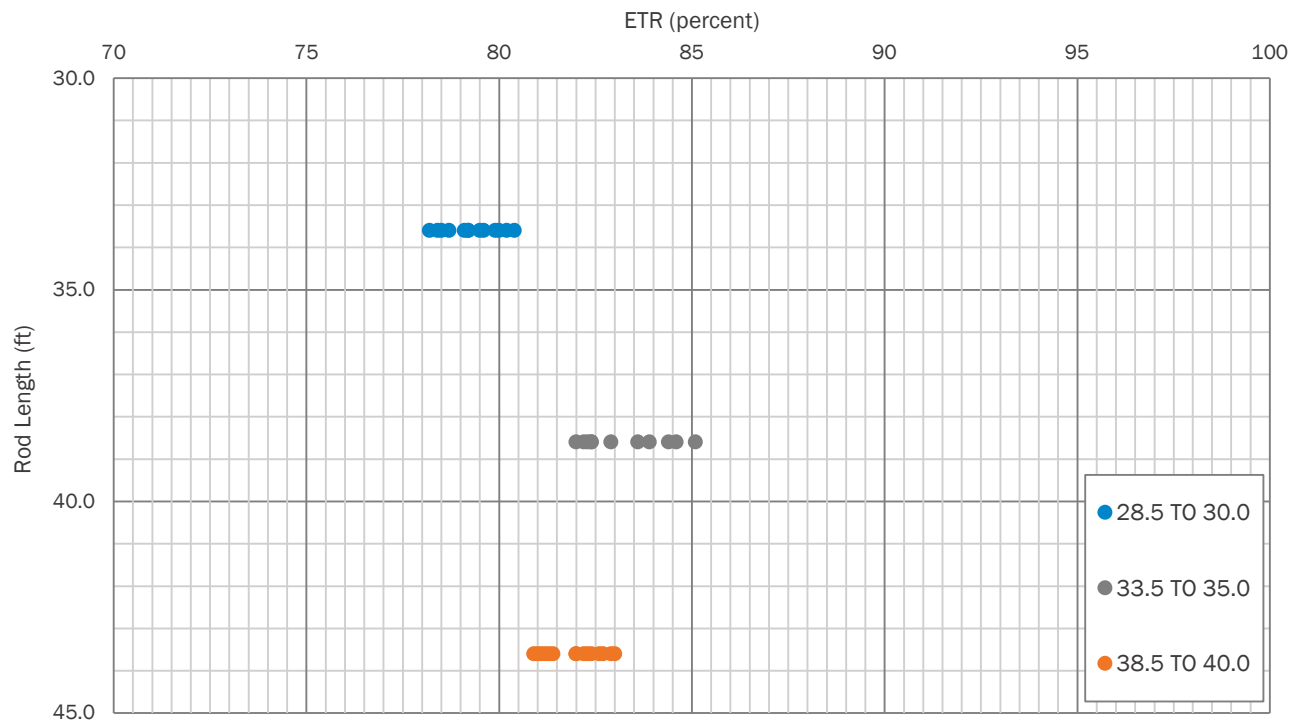


CME 45B (SN 303304) - 33.5 TO 35.0

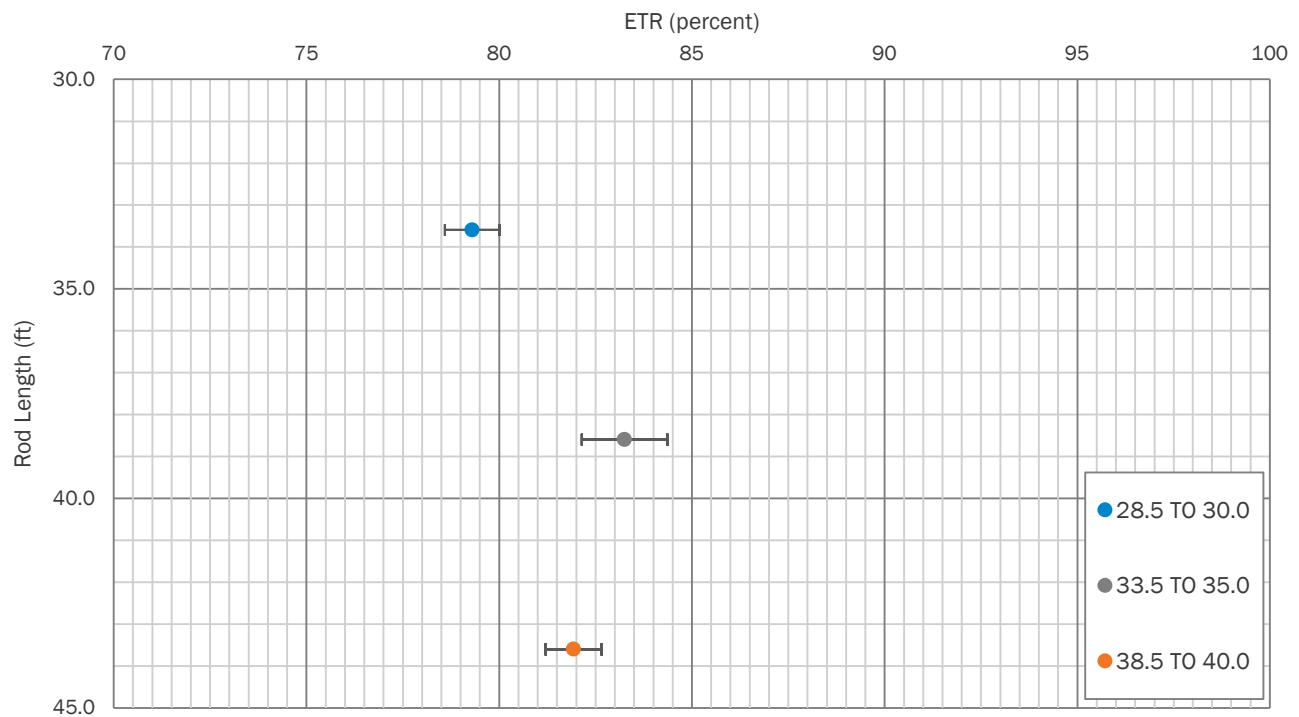




**ETR versus Rod Length  
CME 45B Trailer (SN 303304)**



**Average ETR versus Rod Length  $\pm$  1 Standard Deviation  
CME 45B Trailer (SN 303304)**







## APPENDIX II

# SPT Hammer Energy Field Form

**Project:** SPT HAMMER ENERGY  
**Project No.:** 240021095  
**Boring No.:** B-1

**Date:** 3/11/2022  
**Weather:** 50's CLOUDY  
**Drill Rod Type:** AWJ

## On-site Personnel

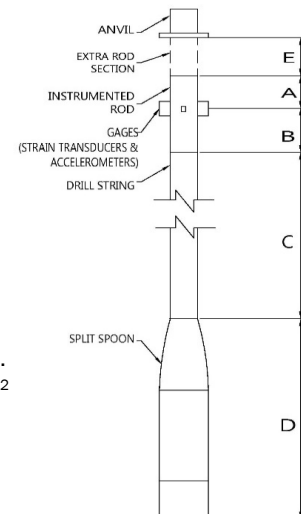
Drilling Company: BRECCIA CONSTRUCTION, LLC  
 Rig Operator: D. HARRIS  
 Engr/Geologist: N/A  
 Client Rep.: N/A  
 Analyzer Oper.: R. KRAL

## Rig/Hammer Info

Drill Rig Make/Model: CME 45B  
 Carrier Type: TRAILER  
 Rig Serial No.: 303304 (DR-1)  
 Hammer Type/Model: CME  
 Hammer Serial No.: N/A  
 Hammer Drop System: AUTO  
 Lubrication Condition: PER MANUFACTURER  
 Manufacturer Recommended  
 Operation Rate (bpm): 55  
 Drop Height (in.): 30  
 Hammer Weight (lbs): 140  
 Anvil Dimension (in.): 11.5  
 Drilling Method: 2.25 HSA

