

S-23-40 (Pace Bridge Road) Bridge Replacement over South Saluda River Overflow

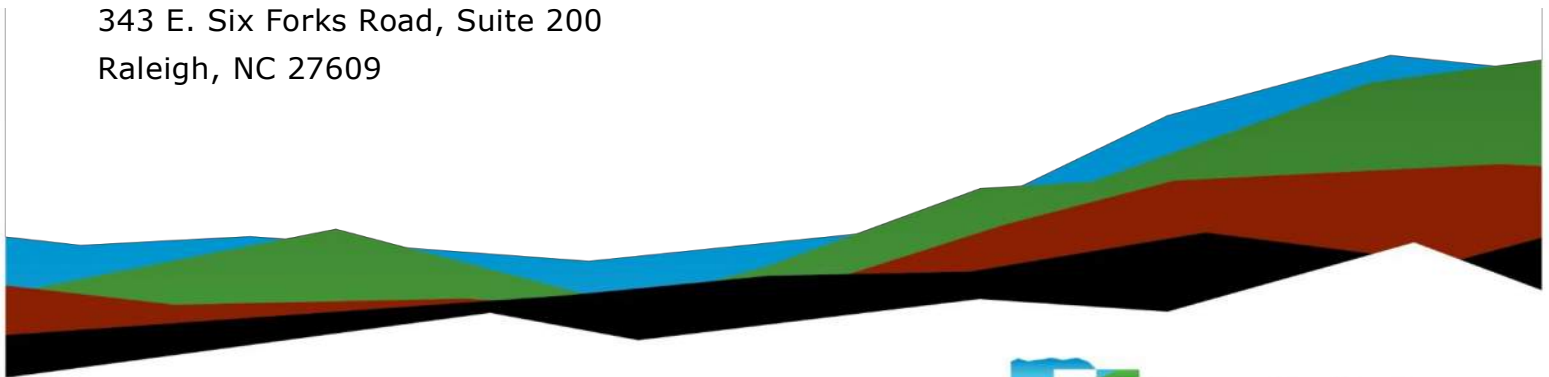
Greenville County, SC

Geotechnical Subsurface Data Report

October 30, 2024 | SCDOT Project ID: P043137
Terracon Project No.: 8623P180 Revision 1

Prepared for:

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





72 Pointe Circle
Greenville, SC 29615
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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 Subsurface Data Report
S-23-40 Bridge Replacement over South Saluda River Overflow
Greenville County, South Carolina
SCDOT Project ID.: P043137
Terracon Project No.: 8623P180 Revision 1

Dear Mr. Franklin:

Terracon Consultants Inc. (Terracon) has completed the exploration, testing and limited engineering analysis services (contained in the geotechnical baseline report) for the above referenced project. The services were conducted in general accordance with our Supplement Number 004 to Task Order Number 001, dated July 19, 2024.

Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, laboratory testing and limited preliminary engineering recommendations for the replacement of the S-23-40 bridge over South Saluda River Overflow in Greenville County, South Carolina. This will be a complete bridge replacement within the project existing alignment. This GSDR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and Preconstruction Design Memorandum (PCDM) 11 - Supplemental Design Criteria for Low Volume Bridge Replacement Projects.

Project Description

The project site is located at the S-23-40 (Pace Bridge Road) crossing over South Saluda River Overflow 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 9/3/2024, the replacement bridge will be constructed in the same alignment as the current

bridge. The current plan indicates the new bridge will be an 80-ft long single span bridge constructed with AASHTO Type BII-36 Box Beams.

Geotechnical Testing

The geotechnical exploration for this project was performed between August 21 and 22, 2024. The results of our fieldwork and our associated laboratory testing are included in Appendices A and B.

Field Exploration

Our field exploration consisted of the following:

- Two (2) Standard Penetration Test (SPT) Borings (S-23-40-1 Overflow and S-23-40-2 Overflow)
- Two (2) offset borings near S-23-40-1 Overflow and S-23-40-2 Overflow 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.

- Eighteen (18) Natural Moisture Content Tests
- Five (5) Atterberg Limits Tests
- Six (6) Fines Content Tests
- Five (5) Grain Size Tests with Hydrometer
- One (1) Remolded, Consolidated-Undrained (CU) Triaxial Compression Test with Pore Pressure Readings
- One (1) Standard Proctor Test
- One (1) Corrosivity Suite (pH, chloride content, sulfate content, and resistivity tests)

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

Closure

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

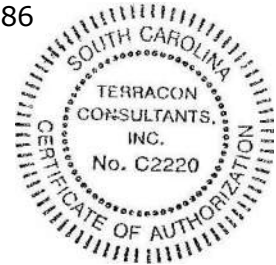
Sincerely,

Terracon Consultants, Inc.



Maggie McKenney, EIT
Senior Staff Engineer

Jonathan Ard, PE
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 – Summary of Boring Data
- Exhibit A-4 – GeoScoping Form (2 Pages)
- Exhibit A-5 – Field Exploration Description (2 Pages)
- Exhibit A-6 – Soil Description Terms
- Exhibit A-7 – Soil/Rock Symbols
- Exhibit A-8 – Boring Logs (4 Pages)

