

S-23-41 (Gap Creek Road) Bridge Replacement over Middle Saluda River

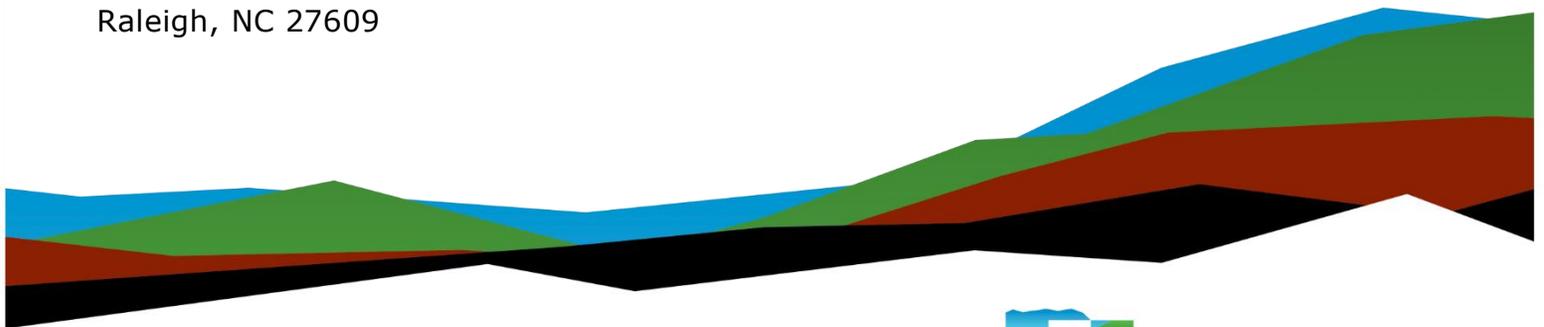
Greenville County, SC

Geotechnical Baseline Report

October 30, 2024 | SCDOT Project ID: P041159
Terracon Project No.: 8623P180 Revision 1

Prepared for:

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



Nationwide
[Terracon.com](https://www.terracon.com)

- Facilities
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October 30, 2024

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

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

Re: Geotechnical Baseline Report
S-23-41 Bridge Replacement over Middle Saluda River
Greenville County, South Carolina
SCDOT Project ID.: P041159
Terracon Project No.: 8623P180 Revision 1

Dear Mr. Franklin:

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

Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, laboratory testing and limited preliminary engineering recommendations for the replacement of the S-23-41 bridge over Middle Saluda River in Greenville County, South Carolina. This will be a complete bridge replacement generally within the project existing alignment. The results of subsurface exploration and laboratory testing have been separately presented in a Geotechnical Subsurface Data Report (GSDR). For convenience, those data are also provided here in this Geotechnical Baseline Report (GBR) along with a characterization of the subsurface conditions for the project. Limited preliminary geotechnical design and construction considerations are associated with the requested scope of work are included in this GBR. This GBR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM).

Project Description

The project site is located at the S-23-41 (Gap Creek Road) crossing over Middle Saluda River in Greenville County, South Carolina. Site location and exploration plans are presented in

Appendix A of this report. Based on the conceptual plans by HNTB dated 8/29/2024, the replacement bridge will be constructed on the approximate same alignment as the current bridge, with some slight straightening of the curve on the east end of the bridge. The current plan indicates the new bridge will be a 130-ft long two-span bridge constructed with a prestressed concrete cored slab for span A and AASHTO Type BIII-36 Box Beams for span B.

Geotechnical Testing

The geotechnical exploration for this project was performed between August 23 and August 27, 2024. The results of our field work and our associated laboratory testing are included in Appendices A and B.

Field Exploration

Our field exploration consisted of the following:

- Three (3) Standard Penetration Test (SPT) Borings (S-23-41-1, S-23-41-2, and S-23-41-3)
- One (1) offset boring near S-23-41-1 for bulk sample collection

The tests were performed at the approximate locations as approved by SCDOT. A description of our testing methods and graphical logs outlining the soil conditions at each test location are presented in Appendix A. The test locations were established in the field by Terracon and surveyed by Thomas & Hutton after completion. Station and offset are based on the plans provided at the time the tests were performed.

Laboratory Testing

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

- Eleven (11) Natural Moisture Content Tests
- Four (4) Atterberg Limits Tests
- Six (6) Fines Content Tests
- Four (4) Grain Size Tests with Hydrometer
- One (1) Remolded, Consolidated-Undrained (CU) Triaxial Compression Test with Pore Pressure Readings
- One (1) Standard Proctor Test
- One (1) Corrosivity Suite (pH, chloride content, sulfate content, and resistivity tests)
- Six (6) Compressive Strength of Rock Cores

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

Subsurface Conditions

Regional Geology

The bridge site is located on route S-23-41, on the outskirts of the town of Marietta in Greenville County, South Carolina. The site lies generally within an area of South Carolina where the Piedmont and Blue Ridge Physiographic merge. More specifically, the site is located within the Walhalla Thrust Sheet. According to regional geologic mapping and published geologic reports, the project area is mapped in the Caesars Head Granite consisting of biotite granitoid gneiss, mainly granodioritic but composition ranges from quartz monozonite to quartz diorite. The bridge end bents and interior bent embankments contain existing fill above alluvial and/or residual soils, very dense residual soils classified as Intermediate Geomaterials (IGM) and bedrock.

Soil and Rock Stratification

The borings encountered 3.5 to 4 inches of asphalt followed by 4 to 17.5 inches of gravel. Beneath the existing roadway section, minimal fill soils consisting of medium dense silty sand was noted at boring S-23-41-1. Below the fill at boring S-23-41-1, alluvial soil consisting of very loose to medium dense silty sand or poorly graded sand with silt and gravel was noted to a depth of about 17 feet below existing grade. Residual soils were encountered below the alluvium at S-23-41-1 and under the existing roadway at S-23-41-2 and S-23-41-3. The residual soils consisted of medium dense to very dense silty sand and well graded sand with silt to a depth of approximately 6 feet to 63 feet below ground surface overlying bedrock. Materials classified as intermediate geomaterials (IGM) were noted below a depth of approximately 38 feet, 6 feet, and 2 feet at borings S-23-41-1, 2 and 3, respectively. Bedrock was present to the maximum depth explored of 78.5 feet, 31 feet, and 17.5 feet at borings S-23-41-1, 2 and 3, respectively.

Geology	Approximate Elevation of Layer Bottom (ft, NAVD88)	USCS Soil Type	Measured Field N Value	Plasticity Index	Fines Content	REC / RQD
Asphalt / Gravel	1093 to 1094	--	--	--	--	--
Fill ³	1091	SM	17 to 22	NP ²	23	--
Alluvium ³	1078	SM, SP-SM	4 to 25	NP ²	7 to 41	--
Residuum	1031 to 1089	SM, SW-SM	17 to 100+	NP ²	11 to 26	--
Rock	PMDE ¹	--	--	--	--	80-100% / 38-80%

1. PMDE = Present to Maximum Depth Explored

2. NP = non-plastic

3. Only present at S-23-41-1.

Design and Construction Considerations

Foundations

Driven steel H-piles driven to practical refusal on rock (i.e., >20 blows per inch [bpi] with appropriately sized hammer) are expected to be feasible for the proposed bridge end abutments. Per 16.3.1 of the SCDOT GDM (2022):

For driven piles bearing in rock with an RQD greater than 10 percent, the nominal resistance of the pile is typically limited by the structural capacity of the foundation element itself. This is especially true with prestressed concrete piles driven into rock, and why prestressed concrete piles typically have pile points when driven to bearing in rock. In many cases steel piles are fitted with “reinforced tips” to avoid damage to the foundation element. If the depth to rock with RQD greater than 10 percent is less than 10 feet, then the pile should be installed as a drilled pile. Therefore, piles should be driven to rock when the depth to top of rock is greater than 10 feet. For rock with RQD less than 10 percent and soils with 100 or more blows per foot of penetration, it has been the experience of SCDOT that piles can be driven into these materials. Penetrations typically range from 5 to 10 feet.

Per the preliminary plans, the estimated bottom of pile cap is at about Elevation 1090 feet, about 2 feet below the existing grades along the alignment. The depth to very dense residual soils/IGM is predicted to be about 35 feet at Bents 1 and 2 and less than about 4 feet at Bent 3 above the estimated bottom of abutment pile cap. Predrilling will likely be required to provide rock sockets to provide sufficient pile penetration at Bent 3. Reinforced pile tips will be needed to minimize potential pile damage while penetrating through IGM. Pile drivability using the wave equation should be performed as part of subsequent detailed geotechnical evaluations.

Piles driven to practical refusal within the IGM or to top of rock can be designed to the factored structural capacity of the pile. The table below provides the maximum factored pile structural capacity assuming an AASHTO permitted factored pile capacity of $0.5A_sF_y$, using 50 ksi steel piles. An efficiency factor (η) of 1.0 can be used if the pile spacing divided by the pile dimension is greater than 2.5 (Per Section 16.3.3 of the GDM).

Pile Size	Area of Steel (As) in ²	Maximum Factored Pile Load (tons) ¹
HP14x73 (21.4 in ²)	21.4	267
HP14x89 (26.1 in ²)	26.1	326

1. Max Load = $0.5 \cdot A_s \cdot F_y$

The nominal geotechnical resistance of the piles considering refusal upon competent rock is typically set at 4 times the minimum compressive strength measured in the rock at the end bents (4,000 psi) times the cross-sectional area of the pile, 171 tons and 209 tons for HP 14x73 and HP14x89 piles, respectively. Piles driven to practical refusal in IGM will have slightly lower

nominal resistance; however, as indicated above for piles driven to practical refusal, the pile design will be governed by the maximum factored structural capacity of the pile rather than geotechnical capacity.

According to the conceptual bridge plans by HNTB dated 8/29/2024, minimal fill is expected at the end bent embankments to support the approach slab. Foundations should typically be installed after the approach embankment construction to reduce potential down drag settlement issues. However, it is noted that piles driven to practical refusal are not considered sensitive to down drag settlement. The pile design should account for drag loads from the settling alluvium at the site; however, this additional drag load is not expected to control the pile design.

Drilled shafts are anticipated to be feasible for the proposed bridge interior Bent 2. Assuming redundant drilled shafts, Table 9-4 GDM 2022 allows using a resistance factor of 0.60 (both side resistance and end bearing) for a single redundant drilled shaft in rock. The shafts at Interior Bent No. 2 will probably be drilled through the very dense IGM and socketed into the underlying top of rock. Per the GDM, shafts constructed through IGM and bearing in rock should be designed using the Beta Method for side resistance in the IGM. The sidewall resistance in the rock is based upon the uniaxial compressive strength of the rock and normal rock sockets (i.e., sockets constructed with normal equipment resulting in clean, smooth sidewalls). The uniaxial strength of the rock will likely be higher than the concrete strength, so the concrete strength should control in the design. The nominal end bearing resistance of the rock should be based upon the quality and strength of the rock within about 2 diameters of the tip. Additional evaluation of the soil conditions should be performed at the planned Bent 2 location during subsequent evaluations.

We have observed variability in the top of rock and thickness of IGM, as seen in **Soil and Rock Stratification**. Therefore, we expect variability in tip elevations at each bent location. Resistance of piles driven to practical refusal in IGM or rock will be limited by their structural resistance. Therefore, likely reinforced pile tips will be required to penetrate to IGM and rock. Pile drivability using the wave equation should be performed 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.

Corrosion and Deterioration

Corrosion testing was performed on a composite sample obtained from split spoons in the upper 2 to 15 feet. Corrosion testing included pH, resistivity, chlorides, and sulfates content as summarized in Table below. Corrosion test results are included in Appendix B.

Corrosion Test	Results Bent 1, Boring S-23-41-1 Composite Sample from 2 to 15 feet	Indication of Corrosivity ¹
pH	5.5	Less than 5.5
Resistivity	1,742 ohm-cm	Less than 2,000 ohm-cm
Chloride	235 ppm	Greater than 500 ppm
Sulfate	27 ppm	Greater than 1,000 ppm

1. AASHTO LRFD bridge design specifications, Ninth Edition 2020, Section 10.7.5.

Based on the criteria for electro-chemical properties in the GDM Section 7.18, the electro-chemical classification of the project site is aggressive. Interpretation of these data should be communicated with the project’s structural engineer.

Embankment Construction

Based on the conceptual plans by HNTB, minimal fill will be placed to support the bridge approach slabs and extend beyond the bridge with relatively short (less than 10 feet tall) 2H:1V rip rap lined fill slopes shown at the end abutment positions. Bulk samples were obtained from near Interior Bent 1 from the top 5 feet of existing embankment material. Per our scope, a bulk sample was tested for soil classification and was also remolded to about 95% of the Standard-effort Proctor prior to being tested for shear strength envelopes under CU Triaxial Compression with pore pressure readings. Test results are presented in Appendix B and summarized in the table below.

Sample No.	Station	Offset (ft)	Sample Depth (ft)	USCS Soil Type	Compaction		Shear Strength ¹	
					Optimum Moisture (%)	Max Dry Density (pcf)	Total	Effective
S-23-41-1 Offset	17+06 and 17+12	11 R	0 – 5	SM	11.5	117.9	c=3.8 psi φ=32°	c’=1.7 psi φ’=37°

1. Based on a maximum deviator stress failure criterion

Retaining Walls

According to information provided by HNTB, a retaining wall is planned along the north side of the roadway from about Station 18+15 to about 19+50 between the roadway edge and the adjacent creek. Another short wall may also be needed along an existing driveway that is perpendicular to the roadway near Bridge Bent No. 3

Based on elevation shown on the preliminary plans, a wall height of about 8 feet is anticipated for the north retaining wall to achieve grade along the north road edge (Elev. ~1094 feet).

Geotechnical Baseline Report

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October 30, 2024 | Terracon Project No. 8623P180 R1 | SCDOT Project ID: P041159



The wall along the driveway will likely retain a cut into the existing slope. The boring performed at about Station 18+28 along the existing road alignment indicated very dense residual soils/IGM near the ground surface with auger refusal encountered at about Elevation 1088 feet. It is noted that relatively massive rock outcrops are readily visible along the cut slope on the opposite side of the road, so it is anticipated that rock will likely be present along the toe of the planned walls. The conditions are conducive to consider using a modular gravity wall system such as a gabion wall, MSE wall, reinforced concrete retaining walls, or possibly a soldier pile wall socketed into rock with precast concrete panels for this application. Additional evaluation should be conducted along the wall alignment to evaluate the available options.

Closure

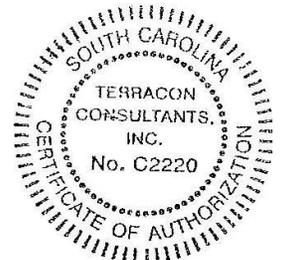
We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

A handwritten signature in black ink that reads 'Maggie McKenney'.

Maggie McKenney, EIT
Senior Staff Engineer

Jonathan Ard
Manager Regional Services
SC Registration No. 30886



Appendix A

Field Exploration

- Exhibit A-1 – Site Location Map
- Exhibit A-2 – Exploration Plans (2 Pages)
- Exhibit A-3 – Subsurface Profile
- Exhibit A-4 – Summary of Boring Data
- Exhibit A-5 – GeoScoping Form (2 Pages)
- Exhibit A-6 – Field Exploration Description (3 Pages)
- Exhibit A-7 – Soil/Rock Description Terms (2 Pages)
- Exhibit A-8 – Soil/Rock Symbols
- Exhibit A-9 – Boring Logs (5 Pages)
- Exhibit A-10 – Rock Core Photograph Logs (2 pages)

Note: All exhibits are one page unless noted above



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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Number	8623P180
Scale	AS SHOWN
Client	HNTB
Date	9/20/2024



72 Pointe Cir
Greenville, South Carolina 29615

SITE LOCATION
S-23-41 BRO Middle Saluda River Gap Creek Road Greenville County, SC

Exhibit
A-1



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager: DJC
 Drawn by: MEM
 Checked by: SG
 Approved by: SG

Project No. 8623P180
 Scale: AS SHOWN
 File Name: -
 Date: 9/20/24

72 Pointe Cir
 Greenville, SC 29615-3506

EXPLORATION PLAN

S-23-41 BRO Middle Saluda River
 Gap Creek Road
 Greenville County, SC

Exhibit
A-2



PRELIMINARY SITE PLAN PROVIDED BY HNTB

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

Project Manager: DJC
 Drawn by: MEM
 Checked by: SG
 Approved by: SG

Project No. 8623P180
 Scale: AS SHOWN
 File Name:
 Date: 9/20/24



72 Pointe Cir
 Greenville, SC 29615-3506

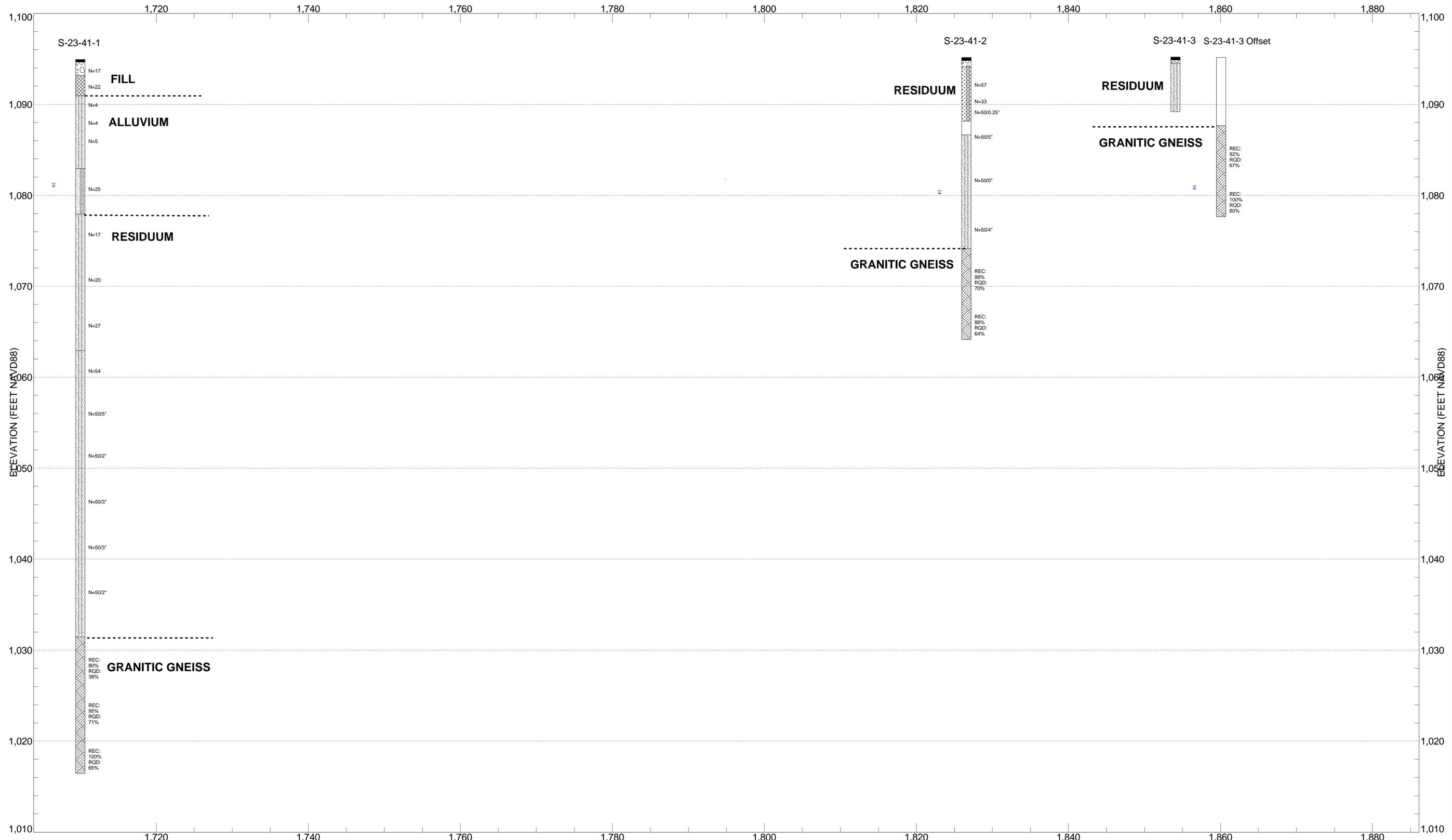
EXPLORATION PLAN

SCDOT S-23-41 BRO Middle Saluda River
 Gap Creek Road
 Greenville County, SC

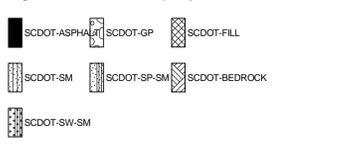
Exhibit

A-2

APPROXIMATE STATIONING (FEET)



DISTANCE ALONG PROFILE (FEET)



NOTES:
 See Exhibit for orientation of soil profile.
 See General Notes in Appendix A for symbols and soil classifications.
 Soils profile provided for illustration purposes only.
 Soils between borings may differ.
 For presentation purposes, some locations are offset to allow display of both borings and CPTs.
 BT - Boring Termination (Ft)
 ▽ Water Level Reading at time of drilling.
 ▼ Water Level Reading after drilling.

Project Manager: DJC	Project No.: 6623P180	<p>72 Pointe Cir Greenville, SC PH: 864-292-2901 FAX: 864-292-6361</p>	<p>SUBSURFACE PROFILE</p> <p>SECTION ALONG GAP CREEK ROAD S-23-41 (GAP CREEK ROAD) BRO MIDDLE SALUDA RIVER SCDOT PROJECT ID: P041159 GREENVILLE COUNTY, SC</p>	<p>EXHIBIT A-3</p>
Drawn by: MEM	Scale: N.T.S.			
Approved by: JNA	File Name:			
Date: 10/30/2024				

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT, BENCH MARK, SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER, TERRACON DATA TEMPLATE GDT, 10/30/24

Summary of Boring Data – Exhibit A-4

S-23-41 Bridge Replacement over Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



Summary of Boring Data

Boring No.	Ground Elevation (ft)	Test Depth (ft)	Northing (ft)	Easting (ft)	Latitude (°)	Longitude (°)	Station (ft) ¹	Offset (ft) ¹
S-23-41-1	1094.9	78.5	1199426.09	1540093.71	35.120283	-82.537705	17+10	11 R
S-23-41-2	1095.2	31	1199508.17	1540176.55	35.120512	-82.537432	18+28	14 R
S-23-41-3	1095.2	6	1199531.28	1540192.17	35.120576	-82.537381	18+55	11 R
S-23-41-3 Offset	1095.2	17.5	1199532.07	1540192.71	35.120578	-82.537379	18+56	11 R

1. Plans were provided by HNTB after the field exploration and survey. Station and offset values are estimated based on overlay in Google Earth™.
2. A bulk sample was collected about 4 feet west and 1.5 feet east of S-23-41-1.
3. Station and offset are based on the plans provided at the time the tests were performed.

