



# Geotechnical Subsurface Data Report

S-12-53 (Ross Dye Rd.) Bridge Replacement  
over Little Rocky Creek

*Chester County, SC*  
September 23, 2022





September 23, 2022

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

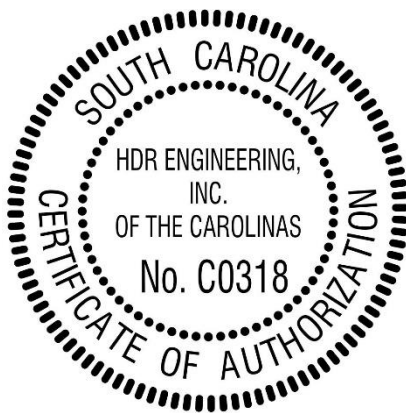
Dear Mr. Harris,

We have completed the Geotechnical Subsurface Data Report for the S-12-53 (Ross Dye Rd.) Bridge Replacement over Little Rocky Creek in Chester 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*

Lila Leon, P.E., Ph.D.  
*Senior Geotechnical Engineer*





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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-12-53 Bridge Replacement over Little Rocky Creek, in Chester County, South Carolina. The proposed bridge intends to replace the existing bridge over Little Rocky Creek on Ross Dye Road.

This Geotechnical Subsurface Data Report was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM). Geotechnical data including standard penetration testing (SPT), cone penetration testing (CPT), bulk sampling, rock cores, shear wave velocity measurements, 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 east of Chester, approximately 3 miles southeast of the intersection of Interstate 77 with Great Falls Hwy. It is bound to the north by Great Falls Highway and to the south by Dewitt Road. A Site Vicinity Map is included in Appendix A.

The existing bridge over Little Rocky Creek is approximately 300 feet in length and 32 feet wide and will be removed and replaced with a new bridge along the existing alignment. The proposed multi span replacement bridge will be approximately 345 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 August 2022. The subsurface investigation consisted of standard penetration test (SPT) borings, rock core samples, bulk sample soil collection, CPTs, and shear wave velocity measurements with MASW testing.

A test location plan showing all testing locations is included in Appendix A. The boring logs, rock core photos, CPT logs, and MASW shear wave velocity profile 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-11 and B-12. Auger refusal was encountered in both borings at depths of 25.5 feet and 51.4 feet, respectively. Advancement of the bridge borings B-11 and B-12 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 35.5 feet and 66.4 feet.



The boring logs from the subsurface investigations are included in Appendix B. The borings were advanced by a CME 45B using mud rotary 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-5 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 Cone Penetrometer Testing

Two (2) cone penetrometer tests (CPT-3 and CPT-4) were performed by F&ME Consultants, Inc., one near each end bent of the existing bridge. Upon encountering refusal, the CPTs were terminated at depths ranging between 17.8 feet to 24.4 feet. CPT sounding logs are included in Appendix B.

## 2.3 MASW Survey

Shear wave velocity measurements were obtained by F&ME Consultants from one (1) Multi-Channel Analysis of Surface Waves, MASW-2, performed on the existing bridge end where boring B-11 was drilled. Active survey data was obtained by a sledgehammer striking an aluminum block and polyethylene block and recording of the resulting vibrations. Passive survey data consisted of the collection of ambient background vibrations resulting from drilling equipment. The resulting shear-wave data from this investigation produced an average shear-wave velocity of 1389.3 ft/sec for the 0 to 100-foot interval. The MASW survey report is included in Appendix B.

## 2.4 Groundwater Conditions

The stabilized groundwater level recorded approximately 24 hours after completion of investigation operations indicated a groundwater depth of 16.1 feet for boring B-11. This depth corresponds to elevation 326.1 feet.

Groundwater level was recorded at the time of completion of soil drilling and/or rock coring at boring B-12 at a depth of 7.3 feet. This depth corresponds to elevation 333.3 feet.

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



## 2.5 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-11	33+52	5 LT	34.58968	-80.97364	342.2	SPT/RC	35.5
B-12	30+38	5 RT	34.59022	-80.97445	340.6	SPT/RC	66.4
BS-5	33+52	5 LT	34.58968	-80.97364	342.2	BULK	5.0
CPT-3	33+51	5 LT	34.58968	-80.97364	342.1	CPT	17.8
CPT-4	30+35	5 RT	34.59022	-80.97446	340.6	CPT	24.4
MASW-2	near boring B-11					MASW	100.0

<sup>a</sup> Stations based on latest S-12-53 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	8
Atterberg Limits	6
Grain Size Analysis with Hydrometer	1
Grain Size Analysis with #200 Wash	5
#200 Wash	2
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-2-4 to A-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty clayey sand (SC-SM) to sandy lean clay (CL). Tested samples yielded liquid limits ranging from 0 to 40 and plasticity indices ranging from 0 to 19.

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 4,920 psi to 11,570 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-12-53 Bridge over Little Rocky Creek in Chester 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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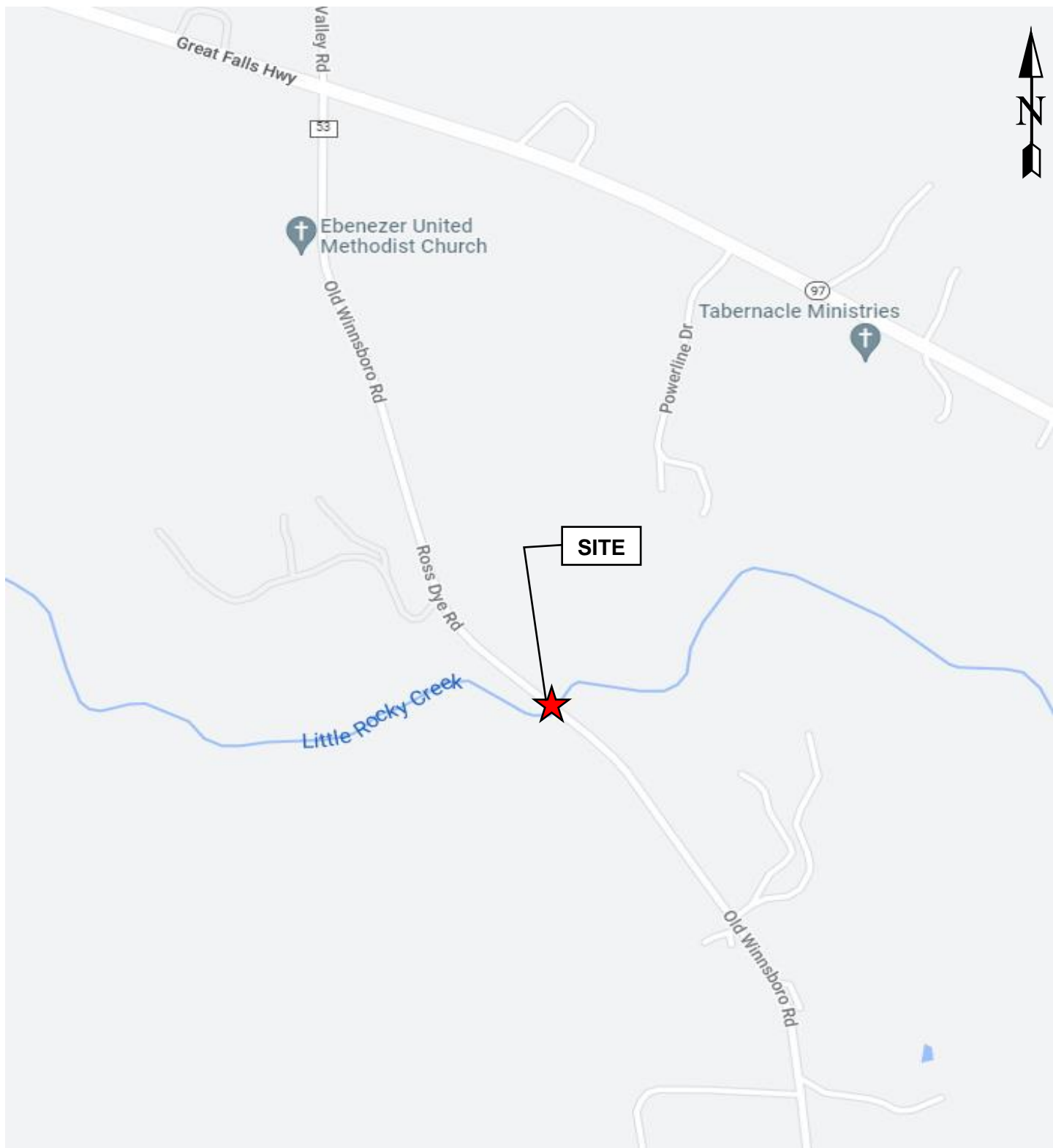
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<https://www.scdot.org/business/pdf/geotech/SCDOT-Geotechnical-Design-Manual-2022.pdf>



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





HDR ENGINEERING INC.  
OF THE CAROLINAS

1201 Main Street, Suite 800  
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### S-12-53 (Ross Dye Rd.) over Little Rocky Creek

COUNTY

CHESTER

SITE VICINITY MAP

Source: Google Maps



# S-12-53 Ross Dye Rd. over Little Rocky Creek

- Legend**
- Bulk Sample
  - CPT
  - MASW
  - SPT Boring

B-12 CPT-4

BS-5  
B-11 CPT-3

MASW-2



100 ft



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## Appendix B. Boring Logs, Rock Core Photos, CPT Logs, MASW Profile



# 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	86to 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)**





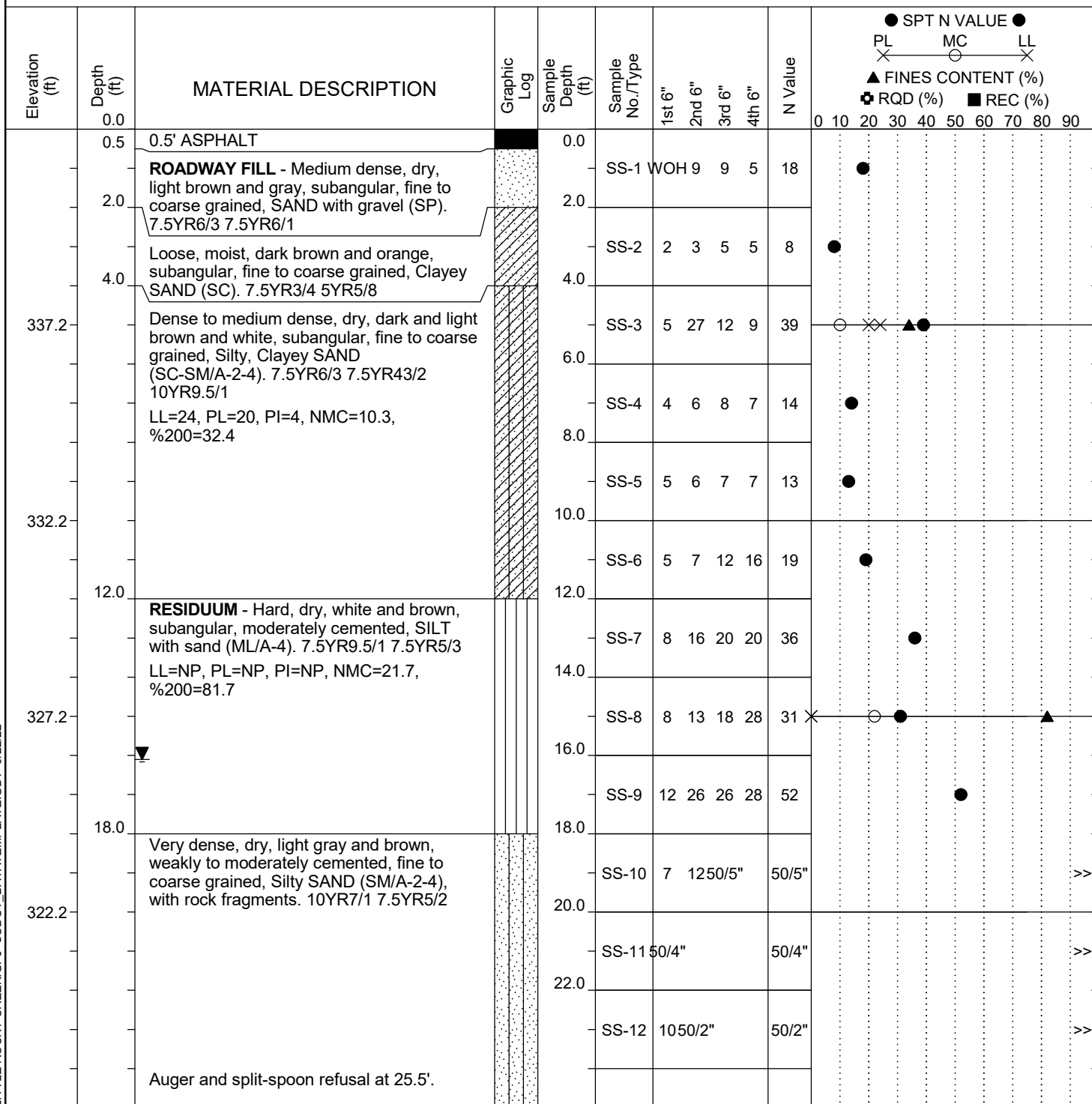
## **Appendix B. Subsurface Investigation**

### **Boring Logs**



# SCDOT Soil Test Log

<b>Project ID:</b>	P041153	<b>County:</b>	Chester, SC	<b>Boring No.:</b>	B-11
<b>Site Description:</b>	S-12-53 (Ross Dye Rd.) over Little Rocky Creek			<b>Route:</b>	S-12-53
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	33+52	<b>Offset:</b>	5 LT
<b>Elev.:</b>	342.2 ft	<b>Latitude:</b>	34.58968	<b>Longitude:</b>	-80.97364
<b>Total Depth:</b>	35.5 ft	<b>Soil Depth:</b>	25.5 ft	<b>Core Depth:</b>	10 ft
<b>Date Started:</b>	8/3/2022				
<b>Date Completed:</b>	8/3/2022				
<b>Bore Hole Diameter (in):</b>	4.5"	<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>	HSA	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	L. Guempel/ F&ME	<b>Groundwater:</b>	TOB N.M.
<b>24HR</b>	16.1 ft				



## 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	

SC\_DOT S-12-53 LITTLE ROCKY CREEK.GPJ SCDOT\_DATATEMPLATE.GDT 9/22/22



# SCDOT Soil Test Log

<b>Project ID:</b>	P041153	<b>County:</b>	Chester, SC	<b>Boring No.:</b>	B-11
<b>Site Description:</b>	S-12-53 (Ross Dye Rd.) over Little Rocky Creek			<b>Route:</b>	S-12-53
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	33+52	<b>Offset:</b>	5 LT
<b>Elev.:</b>	342.2 ft	<b>Latitude:</b>	34.58968	<b>Longitude:</b>	-80.97364
<b>Date Started:</b>	8/3/2022				
<b>Total Depth:</b>	35.5 ft	<b>Soil Depth:</b>	25.5 ft	<b>Core Depth:</b>	10 ft
<b>Date Completed:</b>	8/3/2022				
<b>Bore Hole Diameter (in):</b>	4.5"	<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>	HSA	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	L. Guempel/ F&ME	<b>Groundwater:</b>	TOB N.M.
<b>24HR</b>	16.1 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 LL X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
	25.5	Begin coring.		25.5							
		<b>METADIORITE</b> - Dark gray to white, brown in weathered sections, very coarse to coarse grained, very thinly/partially foliated, slightly to moderately weathered, medium strong to strong, low to moderately hard. Very close joints, open to moderately open, irregular joints, slightly rough to rough, no infilling.			NQ-1						
312.2		NQ-1: %REC=80, RQD=17, 2.3 min/ft, qu=9,520 psi, RMR=42, GSI=50-55		30.5							
		NQ-2: %REC=83, RQD=22, qu=11,570 psi, RMR=42, GSI=60-65			NQ-2						
307.2	35.5	Quartz rich zone in upper 2.5'.									
		Boring Terminated at 35.5' (Elev. 306.7')									
302.2											
297.2											

## 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 S-12-53 LITTLE ROCKY CREEK.GPJ SCDOT\_DATATEMPLATE.GDT 9/22/22



# Rock Core Photos

B-11

Box 1 of 1 (25.5' to 35.5')





# SCDOT Soil Test Log

<b>Project ID:</b>	P041153	<b>County:</b>	Chester, SC	<b>Boring No.:</b>	B-12
<b>Site Description:</b>	S-12-53 (Ross Dye Rd.) over Little Rocky Creek			<b>Route:</b>	S-12-53
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	30+38	<b>Offset:</b>	5 RT
<b>Elev.:</b>	340.6 ft	<b>Latitude:</b>	34.59022	<b>Longitude:</b>	-80.97445
<b>Total Depth:</b>	66.4 ft	<b>Soil Depth:</b>	51.4 ft	<b>Core Depth:</b>	15 ft
<b>Date Started:</b>	8/4/2022				
<b>Date Completed:</b>	8/4/2022				
<b>Bore Hole Diameter (in):</b>	4.5"	<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>	HSA	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	L. Guempel/ F&ME	<b>Groundwater:</b>	TOB 7.3 ft
<b>24HR</b>	N.M.				

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 MC LL X X X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
	0.0										0 10 20 30 40 50 60 70 80 90
	0.5	0.5' ASPHALT		0.0	SS-1	10	3	3		13	●
	2.0	ROADWAY FILL - Medium dense, dry, brown, subangular, fine to coarse grained, SAND (SP). 7.5YR4/3		2.0							
	4.0	Loose, dry, brown and orange, subangular, fine to coarse grained, Clayey SAND (SC/A-6). 7.5YR5/4 5YR7/6		4.0	SS-2	3	3	2	6	5	● ○ X X ▲
335.6		LL=40, PL=21, PI=19, NMC=16.7, %200=41.7			SS-3	3	4	4	3	8	●
	6.0	Loose, dry, brown, dark brown and white, subangular, fine to coarse grained, Clayey SAND with gravel (SC/A-4). 7.5YR2.5/2		6.0							
	8.0	7.5YR8/1		8.0	SS-4	3	3	4	3	7	● ○ X X X ▲
		LL=28, PL=20, PI=8, NMC=14.3, %200=37.1			SS-5	1	2	3	3	5	●
330.6											
	12.0	ALLUVIUM - Very soft to firm, moist, gray to brown, Sandy Lean CLAY (CL/A-4). 7.5YR5/1 7.5YR4/2		13.5	SS-6	WOW/OH				0	● X X X ▲
325.6		LL=27, PL=18, PI=9, NMC=25.4, %200=68.4									
	18.5			18.5	SS-7	3	3	2		5	●
320.6											
	22.0	RESIDUUM - Dense to very dense, moist to wet, gray/white, orange and brown, subangular, weakly to strongly cemented, fine to coarse grained, Silty SAND (SM/A-2-4) with rock fragments. 10YR8.5/1 5YR6/6 7.5YR5/4		23.5	SS-8	9	16	28		44	▲ ○ ●

## 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	

SC\_DOT S-12-53 LITTLE ROCKY CREEK.GPJ SCDOT\_DATATEMPLATE.GDT 9/22/22



# SCDOT Soil Test Log

<b>Project ID:</b>	P041153	<b>County:</b>	Chester, SC	<b>Boring No.:</b>	B-12
<b>Site Description:</b>	S-12-53 (Ross Dye Rd.) over Little Rocky Creek			<b>Route:</b>	S-12-53
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	30+38	<b>Offset:</b>	5 RT
<b>Elev.:</b>	340.6 ft	<b>Latitude:</b>	34.59022	<b>Longitude:</b>	-80.97445
<b>Date Started:</b>	8/4/2022				
<b>Total Depth:</b>	66.4 ft	<b>Soil Depth:</b>	51.4 ft	<b>Core Depth:</b>	15 ft
<b>Date Completed:</b>	8/4/2022				
<b>Bore Hole Diameter (in):</b>	4.5"	<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>	HSA	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	L. Guempel/ F&ME	<b>Groundwater:</b>	TOB 7.3 ft
<b>24HR</b>	N.M.				