Note: All exhibits are one page unless noted above

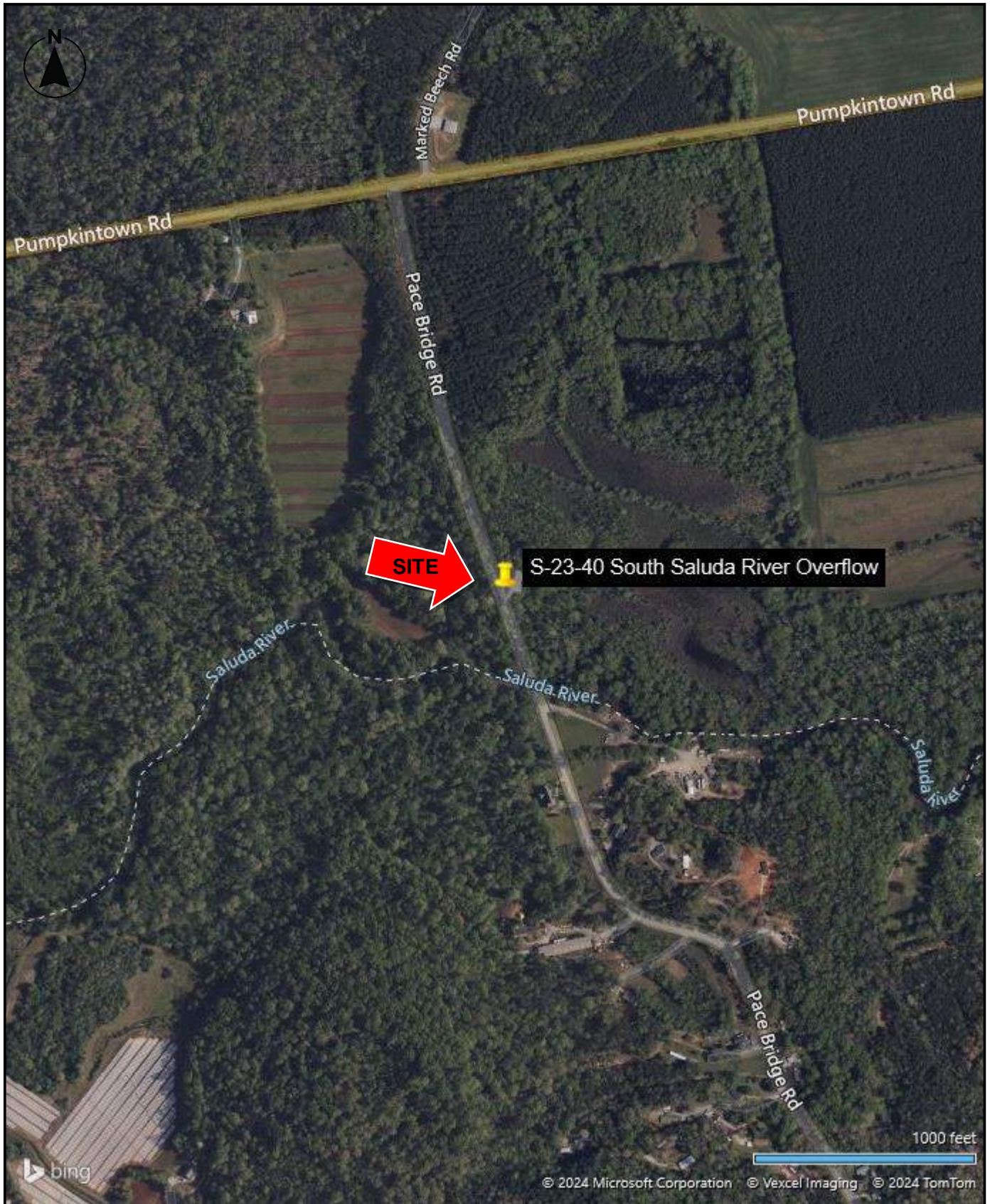



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND
IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Number	8623P180	 72 Pointe Cir Greenville, South Carolina 29615	SITE LOCATION		Exhibit
Scale	AS SHOWN		S-23-40 BRO South Saluda River Overflow Pace Bridge Road Greenville County, SC		A-1
Client	HNTB				
Date	9/20/2024				



SPT Boring Location

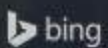
Pace Bridge Rd

S-23-40-2 Overflow



S-23-40-1 Overflow

50 feet



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BY MICROSOFT BING MAPS

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



72 Pointe Cir
Greenville, South Carolina 29615

EXPLORATION PLAN

S-23-40 BRO South Saluda River Overflow
Pace Bridge Road
Greenville County, SC

Exhibit


A-2



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

PRELIMINARY SITE PLAN
PROVIDED BY HNTB

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



72 Pointe Cir
Greenville, South Carolina 29615

EXPLORATION PLAN
S-23-40 BRO South Saluda River Overflow Pace Bridge Road Greenville County, SC

Exhibit
A-2

Summary of Boring Data – Exhibit A-3

S-23-40 BRO South Saluda River Overflow | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P043137



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-23-40-1 Overflow	916.84	100	1160599.68	1529533.29	35.013197	-82.571035	35+27	6 L
S-23-40-2 Overflow	916.97	100	1160668.00	1529520.64	35.013384	-82.571081	35+97	3 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 TM.
2. A composite bulk sample was collected about 3 feet northeast of S-23-40-1 Overflow and about 6 feet west of S-23-40-2 Overflow.
3. Station and offset are based on the plans provided at the time the tests were performed.