GeoScoping Form

PROJECT INFORMATION			
Project ID:	P041159	Date of Trip:	8/23/2024
County:	Greenville	Location:	Marietta, SC
Rd/ Route:	S-23-41	Local Name:	Gap Creek Road
Attendees:	M. McKenney		

EXISTING BRIDGE INFORMATION			
Bridge Length:	90 ft	Bridge Width:	27.5 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber Piles
Begin Bridge Sta ¹ :	16+80	End Bridge Sta ¹ :	18+10
Begin Bridge Embankment Sta ¹ :	15+80	End Bridge Embankment Sta ¹ :	19+10
Structure Number:	04329	Posted Weight Limit:	14 tons
Crossing:	Middle Saluda River	Skew:	N/A
Latitude:	35.120412°	Longitude:	-82.537574°
Existing Fill Height:	approx 2 ft	Approx Existing Slope Angle:	2H:1V
1. Begin & End Bridge Embankment 100 ft down Sta. or up Sta., respectively. Sta. estimated from overlay of bridge plan provided by HNTB.			

EXISTING ROADWAY EMBANKMENT INFORMATION			
Begin Project Sta:	15+80	Begin Bridge Embankment Sta:	15+80
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement, trees, grass		
Existing Fill Height:	2 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	slope to river		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	silty sand	Muck:	No
Exposed Rock in Stream Bed:	Yes	Exposed Rock in banks:	Yes
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	15 ft	Water Depth:	3 ft
Depth to Existing Ground:	approximately 18 ft at center of bridge		
Scour Condition at EB:	N/A	Scour Condition at IB:	N/A

End Bridge Embankment Sta:	19+10	End Project Sta:	19+70
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement, trees, rock slope		
Existing Fill Height:	N/A	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	slope to river		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	silty sand	Muck:	No
Exposed Rock in Stream Bed:	Yes	Exposed Rock in banks:	Yes
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	15 ft	Water Depth:	3 ft
Depth to Existing Ground:	approximately 18 ft at center of bridge		
Scour Condition at EB:	N/A	Scour Condition at IB:	N/A

GeoScoping Form

UTILITIES INFORMATION	
Attached:	A fiber optic cable was observed to be attached along the northwest side of the bridge
Above Ground:	A phone line was observed crossing diagonally over head
Underground:	N/A

Comments:

Field Exploration Description Overview

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

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

Soil Test Borings (STB)

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

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

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

Test ID	Total Depth	Interval of Continuous Sampling
S-23-41-1	78.5 feet w/ 15 feet rock coring	0.5 to 10 feet
S-23-41-2	31 feet w/ 10 feet rock coring	2 to 7 feet
S-23-41-3	6 feet	2 to 6
S-23-41-3 Offset	17.5 feet w/ 10 feet rock coring	No sampling
S-23-41-1 Offset	5 feet	Bulk Sample ¹

1. Bulk sample was obtained with 2 ¼-inch Hollow Stem Auger (HSA).

Exhibit A-6 – Field Exploration Description

S-23-41 Bridge Replacement over Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



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

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

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

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

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

SOIL DESCRIPTION TERMS

Relative Density/Consistency Terms

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

Moisture Condition

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

Color

Describe the sample color while sample is still moist.

Angularity¹

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

HCl Reaction³

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

Cementation³

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

Particle-Size Range¹

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

Primary Soil Type^{1, 2}

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

USCS Soil Designation

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

AASHTO Soil Designation

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

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

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

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

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

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

Joint, Bedding, and Foliation Spacing in Rock^a

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

^aSpacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designation (RQD)^a

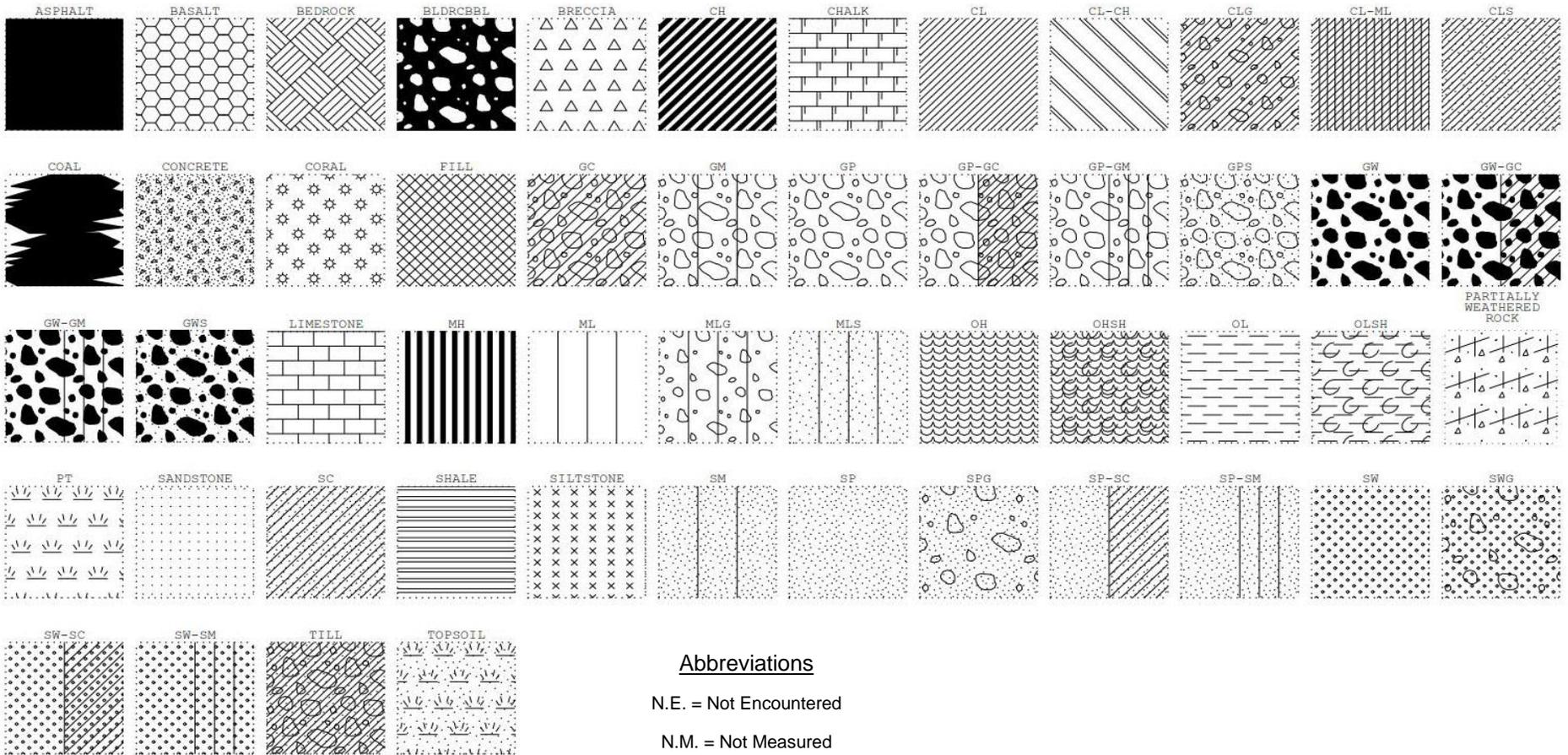
RQD, as a percentage	Diagnostic Description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

^aRQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors

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

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



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

Project Manager:
MEM
Drawn by:
KJZ
Checked by:
SG
Approved by:
DJC

Project No.
8623P180
Scale:
N.T.S.
File Name:
Soil - Rock - Log
Date:
Jul 2023



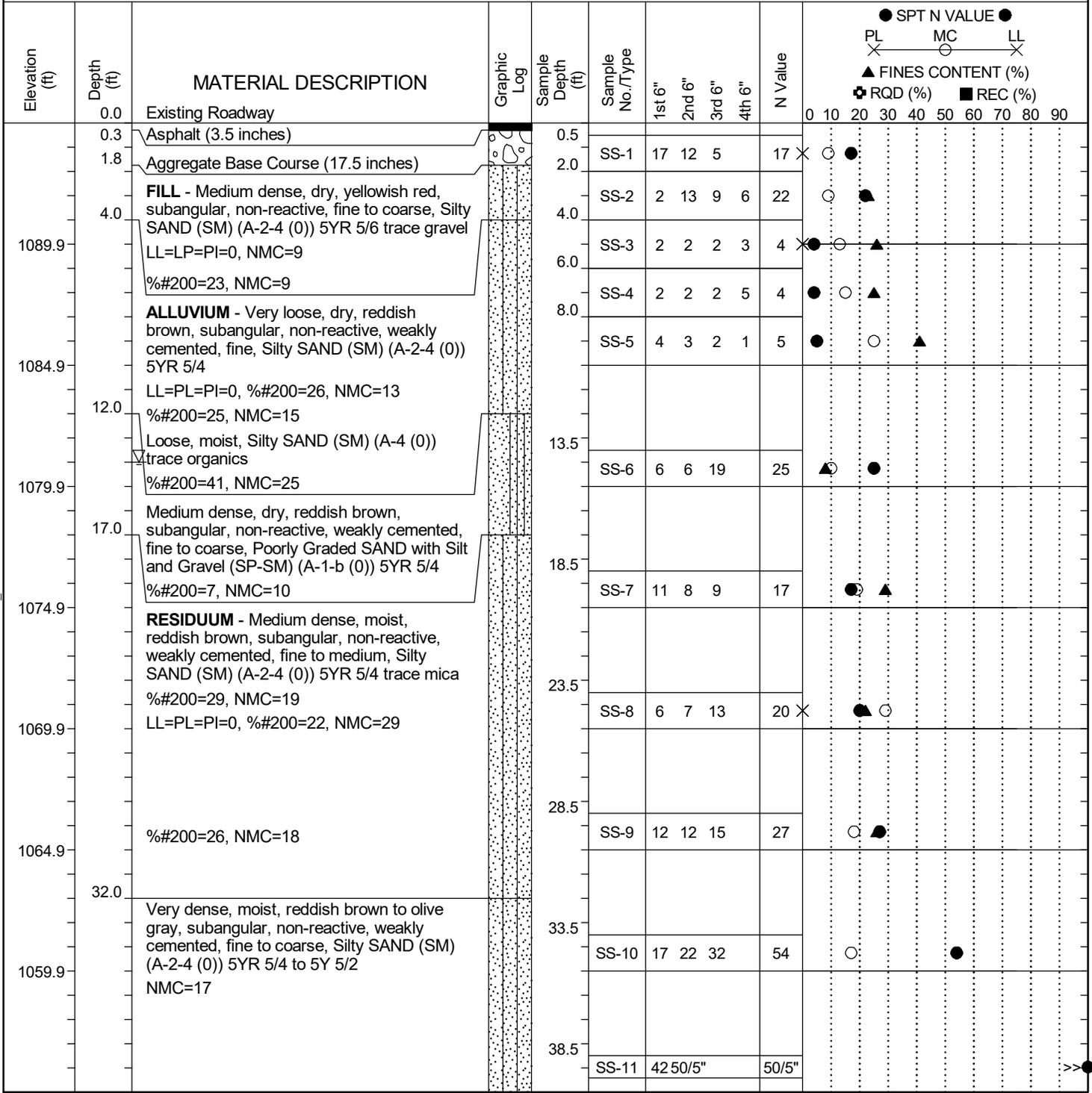
72 Pointe Circle
Greenville, SC 29615
PH. (864) 292-2901
FAX. (864) 292-6361

SOIL AND ROCK SYMBOLS

Exhibit A-8

SCDOT Soil Test Log

Project ID: P041159	County: Greenville	Boring No.: S-23-41-1
Site Description: S-23-41 BRO Middle Saluda River		Route: S-23-41
Eng./Geo.: S. Greaber	Boring Location: 17+10	Offset: 11 R
Alignment: Existing	Elev.: 1094.9 ft	Latitude: 35.12028
Longitude: -82.53771	Date Started: 8/23/2024	
Total Depth: 78.5 ft	Soil Depth: 63.5 ft	Core Depth: 15 ft
Date Completed: 8/23/2024	Bore Hole Diameter (in): 4	Sampler Configuration
Liner Required: Y (N)	Liner Used: Y (N)	
Drill Machine: DR#1327	Drill Method: RW/RC	Hammer Type: Automatic
Energy Ratio: 92.6%	Core Size: NQ2	Driller: B. Burnette
Groundwater: TOB	14 (After 1hr)	24HR
		N.M.



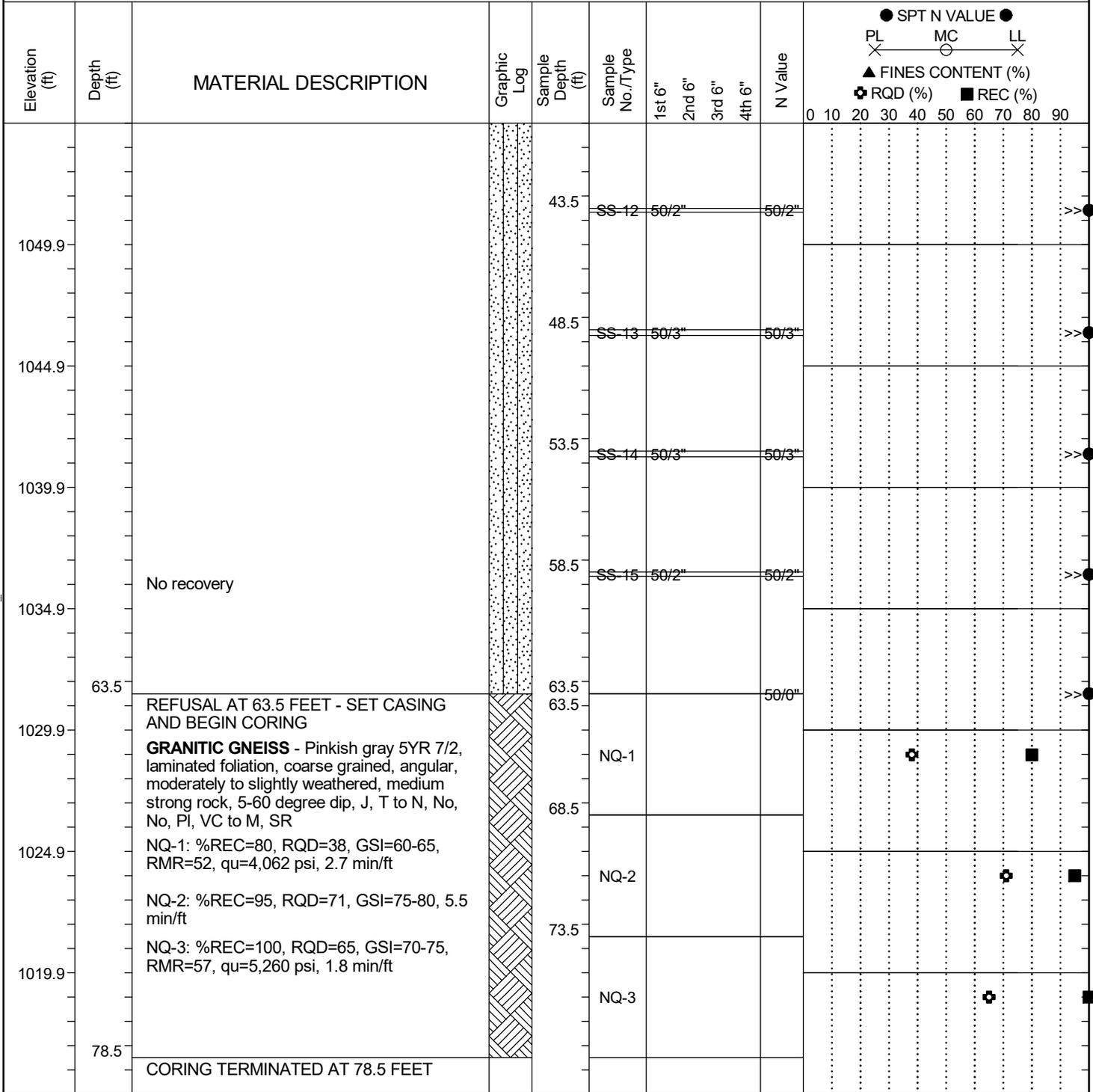
LEGEND Continued Next Page

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 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT_DATATEMPLATE.GDT 9/24/24

SCDOT Soil Test Log

Project ID: P041159	County: Greenville	Boring No.: S-23-41-1
Site Description: S-23-41 BRO Middle Saluda River	Route: S-23-41	
Eng./Geo.: S. Greaber	Boring Location: 17+10	Offset: 11 R
Alignment: Existing		
Elev.: 1094.9 ft	Latitude: 35.12028	Longitude: -82.53771
Date Started: 8/23/2024		
Total Depth: 78.5 ft	Soil Depth: 63.5 ft	Core Depth: 15 ft
Date Completed: 8/23/2024		
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)
Liner Used: Y (N)		
Drill Machine: DR#1327	Drill Method: RW/RC	Hammer Type: Automatic
Energy Ratio: 92.6%		
Core Size: NQ2	Driller: B. Burnette	Groundwater: TOB
		14 (After 1hr) 24HR
		N.M.



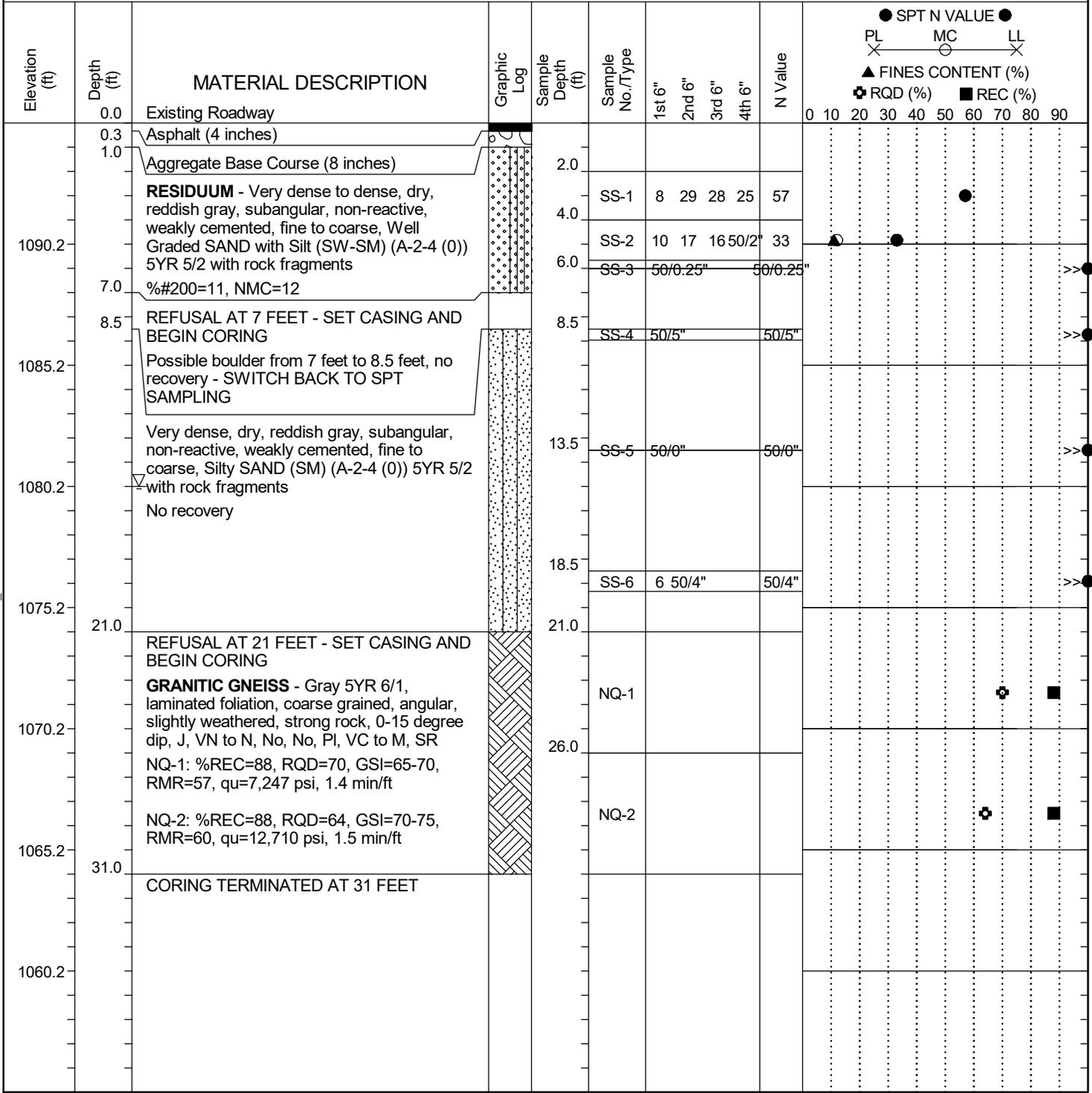
LEGEND

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 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER.DOT.GPJ SCDOT_DATATEMPLATE.GDT 9/24/24

SCDOT Soil Test Log

Project ID: P041159	County: Greenville	Boring No.: S-23-41-2
Site Description: S-23-41 BRO Middle Saluda River		Route: S-23-41
Eng./Geo.: S. Greaber	Boring Location: 18+28	Offset: 14 R
Alignment: Existing	Date Started: 8/23/2024	Date Completed: 8/27/2024
Elev.: 1095.2 ft	Latitude: 35.12051	Longitude: -82.53742
Total Depth: 31 ft	Soil Depth: 21 ft	Core Depth: 10 ft
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)
Liner Used: Y (N)	Drill Machine: DR#554	Drill Method: RW/RC
Hammer Type: Automatic	Energy Ratio: 88.5%	Groundwater: TOB
Core Size: NQ2	Driller: G. Robinson	15 (After 2hr): 34HR
		N.M.