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 LL X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%)
		NMC=25.4, %200=16.2									0 10 20 30 40 50 60 70 80 90
310.6				28.5	SS-9	50/5"				50/5"	>>●
305.6		NMC=10.5, %200=17.4		33.5	SS-10	49	50			50	○▲>>●
300.6				38.5	SS-11	50				50	>>●
295.6				43.5	SS-12	50/2"				50/2"	>>●
				48.5							
		Auger and split-spoon refusal at 51.4'		49.9	SS-13	50/5"				50/5"	>>●

## LEGEND

Continued Next Page

### SAMPLER TYPE

### DRILLING METHOD

SS - Split Spoon  
UD - Undisturbed Sample  
AWG - Rock Core, 1-1/8"

NQ - Rock Core, 1-7/8"  
CU - Cuttings  
CT - Continuous Tube

HSA - Hollow Stem Auger  
CFA - Continuous Flight Augers  
DC - Driving Casing

RW - Rotary Wash  
RC - Rock Core



# SCDOT Soil Test Log

<b>Project ID:</b>	P041153	<b>County:</b>	Chester, SC	<b>Boring No.:</b>	B-12
<b>Site Description:</b>	S-12-53 (Ross Dye Rd.) over Little Rocky Creek			<b>Route:</b>	S-12-53
<b>Eng./Geo.:</b>	N. Yacobi /HDR	<b>Boring Location:</b>	30+38	<b>Offset:</b>	5 RT
<b>Elev.:</b>	340.6 ft	<b>Latitude:</b>	34.59022	<b>Longitude:</b>	-80.97445
<b>Total Depth:</b>	66.4 ft	<b>Soil Depth:</b>	51.4 ft	<b>Core Depth:</b>	15 ft
<b>Date Started:</b>	8/4/2022				
<b>Date Completed:</b>	8/4/2022				
<b>Bore Hole Diameter (in):</b>	4.5"	<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>	HSA	<b>Hammer Type:</b>	Automatic
<b>Energy Ratio:</b>	81.4%				
<b>Core Size:</b>	NQ	<b>Driller:</b>	L. Guempel/ F&ME	<b>Groundwater:</b>	TOB 7.3 ft
<b>24HR</b>	N.M.				

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 (%)
	51.4	Begin coring.		51.4	SS-14	50/1"				50/1"	
285.6		<b>METADIORITE</b> - Gray/white/black, brown in highly weathered areas, very fine to coarse grained, thinly foliated, moderately to highly weathered, weak to strong rock, low to moderately hard. Joints very close, open to moderately open, irregular joints, smooth to rough, no infilling. NQ-1: %REC=68, RQD=0, 2.6 min/ft, GSI=20-25  NQ-2: %REC=83, RQD=30, 2.0 min/ft, qu=6,030 psi, RMR=44, GSI=25-30  qu=4,920 psi  NQ-3: %REC=75, RQD=7, 2.2 min/ft, GSI=25-30			NQ-1						
280.6				56.4							
					NQ-2						
275.6				61.4							
					NQ-3						
270.6	66.4	Boring Terminated at 66.4' (Elev. 274.2')									

## LEGEND

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

SC\_DOT S-12-53 LITTLE ROCKY CREEK.GPJ SCDOT\_DATATEMPLATE.GDT 9/22/22



# Rock Core Photos

B-12

Box 1 of 2 (51.4' to 61.4')



B-12

Box 2 of 2 (61.4' to 66.4')







## **Appendix B. Subsurface Investigation**

### **CPT Logs**





S-12-53 (Ross Dye Rd.) over Little Rocky Creek  
Chester (South Carolina)  
Project No. :P041153

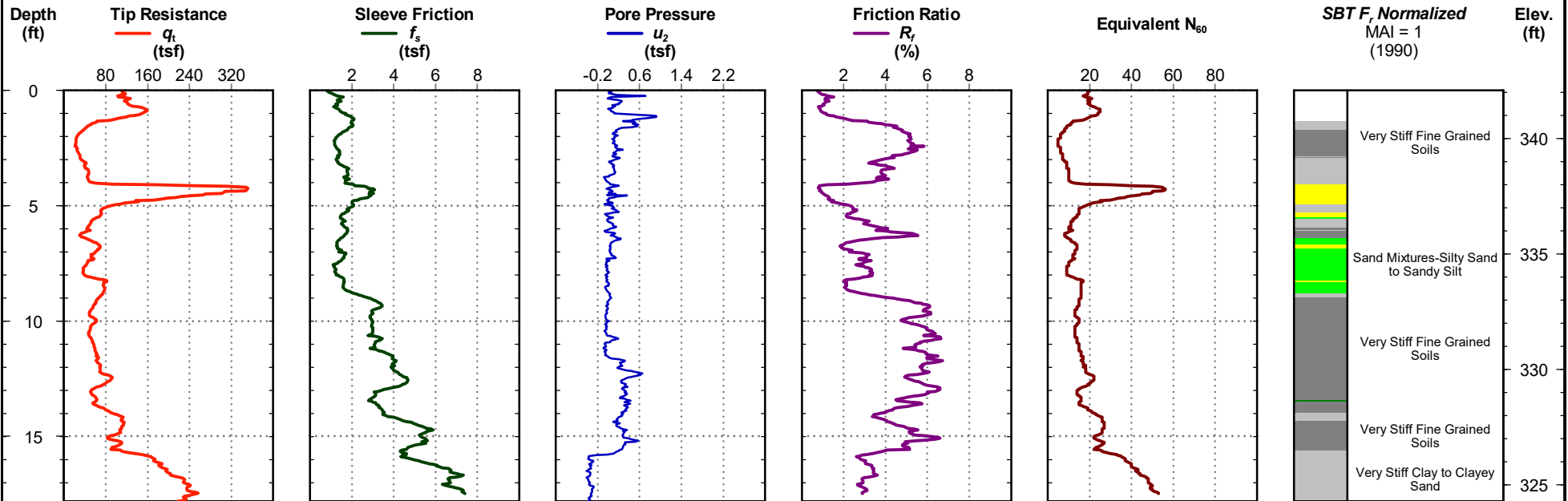
# Cone Penetration Test

CPT-3/B-11

Date: Aug. 10, 2022  
Estimated Water Depth: 16.1 ft  
Rig/Operator: C Piercy

Station: 33+50.78  
Offset: -5.2387  
Elevation: 342.1 ft-MSL

Total Depth: 17.8 ft  
Termination Criteria: Maximum Reaction Force  
CPT Probe ID: DDG1329



CPT-3/B-11





S-12-53 (Ross Dye Rd.) over Little Rocky Creek  
Chester (South Carolina)  
Project No. :P041153

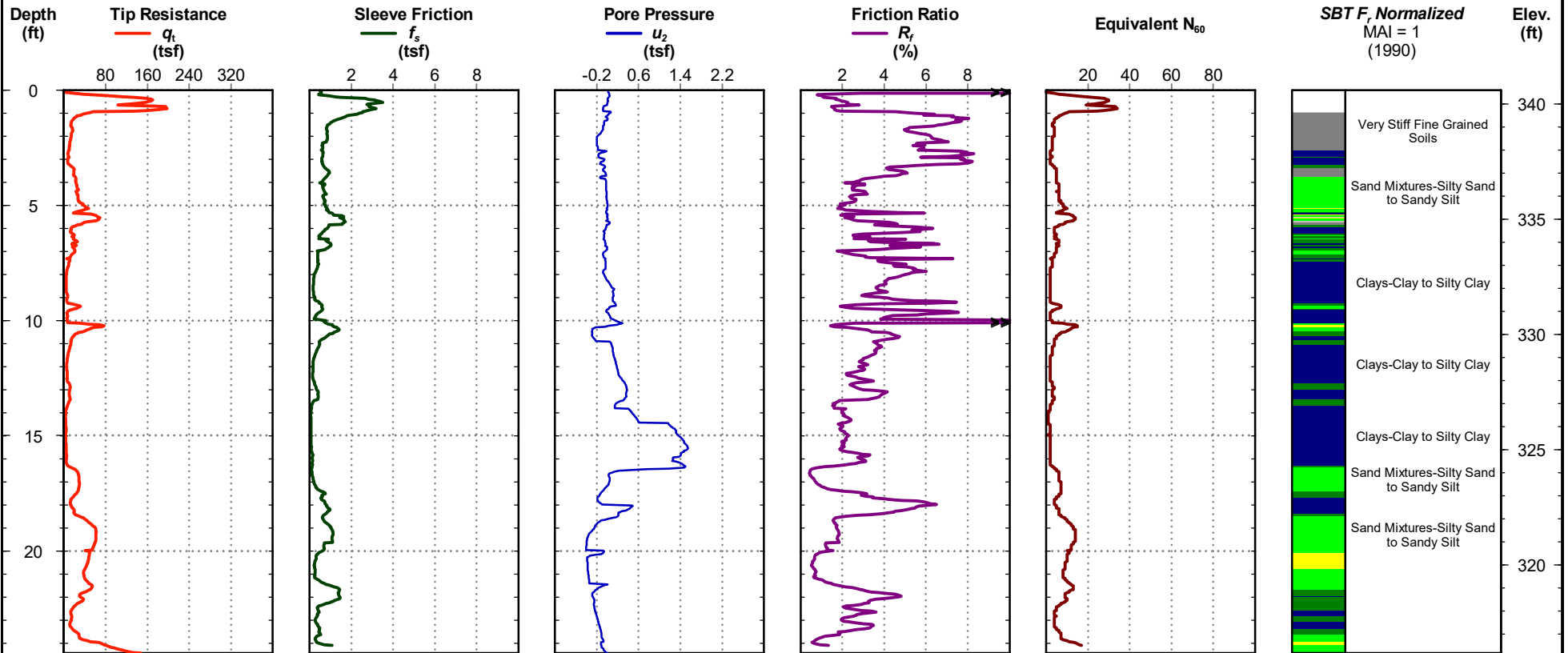
# Cone Penetration Test

CPT-4/B-12

Date: Aug. 10, 2022  
Estimated Water Depth: 7.3 ft  
Rig/Operator: C Piercy

Station: 30+35.10  
Offset: 4.7319  
Elevation: 340.6 ft-MSL

Total Depth: 24.4 ft  
Termination Criteria: Maximum Reaction Force  
CPT Probe ID: DDG1329



CPT-4/B-12





## **Appendix B. Subsurface Investigation**

### **Multichannel Analysis of Surface Waves (MASW)**



August 19, 2022

Ms. Lila Leon, P.E., PhD  
South Carolina Geotechnical Lead  
HDR  
1201 Main Street Suite 800  
Columbia, South Carolina 29201

Re: Report of Multi-Channel Analysis of Surface Waves  
S-12-53 Replacement Bridge over Little Rocky Creek  
Chester County, South Carolina  
F&ME Project No.: G6656.002Rev1

Dear Ms. Leon:

On August 9th, 2022, F&ME Consultants performed one (1) Multi-Channel Analysis of Surface Waves (MASW) test near the S-53 bridge over Little Rocky Creek to determine the average shear wave velocity to a depth of 100 feet at the location. A 16-channel Geometrics ES-3000 seismograph with 4.5 Hz geophones was used for data collection. Active and Passive survey data was obtained using a 225-foot linear array with 16 geophones spaced at 15 feet.

A 16-pound sledge hammer striking an aluminum block and a polyethylene block were used as the energy source for the active survey. Six (6) active shots were performed at various distances (25, 50 and 75 feet) off the array ends. Resultant vibrations were recorded with a sample rate of 0.5 milliseconds and a recording length of 2 seconds after each hammer blow. The data was stacked five times at each location to minimize the effect of unknown ambient vibrations commonly referred to as noise. The stacking process increases the signal to noise ratio.

The passive survey consisted of the collection of ambient background vibrations, which consisted of drilling equipment. Seventy-five (75) recordings with a record length of 32 seconds and a sample rate of 2 milliseconds were made during this phase of data acquisition.

Prior to departing the site, the data collected from both the passive and active surveys were reviewed and checked for variations from what would be typically expected from the prevailing area geology.

After completion of passive and active survey the data was processed and analyzed using Geometric's SeisImager software suite (Pickwin and WaveEq). This resulted in a one-dimensional subsurface shear wave velocity curve that is developed utilizing both the passive and active survey data. The data from the active survey defines the near surface shear wave velocities, while the passive survey data defines deeper shear wave velocities due to the lower frequencies. The resulting curve represents the average shear wave velocities below the surface arrays to a depth of 100 feet.





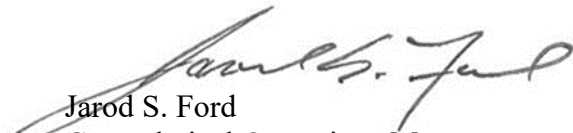
The resulting Shear Wave Velocity Curve, Vs100, for the location defined on Figure 1 of this report. The following table summarizes the average shear wave velocity (Vs100) at the aforementioned location.

Boring No.	Average Shear Wave Velocity (Vs100)
MASW-2	1389.3 ft/sec

It has been a pleasure working for you on this project and we appreciate the opportunity to be of service. Please contact us if you have any questions or concerns.

Sincerely,

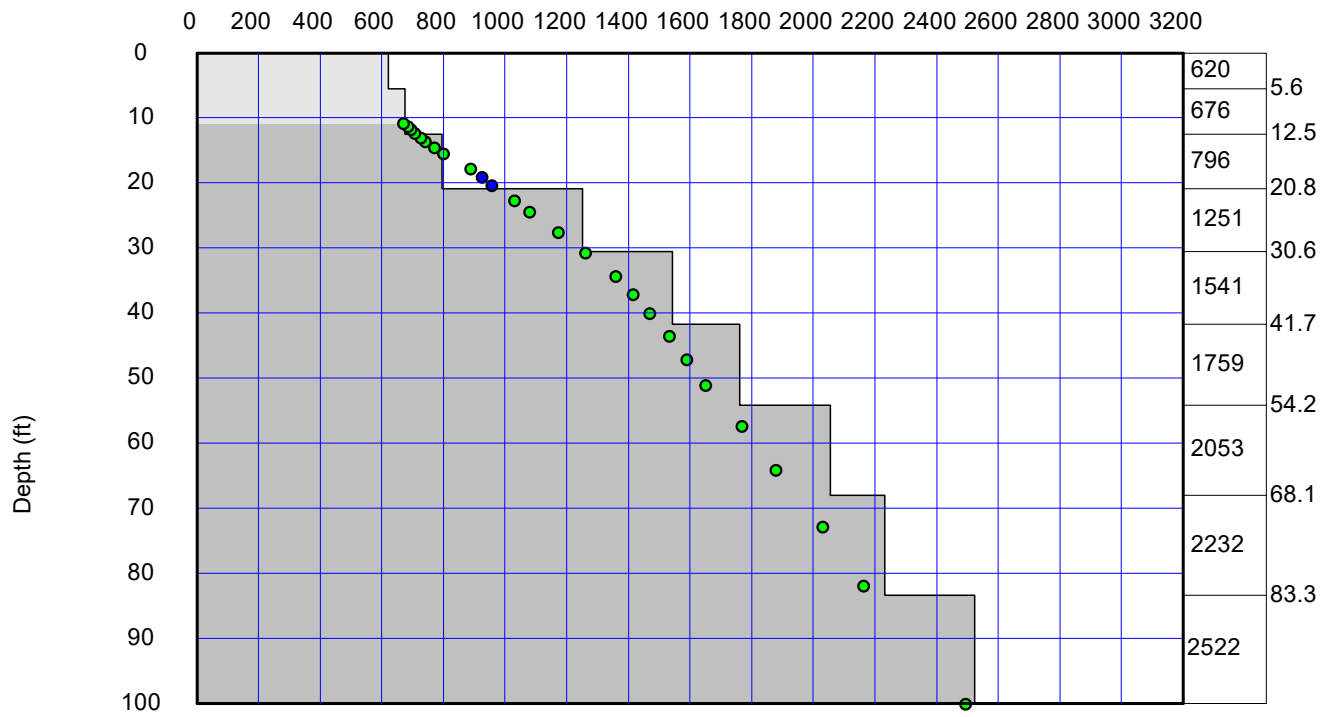
**F&ME CONSULTANTS**



Jarod S. Ford  
Geotechnical Operations Manager



# S-wave velocity (ft/s)



S-wave velocity model (inverted) : combo.rst

Average Vs 100ft = 1389.3 ft/sec





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F&ME CONSULTANTS, INC.  
COLUMBIA, SC

4			
3			
2			
1			
REV.	BY	DATE	DESCRIPTION OF REVISION
TOPO.		DATE	
DWG.	CTC	DATE 8.17.22	GROUP ____ - ____
R/W		DATE	

S-53 REPLACEMENT BRIDGE OVER LITTLE ROCKY CREEK  
CHESTER, SOUTH CAROLINA

MASW LOCATION PLAN

F&ME JOB NO. G6656.002

SCALE: 1"=100'

FIGURE 1



## Appendix C. Laboratory Testing





# SUMMARY OF LABORATORY RESULTS

PAGE 1 OF 1

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-11	6.0	24	20	4	0.075	34	SC-SM	10.3			
B-11	16.0	NP	NP	NP	0.075	82	ML	21.7			
B-12	4.0	40	21	19	0.075	42	SC	16.7			
B-12	8.0	28	20	8	0.075	37	SC	14.3			
B-12	15.0	27	18	9	0.075	68	CL	25.4			



# Rock Coring Summary

PAGE 1 OF 1



PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, 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-11	NQ-1	25.5	80	17	9520	0.15	1970	162	42	53
B-11	NQ-2	30.5	83	22	11570	0.13	1820	164	42	63
B-12	NQ-1	51.4	68	0						23
B-12	NQ-2.1	56.4	83	30	6030	0.12	6760	159	44	28
B-12	NQ-2.2	56.4	83	30	4920	0.13	4310	159	44	28
B-12	NQ-3	61.4	75	1						28