GeoScoping Form

PROJECT INFORMATION			
Project ID:	P043137	Date of Trip:	8/22/2024
County:	Greenville	Location:	Marietta
Rd/ Route:	S-23-40 Overflow	Local Name:	Pace Bridge Rd
Attendees:	M. McKenney		

EXISTING BRIDGE INFORMATION			
Bridge Length:	56 ft	Bridge Width:	24 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber and Steel H-Piles
Begin Bridge Sta ¹ :	35+25	End Bridge Sta ¹ :	36+05
Begin Bridge Embankment Sta ¹ :	34+25	End Bridge Embankment Sta ¹ :	37+05
Structure Number:	02541	Posted Weight Limit:	11 tons
Crossing:	South Saluda River Overflow	Skew:	N/A
Latitude:	35.01331°	Longitude:	-82.57105°
Existing Fill Height:	approx. 8 to 12 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:	33+50	Begin Bridge Embankment Sta:	34+25
Accessibility Issues:	Dirt mounds		
Ground Cover:	Asphalt pavement and vegetation along shoulder		
Existing Fill Height:	12 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to overflow		
Traffic Control Necessary:	No		
Surface Soils:	silty sand	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	13 feet	Water Depth:	2 to 4 feet
Depth to Existing Ground:	approximately 15 to 17 feet at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical
End Bridge Embankment Sta:	37+05	End Project Sta:	37+05
Accessibility Issues:	Dirt mounds		
Ground Cover:	Asphalt pavement and vegetation along shoulder		
Existing Fill Height:	8 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to overflow		
Traffic Control Necessary:	No		
Surface Soils:	silty sand	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	13 feet	Water Depth:	2 to 4 feet
Depth to Existing Ground:	approximately 15 to 17 feet at center of bridge		
Scour Condition at EB:	Critical	Scour Condition at IB:	Critical

GeoScoping Form

UTILITIES INFORMATION	
Attached:	N/A
Above Ground:	Overhead power was observed on the southwest side of the road
Underground:	An underground fiber optic cable was observed in the southwest shoulder

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, LLC after testing and drilling was complete. The locations as shown in the Exploration Plan are shown to the scale indicated.

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

Soil Test Borings (STB)

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

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

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

Test ID	Total Depth	Interval of Continuous Sampling
S-23-40-1 Overflow	100 feet	2 to 10 feet
S-23-40-2 Overflow	100 feet	2 to 10 feet
S-23-40-1/2 Overflow Offset	5 feet	Bulk Sample ¹

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

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

Exhibit A-5 – Field Exploration Description

S-23-40 BRO South Saluda River Overflow | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P043137



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 to the planned drilling depth at which they were terminated. 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 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
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