## Rod Info

**(A + E)** Impact Surface to Gages Length: 1.36 ft  
**(B)** Instr. Rod Length below Gages: 0.70 ft  
**(A) + (B)** Instr. Rod Length: 2.00 ft  
**(D)** Spoon Length: 2.85 ft  
**(E)** Rod Length Above Instr. Rod (if applicable): 0.06 ft  
 Instr. Rod S/N: 528AWJ  
 Instr. Rod Outside Dia.: 1.75 in.  
 Instr. Rod Area: 1.19 in<sup>2</sup>  
 PDA Make/Model: SPT  
 PDA Serial No.: 4549 TB  
 Calib. Pulse Test (y/n): Y



## Gage Info

Gage		Serial No.	Calibration No.
Accel.	A3	K11957	407.00
	A4	K10959	417.30
Strain	F3	528AWJ-1	205.26
	F4	528AWJ-2	205.86

Date of Test	Test Depth Increment (ft to ft)	Test Time Start / Stop (military)	Length of Drill String (ft) (C)	(LE) Length below Gages (ft) (B) + (C) + (D)	Avg. Meas. Hammer Rate (BPM)	SPT Blow Counts				Drop Height in Tolerance (y/n)	Soil Class.
						6"	12"	18"	N-Value		
11-Mar	28.5 TO 30.0	0830/0830	30	33.6	53	4	6	7	13	Y	SA SI
11-Mar	33.5 TO 35.0	0837/0837	35	38.6	57	3	5	6	11	Y	SA SI
11-Mar	38.5 TO 40.0	0842/0843	40	43.6	56	4	6	9	15	Y	SA SI

## Notes:

TESTING PERFORMED AT 1817 LOWRYS HIGHWAY IN CHESTER, SOUTH CAROLINA (CHESTER COUNTY). THE APPROXIMATE COORDINATES ARE 34.770585, - 81.245517.

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



Prepared By (print/signature)