# INDEX PROPERTIES VERSUS DEPTH

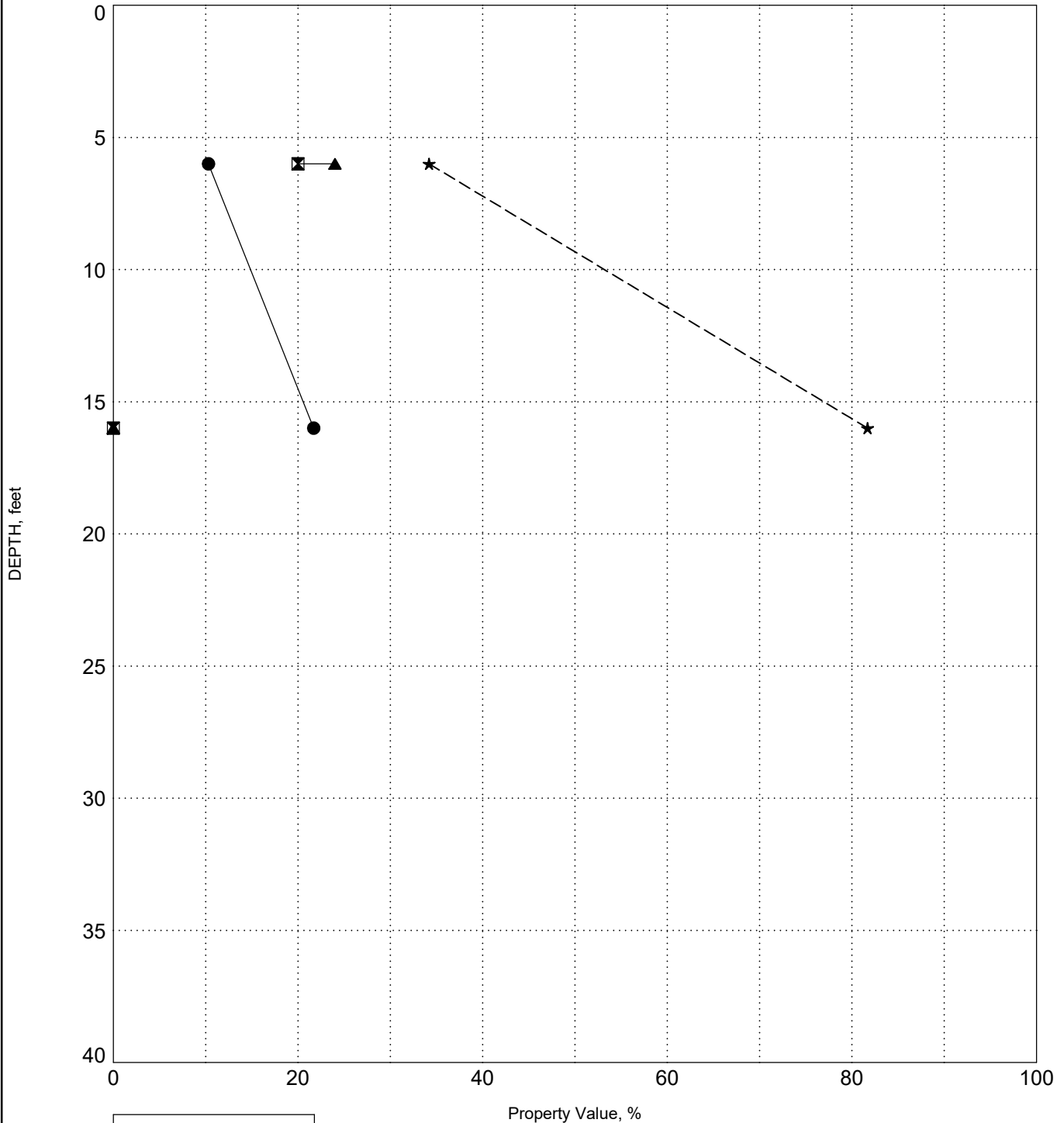
PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC

SURFACE ELEVATION: 342.2

## BORING B-11



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





# INDEX PROPERTIES VERSUS DEPTH

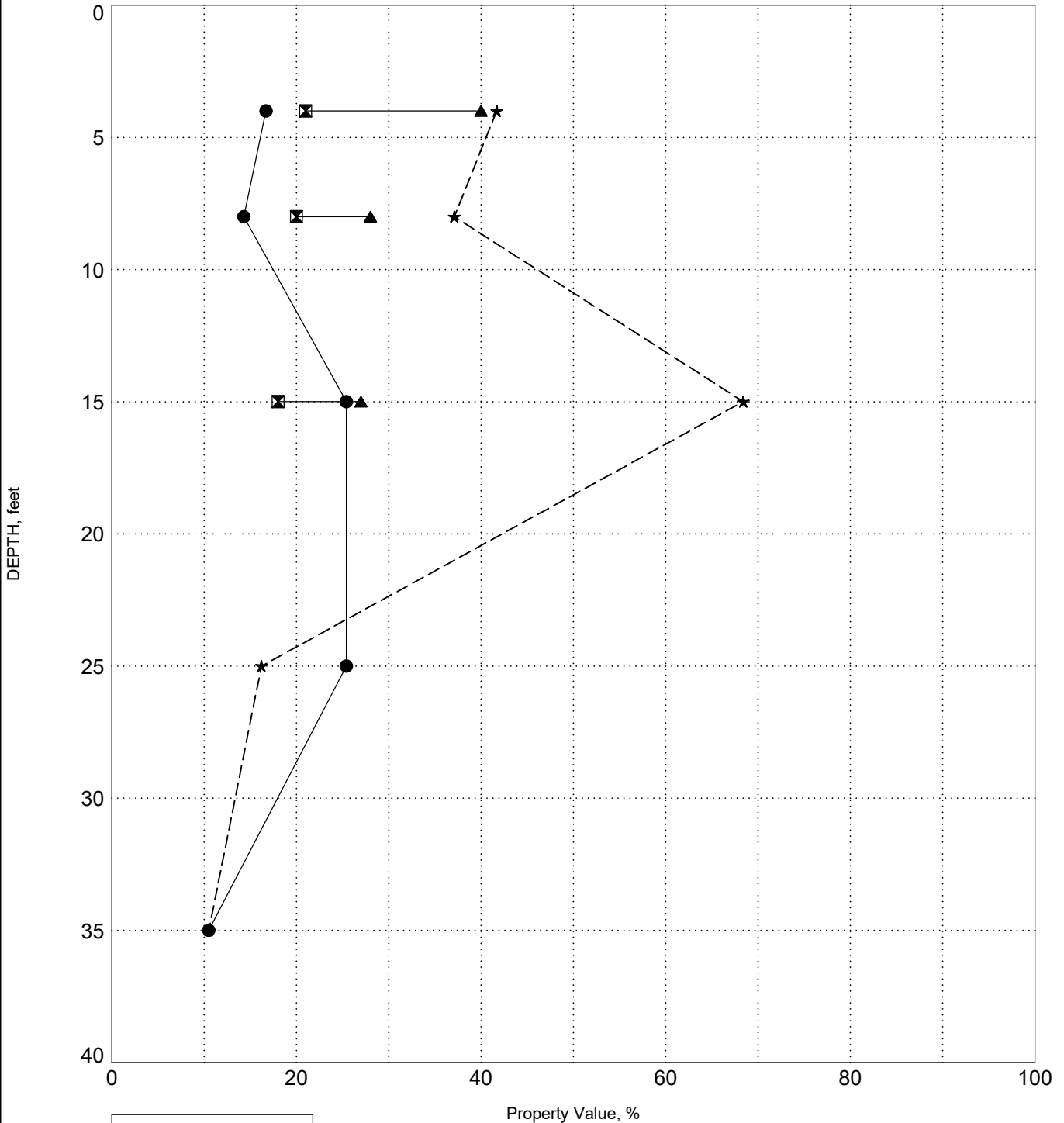
PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC

SURFACE ELEVATION: 340.6

## BORING B-12



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**

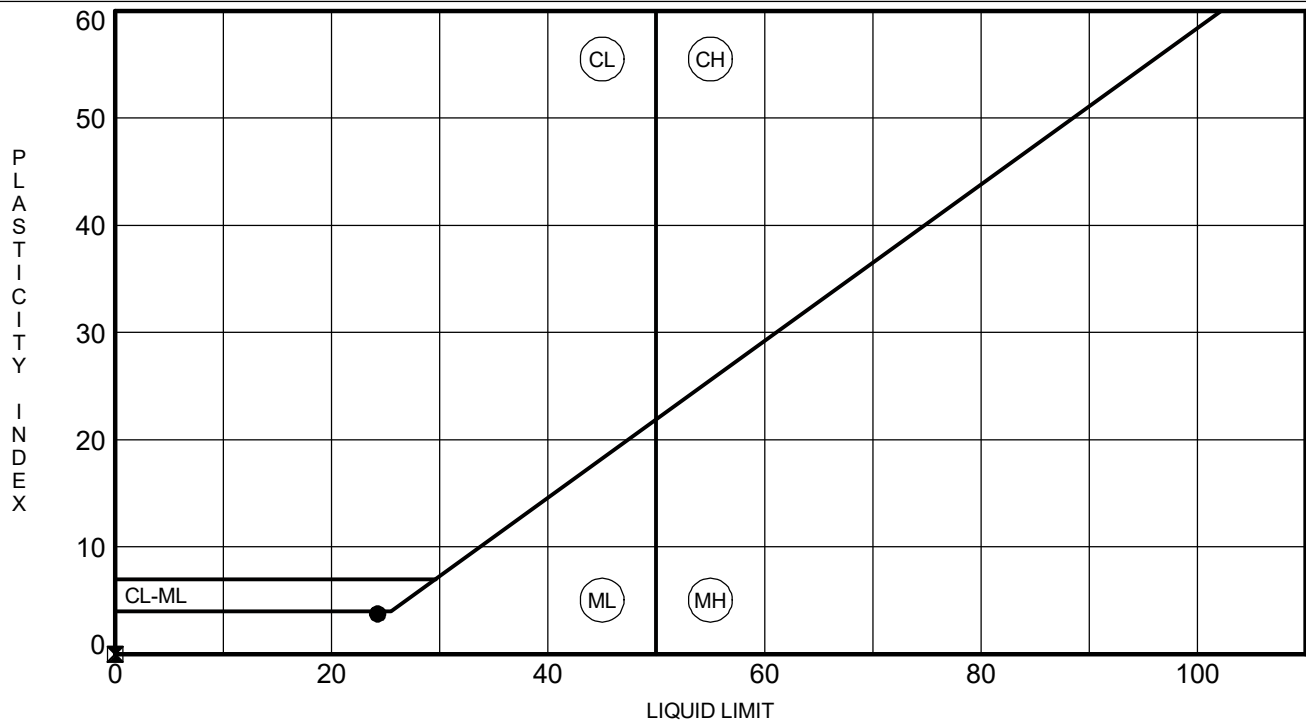


## ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041153

**PROJECT NAME** S-12-53 (Ross Dye Rd.) over Little Rocky Creek

**PROJECT COUNTY** Chester, SC

[illegible]



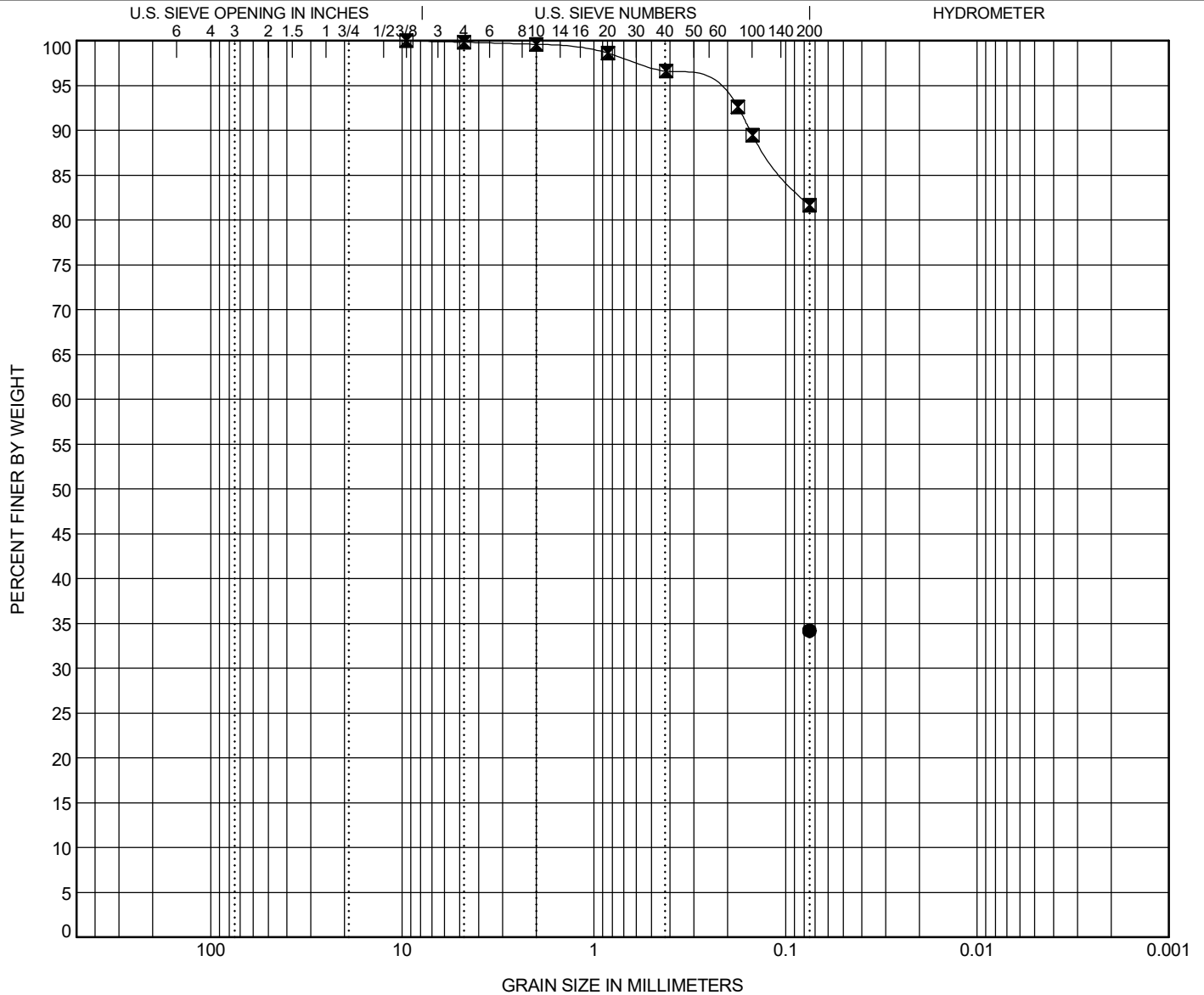


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC





# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-12-53 (Ross Dye Rd.) over Little Rocky Creek **SCDOT PROJECT ID:** P041153  
**SAMPLE NUMBER:** 22-2325 **DATE SAMPLE RECEIVED:** 8/8/2022  
**DESCRIPTION OF SOIL:** Various  
**TESTED BY:** CM **DATE SETUP:** 8/8/2022  
**WEIGHED BY:** AP **DATE OF WEIGHING:** 8/9/2022

BORING NO.	B-11	B-11			
SAMPLE NO.	SS-3	SS-8			
SAMPLE DEPTH (FT.)	4.0 - 6.0	14.0 - 16.0			
WATER CONTENT, W%	10.3	21.7			

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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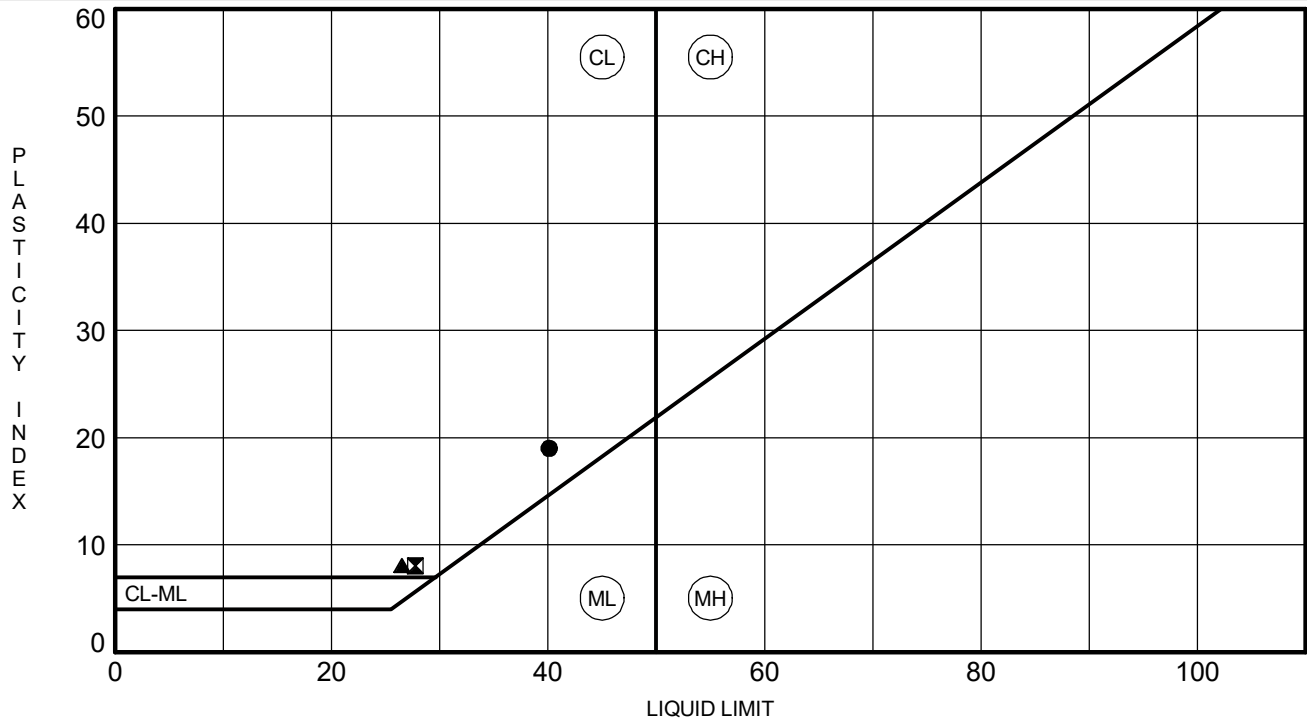


# ATTERBERG LIMITS' RESULTS

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC



ATTERBERG LIMITS G6656.002 - S-12-53 RBO ROCKY CREEK.GPJ SCDOT DATA TEMPLATE 01\_30\_2015.GDT 8/12/22



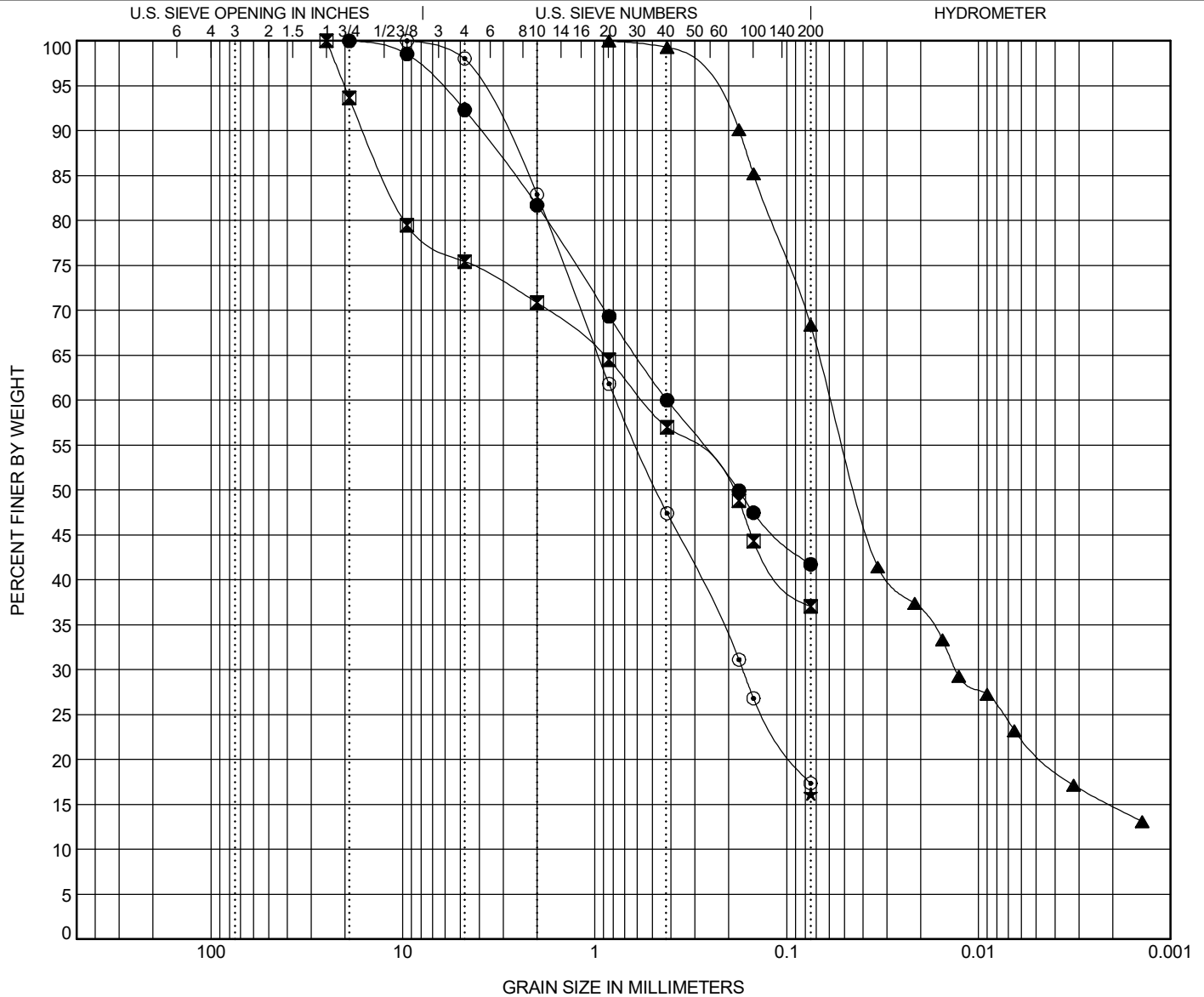


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC





# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-12-53 (Ross Dye Rd.) over Little Rocky Creek **SCDOT PROJECT ID:** P041153  
**SAMPLE NUMBER:** 22-2325 **DATE SAMPLE RECEIVED:** 8/8/2022  
**DESCRIPTION OF SOIL:** Various  
**TESTED BY:** CM **DATE SETUP:** 8/8/2022  
**WEIGHED BY:** AP **DATE OF WEIGHING:** 8/9/2022

