



Geotechnical Baseline Report

SC 183 (Walhalla Hwy.) Bridge Replacement
over Twelve Mile Creek

Pickens County, SC
January 4, 2023



January 4, 2023

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 Baseline Report for the SC 183 (Walhalla Hwy.) Bridge Replacement over Twelve Mile Creek in Pickens 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 Baseline Report (GBR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed SC 183 Bridge Replacement over Twelve Mile Creek, in Pickens County, South Carolina. The proposed bridge intends to replace the existing bridge over Twelve Mile Creek on Walhalla Highway.

This Geotechnical Baseline 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. Preliminary geotechnical considerations for design and construction are also included in this report.

1.1 Project Description

The project site is located west of Pickens, approximately 1 mile southwest of the intersection of SC 183 with Shady Grove Rd. It is bound to the east by Allgood Farm Road and to the west by Holder Knob Road. A Site Vicinity Map is included in Appendix A.

The existing bridge over Twelve Mile Creek is approximately 250 feet in length and 36 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 290 feet in length and will accommodate two 12-foot lanes with 10-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 October 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 four (4) SPT borings were performed during the subsurface investigation, B-21, B-22, B-23, and B-24. Auger refusal was encountered in all four borings at depths of 28.0 feet, 20.1 feet, 31.3 feet and 63.1 feet, respectively. Advancement of the bridge borings B-21, B-22, B-23 and B-24 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 38.3 feet, 44.4 feet, 52.0 feet and 73.9 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-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 and bulk sample were sent to the F&ME laboratory for testing.

2.2 Cone Penetrometer Testing

Two (2) cone penetrometer tests (CPT-7 and CPT-8) 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 25.1 feet to 38.2 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-4, performed on the existing bridge end where boring B-24 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 1327.4 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 levels recorded approximately 24 hours after completion of investigation operations indicated groundwater depths of 22.0 feet, 0.7 feet and 22.2 feet for borings B-21, B-22, and B-24, respectively. These depths correspond to elevations 880.4 feet, 879.9 feet, and 880.4 feet.

Groundwater levels recorded at the time of completion of soil drilling and/or rock coring indicated groundwater depths of 15.9 feet, 0.0 feet, 9.4 feet, and 19.9 feet for borings B-21, B-22, B-23, and B-24, respectively. These depths correspond to elevations 886.5 feet, 880.6 feet, 880.3 feet, and 882.7 feet.

These reported groundwater levels are interpreted to be dependent upon seasonal fluctuations, individual event intensity and/or level of Twelve Mile 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 test location plan included in Appendix A.

Table 2-1. Field Soil Testing Summary

Test Hole No.	Station ^a	Offset (ft)	Latitude	Longitude	Top of Boring Elevation (ft)	Test Type	Total Depth (ft)
B-21	96+72	36 RT	34.87559	-82.74308	902.4	SPT/RC	38.3
B-22	97+64	37 RT	34.87558	-82.74339	880.6	SPT/RC	44.4
B-23	98+66	37 RT	34.87556	-82.74373	889.7	SPT/RC	52.0
B-24	99+44	36 RT	34.87555	-82.74399	902.6	SPT/RC	73.9
BS-1	99+57	65 RT	34.87564	-82.74406	902.6	BULK	5.0
CPT-7	96+74	36 RT	34.87555	-82.74400	902.5	CPT	35.1
CPT-8	99+48	35 RT	34.87559	-82.74308	902.4	CPT	38.2
MASW-4	near boring B-24					MASW	100.0

^a Stations based on latest SC 183 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, 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	20
Atterberg Limits	12
Grain Size Analysis with Hydrometer	4
Grain Size Analysis with #200 Wash	2
#200 Wash	6
CU Triaxial	1

Table 3-1. Laboratory Testing Summary

Test Type	Quantity
Unconfined Compression of Rock	9
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-7-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty sand (SM) and poorly graded sand (SP) to sandy fat clay (CH). Tested samples yielded liquid limits ranging from 0 to 51 and plasticity indices ranging from 0 to 29.

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, nine (9) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 4,800 psi to 22,640 psi. Results of laboratory testing are included in Appendix C.

4 Subsurface Conditions

4.1 Regional Geology

The bridge site is located on SC 183 in Pickens County, South Carolina and crosses over Twelve Mile Creek which is part of the Savannah River watershed (DHEC, 2016). The bridge site lies within the Piedmont Physiographic Province of South Carolina. The Piedmont Province is bounded by the Blue Ridge Physiographic Province to the west and the Upper Coastal Plain Province to the east. Elevations throughout the Piedmont vary from 300 feet to 1,400 feet. The Piedmont Province is characterized by gently rolling topography, deeply weathered bedrock, few rock outcrops and complex geology with a multitude of rock types formed during the Paleozoic Era (250 to 570 MYA). The geology of this region is further complicated by the Alleghanian orogeny (325 to 260 MYA), the mountain building event which helped to form the present-day Appalachian Mountain chain, and subsequent deformation/metamorphism of the region (Butler, 1991). Soils overlying bedrock in the Piedmont are typically considered to be residual soils (soils weathered in place from bedrock). However, Twelve Mile Creek provides a transport mechanism for soil eroded from higher elevations to be carried downstream and deposited at banks of the particular bridge site. The contact between soil and bedrock is not strongly defined and is often marked by an intermediate transition zone. The materials of this zone can be soil, partially decomposed rock, and fragments of the underlying bedrock.

4.2 Soil Stratification

In general, the soil profile is dominated by sandy fat clay, clayey sand, sandy silt, and silty sand. These comprise the alluvial and residual soils overlying the biotite gneiss and mica schist bedrock. Bedrock was intercepted within a depth of 20.1 feet to 63.1 feet from the existing ground.

Roadway fill consisting of soft to firm sandy fat clay and loose to medium dense silty sand was interpreted to range from 0.7 feet to 15.0 feet of the profile. Underlying alluvium was sampled as very loose to medium dense poorly-graded sand to soft to stiff sandy silt. Residual soil underlying alluvium ranges from medium dense to very dense silty sand. The thickness of the residual zone ranged from 1.0 feet to 29.1 feet between borings B-21 and B-24. Biotite gneiss and mica schist make up the bedrock underlying the project site. Recovered rock core was in general fresh to highly weathered. Discontinuities were spaced close to very close, with planar and irregular, slickensided to rough joint surfaces. Rock core recovery ranged from 58 to 98 percent, RQD ranged from 13 to 93 percent, and rock unconfined compression testing revealed medium strong to very strong rock with values ranging from 4,800 psi to 22,640 psi.

A summary of the main strata intercepted by the soil test borings is provided in Table 4-1 below. A subsurface profile developed based on the collected soil and rock information is included in Appendix A.

Table 4-1. Soil Stratification

Geology	Top of Layer Elev. (ft)	USCS Soil Type	SPT-N ⁽¹⁾	Plasticity Index ⁽¹⁾	Fines Content ⁽¹⁾	REC / RQD
Roadway Fill	902	CH, SM	4-15 (7)	0-29 (15)	21-55 (38)	-
Alluvium	890-887	SC-SM, SP, SM, ML	0-19 (6)	0-7 (4)	5-67 (28)	-
Residuum	875-864	SM	8-100+ (63)	0	16-40 (28)	-
Rock	874-840	-	-	-	-	58-98% / 13-93% (89%) / (64%)

⁽¹⁾ Values in parentheses indicate the average of the values in the range

5 Seismic Conditions

The proposed bridge is classified as OC II. Per SCDOT GDM 2022, the bridge approach embankments shall be designed to meet the performance limits that are established by the design team based on the performance objectives for the bridge

5.1 Acceleration Design Response Spectrum (ADRS)

The shear wave velocity results, as measured from the MASW test, were provided to SCDOT (Pre-Construction Support - Geotechnical Design Section). SCDOT used these results to determine the site amplification factors that would be used to correct for site effects the bedrock motion determined from regional probabilistic seismic hazard maps.

SCDOT provided a “3-Point Acceleration Design Response Spectrum” data sheet that included pseudo-spectral accelerations (PSA) for 5% critical damping and at selected frequencies, consistent with a Geologically Realistic condition (shear wave velocity, $V_s=2,500$ fps). PSA values were provided for the:

- Functional Evaluation Earthquake (FEE): 15% probability of exceedance in 75 years;
- Safety Evaluation Earthquake (SEE): 3% probability of exceedance in 75 years.

Table 5-1 below summarizes the peak ground acceleration (PGA), the short period acceleration (S_{DS}), and one-second period acceleration (S_{D1}) for the FEE and SEE earthquakes for the ground surface. A copy of the “3-Point Acceleration Design Response Spectrum” output form presenting the PSA data at the B-C boundary and the results of the ADRS analysis are included in Appendix D.

Table 5-1. Seismic Design Parameters

Seismic Design parameter	FEE	SEE
PGA	0.12	0.28
S_{DS}	0.19	0.42
S_{D1}	0.05	0.11

5.2 Shear Strength Loss (SSL)

Based on a preliminary review of the physical properties of the site soils, these appear to be susceptible to shear strength loss during the design earthquake. The potential of shear strength loss of the site soils and contribution to ground deformations that adversely affect the bridge structure should be carefully evaluated during the design phase of the project.

6 Design and Construction Considerations

6.1 Foundations

Driven steel H-piles are anticipated to be the most feasible foundation type for the proposed bridge abutments. Based on Table 9-3 in SCDOT GDM 2022, assuming redundant piles, a resistance factor of 0.5 will be used for design if wave equation is applied for verification and a resistance factor of 0.65 will be used assuming Dynamic Monitoring (PDA) with wave equation analysis. It is anticipated that foundation piles will be installed following the approach embankment construction. If for any reason foundation piles will already be in-place when the approach embankment construction begins, foundation pile design must account for any downdrag loads subjected to the piles.

Due to the variability in the thickness of weathered rock underlying the site, tip elevations are also anticipated to exhibit variability across the site. For piles driven to practical refusal in PWR or rock, their resistance will be limited by their structural resistance. Reinforced pile tips will be required to penetrate to PWR. The wave equation analysis should be performed for predicting the drivability of piles along with estimating stresses during driving and, in general, verifying the ability of the Contractor's selected hammer to drive the piles to the desired penetration while preventing overstressing.

For the bridge interior bents, drilled shafts appear to be the most appropriate foundation type due to the shallow PWR anticipated conditions. Drilled shaft diameters should be a minimum of 6 inches larger than the column and the rock socket diameters. Installation of permanent casing will be required for the construction of the drilled shafts. Permanent casing will need to extend into PWR or rock to ensure sufficient support is provided while advancing the drilled shaft excavation through the overlying saturated soils. For the design of the drilled shafts with rock sockets, a resistance factor of 0.60 for both side friction and end bearing will be used in accordance with Table 9-4 of the SCDOT GDM 2022, assuming redundant drilled shafts are used. It must be noted that side resistance along the cased length of the drilled shaft, will not be considered in the calculated axial resistances.

6.2 Embankment Slopes

The loose silty sands and soft sandy silts that comprise the alluvial soils within the footprint of new bridge approach embankment slopes and are susceptible to SSL could potentially trigger instability of the bridge approach embankment slopes. Further assessment of the slope stability in conjunction with lateral spreading effects and evaluation of any necessary ground modification or structural mitigation measures must be explored during the design phase of the project.

6.3 Corrosion Potential Results

Corrosion testing of a representative split spoon sample was performed by F&ME Consultants and the results are included in Appendix C. The full corrosion and deterioration testing results included pH, resistivity, chlorides and sulfates content and are summarized in Table 5-1 below.

Table 5-1. Corrosion Series Laboratory Testing Summary

Test Hole No.	Alignment	Station	Offset (ft)	Sample Depth (ft)	Chloride (ppm)	Sulfate (ppm)	pH	Resistivity (ohm-cm)
B-24	SC 183	99+44	36 RT	14.0-20.0	40.4	14.0	5.7	17,020

Based on the criteria set forth in section 7.18 in SCDOT GDM 2022, the environmental classification of the project site is non-aggressive. Interpretation of these data shall be communicated with the structural engineer for the project.

6.4 Embankment Construction

Some fill quantities may be required for construction of the embankments on this project. Assuming that the majority of embankment construction will utilize the available on-site materials, a bulk sample obtained from the top 5 ft of existing embankment material along the alignment was used to provide a better characterization of the material locally available. The bulk samples were tested for soil classification and was also remolded and compacted to 95% of the Standard Proctor prior to being tested under CU Triaxial Compression. Results are summarized in Table 5-2 below.

Table 5-2. Bulk Sample Testing Summary

Sample No.	Station	Offset (ft)	Sample Depth (ft)	USCS Soil Type	Compaction		Shear Strength			
					Optimum Moisture (%)	Max Dry Density (pcf)	c' (psf)	φ' (°)	c (psf)	φ (°)
BS-1	99+57	65 RT	0.0-5.0	SM	21.5	99.4	117	34.9	258	16.8

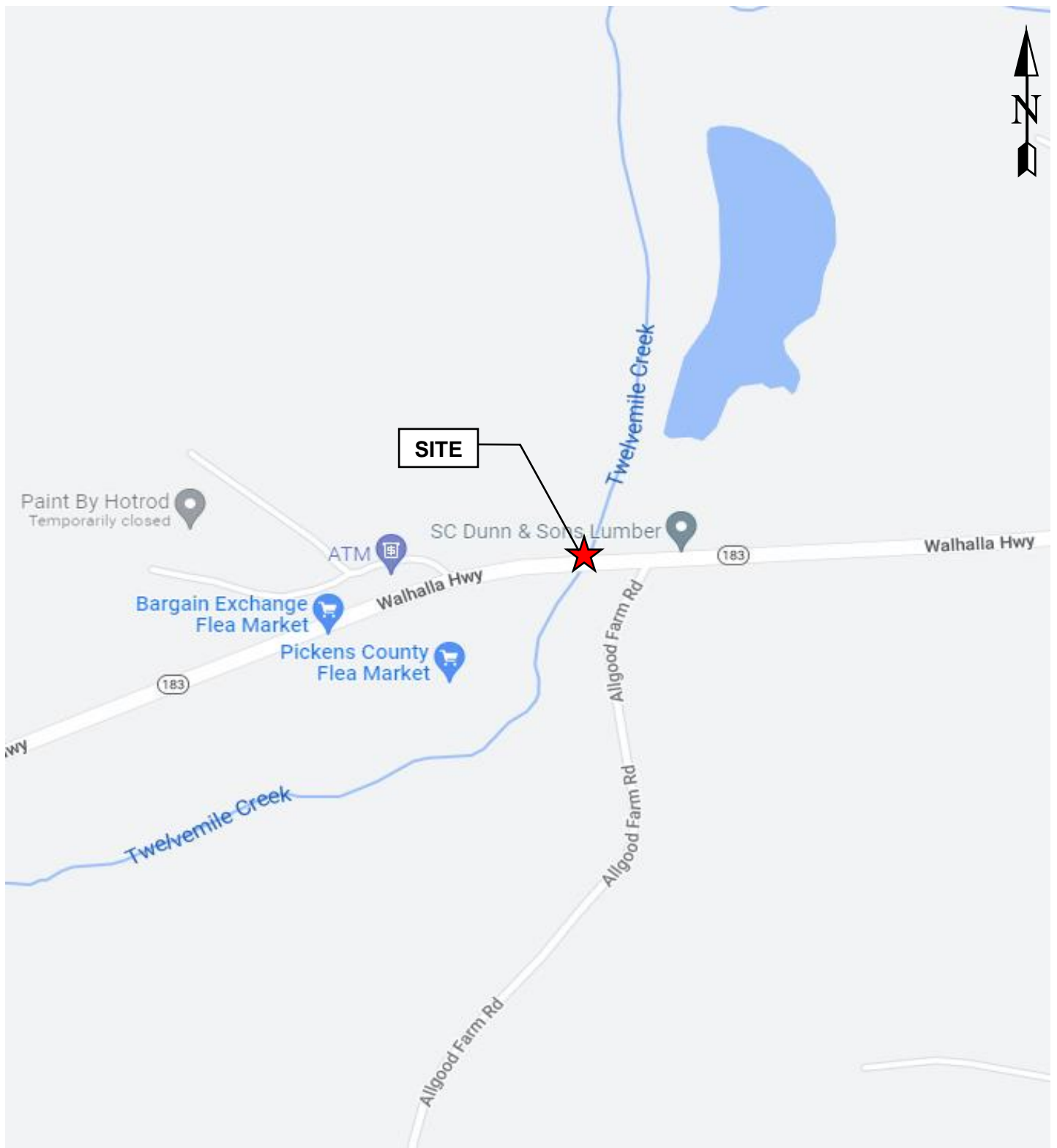
7 Limitations to Report

This report has been prepared in general accordance with procedures in SCDOT GDM Chapter 21 and generally accepted soil and foundation engineering practices for specific application to the proposed SC 183 Bridge over Twelve Mile Creek in Pickens County, South Carolina. No other warranty expressed or implied is made. The Geotechnical Engineer of Record for the project must review the data submitted in this report and develop their own interpretation of the testing results as they apply to design. 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.

8 References

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- SCDNR "Geologic Map of South Carolina", March 2012
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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, Subsurface Profile



HDR ENGINEERING INC.
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SC 183 (Walhalla Hwy.) over Twelve Mile Creek

COUNTY

PICKENS

SITE VICINITY MAP

Source: Google Maps

SC 183 (Walhalla Hwy.) over Twelve Mile Creek

Field Test Location Plan

Legend

- Bulk Sample
- △ CPT
- ✦ SPT Boring



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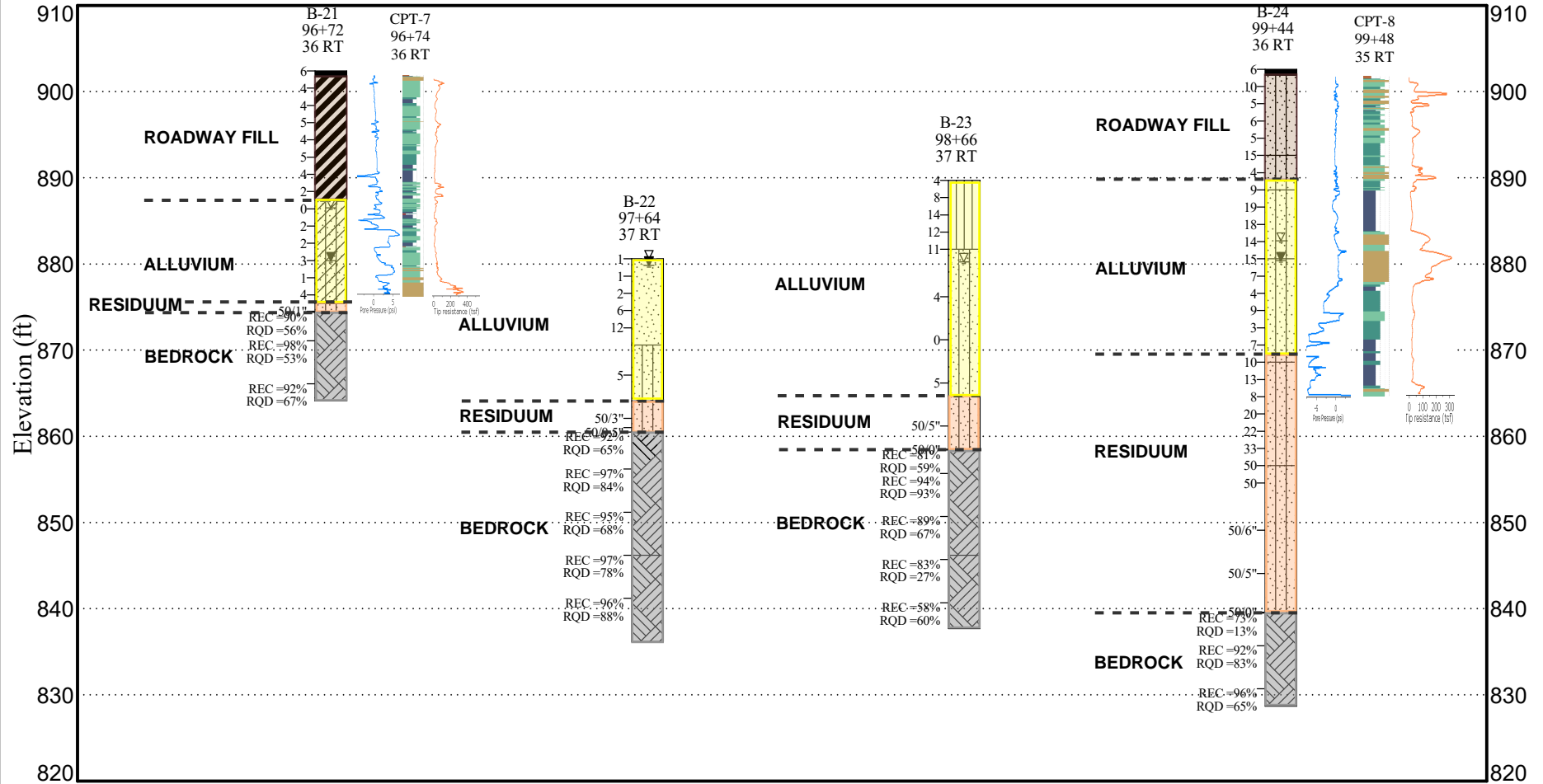
SC 183 (Walhalla Hwy.) over Twelve Mile Creek

COUNTY

PICKENS

FIELD TEST LOCATION PLAN

Source: Google Earth



BORING	ELEVATION	STATION	OFFSET
B-21	902.4	96+72	36 RT
B-22	880.6	97+64	37 RT
B-23	889.7	98+66	37 RT
B-24	902.6	99+44	36 RT

	<u>Roadway Fill - Sandy Fat Clay, Silty Sand</u> (CH, SM/A-7-6, A-7-5)
	<u>Alluvium - Clayey Sand, Poorly-graded Sand,</u> <u>Silty Clayey Sand, Sandy Silt</u> (SC-SM, SP, SM, ML/A-4, A-1-b, A-2-4)
	<u>Residuuum - Silty Sand</u> (SM/A-2-4)
	<u>Bedrock - Biotite Gneiss and Mica Schist</u>



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SUBSURFACE PROFILE

SC 183 over Twelve Mile Creek
Pickens, SC County, South Carolina




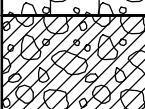
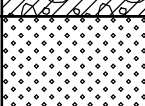
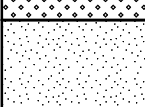
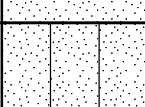
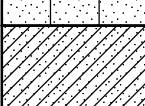
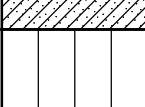
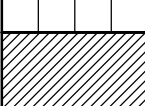
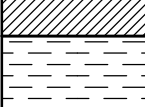
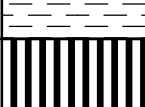

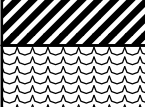
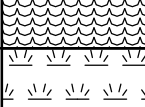
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Nov 2022

PLATE
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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 ¹			Consistency ²		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q _u) (tsf)	SPT Blow Count
Very Loose	0 to 15%	< 4	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

Angularity¹

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 Reaction³

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

Cementation³

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 Range¹

Gravel		Sand	
mm	Sieve size	mm	Sieve size
Fine	4.76 to 19.1	Fine	0.074 to 0.42
Coarse	19.1 to 76.2	Medium	0.42 to 2.00
		Coarse	4.00 to 4.76

h

Primary Soil Type^{1,2}

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

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

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)

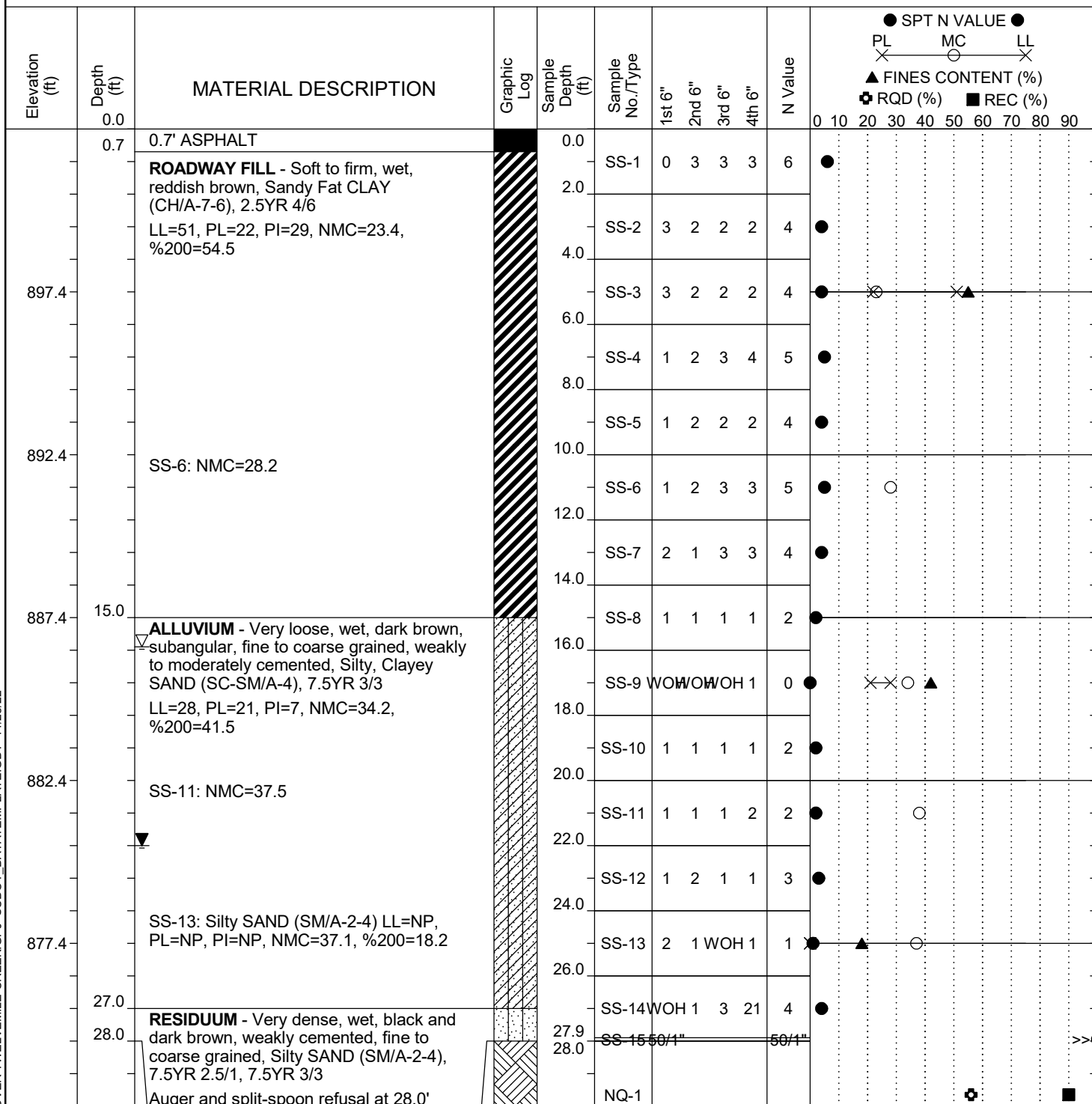


Appendix B. Subsurface Investigation

Boring Logs

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-21
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	96+72	Offset:	36 RT
Elev.:	902.4 ft	Latitude:	34.87559	Longitude:	-82.74308
Date Started:	10/4/2022				
Total Depth:	38.3 ft	Soil Depth:	28.0 ft	Core Depth:	10.3 ft
Date Completed:	10/5/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 15.9 ft
24HR	22 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	

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-21
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	96+72	Offset:	36 RT
Elev.:	902.4 ft	Latitude:	34.87559	Longitude:	-82.74308
Date Started:	10/4/2022				
Total Depth:	38.3 ft	Soil Depth:	28.0 ft	Core Depth:	10.3 ft
Date Completed:	10/5/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 15.9 ft
24HR	22 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 (%)
		Begin coring.									0 10 20 30 40 50 60 70 80 90
867.4		MICA SCHIST - Light gray, fine to coarse grained, no foliation to very thinly bedded, slightly weathered, strong to very strong, moderately hard rock. Very close joint spacing, very tight to partly open, planar, slickensided to slightly rough.		31.3							
		NQ-1: %REC=90, RQD=56, 2.6 min/ft, GSI=50-55			NQ-2						
		NQ-2: %REC=98, RQD=53, 3.3 min/ft, qu=12,890 psi, RMR= 57, GSI=50-55		36.3							
		NQ-3: %REC=92, RQD=71, 2.5 min/ft, qu=22,640 psi, RMR=54, GSI=50-55			NQ-3						
		Boring terminated at 38.3' (Elev. 864.1')									
862.4											
857.4											
852.4											
847.4											

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 SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 11/28/22

Rock Core Photos

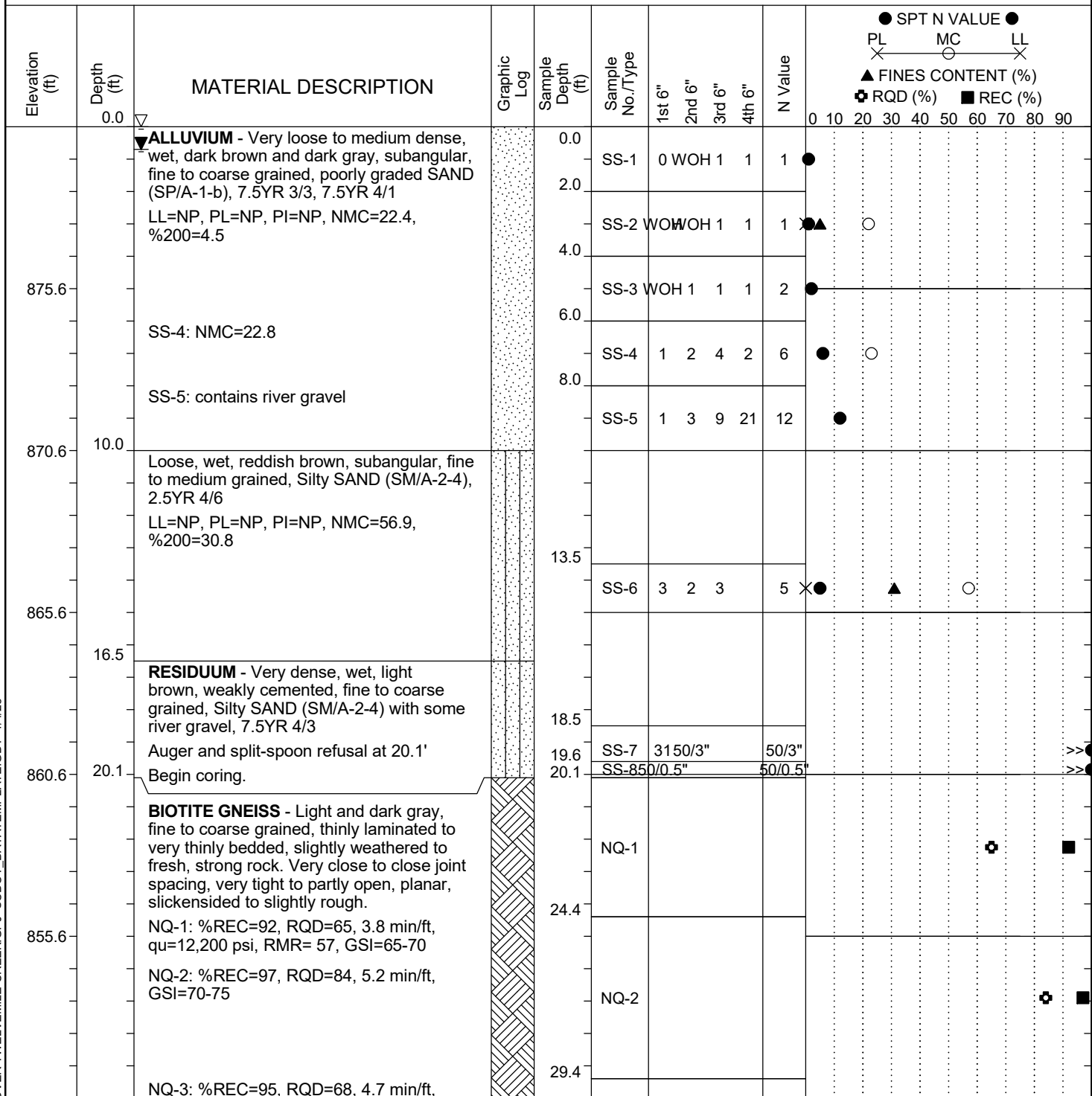
B-21

Box 1 of 1 (28.0' to 38.3')



SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-22
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	97+64	Offset:	37 RT
Elev.:	880.6 ft	Latitude:	34.87558	Longitude:	-82.74339
Date Started:	10/5/2022				
Total Depth:	44.4 ft	Soil Depth:	20.1 ft	Core Depth:	20.3 ft
Date Completed:	10/6/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 0 ft
24HR	0.7 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	

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-22
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	97+64	Offset:	37 RT
Elev.:	880.6 ft	Latitude:	34.87558	Longitude:	-82.74339
Date Started:	10/5/2022				
Total Depth:	44.4 ft	Soil Depth:	20.1 ft	Core Depth:	20.3 ft
Date Completed:	10/6/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 0 ft
24HR	0.7 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 (%)
		qu=18,170 psi, RMR=62, GSI=65-70									0 10 20 30 40 50 60 70 80 90
845.6	34.4			34.4	NQ-3						
		MICA SCHIST - Light and dark gray, fine to coarse grained, very thinly laminated, slightly weathered to fresh, medium strong to very strong rock. Very close to close joint spacing, very tight to partly open, planar, slickensided to slightly rough.									
840.6		NQ-4: %REC=97, RQD=78, 5.8 min/ft, qu=4,800 psi, RMR=58, GSI=70-75		39.4	NQ-4						
		NQ-5: %REC=96, RQD=88, GSI=65-70									
835.6	44.4	Boring terminated at 44.4' (Elev. 836.2')			NQ-5						
830.6											
825.6											

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 SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 1/4/23

Rock Core Photos

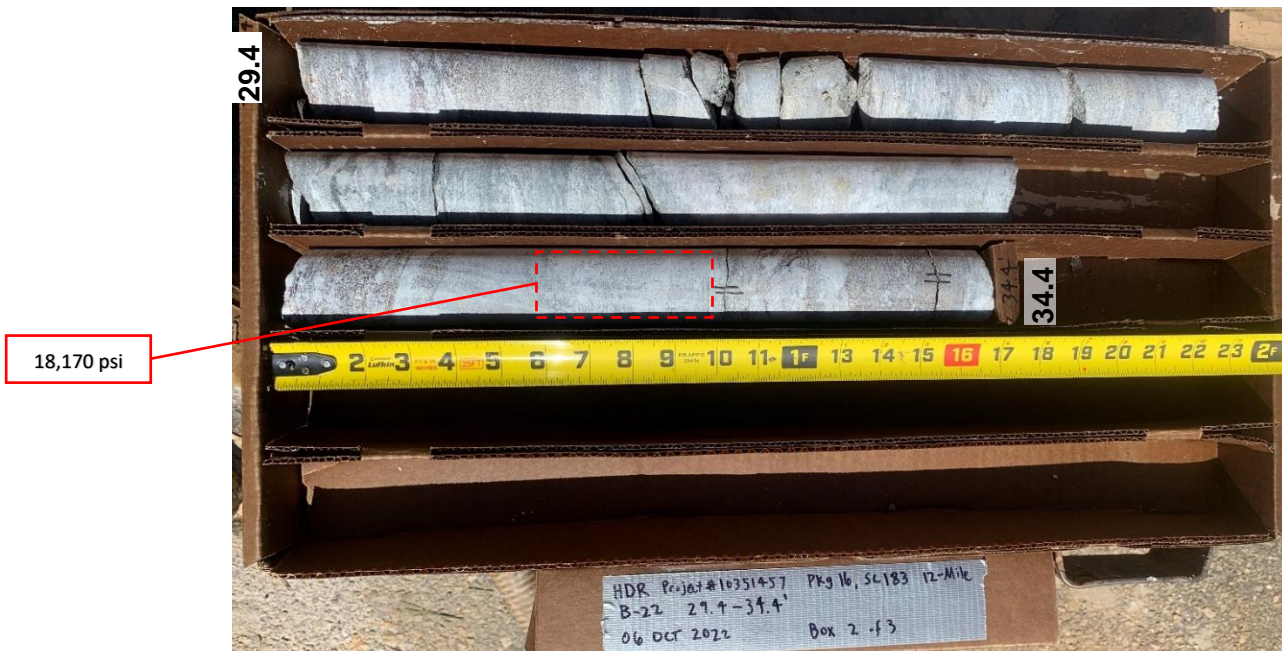
B-22

Box 1 of 3 (20.1' to 29.4')



B-22

Box 2 of 3 (29.4' to 34.4')



Rock Core Photos

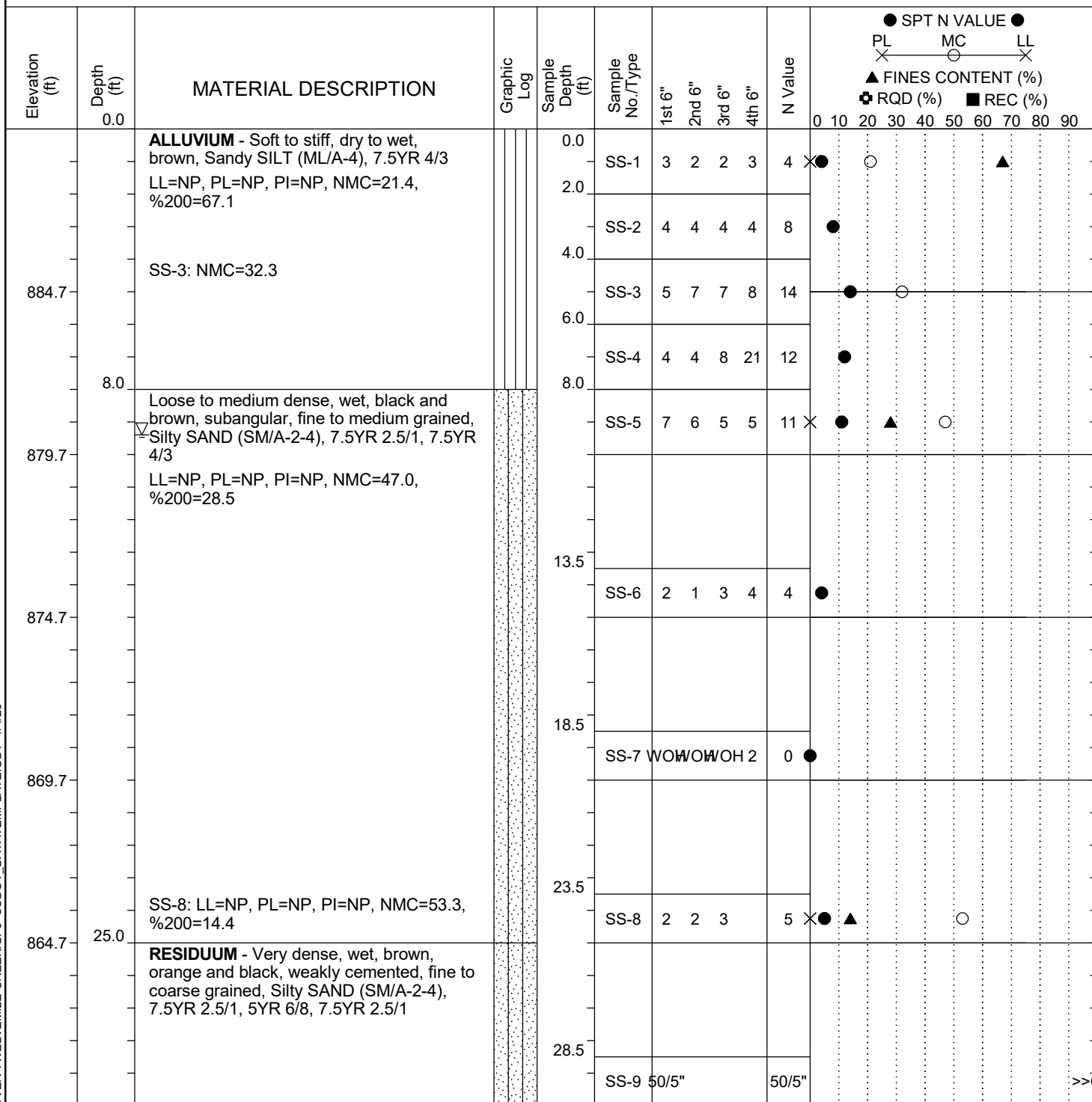
B-22

Box 3 of 3 (34.4' to 40.4')



SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-23
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	98+66	Offset:	37 RT
Elev.:	889.7 ft	Latitude:	34.87556	Longitude:	-82.74373
Date Started:	10/6/2022				
Total Depth:	52 ft	Soil Depth:	31.3 ft	Core Depth:	20.7 ft
Date Completed:	10/7/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 9.4 ft
24HR	N.M.				