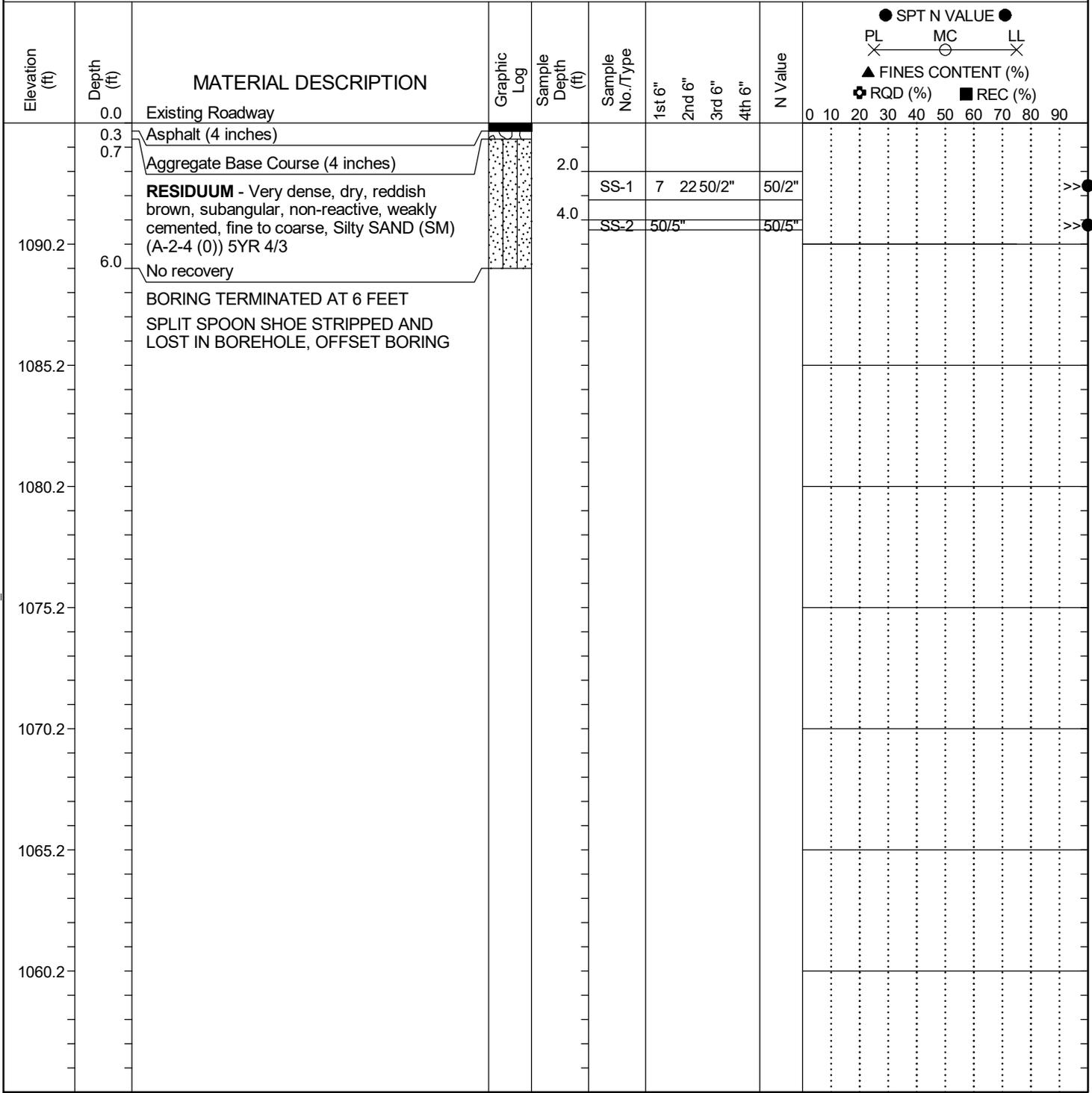
SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER.DOT.GPJ SCDOT_DATATEMPLATE.GDT 9/24/24

LEGEND

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

SCDOT Soil Test Log

Project ID: P041159	County: Greenville	Boring No.: S-23-41-3
Site Description: S-23-41 BRO Middle Saluda River	Route: S-23-41	
Eng./Geo.: M. McKenney	Boring Location: 18+55	Offset: 11 R
Alignment: Existing		
Elev.: 1095.2 ft	Latitude: 35.12058	Longitude: -82.53738
Date Started: 8/23/2024		
Total Depth: 6 ft	Soil Depth: 6 ft	Core Depth: 0 ft
Date Completed: 8/27/2024		
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)
Liner Used: Y (N)		
Drill Machine: DR#554	Drill Method: RW	Hammer Type: Automatic
Energy Ratio: 88.5%		
Core Size: N/A	Driller: G. Robinson	Groundwater: TOB N.M.
24HR: N.M.		



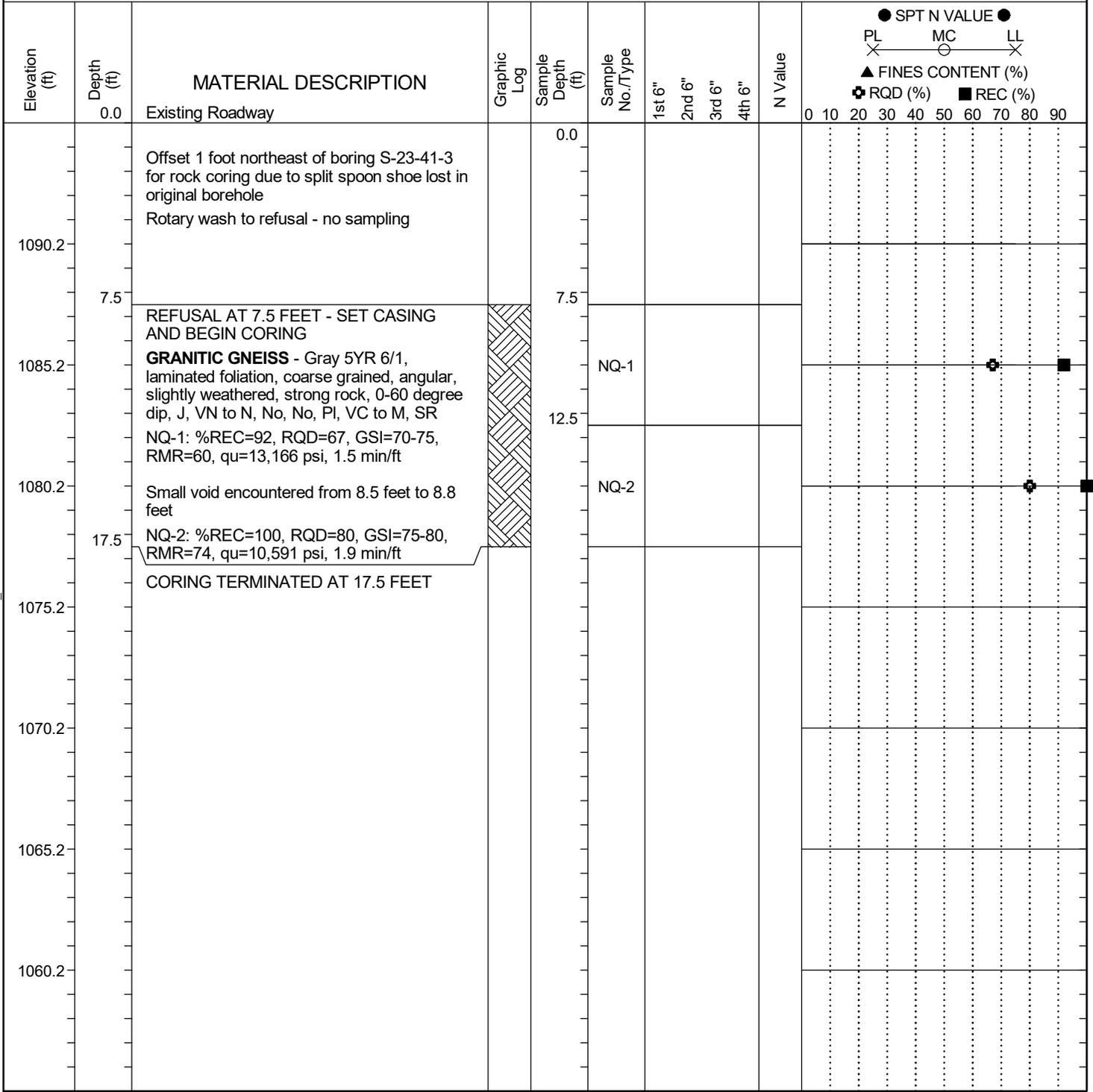
LEGEND

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 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT_DATATEMPLATE.GDT 9/24/24

SCDOT Soil Test Log

Project ID: P041159	County: Greenville	Boring No.: S-23-41-3 Offset
Site Description: S-23-41 BRO Middle Saluda River	Route: S-23-41	
Eng./Geo.: S. Greaber	Boring Location: 18+56	Offset: 11 R
Elev.: 1095.2 ft	Latitude: 35.12058	Longitude: -82.53738
Total Depth: 17.5 ft	Soil Depth: 7.5 ft	Core Depth: 10 ft
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)
Drill Machine: DR#554	Drill Method: RW/RC	Hammer Type: Automatic
Core Size: NQ2	Driller: G. Robinson	Groundwater: TOB N.M.
		Energy Ratio: 88.5%
		24HR: N.M.



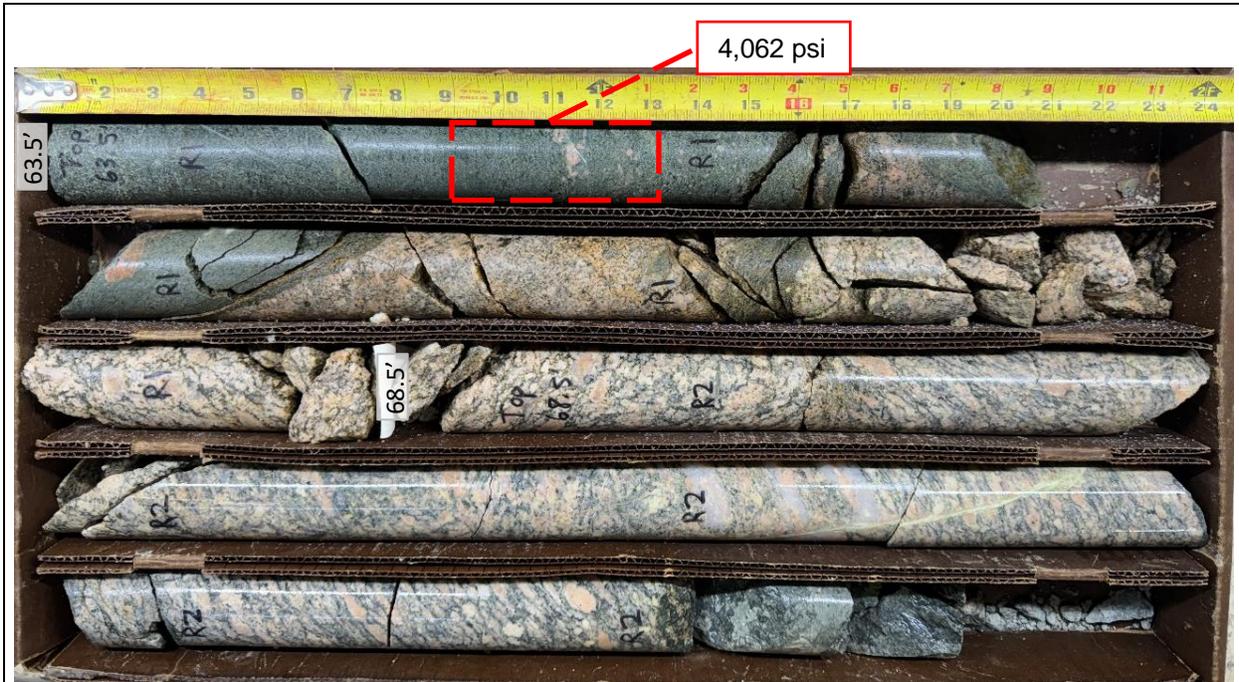
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT_DATATEMPLATE.GDT 9/24/24

Rock Core Photograph Logs – Exhibit A-10

S-23-41 BRO Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



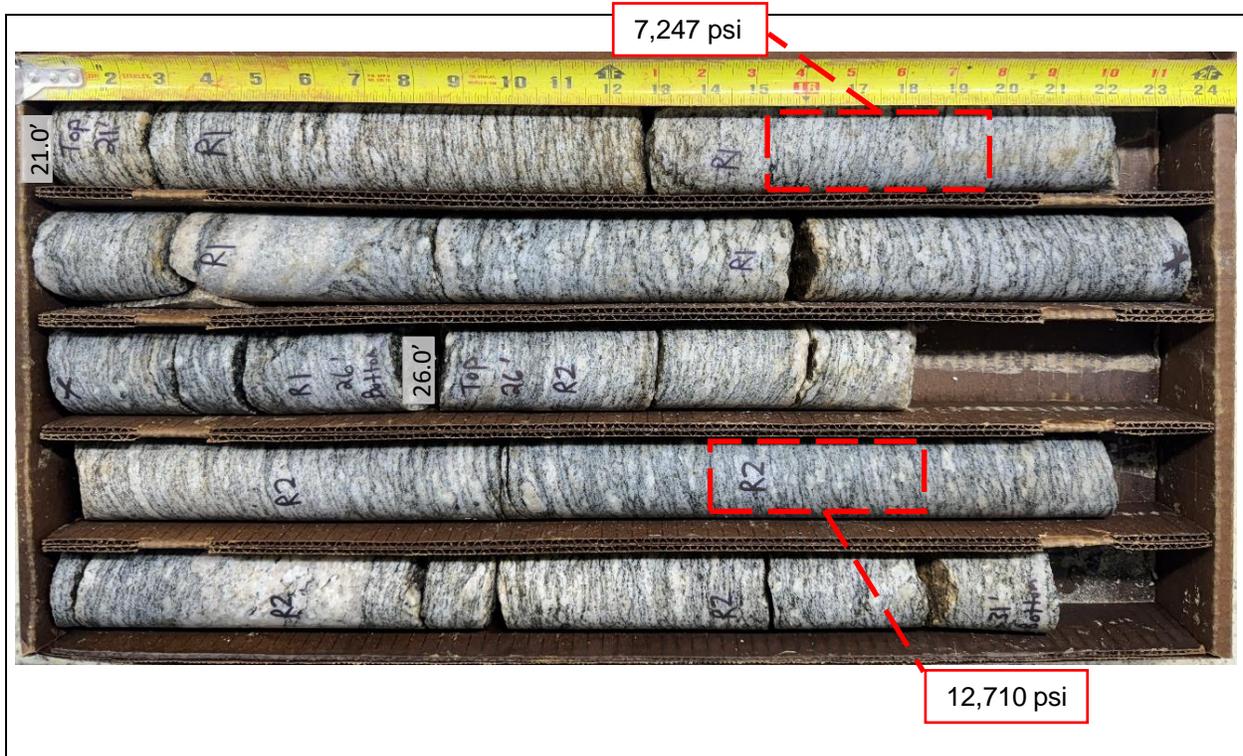
S-23-41-1, NQ-1 and NQ-2 (63.5 to 73.5 feet)



S-23-41-1, NQ-3 (73.5 to 78.5 feet)

Rock Core Photograph Logs – Exhibit A-10

S-23-41 BRO Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



S-23-41-2, NQ-1 and NQ-2 (21 to 31 feet)



S-23-41-3, NQ-1 and NQ-2 (7.5 to 17.5 feet)

Appendix B – Laboratory Testing

S-23-41 Bridge Replacement over Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



Appendix B

Laboratory Testing

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

Note: All exhibits are one page unless noted above.

Summary of Laboratory Results

Boring ID	Depth (Ft.)	Soil Classification USCS & AASHTO	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Fines	% Silt	% Clay	Water Content (%)	Proctor Dry Density (pcf)/Opt. Moisture (%)
S-23-41-1	0.5-2	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP						9.0	
S-23-41-1	2-4	SILTY SAND(SM) / A-2-4 (0)				0.3	77.0	22.7			8.6	
S-23-41-1	4-6	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	1.1	72.9	26.0	20.5	5.5	13.1	
S-23-41-1	6-8	SILTY SAND(SM) / A-2-4 (0)				0.0	74.6	25.4	19.3	6.2	15.0	
S-23-41-1	8-10	SILTY SAND(SM) / A-4 (0)				0.0	59.4	40.6	27.6	13.0	25.2	
S-23-41-1	13.5-15	POORLY GRADED SAND with SILT and GRAVEL(SP-SM) / A-1-B (0)				33.6	59.0	7.5	6.7	0.8	9.5	
S-23-41-1	18.5-20	SILTY SAND(SM) / A-2-4 (0)				1.7	69.6	28.7			18.9	
S-23-41-1	23.5-25	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	2.1	75.9	22.0			28.8	
S-23-41-1	28.5-30	SILTY SAND(SM) / A-2-4 (0)				1.5	72.5	26.0			18.0	
S-23-41-1	33.5-35	SILTY SAND(SM) / A-2-4 (0)									17.0	
S-23-41-2	4-5.67	WELL GRADED SAND with SILT (SW-SM) / A-2-4 (0)				3.0	86.0	11.0			12.4	
S-23-41-1 Offset	0-5	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	14.8	59.4	25.8				117.9 / 11.5