BORING NO.	B-12	B-12	B-12	B-12	B-12
SAMPLE NO.	SS-2	SS-4	SS-6	SS-8	SS-10
SAMPLE DEPTH (FT.)	2.0 - 4.0	6.0 - 8.0	13.5 - 15.0	23.5 - 25.0	33.5 - 35.0
WATER CONTENT, W%	16.7	14.3	25.4	25.4	10.5

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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3112 Devine St., Columbia, SC 29205





Client:	F&ME Consultants
Project Name:	S-12-53 Bridge Replacement
Project Location:	Chester County, SC
GTX #:	316003
Test Date:	09/01/22
Tested By:	mgh
Checked By:	mcm

## pH by AASHTO T 289

Boring ID	Sample ID	Depth, ft	Description	pH
B-12	---	33.5-49.9	Moist, brown silty sand	7.1

Notes:





Client:	F&ME Consultants
Project:	S-12-53 Bridge Replacement
Location:	Chester County, SC
GTX#:	316003
Test Date:	09/01/22
Tested By:	mgh
Checked By:	mcm

## Minimum Laboratory Soil Resistivity by AASHTO T 288

Boring ID	Sample ID	Depth, ft.	Sample Description	Minimum Soil Resistivity, ohm-cm
B-12	---	33.5-49.9	Moist, brown silty sand	28,542

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-A2210532  
Report Date 01 September 2022  
Date Sampled 26 August 2022  
Date Received 30 August 2022  
Where Sampled Atlanta, GA USA  
Sampled By Client

This is to attest that we have examined: Soil: Project: S-12-53 Bridge Replacement over Little Rocky Creek; Site Location: - — -; Job Number: GTX-316003

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>	
- - -		< 10.	< 0.0010	10.
B-12	33.5 – 49.9'			

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>	
- - -		16.	0.0016	10.
B-12	33.5 – 49.9'			

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**

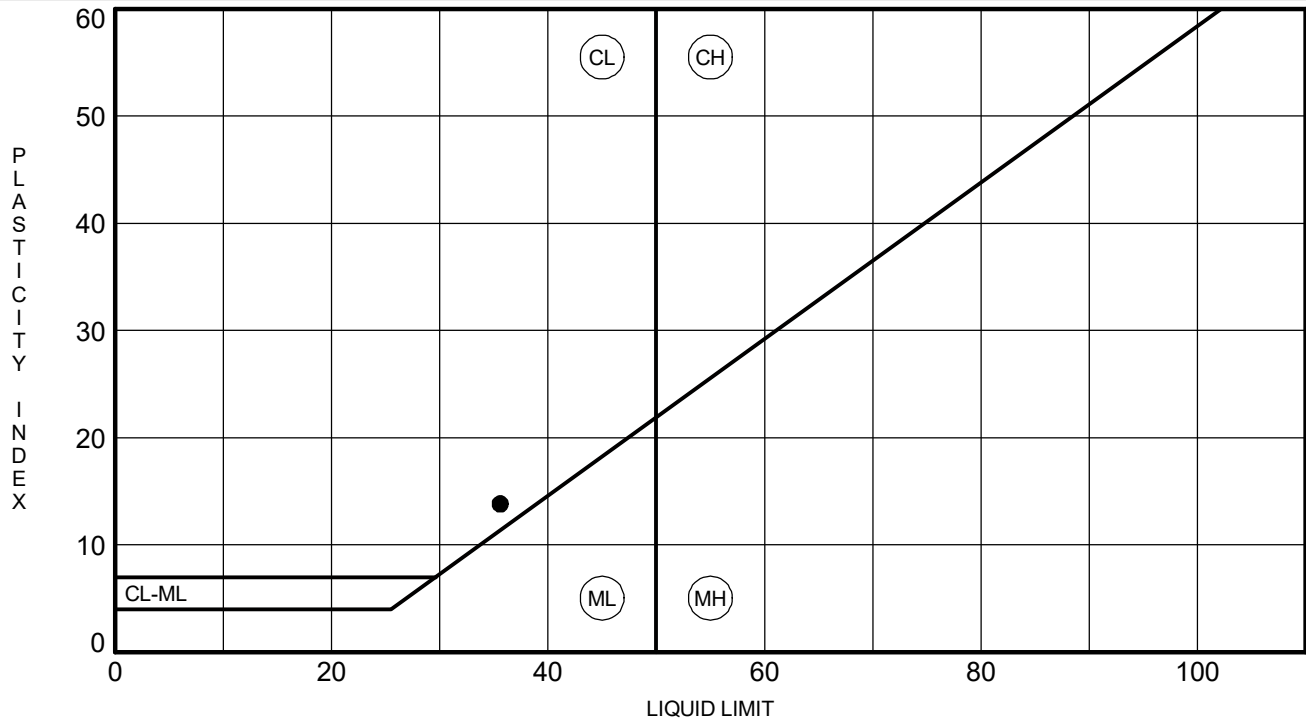


## ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041153

**PROJECT NAME** S-12-53 (Ross Dye Rd.) over Little Rocky Creek

**PROJECT COUNTY** Chester, SC

[illegible]



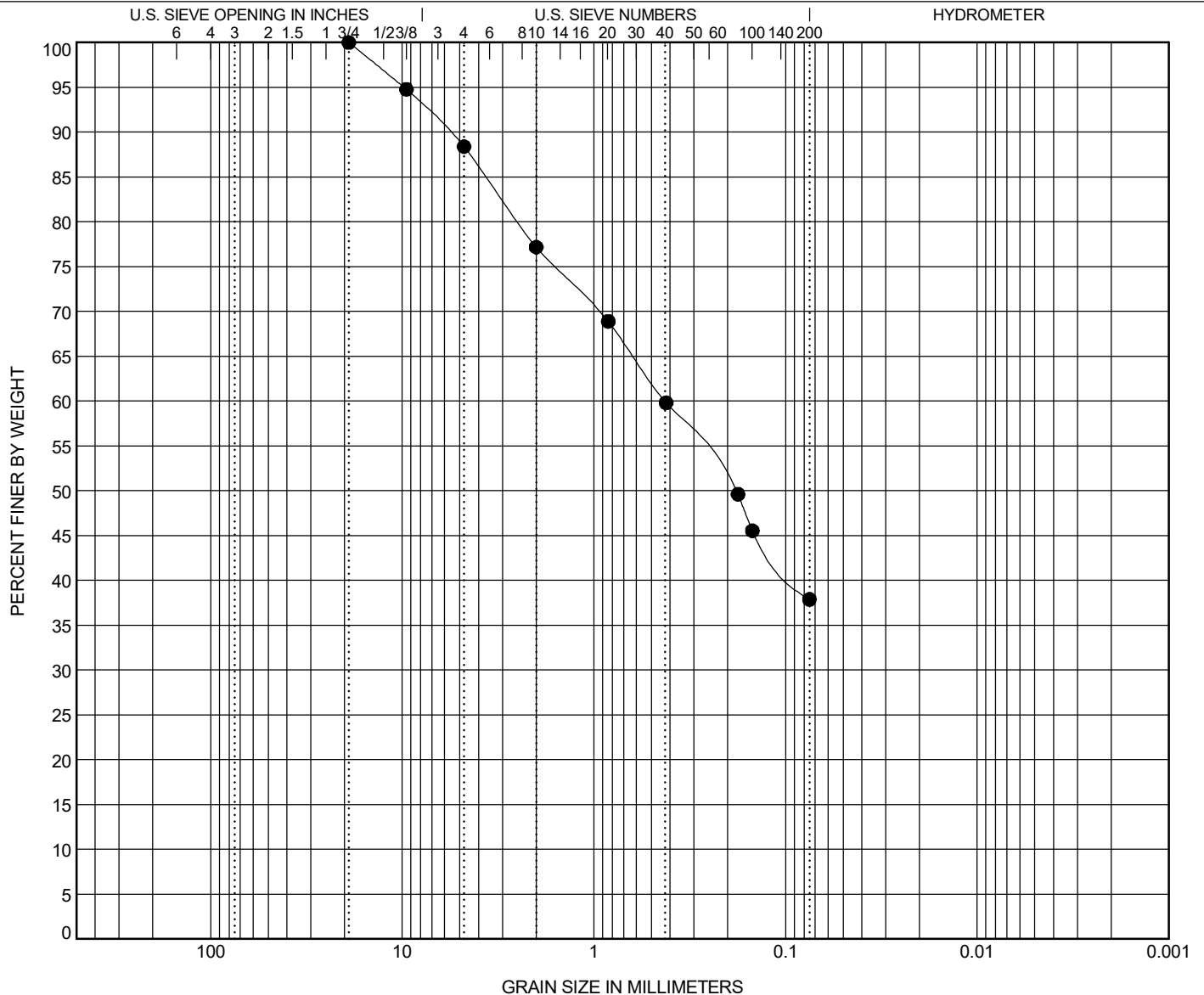


# GRAIN SIZE DISTRIBUTION

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● BS-5	5.0	CLAYEY SAND (SC/A-6)					36	22	14		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BS-5	5.0	19	0.426			11.6	50.5	37.9			



# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION (AASHTO T265)

**PROJECT:** S-12-53 (Ross Dye Rd.) over Little Rocky Creek **SCDOT PROJECT ID:** P041153  
**SAMPLE NUMBER:** 22-2329 **DATE SAMPLE RECEIVED:** 8/8/2022  
**DESCRIPTION OF SOIL:** Clayey SAND (SC/A-6)  
**TESTED BY:** CM **DATE SETUP:** 8/8/2022  
**WEIGHED BY:** AP **DATE OF WEIGHING:** 8/9/2022

BORING NO.	BS-5				
SAMPLE NO.	--				
SAMPLE DEPTH (FT.)	0.0 - 5.0				
WATER CONTENT, W%	14.1				

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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3112 Devine St., Columbia, SC 29205



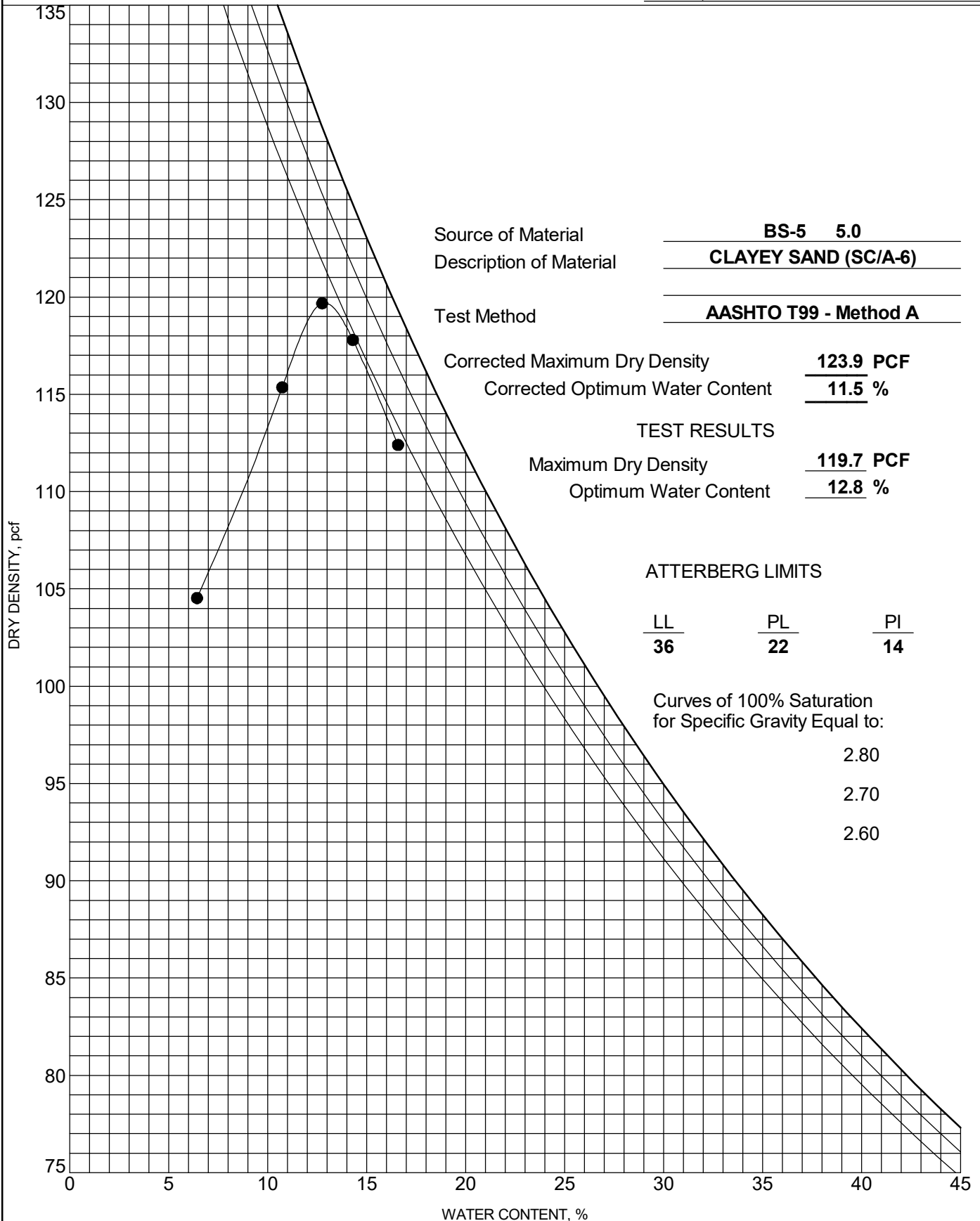


# MOISTURE-DENSITY RELATIONSHIP

PROJECT ID P041153

PROJECT NAME S-12-53 (Ross Dye Rd.) over Little Rocky Creek

PROJECT COUNTY Chester, SC







Client: F&ME Consultants

Project Name: S-12-53 Bridge Replacement

Project Location: Chester County, SC.

Project Number: GTX: 316003

Tested By: jm

Checked By: mcm

Boring ID: BS-5

Preparation: reconstituted

Description: Moist, pale olive clayey sand

Classification: ---

Group Symbol: ---

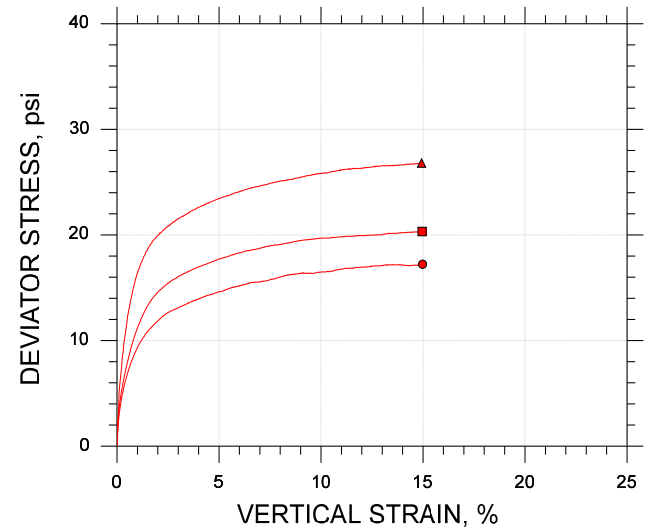
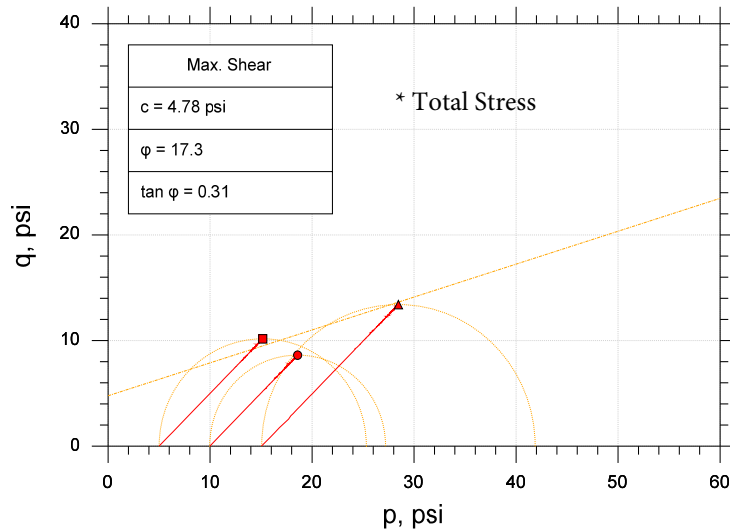
Liquid Limit: ---

Plastic Limit: ---

Plasticity Index: ---

Estimated Specific Gravity: 2.7

## CONSOLIDATED UNDRAINED TRIAXIAL TEST by AASHTO T297



Symbol	■	●	▲	
Sample ID	---	---	---	
Depth, ft	0-5 ft	0-5 ft	0-5 ft	
Test Number	CU-1-1	CU-1-2	CU-1-3	
Initial	Height, in	4.100	4.070	4.110
	Diameter, in	2.020	2.020	2.010
	Moisture Content (from Cuttings), %	12.6	12.4	12.3
	Dry Density, pcf	114.	114.	113.
	Saturation (Wet Method), %	70.2	70.8	68.7
	Void Ratio	0.483	0.475	0.485
Before Shear	Moisture Content, %	17.5	16.6	16.9
	Dry Density, pcf	114.	116.	116.
	Cross-sectional Area (Method A), in <sup>2</sup>	3.191	3.166	3.132
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.474	0.450	0.457
	Back Pressure, psi	134.7	134.9	128.9
Vertical Effective Consolidation Stress, psi		5.016	9.967	15.04
Horizontal Effective Consolidation Stress, psi		5.003	9.970	15.04
Vertical Strain after Consolidation, %		0.07999	0.2498	0.4895
Volumetric Strain after Consolidation, %		0.2849	0.9323	1.522
Time to 50% Consolidation, min		---	---	4.410
Shear Strength, psi		10.16	8.614	13.40
Strain at Failure, %		15.0	15.0	14.9
Strain Rate, %/min		0.06000	0.06000	0.06000
Deviator Stress at Failure, psi		20.33	17.23	26.80
Effective Minor Principal Stress at Failure, psi		9.433	8.577	13.15
Effective Major Principal Stress at Failure, psi		29.76	25.80	39.95
B-Value		0.95	0.96	0.96
Notes: - Before Shear Saturation set to 100% for phase calculation. - Moisture Content determined by ASTM D2216. - 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.				
Remarks:				