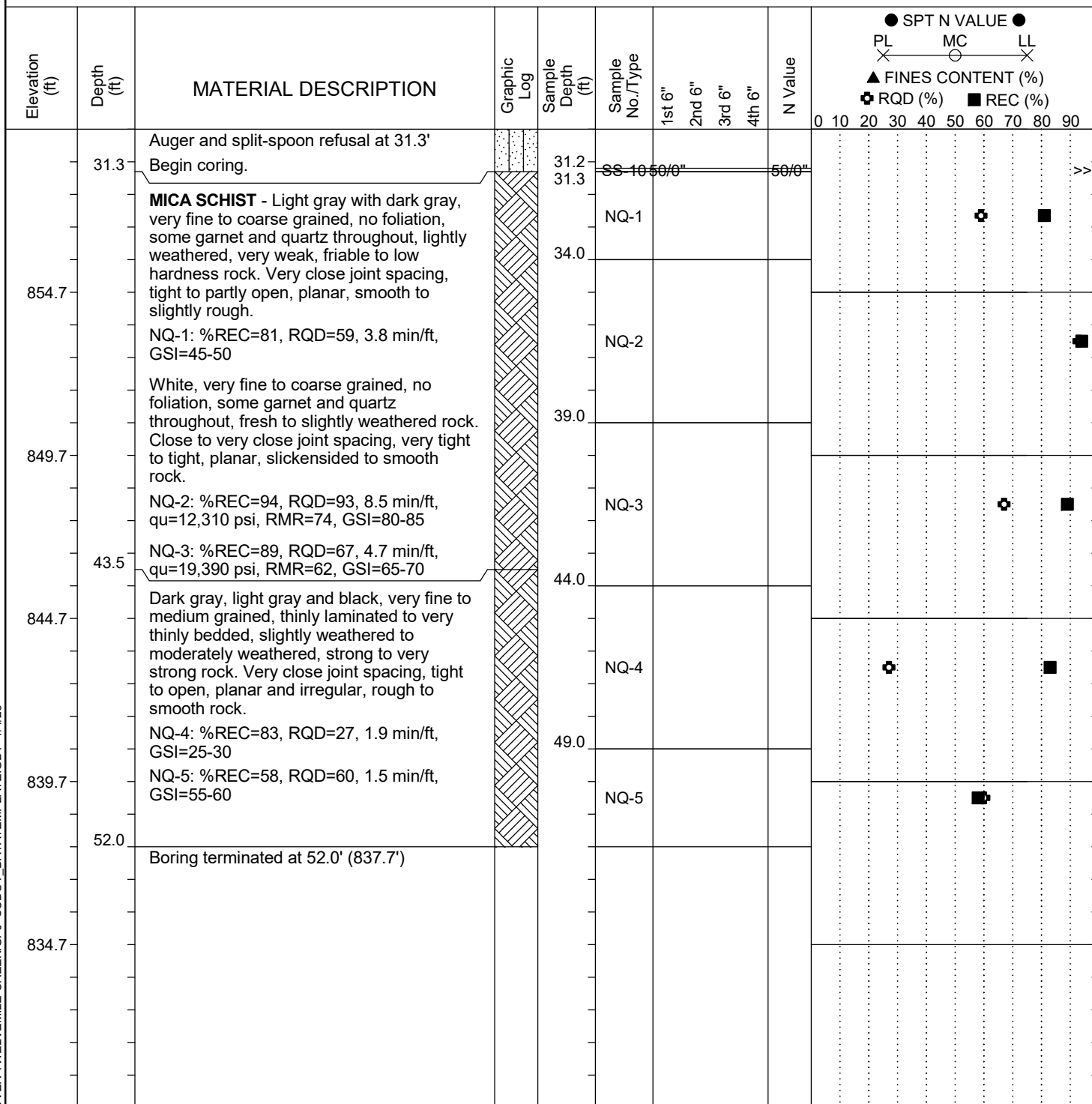
LEGEND

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

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-23
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	98+66	Offset:	37 RT
Elev.:	889.7 ft	Latitude:	34.87556	Longitude:	-82.74373
Date Started:	10/6/2022				
Total Depth:	52 ft	Soil Depth:	31.3 ft	Core Depth:	20.7 ft
Date Completed:	10/7/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 9.4 ft
24HR	N.M.				



LEGEND

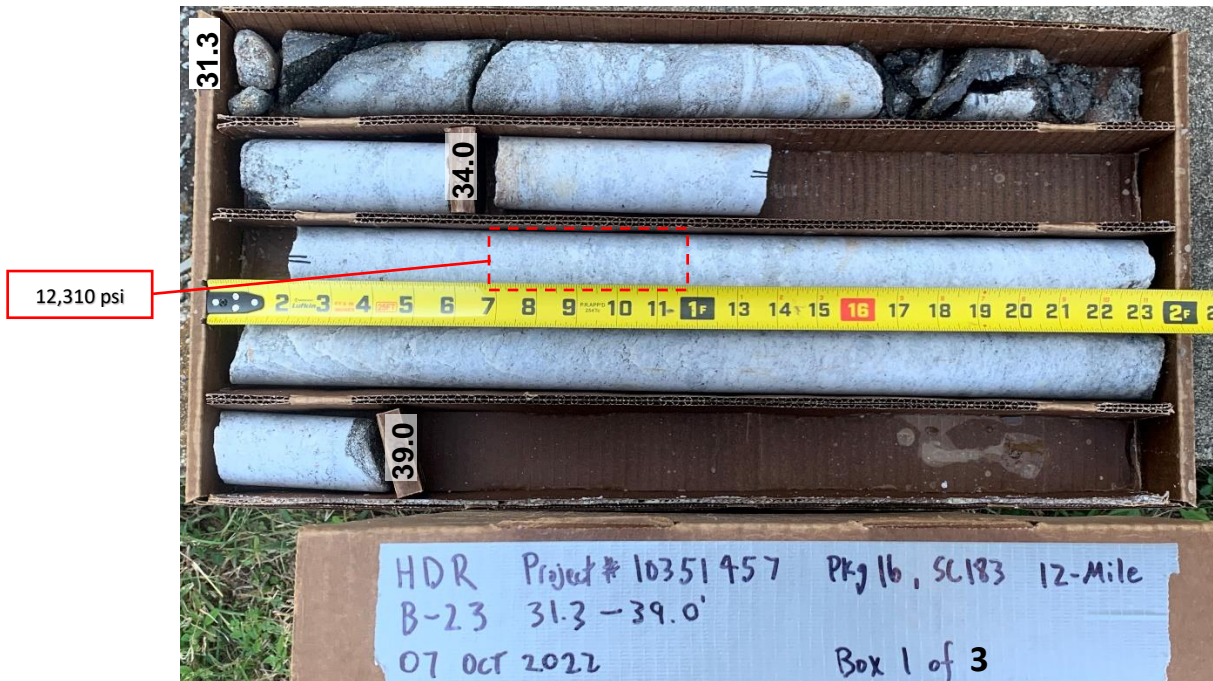
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 1/4/23

Rock Core Photos

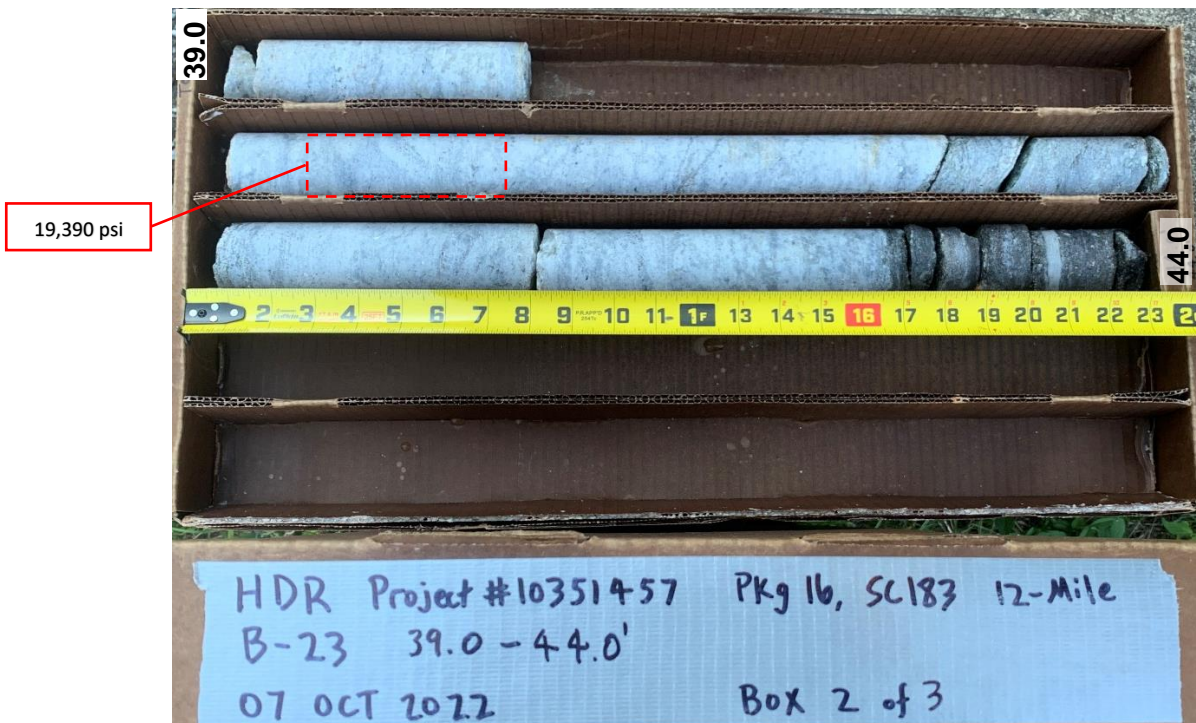
B-23

Box 1 of 3 (31.3' to 39.0')



B-23

Box 2 of 3 (39.0' to 44.0')



Rock Core Photos

B-23

Box 3 of 3 (44.0' to 52.0')



SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-24
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	99+44	Offset:	36 RT
Elev.:	902.6 ft	Latitude:	34.87555	Longitude:	-82.74399
Date Started:	10/3/2022				
Total Depth:	73.9 ft	Soil Depth:	63.1 ft	Core Depth:	10.8 ft
Date Completed:	10/3/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 19.9 ft
24HR	22.2 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 X MC X LL X ▲ FINES CONTENT (%) ⊕ RQD (%) ■ REC (%) </div>
	0.0										0 10 20 30 40 50 60 70 80 90
	0.7	0.7' ASPHALT		0.0	SS-1	0	2	4	4	6	●
		ROADWAY FILL - Loose, moist to wet, red/orange, dark brown, and reddish brown, subangular, fine to coarse grained, Silty SAND (SM/A-7-5), 10R 5/8, 7.5YR 3/4, 5YR 5/8		2.0	SS-2	11	5	5	8	10	●
		SS-3: NMC=23.8		4.0	SS-3	4	3	2	3	5	●
897.6				6.0	SS-4	4	3	3	2	6	●
				8.0	SS-5	2	2	3	2	5	●
892.6	10.0	Medium dense to loose, wet, dark brown and red, subangular, fine to coarse grained, Silty SAND (SM), 5YR 3/4, 2.5YR 4/6		10.0	SS-6	6	7	8	5	15	●
		SS-6: contains rock fragments		12.0	SS-7	2	2	2	1	4	●
	14.0	SS-7: No recovery.		14.0	SS-8	2	3	6	8	9	●
887.6		ALLUVIUM - Medium dense, wet, orange and black subangular, fine to coarse grained, Silty SAND (SM/A-1-b), 5YR 6/8, 5YR 2.5/1		16.0	SS-9	3	8	11	10	19 X	●
		LL=NP, PL=NP, PI=NP, NMC=17.1, %200=21.0		18.0	SS-10	4	9	9	9	18	●
882.6				20.0	SS-11	4	6	8	10	14	●
	22.0	Medium dense, wet, dark brown and red, subangular, fine to coarse grained, Silty SAND (SM/A-2-4), 5YR 3/4, 2.5YR 4/6		22.0	SS-12	3	11	4	5	15	●
		NMC=29.1		24.0	SS-13	3	3	4	3	7	●
877.6		SS-13: No recovery.		26.0	SS-14	2	2	2	3	4	●
				28.0	SS-15	4	4	5	6	9	●
				30.0							

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 SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 11/28/22

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-24
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	99+44	Offset:	36 RT
Elev.:	902.6 ft	Latitude:	34.87555	Longitude:	-82.74399
Date Started:	10/3/2022				
Total Depth:	73.9 ft	Soil Depth:	63.1 ft	Core Depth:	10.8 ft
Date Completed:	10/3/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 19.9 ft
24HR	22.2 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 O X ▲ FINES CONTENT (%) + RQD (%) ■ REC (%) </div>
867.6	34.0	RESIDUUM - Medium dense, wet, orange, white, dark brown and red, subangular, weakly cemented, fine to coarse grained, Silty SAND (SM/A-4), 5YR 5/8, 5YR 8/1, 5YR 3/4 SS-18: NMC=33.0		32.0	SS-16	1	1	2	2	3	●
				34.0	SS-17	4	3	4	5	7	●
				36.0	SS-18	2	3	7	9	10	●
				38.0	SS-19	7	5	8	8	13	●
				40.0	SS-20	2	3	5	5	8	●
862.6		SS-21: LL=NP, PL=NP, PI=NP, NMC=26.1, %200=39.6		42.0	SS-21	6	7	13	14	20	X ● ○ ▲
				44.0	SS-22	8	12	10	12	22	●
				46.0	SS-23	7	11	22	21	33	●
857.6	46.0	Very dense, wet, orange white, black and brown, subangular, weakly to moderately cemented, fine to coarse grained, Silty SAND (SM/A-2-4), 5YR 5/8, 5YR 8/1, 7.5YR 2.1/1, 7.5YR 3/4 LL=NP, PL=NP, PI=NP, NMC=22.8, %200=16.4		48.0	SS-24	8	20	50		50	X ▲ ○ >> ●
					SS-25	25	30	50		50	>> ●
852.6				53.5							
		SS-26: 2650/6"			SS-26	2650/6"				50/6"	>> ●
847.6				58.5							
		SS-27: NMC=16.5			SS-27	50/5"				50/5"	○ >> ●

LEGEND

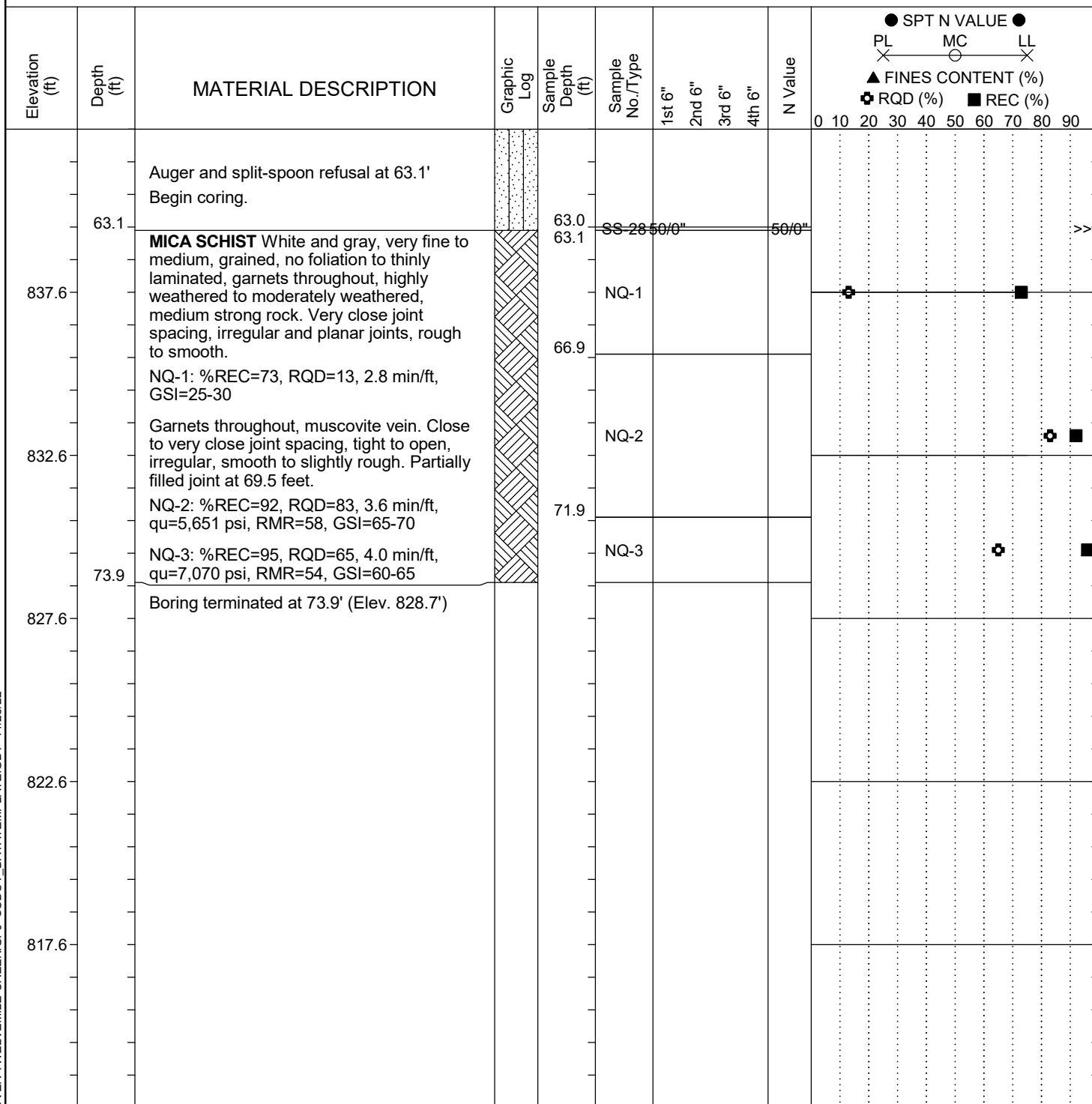
Continued Next Page

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 SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 11/28/22

SCDOT Soil Test Log

Project ID:	P041231	County:	Pickens, SC	Boring No.:	B-24
Site Description:	SC 183 over Twelve Mile Creek			Route:	SC 183
Eng./Geo.:	B. Gedney/HDR	Boring Location:	99+44	Offset:	36 RT
Elev.:	902.6 ft	Latitude:	34.87555	Longitude:	-82.74399
Date Started:	10/3/2022				
Total Depth:	73.9 ft	Soil Depth:	63.1 ft	Core Depth:	10.8 ft
Date Completed:	10/3/2022				
Bore Hole Diameter (in):	2.97"	Sampler Configuration	Liner Required: Y (N)		Liner Used: Y (N)
Drill Machine:	CME 45B	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	81.4%				
Core Size:	NQ	Driller:	D. Harris/F&ME	Groundwater:	TOB 19.9 ft
24HR	22.2 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 SC 183 OVER TWELVEMILE CREEK.GPJ SCDOT_DATATEMPLATE.GDT 11/28/22

Rock Core Photos

B-24

Box 1 of 1 (63.1' to 73.9')





Appendix B. Subsurface Investigation

CPT Logs

Total depth: 25.06 ft, Date: 11/9/2022

Surface Elevation: 902.40 ft

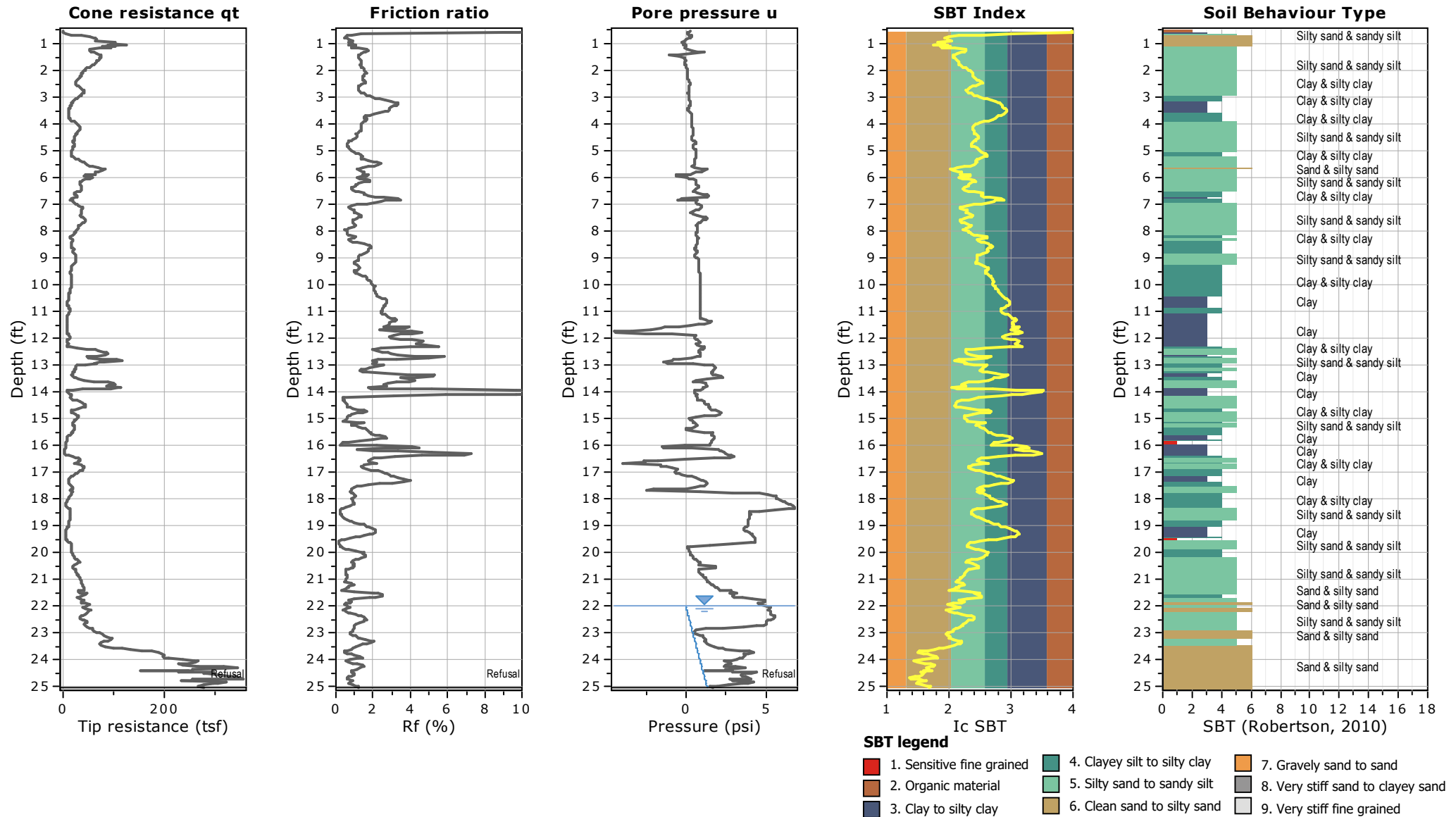
Coords: lat 34.875591° lon -82.743089°

Cone Type: DDG1329

Cone Operator: F&ME Consultants

Project: SC 183 over Twelvemile Creek

Location: Pickens County



Total depth: 38.20 ft, Date: 11/9/2022

Surface Elevation: 902.50 ft

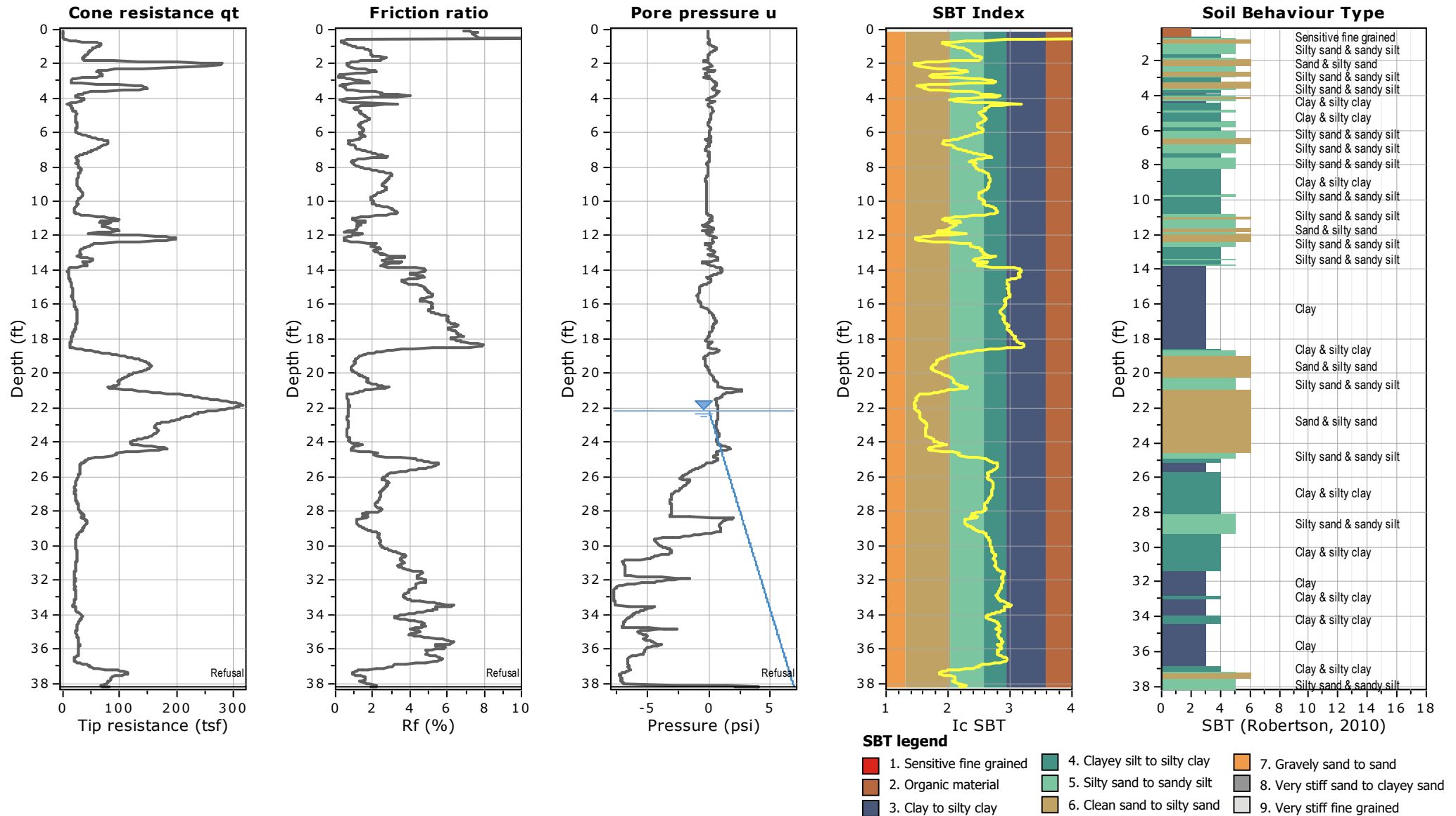
Coords: lat 34.875548° lon -82.744°

Cone Type: DDG1329

Cone Operator: F&ME Consultants

Project: SC 183 over Twelvemile Creek

Location: Pickens County





Appendix B. Subsurface Investigation

Multichannel Analysis of Surface Waves (MASW)

November 17, 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
SC-183 Replacement Bridge over Twelve Mile Creek
Pickens County, South Carolina
F&ME Project No.: G6657.001

Dear Ms. Leon:

On October 10th, 2022, F&ME Consultants performed one (1) Multi-Channel Analysis of Surface Waves (MASW) test near the S-183 bridge over Twelve Mile 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. Ten (10) active shots were performed at various distances (25, 50 and 100 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. Fifty (50) 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-4	1327.4 ft/sec

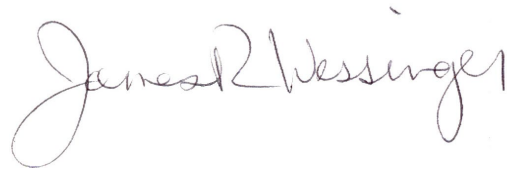
It has been a pleasure working for you on this project and we appreciate the opportunity to be of service. Please contact us if you have any questions or concerns.