INDEX PROPERTIES VERSUS DEPTH

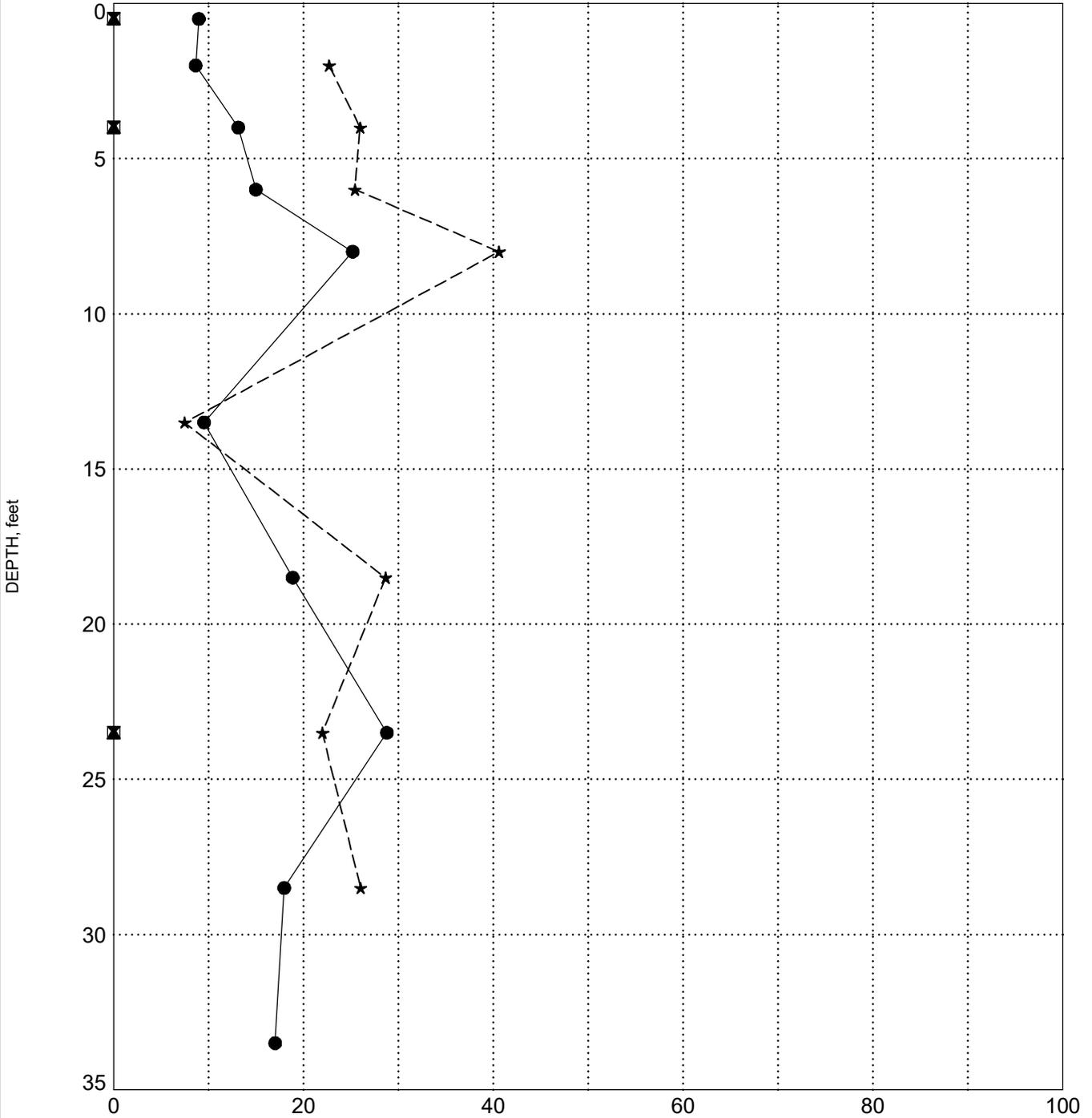
PROJECT ID P041159

PROJECT NAME S-23-41 BRO Middle Saluda River

PROJECT COUNTY Greenville

BORING S-23-41-1

SURFACE ELEVATION: 1094.9



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

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 9/24/24



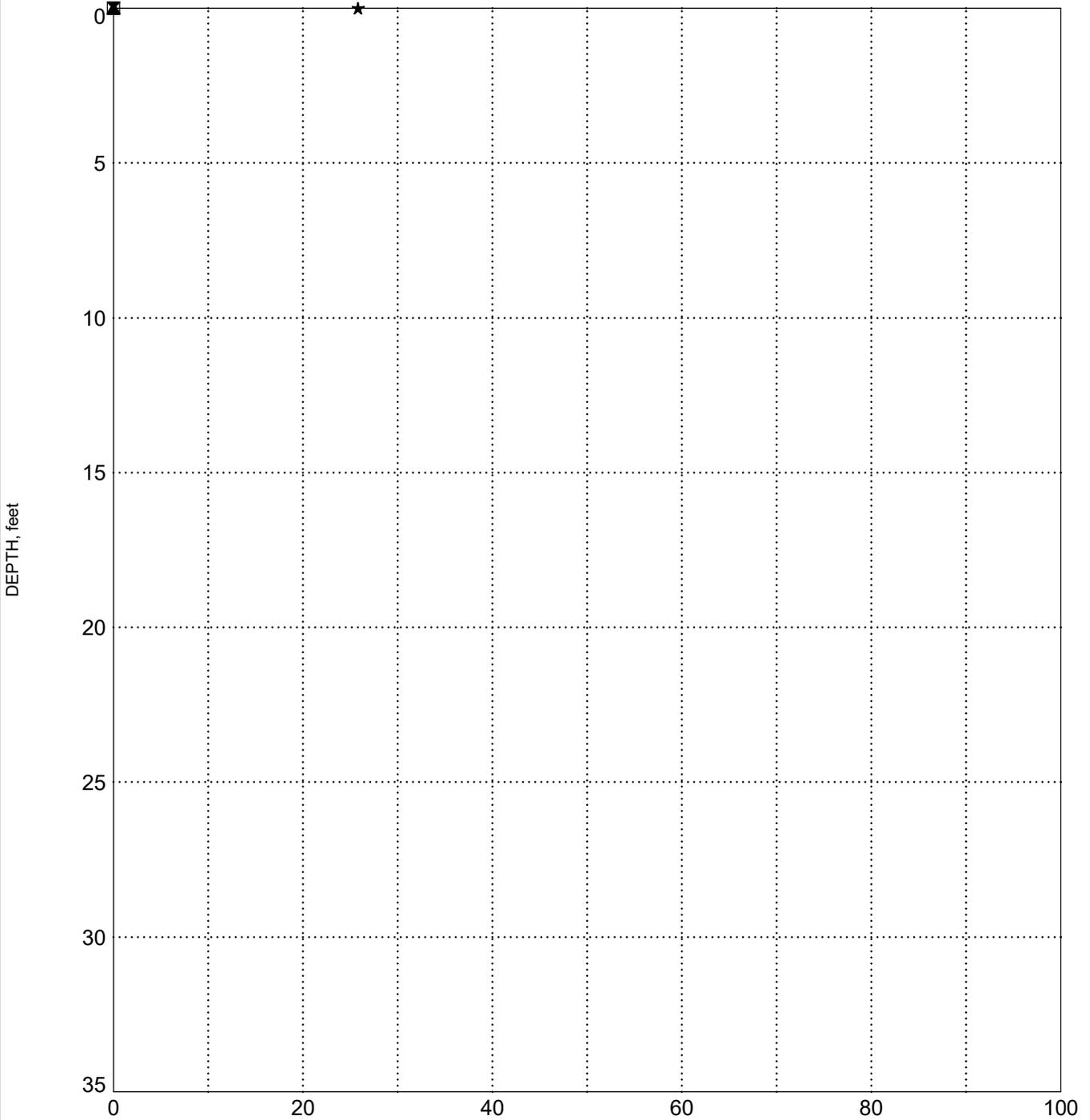
INDEX PROPERTIES VERSUS DEPTH

PROJECT ID P041159

PROJECT NAME S-23-41 BRO Middle Saluda River

PROJECT COUNTY Greenville

BORING S-23-41-1 Offset



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

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 9/24/24



INDEX PROPERTIES VERSUS DEPTH

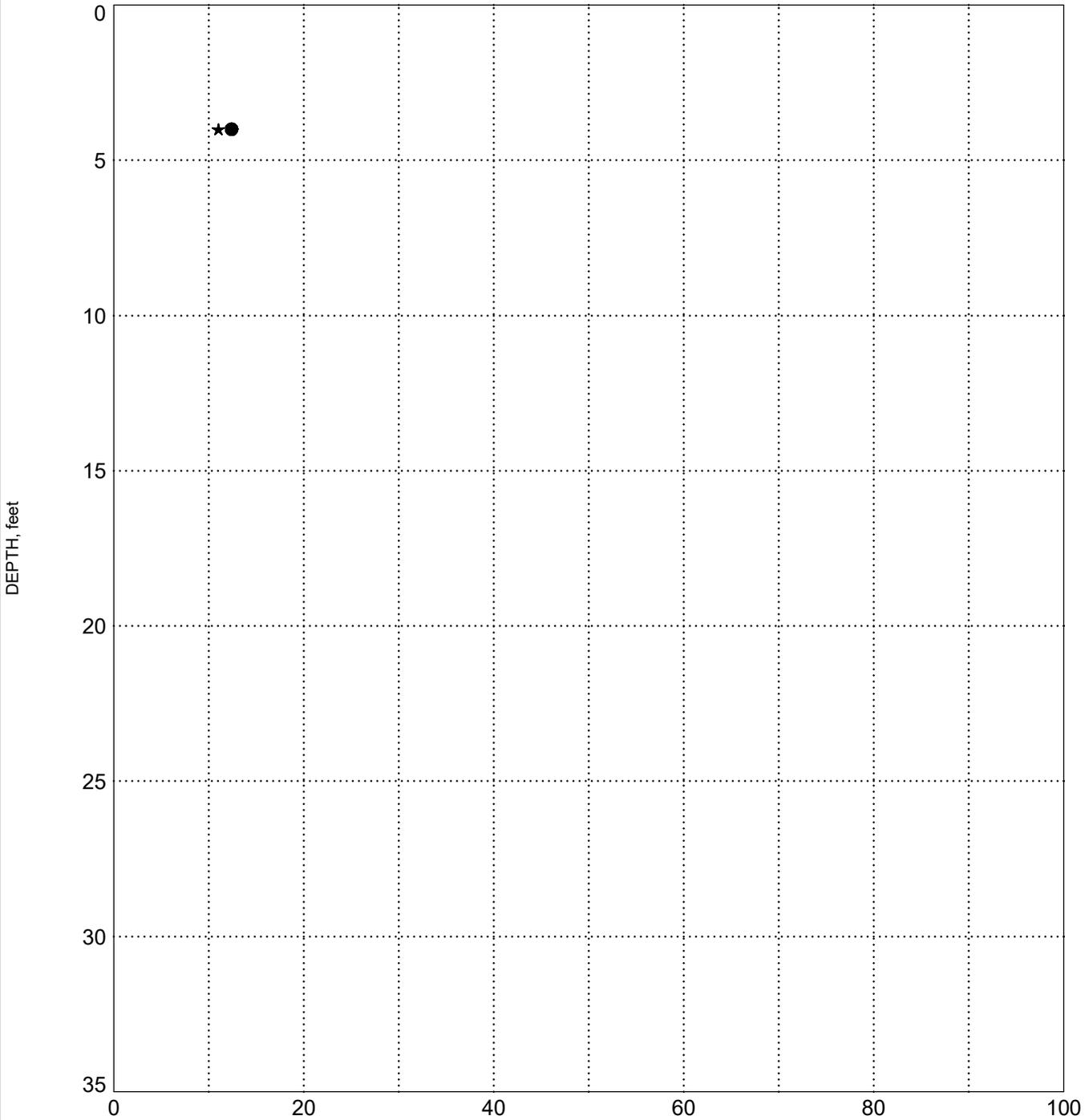
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PROJECT NAME S-23-41 BRO Middle Saluda River

PROJECT COUNTY Greenville

SURFACE ELEVATION: 1095.2

BORING S-23-41-2

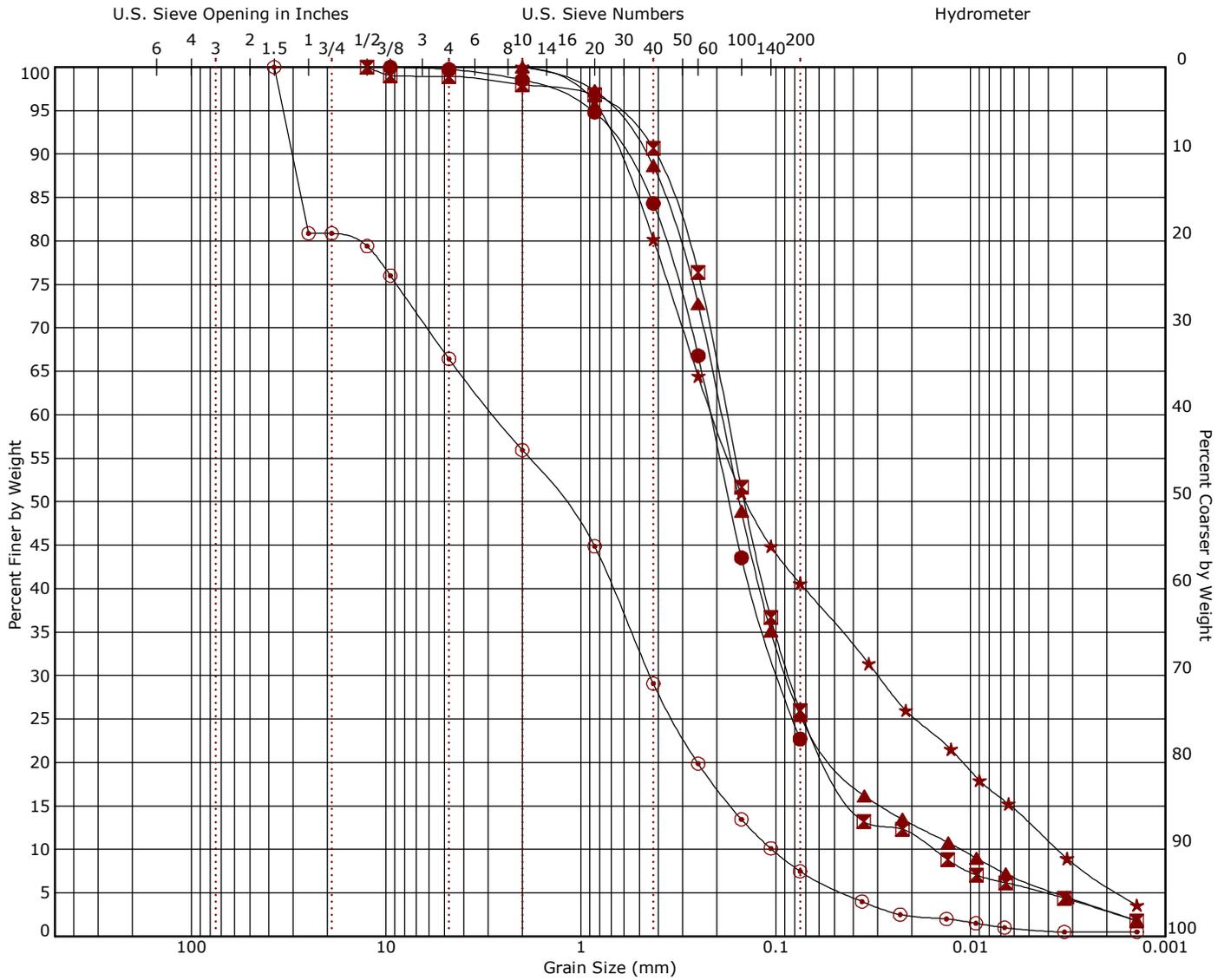


LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines

INDEX PROPS 8623P180T SCDOT BRIDGE PACK 19 S-23-41 OVER MIDDLE SALUDA RIVER-DOT.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 9/24/24

Grain Size Distribution

ASTM D422 / ASTM C136



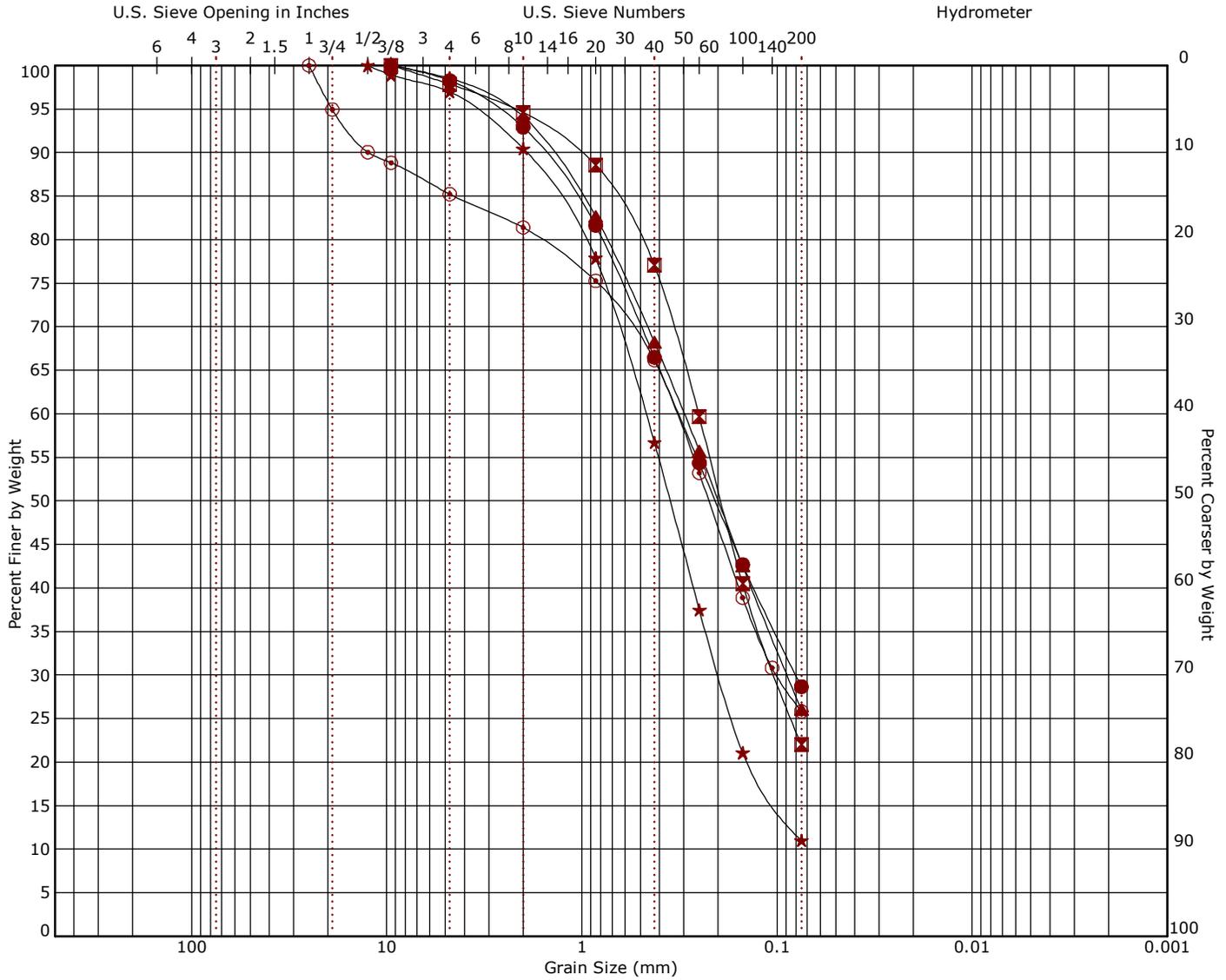
Cobbles	Gravel			Sand			Silt or Clay
	coarse	fine	coarse	medium	fine		

Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-41-1	2 - 4	SILTY SAND	SM	A-2-4 (0)					
☒ S-23-41-1	4 - 6	SILTY SAND	SM	A-2-4 (0)	NP	NP	NP	2.60	11.34
▲ S-23-41-1	6 - 8	SILTY SAND	SM	A-2-4 (0)				3.65	16.91
★ S-23-41-1	8 - 10	SILTY SAND	SM	A-4 (0)				1.17	58.86
⊙ S-23-41-1	13.5 - 15	POORLY GRADED SAND with SILT and GRAVEL	SP-SM	A-1-b (0)				0.67	26.75

Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-23-41-1	2 - 4	9.5	0.215	0.096		0.0	0.3	77.0	22.7		
☒ S-23-41-1	4 - 6	12.5	0.178	0.085	0.016	0.0	1.1	72.9		20.5	5.5
▲ S-23-41-1	6 - 8	2	0.19	0.088	0.011	0.0	0.0	74.6		19.3	6.2
★ S-23-41-1	8 - 10	2	0.211	0.03	0.004	0.0	0.0	59.4		27.6	13.0
⊙ S-23-41-1	13.5 - 15	37.5	2.793	0.442	0.104	0.0	33.6	59.0		6.7	0.8

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles |
 Gravel |
 Sand |
 Silt or Clay

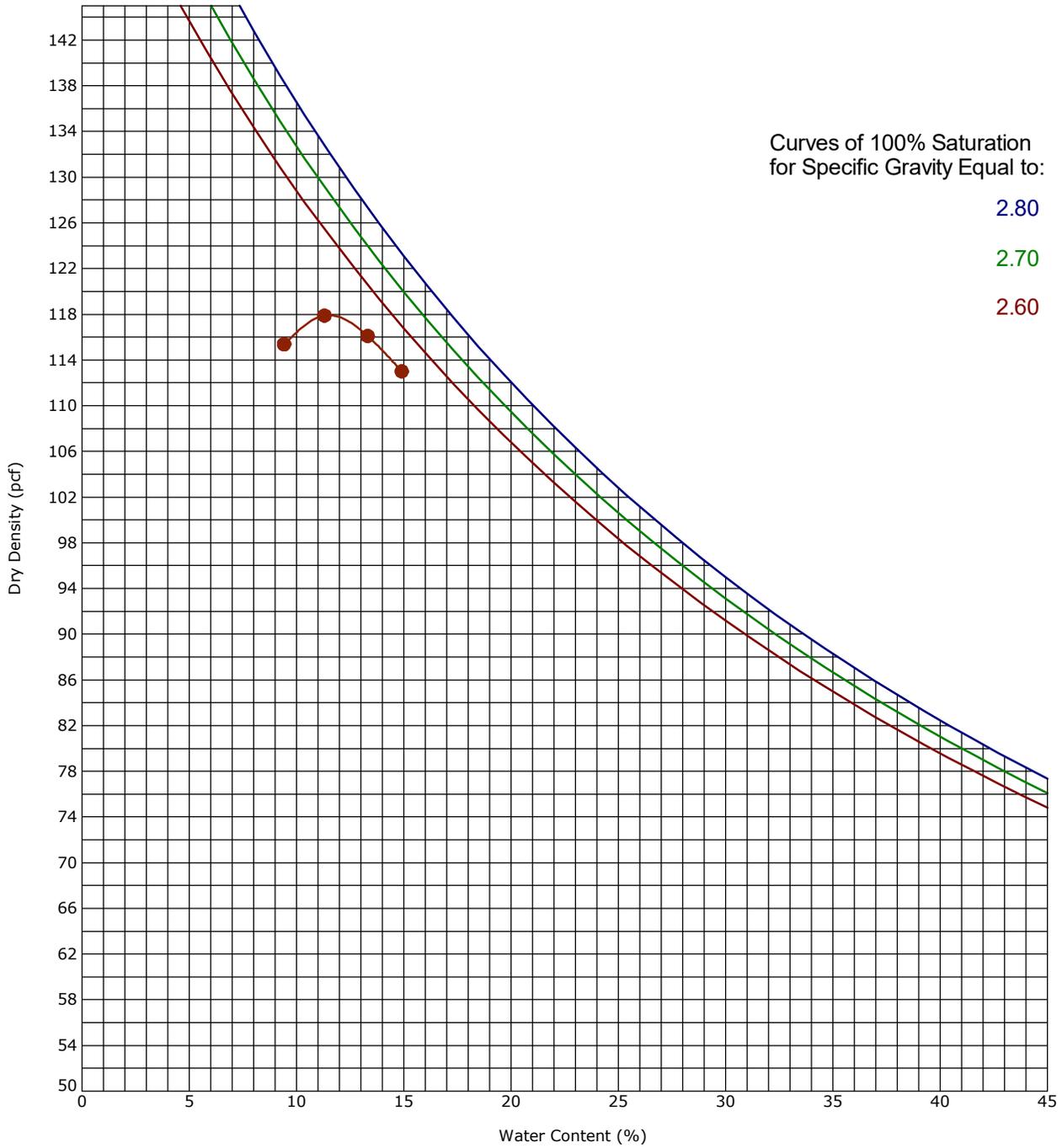
coarse |
 fine |
 coarse |
 medium |
 fine

Boring ID	Depth (Ft)	USCS Classification	USCS	AASHTO	LL	PL	PI	Cc	Cu
● S-23-41-1	18.5 - 20	SILTY SAND	SM	A-2-4 (0)					
☒ S-23-41-1	23.5 - 25	SILTY SAND	SM	A-2-4 (0)	NP	NP	NP		
▲ S-23-41-1	28.5 - 30	SILTY SAND	SM	A-2-4 (0)					
★ S-23-41-2	4 - 5.7	WELL GRADED SAND with SILT	SW-SM	A-2-4 (0)				1.18	6.76
⊖ S-23-41-1 Offset	0 - 5	SILTY SAND	SM	A-2-4 (0)	NP	NP	NP		