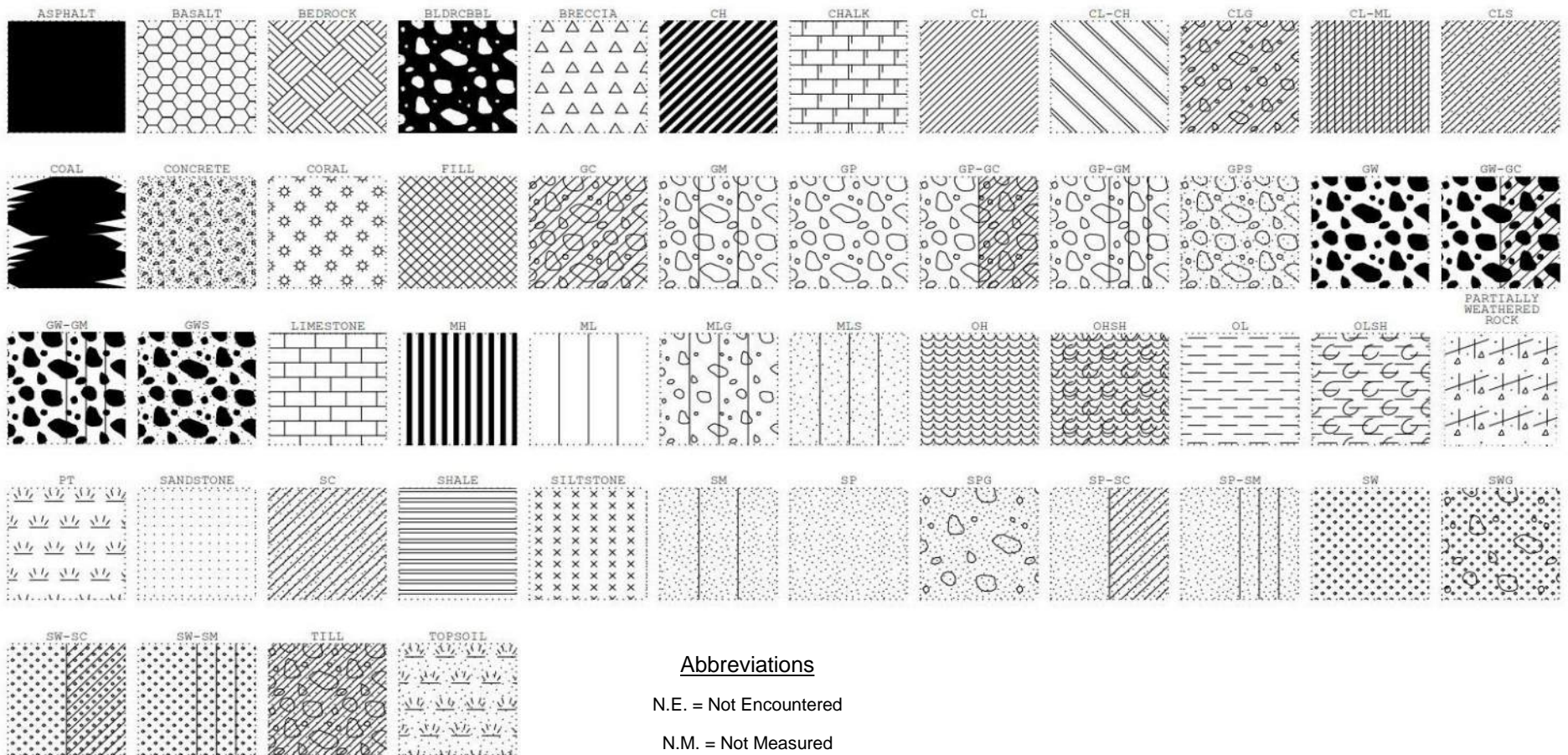
AASHTO Soil Designation

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



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



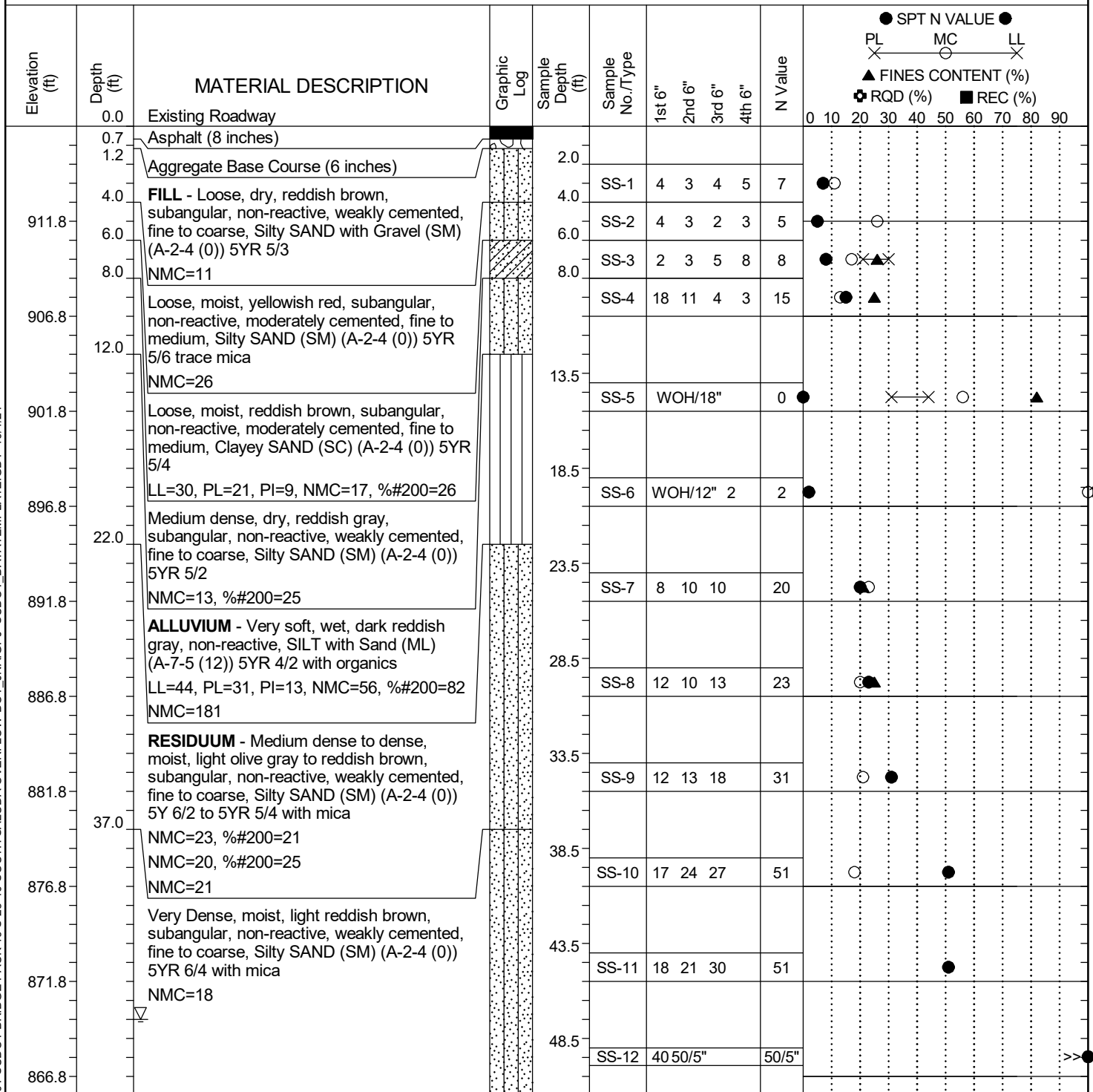
72 Pointe Circle
PH. (864) 292-2901
Greenville, SC 29615
FAX. (864) 292-6361

SOIL AND ROCK SYMBOLS

Exhibit A-7

SCDOT Soil Test Log

Project ID:	P043137	County:	Greenville	Boring No.:	S-23-40-1 Overflow
Site Description:	S-23-40 BRO South Saluda Overflow			Route:	S-23-40
Eng./Geo.:	S. Greaber	Boring Location:	35+27	Offset:	6 L
Elev.:	916.8 ft	Latitude:	35.0132	Longitude:	-82.57104
Date Started:	8/21/2024				
Total Depth:	100 ft	Soil Depth:	100 ft	Core Depth:	0 ft
Date Completed:	8/21/2024				
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR#1327	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	92.6%				
Core Size:	N/A	Driller:	B. Burnette	Groundwater:	TOB 47 (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	

SCDOT Soil Test Log

Project ID:	P043137	County:	Greenville	Boring No.:	S-23-40-1 Overflow
Site Description:	S-23-40 BRO South Saluda Overflow			Route:	S-23-40
Eng./Geo.:	S. Greaber	Boring Location:	35+27	Offset:	6 L
Elev.:	916.8 ft	Latitude:	35.0132	Longitude:	-82.57104
Date Started:	8/21/2024				
Total Depth:	100 ft	Soil Depth:	100 ft	Core Depth:	0 ft
Date Completed:	8/21/2024				
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR#1327	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	92.6%				
Core Size:	N/A	Driller:	B. Burnette	Groundwater:	TOB 47 (After 1hr) 24HR N.M.