Sincerely,

F&ME CONSULTANTS

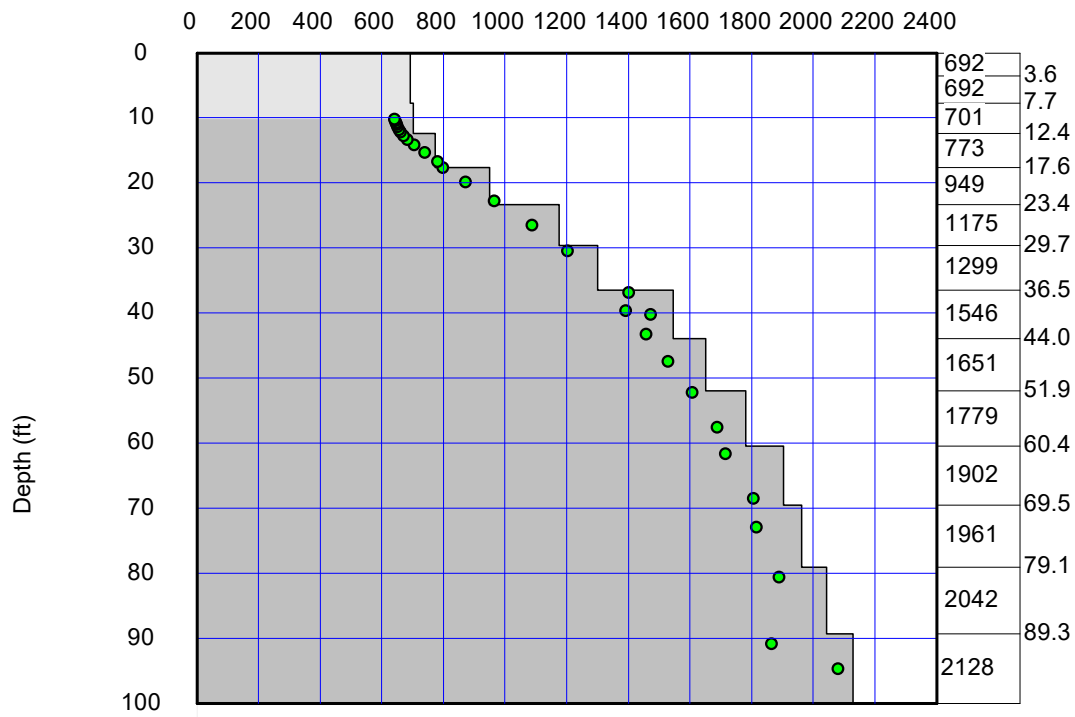


Alex M Chandler, EIT
Geotechnical Staff Professional



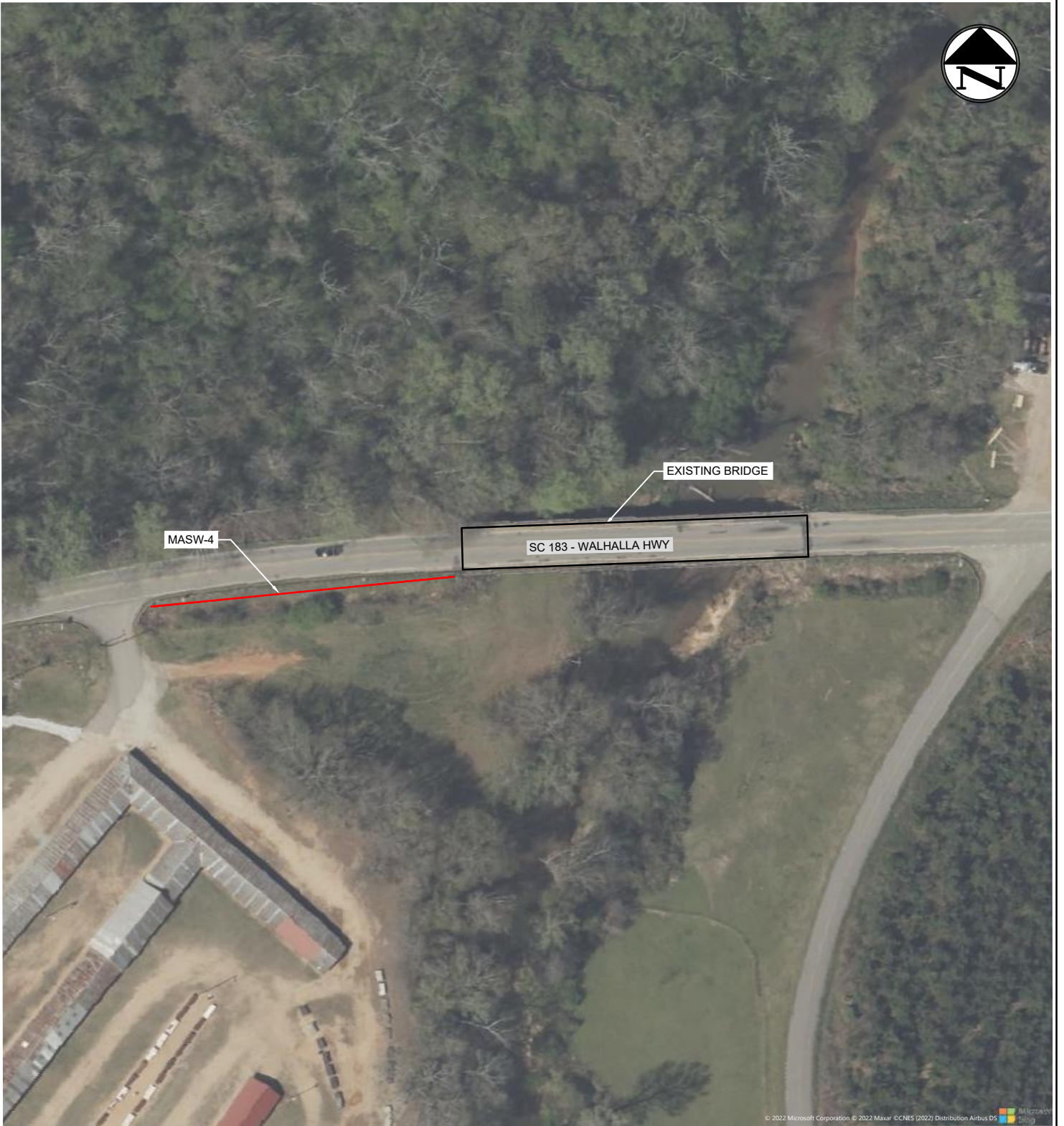
Ricky Wessinger, PG
Chief Geologist


S-wave velocity (ft/s)



S-wave velocity model (initial) : Vs100 SC183 RBO 12 mile cr.rst

Average Vs 100ft = 1327.4 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 11.17.22	GROUP ____ - ____
R/W		DATE	

SC 183 RBO TWELVE MILE CREEK
PICKENS COUNTY, SOUTH CAROLINA

MASW LOCATION PLAN

F&ME JOB NO. G6657.001

SCALE: 1"=100'

FIGURE 1

Appendix C. Laboratory Testing



SUMMARY OF LABORATORY RESULTS

PAGE 1 OF 1

PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-21	6.0	51	22	29	0.075	55	CH	23.4			
B-21	12.0						CH	28.2			
B-21	18.0	28	21	7	0.075	42	SC-SM	34.2			
B-21	22.0						SC-SM	37.5			
B-21	26.0	NP	NP	NP	0.075	18	SM	37.1			
B-22	4.0	NP	NP	NP	0.075	5	SP	22.4			
B-22	8.0						SP	22.8			
B-22	15.0	NP	NP	NP	0.075	31	SM	56.9			
B-23	2.0	NP	NP	NP	0.075	67	ML	21.4			
B-23	6.0						ML	32.3			
B-23	10.0	NP	NP	NP	0.075	29	SM	47.0			
B-23	25.0	NP	NP	NP	0.075	14	SM	53.3			
B-24	6.0						SM	23.8			
B-24	18.0	NP	NP	NP	0.075	21	SM	17.1			
B-24	24.0						SM	29.1			
B-24	36.0						SM	33.0			
B-24	42.0	NP	NP	NP	0.075	40	SM	26.1			
B-24	48.0	NP	NP	NP	0.075	16	SM	22.8			
B-24	60.0						SM	16.5			



Rock Coring Summary

PAGE 1 OF 1

PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q _u (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
B-21	NQ-1	28.0	90	56						53
B-21	NQ-2	31.3	98	53	12890	0.16	3290	168	57	53
B-21	NQ-3	36.3	92	67	22640	0.20	6040	169	54	53
B-22	NQ-1	20.1	92	65	12220	0.15	5050	169	57	68
B-22	NQ-2	24.4	97	84						73
B-22	NQ-3	29.4	95	68	18170	0.05	8260	169	62	68
B-22	NQ-4	34.4	97	78	4800	0.07	1390	162	58	73
B-22	NQ-5	39.4	96	88						68
B-23	NQ-1	31.3	81	59						48
B-23	NQ-2	34.0	94	93	12310	0.17	5190	161	74	83
B-23	NQ-3	39.0	89	67	19390	0.10	5300	159	62	68
B-23	NQ-4	44.0	83	27						28
B-23	NQ-5	49.0	58	60						58
B-24	NQ-1	63.1	73	13						28
B-24	NQ-2	66.9	92	83	5651	0.18	2890	172	58	68
B-24	NQ-3	71.9	96	65	7070	0.04	2960	165	54	63



INDEX PROPERTIES VERSUS DEPTH

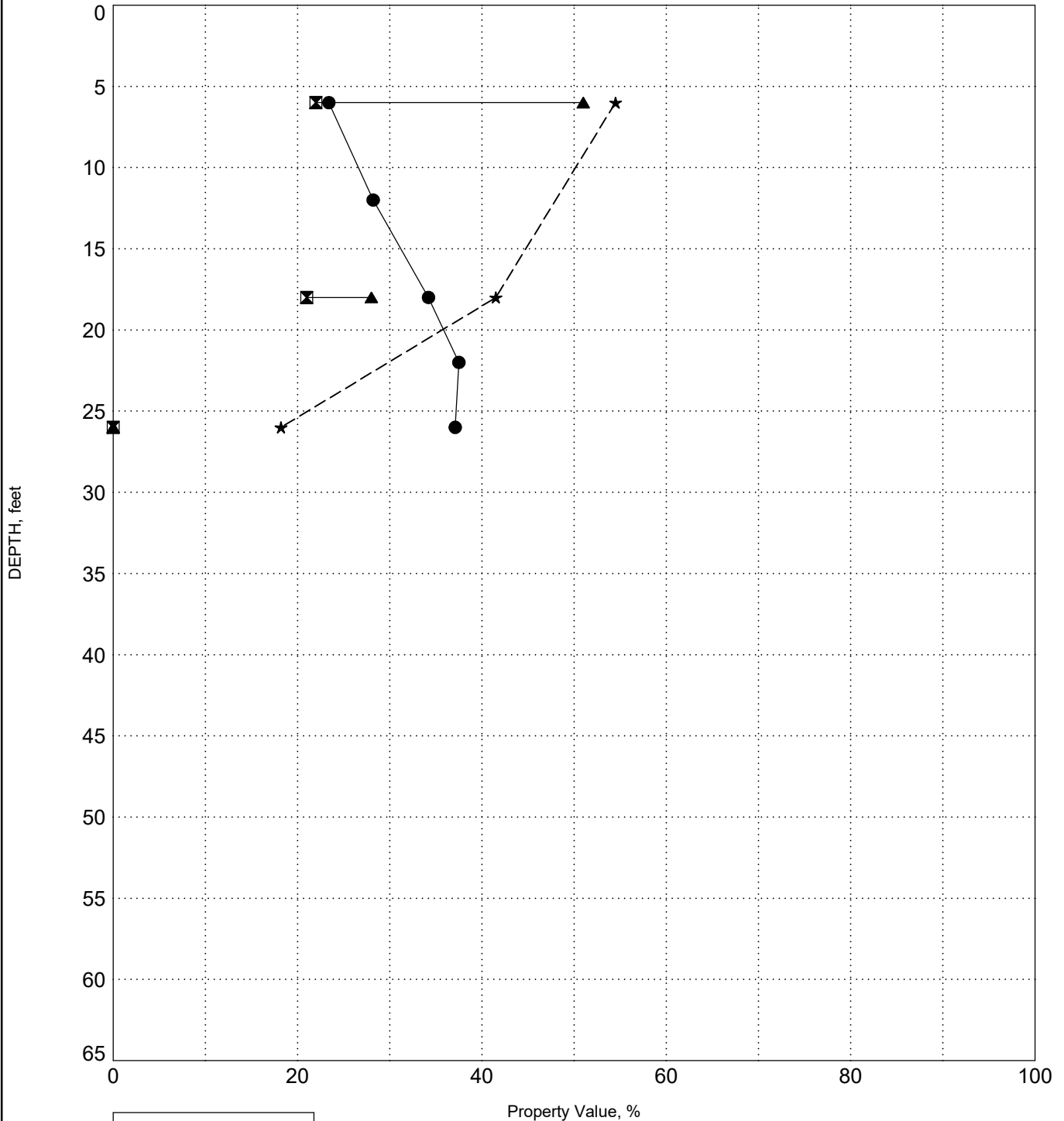
PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

SURFACE ELEVATION: 902.4

BORING B-21



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



INDEX PROPERTIES VERSUS DEPTH

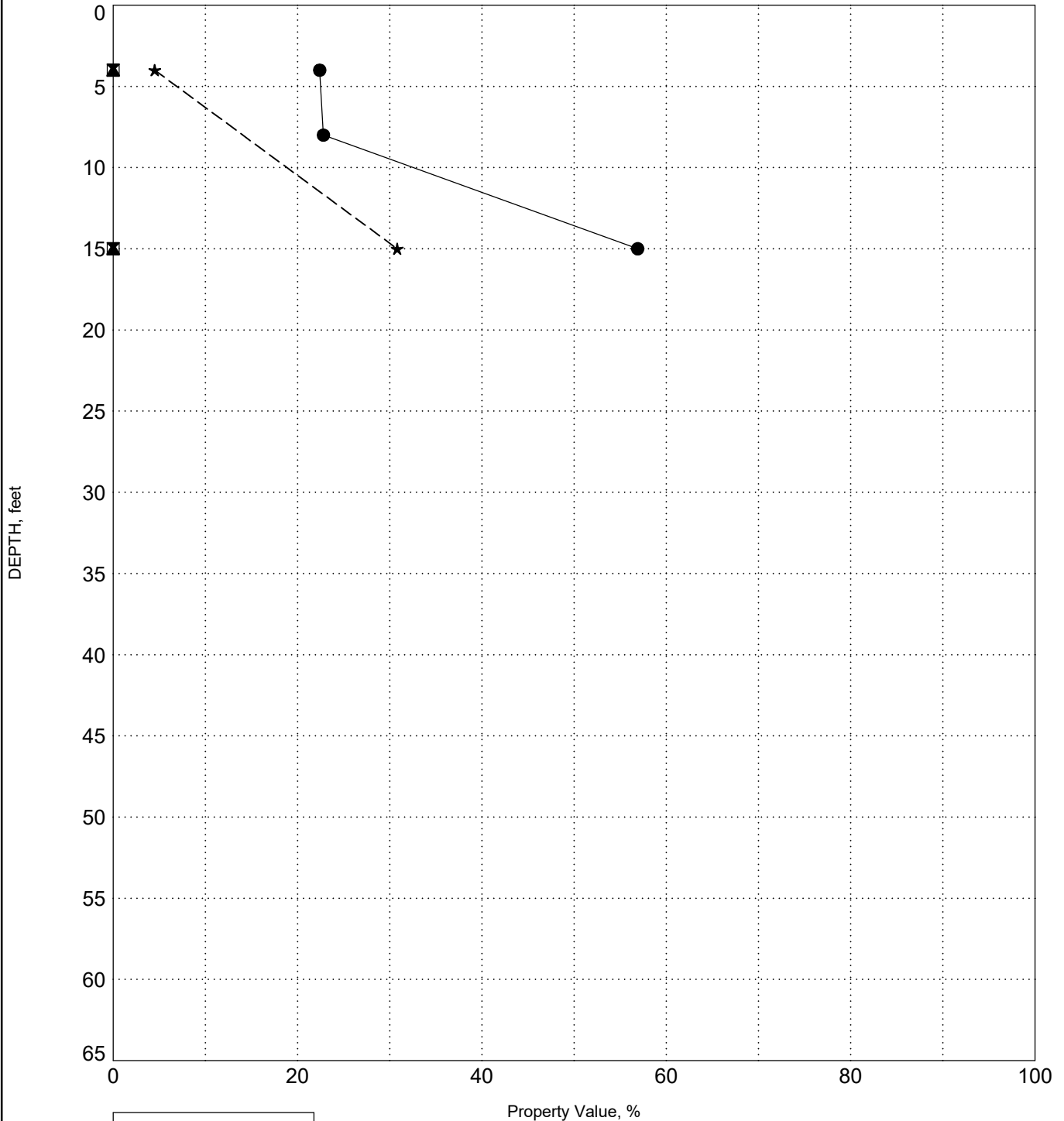
PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

SURFACE ELEVATION: 880.6

BORING B-22



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



INDEX PROPERTIES VERSUS DEPTH

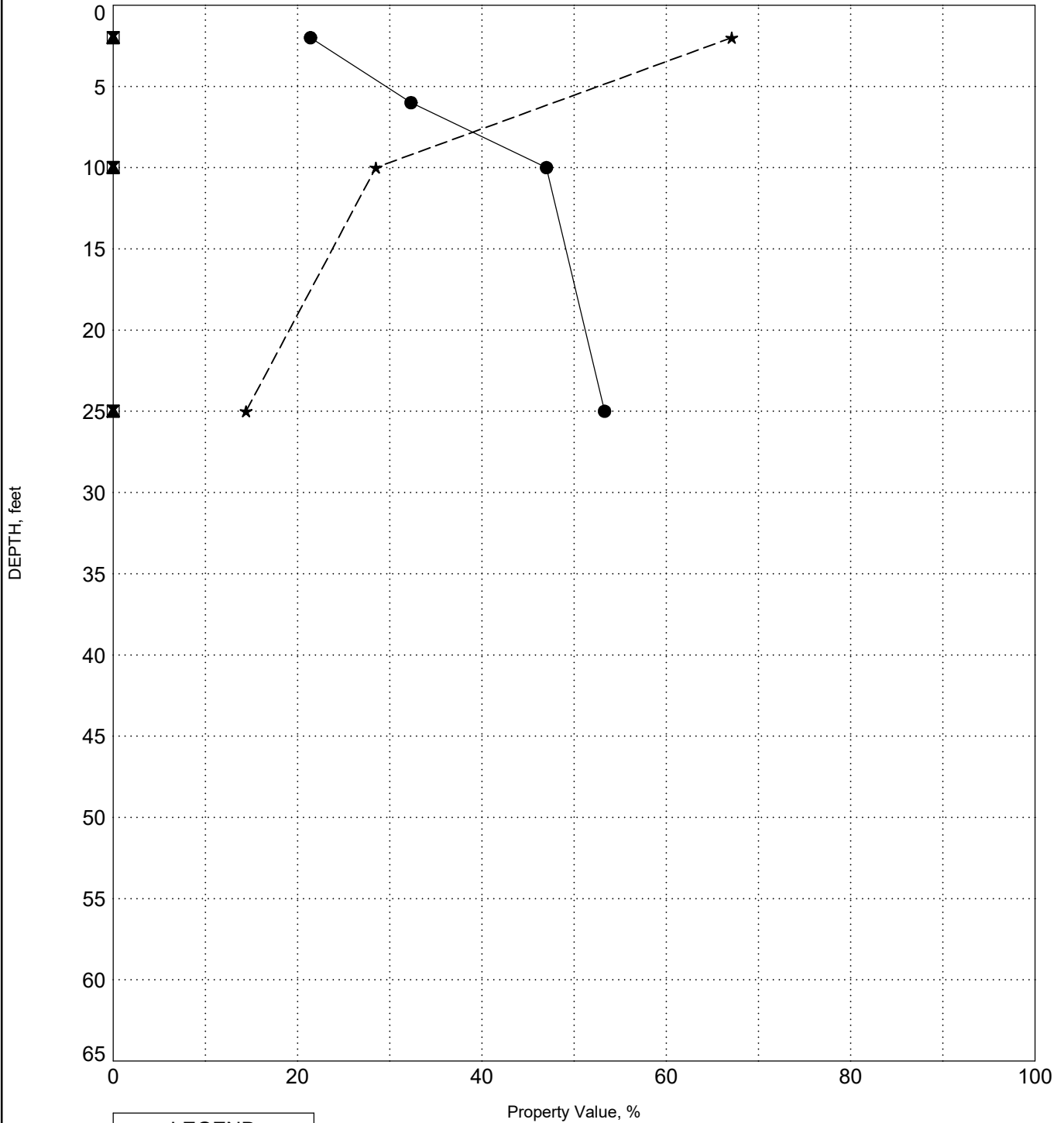
PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

SURFACE ELEVATION: 889.7

BORING B-23



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



INDEX PROPERTIES VERSUS DEPTH

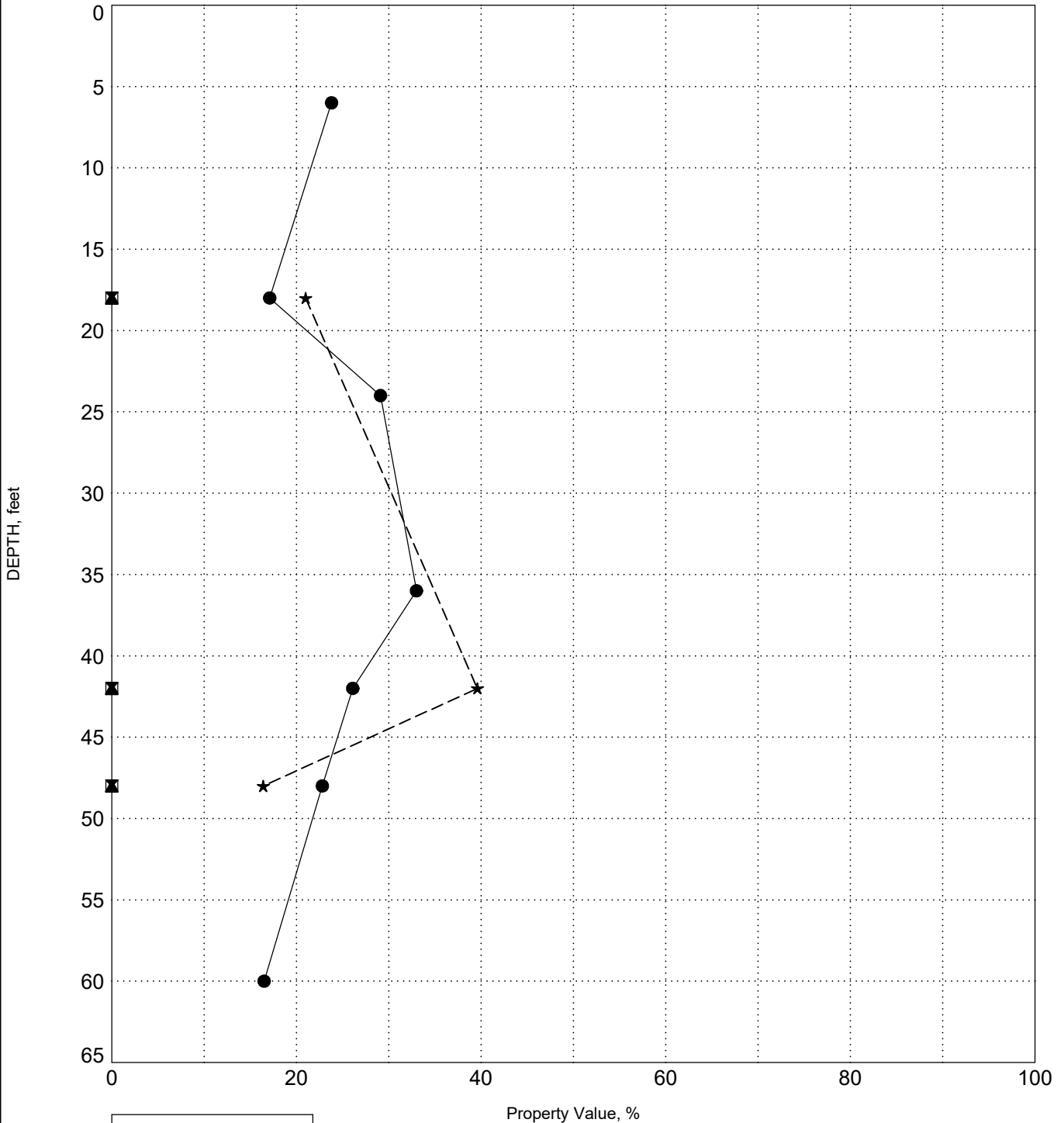
PROJECT ID P041231

PROJECT NAME SC 183 over Twelvemile Creek

PROJECT COUNTY Pickens, SC

SURFACE ELEVATION: 902.6

BORING B-24



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- μ 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/ft³ (600kN-m/m³)).

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

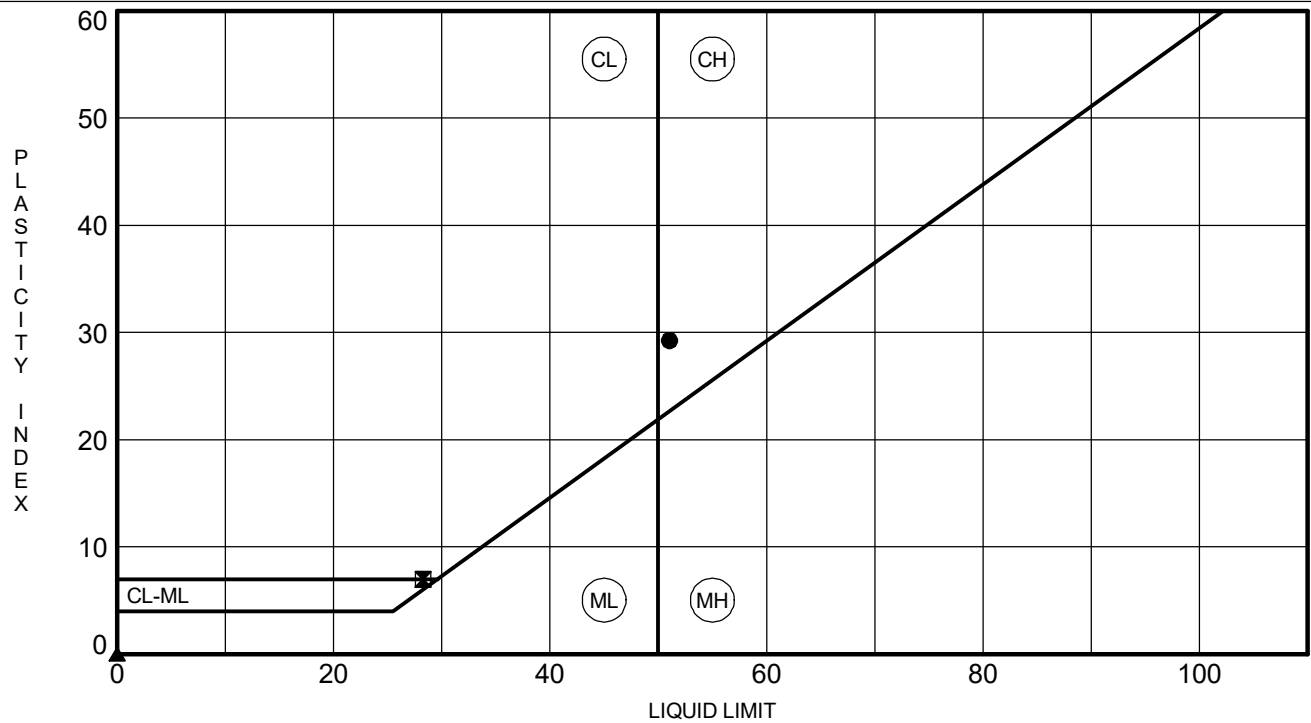
Split Spoon Samples



PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC

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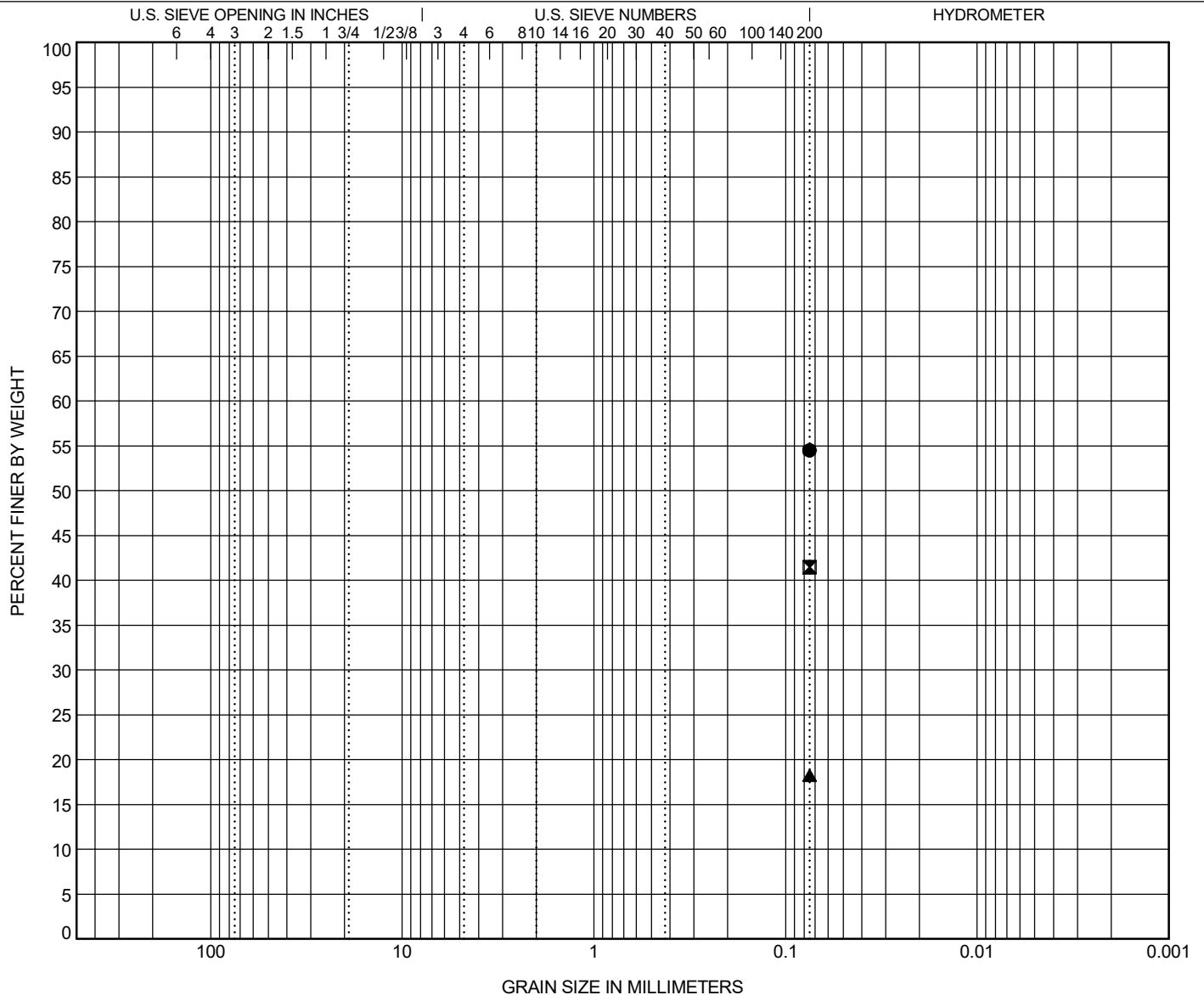


GRAIN SIZE DISTRIBUTION

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-21	6.0	SANDY FAT CLAY (CH/A-7-6)					51	22	29		
☒ B-21	18.0	SILTY, CLAYEY SAND (SC-SM/A-4)					28	21	7		
▲ B-21	26.0	SILTY SAND (SM/A-2-4)					NP	NP	NP		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-21	6.0	0.075						54.5			
☒ B-21	18.0	0.075						41.5			
▲ B-21	26.0	0.075						18.2			

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 183 RBO Twelve Mile Creek **SCDOT PROJECT ID:** P041321
SAMPLE NUMBER: 22-2790 **DATE SAMPLE RECEIVED:** 10/10/2022
DESCRIPTION OF SOIL: Various
TESTED BY: CM & DH **DATE SETUP:** 10/11/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 10/12/2022

BORING NO.	B-21	B-21	B-21	B-21	B-21
SAMPLE NO.	SS-3	SS-6	SS-9	SS-11	SS-13
SAMPLE DEPTH (FT.)	4.0 - 6.0	10.0 - 12.0	16.0 - 18.0	20.0 - 22.0	24.0 - 26.0
WATER CONTENT, W%	23.4	28.2	34.2	37.5	37.1

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%					



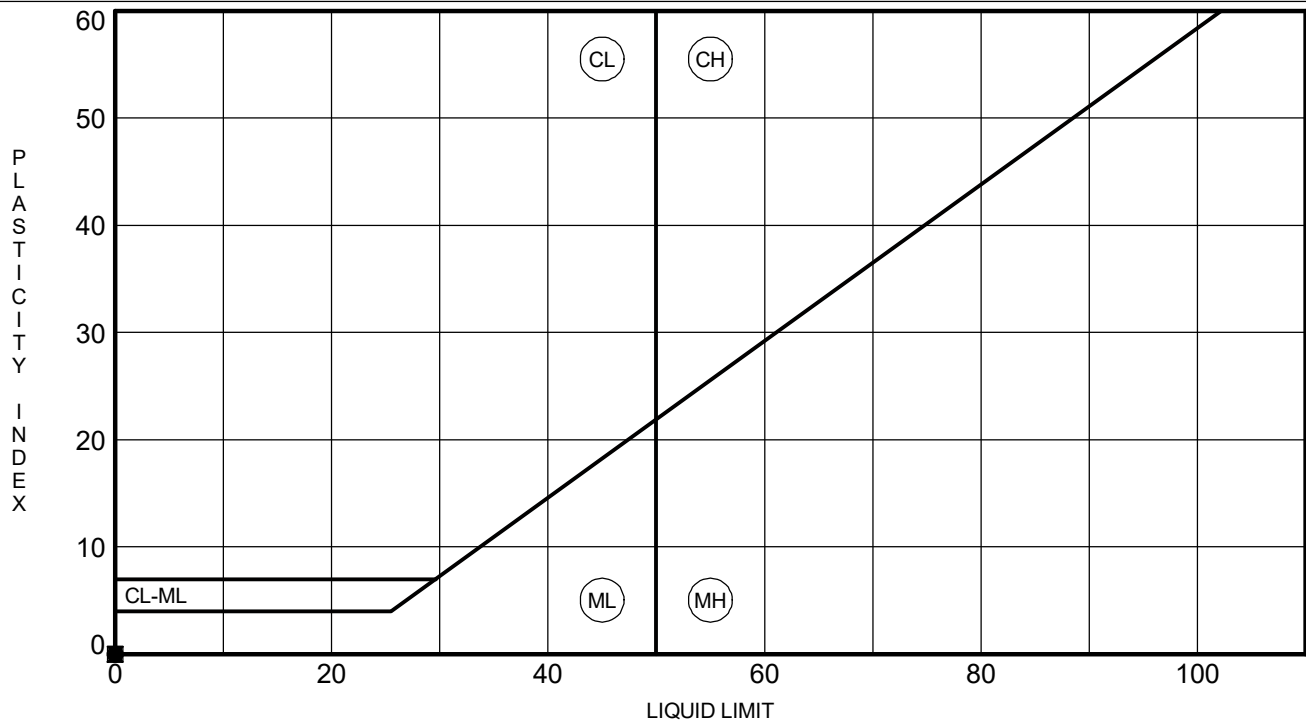
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ATTERBERG LIMITS' RESULTS

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC

[illegible]

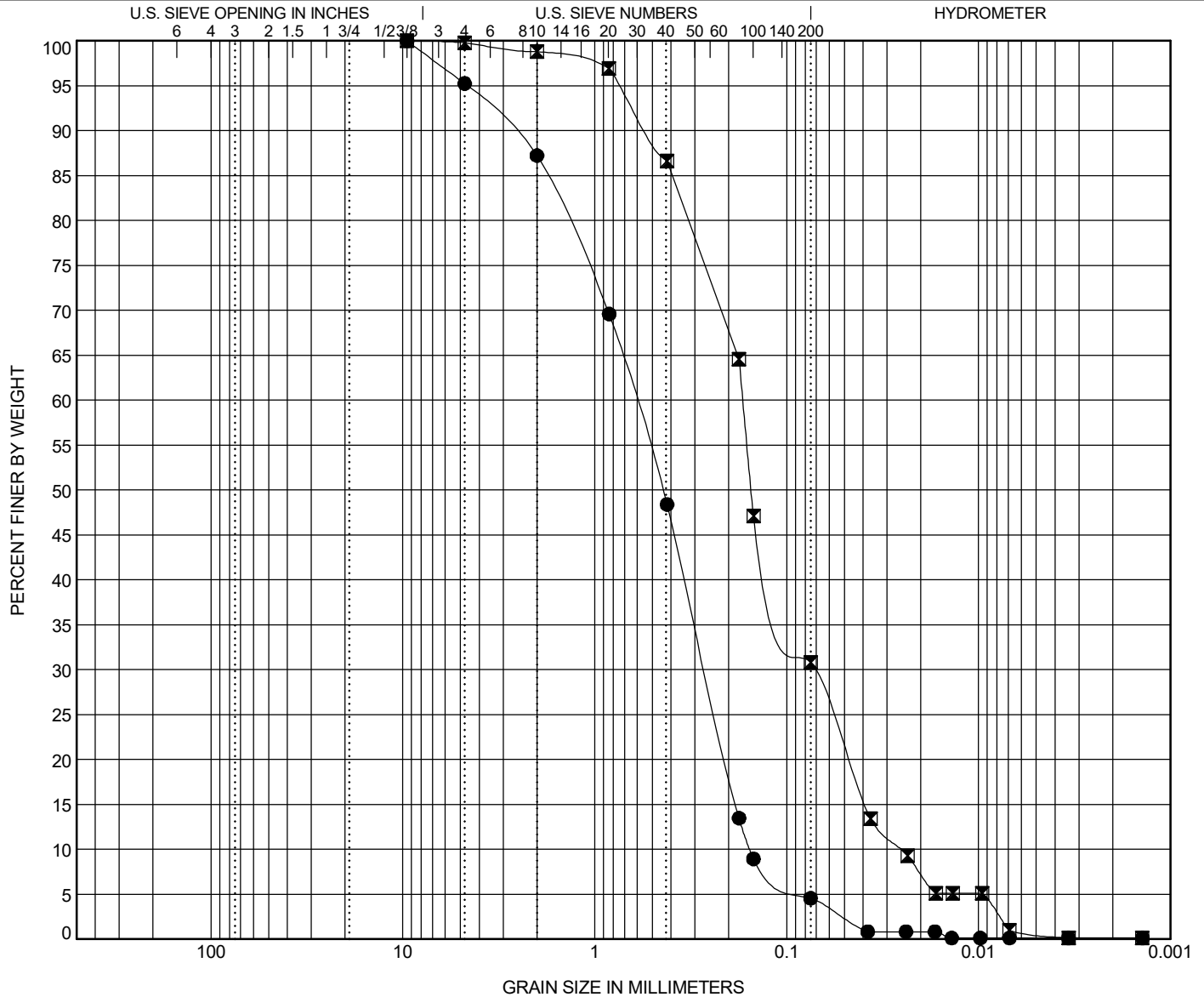


GRAIN SIZE DISTRIBUTION

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-22	4.0	POORLY GRADED SAND (SP/A-1-b)					NP	NP	NP	0.75	3.96
✕ B-22	15.0	SILTY SAND (SM/A-2-4)					NP	NP	NP	1.23	6.70
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-22	4.0	9.5	0.614	0.266	0.155	4.8	90.7	4.4		0.1	
✕ B-22	15.0	9.5	0.169	0.072	0.025	0.2	68.9	30.2		0.6	