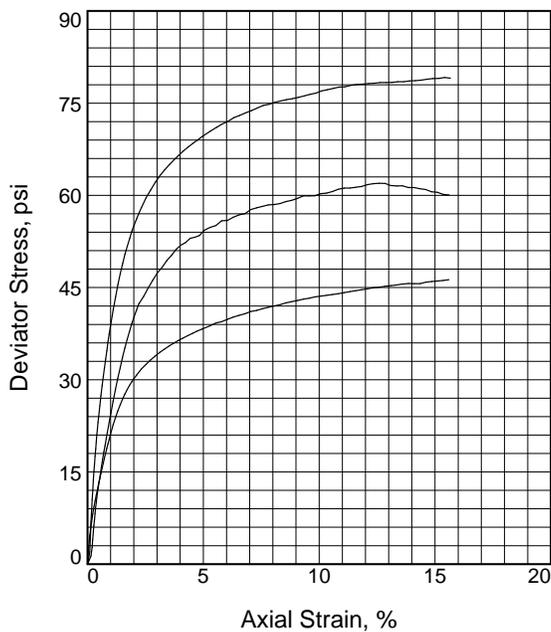
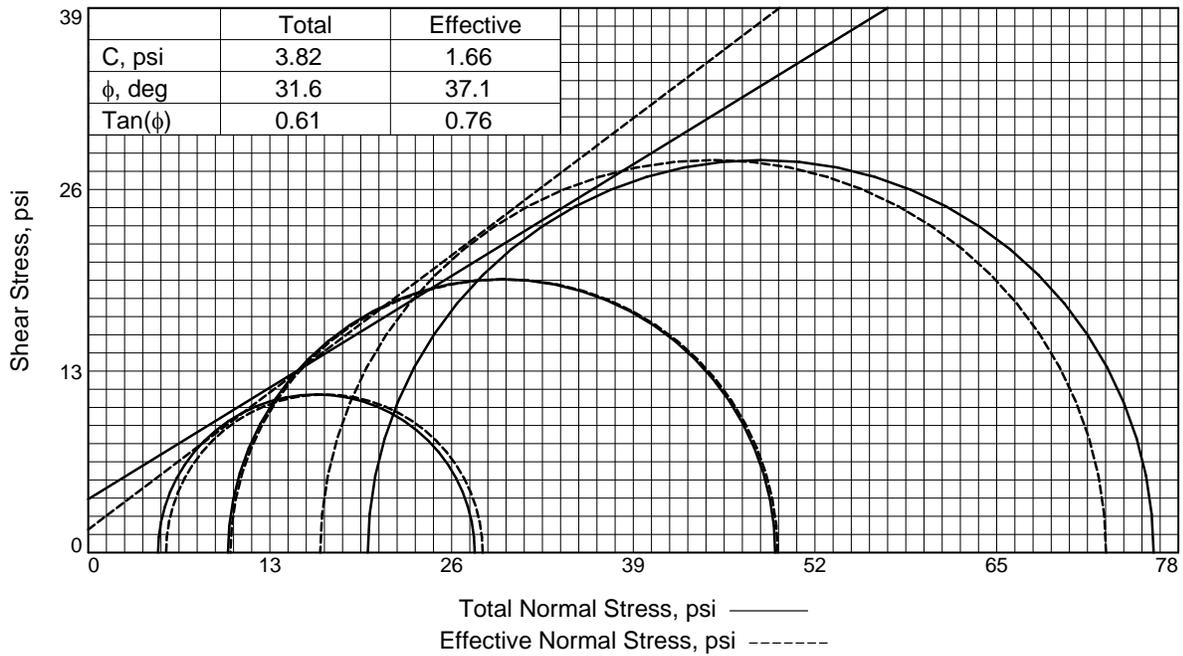
Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-23-41-1	18.5 - 20	9.5	0.32	0.08		0.0	1.7	69.6	28.7		
☒ S-23-41-1	23.5 - 25	9.5	0.252	0.101		0.0	2.1	75.9	22.0		
▲ S-23-41-1	28.5 - 30	9.5	0.3	0.089		0.0	1.5	72.5	26.0		
★ S-23-41-2	4 - 5.7	12.5	0.473	0.198		0.0	3.0	86.0	11.0		
⊖ S-23-41-1 Offset	0 - 5	25	0.33	0.1		0.0	14.8	59.4	25.8		

Moisture-Density Relationship

ASTM D698-Method B



Boring ID		Depth (Ft)		Description of Materials				
S-23-41-1 Offset		0 - 5		SILTY SAND(SM)				
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)	
26	0.0	NP	NP	NP	ASTM D698-Method B	117.9	11.5	



Sample No.		1	2	3
Initial	Water Content, %	11.3	11.4	11.4
	Dry Density, pcf	112.3	112.5	112.4
	Saturation, %	61.1	61.6	61.9
	Void Ratio	0.5013	0.4985	0.4990
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.62	5.62	5.62
At Test	Water Content, %	17.2	17.0	16.8
	Dry Density, pcf	115.1	115.6	116.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4642	0.4583	0.4531
	Diameter, in.	2.77	2.77	2.77
	Height, in.	5.58	5.58	5.56
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		50.0	50.0	50.0
Cell Pressure, psi		55.0	60.0	70.0
Fail. Stress, psi		22.7	39.2	56.2
Excess Pore Pr., psi		-0.6	-0.2	3.4
Ult. Stress, psi		46.1	60.5	79.0
Excess Pore Pr., psi		-10.5	-11.1	-7.6
$\bar{\sigma}_1$ Failure, psi		28.2	49.3	72.8
$\bar{\sigma}_3$ Failure, psi		5.6	10.2	16.6

Type of Test:

CU with Pore Pressures

Sample Type: Remolded

Description: Silty Sand (SM)

LL= NV

PI= NP

Specific Gravity= 2.7

Remarks: Specimens were remolded to approximately 95% MDD at optimum water content.

Figure _____

Client: HNTB North Carolina PC

Project: S-23-41 (Gap Creek Road) BRO Middle Saluda River

Source of Sample: S-23-41-1 Offset **Depth:** 0-5'

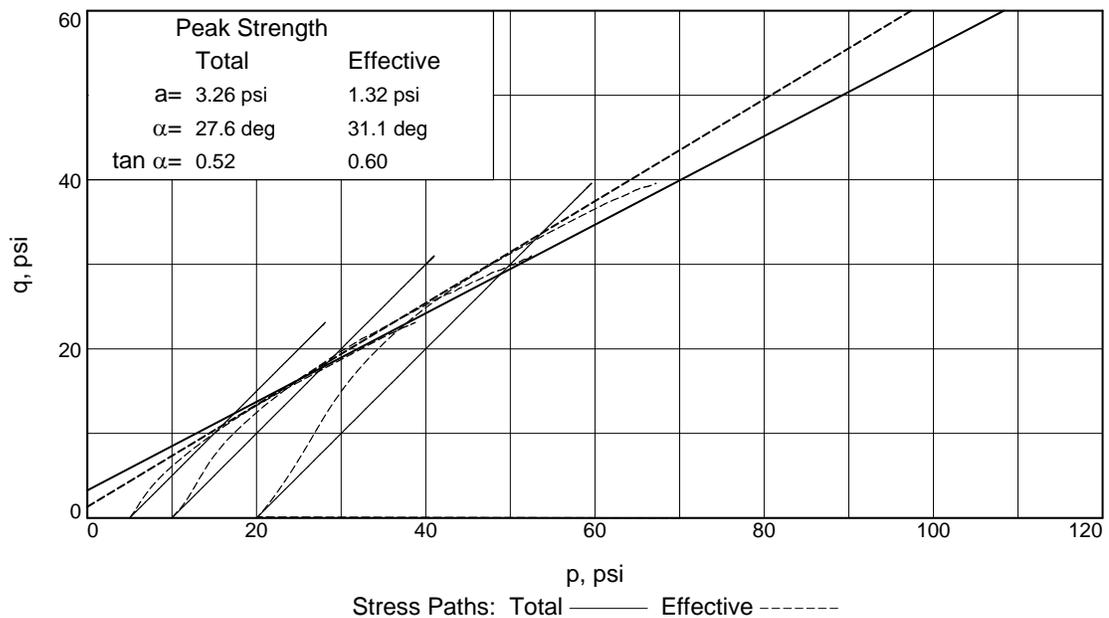
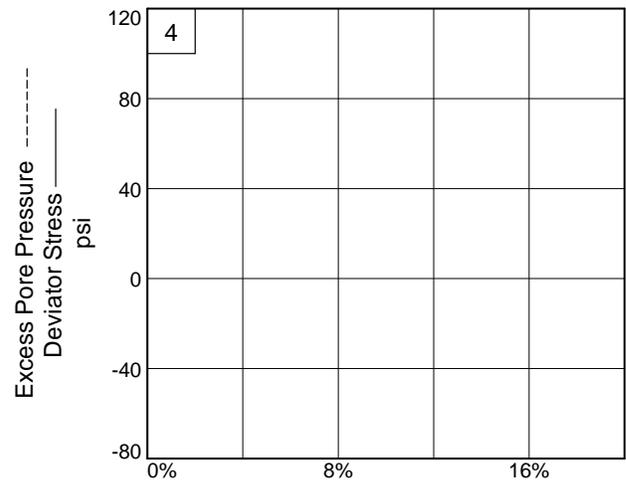
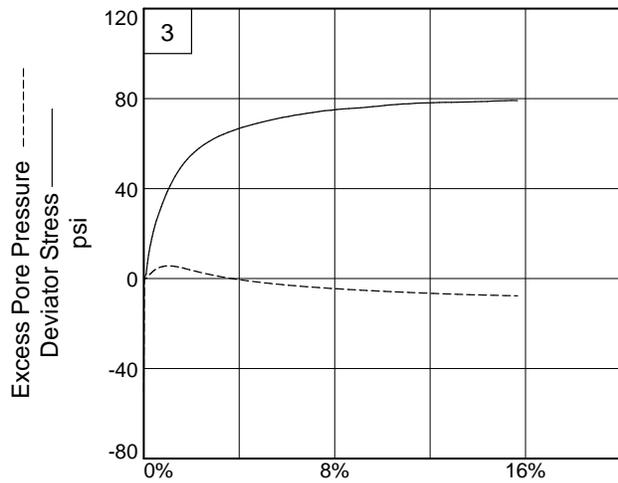
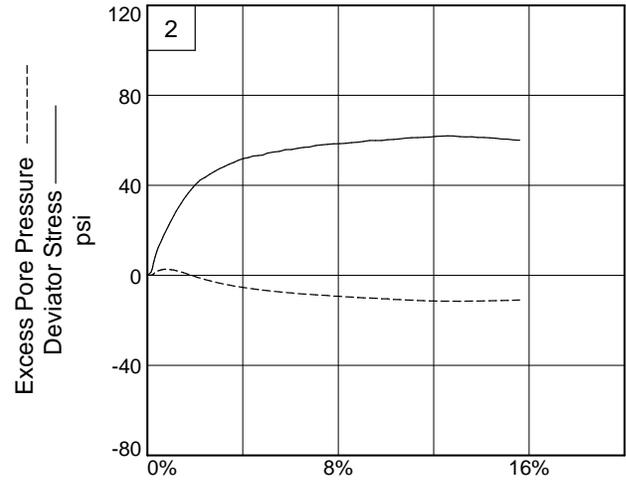
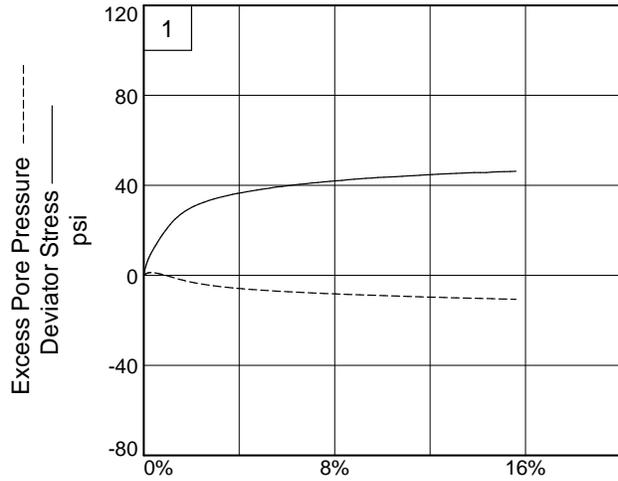
Proj. No.: 8623P180

Date Sampled: N/A

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.

Chattanooga, TN



Client: HNTB North Carolina PC

Project: S-23-41 (Gap Creek Road) BRO Middle Saluda River

Source of Sample: S-23-41-1 Offset **Depth:** 0-5'

Project No.: 8623P180

Figure _____

Terracon Consultants, Inc.

750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393



Client

HNTB North Carolina PC

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Sample Submitted By: Terracon (86)

Date Received: 8/29/2024

Lab No.: 24-0289

Results of Corrosion Analysis

Sample Number	S-23-41-1
Sample Location	--
Sample Depth (ft.)	2.0-15.0
pH Analysis, AASHTO T289	5.50
Water Soluble Sulfate (SO4), AASHTO T290 (mg/kg)	27
Chlorides, AASHTO T291, (mg/kg)	235
Saturated Minimum Resistivity, AASHTO T288, (ohm-cm)	1742

A handwritten signature in black ink, appearing to read "N. Campo".

Analyzed By _____

Nathan Campo
Laboratory Coordinator

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



Rock Coring Summary

PROJECT ID P041159

PROJECT NAME S-23-41 BRO Middle Saluda River

PROJECT COUNTY Greenville

Borehole	Core Run Number	Core Run Top Depth	REC (%)	RQD (%)	q _u (psi)	Poisson's Ratio	Secant Modulus (ksi)	Unit Weight (pcf)	RMR	GSI
S-23-41-1	NQ-1	63.5	80	38	4062	0.001	712	171	52	60
S-23-41-1	NQ-2	68.5	95	71						75
S-23-41-1	NQ-3	73.5	100	65	5260	0.000	768	162	57	70
S-23-41-2	NQ-1	21.0	88	70	7247	0.001	725	166	57	65
S-23-41-2	NQ-2	26.0	88	64	12710	0.001	1095	167	60	70
S-23-41-3 Offset	NQ-1	7.5	92	67	13166	0.000	1168	168	60	70
S-23-41-3 Offset	NQ-2	12.5	100	80	10591	0.001	1158	167	74	75

Client

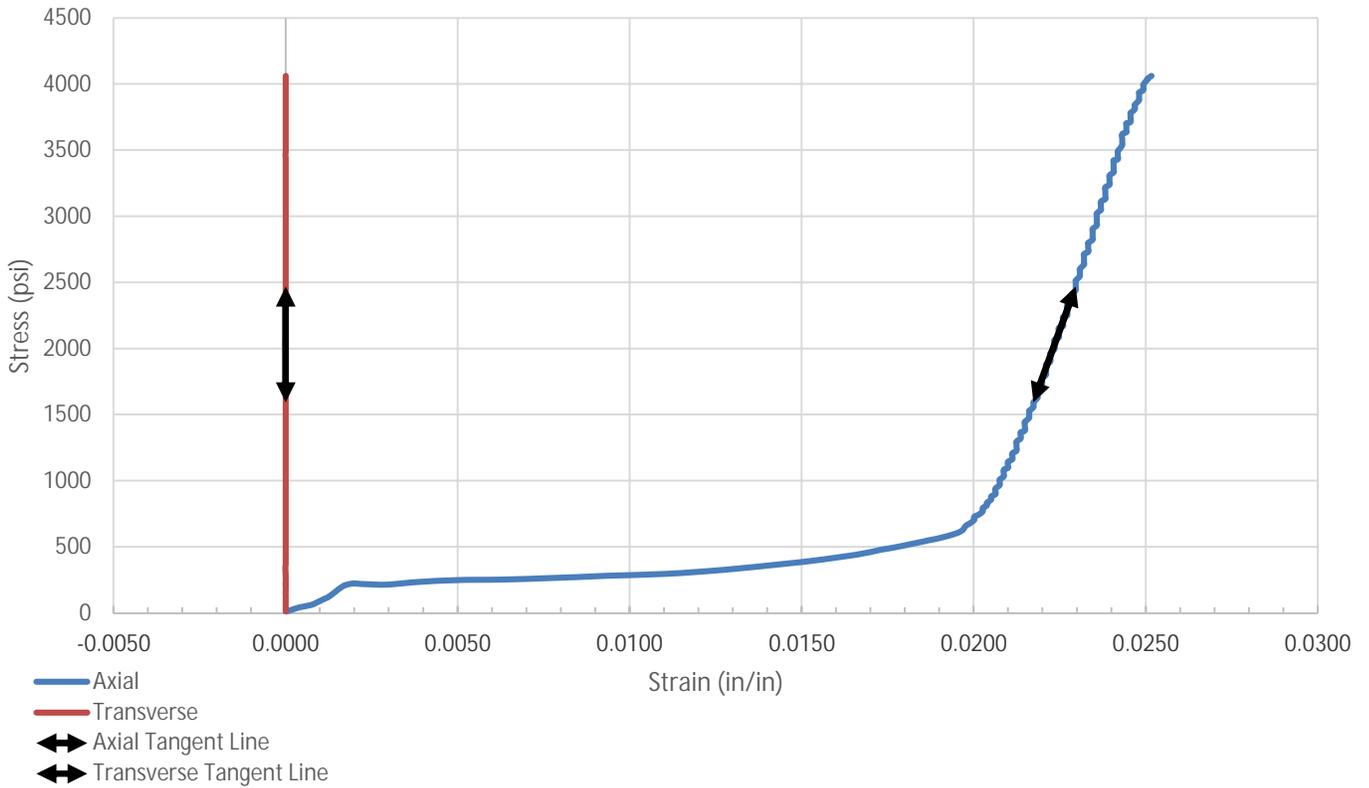
HNTB North Carolina PC
 Attn: Spencer Franklin
 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granitic Gneiss		
Boring:	S-23-41-1	Depth (feet):	64-64.8

SPECIMEN INFORMATION

Sample No.:	NQ-1	Mass (g):	568.44
Length (in.):	4.08	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	170.65

TEST RESULTS

Failure Load (lbs):	12634
Failure Strain (%):	3.67
Unconfined Compressive Strength (psi):	4,062
Elastic Modulus, E, (ksi):	712
Poisson's Ratio, u:	0.0013
Time of Failure (min):	00:37
Rate of Loading (psi/sec):	109.788
Moisture Content Post-break:	0.01%

Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:
Notes:

Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.

Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.

Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.

According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

Client

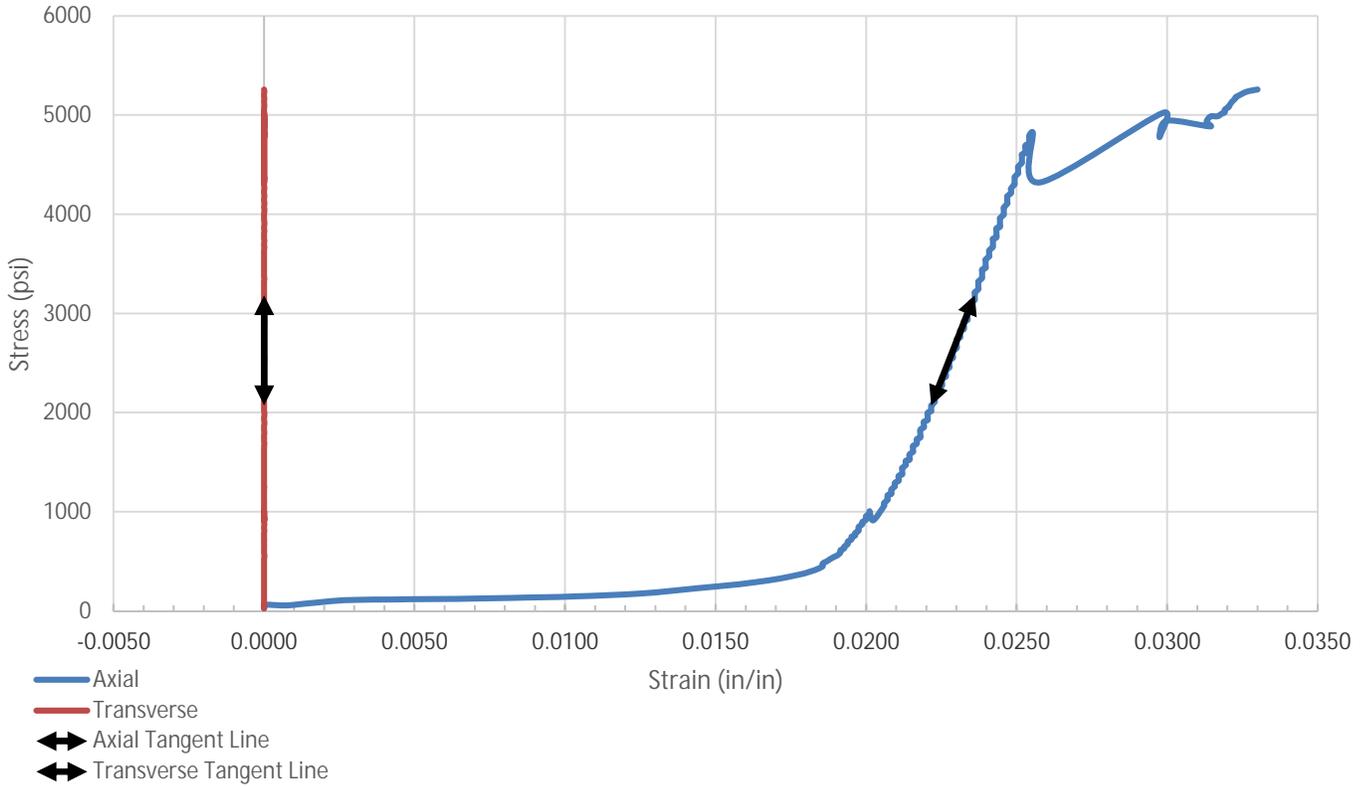
HNTB North Carolina PC
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 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-23-41-1	Depth (feet):	74.7-75.5

SPECIMEN INFORMATION

Sample No.:	NQ-3	Mass (g):	551.48
Length (in.):	4.16	Diameter (in.):	1.99
L/D Ratio:	2.1	Density (pcf):	162.37

TEST RESULTS

Failure Load (lbs):	16359
Failure Strain (%):	3.53
Unconfined Compressive Strength (psi):	5,260
Elastic Modulus, E, (ksi):	768
Poisson's Ratio, u:	0.000
Time of Failure (min):	00:48
Rate of Loading (psi/sec):	110.035
Moisture Content Post-break:	0.01%



Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

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Client

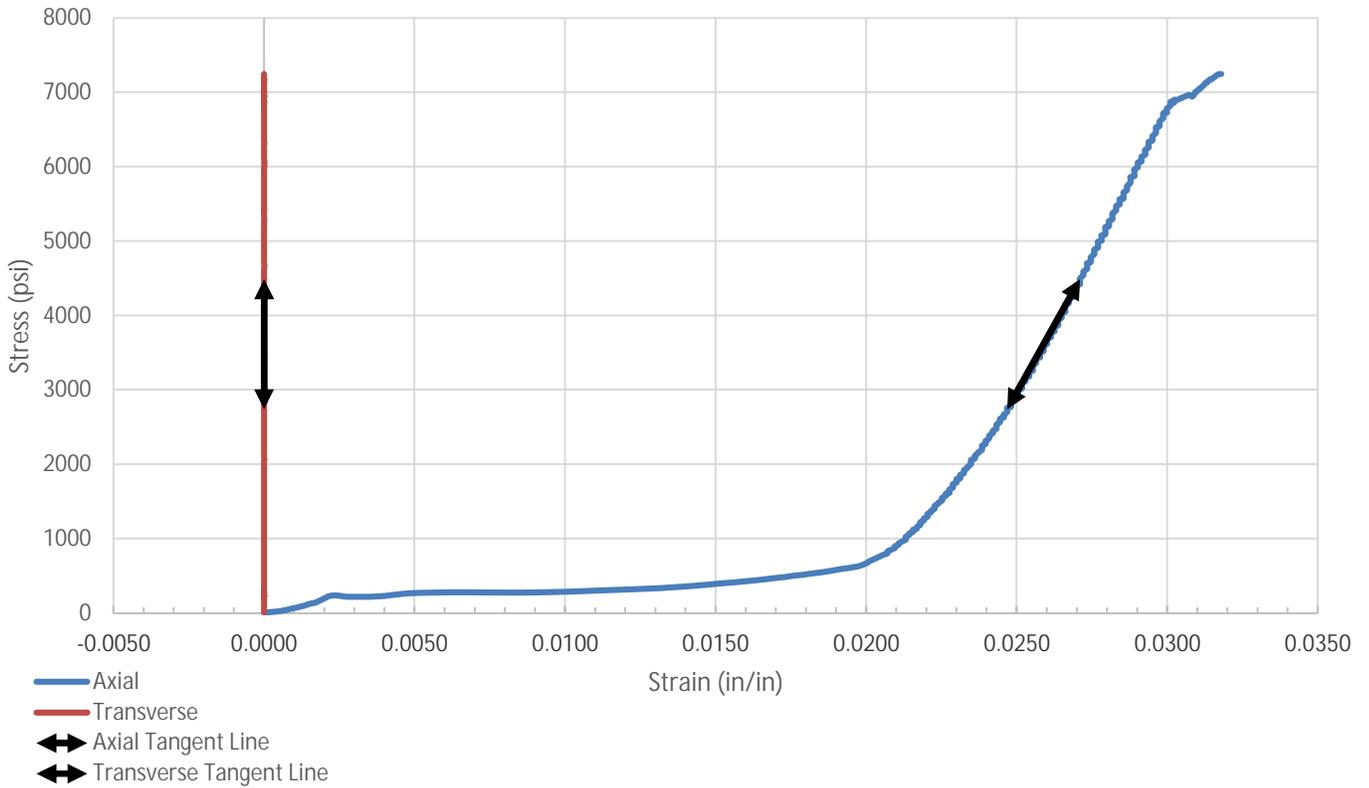
HNTB North Carolina PC
 Attn: Spencer Franklin
 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-23-41-2	Depth (feet):	22.1-22.8