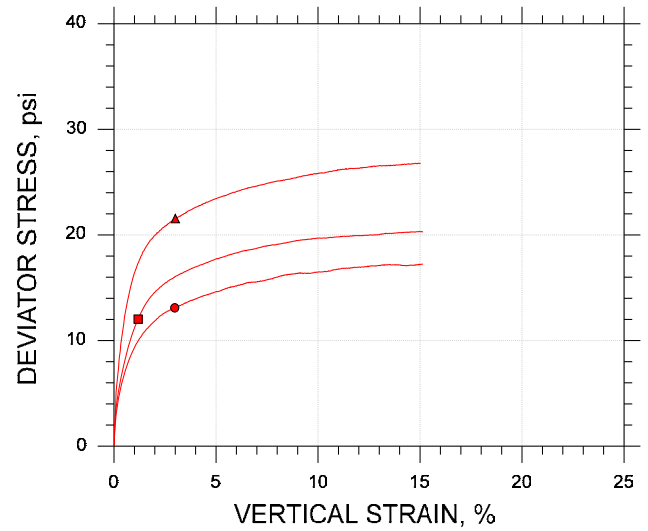
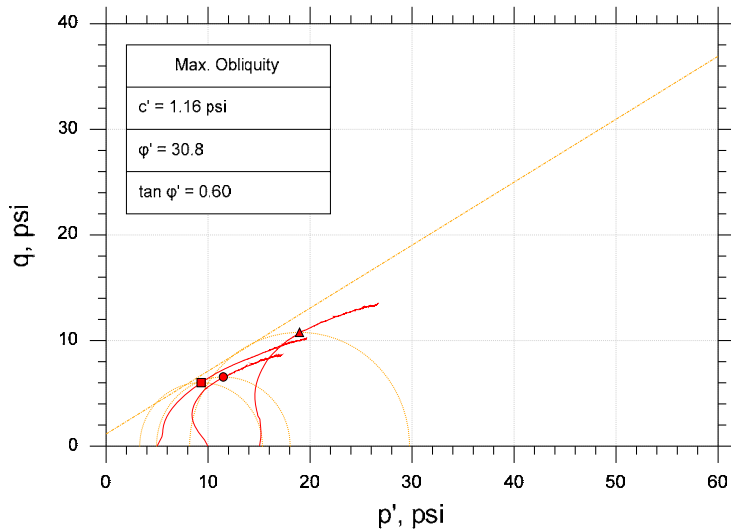
Target Compaction: 95% of (119.7 pcf) at Optimum Moisture Content (12.8%) +/- 2% - Values Provided by Client





Client: F&ME Consultants	
Project Name: S-12-53 Bridge Replacement	
Project Location: Chester County, SC.	
Project Number: GTX: 316003	
Tested By: jm	Checked By: mcm
Boring ID: BS-5	
Preparation: reconstituted	
Description: Moist, pale olive clayey sand	
Classification: ---	
Group Symbol: ---	
Liquid Limit: ---	Plastic Limit: ---
Plasticity Index: ---	Estimated Specific Gravity: 2.7


### CONSOLIDATED UNDRAINED TRIAXIAL TEST by AASHTO T297



Symbol	■	●	▲	
Sample ID	---	---	---	
Depth, ft	0-5 ft	0-5 ft	0-5 ft	
Test Number	CU-1-1	CU-1-2	CU-1-3	
Initial	Height, in	4.100	4.070	4.110
	Diameter, in	2.020	2.020	2.010
	Moisture Content (from Cuttings), %	12.6	12.4	12.3
	Dry Density, pcf	114.	114.	113.
	Saturation (Wet Method), %	70.2	70.8	68.7
	Void Ratio	0.483	0.475	0.485
Before Shear	Moisture Content, %	17.5	16.6	16.9
	Dry Density, pcf	114.	116.	116.
	Cross-sectional Area (Method A), in <sup>2</sup>	3.191	3.166	3.132
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.474	0.450	0.457
	Back Pressure, psi	134.7	134.9	128.9
Vertical Effective Consolidation Stress, psi		5.016	9.967	15.04
Horizontal Effective Consolidation Stress, psi		5.003	9.970	15.04
Vertical Strain after Consolidation, %		0.07999	0.2498	0.4895
Volumetric Strain after Consolidation, %		0.2849	0.9323	1.522
Time to 50% Consolidation, min		---	---	4.410
Shear Strength, psi		6.014	6.549	10.78
Strain at Failure, %		1.18	2.98	3.00
Strain Rate, %/min		0.06000	0.06000	0.06000
Deviator Stress at Failure, psi		12.03	13.10	21.56
Effective Minor Principal Stress at Failure, psi		3.295	4.940	8.186
Effective Major Principal Stress at Failure, psi		15.32	18.04	29.74
B-Value		0.95	0.96	0.96
Notes: - Before Shear Saturation set to 100% for phase calculation. - Moisture Content determined by ASTM D2216. - 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.				
Remarks:				

Target Compaction: 95% of (119.7 pcf) at Optimum Moisture Content (12.8%) +/- 2% - Values Provided by Client



			
	Project: S-12-53 Bridge Replacement	Location: Chester County, SC.	Project No.: GTX- 316003
	Boring No.: BS-5	Sample Type: reconstituted	
	Description: Moist, pale olive clayey sand		
	Remarks: Target Compaction: 95% of (119.7 pcf) at Optimum Moisture Content (12.8%) +/- 2% - Values Provided by Client		





## **Appendix C. Laboratory Testing**

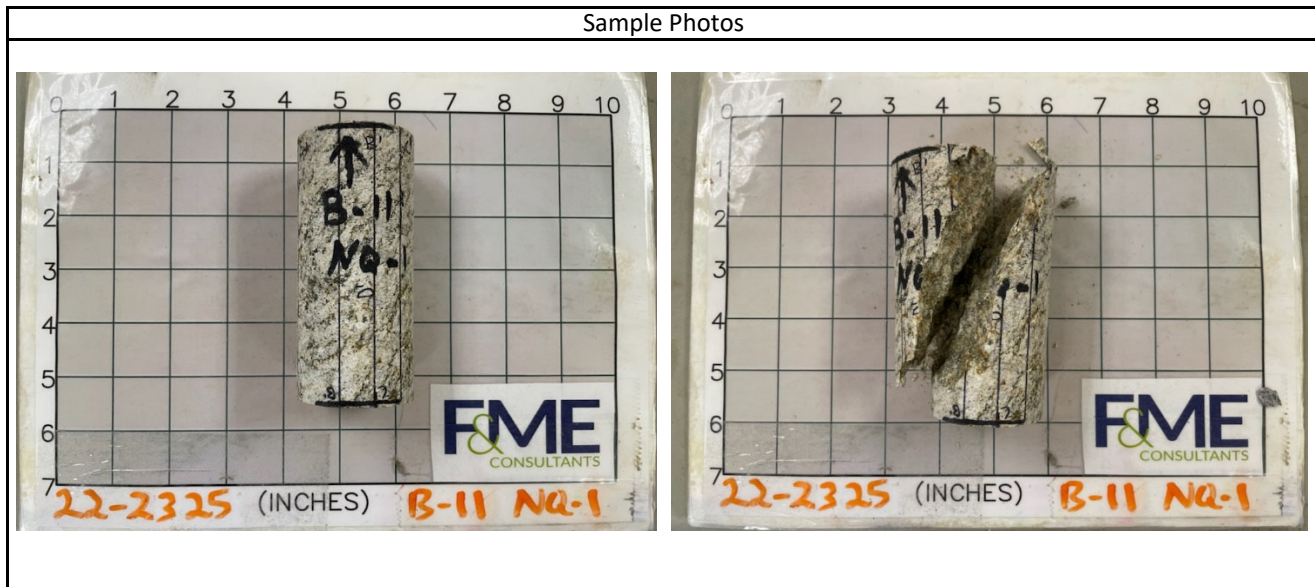
### **Rock Cores**



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

Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.865	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.289	Reviewed By	WJG
Boring	B-11	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-1 / 22-2325A	L/D Ratio	2.30	Recovery	80%
Depth	26.0' - 26.3'	Load Rate (psi/sec)	20	RQD	17%
Description	Black/White/Gray Metadiorite				

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%	-1257	79	2,612	956	1.52	0.06
20%	-2235	198	5,200	1,904	1.70	0.09
30%	-3134	362	7,820	2,863	1.83	0.12
40%	-3909	541	10,410	3,811	1.95	0.14
50%	-4647	766	13,003	4,760	2.05	0.16
60%	-5330	1037	15,570	5,700	2.14	0.19
70%	-6035	1414	18,201	6,663	2.21	0.23
80%	-6723	1941	20,817	7,620	2.27	0.29
90%	-7443	2946	23,440	8,581	2.31	0.40
100%	-8809	5945	26,004	9,519		

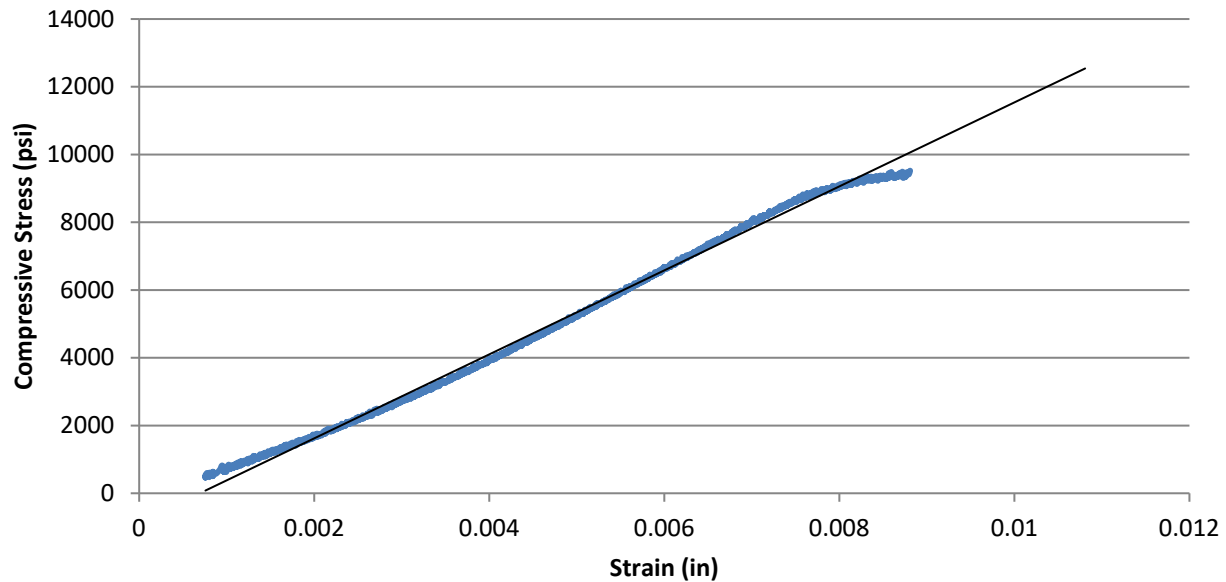


Test Results			
Unconfined Compressive Strength (psi)	<b>9,520</b>	Elastic Modulus (psi)	1.97E+06
		Poisson's Ratio in Elastic Range	0.15
Comments	Elastic range was taken as between 0.002 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

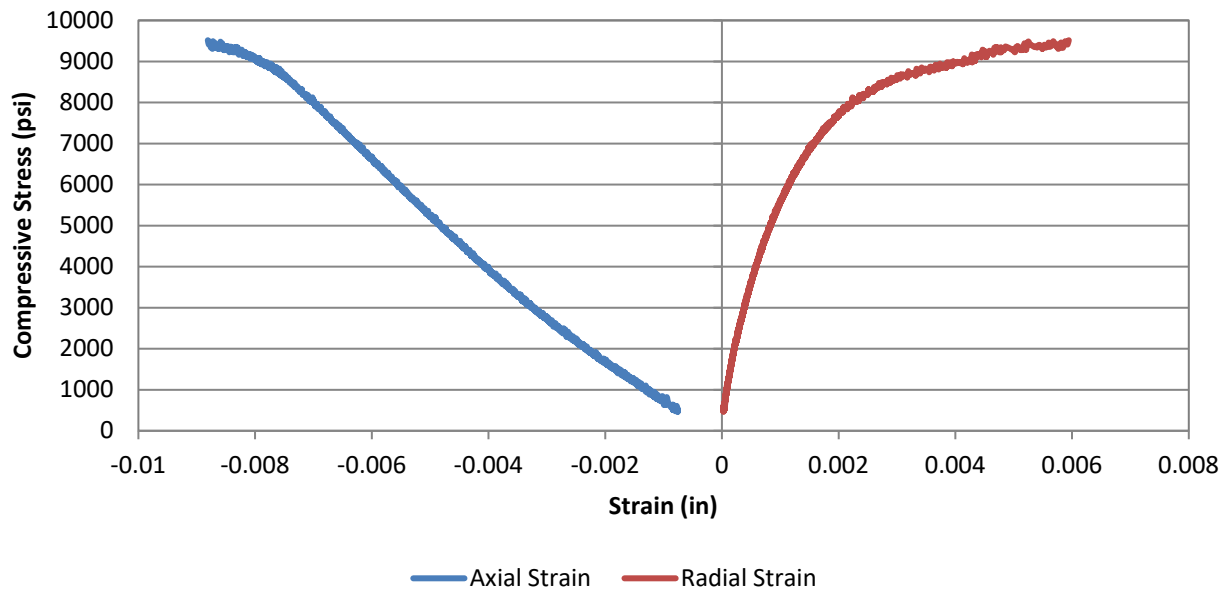


Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.865	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.289	Reviewed By	WJG
Boring	B-11	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-1 / 22-2325A	L/D Ratio	2.30	Recovery	80%
Depth	26.0' - 26.3'	Load Rate (psi/sec)	20	RQD	17%
Description	Black/White/Gray Metadiorite				

**Axial Stress vs. Strain**



**Stress vs. Strain**

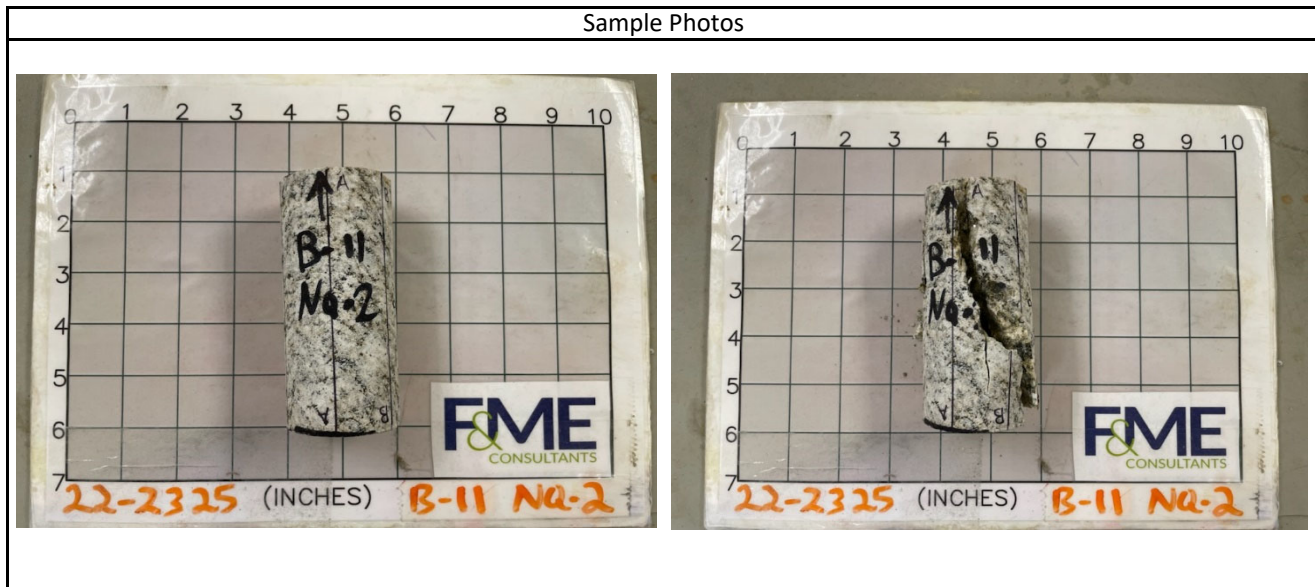




Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.863	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.238	Reviewed By	WJG
Boring	B-11	Unit Weight (pcf)	163.5	Core Size	NQ
Sample No.	NQ-2 / 22-2325B	L/D Ratio	2.27	Recovery	83%
Depth	31.6' - 31.9'	Load Rate (psi/sec)	20	RQD	22%
Description	Black/White/Gray Metadiorite				

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%	-1786	125	3,148	1,155	1.29	0.07
20%	-3036	285	6,302	2,312	1.52	0.09
30%	-4043	468	9,469	3,474	1.72	0.12
40%	-4925	678	12,631	4,633	1.88	0.14
50%	-5699	919	15,736	5,773	2.03	0.16
60%	-6437	1213	18,913	6,938	2.16	0.19
70%	-7165	1594	22,043	8,087	2.26	0.22
80%	-7929	2138	25,229	9,255	2.33	0.27
90%	-8735	3002	28,318	10,388	2.38	0.34
100%	-7892	9344	31,532	11,567		

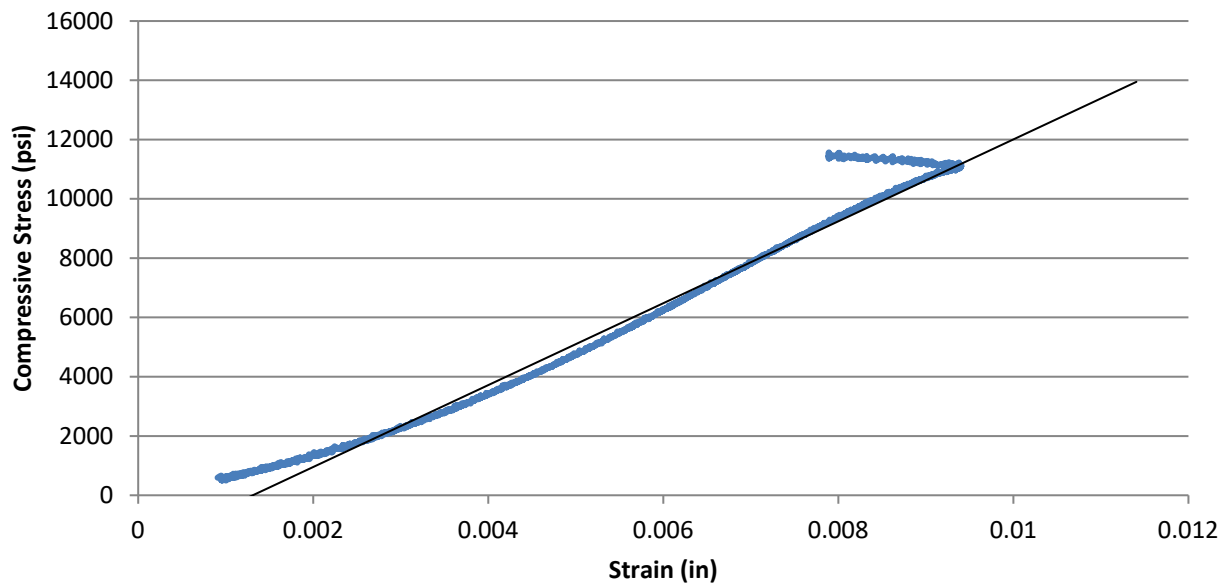


Test Results			
Unconfined Compressive Strength (psi)	<b>11,570</b>	Elastic Modulus (psi)	1.82E+06
		Poisson's Ratio in Elastic Range	0.13
Comments	Elastic range was taken as between 0.002 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