GRAIN SIZE G6657.001 - SC 183 RBO TWELVE MILE CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 10/19/22

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 183 RBO Twelve Mile Creek **SCDOT PROJECT ID:** P041321
SAMPLE NUMBER: 22-2791 **DATE SAMPLE RECEIVED:** 10/10/2022
DESCRIPTION OF SOIL: Various
TESTED BY: CM & DH **DATE SETUP:** 10/11/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 10/12/2022

BORING NO.	B-22	B-22	B-22		
SAMPLE NO.	SS-2	SS-4	SS-6		
SAMPLE DEPTH (FT.)	2.0 - 4.0	6.0 - 8.0	13.5 - 15.0		
WATER CONTENT, W%	22.4	22.8	56.9		

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%					



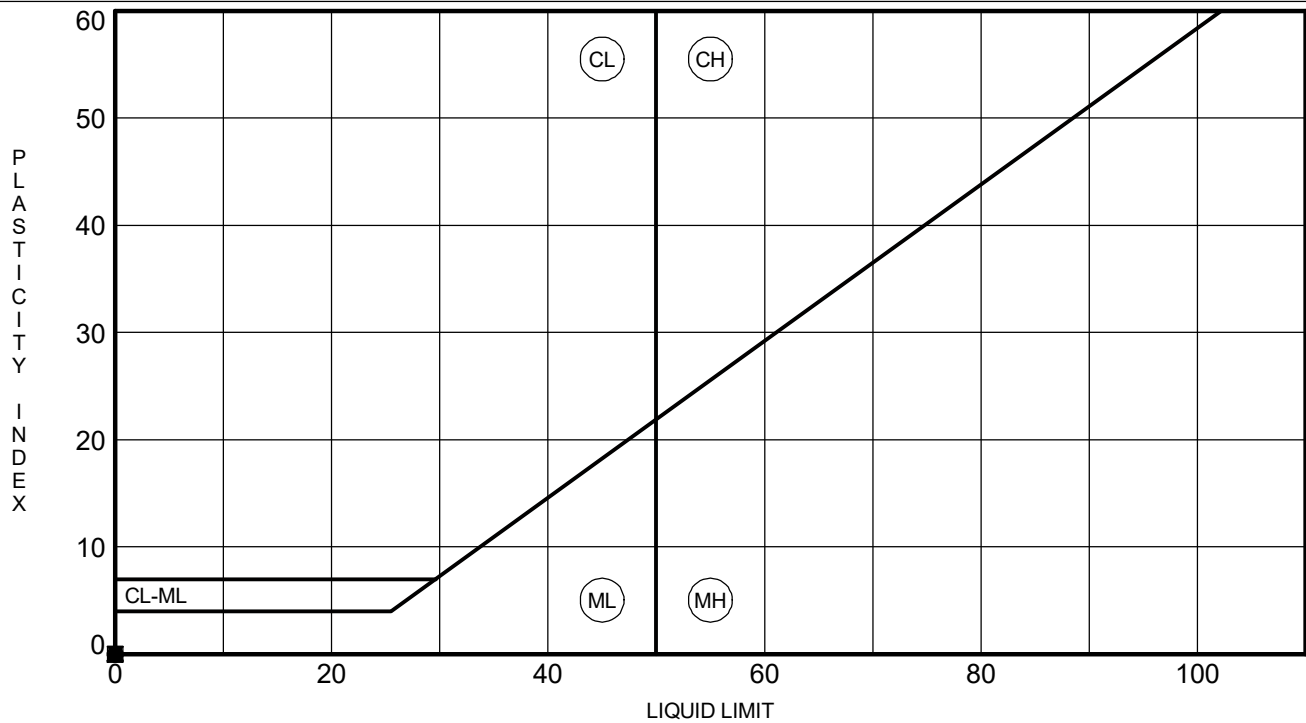
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ATTERBERG LIMITS' RESULTS

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC

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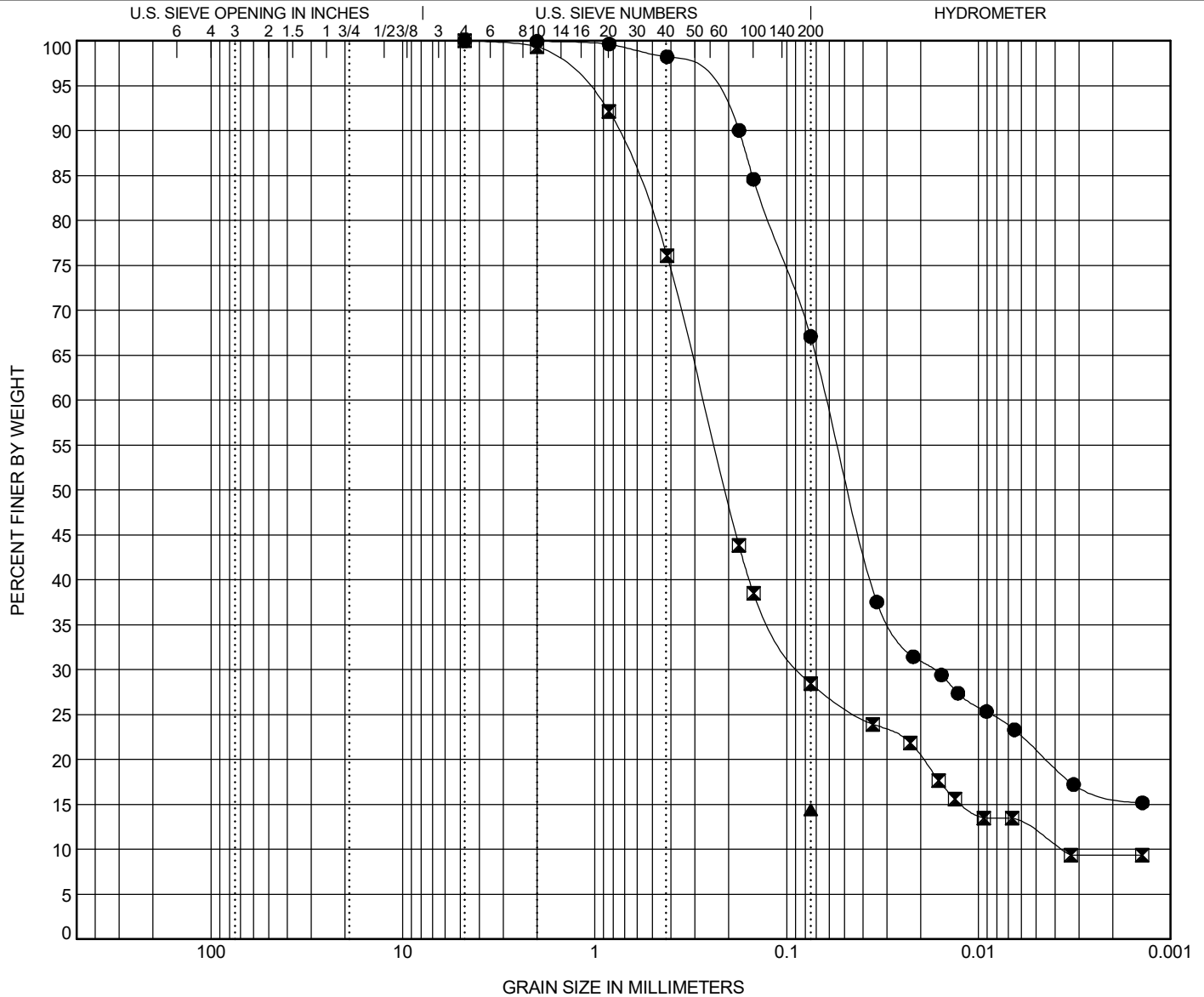


GRAIN SIZE DISTRIBUTION

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE		DEPTH	Classification					LL	PL	PI	Cc	Cu
●	B-23	2.0	SANDY SILT (ML/A-4)					NP	NP	NP		
▣	B-23	10.0	SILTY SAND (SM/A-2-4)					NP	NP	NP	6.88	73.92
▲	B-23	25.0	SILTY SAND (SM/A-2-4)					NP	NP	NP		
BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay		
●	B-23	2.0	4.76	0.062	0.017		0.0	32.9	46.0	21.1		
▣	B-23	10.0	4.76	0.273	0.083	0.004	0.0	71.5	16.7	11.8		
▲	B-23	25.0	0.075						14.4			

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 183 RBO Twelve Mile Creek **SCDOT PROJECT ID:** P041321
SAMPLE NUMBER: 22-2792 **DATE SAMPLE RECEIVED:** 10/10/2022
DESCRIPTION OF SOIL: Various
TESTED BY: CM & DH **DATE SETUP:** 10/11/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 10/12/2022

BORING NO.	B-23	B-23	B-23	B-23	
SAMPLE NO.	SS-1	SS-3	SS-5	SS-8	
SAMPLE DEPTH (FT.)	0.0 - 2.0	4.0 - 6.0	8.0 - 10.0	23.5 - 25.0	
WATER CONTENT, W%	21.4	32.3	47.0	53.3	

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

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

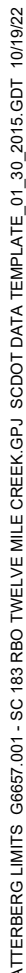
BORING NO.					
SAMPLE NO.					
SAMPLE DEPTH (FT.)					
WATER CONTENT, W%					



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PROJECT COUNTY Pickens County, SC

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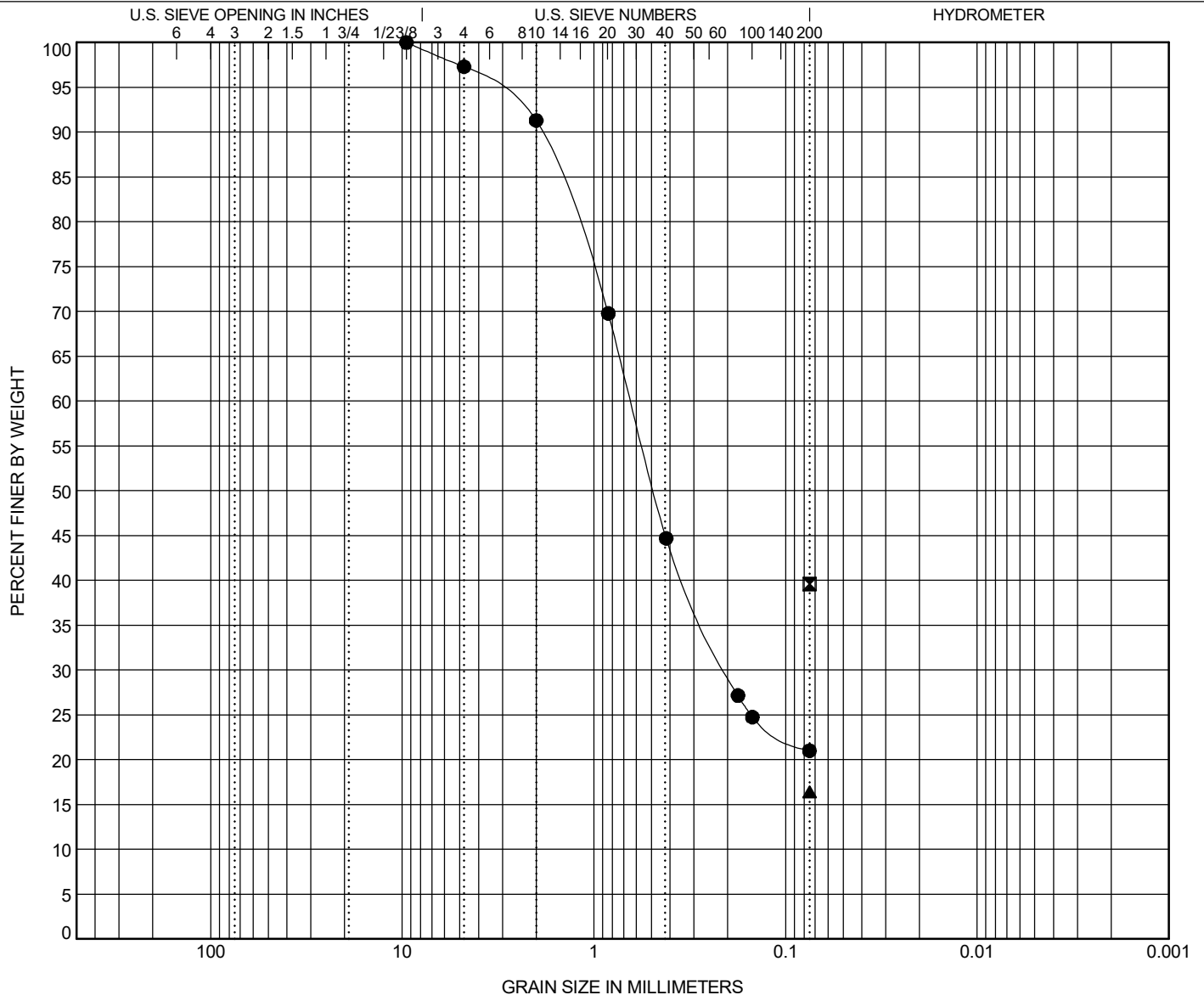


GRAIN SIZE DISTRIBUTION

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● B-24	18.0	SILTY SAND (SM/A-1-b)					NP	NP	NP		
☒ B-24	42.0	SILTY SAND (SM/A-4)					NP	NP	NP		
▲ B-24	48.0	SILTY SAND (SM/A-2-4)					NP	NP	NP		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● B-24	18.0	9.51	0.641	0.204		2.7	76.3	21.0			
☒ B-24	42.0	0.075						39.6			
▲ B-24	48.0	0.075						16.4			

GRAIN SIZE G6657.001 - SC 183 RBO TWELVE MILE CREEK GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 10/19/22

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 183 RBO Twelve Mile Creek **SCDOT PROJECT ID:** P041321
SAMPLE NUMBER: 22-2793 **DATE SAMPLE RECEIVED:** 10/10/2022
DESCRIPTION OF SOIL: Various
TESTED BY: CM & DH **DATE SETUP:** 10/11/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 10/12/2022

BORING NO.	B-24	B-24	B-24	B-24	B-24
SAMPLE NO.	SS-3	SS-9	SS-12	SS-18	SS-21
SAMPLE DEPTH (FT.)	4.0 - 6.0	16.0 - 18.0	22.0 - 24.0	34.0 - 36.0	40.0 - 42.0
WATER CONTENT, W%	23.8	17.1	29.1	33.0	26.1

BORING NO.	B-24	B-24			
SAMPLE NO.	SS-24	SS-27			
SAMPLE DEPTH (FT.)	46.0 - 48.0	58.5 - 60.0			
WATER CONTENT, W%	22.8	16.5			

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

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



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F&ME CONSULTANTS
3112 Devine Street
Columbia, South Carolina 29205

pH Determination
(AASHTO T289)

Project Name:	SC 183 RBO Twelve Mile Creek	Project Number:	G6657.001
Sample Location:	B-24	Sample Elevation/Depth:	14.0' - 24.0'
Description of Sample:	--	Date Sampled:	10/10/2022
Tested By:	RC	Date Tested:	10/17/2022

Sample ID	B-24			
FME Lab ID No.	22-2793			
Pan No.	D			
Depth (ft.)	14.0 - 20.0			
pH Value	5.69			
Temperature (°C)	19.60			

Date Reviewed: 10/18/2022Reviewed By: 

**SOIL RESISTIVITY
(AASHTO T288)**

Project Name:	SC 183 RBO 12 Mile Creek	Project ID:	P041321
Location:	Pickens County, SC	FME Lab ID No.:	22-2793
Sampled By:	HDR	Date Sampled:	10/10/2022
Soil Description:	Silty <u>SAND (SM/A-1-b)</u>	Date Received:	10/10/2022
Tested By:	AA	Date Tested:	10/18/2022

Boring No.	Sample Depth (ft.)	Minimum Soil Resistivity, Ω -cm
B-24	14.0 - 20.0	17,020

Date Reviewed: 10/19/2022 Reviewed By: J. Hiers

CHLORIDE ION CONTENT IN SOILS

AASHTO T 291 - 94 (2018) (Method B)

Client: F&ME Consultants, Inc.
 Client Reference: Twelve Mile Cr. G6657.001
 Project No.: 2022-738-001
 Lab ID: 2022-738-001-001

Boring No.: B-24
 Depth (ft): 14.0-20.0'
 Sample No.: SS-8/SS-9/SS-10
 Description: Red Soil

(- # 10 Sieve material)

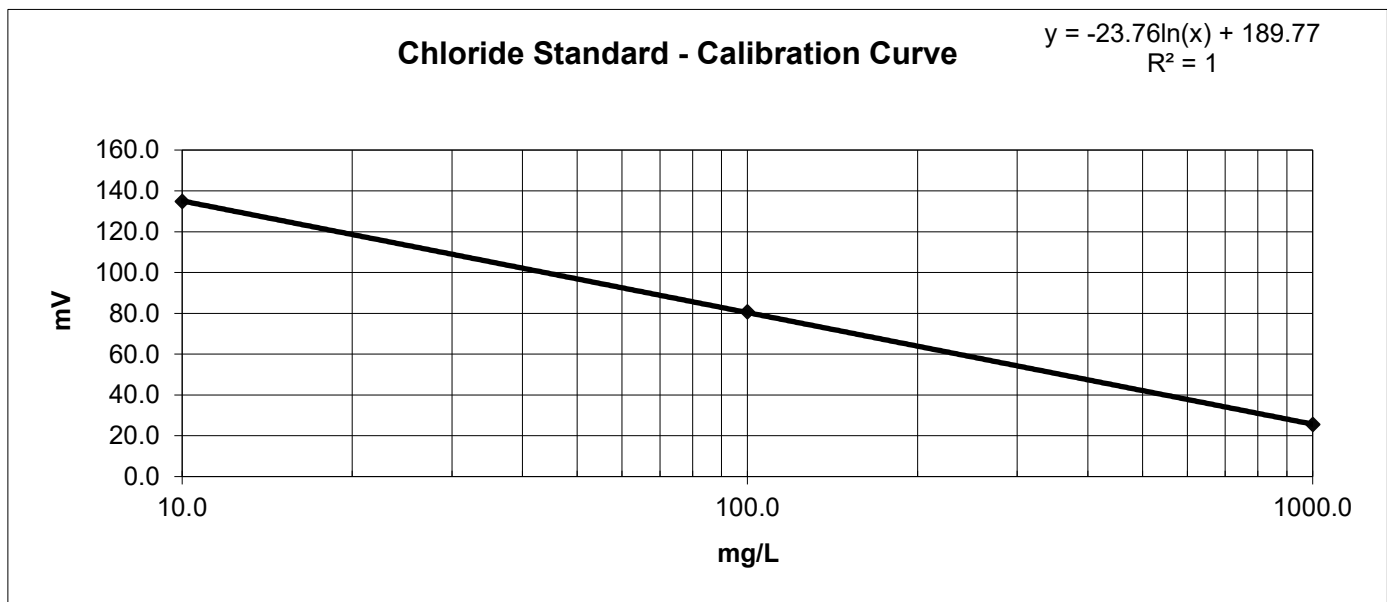
CHLORIDE STANDARD: CALIBRATION CURVE

STANDARD	MILLIVOLTS (mV)
10.0 mg/L	134.9
100.0 mg/L	80.7
1000.0 mg/L	25.5

MEASUREMENT OF CHLORIDES

Sample Weight (g):	100.0	CONCENTRATION	CONCENTRATION
Water added to Sample (ml):	100.0	(mg/L)	(mg/kg)
Size of Sample Aliquot (ml):	25.0		
Sample Reading (mV):	101.9	40.40	40.40

Notes: 1) Samples and standards were buffered by the addition of an equal volume of the 0.2 M KNO₃ solution (1:1 volume).
 2) Samples were dried for a minimum of 12 hours at 110 °F ± 5°C.



Notes:

Tested By JAM Date 11/3/22 Checked By BRB Date 11/3/22

Water-Soluble Sulfate Ion Content in Soil

AASHTO T 290-95 (2020)

Client: F&ME Consultants, Inc.
 Client Reference: Twelve Mile Cr. G6657.001
 Project No.: 2022-738-001
 Lab ID: 2022-738-001-001

Boring No.: B-24
 Depth (ft): 14.0-20.0'
 Sample No.: SS-8/SS-9/SS-10
 Soil Description: Red Soil

Sulfate Standard - Calibration Curve Spectrophotometer Readings

<u>Sulfate Ion Concentrations (mg/L)</u>								
0.0	4.0	10.0	20.0	30.0	40.0	60.0	80.0	100.0
<u>Spectrophotometer Readings (FAU)</u>								
Underrange	Underrange	6	22	47	68	129	179	241

Measurement of Barium Chloride Turbidity

(Sample contains 5.0 mL NaCl solution and 0.3 g BaCl₂·2H₂O)

Sample Weight (g): 100.0
 Water added to Sample (mL): 300.0
 Size of Sample Aliquot (mL): 50.0
 Sample Reading (FAU): 6

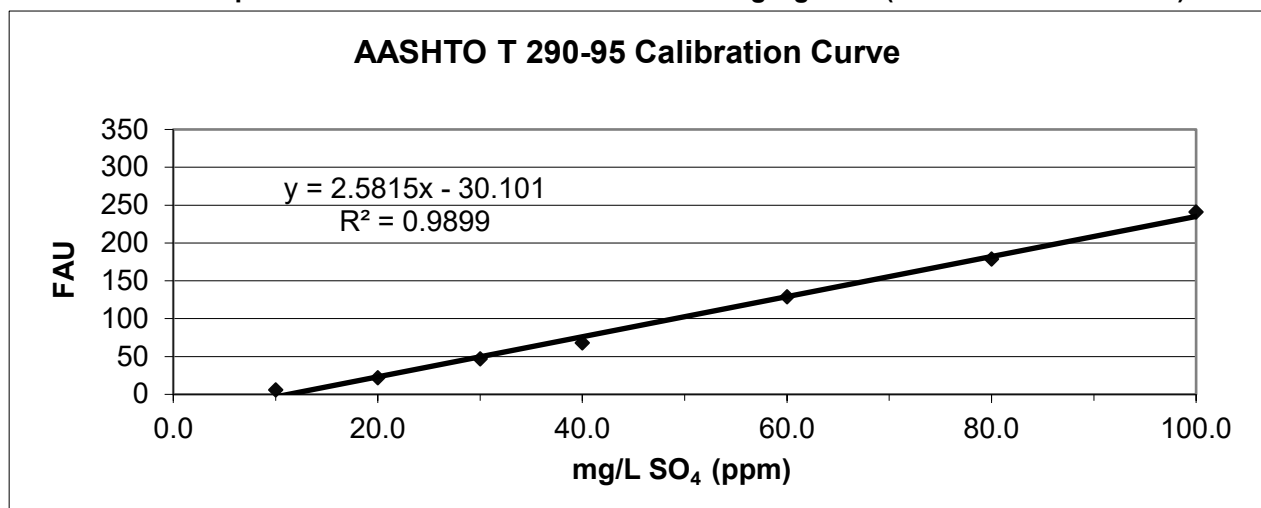
Sample Diluted: No

Sulfate Solution Added (ml): 0

Sample Moisture Content

Tare Number: 630
 Weight of Tare & Wet Sample (g): 200.39
 Weight of Tare & Dry Sample (g): 198.25
 Weight of Tare (g): 82.18
 Weight of Water (g): 2.14
 Weight of Dry Sample (g): 116.07
 Moisture Content (%): 1.84

Sample Sulfate Ion Concentration:	13.98	mg/L SO ₄ (ppm)
Sample Sulfate Ion Content:	42.0	mg/Kg SO ₄ (not corrected for moisture)
Sample Sulfate Ion Content:	42.7	mg/Kg SO ₄ (corrected for moisture)



Tested by: JAM Date: 11/3/22 Checked by: BRB Date: 11/3/2022

page 1 of 1 DCN: CT-S87 DATE: 3/5/2020 REVISION: 1



Appendix C. Laboratory Testing

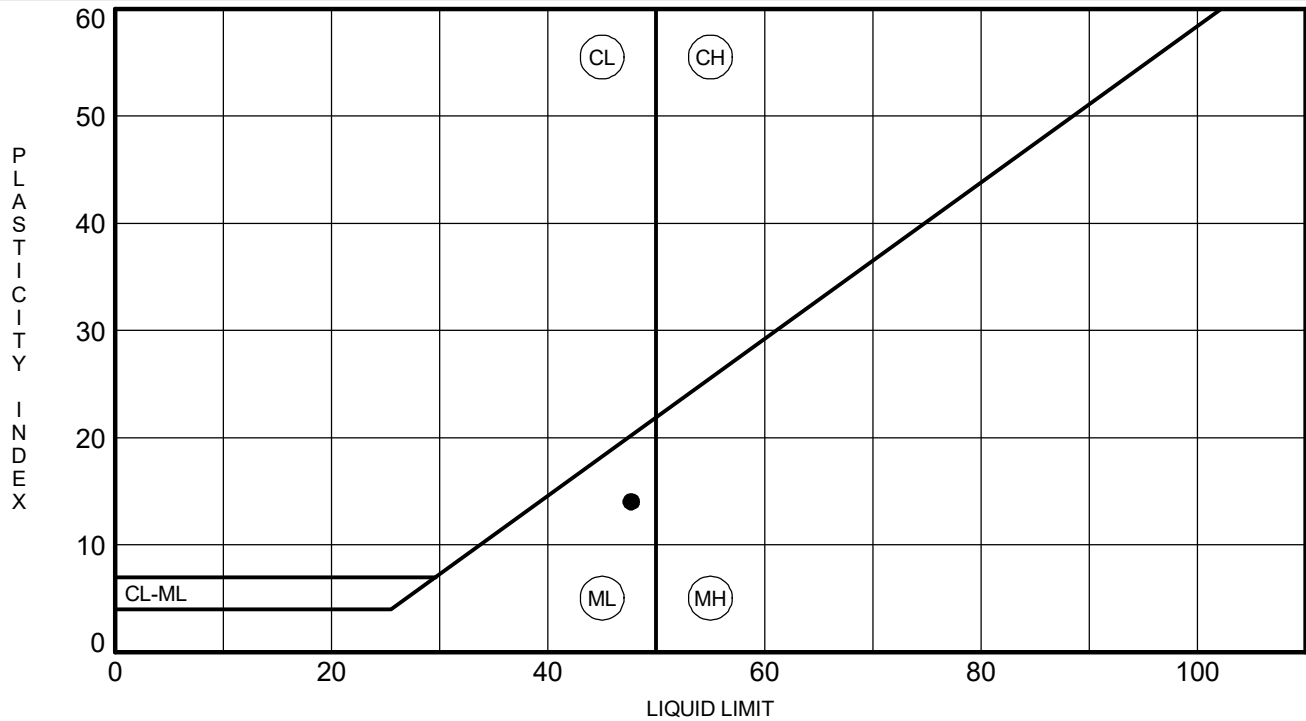
Bulk Samples

ATTERBERG LIMITS' RESULTS

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC

[illegible]

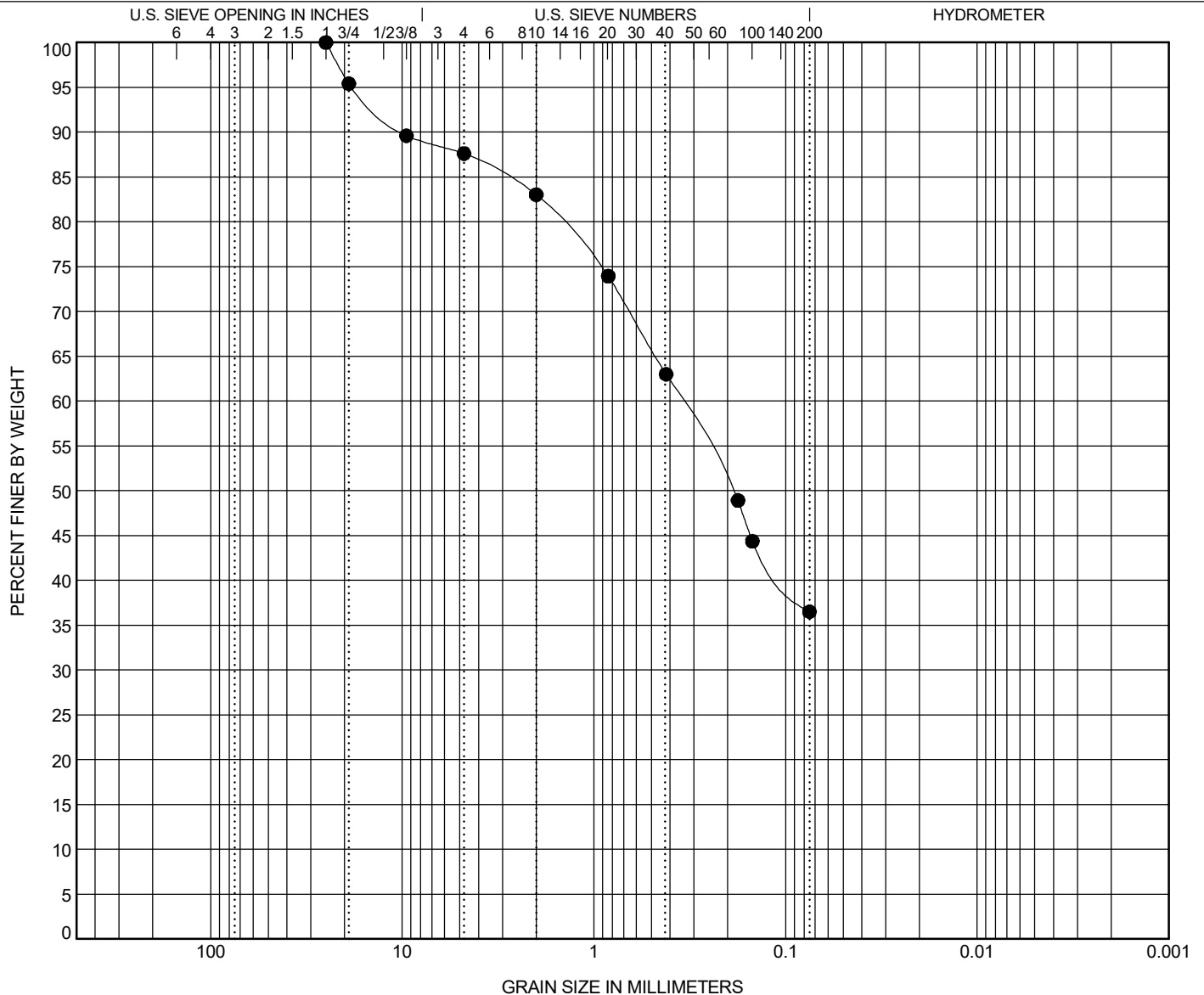


GRAIN SIZE DISTRIBUTION

PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile Creek

PROJECT COUNTY Pickens County, SC



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification					LL	PL	PI	Cc	Cu
● BS-1	5.0	SILTY SAND (SM/A-7-5)					48	34	14		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BS-1	5.0	25	0.349			12.4	51.1	36.5			

GRAIN SIZE G6657.001 - SC 183 RBO TWELVE MILE CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 10/19/22

F&ME CONSULTANTS, INC.