SPECIMEN INFORMATION

Sample No.:	NQ-1	Mass (g):	558.92
Length (in.):	4.16	Diameter (in.):	1.98
L/D Ratio:	2.1	Density (pcf):	166.23

TEST RESULTS

Failure Load (lbs):	22315
Failure Strain (%):	3.22
Unconfined Compressive Strength (psi):	7,247
Elastic Modulus, E, (ksi):	725
Poisson's Ratio, u:	0.001
Time of Failure (min):	01:06
Rate of Loading (psi/sec):	109.476
Moisture Content Post-break:	0.01%

Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

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Client

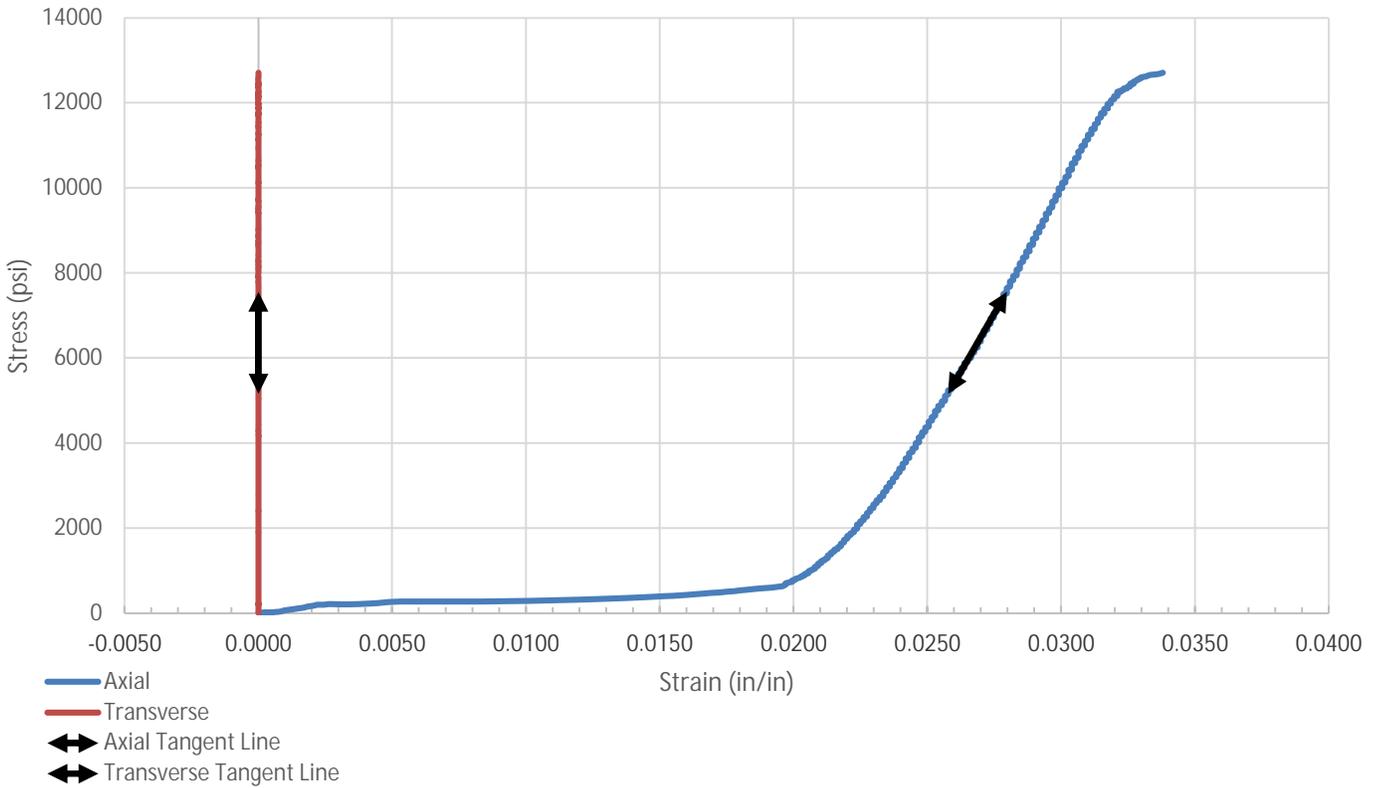
HNTB North Carolina PC
 Attn: Spencer Franklin
 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-23-41-2	Depth (feet):	27.6-28.7

SPECIMEN INFORMATION

Sample No.:	NQ-2	Mass (g):	555.23
Length (in.):	4.12	Diameter (in.):	1.98
L/D Ratio:	2.1	Density (pcf):	166.74

TEST RESULTS

Failure Load (lbs):	39134
Failure Strain (%):	3.89
Unconfined Compressive Strength (psi):	12,710
Elastic Modulus, E, (ksi):	1095
Poisson's Ratio, u:	0.001
Time of Failure (min):	01:57
Rate of Loading (psi/sec):	108.816
Moisture Content Post-break:	0.012%



Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

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Client

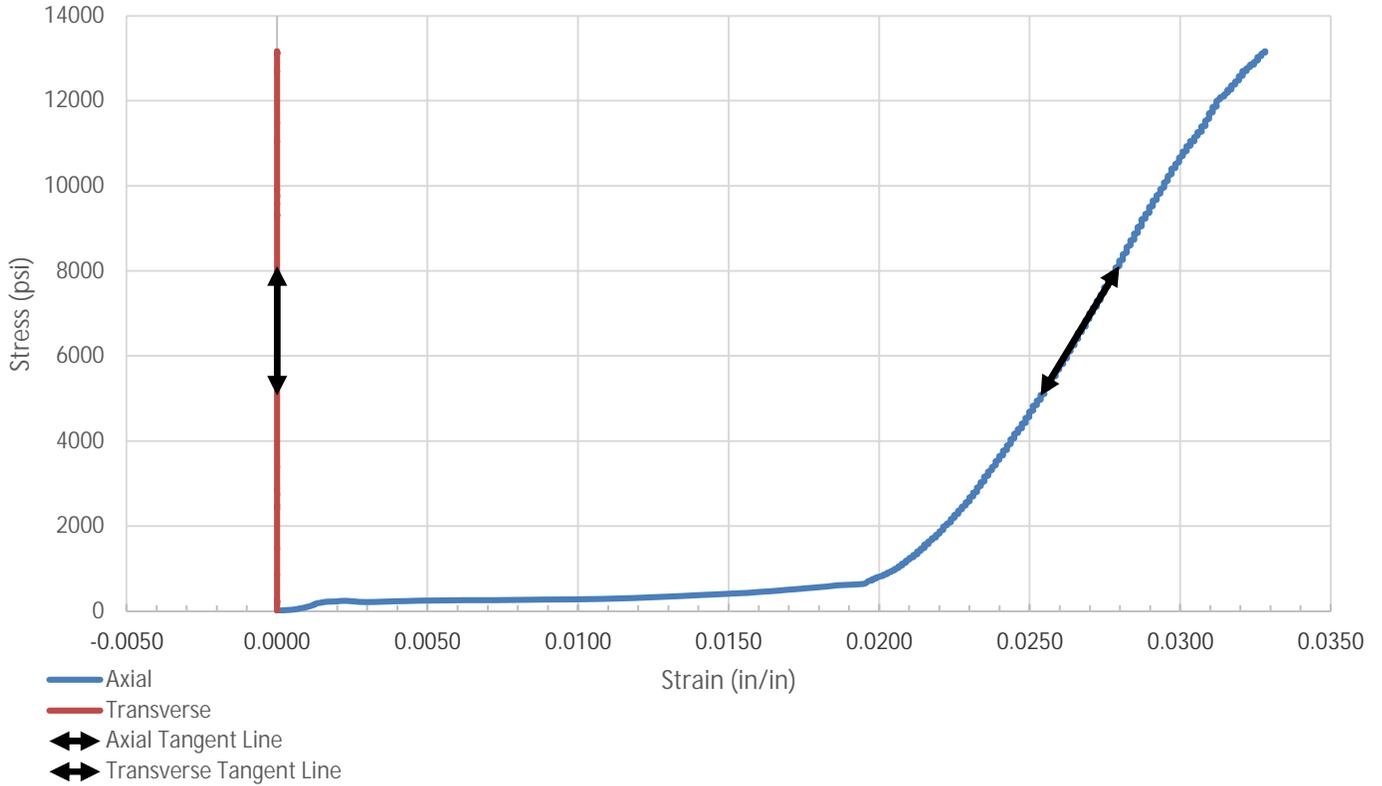
HNTB North Carolina PC
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 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-23-41-3	Depth (feet):	8.9-9.6

SPECIMEN INFORMATION

Sample No.:	NQ-1	Mass (g):	546.67
Length (in.):	4.03	Diameter (in.):	1.98
L/D Ratio:	2.0	Density (pcf):	167.83

TEST RESULTS

Failure Load (lbs):	40538
Failure Strain (%):	3.41
Unconfined Compressive Strength (psi):	13,166
Elastic Modulus, E, (ksi):	1168
Poisson's Ratio, u:	0.0002
Time of Failure (min):	02:00
Rate of Loading (psi/sec):	109.350
Moisture Content Post-break:	0.01%



Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

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Client

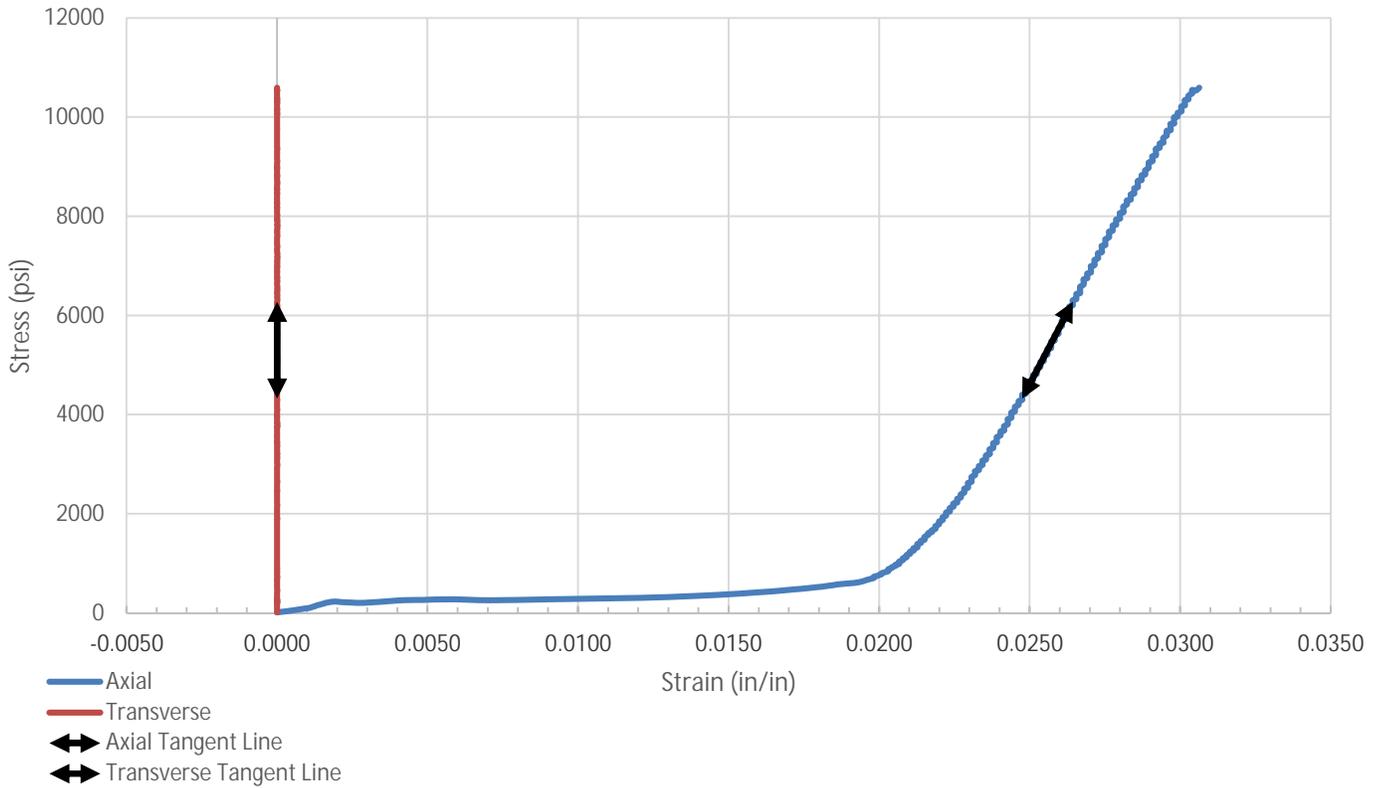
HNTB North Carolina PC
 Attn: Spencer Franklin
 343 E Six Forks Rd Ste 200
 Raleigh, NC 27609

Project

S-23-41 (Gap Creek Road) BRO Middle Saluda River

Project No. 8623P180

ASTM D7012 Stress/ Strain Curve



SAMPLE LOCATION

Site:	SCDOT Bridge Package 19		
Rock Type:	Granite		
Boring:	S-23-41-3	Depth (feet):	13.9-15.6

SPECIMEN INFORMATION

Sample No.:	NQ-2	Mass (g):	563.21
Length (in.):	4.17	Diameter (in.):	1.98
L/D Ratio:	2.1	Density (pcf):	167.11

TEST RESULTS

Failure Load (lbs):	32610
Failure Strain (%):	3.44
Unconfined Compressive Strength (psi):	10,591
Elastic Modulus, E, (ksi):	1158
Poisson's Ratio, u:	0.001
Time of Failure (min):	01:36
Rate of Loading (psi/sec):	109.863
Moisture Content Post-break:	0.01%



Client

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

Project

SCDOT Bridge Package 19

Project No. 8623P180

Equipment:

	TICCS ID:
Calipers:	W-54522
Scale:	B-71466
Dial Indicator:	C-70608
Compression (spherically seated):	C-48999

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Appendix C – Supporting Documents

S-23-41 Bridge Replacement over Middle Saluda River | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P041159



Appendix C

Supporting Documents

Rig Calibration Report – DR#1327 (8 Pages)

Rig Calibration Report – DR#554 (5 Pages)

Note: All exhibits are one page unless noted above.

For Boring S-23-41-1

SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: Geoprobe 3126GT

Drill Rig Serial Number: 3126S5V224106

Asset Number: DR#1327

September 13, 2024

September 13, 2024

Terracon Consultants Inc.
72 Pointe Circle
Greenville, SC 29615

Attn: Nitin Dudani
E: nitin.dudani@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report
Rig No: 1327
Terracon Project Number: 73245115

Dear Mr. Dudani:

This report provides the Energy Transfer Ratio (ETR) for the Standard Penetration Testing (SPT) automatic hammer as summarized below:

Table 1: Hammer Efficiency Summary

Drill Rig Make/Model	Drill Rig Serial Number	Drill Rig Year	Asset Number	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (C _e)
Geoprobe	3126S5V224106	2024	DR#1327	92.6% ± 1.75%	1.54

*Please Note: according to ASTM standard, a minimum of three recordings should be collected at five-foot intervals no shallower than twenty feet below current ground surface (bgs). The sample intervals were obtained between 30 and 50 feet bgs.

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

Ryan C. Wakeford, P.E.
Geotechnical Engineer

Susheel R. Kolwalkar, Ph.D., P.E.
Regional Services Manager

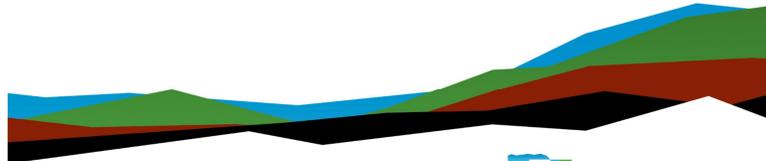


Micah Hatch, P.E.
Geotechnical Department Manager



Attachments:

- Exhibit A: SPT Representative Blow
- Exhibit B: SPT Analyzer Literature and Equipment Calibrations
- Exhibit C: SPT Analyzer Results
- Exhibit D: Field Log
- Exhibit E: Copy of Certificate of Proficiency



Prepared for:

Terracon Consultants, Inc.
Greenville, South Carolina



1.0 MEASUREMENT SUMMARY

ITEM	DESCRIPTION
Drill Rig Owner	Terracon Consultant, Inc. – Greenville, SC
Drill Rig Operator	Brett Burnett: Terracon Exploration
Testing Date	9/5/2024
Testing Location	Sumter County, SC
Boring Identification	B-3
Energy Measurement Depths	30 ft, 40 ft, 45 ft, 50 ft
Subsurface Soils	Poorly graded sands (SP) to clayey sands (SC)
Hammer Type/Height	140 pounds (automatic) with 2.5-foot drop height
Boring Method	Mud rotary
Drill Rods	<ul style="list-style-type: none"> AWJ 1-3/4" outside diameter 1-1/4" inside diameter 1.15 in² cross sectional area 1/4" wall thickness
Calibration Testing Equipment	<ul style="list-style-type: none"> 2-foot AWJ rod instrumented w/ two strain gauges and two accelerometers manufactured by Pile Dynamics Inc. (PDI) SN: 746AWJ Model SPT Analyzer™ (PDA) SN: 4621 TB
ASTM Methods Used	<p>ASTM D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils</p> <p>ASTM D4633-16, Standard Method for Energy Measurement for Dynamic Penetrometers</p>
SPT Calibration Personnel	Ryan Wakeford – Intermediate PDA Proficiency, Terracon Consultants, Inc.

2.0 PURPOSE AND SCOPE OF WORK

The North Charleston office of Terracon Consultants, Inc. conducted SPT energy measurements in accordance with ASTM D4633-16 at a site off Panola Road in Sumter County, South Carolina. Energy measurements on the rig were taken during eight samples events.

3.0 TEST RESULTS

Table 2: SPT Hammer Energy Calibration Testing Summary

Boring	Start Depth ¹ (ft)	Rod Length ² (ft)	Rod Sections ³				Measured Blow Counts (blows/6 inches)				SPT N _{meas} (bpf)	Soil Type ⁴
			2 ft	5 ft	10 ft	1 st 1 inc.	2 nd 1 inc.	3 rd 1 inc.	4 th 1 inc.			
B-3	28.5	33.7	0	6	0	4	5	6	-	11	SP	
	38.5	43.7	0	8	0	7	10	10	-	20	SP	
	43.5	48.7	0	9	0	4	5	7	-	12	SP	
	48.5	53.7	0	10	0	4	4	7	-	11	SP	

- Depth from existing ground surface to start of SPT
- Total rod length from instrumentation to bottom of sampler
- Two-foot section is instrumented and is located at top of drill rods
- Soil type visually classified by Terracon

Table 3: Energy Measurement and Analysis Summary

Boring	Start Depth ¹ (ft)	SPT N _m (bpf)	No. of Blows ²	EMX ³ (ft-lbs)			ETR ³ (%)		
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
B-3	28.5	11	11	340	313	327	8.8	93.4	2.5
	38.5	20	20	334	309	318	5.6	90.9	1.6
	43.5	12	12	330	309	323	5.5	92.4	1.6
	48.5	11	11	334	320	328	4.5	93.7	1.3
Average:				335	313	334	6.1	92.6	1.75

- Boring ID and depth from existing ground surface to start of SPT
- Number of blows used in energy calibration analysis; limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the first increment if refusal were encountered
- EMX = Maximum Transferred Energy, ETR = Energy Transfer Ratio.