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value	<div> ● SPT N VALUE ● PL MC LL X X X ▲ FINES CONTENT (%) ⊕ RQD (%) ■ REC (%) </div>
861.8				53.5	SS-13	35	50/5"		50/5"		>>●
856.8				58.5	SS-14	43	50/3"		50/3"		>>●
851.8				63.5	SS-15	50/2"			50/2"		>>●
846.8		No recovery		68.5	SS-16	50/2"			50/2"		>>●
841.8				73.5	SS-17	50/2"			50/2"		>>●
836.8		No recovery		78.5	SS-18	50/2"			50/2"		>>●
831.8				83.5	SS-19	50/2"			50/2"		>>●
826.8				88.5	SS-20	50/2"			50/2"		>>●
821.8				93.5	SS-21	50/2"			50/2"		>>●
816.8	100.0	BORING TERMINATED AT 100 FEET		98.5	SS-22	50/2"			50/2"		>>●

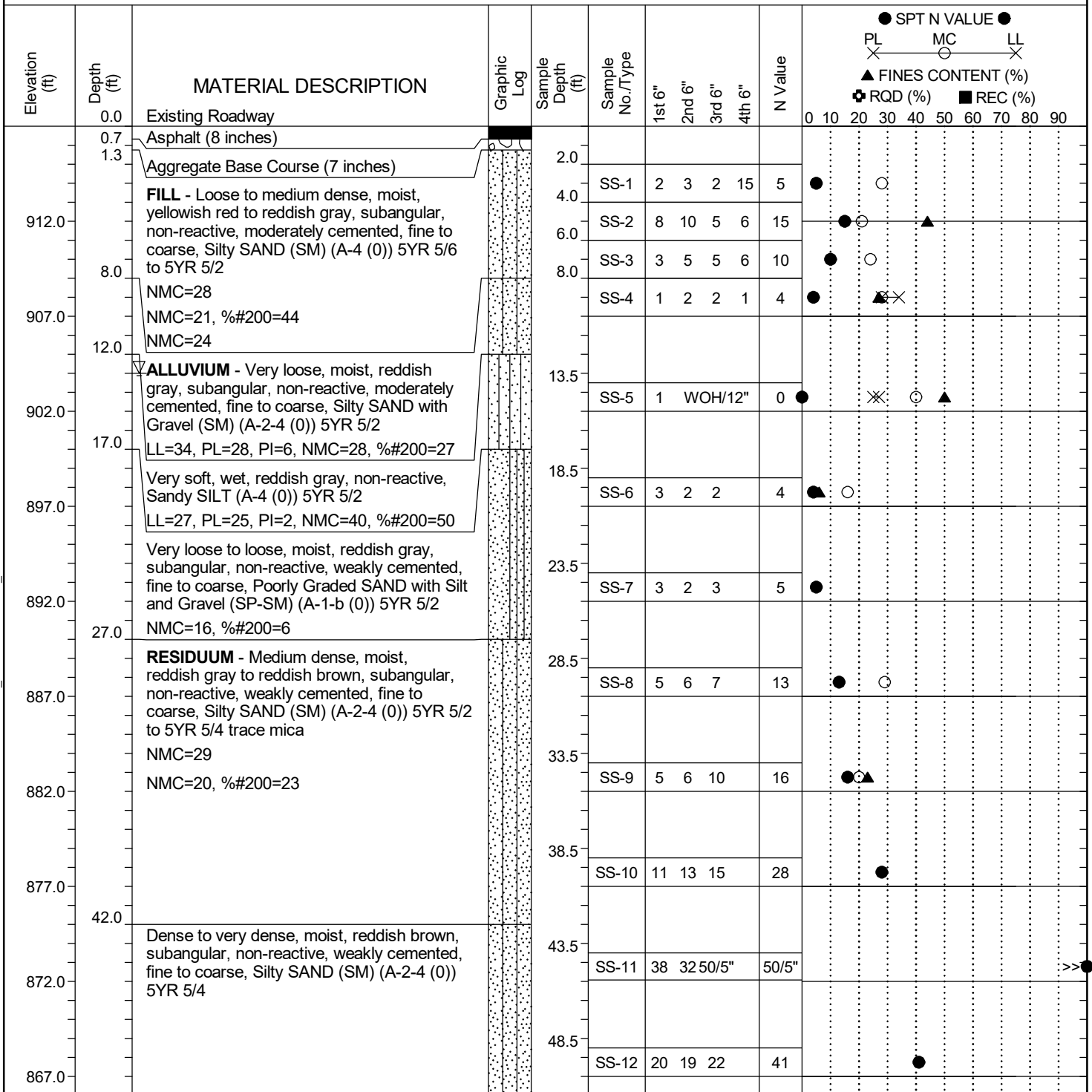
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 SOUTH SALUDA OVERFLOW-DOT_JNA.GPJ SCDOT_DATATEMPLATE.GDT 10/1/24

SCDOT Soil Test Log

Project ID:	P043137				County:	Greenville		Boring No.:	S-23-40-2 Overflow	
Site Description:	S-23-40 BRO South Saluda Overflow							Route:	S-23-40	
Eng./Geo.:	S. Greaber		Boring Location:	35+97		Offset:	3 R		Alignment:	Existing
Elev.:	917.0 ft		Latitude:	35.01338		Longitude:	-82.57108		Date Started:	8/21/2024
Total Depth:	100 ft		Soil Depth:	100 ft		Core Depth:	0 ft		Date Completed:	8/22/2024
Bore Hole Diameter (in):	4		Sampler Configuration			Liner Required:	Y (N)		Liner Used:	Y (N)
Drill Machine:	DR#1327		Drill Method:	RW		Hammer Type:	Automatic		Energy Ratio:	92.6%
Core Size:	N/A		Driller:	B. Burnette		Groundwater:	TOB	13 (After 1hr)	24HR	N.M.