3/11/2022  
Date





Figure No. 1: Rear View of Drill Rig



Figure No. 2: Side View of Drill Rig



Figure No. 3: Serial Number Plate



Figure No. 4: Automatic Hammer



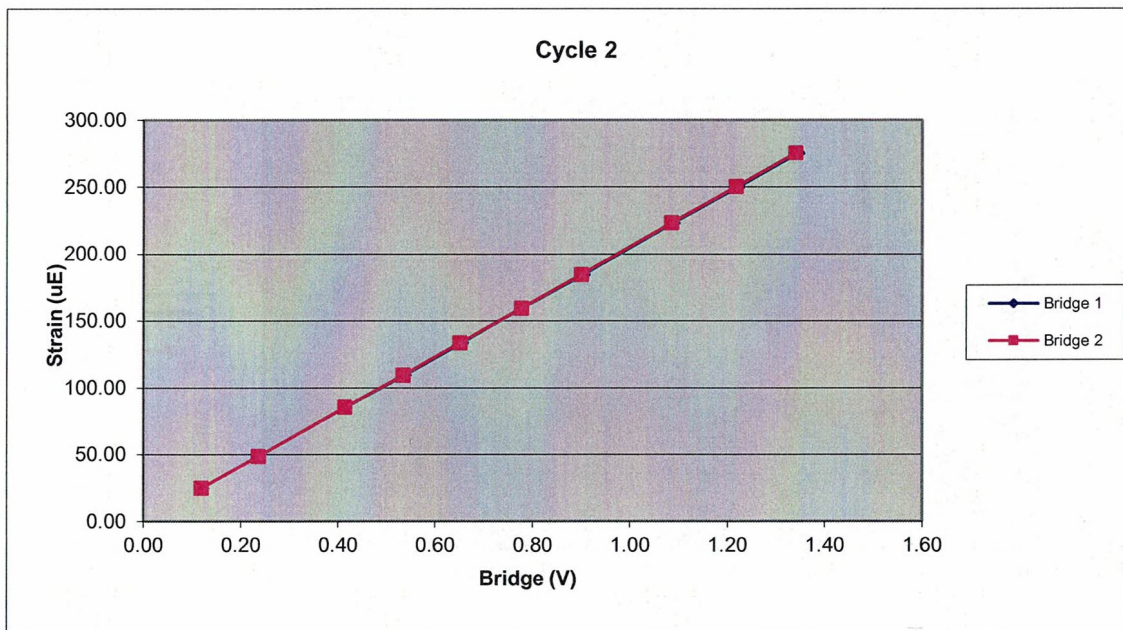
## APPENDIX III



528AWJ		Cycle 2		
Sample	Force (lb)	Strain ( $\mu$ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	905.16	24.61	0.12	0.12
3	1753.20	48.18	0.24	0.24
4	3064.74	84.99	0.42	0.41
5	3947.87	108.99	0.54	0.53
6	4813.36	133.40	0.65	0.65
7	5727.49	159.02	0.78	0.78
8	6643.67	184.17	0.90	0.90
9	8004.82	222.89	1.09	1.09
10	8980.07	249.70	1.22	1.22
11	9885.91	275.04	1.35	1.34

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7340.27	Force Calibration (lb/V)	7362.32
Offset	12.98	Offset	13.21
Correlation	1.000000	Correlation	0.999999
Strain Calibration ( $\mu$ E/V)	204.74	Strain Calibration ( $\mu$ E/V)	205.35
Offset	-0.39	Offset	-0.39
Correlation	0.999993	Correlation	0.999995

Force Strain Calibration	
EA (Kips)	35851.72
Offset	27.08
Correlation	0.999996



528AWJ		Cycle 1		
Sample	Force (lb)	Strain ( $\mu\text{E}$ )	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1278.49	35.63	0.17	0.17
3	2188.92	61.59	0.30	0.30
4	3085.11	86.16	0.42	0.42
5	3944.56	110.01	0.53	0.54
6	5284.17	147.69	0.72	0.72
7	6199.57	172.59	0.84	0.84
8	7071.20	197.80	0.96	0.96
9	8023.54	224.47	1.09	1.09
10	8958.62	250.45	1.22	1.22
11	9876.55	276.81	1.34	1.34

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7346.16	Force Calibration (lb/V)	7359.87
Offset	9.71	Offset	6.72
Correlation	0.999998	Correlation	0.999999
Strain Calibration ( $\mu\text{E/V}$ )	205.65	Strain Calibration ( $\mu\text{E/V}$ )	206.03
Offset	0.08	Offset	-0.01
Correlation	0.999990	Correlation	0.999993

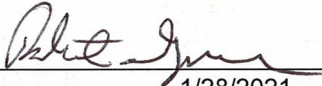
Force Strain Calibration	
EA (Kips)	35721.25
Offset	7.11
Correlation	0.999990





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

Calibration Factors	528AWJ		
Bridge 1 ( $\mu\text{E/V}$ )	205.26	Bridge 2 ( $\mu\text{E/V}$ )	205.86
EA Factor (Kips)	35777.05	Area ( $\text{in}^2$ )	1.19

Calibrated by: 

Calibrated Date:

1/28/2021

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 19Apr2021

Serial No: K10959 Temperature: 21.0 °C

Model: PR Humidity: 38%

Calibrated on: Channel 3 on 8G 5161 LE

### PDA CALIBRATION FACTOR

417.3 mv/5000g

(83.5  $\mu$ v/g)

R<sup>2</sup>: 0.999987 [Chip programmed]