Table 4: Hammer Blow Rate Summary

Boring	Start Depth ¹ (ft)	SPT N _{meas} (bpf)	No. of Blows ²	BPM ³			
				Max.	Min.	Ave.	Std. Dev.
B-3	28.5	11	11	53.8	53.1	53.5	0.2
	38.5	20	20	53.7	53.0	53.4	0.1
	43.5	12	12	53.6	53.2	53.4	0.1
	48.5	11	11	53.8	53.1	53.4	0.2
Average:				53.7	53.1	53.4	0.2

- Boring ID and depth from existing ground surface to start of SPT.
- Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
- BPM = Blows per minute

Exhibit A

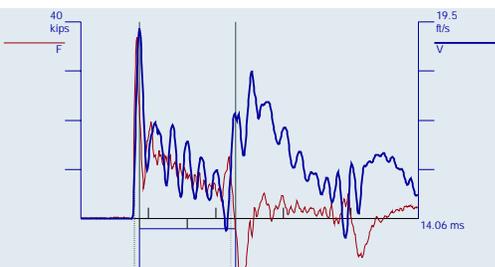
SPT Representative Blow

GRL Engineers, Inc.
 GEOPROBE 3126GT
 28.5-30
 B3
 PDA Operator: RW

Pile Driving Analyzer ® (PDA)
 Version: 2022.35.2

GRL Engineers, Inc.
 GEOPROBE 3126GT
 38.5-40
 B3
 PDA Operator: RW

Pile Driving Analyzer ® (PDA)
 Version: 2022.35.2

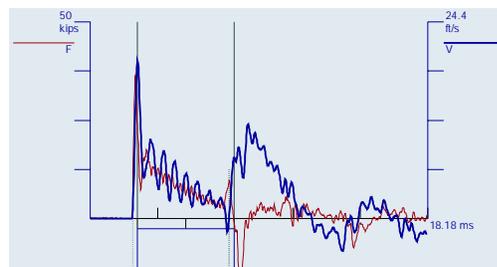


BN 13
 05Sep2024 10:07:23 AM

CSX	32.1 ksi
DMX	1.11 in
EFV	331 ft-lb
ETR	94.7 %
BPM	53.8 bpm
RAT	1.0
VMX	18.9 ft/s
FMX	37 kips
DFN	1.00 in
MEX	1070 µE
AMX	3001 g/s
FVP	0.6

LE	33.70 ft
AR	1.15 in ²
EM	30000 ksi
SP	0.492 k-ft ³
WS	16807.9 ft/s
WC	16766.2 ft/s
JC	0.90
JF	1.00

F1: [746AWJ1]	222.05 PDICAL (1) FF1
F2: [746AWJ2]	222.19 PDICAL (1) FF1
A3 (PR): [K14007]	407.233 mv/6.4v/5000g (1) VF1
A4 (PR): [K14006]	375.226 mv/6.4v/5000g (1) VF1

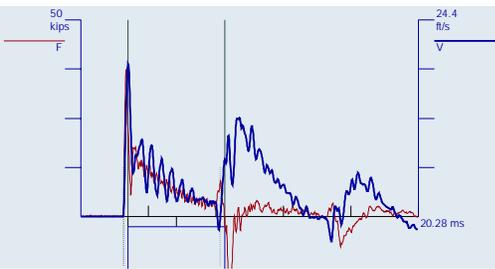


BN 25
 05Sep2024 10:24:35 AM

CSX	31.7 ksi
DMX	0.66 in
EFV	324 ft-lb
ETR	92.6 %
BPM	53.4 bpm
RAT	1.1
VMX	19.6 ft/s
FMX	36 kips
DFN	0.60 in
MEX	1056 µE
AMX	3358 g/s

LE	43.70 ft
AR	1.15 in ²
EM	30000 ksi
SP	0.492 k-ft ³
WS	16807.9 ft/s
WC	16807.7 ft/s
JC	0.90
JF	1.00

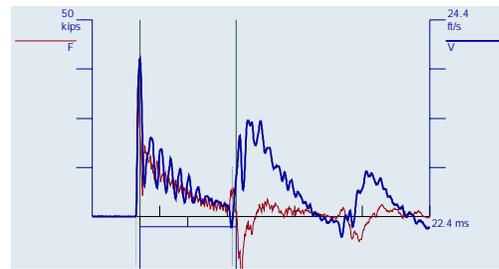
F1: [746AWJ1]	222.05 PDICAL (1) FF1
F2: [746AWJ2]	222.19 PDICAL (1) FF1
A3 (PR): [K14007]	407.233 mv/6.4v/5000g (1) VF1
A4 (PR): [K14006]	375.226 mv/6.4v/5000g (1) VF1



BN 14
05Sep2024 10:32:57 AM

CSX	32.6 ksi
DMX	0.91 in
EFV	325 ft-lb
ETR	92.8 %
BPM	53.4 bpm
RAT	1.0
VMX	19.0 ft/s
FMX	37 kips
DFN	0.86 in
MEX	1086 µE
AMX	3426 g's
LE	48.70 ft
AR	1.15 m ²
EM	30000 ksi
SP	0.492 k-ft ³
WS	16807.9 ft/s
WC	16793.1 ft/s
JC	0.90
JF	1.00

F1: [746AWJ1] 222.05 PDICAL (1) FF1
 F2: [746AWJ2] 222.19 PDICAL (1) FF1
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1



BN 13
05Sep2024 10:42:13 AM

CSX	31.5 ksi
DMX	1.01 in
EFV	320 ft-lb
ETR	91.4 %
BPM	53.7 bpm
RAT	1.1
VMX	19.6 ft/s
FMX	36 kips
DFN	0.86 in
MEX	1049 µE
AMX	4077 g's
LE	53.70 ft
AR	1.15 m ²
EM	30000 ksi
SP	0.492 k-ft ³
WS	16807.9 ft/s
WC	16781.3 ft/s
JC	0.90
JF	1.00

F1: [746AWJ1] 222.05 PDICAL (1) FF1
 F2: [746AWJ2] 222.19 PDICAL (1) FF1
 A3 (PR): [K14007] 407.233 mv/6.4v/5000g (1) VF1
 A4 (PR): [K14006] 375.226 mv/6.4v/5000g (1) VF1

Exhibit B

SPT Analyzer Literature and Equipment Calibrations



PI SPT Analyzer

SPT Analyzer

Measures the energy transferred into an instrumented SPT rod during a Standard Penetration Test (SPT)

Reliable. Simplified. Rugged.

The SPT Analyzer determines the energy transferred by SPT hammers using force and velocity measurements, for improved reliability of SPT N-values.

What is SPT?

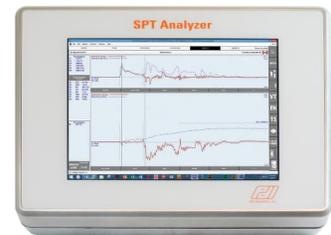
The Standard Penetration Test (SPT) is a widely-employed soil exploration tool that involves using an SPT hammer to drive a split sampler at the bottom of a drill string to obtain soil samples. The number of blows required to penetrate the last 300mm (1ft) is the "N value" which is related to soil strength.

Why measure the energy transferred by the SPT hammer?

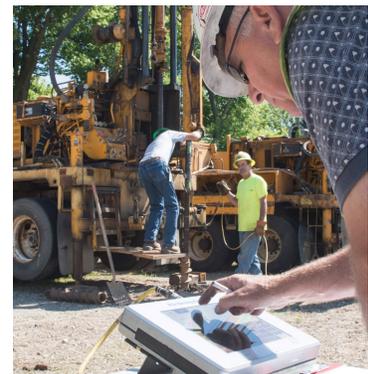
Several different types of SPT hammers are used to conduct Standard Penetration Tests. Their varying efficiencies influence the N value. The measured N value is normalized by multiplying it by the ratio of the measured energy transferred to the rod to 60% of the theoretical potential energy. The normalization compensates for the variability of the efficiencies of different SPT hammer types, and improves the reliability of soil strength estimates used in geotechnical applications.

The SPT Analyzer is furnished with a 0.6m sub assembly (or section) of an SPT rod (AW, NW or other type) instrumented with two strain gage bridges, and calibrated by Pile Dynamics. Once in the field, two accelerometers are bolted to the rod section. The instrumented section is inserted at the top of the drill string between the hammer and the existing sampling rod. The sensors on the rod are connected to the SPT Analyzer.

Smart Sensor technology allows the SPT Analyzer to read the rod instrumentation, obtaining the sensor calibration and rod cross sectional area.



- Calculates energy transferred by SPT hammers using force and velocity measurements
- Determines N value to help improve reliability of soil strength estimates
- Offers simplified reporting and analysis option to speed testing results
- Operates in English, SI, or Metric units



EN ISO 22486-3:2005/ASTM Compliant

The SPT Analyzer is compliant with EN ISO 22476-3:2005. ASTM D1586 recommends normalizing results from any SPT test using energy measurements. When these tests are performed to determine the liquefaction potential of sands, ASTM D6066 not only recommends but mandates the normalization. ASTM D4633 states that the only acceptable method of determining energy for normalization of N values is by force and velocity measurements.

These quantities are input to the SPT Analyzer automatically. This significantly simplifies the initial test setup.

The strain gages and accelerometers obtain the force and velocity signals necessary for the calculation of transferred energy to the drill string for each hammer blow. The energy is displayed in real time on the SPT Analyzer screen.

Output

SPT Analyzer data is stored and transferred to a computer via USB memory stick. The software furnished with the SPT Analyzer has a Report Creation Option that makes it quick and easy to summarize results and create output graphs of Force, Velocity, Energy and Displacement versus Time, as well as numerical, statistical, and graphical results for each data set. The software is fully customizable.



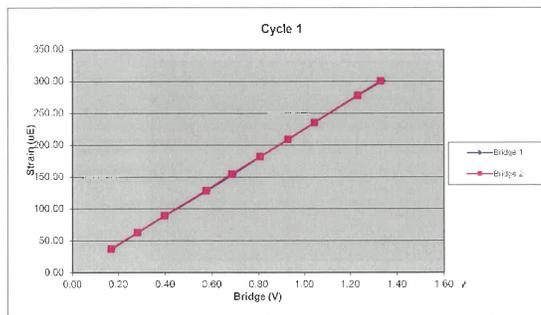
Pile Dynamics, Inc. (PDI) is the world leader in developing, manufacturing and supplying state of the art QA/QC products and systems for the deep foundations industry. The company is headquartered in Cleveland, Ohio, USA, with offices and representatives worldwide. For additional information visit us at www.pile.com or contact info@pile.com.

www.pile.com | +1 (216) 831-6131 | info@pile.com

746AWJ		Cycle 1		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1296.93	37.22	0.17	0.17
3	2135.32	62.74	0.28	0.28
4	3028.79	89.39	0.40	0.40
5	4377.09	128.61	0.58	0.57
6	5243.07	154.57	0.69	0.68
7	6143.17	181.90	0.81	0.81
8	7067.95	208.93	0.93	0.93
9	7958.18	238.42	1.04	1.05
10	9380.66	278.02	1.23	1.23
11	10161.74	300.76	1.34	1.33

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7605.07	Force Calibration (lb/V)	7606.74
Offset	-0.16	Offset	12.66
Correlation	0.999997	Correlation	0.999999
Strain Calibration (µE/V)	225.99	Strain Calibration (µE/V)	226.04
Offset	-1.01	Offset	-8.33
Correlation	0.999989	Correlation	0.999992

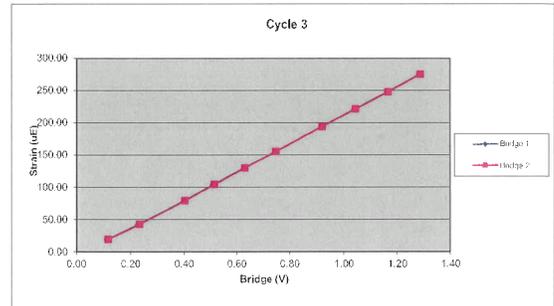
Force Strain Calibration	
EA (Kips)	33651.50
Offset	33.98
Correlation	0.999994



746AWJ		Cycle 3		
Sample	Force (lb)	Strain (µE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	838.16	19.27	0.11	0.12
3	1786.75	42.28	0.23	0.23
4	3083.67	79.12	0.40	0.40
5	3943.80	104.13	0.51	0.51
6	4839.52	129.87	0.63	0.63
7	5750.14	155.24	0.75	0.75
8	7079.92	194.22	0.92	0.92
9	8007.70	221.43	1.04	1.05
10	8943.28	247.95	1.17	1.17
11	9871.55	275.44	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7659.96	Force Calibration (lb/V)	7667.39
Offset	13.76	Offset	-1.59
Correlation	0.999999	Correlation	0.999998
Strain Calibration (µE/V)	219.43	Strain Calibration (µE/V)	219.64
Offset	-7.95	Offset	-8.39
Correlation	0.999934	Correlation	0.999939

Force Strain Calibration	
EA (Kips)	34904.41
Offset	291.93
Correlation	0.999935



Accelerometer Calibration Certificate
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on **MAY 16 2024**

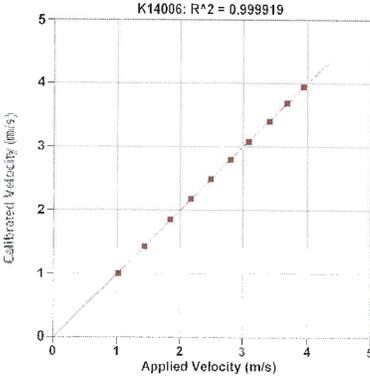
Serial No: K14006 Temperature: 24.0 °C
Model: PR Humidity: 42%
Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR
375.2 mv/5000g
(75.0 μv/g)
R²: 0.999919 [Chip programmed]

Operator: William Johnson
William Johnson
Signed

Ref Acc 1: 78268! Cal on: 11Jan2024
986 g/s/volt
Ref Acc 2: 78270! Cal on: 11Jan2024
971 g/s/volt

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



Reference Velocity	S/N K14006 Velocity
m/s	m/s
1.015	1.001
1.426	1.425
1.839	1.850
2.171	2.177
2.489	2.491
2.930	2.796
3.087	3.078
3.408	3.397
3.681	3.688
3.938	3.946

Maximum Acceleration: 848 gs

Version: 2023-09-17 4: 17

Accelerometer Calibration Certificate
Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
Calibration performed on **MAY 16 2024**

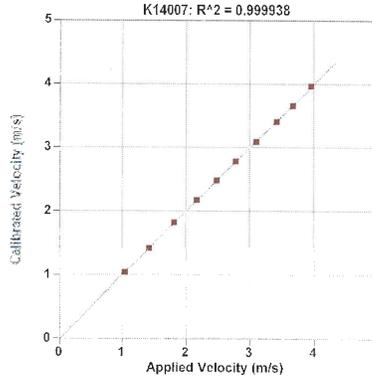
Serial No: K14007 Temperature: 23.8 °C
Model: PR Humidity: 42%
Calibrated on: Channel 4 on 8G 5161 LE

PDA CALIBRATION FACTOR
407.2 mv/5000g
(81.4 μv/g)
R²: 0.999938 [Chip programmed]

Operator: William Johnson
William Johnson
Signed

Ref Acc 1: 78268! Cal on: 11Jan2024
986 g/s/volt
Ref Acc 2: 78270! Cal on: 11Jan2024
971 g/s/volt

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



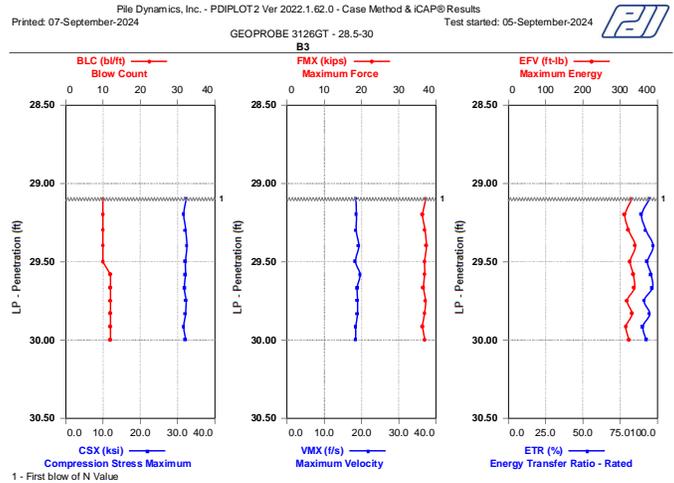
Reference Velocity	S/N K14007 Velocity
m/s	m/s
1.042	1.032
1.417	1.411
1.812	1.817
2.168	2.173
2.476	2.483
2.777	2.783
3.098	3.090
3.411	3.406
3.666	3.657
3.955	3.967

Maximum Acceleration: 852 gs

Version: 2023-09-17 4: 24



Exhibit C
SPT Analyzer Results





GEOPROBE 3126GT - 28.5-30

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW
AR: 1.15 in² SP: 0.492 klf²
LE: 33.70 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force
VMX: Maximum Velocity
EMX: Maximum Energy
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute
DMX: Maximum Displacement
DFN: Final Displacement
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	29.10	10	37	18.4	331.0	331.0	94.6	53.1	1.58	1.20	32.3
6	29.20	10	36	18.7	312.7	312.7	89.3	53.4	1.47	1.20	31.7
7	29.30	10	37	18.5	323.0	323.0	92.3	53.6	1.54	1.20	32.2
8	29.40	10	37	19.2	340.4	340.4	97.3	53.4	1.57	1.20	32.5
9	29.50	10	37	18.4	326.6	326.6	93.3	53.5	1.48	1.20	32.1
10	29.58	12	37	19.6	335.5	335.5	95.9	53.3	1.41	1.00	32.1
11	29.67	12	37	18.8	338.0	338.0	96.6	53.7	1.58	1.00	31.8
12	29.75	12	37	18.9	318.3	318.3	90.9	53.5	1.37	1.00	32.3
13	29.83	12	37	18.9	331.4	331.4	94.7	53.8	1.11	1.00	32.1
14	29.92	12	36	18.5	315.2	315.2	90.1	53.8	1.09	1.00	31.7
15	30.00	12	37	18.4	324.1	324.1	92.6	53.6	1.07	1.00	32.1
Average			37	18.8	326.9	326.9	93.4	53.5	1.39	1.09	32.1
Std. Dev.			0	0.4	8.8	8.8	2.5	0.2	0.19	0.10	0.3
Maximum			37	19.6	340.4	340.4	97.3	53.8	1.58	1.20	32.5
Minimum			36	18.4	312.7	312.7	89.3	53.1	1.07	1.00	31.7

Total number of blows analyzed: 11

BL# Sensors

5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 15 seconds 10:07 AM - 10:07 AM BN 1 - 15



GEOPROBE 3126GT - 38.5-40

Case Method & iCAP® Results

Date: 05-September-2024

OP: RW
AR: 1.15 in² SP: 0.492 klf²
LE: 43.70 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.00

FMX: Maximum Force
VMX: Maximum Velocity
EMX: Maximum Energy
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BPM: Blows/Minute
DMX: Maximum Displacement
DFN: Final Displacement
CSX: Compression Stress Maximum

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
7	39.05	20	36	18.7	320.4	320.4	91.5	53.3	0.91	0.60	31.6
8	39.10	20	36	18.5	313.6	313.6	89.6	53.2	0.65	0.60	31.6
9	39.15	20	37	18.9	318.4	318.4	91.0	53.4	0.66	0.60	32.1
10	39.20	20	37	18.9	309.8	309.8	88.5	53.5	0.64	0.60	31.9
11	39.25	20	37	19.1	321.4	321.4	91.8	53.2	0.93	0.60	31.9
12	39.30	20	36	18.5	309.3	309.3	88.4	53.5	0.64	0.60	31.5
13	39.35	20	37	19.5	320.6	320.6	91.6	53.0	0.69	0.60	31.9
14	39.40	20	36	18.4	314.3	314.3	89.8	53.3	0.80	0.60	30.9
15	39.45	20	37	19.5	326.5	326.5	93.3	53.5	0.92	0.60	32.0
16	39.50	20	36	18.6	320.6	320.6	91.6	53.5	1.02	0.60	31.7
17	39.55	20	37	19.1	316.4	316.4	90.4	53.7	0.68	0.60	31.8
18	39.60	20	36	19.0	312.4	312.4	89.2	53.3	0.66	0.60	31.7
19	39.65	20	36	18.8	315.8	315.8	90.2	53.5	0.70	0.60	31.1
20	39.70	20	36	19.2	320.1	320.1	91.5	53.4	0.78	0.60	31.1
21	39.75	20	36	19.5	320.9	320.9	91.7	53.3	0.63	0.60	31.0
22	39.80	20	37	19.2	317.1	317.1	90.6	53.5	0.74	0.60	31.7
23	39.85	20	36	18.8	315.1	315.1	90.0	53.5	0.61	0.60	31.1
24	39.90	20	36	19.7	333.6	333.6	95.3	53.5	0.83	0.60	31.3
25	39.95	20	36	19.6	323.9	323.9	92.6	53.4	0.66	0.60	31.7
26	40.00	20	35	18.9	313.5	313.5	89.6	53.5	0.60	0.60	30.6
Average			36	19.0	318.2	318.2	90.9	53.4	0.74	0.60	31.5
Std. Dev.			0	0.4	5.6	5.6	1.6	0.1	0.12	0.00	0.4
Maximum			37	19.7	333.6	333.6	95.3	53.7	1.02	0.60	32.1
Minimum			35	18.4	309.3	309.3	88.4	53.0	0.60	0.60	30.6

Total number of blows analyzed: 20

BL# Sensors

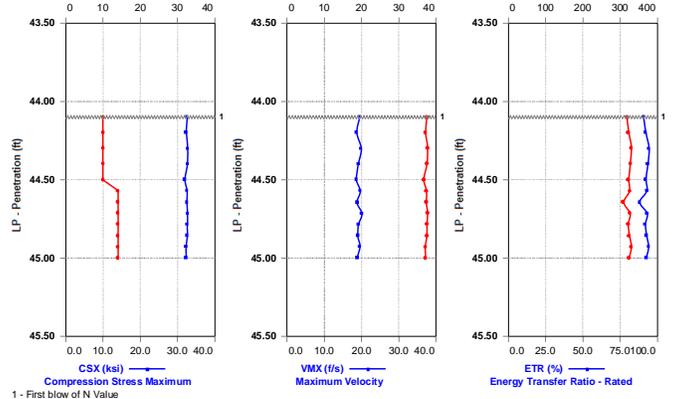
7-26 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00); A4: [K14006] 375.2 (1.00)

BL# Comments

7 First blow of N Value

Time Summary

Drive 28 seconds 10:24 AM - 10:24 AM BN 1 - 26



1 - First blow of N Value



GEOPROBE 3126GT - 43.5-45

Case Method & iCAP® Results

B3

OP: RW Date: 05-September-2024
AR: 1.15 in² SP: 0.492 klf/ft
LE: 48.70 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.00

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

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	44.10	10	37	19.5	317.4	317.4	90.7	53.2	1.23	1.19	32.6
6	44.20	10	37	18.7	322.7	322.7	92.2	53.3	1.22	1.20	32.4
7	44.30	10	38	19.9	330.1	330.1	94.3	53.4	1.30	1.20	32.8
8	44.40	10	38	19.2	327.2	327.2	93.5	53.5	1.22	1.20	32.6
9	44.50	10	37	18.6	323.0	323.0	92.3	53.5	1.21	1.20	32.0
10	44.57	14	37	19.7	325.2	325.2	92.9	53.4	0.95	0.85	32.6
11	44.64	14	37	18.8	309.1	309.1	88.3	53.6	0.90	0.85	32.5
12	44.71	14	38	20.1	326.0	326.0	93.2	53.5	1.06	0.86	32.8
13	44.79	14	37	19.2	321.1	321.1	91.8	53.4	1.05	0.86	32.6
14	44.86	14	37	19.0	324.7	324.7	92.8	53.4	0.91	0.86	32.6
15	44.93	14	37	19.5	329.6	329.6	94.2	53.5	0.99	0.86	32.3
16	45.00	14	37	18.8	323.5	323.5	92.4	53.4	0.89	0.86	32.3
Average			37	19.3	323.3	323.3	92.4	53.4	1.08	1.00	32.5
Std. Dev.			0	0.5	5.5	5.5	1.6	0.1	0.15	0.17	0.2
Maximum			38	20.1	330.1	330.1	94.3	53.6	1.30	1.20	32.8
Minimum			37	18.6	309.1	309.1	88.3	53.2	0.89	0.85	32.0