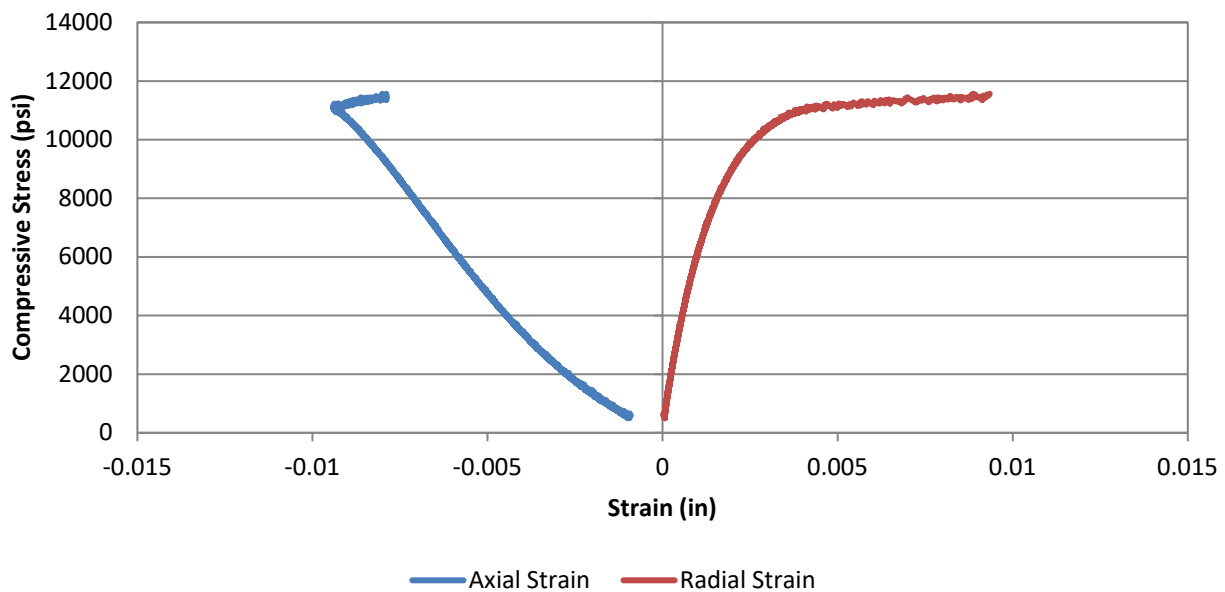


Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.863	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.238	Reviewed By	WJG
Boring	B-11	Unit Weight (pcf)	163.5	Core Size	NQ
Sample No.	NQ-2 / 22-2325B	L/D Ratio	2.27	Recovery	83%
Depth	31.6' - 31.9'	Load Rate (psi/sec)	20	RQD	22%
Description	Black/White/Gray Metadiorite				

**Axial Stress vs. Strain**



**Stress vs. Strain**

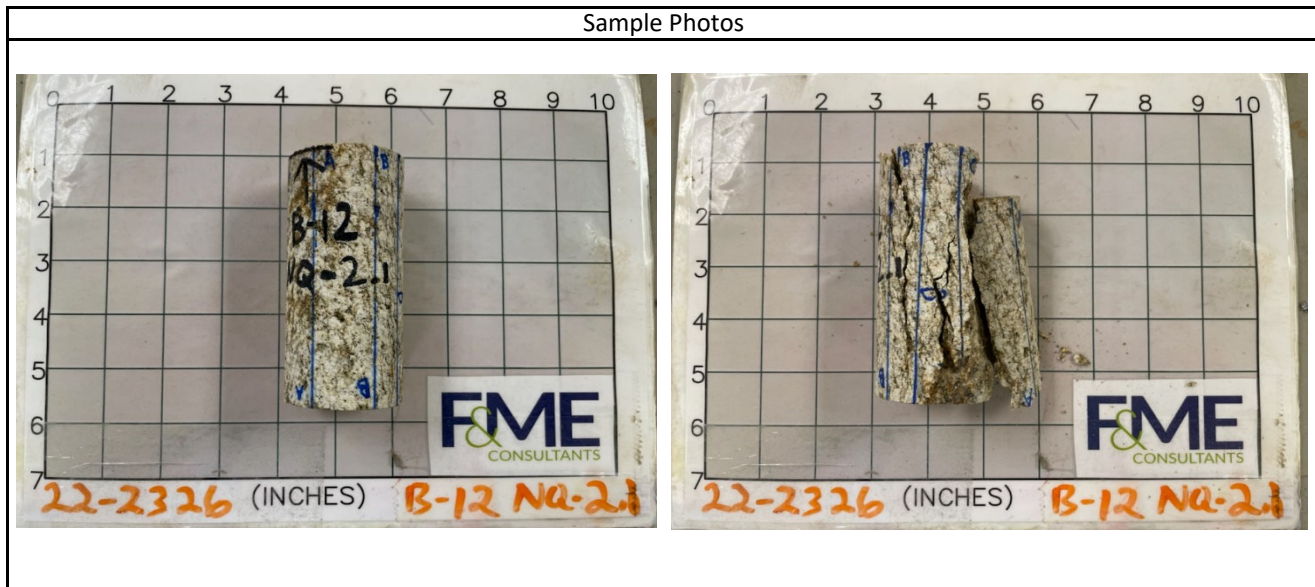




Compressive Strength and Elastic Moduli of Intact Rock Core Specimens  
ASTM D7012 - Method D / SC-T-39

Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.858	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.002	Reviewed By	WJG
Boring	B-12	Unit Weight (pcf)	159.1	Core Size	NQ
Sample No.	NQ-2.1 / 22-2326A	L/D Ratio	2.15	Recovery	83%
Depth	58.9' - 59.2'	Load Rate (psi/sec)	20	RQD	30%
Description	Black/White/Gray/Brown Metadiorite				

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%	-2695	10	1,627	600	0.45	0.00
20%	-4860	195	3,291	1,214	0.50	0.04
30%	-6431	493	4,987	1,839	0.57	0.08
40%	-7615	839	6,562	2,420	0.64	0.11
50%	-8667	1275	8,177	3,016	0.70	0.15
60%	-9573	1781	9,861	3,637	0.76	0.19
70%	-10372	2414	11,444	4,221	0.81	0.23
80%	-11056	3156	13,020	4,802	0.87	0.29
90%	-11802	4506	14,722	5,430	0.92	0.38
100%	-11647	8601	16,359	6,034		

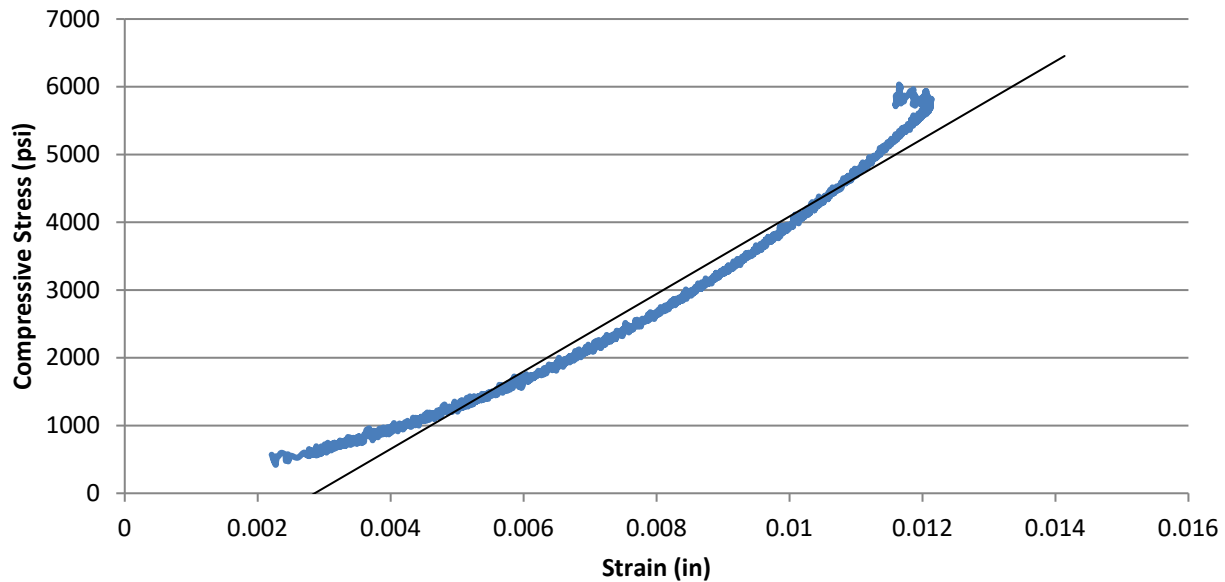


Test Results				
Unconfined Compressive Strength (psi)		6,030	Elastic Modulus (psi)	6.76E+05
			Poisson's Ratio in Elastic Range	0.12
Comments	Elastic range was taken as between 0.004 and 0.008 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.			

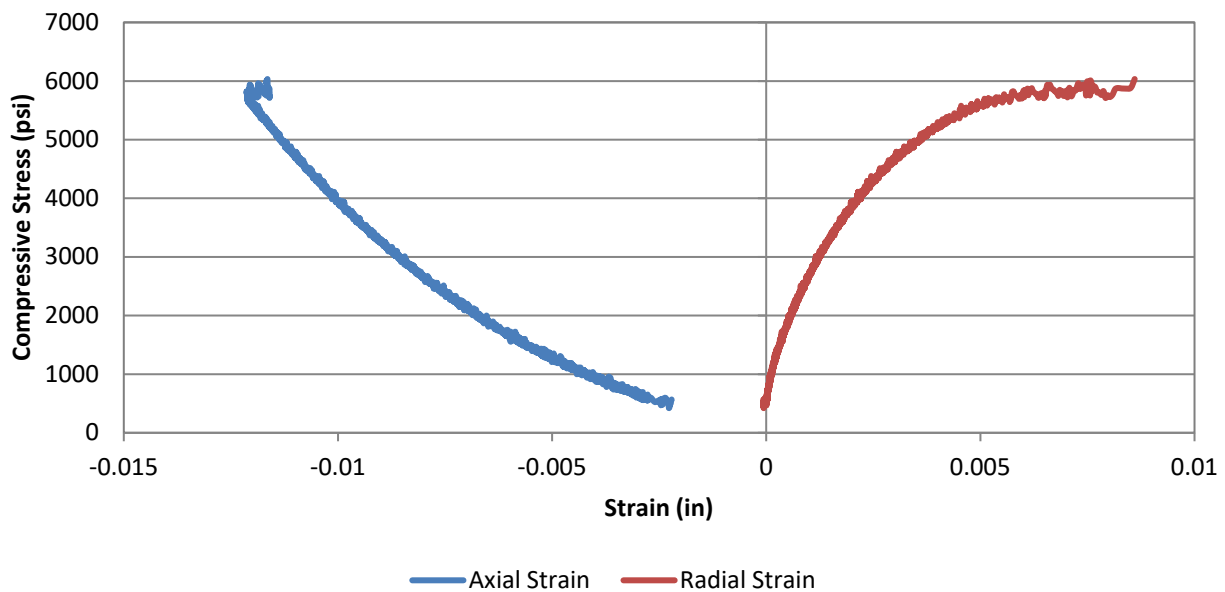


Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.858	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.002	Reviewed By	WJG
Boring	B-12	Unit Weight (pcf)	159.1	Core Size	NQ
Sample No.	NQ-2.1 / 22-2326A	L/D Ratio	2.15	Recovery	83%
Depth	58.9' - 59.2'	Load Rate (psi/sec)	20	RQD	30%
Description	Black/White/Gray/Brown Metadiorite				

**Axial Stress vs. Strain**



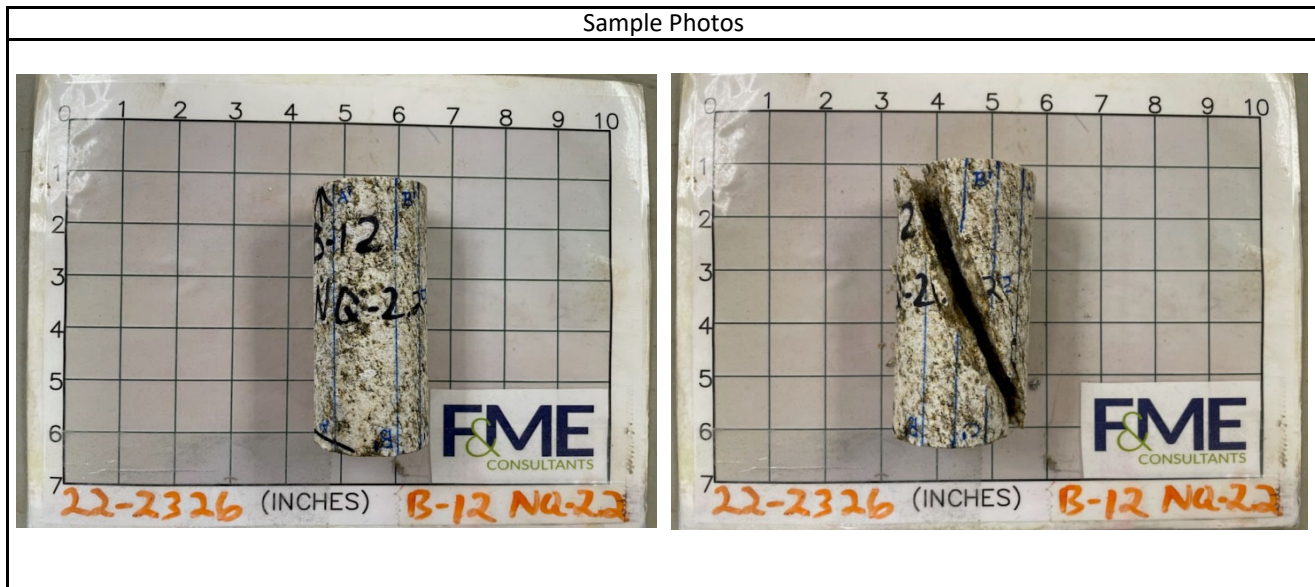
**Stress vs. Strain**





Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.866	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.347	Reviewed By	WJG
Boring	B-12	Unit Weight (pcf)	158.9	Core Size	NQ
Sample No.	NQ-2.2 / 22-2326B	L/D Ratio	2.33	Recovery	83%
Depth	60.7' - 61.0'	Load Rate (psi/sec)	20	RQD	30%
Description	Black/White/Gray/Brown Metadiorite				

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%	-3440	3	1,281	468	0.27	0.00
20%	-5893	252	2,648	968	0.33	0.04
30%	-7773	636	4,054	1,483	0.38	0.08
40%	-9244	1094	5,374	1,965	0.43	0.12
50%	-10521	1643	6,734	2,462	0.47	0.16
60%	-11744	2312	8,086	2,957	0.50	0.20
70%	-12707	2939	9,415	3,443	0.54	0.23
80%	-13734	3523	10,760	3,934	0.57	0.26
90%	-14755	4026	12,145	4,441	0.60	0.27
100%	-15562	4586	13,447	4,917		

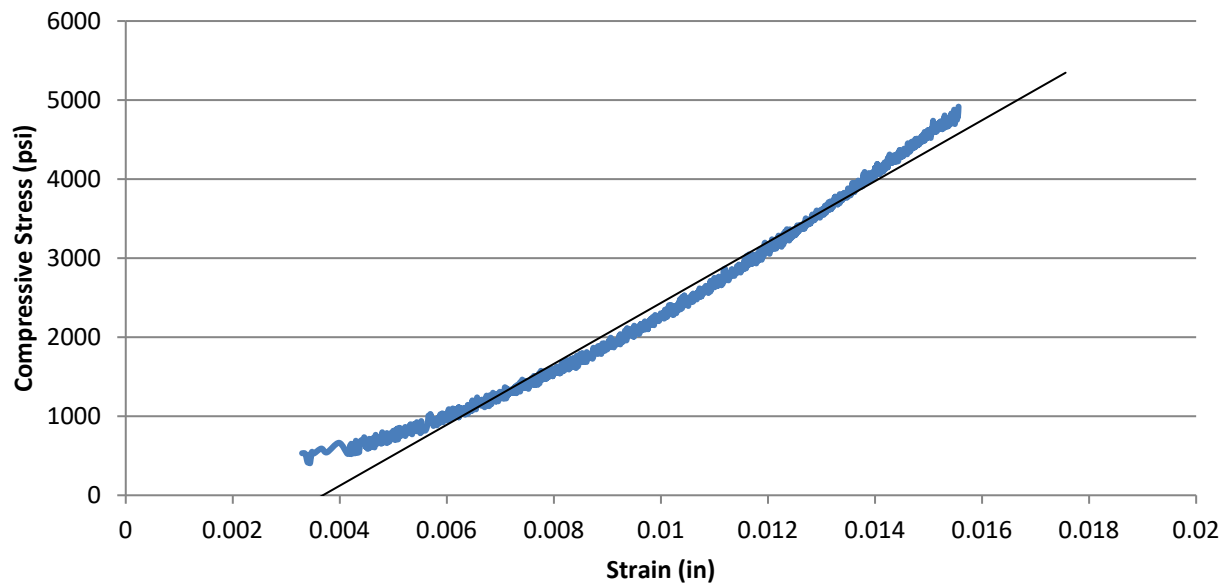


Test Results			
Unconfined Compressive Strength (psi)		4,920	Elastic Modulus (psi)
			4.31E+05
			Poisson's Ratio in Elastic Range
			0.13
Comments	Elastic range was taken as between 0.006 and 0.012 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

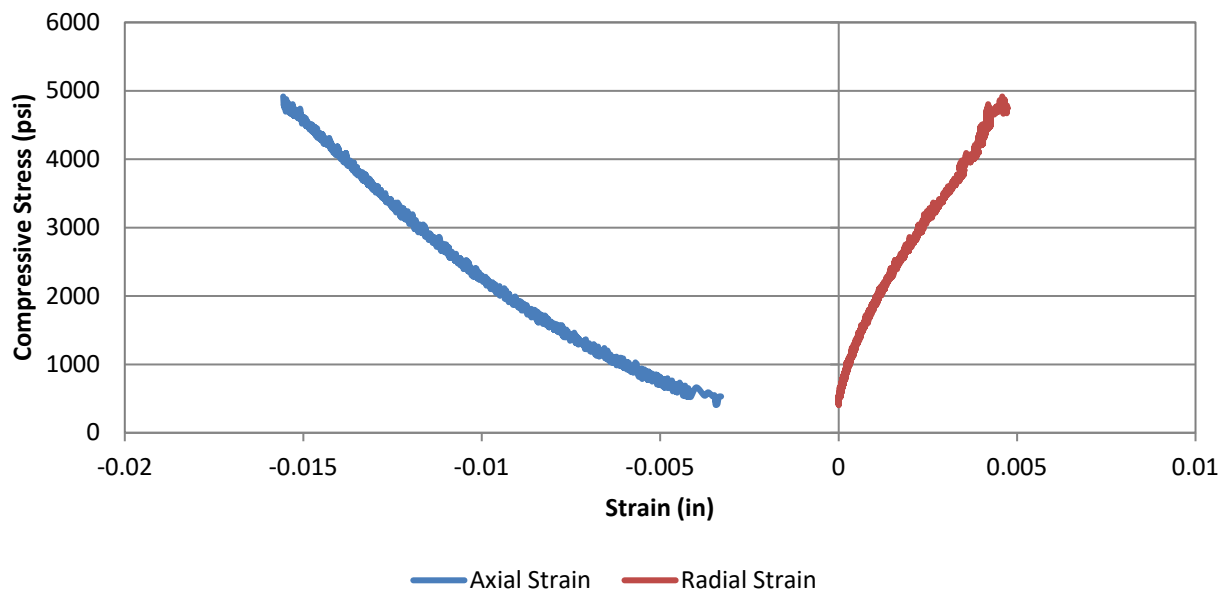


Project	S-53 RBO Little Rocky Creek			Date	8/26/2022
Project No.	G6656.002	Sample Diameter (in.)	1.866	Tested By	WAP
SCDOT ID	P041153	Sample Length (in.)	4.347	Reviewed By	WJG
Boring	B-12	Unit Weight (pcf)	158.9	Core Size	NQ
Sample No.	NQ-2.2 / 22-2326B	L/D Ratio	2.33	Recovery	83%
Depth	60.7' - 61.0'	Load Rate (psi/sec)	20	RQD	30%
Description	Black/White/Gray/Brown Metadiorite				