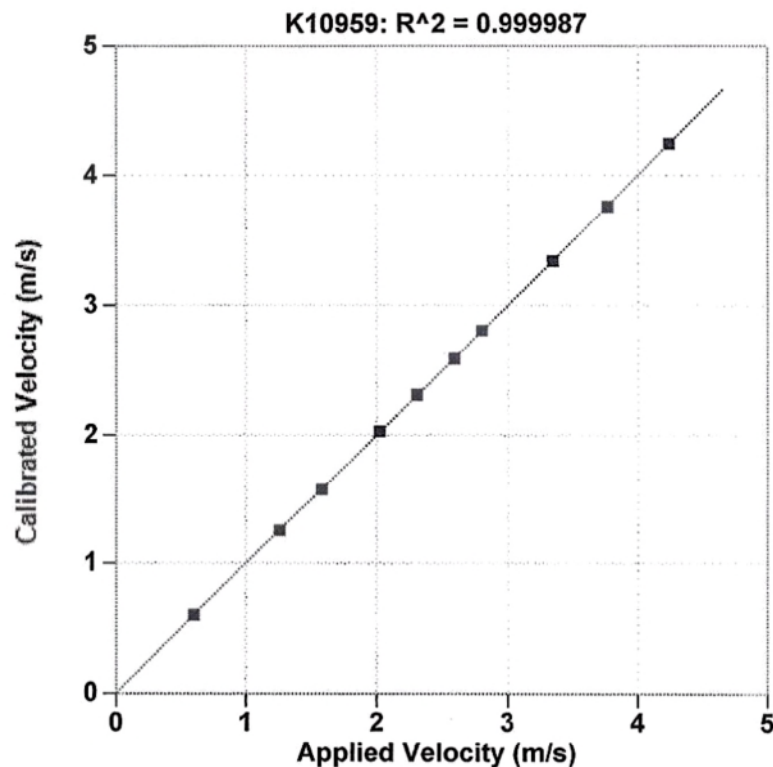
Operator: William Johnson

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

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

Signed

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



Reference Velocity	S/N K10959 Velocity
m/s	m/s
0.600	0.600
1.260	1.255
1.578	1.577
2.021	2.028
2.306	2.311
2.590	2.590
2.801	2.806
3.346	3.344
3.767	3.762
4.241	4.241

Maximum Acceleration: 938 g's



# Accelerometer Calibration Certificate

## Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on 22Jan2021

Serial No: K10960 Temperature: 20.0 °C

Model: PR Humidity: 28%

Calibrated on: Channel 4 on 8G 5161 LE

### PDA CALIBRATION FACTOR

**425.7 mv/5000g**

(85.1  $\mu\text{v/g}$ )

R<sup>2</sup>: 0.999987 [Chip programmed]

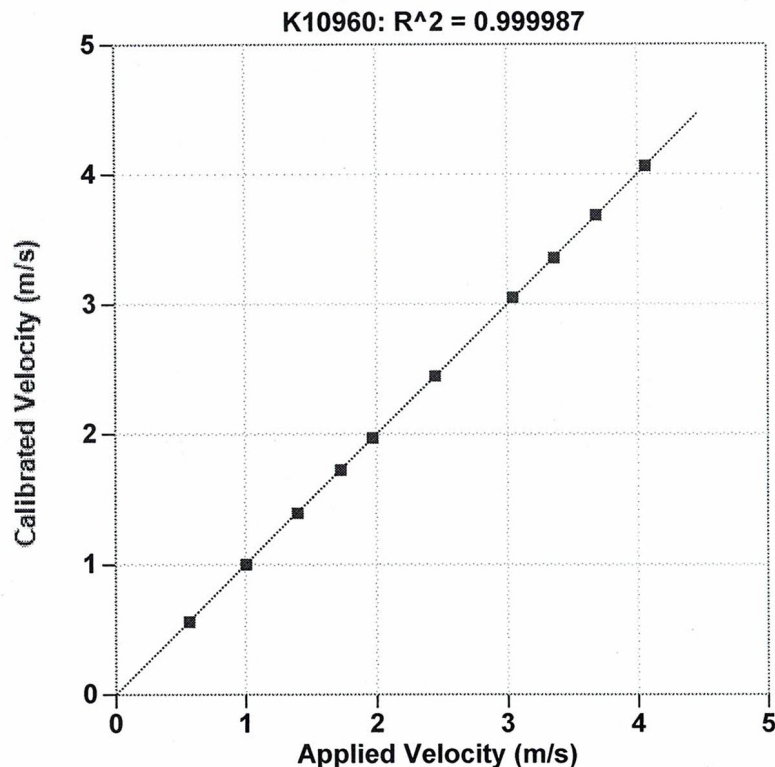
Operator: William Johnson

Ref Acc 1: 63479! Cal on: 09Sep2020  
1080 g's/volt

Ref Acc 2: 65538! Cal on: 27Jan2020  
1040 g's/volt

  
Signed

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



Reference Velocity	S/N K10960 Velocity
m/s	m/s
0.568	0.564
1.006	1.001
1.400	1.393
1.728	1.726
1.969	1.970
2.447	2.448
3.043	3.051
3.359	3.356
3.683	3.684
4.063	4.062