Total number of blows analyzed: 12

BL# Sensors

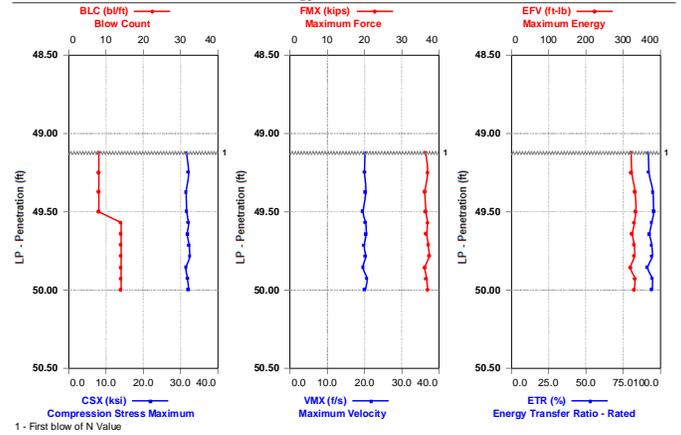
5-16 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 16 seconds 10:32 AM - 10:33 AM BN 1 - 16



1 - First blow of N Value

GEOPROBE 3126GT - 48.5-50

Case Method & iCAP® Results

B3

OP: RW Date: 05-September-2024
AR: 1.15 in² SP: 0.492 klf/ft
LE: 53.70 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.00

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

BL#	Depth ft	BLC b/ft	FMX kips	VMX f/s	EMX ft-lb	EFV ft-lb	ETR (%)	BPM bpm	DMX in	DFN in	CSX ksi
5	49.13	8	36	20.1	321.6	321.6	91.9	53.3	1.81	1.50	31.6
6	49.25	8	37	20.1	323.0	323.0	92.3	53.4	1.81	1.50	32.1
7	49.38	8	36	20.3	332.2	332.2	94.9	53.5	1.50	1.50	31.5
8	49.50	8	36	19.6	334.0	334.0	95.4	53.3	1.50	1.50	31.7
9	49.57	14	37	20.3	329.3	329.3	94.1	53.8	0.87	0.86	32.1
10	49.64	14	37	20.4	324.8	324.8	92.8	53.4	1.00	0.86	31.9
11	49.71	14	37	19.9	329.7	329.7	94.2	53.2	0.89	0.86	32.2
12	49.79	14	37	20.2	330.1	330.1	94.3	53.7	0.89	0.86	32.4
13	49.86	14	36	19.6	319.8	319.8	91.4	53.7	1.01	0.86	31.5
14	49.93	14	37	20.7	331.0	331.0	94.6	53.1	0.91	0.86	31.9
15	50.00	14	37	20.1	330.2	330.2	94.4	53.2	1.03	0.86	32.1
Average			37	20.1	327.8	327.8	93.7	53.4	1.20	1.09	31.9
Std. Dev.			0	0.3	4.5	4.5	1.3	0.2	0.36	0.31	0.3
Maximum			37	20.7	334.0	334.0	95.4	53.8	1.81	1.50	32.4
Minimum			36	19.6	319.8	319.8	91.4	53.1	0.87	0.86	31.5

Total number of blows analyzed: 11

BL# Sensors

5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

Drive 15 seconds 10:42 AM - 10:42 AM BN 1 - 15

Exhibit D
Field Log





SPT HAMMER CALIBRATION FIELD WORKSHEET

PROJECT NAME: 7324515
 PROJECT NO.: Terracon Associates, Inc.
 BORING NO.: 8-3
 CLIENT:

ARRIVAL TIME:
 DEPART TIME:
 TOTAL TRAVEL:
 TOTAL TIME:
 CLIENT REP:
 MILEAGE:
 DATE: 9/5/24
 TERRACON REP: (N/A)
 PDA MODEL/SN: SPT 4621 TR
 TERRACON RIG #: 1307

DRILL RIG DATA
 Type/Transport: Fork
 Manufacturer: Geopole
 Model No.: 3026GS
 Serial No.: 7126550224106
 Year Built: 2024
 Modifications: N/A
 Maint. Schedule: 50 hrs

SPT HAMMER DATA
 Type: ATO
 Manufacturer: Geopole
 Lifting Mechanism: Claw
 Model No.: AD1131
 Serial No.: 10201
 Hammer Weight: 140
 Hammer Operator(s): B. R. MEHTA

PDA INPUT DATA
 Operator: OP (N/A)
 Project No./Location: PJ 7324515/
 Rig Mode & SN: PN 60000/3026GS
 Hammer Type, LM, Rods: PD ATO/ANJ
 Drill Rod Area (in²): AR 115
 Elastic Modulus (ksi): EM 3000
 Specific Weight (kips/ft³): SP 0.492
 Wave Speed (ft/sect): WS 16808
 Increment Length (ft): LI 0.5
 Sampling Freq. (kHz): FR 50

TRANSDUCER INFORMATION
 Gage SN Calibration
 F1/F3: 746 ANJ1 222.05
 F2/F4: 746 ANJ2 222.09
 A1/A3: K14002 402.23
 A2/A4: K14006 375.83
 NOTES: 286.25 + 1.875
 24.38 * 25 + 10.25 = 288.75
 SPLIT SPOON SAMPLER LENGTH: 38K + 0.88
 = 3.3
 * LE is Measured from the Center of the Strain Gauges to the bottom of Split Spoon Sampler

SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		LE (ft)	Rods & Lengths	PDA Blows		SPT Blows			
			Start	End			Start	End	1st 6"	2nd 6"	3rd 6"	4th 6"
9:55	CL		27.5	25	48.7	5x5	1	30	5	10	14	24
10:05	SP		28.5	30	53.7	5x6	3	18	4	5	6	11
10:10	CL		33.5	35	58.7	5x7	1	1	0	0	0	0
10:15	SP		38.5	40	63.7	5x8	3	30	7	10	10	20
10:25	SP		43.5	45	68.7	5x9	1	18	4	5	7	12
10:35	SP		48.5	50	73.7	5x10	1	17	4	4	7	11
10:50	SC		53.5	55	78.7	5x11	1	6	2	1	2	3
11:10	CL		58.5	60	83.7	5x12	1	2	0	0	0	1

Individual pairs of F or V signals versus time shall be very similar for good quality data.
 If you see Force goes negative before 2L/C after impact, drill rod joints should be carefully tightened for good quality data

PICTURE NUMBERS AND INFO:

Take Photo of Each Rigs, Boring Locations at the Site

Terracon SPT Rig Calibration Worksheet.xlsx



This documents that
Susheel R. Kolwalker
Terracon Consultants
 has on March 11, 2016 achieved the rank of
EXPERT

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.

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

Steven A. Hall
 Steven A. Hall, Executive Director
 Pile Driving Contractors Association

Garland Likins
 Garland Likins, Senior Partner
 Pile Dynamics, Inc.

No. 2005



Exhibit E

Copy of Certificate of Proficiency



For Borings S-23-41-2 and S-23-41-3

SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: GeoProbe 3126

Drill Rig Serial Number: 3126TTS52010006

Asset Number: DR#554

August 21, 2023



July 19, 2023

Terracon
72 Pointe Circle
Greenville, South Carolina 29607

Attn: Maggie McKenney
E: m.mckenney@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report
Rig Serial Number: 3126TTS52010006
Terracon Project Number: DYXX0500

Dear Ms. McKenney:

This report provides the Energy Transfer Ratio (ETR) for the Standard Penetration Testing (SPT) automatic hammer as summarized below:

Table 1: Hammer Efficiency Summary

Drill Rig Make/Model	Drill Rig Serial Number	Drill Rig Year	Asset Number	Energy Transfer Ratio (ETR)	Hammer Efficiency Correction (Ce)
GeoProbe 3126	3126TTS52010006	2021	GP#554	88.5% ± 4.2%	1.48

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

Jim Smith

James P. Smith
National Manager of Equipment & Training

Rob Kramer

Rob Kramer
Group Manager Geophysics

Attachments:

- Exhibit A: PDA SPT Analyzer Results
- Exhibit B: PDA Equipment Calibration

Prepared for:

Terracon
Greenville-Spartanburg, South Carolina



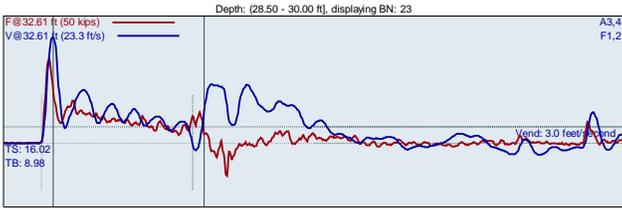
MEASUREMENT SUMMARY

ITEM	DESCRIPTION
Drill Rig Owner	Terracon Greenville-Spartanburg – Greenville, SC
Drill Rig Operator	Brett Burnett; Terracon Exploration Services
Testing Date	08/21/2023
Testing Location	Spartanburg, SC
Boring Identification	B-1
Hammer Type	140 pounds (automatic)
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> AWJ 1-3/4" outside diameter 3/16" wall thickness
Calibration Testing Equipment	<ul style="list-style-type: none"> 2-foot AWJ rod instrumented w/ two strain gauges and two accelerometers Model SPT Analyzer™ (PDA)
ASTM Methods Used	<p>ASTM D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils</p> <p>ASTM D4633-16, Standard Method for Energy Measurement for Dynamic Penetrometers</p>
SPT Calibration Personnel	Jim Smith, National Manager of Equipment and Training

Exhibit A

PDA SPT Analyzer Results

GP554-3126 28.530
JIM SMITH Interval start: 8/21/2023
TB-1
AR: 1.20 in/2 SP: 0.492 k/ft3
LE: 32.61 ft EM: 30000 ksi
WS: 16807.9 fts



F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4w5000g (1) VF1
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w5000g (1) VF1

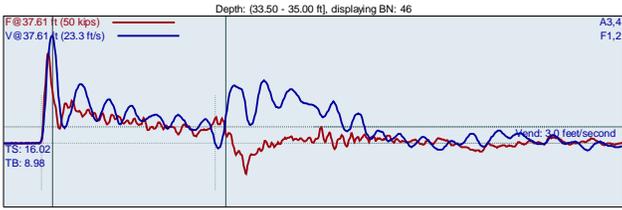
FMX: Maximum Force EFV: Maximum Energy
VMX: Maximum Velocity ETR: Energy Transfer Ratio - Rated
BPM: Blows/Minute

BL#	BC /6"	FMX kips	VMX fts	BPM bpm	EFV ft-lb	ETR %
1	6	40	19.4	1.9	234	84.1
2	6	39	19.2	51.9	232	83.4
3	6	25	16.9	52.7	274	78.2
4	6	28	17.9	52.4	273	77.9
5	6	32	19.6	52.6	294	83.9
6	6	27	17.3	53.1	269	79.5
7	8	38	19.0	52.7	289	82.5
8	8	39	19.6	52.4	305	87.2
9	8	36	19.2	52.7	290	82.8
10	8	28	18.2	52.5	292	83.4
11	8	38	19.0	53.0	293	83.8
12	8	35	19.4	52.6	282	80.4
13	8	36	19.1	52.9	299	85.3
14	8	34	19.8	52.8	307	87.7
15	11	34	19.5	52.7	307	87.6
16	11	33	19.5	52.9	299	85.6
17	11	36	19.4	52.7	308	88.1
18	11	37	18.5	52.8	320	91.4
19	11	32	19.6	52.9	301	86.1
20	11	39	18.7	52.9	301	85.9
21	11	26	17.5	52.8	277	79.1
22	11	30	19.1	52.6	306	87.4
23	11	33	19.5	52.7	298	85.1
24	11	35	19.9	52.4	303	86.5
25	11	36	19.4	53.1	313	89.6

Average	34	19.2	52.8	299	85.6
Std Dev	3	0.6	0.2	10	3.0
Maximum	39	19.9	53.1	320	91.4
Minimum	26	17.5	52.4	277	79.1
N-value: 19					

Sample Interval Time: 27.36 seconds.

GP554-3126 28.530
JIM SMITH Interval start: 8/21/2023
TB-1
AR: 1.20 in/2 SP: 0.492 k/ft3
LE: 37.61 ft EM: 30000 ksi
WS: 16807.9 fts

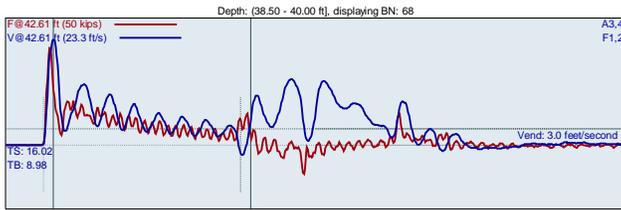


F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4w5000g (1) VF1
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w5000g (1) VF1

BL#	BC /6"	FMX kips	VMX fts	BPM bpm	EFV ft-lb	ETR %
26	5	38	19.1	1.9	302	86.4
27	5	35	18.9	52.0	301	86.1
28	5	29	18.8	52.0	299	85.5
29	5	35	19.2	52.7	299	85.5
30	5	37	19.4	52.5	297	84.8
31	8	37	19.5	52.4	307	87.7
32	8	26	16.4	52.7	282	80.5
33	8	34	19.5	52.4	307	87.6
34	8	40	19.1	52.2	307	87.6
35	8	37	19.4	52.6	299	85.5
36	8	40	20.6	52.4	321	91.7
37	8	41	19.6	52.8	308	87.9
38	8	40	19.8	52.7	313	89.5
39	10	34	20.2	52.2	323	92.2
40	10	32	19.4	52.8	297	84.9
41	10	36	19.8	52.6	311	88.8
42	10	37	19.7	52.5	317	90.7
43	10	35	20.0	52.6	324	92.6
44	10	38	19.5	52.7	308	88.1
45	10	34	20.1	52.4	322	92.0
46	10	35	19.7	52.4	322	92.0
47	10	37	19.9	52.6	314	89.7
48	10	37	19.8	52.7	332	94.8
Average						
		36	19.6	52.6	312	89.1
Std Dev						
		3	0.8	0.2	12	3.3
Maximum						
		41	20.6	52.8	332	94.8
Minimum						
		26	16.4	52.2	282	80.5
N-value: 18						

Sample Interval Time: 25.16 seconds.

GP554-3126 28.5-30
JIM SMITH Interval start: 8/21/2023
TB-1 SP: 0.492 k/ft
AR: 1.20 in/2 EM: 30000 ksi
LE: 42.61 ft
WS: 16807.9 ft/s



F1 : [648AWJ1] 226.21 PDICAL (1) FF1 A3 (PR): [K4483] 410.187 mv/6.4w/5000g (1) VF1
F2 : [648AWJ2] 225.58 PDICAL (1) FF1 A4 (PR): [K10491] 421.907 mv/6.4w/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
49	5	34	19.6	1.9	307	87.6
50	5	34	19.3	52.0	301	86.1
51	5	27	16.5	52.7	279	79.4
52	5	33	19.9	52.5	310	88.6
53	5	29	17.7	52.7	288	82.2
54	8	29	18.6	52.5	295	84.2
55	8	23	15.6	52.9	287	82.0
56	8	34	20.1	52.6	323	92.2
57	8	28	18.1	52.8	295	84.3
58	8	38	18.8	53.1	312	89.1
59	8	35	19.2	52.6	329	94.0
60	8	36	19.3	52.9	327	93.3
61	8	40	19.7	52.8	323	92.4
62	9	35	18.8	53.0	320	91.3
63	9	37	19.1	52.7	320	91.3
64	9	35	19.9	52.9	327	93.4
65	9	29	18.8	52.7	314	89.7
66	9	35	19.7	53.0	342	97.8
67	9	36	19.9	52.8	331	94.5
68	9	38	19.3	52.8	335	95.8
69	9	36	19.9	52.5	325	92.9
70	9	39	19.5	52.9	329	94.0
Average		34	19.1	52.8	320	91.3
Std Dev		4	1.0	0.2	15	4.1
Maximum		40	20.1	53.1	342	97.8
Minimum		23	15.6	52.5	287	82.0
N-value: 17						

Sample Interval Time: 23.91 seconds.

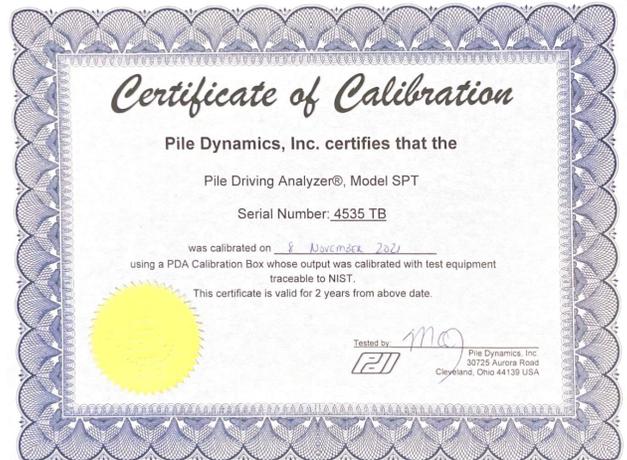
Summary of SPT Test Results

Project: GP554-3126, Test Date: 8/21/2023

Blow/Minute	Blows Applied /6"	N Value	N60 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
32.61	6-8-11	19	28	34	19.2	52.8	299	85.6
37.61	5-8-10	18	26	36	19.6	52.6	312	89.1
42.61	5-9-9	17	25	34	19.1	52.8	320	91.3
Overall Average Values:				35	19.3	52.7	310	88.5
Standard Deviation:				4	0.8	0.2	15	4.2
Overall Maximum Value:				41	20.6	53.1	342	97.8
Overall Minimum Value:				23	15.6	52.2	277	79.1



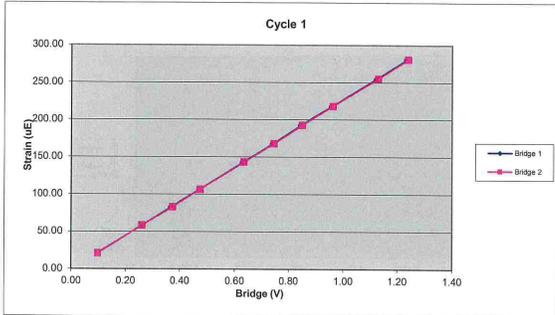
Exhibit B
PDA Equipment Calibration



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

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

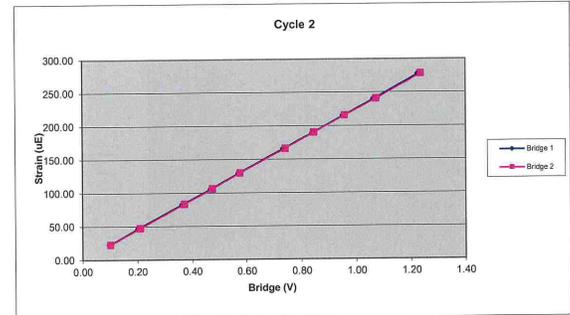
Force Strain Calibration	
EA (Kips)	35527.98
Offset	51.69
Correlation	0.999986



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

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

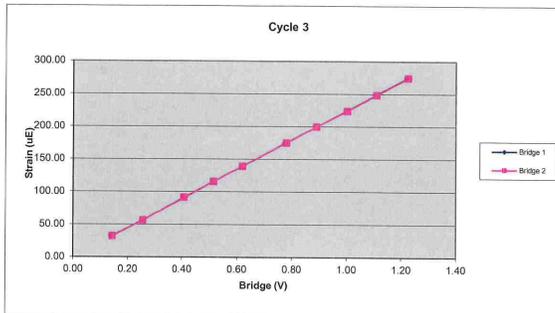
Force Strain Calibration	
EA (Kips)	36073.41
Offset	-2.66
Correlation	0.999993



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

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

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



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

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

Calibrated by: *Aht*
Calibrated Date: 3/3/2022

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Accelerometer Calibration Certificate
Pile Dynamics, Inc.



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

Serial No: K4483 Temperature: 22.1 °C
Model: PR Humidity: 45%
Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR
410.2 mv/5000g
(62.0 μv/g)
R²: 0.999973 [Chip programmed]

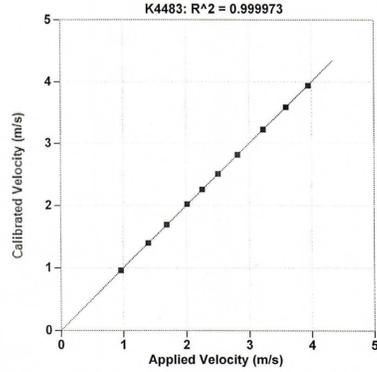
Operator: William Johnson

William Johnson
Signed

Ref Acc 1: 690961 Cal on: 27Jan2021
978 g's/volt

Ref Acc 2: 691321 Cal on: 09Feb2021
960 g's/volt

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



Date printed: 26Oct2021, version: 2020.30.170 0.57

Accelerometer Calibration Certificate
Pile Dynamics, Inc.



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

Serial No: K10491 Temperature: 19.3 °C
Model: PR Humidity: 30%
Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR
421.9 mv/5000g
(84.4 μv/g)
R²: 0.999915 [Chip programmed]

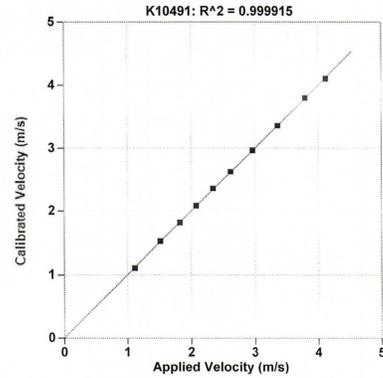
Operator: William Johnson

William Johnson
Signed

Ref Acc 1: 691321 Cal on: 09Feb2021
960 g's/volt

Ref Acc 2: 690961 Cal on: 27Jan2021
978 g's/volt

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



Date printed: 25Jan2022, version: 2020.30.170 0.05