**Axial Stress vs. Strain**



**Stress vs. Strain**





# Appendix D. SPT Hammer Energy Calibration Report



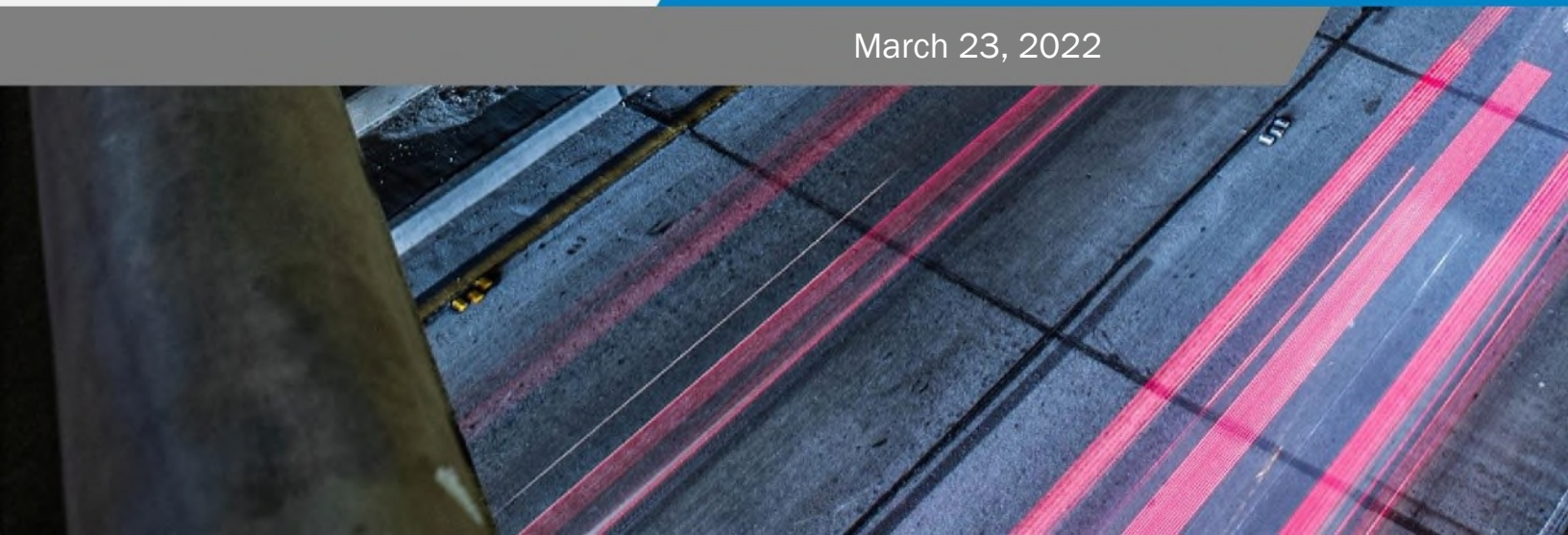


**CAROLINAS  
GEOTECHNICAL  
GROUP**

## **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

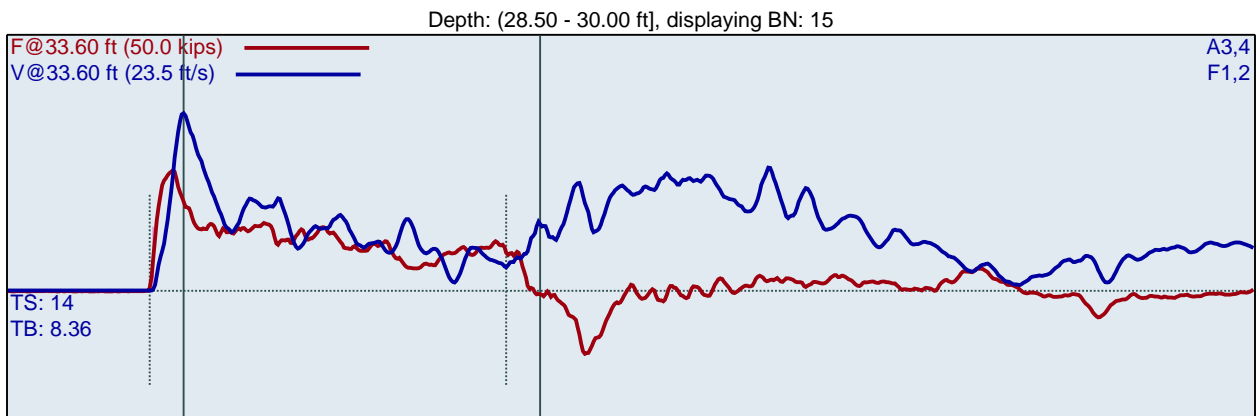


CME 45B (SN 303304)  
REK  
B-1

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.

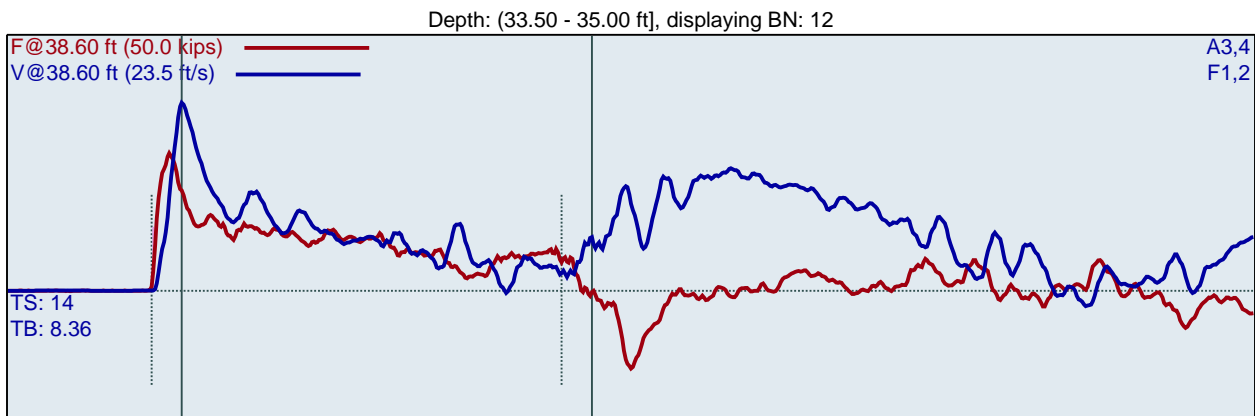


CME 45B (SN 303304)  
REK  
B-1

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.

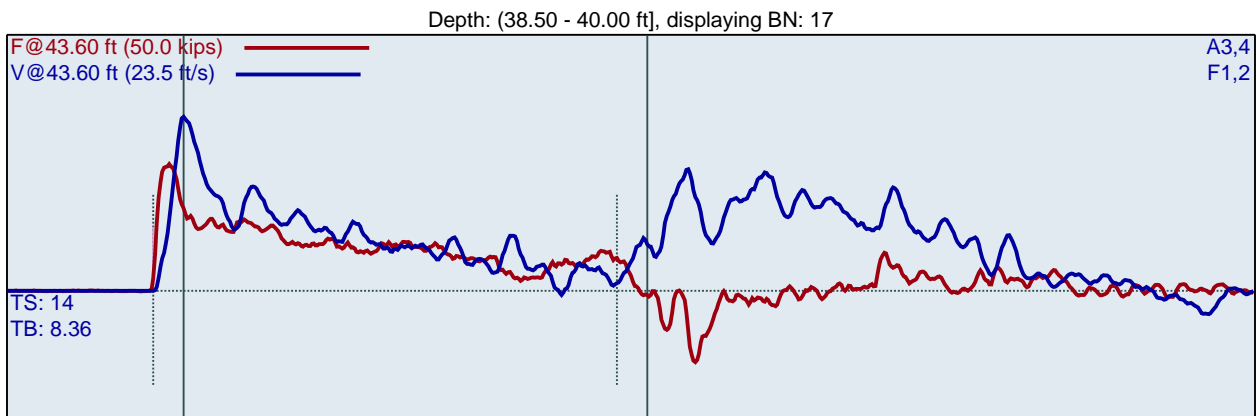


CME 45B (SN 303304)  
REK  
B-1

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

N-value: 15

Sample Interval Time: 19.28 seconds.



**Summary of SPT Test Results**

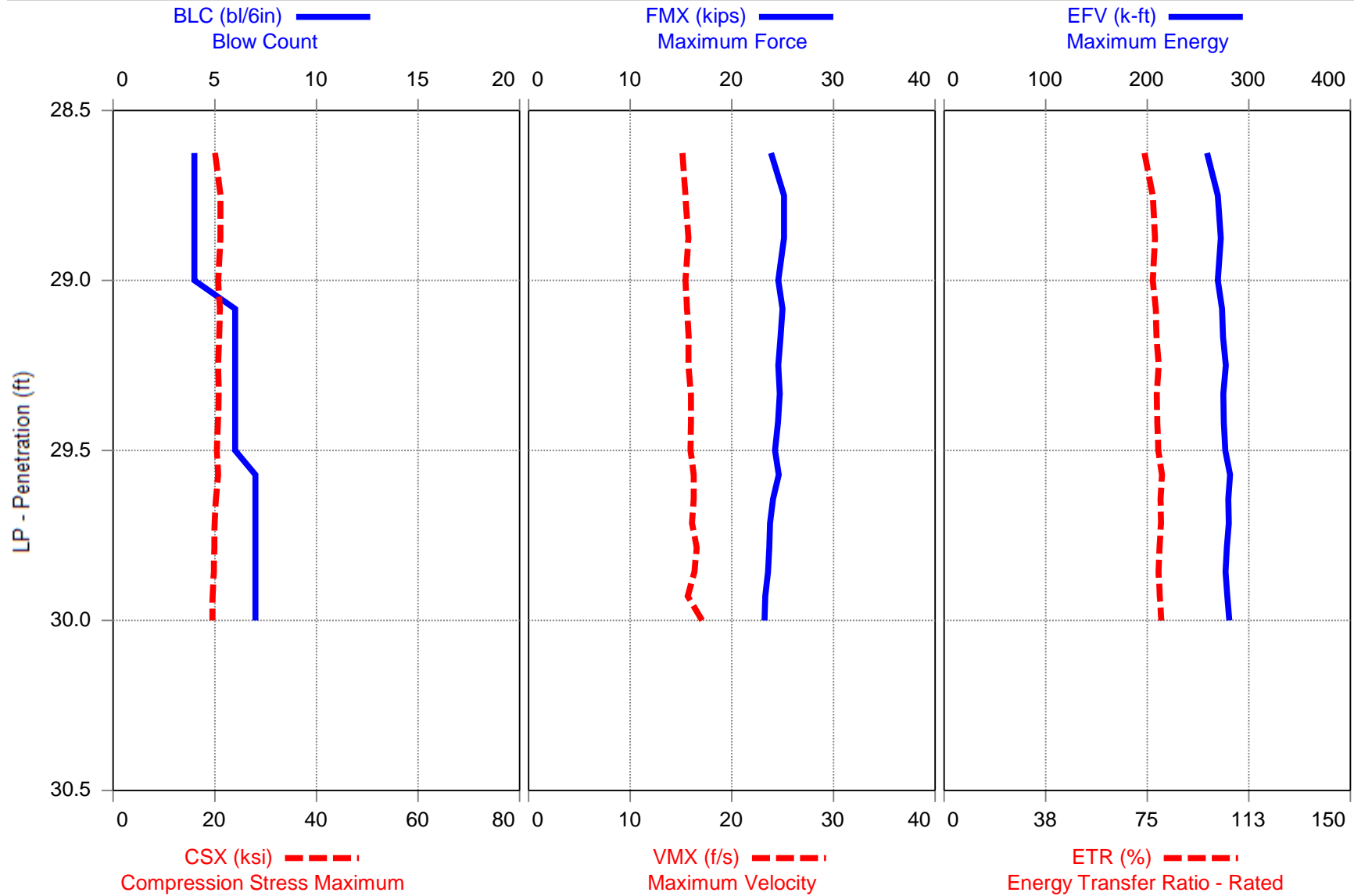
Project: CME 45B (SN 303304), Test Date: 3/11/2022