MOISTURE CONTENT DETERMINATION (AASHTO T265)

PROJECT: SC 183 RBO Twelve Mile Creek **SCDOT PROJECT ID:** P041321
SAMPLE NUMBER: 22-2224 **DATE SAMPLE RECEIVED:** 10/10/2022
DESCRIPTION OF SOIL: Silty SAND (SM/A-7-5)
TESTED BY: CM & DH **DATE SETUP:** 10/11/2022
WEIGHED BY: MD **DATE OF WEIGHING:** 10/12/2022

BORING NO.	BS-1				
SAMPLE NO.	--				
SAMPLE DEPTH (FT.)	0.0 - 5.0				
WATER CONTENT, W%	10.8				

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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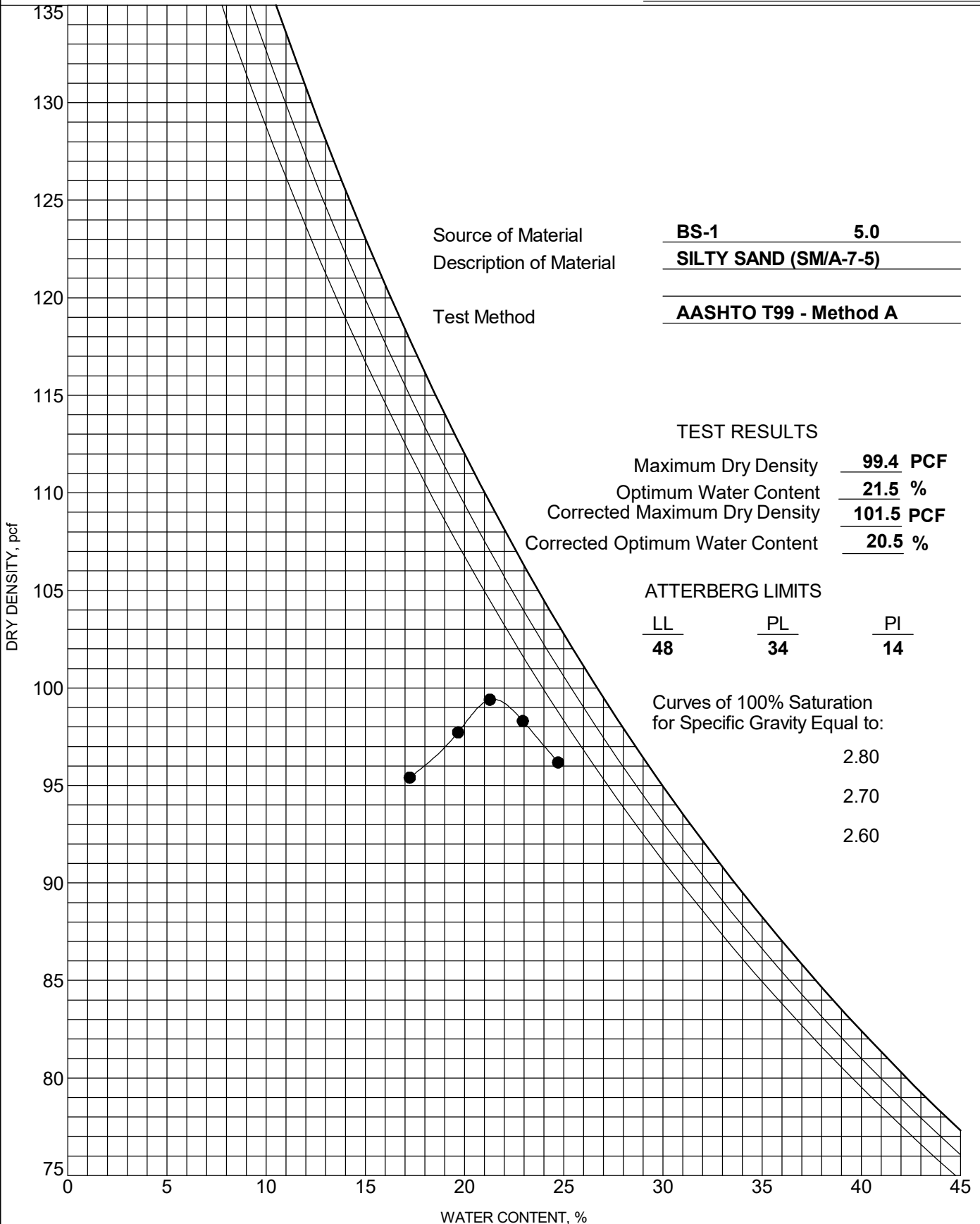


MOISTURE-DENSITY RELATIONSHIP

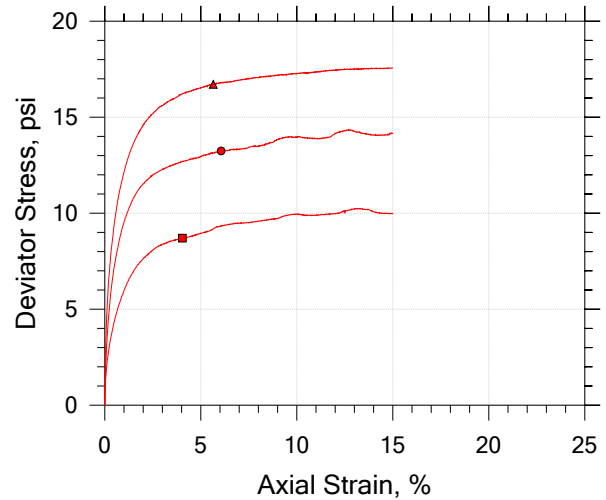
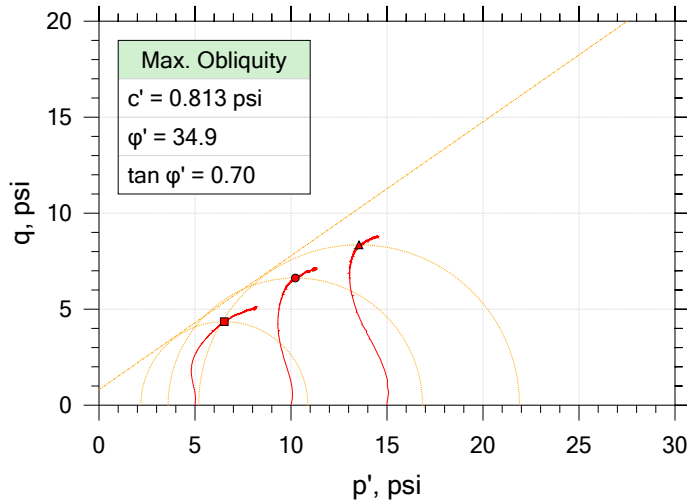
PROJECT ID P041231

PROJECT NAME SC 183 RBO Twelve Mile

Creek PROJECT COUNTY Pickens County, SC



Consolidated Undrained by AASHTO T297

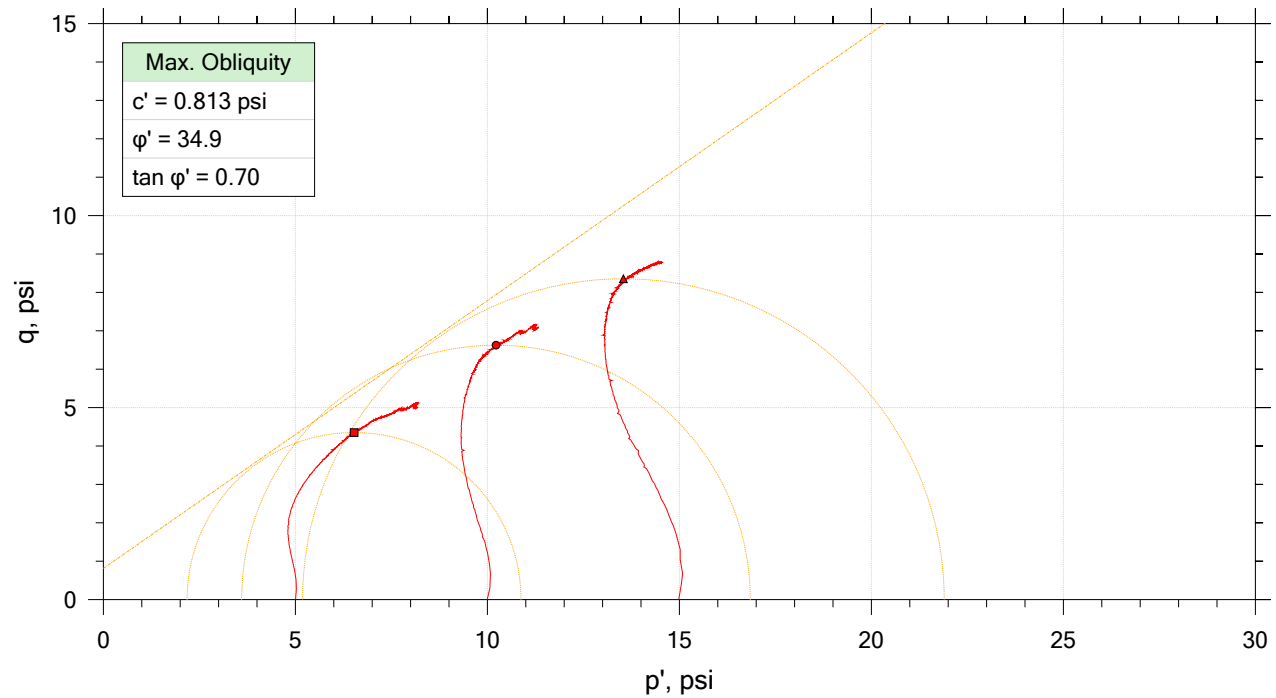
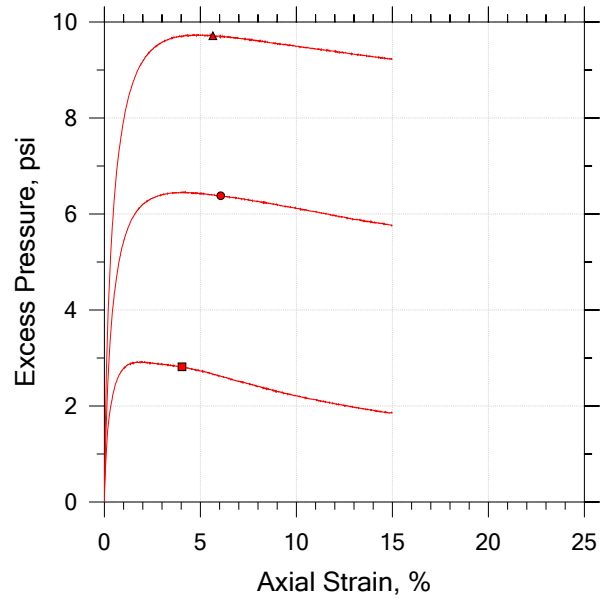
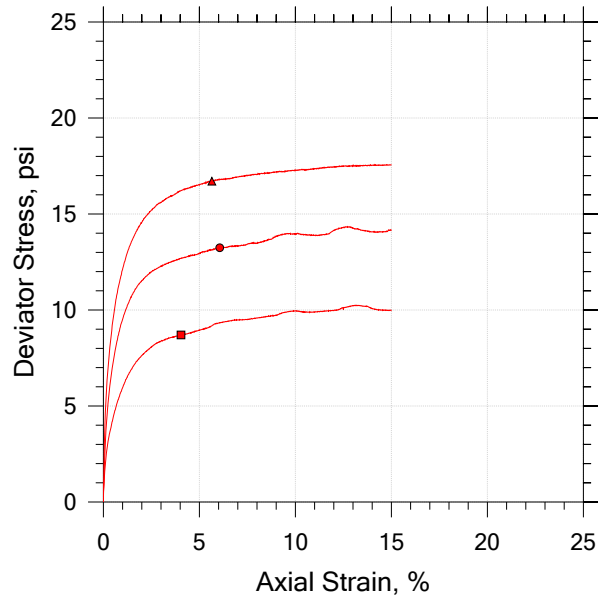


Symbol	■	●	▲	
Sample ID	22-2794	22-2794	22-2794	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0' - 5.0'	
Test Number	A	B	C	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	21.8	21.8	21.7	
Dry Density, pcf	94.0	94.0	94.1	
Saturation (Wet Method), %	74.8	75.0	74.9	
Void Ratio	0.781	0.779	0.777	
Final				
Moisture Content, %	27.9	26.9	25.6	
Dry Density, pcf	95.7	97.3	99.3	
Cross-Sectional Area (Method A), in ²	6.079	6.016	5.933	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.748	0.720	0.686	
Back Pressure, psi	98.00	97.99	100.9	
Vertical Effective Consolidation Stress, psi	4.983	9.945	14.91	
Horizontal Effective Consolidation Stress, psi	4.997	9.997	14.98	
Vertical Strain after Consolidation, %	0.4159	0.8396	1.273	
Volumetric Strain after Consolidation, %	1.340	2.659	4.305	
Time to 50% Consolidation, min	0.3500	0.3800	0.6000	
Shear Strength, psi	4.349	6.624	8.356	
Strain at Failure, %	4.04	6.06	5.65	
Strain Rate, %/min	0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi	8.698	13.25	16.71	
Effective Minor Principal Stress at Failure, psi	2.178	3.599	5.186	
Effective Major Principal Stress at Failure, psi	10.88	16.85	21.90	
B-Value	0.92	0.93	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 ϕ 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: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, Samples Molded at 95% of Max Dry Density		

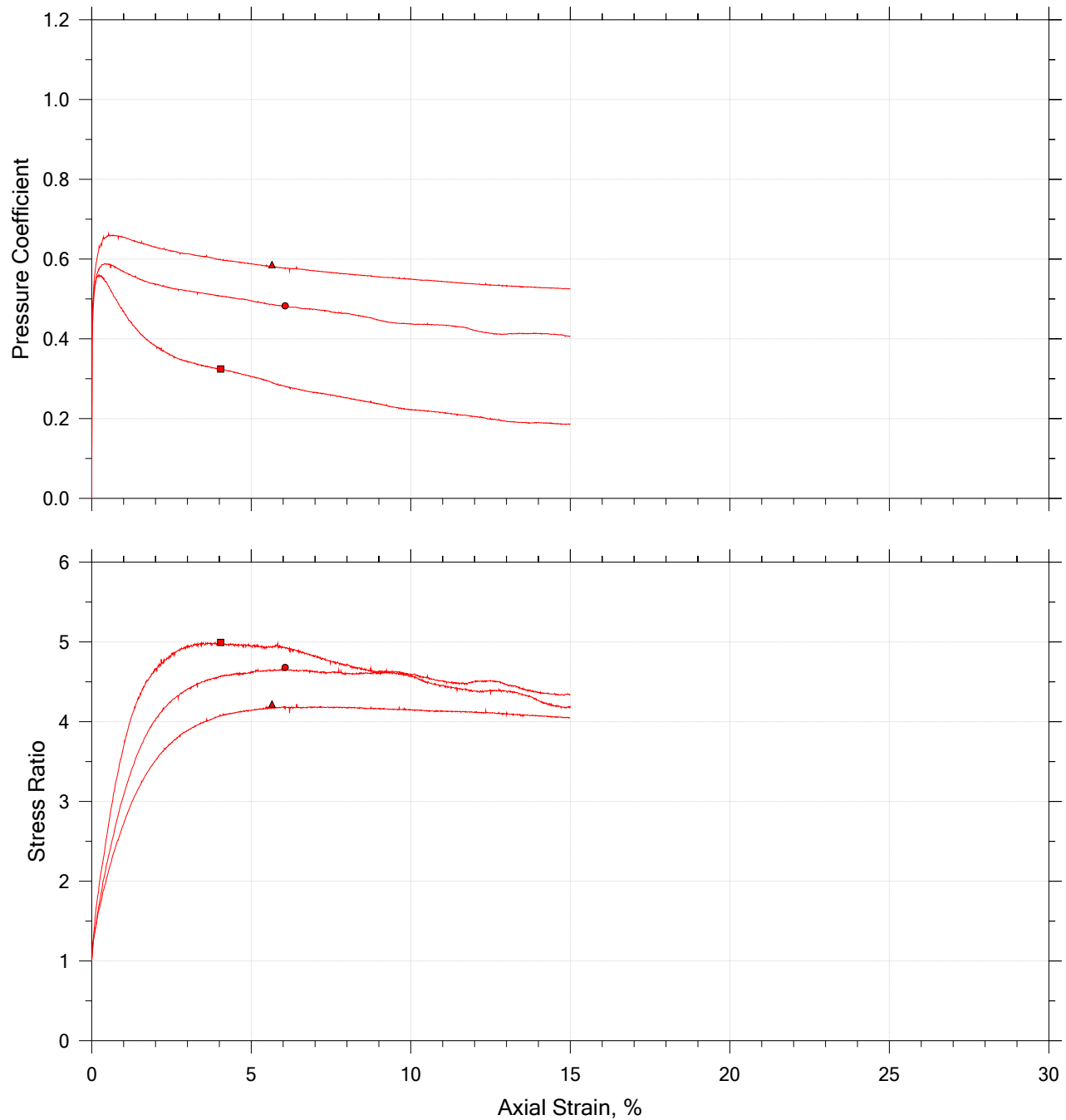
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	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-2794	A	0.0' - 5.0'	WAP/RMC	10/19/2022	WAP/ WJG	10/24/2022	BS-1_Test.A.dat
●	22-2794	B	0.0' - 5.0'	TL/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.B.dat
▲	22-2794	C	0.0' - 5.0'	WAP/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.C.dat

	Project Name: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, Samples Molded at 95% of Max Dry Density		

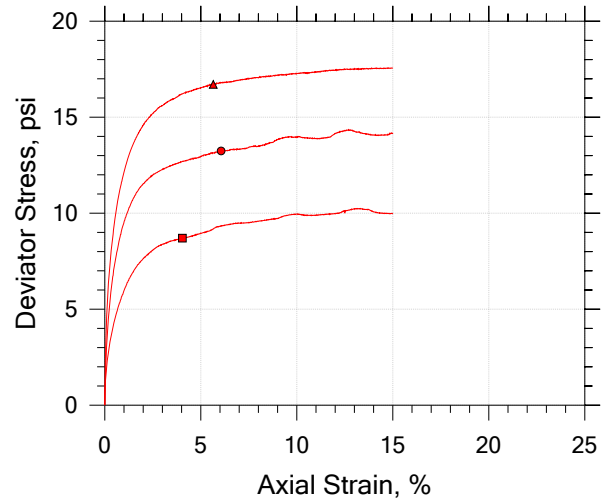
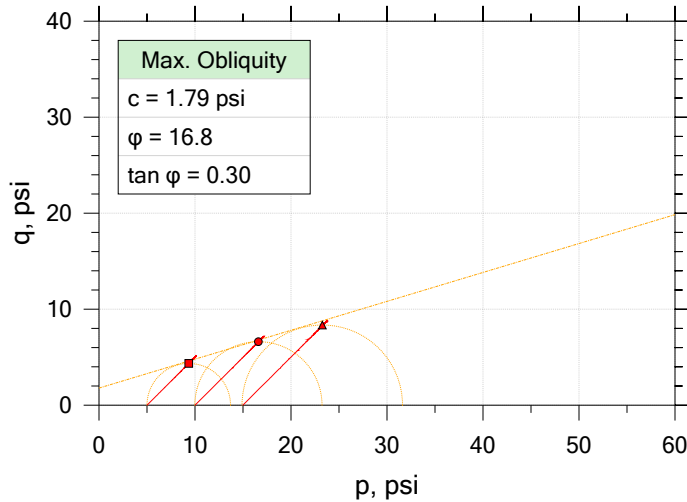
Consolidated Undrained by AASHTO T297



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-2794	A	0.0' - 5.0'	WAP/RMC	10/19/2022	WAP/ WJG	10/24/2022	BS-1_Test.A.dat
●	22-2794	B	0.0' - 5.0'	TL/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.B.dat
▲	22-2794	C	0.0' - 5.0'	WAP/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.C.dat

	Project Name: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, Samples Molded at 95% of Max Dry Density		

Consolidated Undrained by AASHTO T297

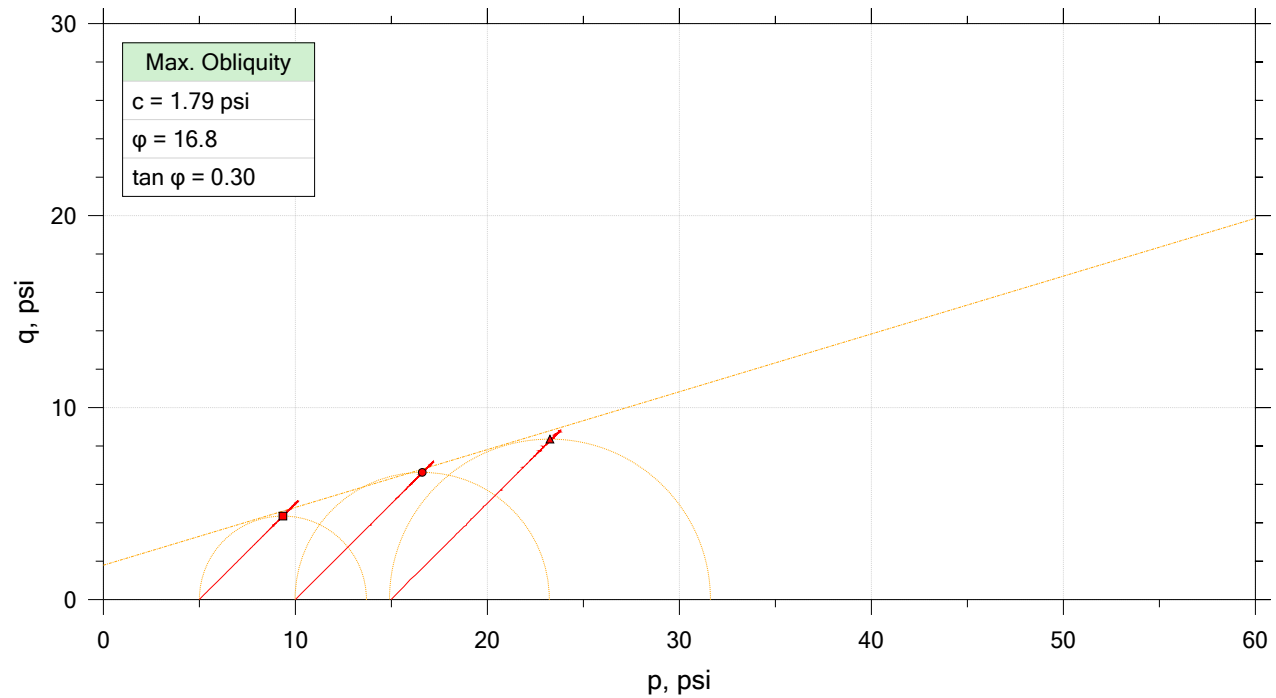
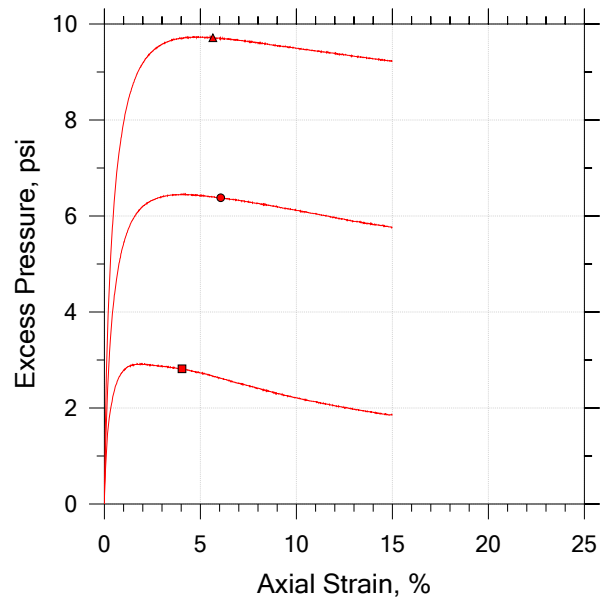
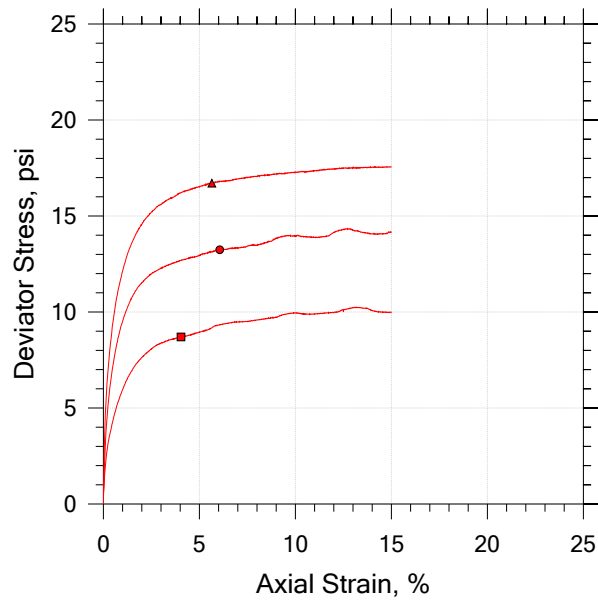


Symbol	■	●	▲	
Sample ID	22-2794	22-2794	22-2794	
Depth	0.0' - 5.0'	0.0' - 5.0'	0.0' - 5.0'	
Test Number	A	B	C	
Initial				
Height, in	6.000	6.000	6.000	
Diameter, in	2.800	2.800	2.800	
Moisture Content (from Cuttings), %	21.8	21.8	21.7	
Dry Density, pcf	94.0	94.0	94.1	
Saturation (Wet Method), %	74.8	75.0	74.9	
Void Ratio	0.781	0.779	0.777	
Final				
Moisture Content, %	27.9	26.9	25.6	
Dry Density, pcf	95.7	97.3	99.3	
Cross-Sectional Area (Method A), in ²	6.079	6.016	5.933	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.748	0.720	0.686	
Back Pressure, psi	98.00	97.99	100.9	
Vertical Effective Consolidation Stress, psi	4.983	9.945	14.91	
Horizontal Effective Consolidation Stress, psi	4.997	9.997	14.98	
Vertical Strain after Consolidation, %	0.4159	0.8396	1.273	
Volumetric Strain after Consolidation, %	1.340	2.659	4.305	
Time to 50% Consolidation, min	0.3500	0.3800	0.6000	
Shear Strength, psi	4.349	6.624	8.356	
Strain at Failure, %	4.04	6.06	5.65	
Strain Rate, %/min	0.0005000	0.0005000	0.0005000	
Deviator Stress at Failure, psi	8.698	13.25	16.71	
Effective Minor Principal Stress at Failure, psi	2.178	3.599	5.186	
Effective Major Principal Stress at Failure, psi	10.88	16.85	21.90	
B-Value	0.92	0.93	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 ϕ 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: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, Samples Molded at 95% of Max Dry Density		

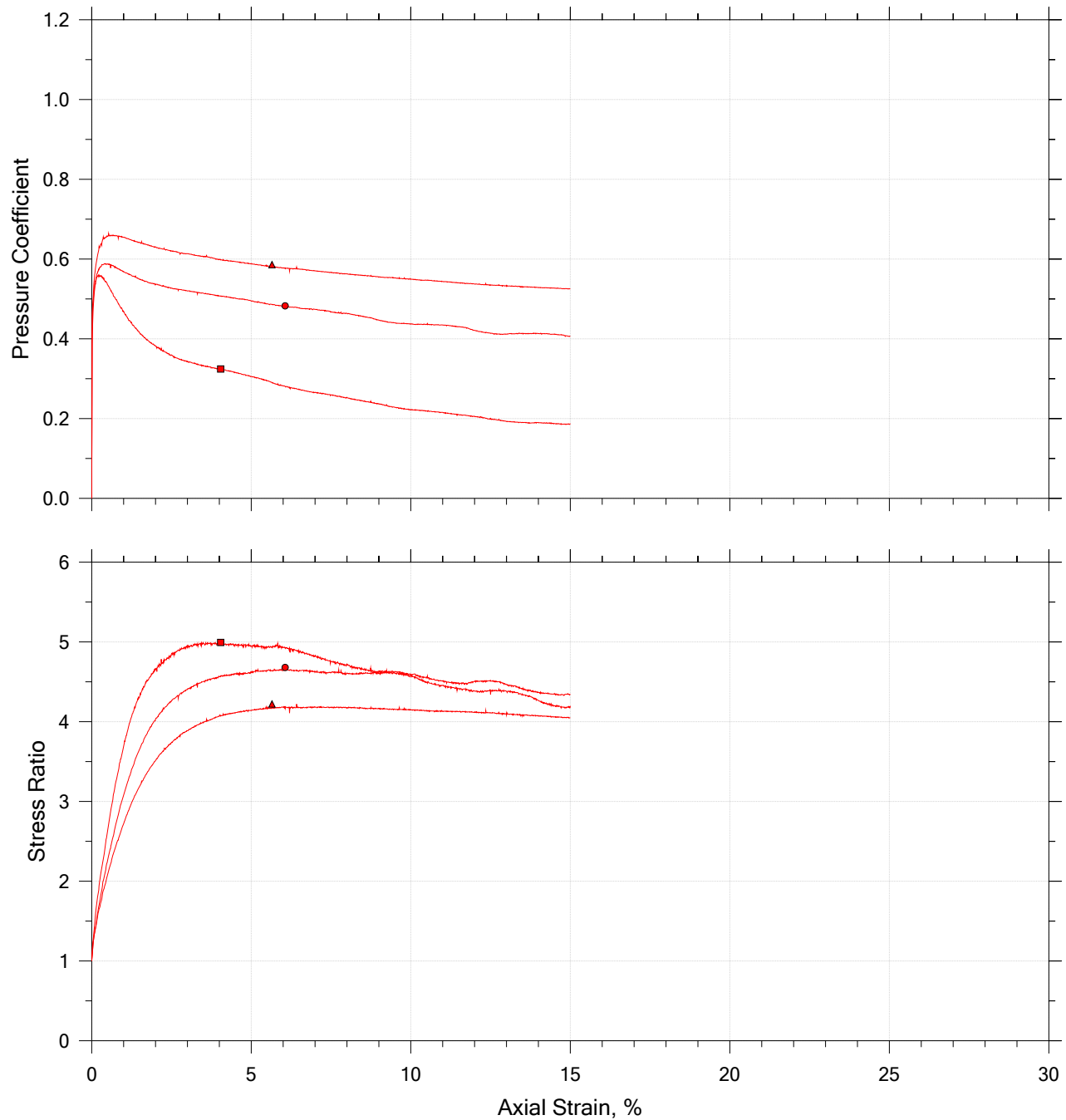
Consolidated Undrained by AASHTO T297




	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	22-2794	A	0.0' - 5.0'	WAP/RMC	10/19/2022	WAP/ WJG	10/24/2022	BS-1_Test.A.dat
●	22-2794	B	0.0' - 5.0'	TL/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.B.dat
▲	22-2794	C	0.0' - 5.0'	WAP/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.C.dat

	Project Name: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, 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
■	22-2794	A	0.0' - 5.0'	WAP/RMC	10/19/2022	WAP/ WJG	10/24/2022	BS-1_Test.A.dat
●	22-2794	B	0.0' - 5.0'	TL/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.B.dat
▲	22-2794	C	0.0' - 5.0'	WAP/RMC	10/20/2022	WAP/ WJG	10/24/2022	BS-1_Test.C.dat

	Project Name: SC 183 Twelve Mile Creek	Location: Pickens county, SC	Project Number: P041231
	Boring Number: BS-1	Tester: WAP/RMC	Checker: WAP/ WJG
	Sample Number: 22-2794	Test Date: 10/19/2022	Depth: 0.0' - 5.0'
	Test Number: ABC	Preparation: Remolded	Elevation:
	Description: Silty SAND (SM/A-7-5) LL=48, PL=34, PI=14, %200=36.5		
	Remarks: Max Dry Density=99.4 pcf, OMC=21.5%, Samples Molded at 95% of Max Dry Density		



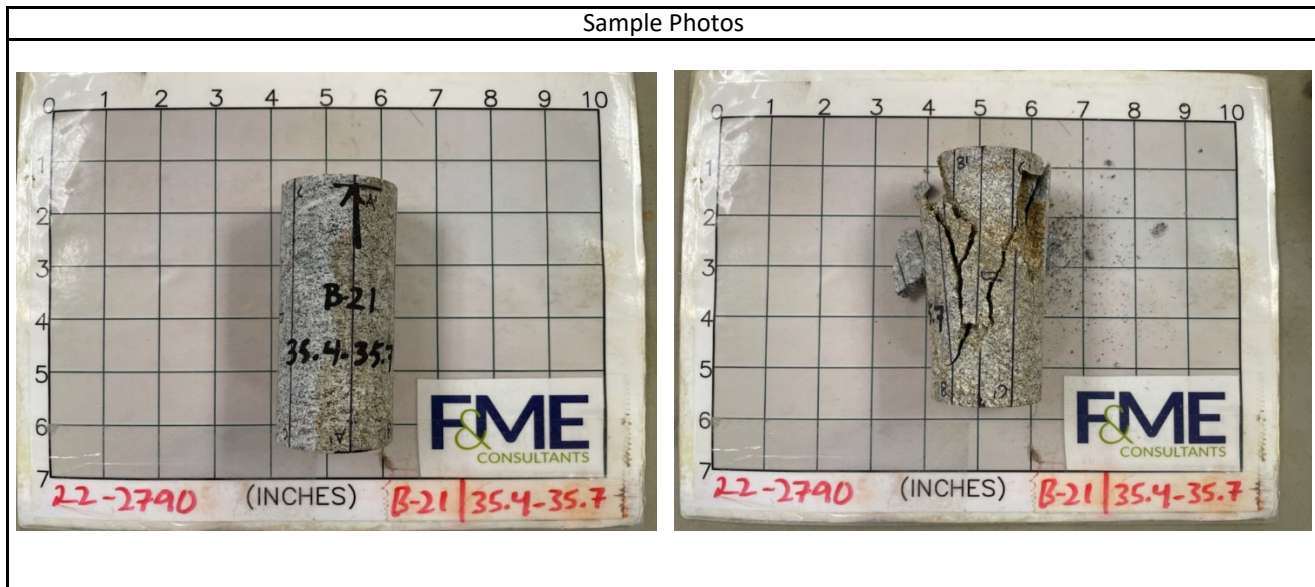
Appendix C. Laboratory Testing

Rock Cores

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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.183	Reviewed By	WJG
Boring	B-21	Unit Weight (pcf)	167.9	Core Size	NQ
Sample No.	NQ-2 / 22-2790A	L/D Ratio	2.24	Recovery	98%
Depth	35.4' - 35.7'	Load Rate (psi/sec)	20	RQD	53%
Description	White/Gray/Black Mica Schist				

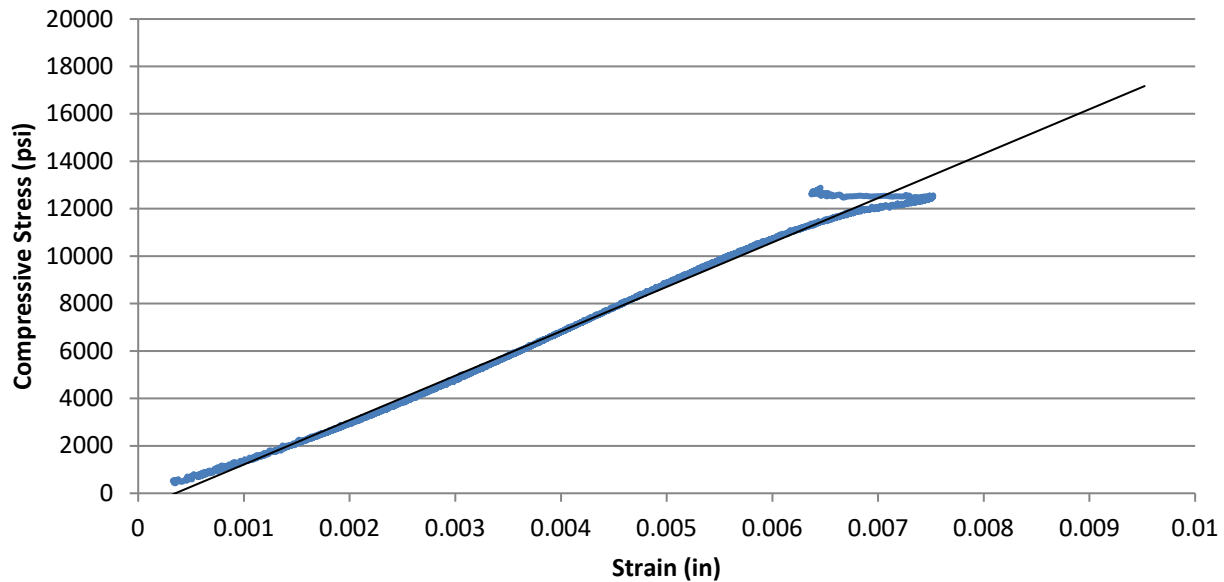
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-965	81	3,551	1,297	2.69	0.08
20%	-1781	190	7,083	2,587	2.90	0.11
30%	-2510	324	10,581	3,865	3.08	0.13
40%	-3184	493	14,145	5,167	3.25	0.15
50%	-3820	681	17,642	6,444	3.37	0.18
60%	-4445	848	21,178	7,736	3.48	0.19
70%	-5072	1077	24,675	9,013	3.55	0.21
80%	-5760	1559	28,276	10,329	3.59	0.27
90%	-6574	2845	31,753	11,599	3.53	0.43
100%	-6456	6040	35,282	12,888		



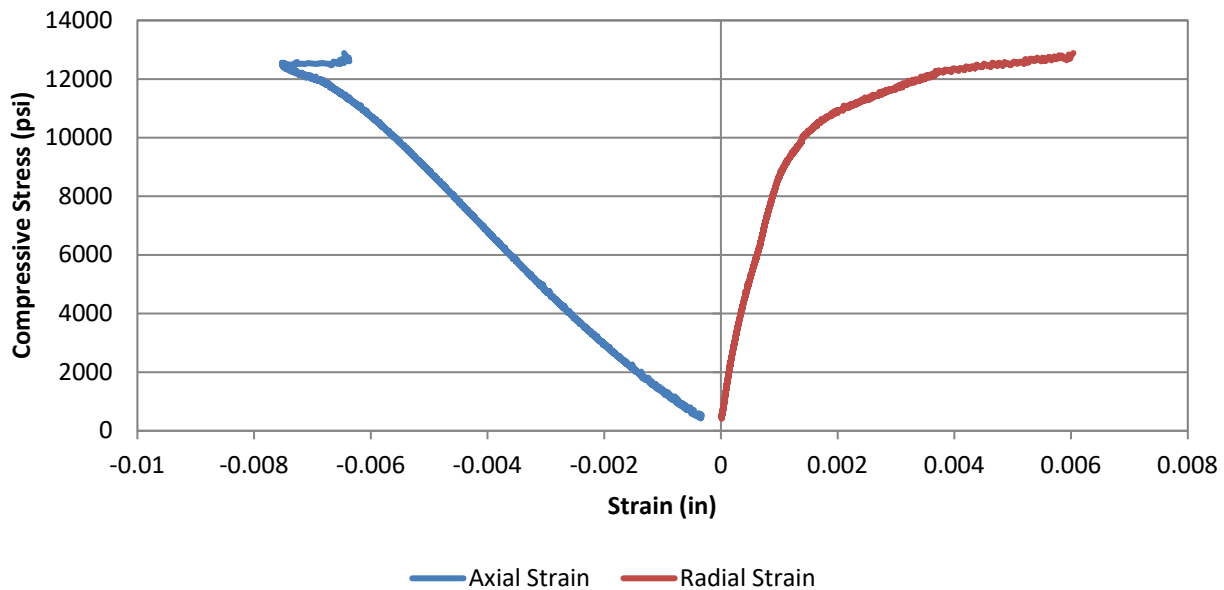
Test Results			
Unconfined Compressive Strength (psi)		12,890	Elastic Modulus (psi)
			3.29E+06
			Poisson's Ratio in Elastic Range
			0.16
Comments	Elastic range was taken as between 0.002 and 0.005 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.183	Reviewed By	WJG
Boring	B-21	Unit Weight (pcf)	167.9	Core Size	NQ
Sample No.	NQ-2 / 22-2790A	L/D Ratio	2.24	Recovery	98%
Depth	35.4' - 35.7'	Load Rate (psi/sec)	20	RQD	53%
Description	White/Gray/Black Mica Schist				