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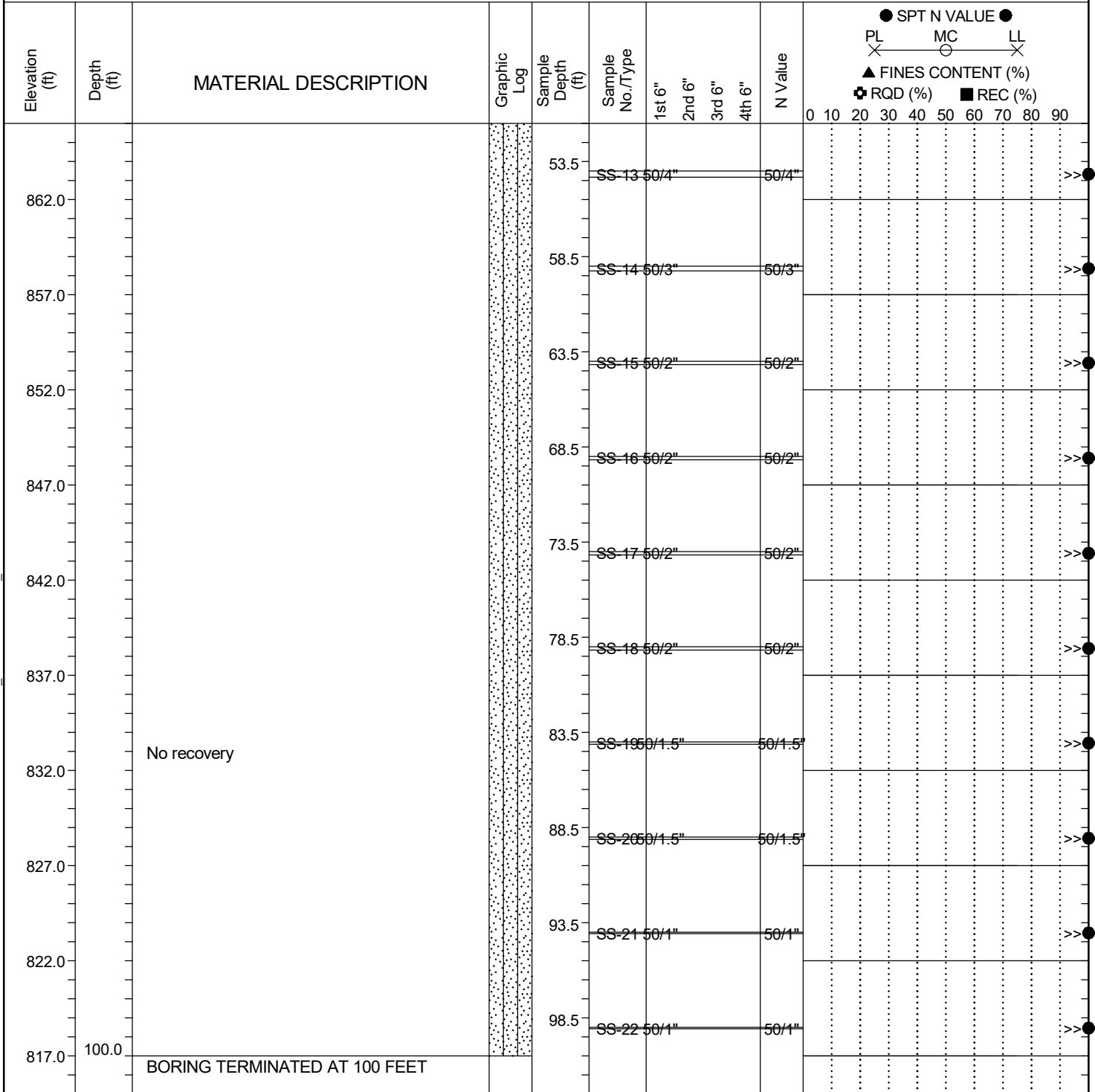
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT 8623P180T SCDOT BRIDGE PACK 19 S-23-40 SOUTH SALUDA OVERFLOW-DOT_JNA.GPJ SCDOT_DATATEMPLATE.GDT 10/1/24

SCDOT Soil Test Log

Project ID:	P043137	County:	Greenville	Boring No.:	S-23-40-2 Overflow
Site Description:	S-23-40 BRO South Saluda Overflow			Route:	S-23-40
Eng./Geo.:	S. Greaber	Boring Location:	35+97	Offset:	3 R
Elev.:	917.0 ft	Latitude:	35.01338	Longitude:	-82.57108
Date Started:	8/21/2024				
Total Depth:	100 ft	Soil Depth:	100 ft	Core Depth:	0 ft
Date Completed:	8/22/2024				
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	DR#1327	Drill Method:	RW	Hammer Type:	Automatic
Energy Ratio:	92.6%				
Core Size:	N/A	Driller:	B. Burnette	Groundwater:	TOB 13 (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-23-40 SOUTH SALUDA OVERFLOW-DOT_JNA.GPJ SCDOT_DATATEMPLATE.GDT 10/1/24

Appendix B – Laboratory Testing

S-23-40 BRO South Saluda River Overflow | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P043137



Appendix B

Laboratory Testing

Exhibit B-1 – Laboratory Testing Description
Summary of Laboratory Data
Laboratory Data Sheets (11 Pages)

Note: All exhibits are one page unless noted above.