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





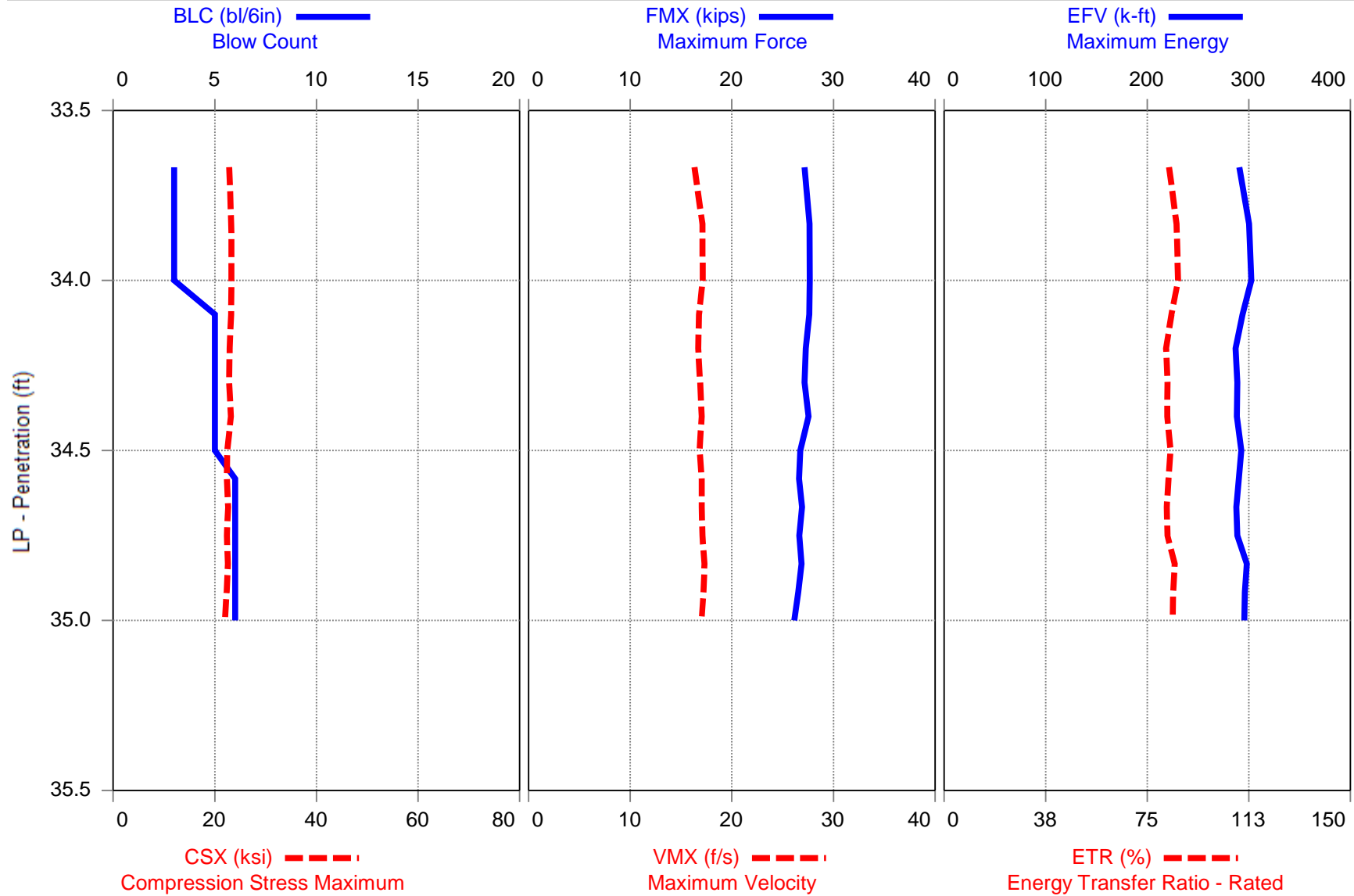
CME 45B (SN 303304) - 28.5 TO 30.0







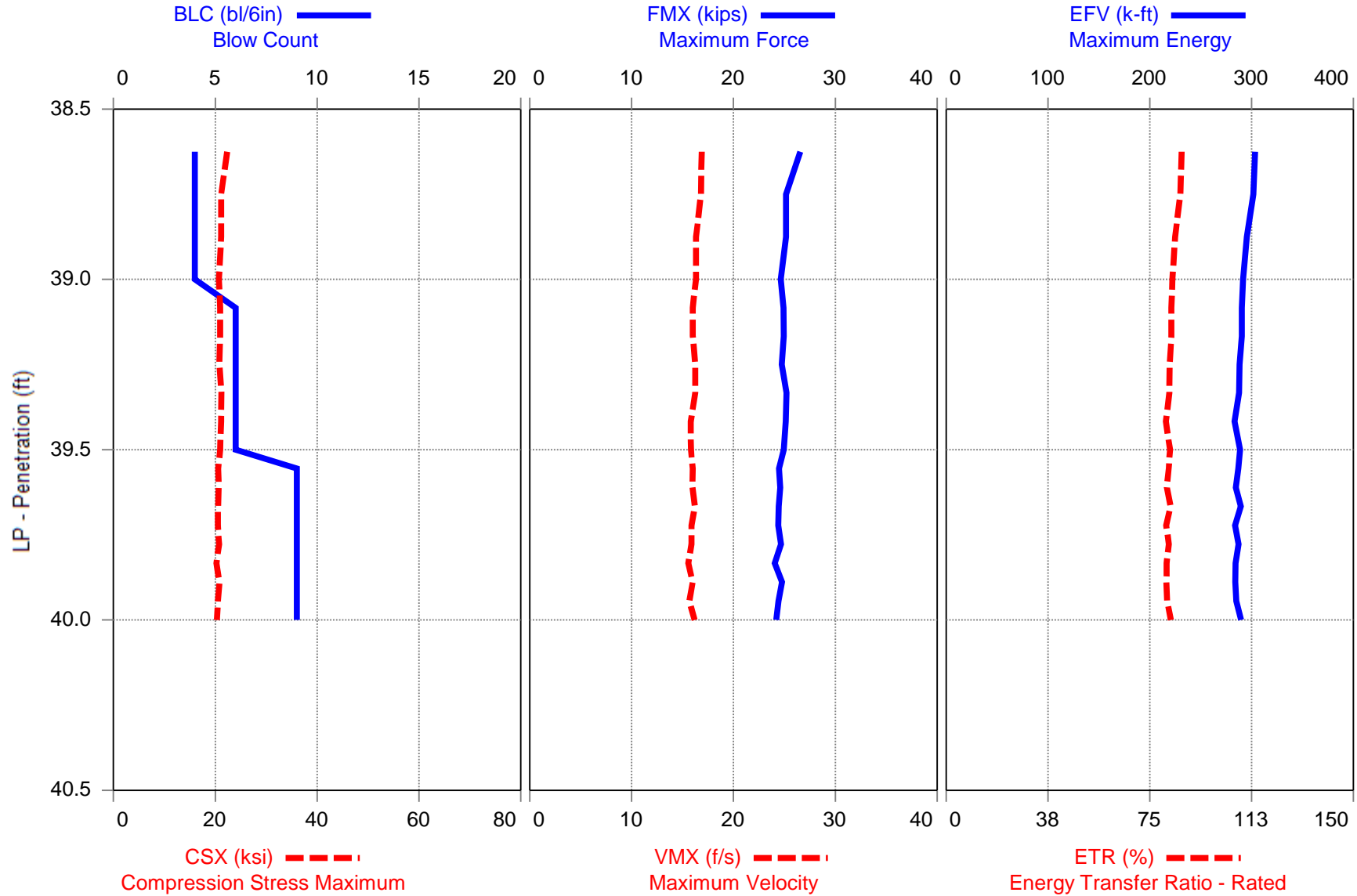
CME 45B (SN 303304) - 33.5 TO 35.0



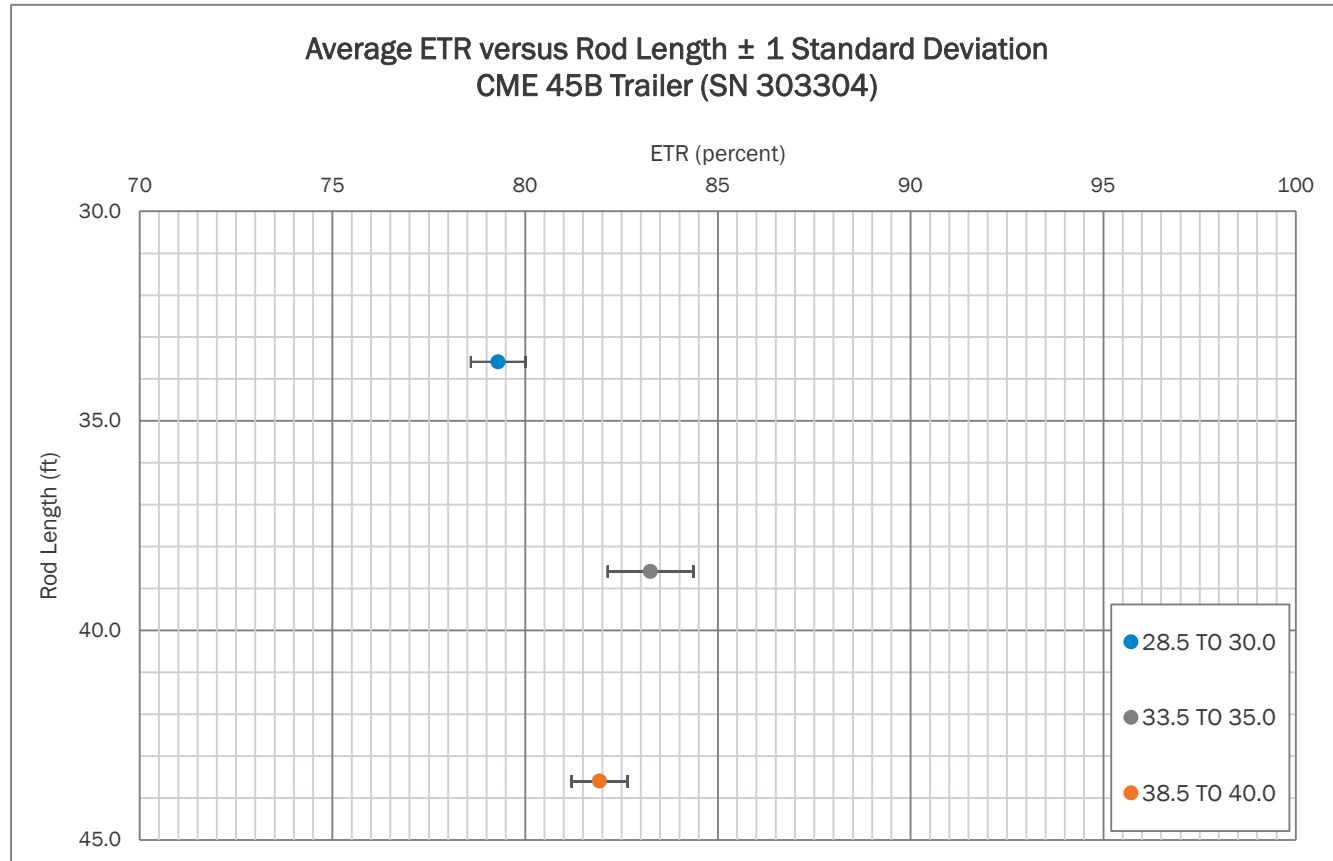
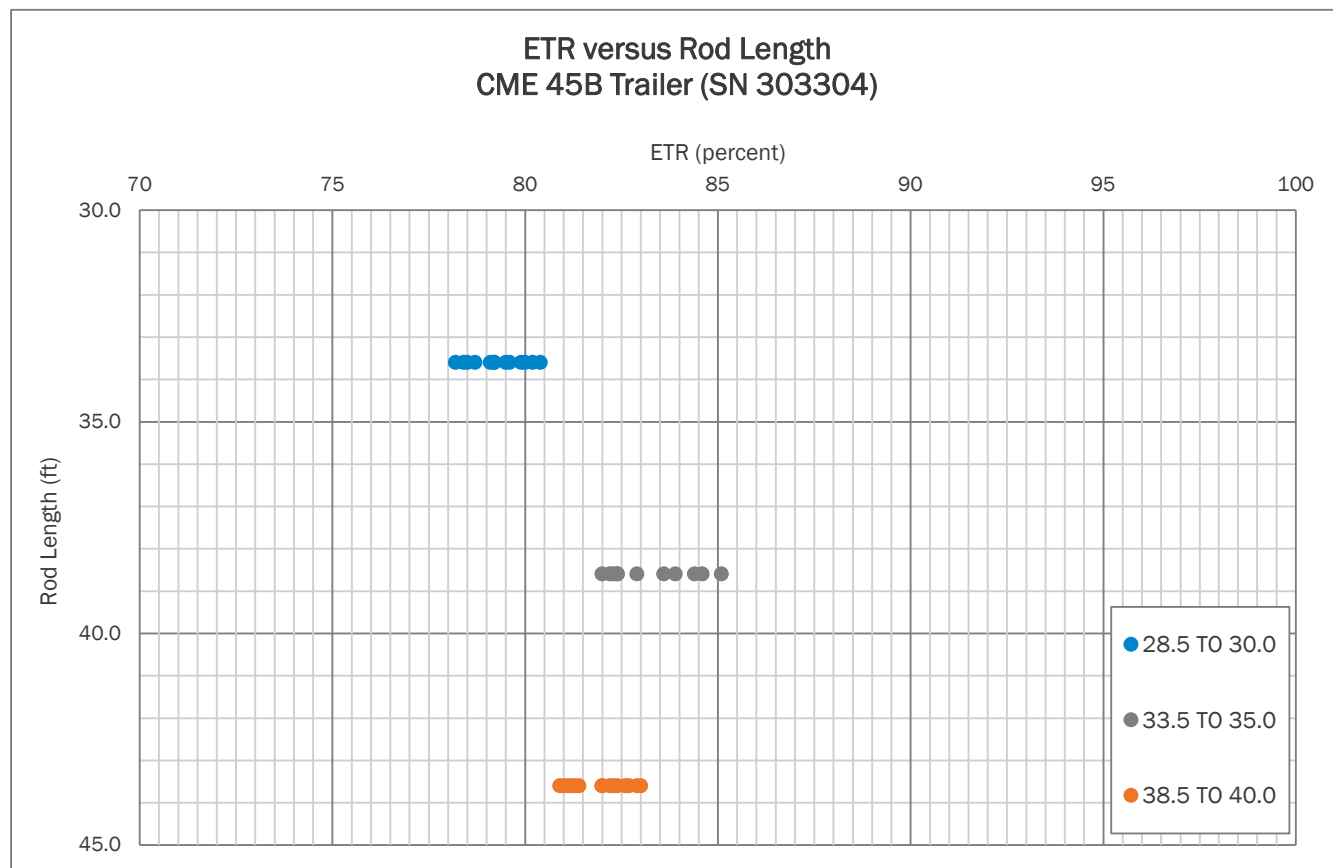




CME 45B (SN 303304) - 38.5 TO 40.0











## 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

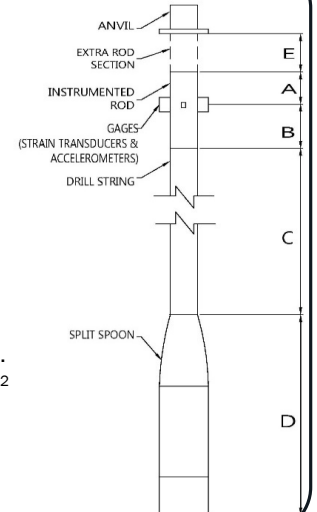
Drilling Company: BRECCIA CONSTRUCTION, LLC  
 Rig Operator: D. HARRIS  
 Engr/Geologist: N/A  
 Client Rep.: N/A  
 Analyzer Oper.: R. KRAL

## 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





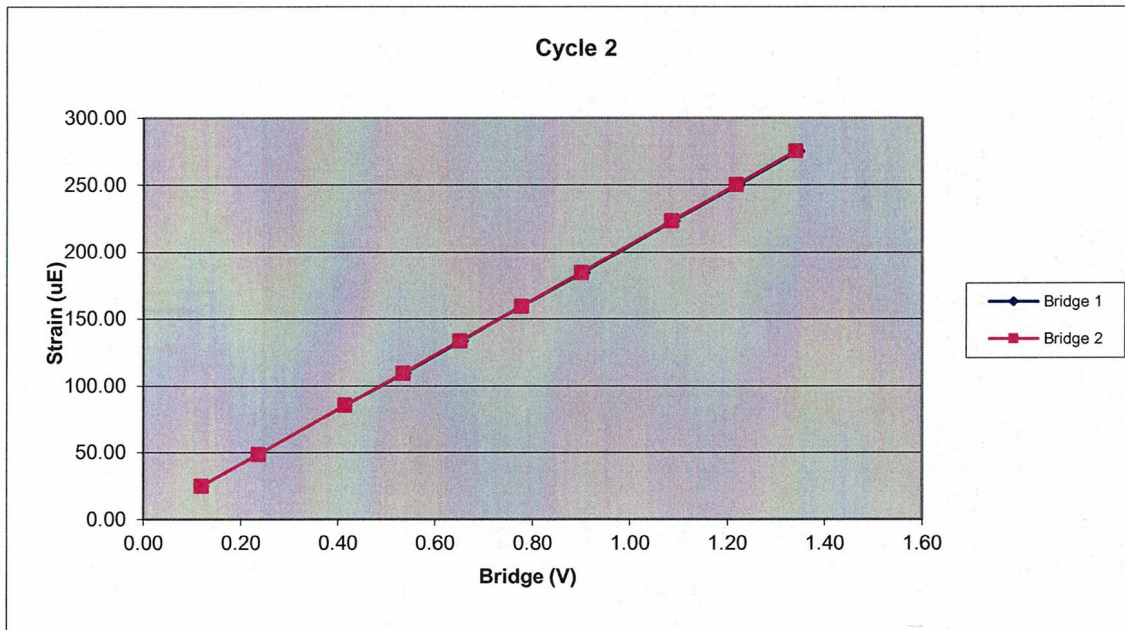
## APPENDIX III



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

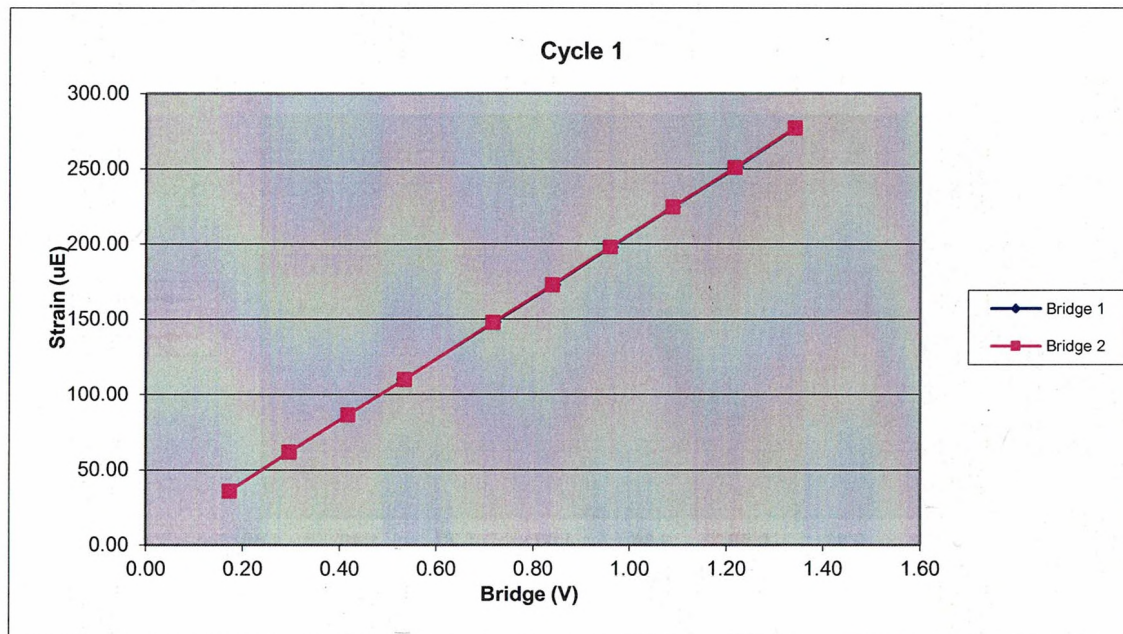




528AWJ		Cycle 1		
Sample	Force (lb)	Strain ( $\mu$ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1278.49	35.63	0.17	0.17
3	2188.92	61.59	0.30	0.30
4	3085.11	86.16	0.42	0.42
5	3944.56	110.01	0.53	0.54
6	5284.17	147.69	0.72	0.72
7	6199.57	172.59	0.84	0.84
8	7071.20	197.80	0.96	0.96
9	8023.54	224.47	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 ( $\mu$ E/V)	205.65	Strain Calibration ( $\mu$ 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]

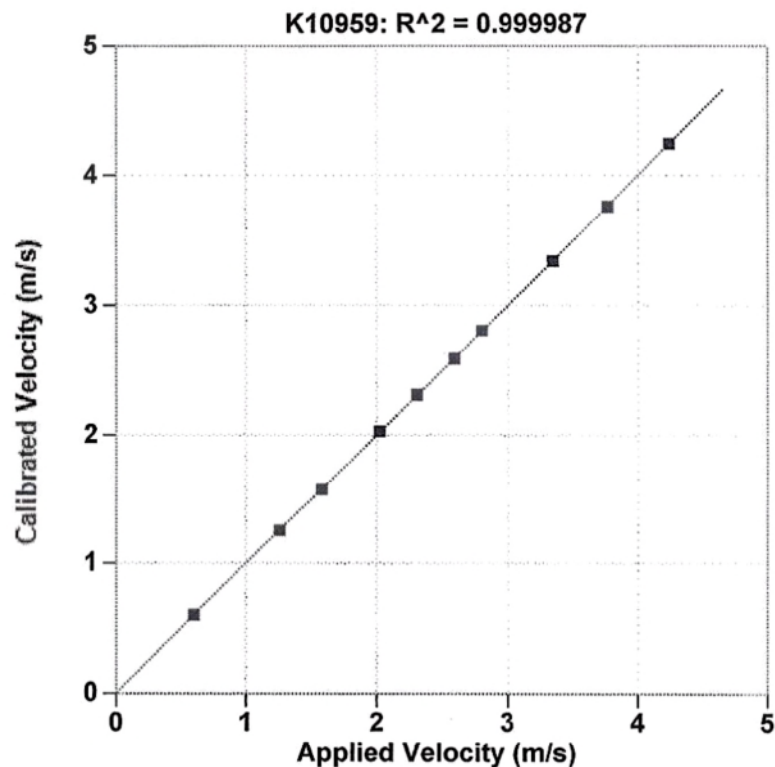
Ref Acc 1: 69096! Cal on: 27Jan2021  
978 g's/volt

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

Operator: William Johnson

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]

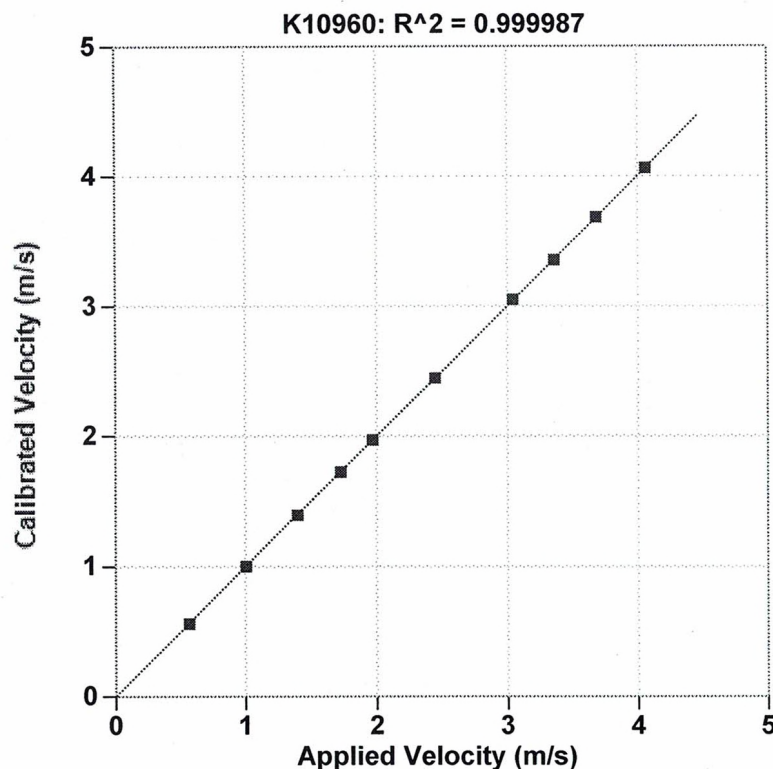
Operator: William Johnson

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

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

*William Johnson*  
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

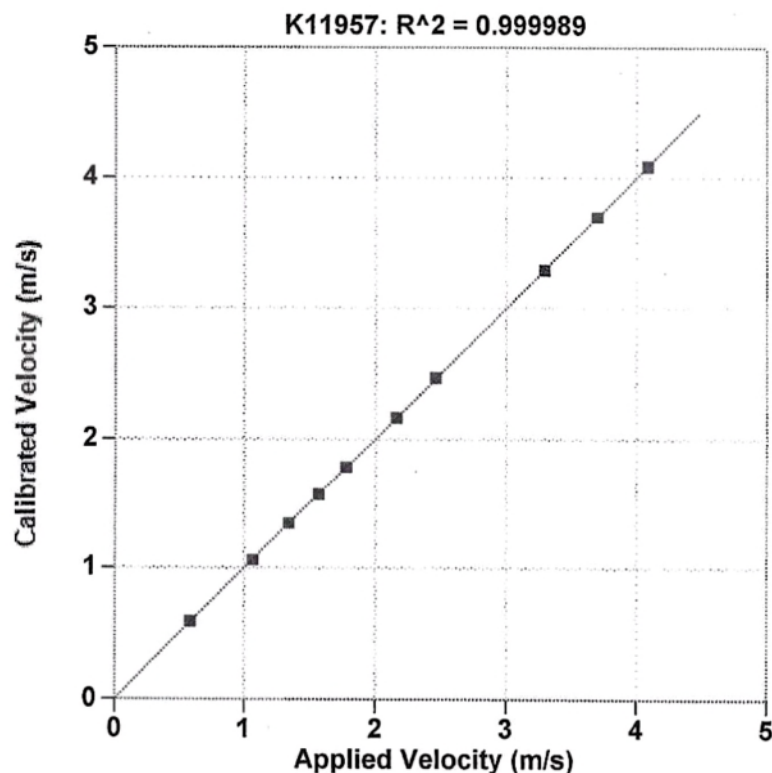
Ref Acc 1: 63479! Cal on: 22Jan2021  
1079 g's/volt

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

*William Johnson*

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





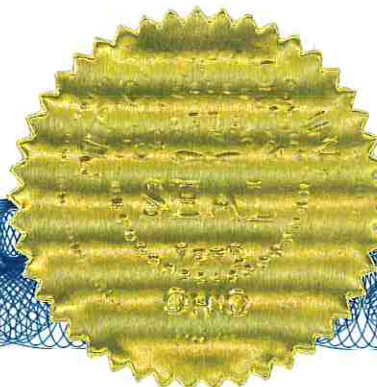
This documents that  
**Robert E. Kral**  
**Carolinas Geotechnical Group**  
has on May 20, 2016 achieved the rank of  
**ADVANCED**


**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