Axial Stress vs. Strain



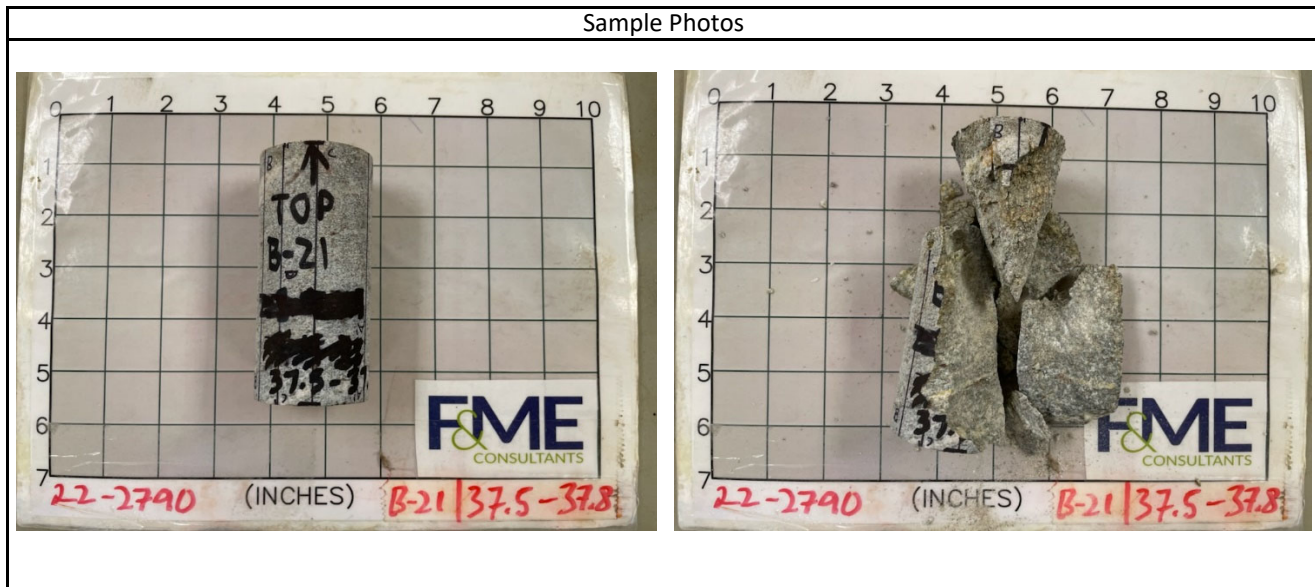
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.869	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.106	Reviewed By	WJG
Boring	B-21	Unit Weight (pcf)	169.1	Core Size	NQ
Sample No.	NQ-3 / 22-2790B	L/D Ratio	2.20	Recovery	92%
Depth	37.5' - 37.8'	Load Rate (psi/sec)	20	RQD	71%
Description	White/Gray/Black Mica Schist				

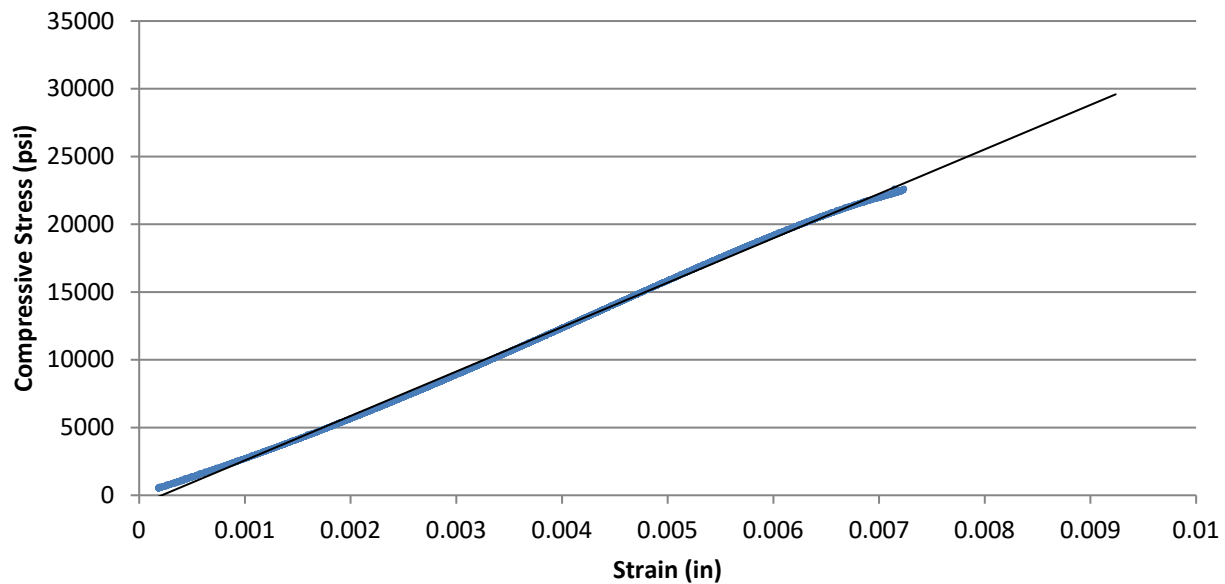
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-828	112	6,206	2,262	5.46	0.13
20%	-1620	251	12,413	4,524	5.59	0.15
30%	-2368	409	18,678	6,808	5.75	0.17
40%	-3047	576	24,838	9,053	5.94	0.19
50%	-3707	765	31,034	11,312	6.10	0.21
60%	-4355	976	37,291	13,592	6.24	0.22
70%	-5005	1225	43,528	15,866	6.34	0.24
80%	-5685	1571	49,800	18,152	6.39	0.28
90%	-6396	2134	55,970	20,401	6.38	0.33
100%	-7144	3887	62,119	22,642		



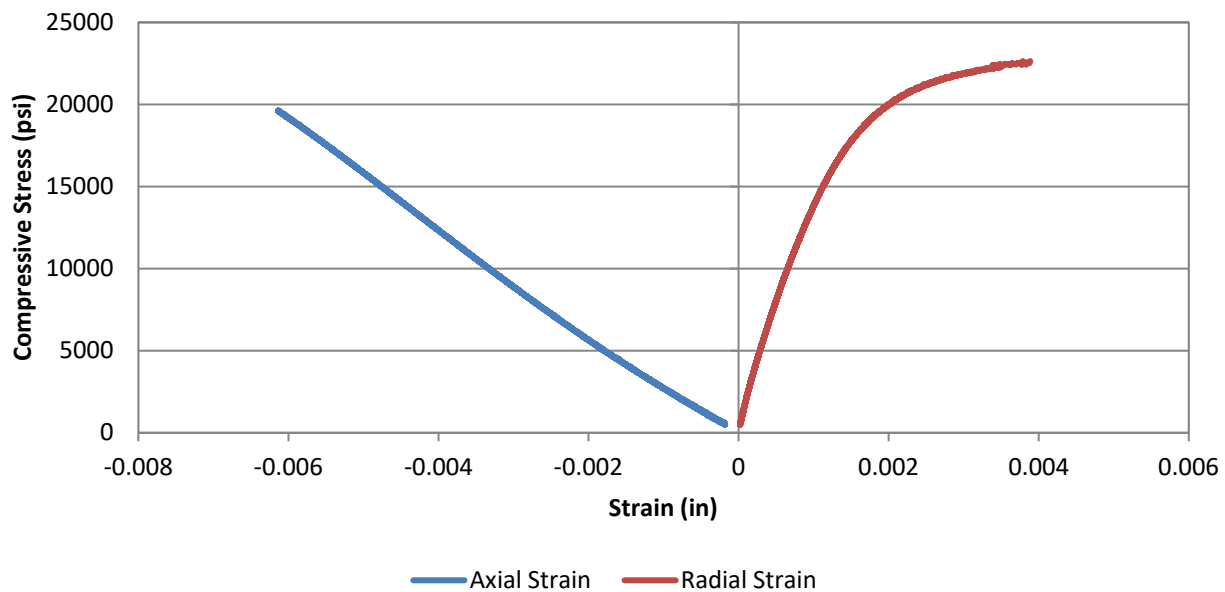
Test Results			
Unconfined Compressive Strength (psi)	22,640	Elastic Modulus (psi)	6.04E+06
		Poisson's Ratio in Elastic Range	0.20
Comments	Elastic range was taken as between 0.002 and 0.005 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.869	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.106	Reviewed By	WJG
Boring	B-21	Unit Weight (pcf)	169.1	Core Size	NQ
Sample No.	NQ-3 / 22-2790B	L/D Ratio	2.20	Recovery	92%
Depth	37.5' - 37.8'	Load Rate (psi/sec)	20	RQD	71%
Description	White/Gray/Black Mica Schist				

Axial Stress vs. Strain



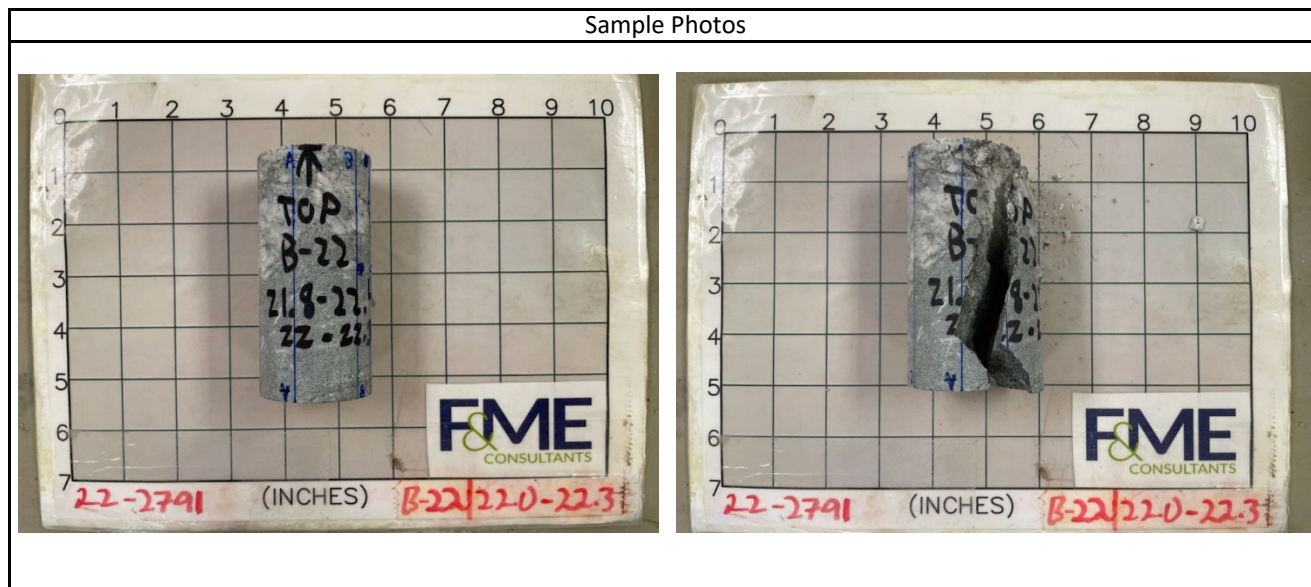
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.865	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.002	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	168.5	Core Size	NQ
Sample No.	NQ-1 / 22-2791A	L/D Ratio	2.15	Recovery	92%
Depth	22.0' - 22.3'	Load Rate (psi/sec)	30	RQD	65%
Description	White/Gray Biotite Gneiss				

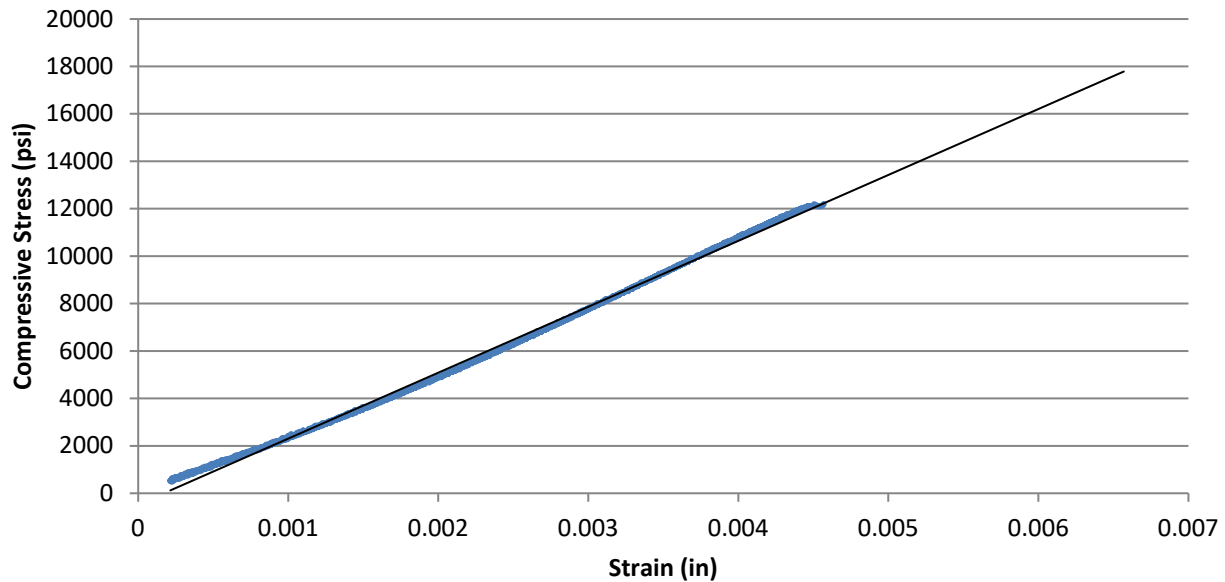
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-510	36	3,307	1,211	4.75	0.07
20%	-1038	95	6,666	2,440	4.70	0.09
30%	-1519	163	9,968	3,649	4.80	0.11
40%	-1995	245	13,326	4,878	4.89	0.12
50%	-2410	332	16,588	6,072	5.04	0.14
60%	-2848	443	19,994	7,319	5.14	0.16
70%	-3257	572	23,341	8,544	5.25	0.18
80%	-3657	739	26,687	9,769	5.34	0.20
90%	-4053	973	29,952	10,964	5.41	0.24
100%	-4569	1846	33,323	12,198		



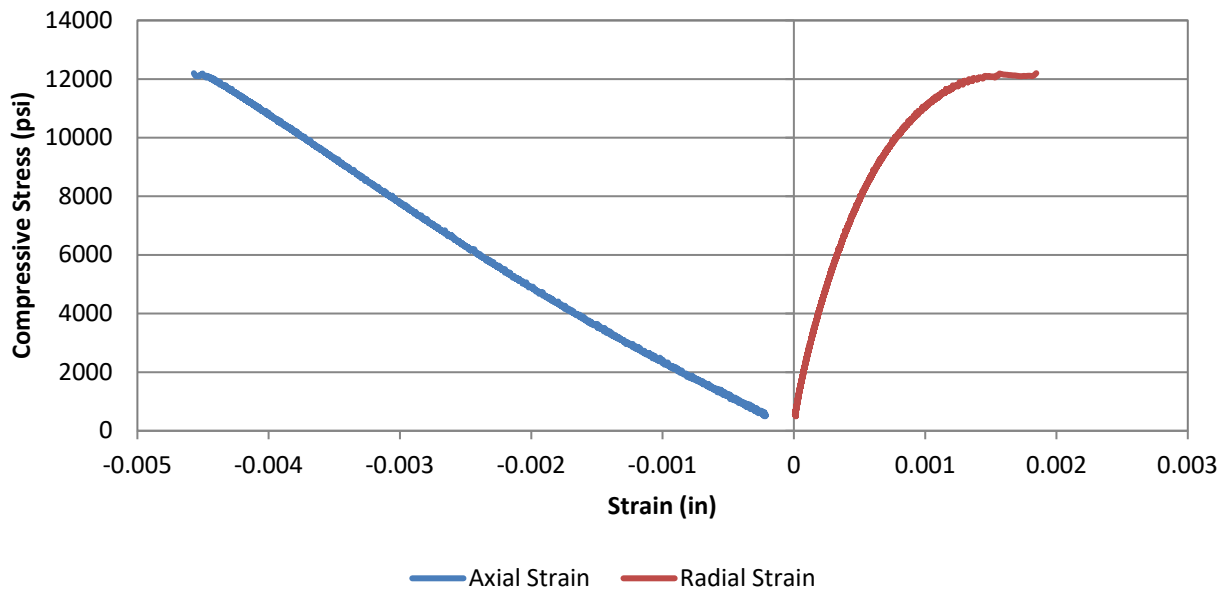
Test Results			
Unconfined Compressive Strength (psi)	12,200	Elastic Modulus (psi)	5.05E+06
		Poisson's Ratio in Elastic Range	0.15
Comments	Elastic range was taken as between 0.001 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.865	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.002	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	168.5	Core Size	NQ
Sample No.	NQ-1 / 22-2791A	L/D Ratio	2.15	Recovery	92%
Depth	22.0' - 22.3'	Load Rate (psi/sec)	30	RQD	65%
Description	White/Gray Biotite Gneiss				

Axial Stress vs. Strain



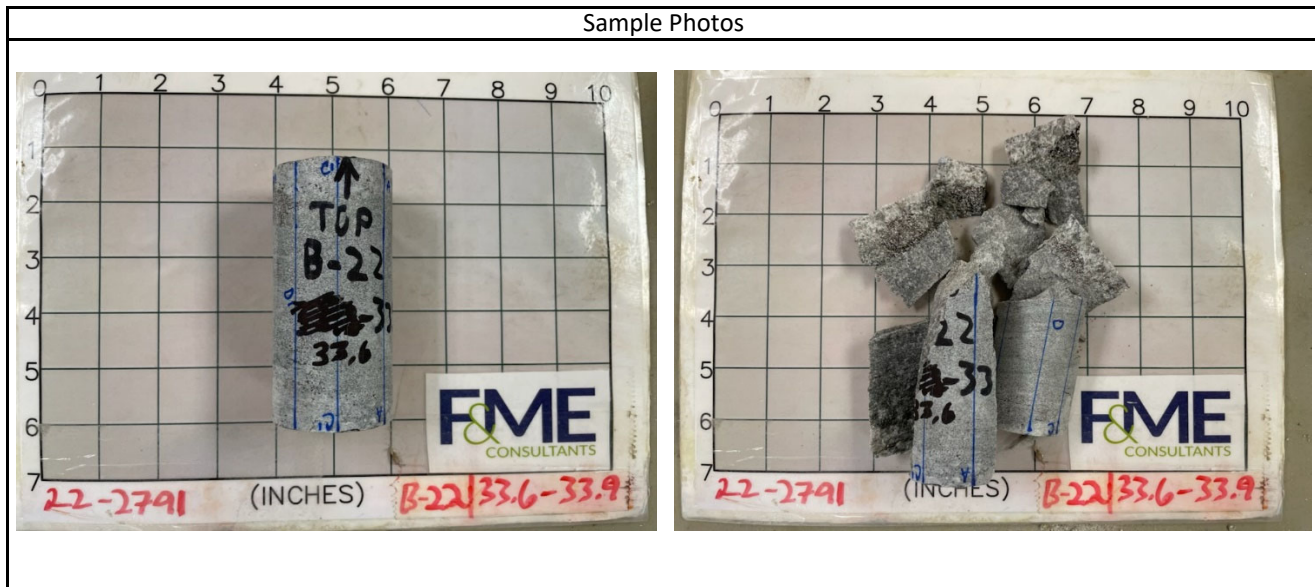
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.015	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	169.4	Core Size	NQ
Sample No.	NQ-3 / 22-2791B	L/D Ratio	2.15	Recovery	95%
Depth	33.6' - 33.9'	Load Rate (psi/sec)	30	RQD	68%
Description	White/Gray Biotite Gneiss				

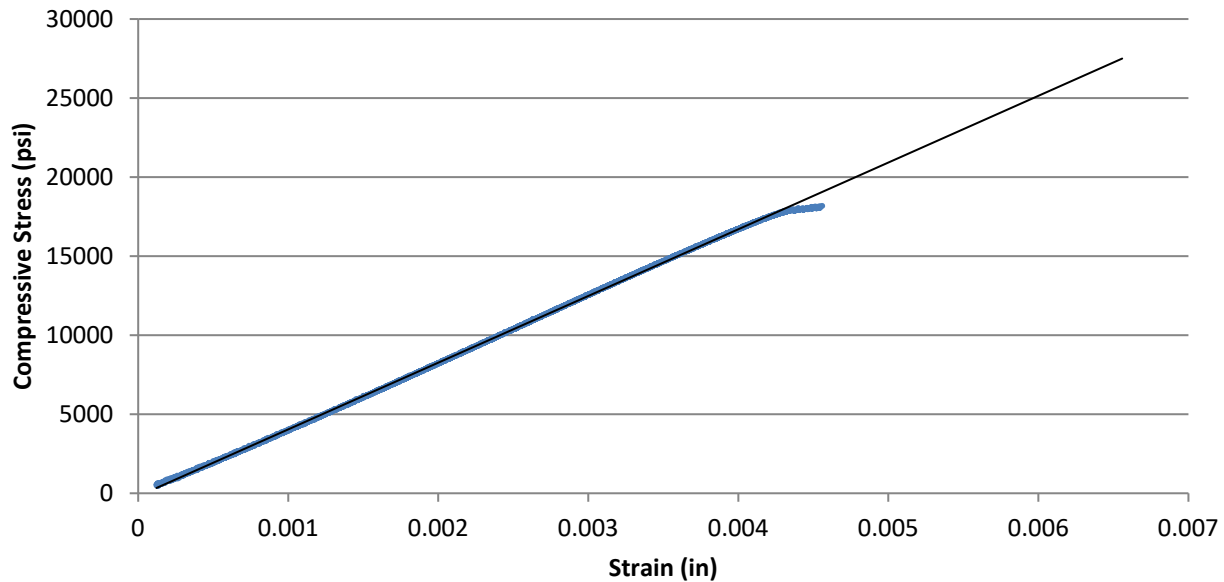
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-464	49	4,972	1,816	7.83	0.10
20%	-917	72	9,984	3,647	7.95	0.08
30%	-1354	87	14,930	5,454	8.06	0.06
40%	-1780	98	19,971	7,295	8.19	0.06
50%	-2196	108	24,832	9,071	8.26	0.05
60%	-2617	120	29,835	10,898	8.33	0.05
70%	-3046	137	34,848	12,729	8.36	0.04
80%	-3464	158	39,818	14,545	8.40	0.05
90%	-3903	185	44,750	16,346	8.38	0.05
100%	-4559	1689	49,753	18,174		



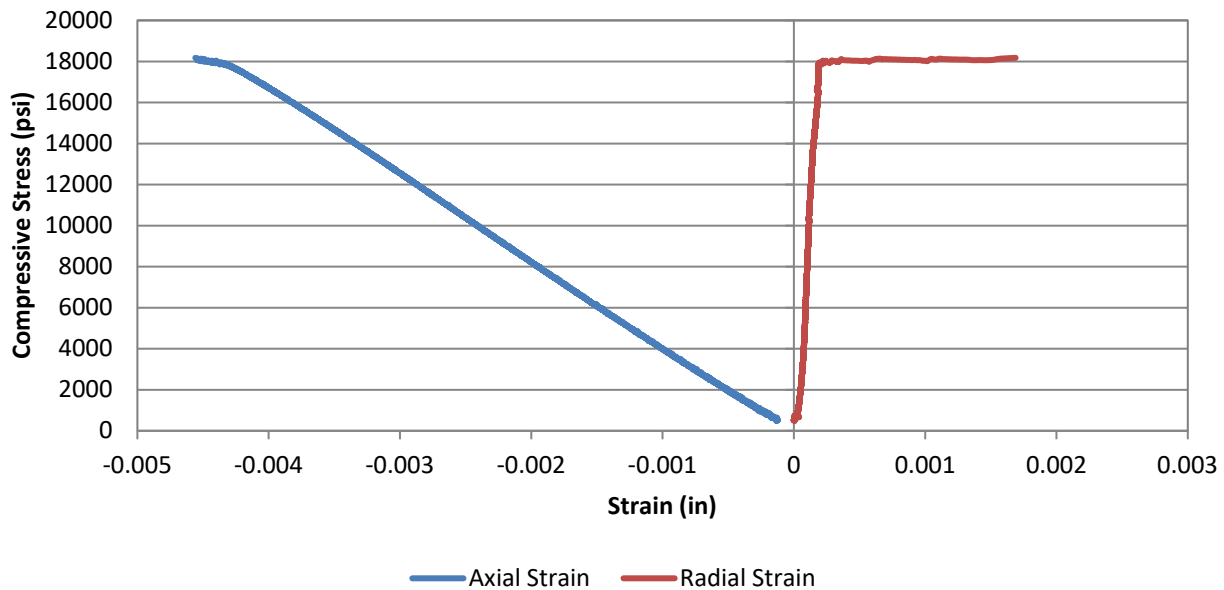
Test Results			
Unconfined Compressive Strength (psi)		18,170	Elastic Modulus (psi)
			8.26E+06
			Poisson's Ratio in Elastic Range
			0.05
Comments	Elastic range was taken as between 0.001 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. Poisson's Ratio appears low for the material.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.015	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	169.4	Core Size	NQ
Sample No.	NQ-3 / 22-2791B	L/D Ratio	2.15	Recovery	95%
Depth	33.6' - 33.9'	Load Rate (psi/sec)	30	RQD	68%
Description	White/Gray Biotite Gneiss				

Axial Stress vs. Strain



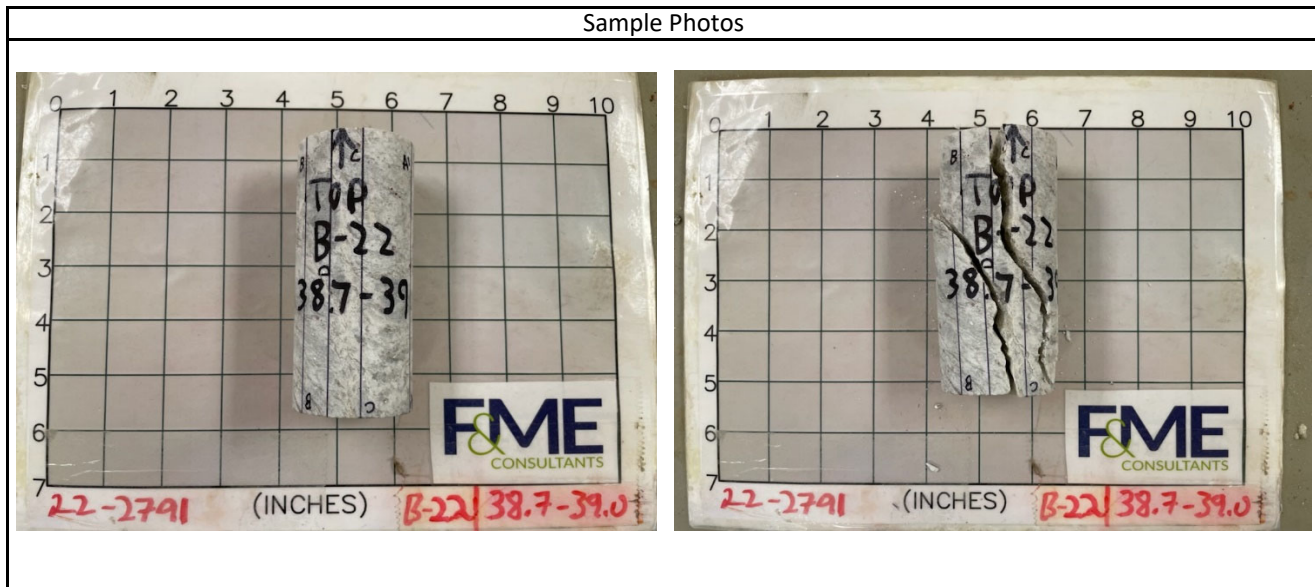
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.304	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-4 / 22-2791C	L/D Ratio	2.31	Recovery	97%
Depth	38.7' - 39.0'	Load Rate (psi/sec)	30	RQD	78%
Description	White/Gray Mica Schist				

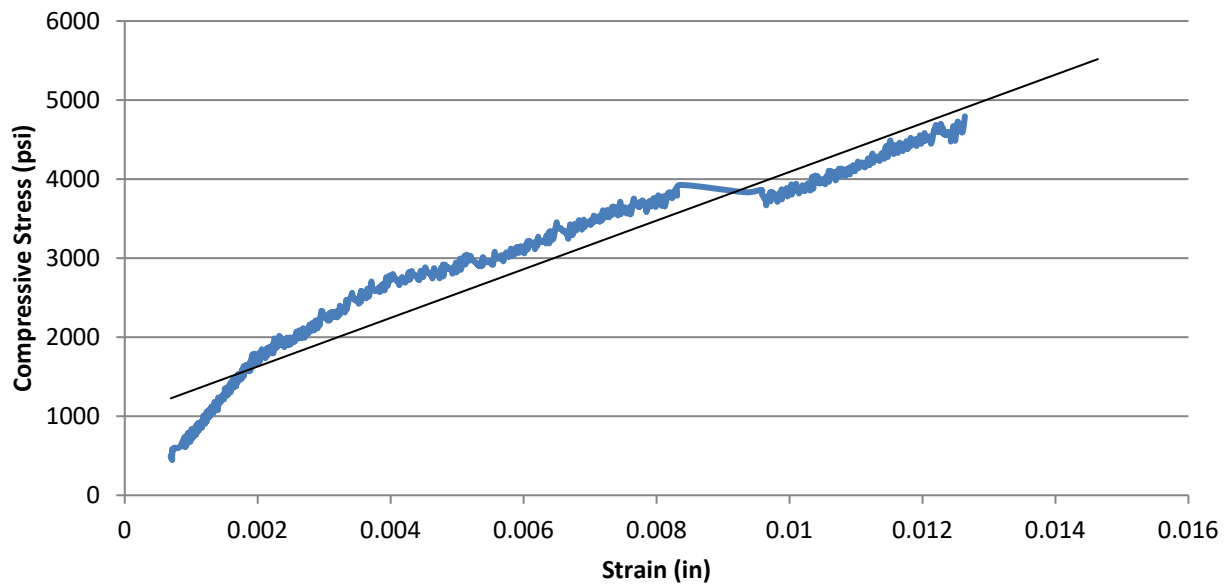
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-710	3	1,320	482	1.36	0.00
20%	-1281	26	2,962	1,082	1.69	0.02
30%	-1701	58	3,957	1,445	1.70	0.03
40%	-2270	117	5,189	1,895	1.67	0.05
50%	-3297	233	6,527	2,384	1.45	0.07
60%	-4964	362	7,831	2,860	1.15	0.07
70%	-6666	635	9,147	3,341	1.00	0.10
80%	-10004	3690	10,439	3,813	0.76	0.37
90%	-11425	5586	11,810	4,314	0.76	0.49
100%	-12637	7603	13,123	4,793		



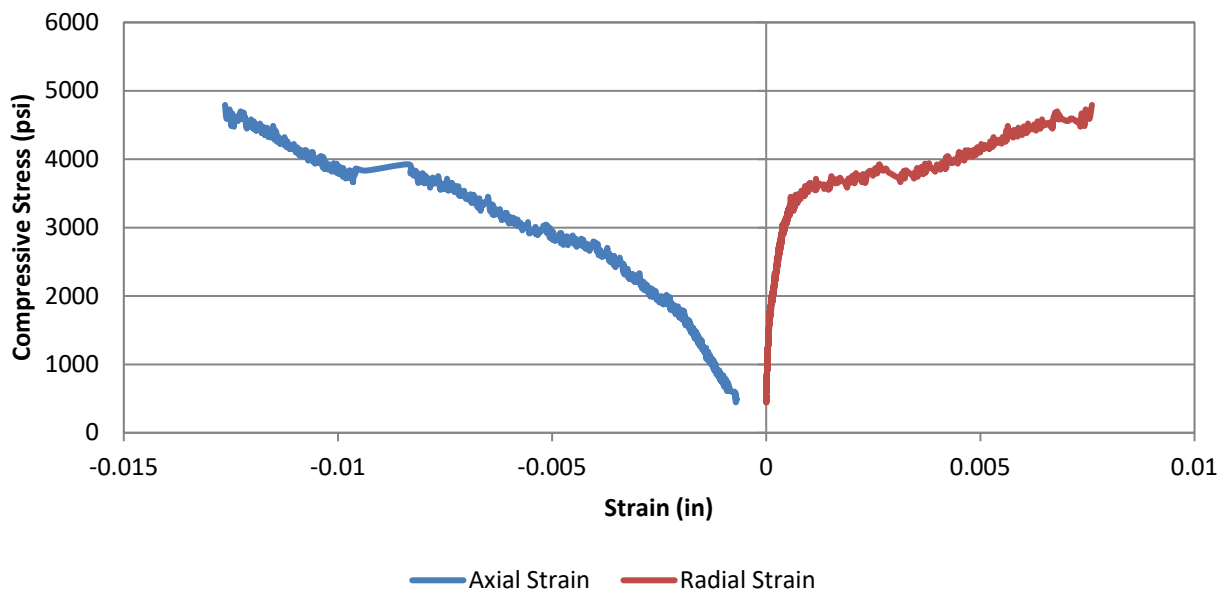
Test Results			
Unconfined Compressive Strength (psi)		4,800	Elastic Modulus (psi)
			1.39E+06
			Poisson's Ratio in Elastic Range
			0.07
Comments	Elastic range was taken as between 0.002 and 0.006 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.867	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.304	Reviewed By	WJG
Boring	B-22	Unit Weight (pcf)	162.4	Core Size	NQ
Sample No.	NQ-4 / 22-2791C	L/D Ratio	2.31	Recovery	97%
Depth	38.7' - 39.0'	Load Rate (psi/sec)	30	RQD	78%
Description	White/Gray Mica Schist				

Axial Stress vs. Strain



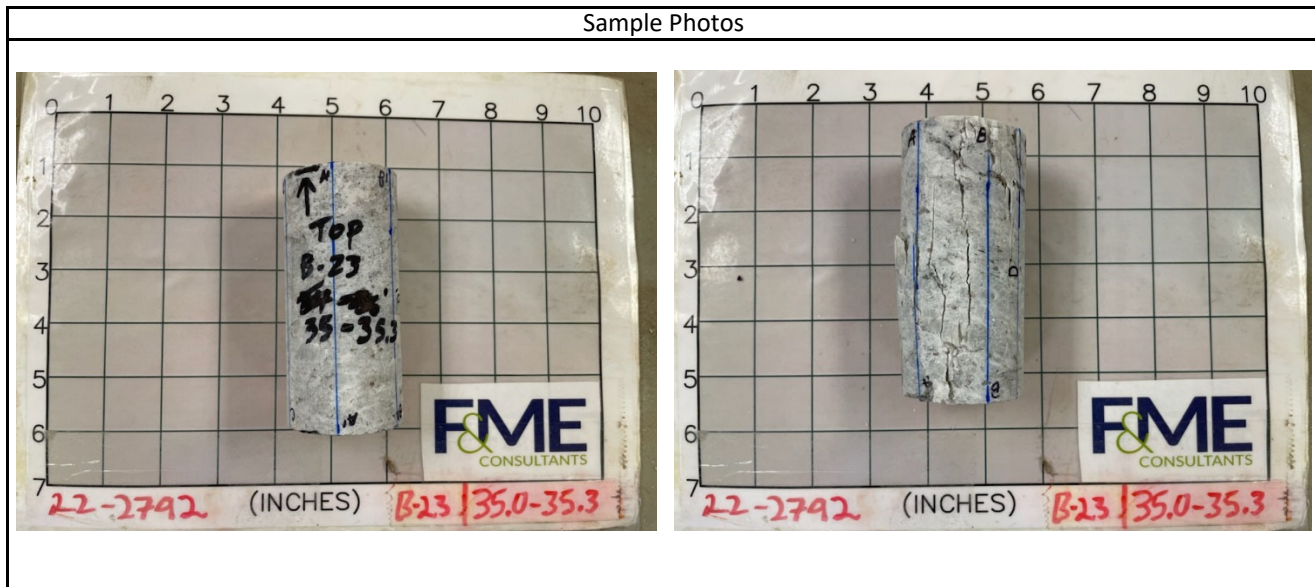
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.872	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.152	Reviewed By	WJG
Boring	B-23	Unit Weight (pcf)	161.4	Core Size	NQ
Sample No.	NQ-2 / 22-2792A	L/D Ratio	2.22	Recovery	94%
Depth	35.0' - 35.3'	Load Rate (psi/sec)	20	RQD	93%
Description	White/Gray Mica Schist				