Exhibit B-1 – Laboratory Testing Description

S-23-40 BRO South Saluda River Overflow | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P043137



Laboratory Testing Description

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

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

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

■	Moisture Content	AASHTO T265/(ASTM D2216)
■	Atterberg Limits	AASHTO T89/T90(ASTM D4318)
■	Wash 200	AASHTO T11/(ASTM D1140)
■	Proctor (Standard effort)	AASHTO T99/ (ASTM D698)
■	Triaxial Shear CU w/ PP	AASHTO T297/(ASTM D4767)
■	Grain Size Distribution	ASTM D6913
■	Hydrometer	ASTM D7928
■	Corrosion Series	AASHTO D422
		AASHTO T289/ASTM G51
		AASHTO T290/ASTM C1580
		AASHTO T291

Summary of Laboratory Results

Boring ID	Depth (Ft.)	Soil Classification USCS & AASHTO	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Fines	% Silt	% Clay	Water Content (%)	Proctor Dry Density (pcf)/Opt. Moisture (%)
S-23-40-1 Overflow	2-4	SILTY SAND with GRAVEL(SM) / A-2-4 (0)									10.9	
S-23-40-1 Overflow	4-6	SILTY SAND(SM) / A-2-4 (0)									25.5	
S-23-40-1 Overflow	6-8	CLAYEY SAND(SC) / A-2-4 (0)	30	21	9	11.1	62.6	26.4			17.2	
S-23-40-1 Overflow	8-10	SILTY SAND(SM) / A-2-4 (0)				0.0	73.2	25.4	15.1	10.3	12.9	
S-23-40-1 Overflow	13.5-15	SILT WITH SAND(ML) / A-7-5 (12)	44	31	13	0.0	17.9	82.1	44.7	37.4	56.3	
S-23-40-1 Overflow	18.5-20	SILT WITH SAND(ML) / A-7-5 (12)									181.3	
S-23-40-1 Overflow	23.5-25	SILTY SAND(SM) / A-2-4 (0)				5.2	74.0	20.7			22.6	
S-23-40-1 Overflow	28.5-30	SILTY SAND(SM) / A-2-4 (0)				4.0	71.2	24.8			20.2	
S-23-40-1 Overflow	33.5-35	SILTY SAND(SM) / A-2-4 (0)									20.7	
S-23-40-1 Overflow	38.5-40	SILTY SAND(SM) / A-2-4 (0)									18.1	
S-23-40-2 Overflow	2-4	SILTY SAND(SM) / A-4 (0)									27.7	
S-23-40-2 Overflow	4-6	SILTY SAND(SM) / A-4 (0)				2.8	53.7	43.5			20.8	
S-23-40-2 Overflow	6-8	SILTY SAND(SM) / A-4 (0)									24.1	
S-23-40-2 Overflow	8-10	SILTY SAND WITH GRAVEL(SM) / A-2-4 (0)	34	28	6	33.2	39.7	27.1	16.4	10.7	28.2	
S-23-40-2 Overflow	13.5-15	SANDY SILT(ML) / A-4 (0)	27	25	2	0.0	49.8	50.2	31.6	18.6	39.8	
S-23-40-2 Overflow	18.5-20	POORLY GRADED SAND with SILT and GRAVEL(SP-SM) / A-1-b (0)				28.1	66.2	5.7	3.7	2.0	16.4	
S-23-40-2 Overflow	28.5-30	SILTY SAND(SM) / A-2-4 (0)									28.5	
S-23-40-2 Overflow	33.5-35	SILTY SAND(SM) / A-2-4 (0)				2.2	74.8	23.0			19.6	
S-23-40-1/2 Overflow Offset	0-5	CLAYEY SAND(SC) / A-2-4 (0)	30	20	10	8.4	65.3	26.3				114.7 / 14.6