Maximum Acceleration: 889 g's

# Accelerometer Calibration Certificate

## Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on

MAR 2 2021

Serial No: K11957 Temperature: 20.0 °C

Model: PR Humidity: 27%

Calibrated on: Channel 4 on 8G 5161 LE

### PDA CALIBRATION FACTOR

407.0 mv/5000g

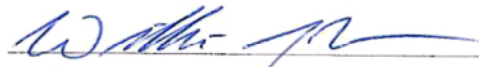
(81.4  $\mu$ v/g)

R<sup>2</sup>: 0.999989 [Chip programmed]

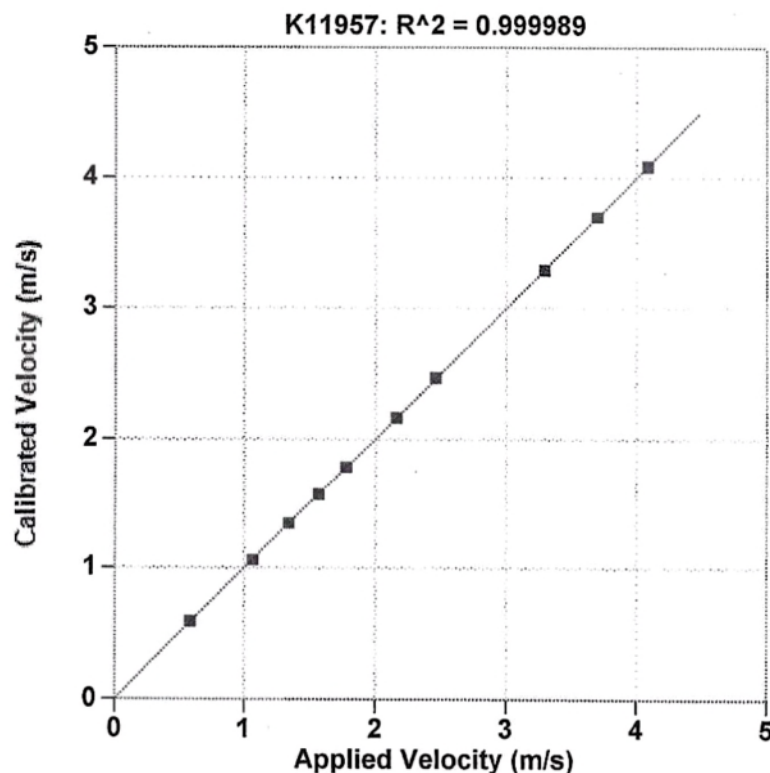
Operator: William Johnson

Ref Acc 1: 63479! Cal on: 22Jan2021  
1079 g's/volt

Ref Acc 2: 65538! Cal on: 22Jan2021  
1043 g's/volt

  
Signed

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



Reference Velocity	S/N K11957 Velocity
m/s	m/s
0.588	0.589
1.066	1.061
1.344	1.345
1.571	1.570
1.779	1.783
2.161	2.164
2.458	2.465
3.294	3.291
3.701	3.700
4.089	4.086
Maximum Acceleration: 894 g's	



## APPENDIX IV





This documents that  
**Robert E. Kral**  
**Carolinas Geotechnical Group**  
has on May 20, 2016 achieved the rank of  
**ADVANCED**


**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 Advanced level seek Master or Expert levels through additional study within six 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. **This certificate can be verified at [www.PDAproficiencytest.com](http://www.PDAproficiencytest.com).** 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.

  
Steven A. Hall, Executive Director  
Pile Driving Contractors Association



  
Garland Likins, Senior Partner  
Pile Dynamics, Inc.

No. 2072