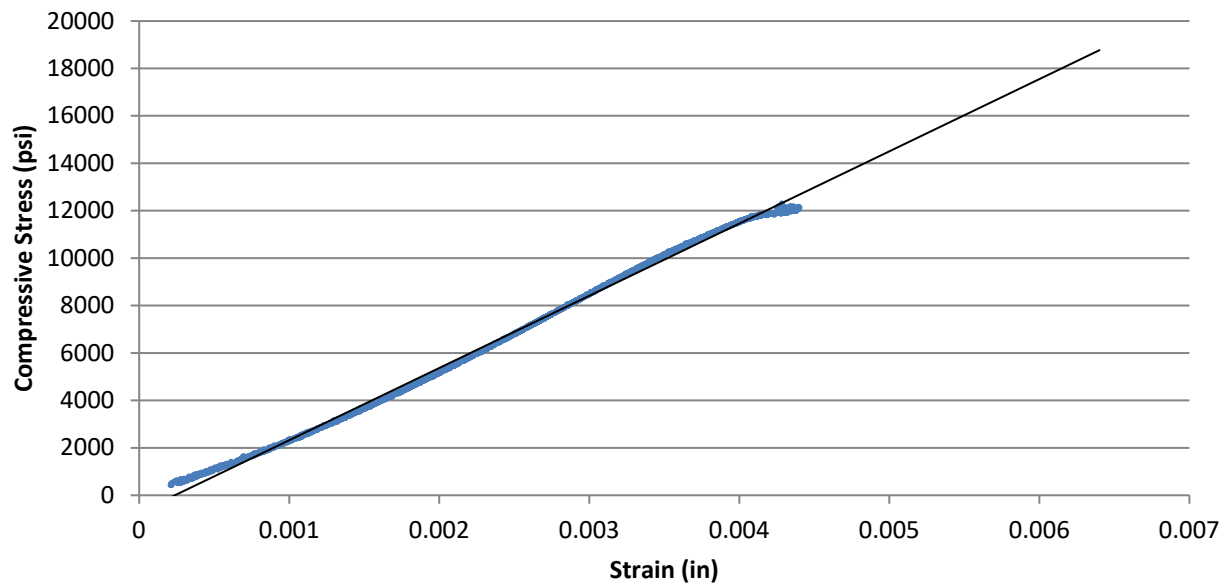
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-561	65	3,383	1,229	4.38	0.12
20%	-1051	142	6,703	2,435	4.63	0.13
30%	-1498	226	10,133	3,681	4.92	0.15
40%	-1916	317	13,560	4,927	5.14	0.17
50%	-2306	413	16,996	6,175	5.36	0.18
60%	-2685	517	20,384	7,406	5.52	0.19
70%	-3033	626	23,702	8,612	5.68	0.21
80%	-3405	759	27,136	9,859	5.79	0.22
90%	-3817	979	30,446	11,062	5.80	0.26
100%	-4283	3369	33,870	12,306		



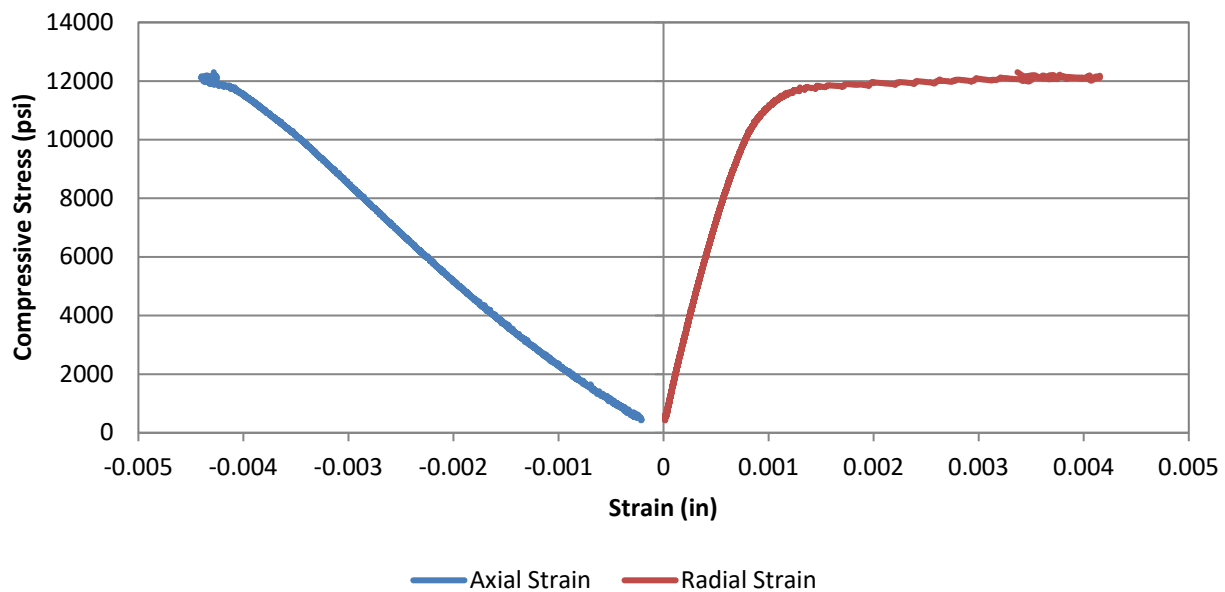
Test Results			
Unconfined Compressive Strength (psi)		12,310	Elastic Modulus (psi)
			5.19E+06
			Poisson's Ratio in Elastic Range
			0.17
Comments	Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.872	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.152	Reviewed By	WJG
Boring	B-23	Unit Weight (pcf)	161.4	Core Size	NQ
Sample No.	NQ-2 / 22-2792A	L/D Ratio	2.22	Recovery	94%
Depth	35.0' - 35.3'	Load Rate (psi/sec)	20	RQD	93%
Description	White/Gray Mica Schist				

Axial Stress vs. Strain



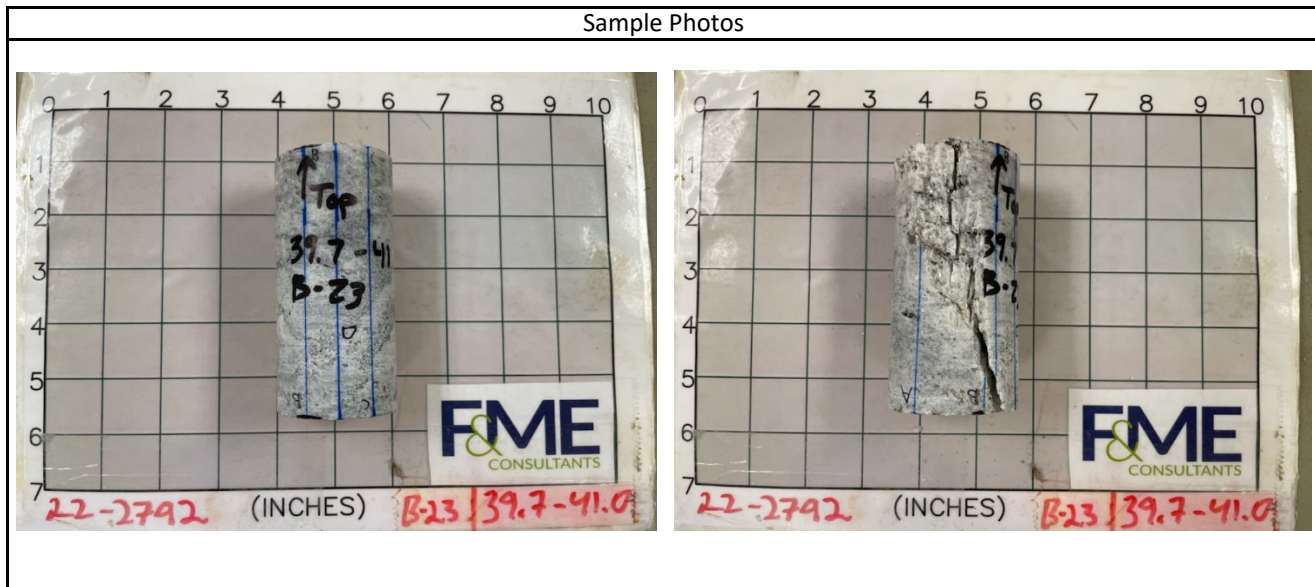
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.22	Reviewed By	WJG
Boring	B-23	Unit Weight (pcf)	158.9	Core Size	NQ
Sample No.	NQ-3 / 22-2792B	L/D Ratio	2.26	Recovery	89%
Depth	39.7' - 41.0'	Load Rate (psi/sec)	20	RQD	67%
Description	White/Gray Mica Schist				

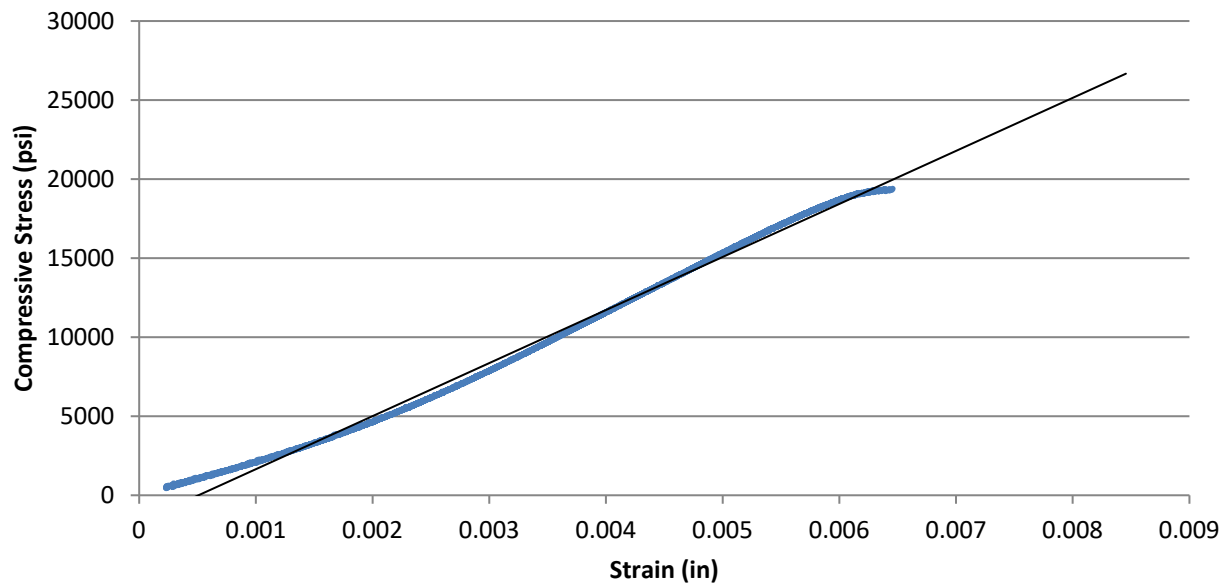
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-908	53	5,305	1,936	4.26	0.06
20%	-1719	126	10,604	3,869	4.50	0.07
30%	-2401	209	16,000	5,838	4.86	0.09
40%	-2963	289	21,257	7,756	5.23	0.10
50%	-3497	376	26,523	9,678	5.54	0.11
60%	-4013	472	31,852	11,622	5.79	0.12
70%	-4532	582	37,203	13,575	5.99	0.13
80%	-5049	731	42,510	15,511	6.14	0.14
90%	-5594	986	47,829	17,452	6.24	0.18
100%	-6457	2511	53,147	19,393		



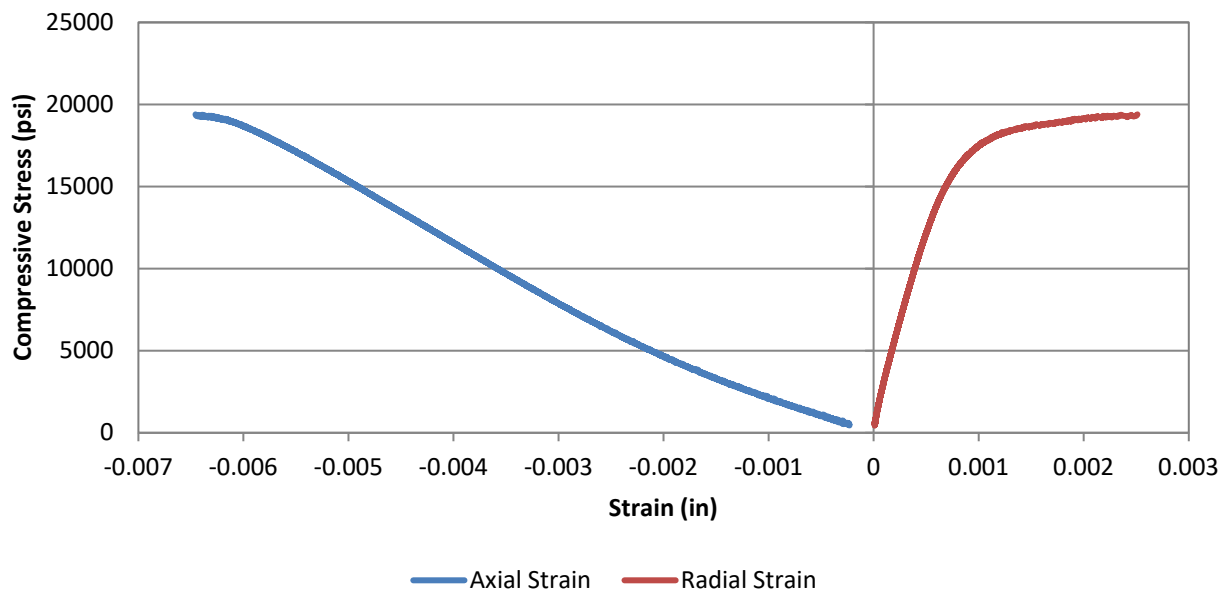
Test Results			
Unconfined Compressive Strength (psi)		19,390	Elastic Modulus (psi)
			5.30E+06
			Poisson's Ratio in Elastic Range
			0.10
Comments	Elastic range was taken as between 0.001 and 0.005 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.22	Reviewed By	WJG
Boring	B-23	Unit Weight (pcf)	158.9	Core Size	NQ
Sample No.	NQ-3 / 22-2792B	L/D Ratio	2.26	Recovery	89%
Depth	39.7' - 41.0'	Load Rate (psi/sec)	20	RQD	67%
Description	White/Gray Mica Schist				

Axial Stress vs. Strain



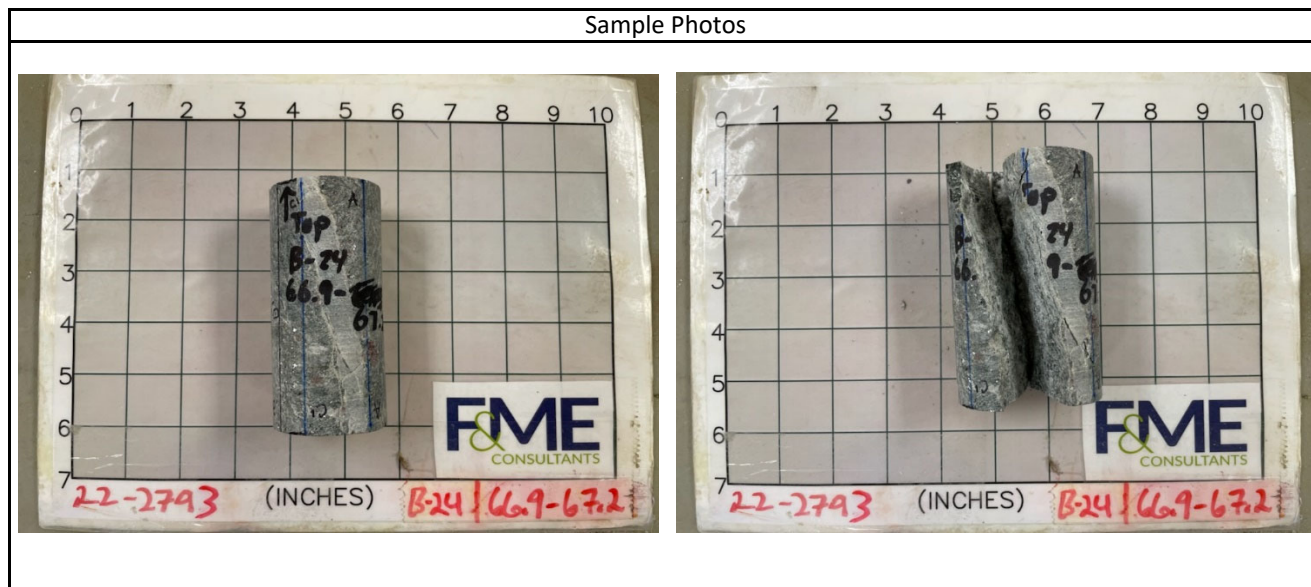
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.057	Reviewed By	WJG
Boring	B-24	Unit Weight (pcf)	172.3	Core Size	NQ
Sample No.	NQ-2 / 22-2793A	L/D Ratio	2.17	Recovery	92%
Depth	66.9' - 67.2'	Load Rate (psi/sec)	20	RQD	83%
Description	White/Gray Mica Schist				

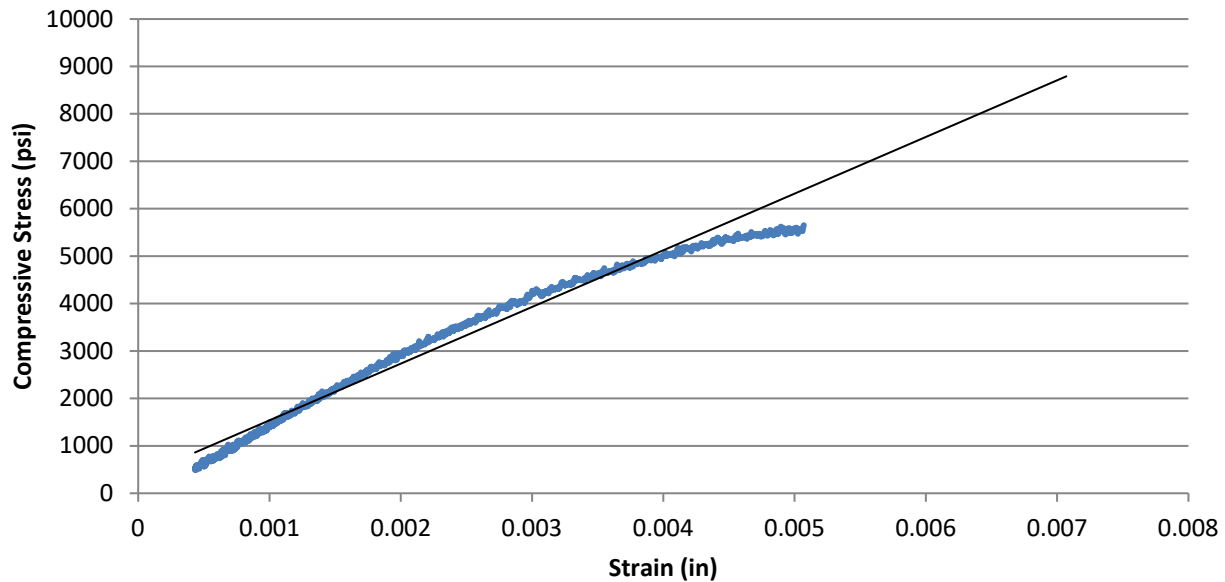
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-464	19	1,547	565	2.43	0.04
20%	-818	6	3,100	1,131	2.77	0.01
30%	-1170	77	4,635	1,691	2.89	0.07
40%	-1544	202	6,192	2,259	2.93	0.13
50%	-1918	357	7,740	2,824	2.94	0.19
60%	-2341	568	9,298	3,393	2.90	0.24
70%	-2809	845	10,856	3,961	2.82	0.30
80%	-3449	1262	12,439	4,539	2.63	0.37
90%	-4017	1693	13,908	5,075	2.53	0.42
100%	-5070	3075	15,488	5,651		



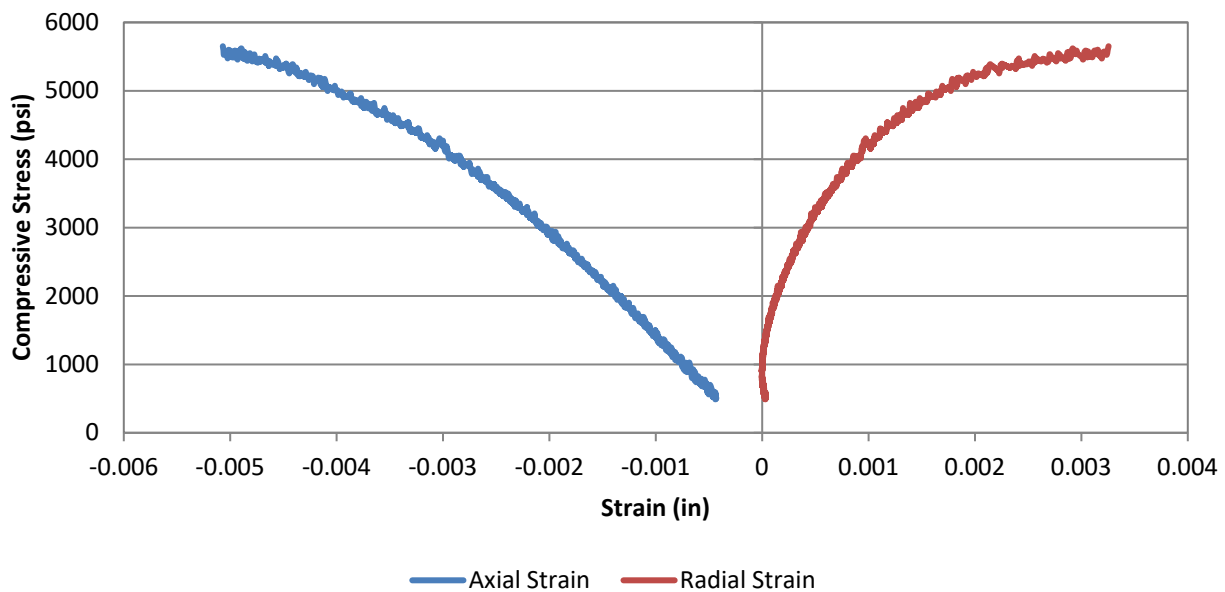
Test Results				
Unconfined Compressive Strength (psi)		5,651	Elastic Modulus (psi)	2.89E+06
			Poisson's Ratio in Elastic Range	0.18
Comments	Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.			

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.868	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.057	Reviewed By	WJG
Boring	B-24	Unit Weight (pcf)	172.3	Core Size	NQ
Sample No.	NQ-2 / 22-2793A	L/D Ratio	2.17	Recovery	92%
Depth	66.9' - 67.2'	Load Rate (psi/sec)	20	RQD	83%
Description	White/Gray Mica Schist				

Axial Stress vs. Strain



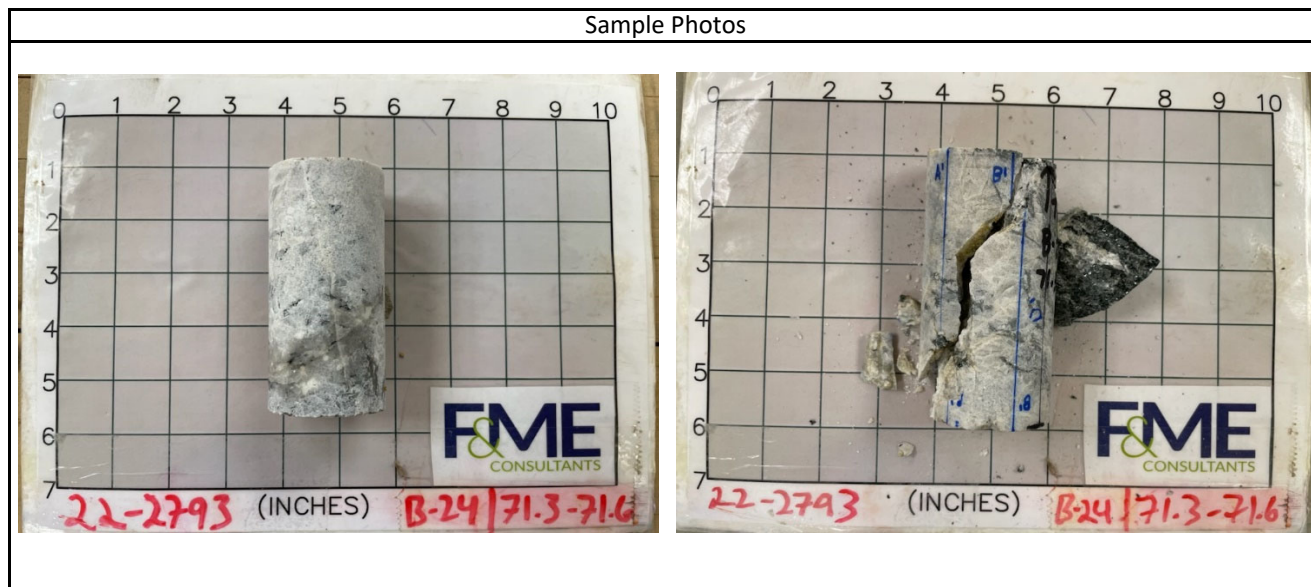
Stress vs. Strain



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

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.864	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.031	Reviewed By	WJG
Boring	B-24	Unit Weight (pcf)	165.1	Core Size	NQ
Sample No.	NQ-2 / 22-2793B	L/D Ratio	2.16	Recovery	92%
Depth	71.3' - 71.6'	Load Rate (psi/sec)	20	RQD	83%
Description	White/Gray Mica Schist				

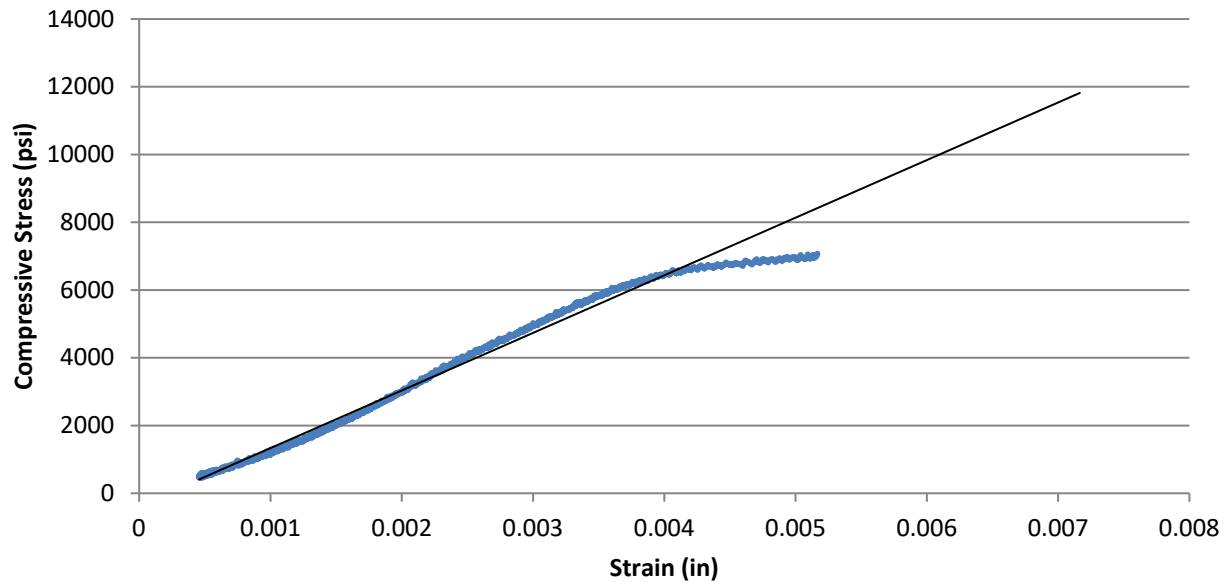
Test Data						
Percent of Failure Load	Strain (10^{-6})		Load (lbs)	Compressive Stress (psi)	Secant Modulus $\times 10^6$ (psi)	Poisson's Ratio
	Axial	Radial				
10%	-585	19	1,912	701	2.40	0.03
20%	-1139	5	3,823	1,401	2.46	0.00
30%	-1558	20	5,793	2,123	2.73	0.01
40%	-1932	50	7,788	2,854	2.95	0.03
50%	-2235	89	9,688	3,550	3.18	0.04
60%	-2591	164	11,527	4,224	3.26	0.06
70%	-3001	327	13,530	4,958	3.30	0.11
80%	-3396	545	15,474	5,671	3.34	0.16
90%	-3890	823	17,388	6,372	3.28	0.21
100%	-5166	1860	19,294	7,070		



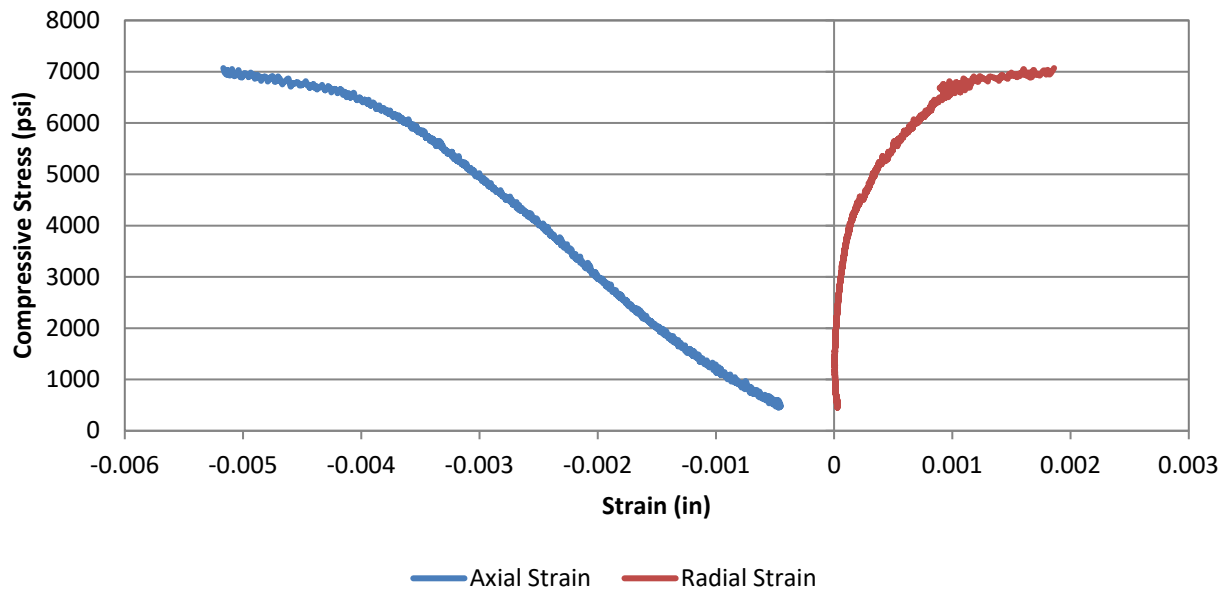
Test Results				
Unconfined Compressive Strength (psi)		7,070	Elastic Modulus (psi)	2.96E+06
			Poisson's Ratio in Elastic Range	0.04
Comments	Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. Poisson's Ratio does not appear reasonable for the material.			

Project	SC 183 RBO Twelvemile Creek			Date	11/8/2022
Project No.	G6657.001	Sample Diameter (in.)	1.864	Tested By	WAP
SCDOT ID	P041231	Sample Length (in.)	4.031	Reviewed By	WJG
Boring	B-24	Unit Weight (pcf)	165.1	Core Size	NQ
Sample No.	NQ-2 / 22-2793B	L/D Ratio	2.16	Recovery	92%
Depth	71.3' - 71.6'	Load Rate (psi/sec)	20	RQD	83%
Description	White/Gray Mica Schist				

Axial Stress vs. Strain



Stress vs. Strain



Appendix D. ADRS Curves

3-Point Acceleration Design Response Spectrum

SCDOT v3.1.1 - 11/29/2022

Project ID:	P041231	Latitude:	34.8755
Route:	SC183	County:	39 - Pickens
Project:	SC 183 over Twelvemile Creek (Walhalla Highway)		
		Longitude:	82.7440

Designer:	N. Harman - Support
Date:	11/29/2022

Design EQ	PGA	S _{DS}	S _{D1}	M _W	R	PGV	D ₅₋₉₅	T _o
	g	g	g	-	km	inches/sec	sec	sec
FEE	0.12	0.19	0.05	5.75	220.33	1.81	38.29	0.03
SEE	0.28	0.42	0.11	5.63	104.67	4.08	20.49	0.07

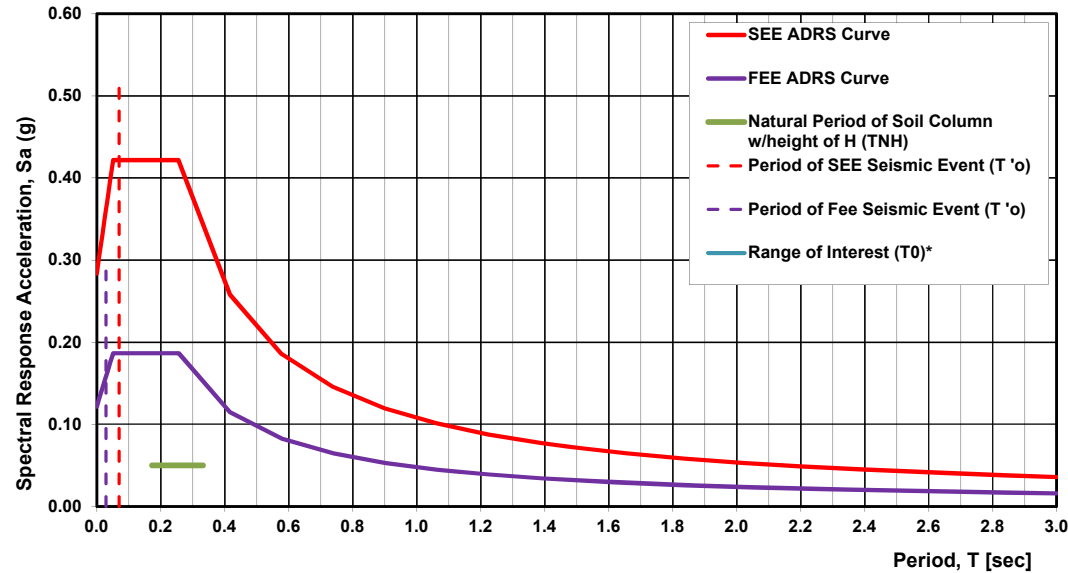
Fundamental Period of Structure, T_o^*	Range of Interest		$V_{s,H}^*$	H	T_{NH}	
	sec				sec	
	sec	0.5^*T_o			2.0^*T_o	ft/sec
0.00	0.00	0.00	1892.38	128.60	0.17	0.33
0.00	0.00	0.00				

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

South Carolina Piedmont

*Same Geologic Condition as used in SCENARIO_PC (2006)

SC Seismic ADRS Curve



FEE Data

T	S _a
0.00	0.122
0.01	0.132
0.02	0.143
0.03	0.154
0.03	0.165
0.04	0.176
0.05	0.187
0.07	0.187
0.09	0.187
0.10	0.187
0.12	0.187
0.14	0.187
0.15	0.187
0.17	0.187
0.19	0.187
0.20	0.187
0.22	0.187
0.24	0.187
0.26	0.187
0.42	0.114
0.58	0.083
0.74	0.065
0.90	0.053
1.06	0.045
1.22	0.039
1.39	0.034
1.55	0.031
1.71	0.028
1.87	0.026
2.03	0.024
2.19	0.022
2.35	0.020
2.52	0.019
2.68	0.018
2.84	0.017
3.00	0.016

SEE Data

T	S _a
0.00	0.284
0.01	0.307
0.02	0.330
0.03	0.353
0.03	0.376
0.04	0.399
0.05	0.422
0.07	0.422
0.08	0.422
0.10	0.422
0.12	0.422
0.14	0.422
0.15	0.422
0.17	0.422
0.19	0.422
0.20	0.422
0.22	0.422
0.24	0.422
0.25	0.422
0.42	0.258
0.58	0.186
0.74	0.145
0.90	0.119
1.06	0.101
1.22	0.088
1.39	0.078
1.55	0.069
1.71	0.063
1.87	0.057
2.03	0.053
2.19	0.049
2.35	0.046
2.52	0.043
2.68	0.040
2.84	0.038
3.00	0.036

Appendix E. SPT Hammer Energy Calibration Report

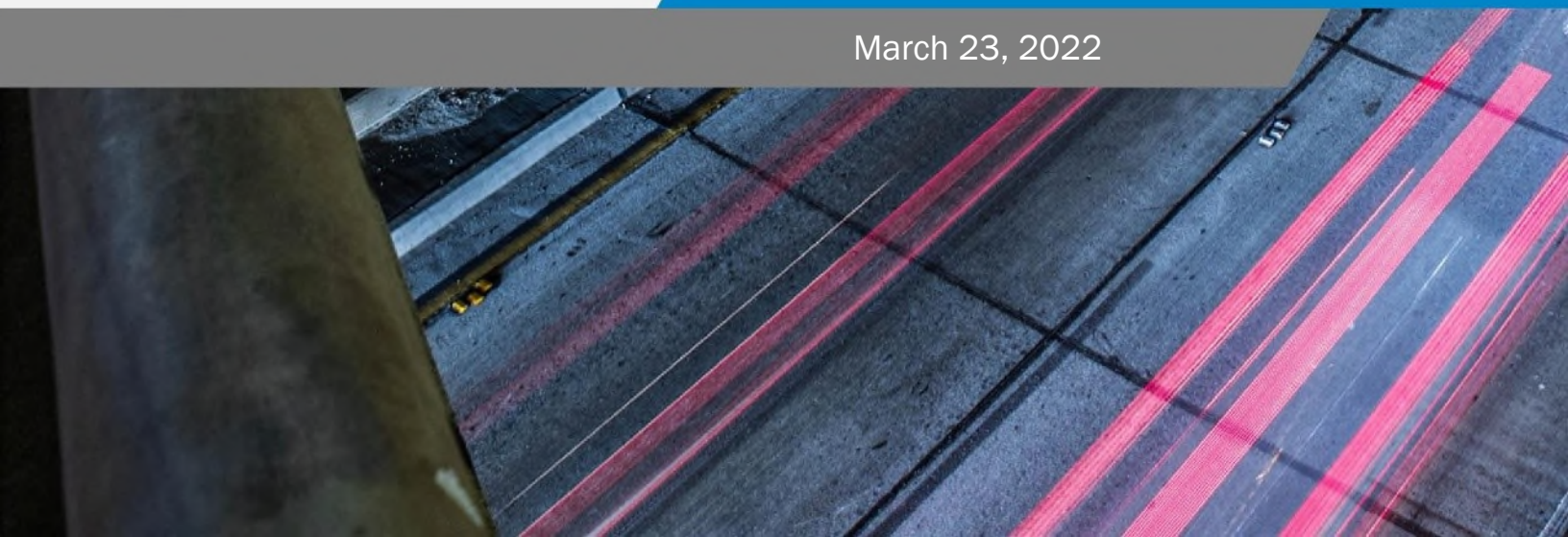


**CAROLINAS
GEOTECHNICAL
GROUP**

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 ²)	1.19
Typical Lengths (feet)	5
Instrumented Rod Type	AWJ (SN 528)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in ²)	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
Overall Average						55.6	285.0	81.4

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



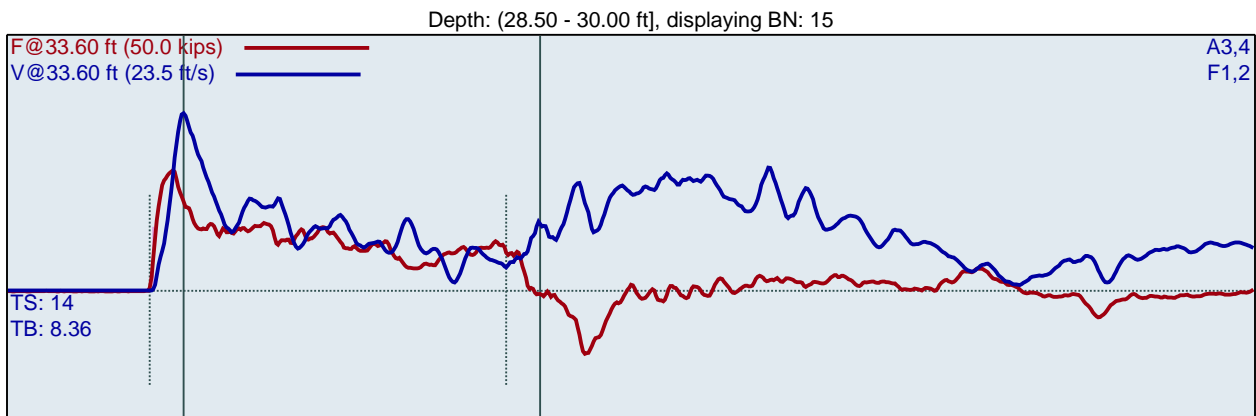
APPENDIX I

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 33.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
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

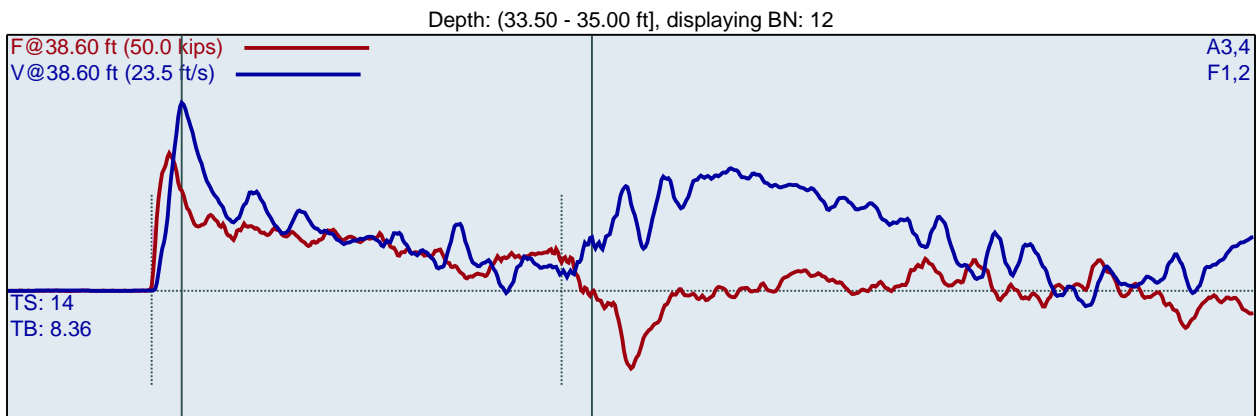
Sample Interval Time: 17.92 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 38.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
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

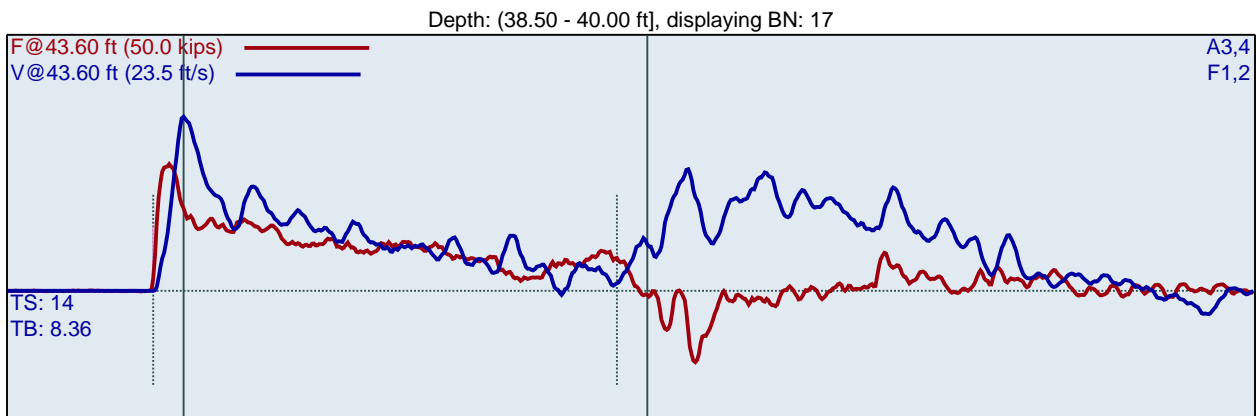
Sample Interval Time: 13.30 seconds.

CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in²
LE: 43.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
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.

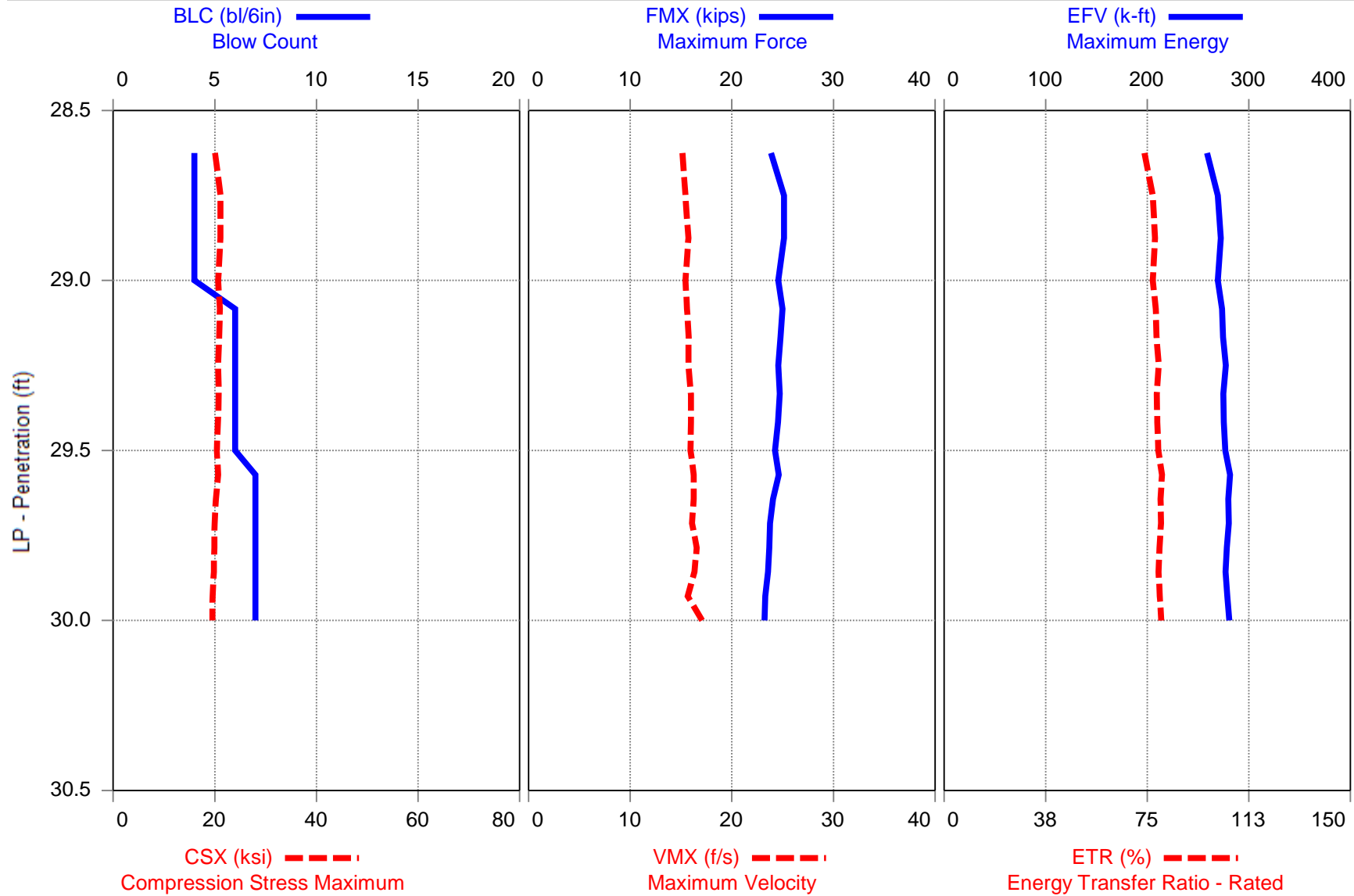
Summary of SPT Test Results

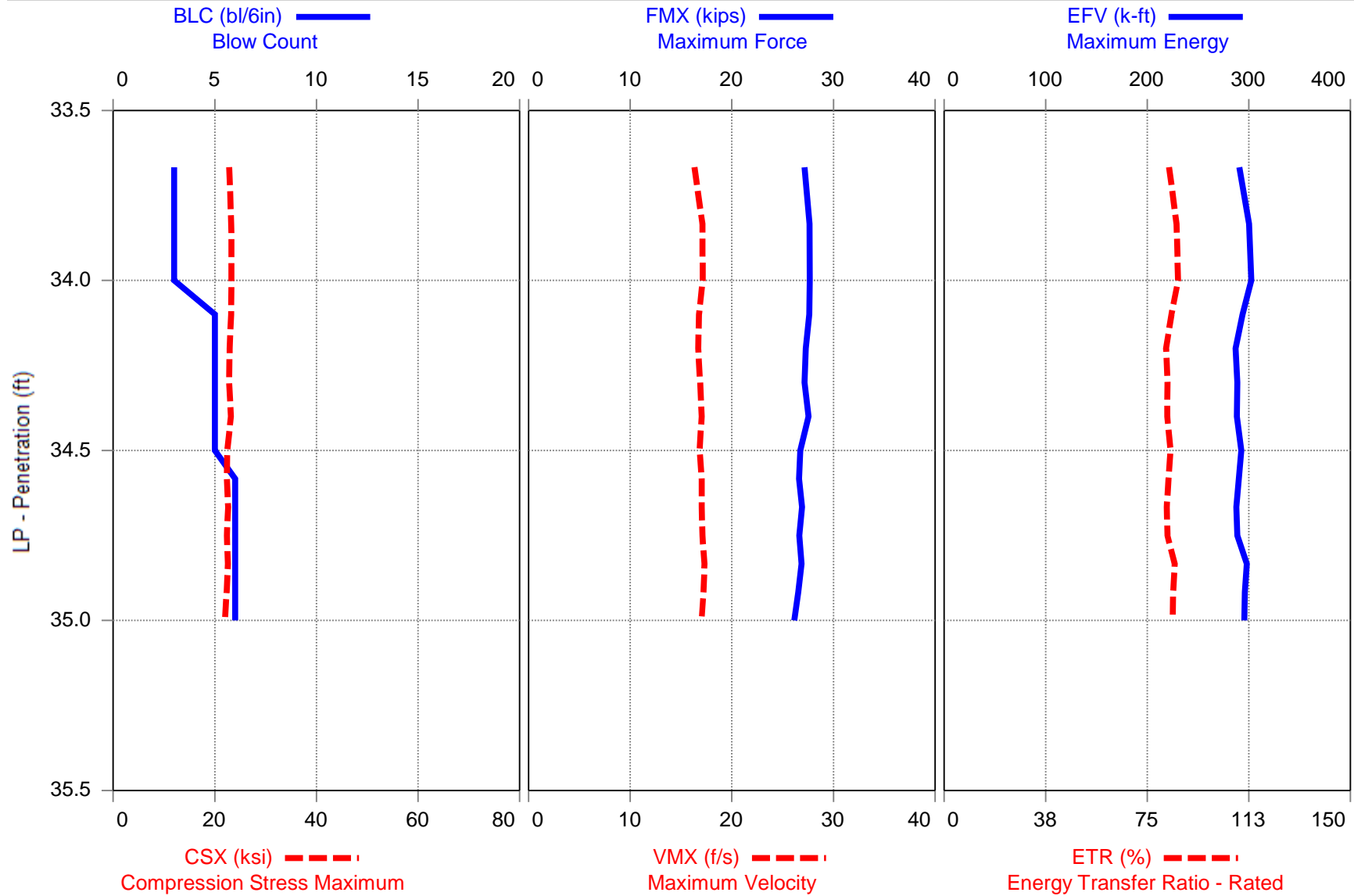
Project: CME 45B (SN 303304), Test Date: 3/11/2022

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



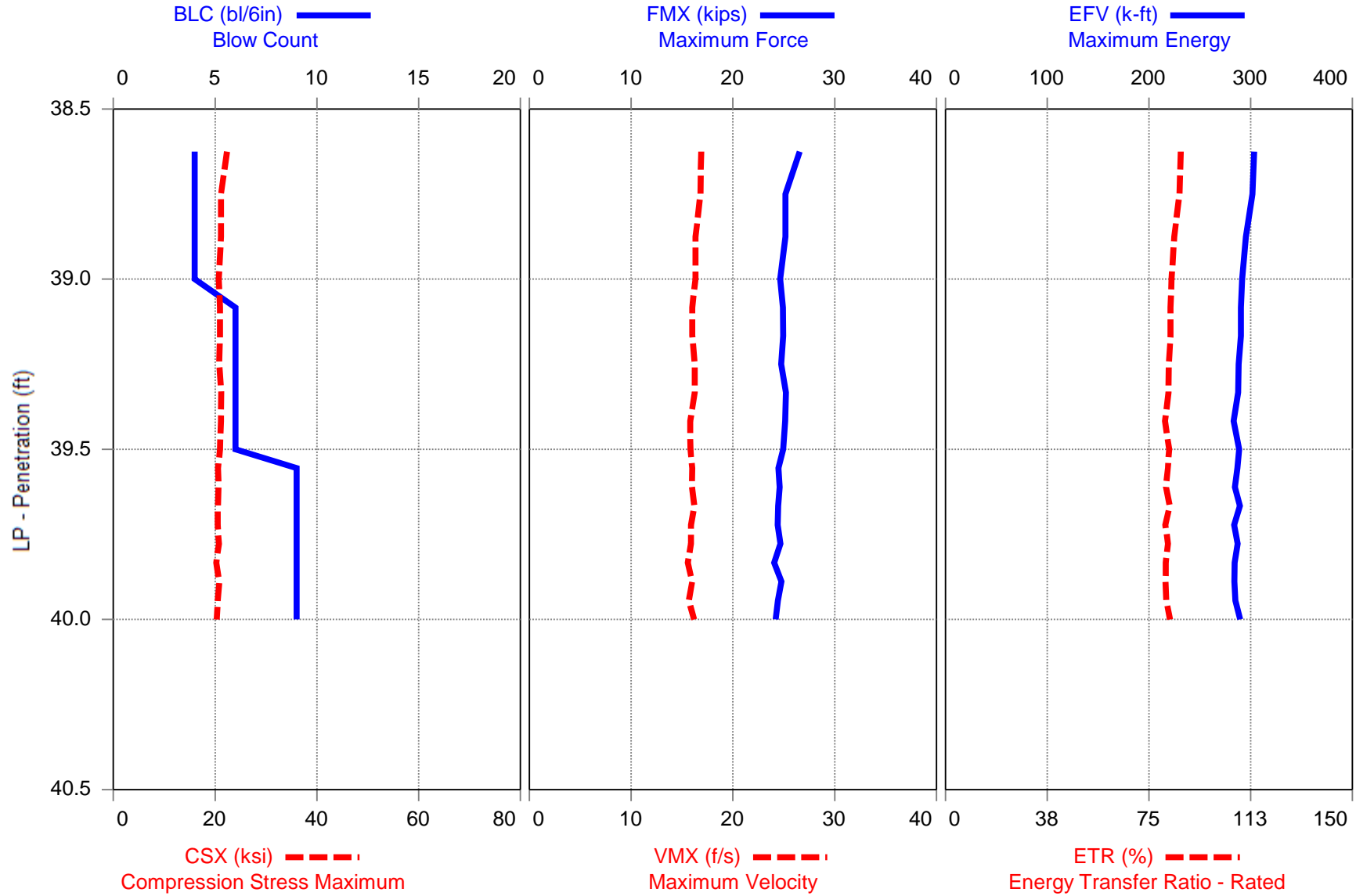
CME 45B (SN 303304) - 28.5 TO 30.0



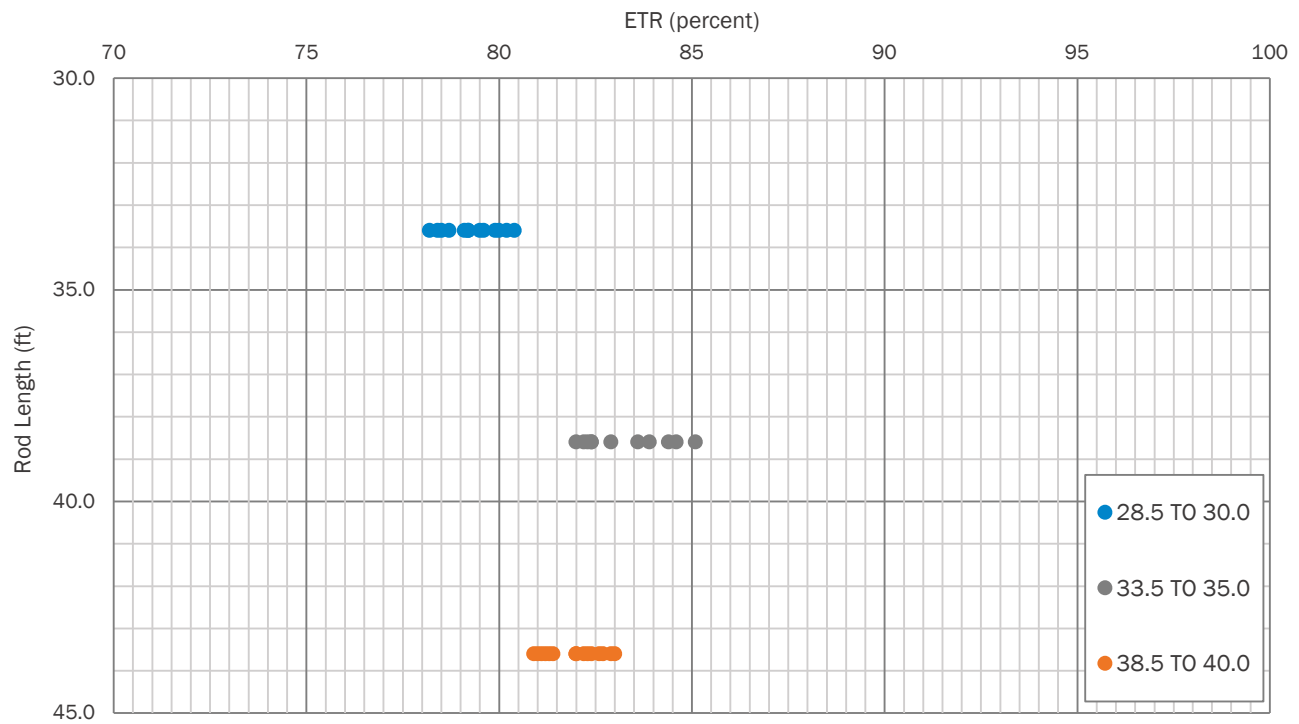




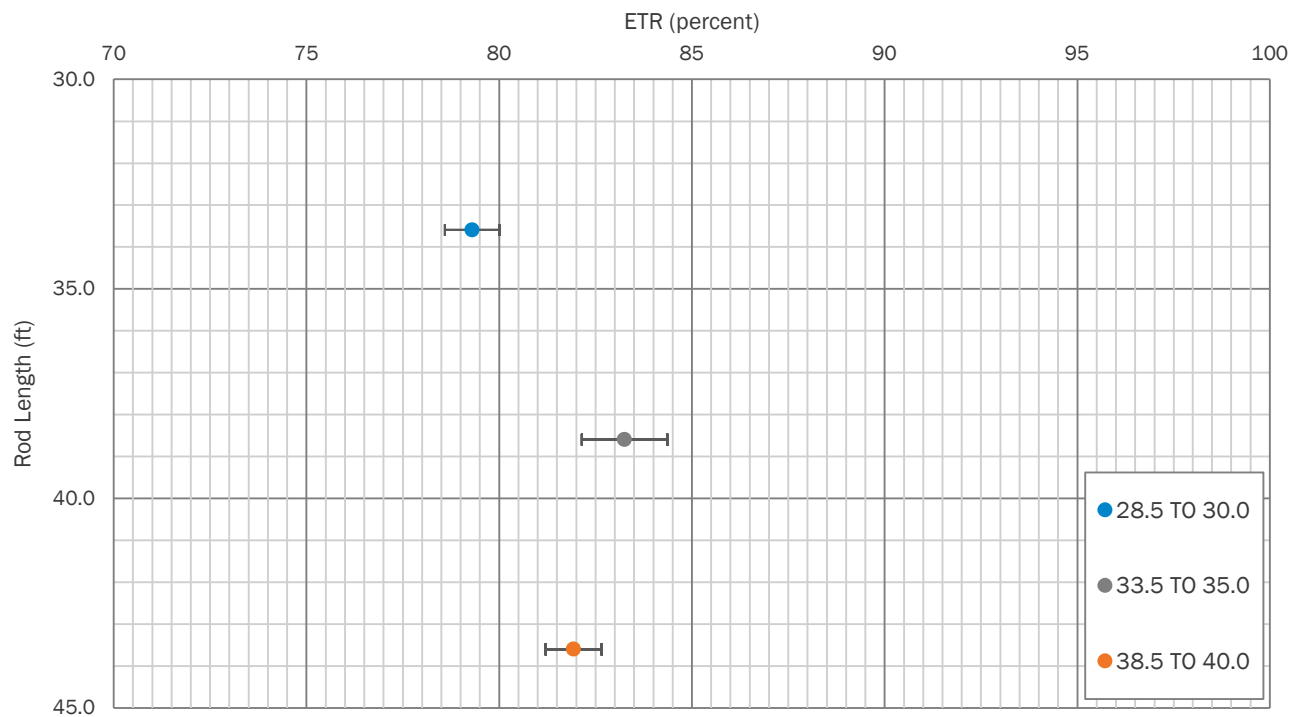
CME 45B (SN 303304) - 38.5 TO 40.0



**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

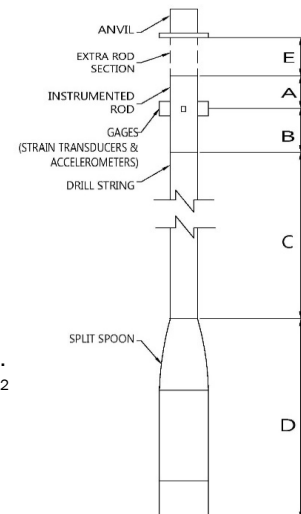
Drilling Company: BRECCIA CONSTRUCTION, LLC
 Rig Operator: D. HARRIS
 Engr/Geologist: N/A
 Client Rep.: N/A
 Analyzer Oper.: R. KRAL

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 in²
 PDA Make/Model: SPT
 PDA Serial No.: 4549 TB
 Calib. Pulse Test (y/n): Y



Gage Info

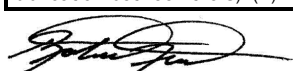
Gage		Serial No.	Calibration No.
Accel.	A3	K11957	407.00
	A4	K10959	417.30
Strain	F3	528AWJ-1	205.26
	F4	528AWJ-2	205.86

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

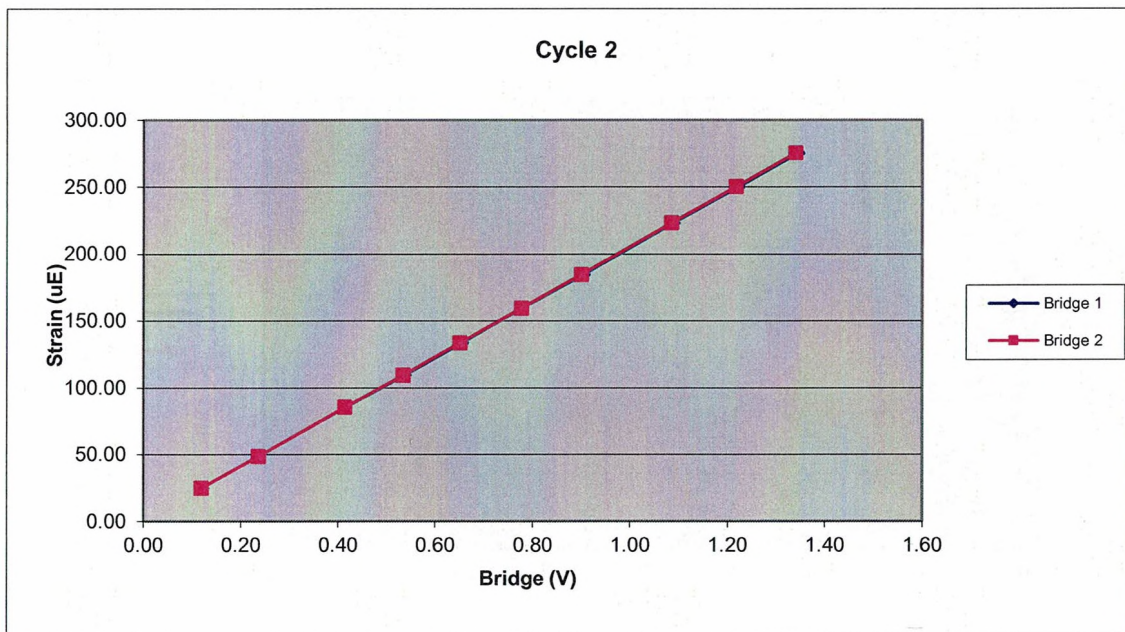


APPENDIX III

528AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	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 ($\mu\text{E/V}$)	204.74	Strain Calibration ($\mu\text{E/V}$)	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 (μ 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 (μ E/V)	205.65	Strain Calibration (μ 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

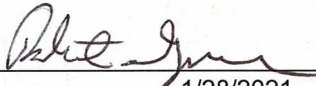


Bridge Excitation (V) 5
Shunt Resistor (ohm) 60.4k

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 (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 μ v/g)

R²: 0.999987 [Chip programmed]

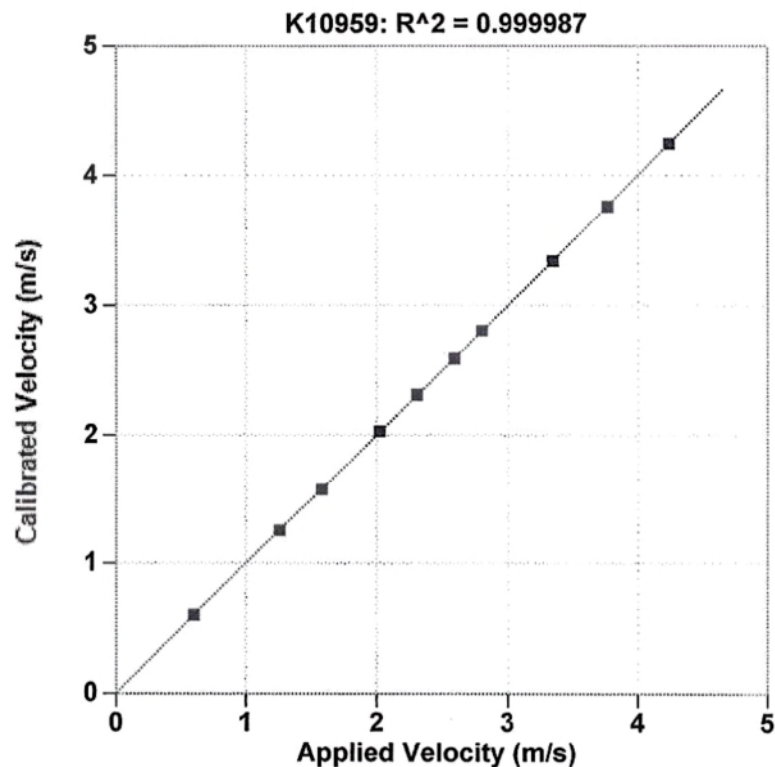
Operator: William Johnson

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

R²: 0.999987 [Chip programmed]

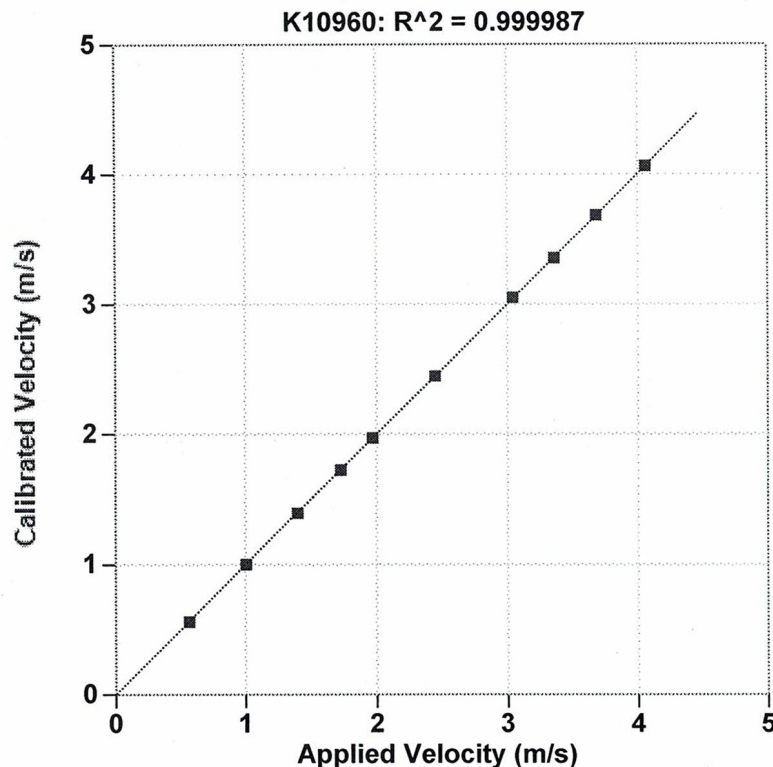
Operator: William Johnson

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 μ v/g)

R²: 0.999989 [Chip programmed]

Operator: William Johnson

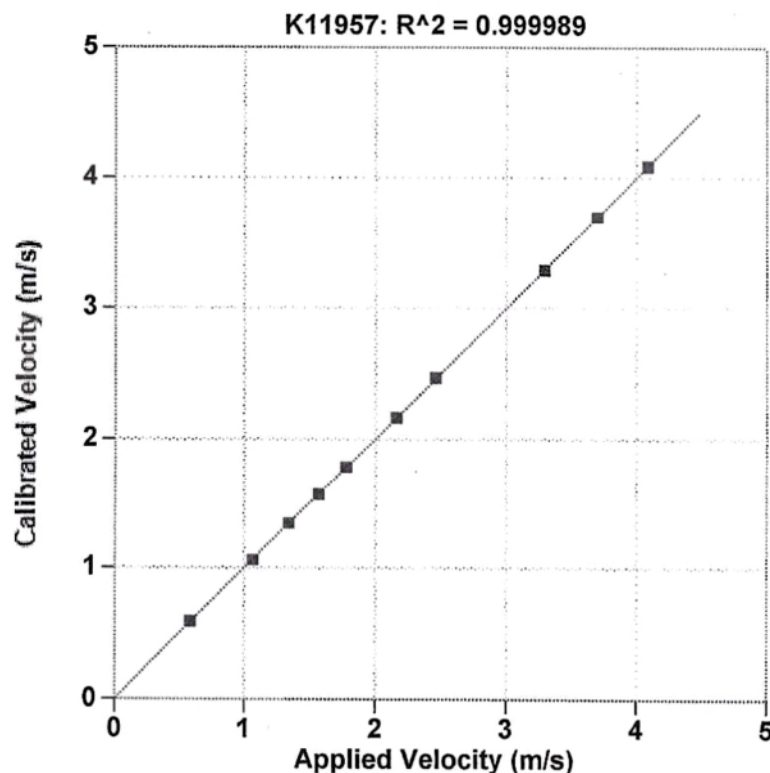
Ref Acc 1: 63479! Cal on: 22Jan2021
1079 g's/volt

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.** 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