INDEX PROPERTIES VERSUS DEPTH

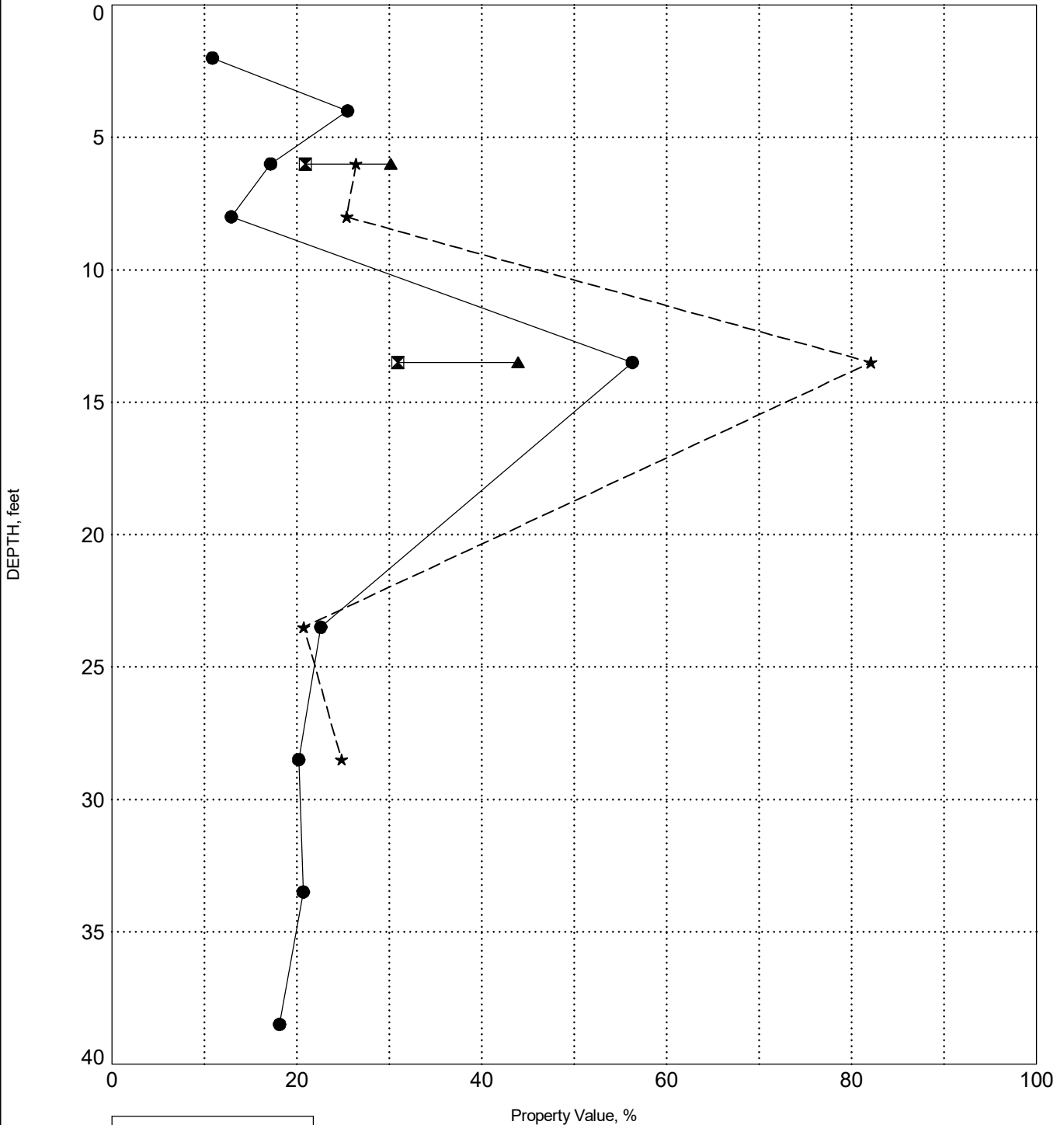
PROJECT ID P043137

PROJECT NAME S-23-40 BRO South Saluda Overflow

PROJECT COUNTY Greenville

SURFACE ELEVATION: 916.8

BORING S-23-40-1 Overflow



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



INDEX PROPERTIES VERSUS DEPTH

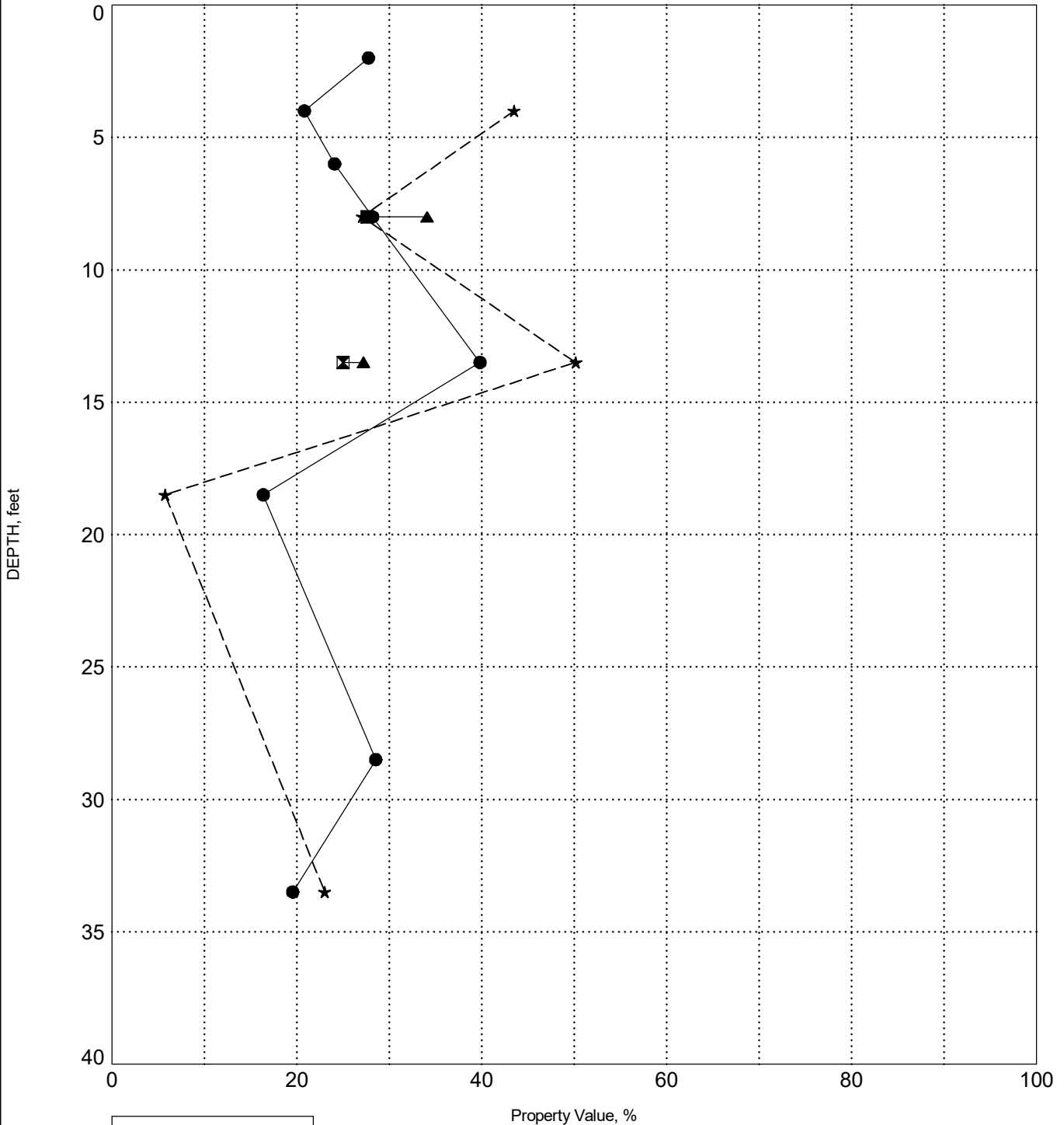
PROJECT ID P043137

PROJECT NAME S-23-40 BRO South Saluda Overflow

PROJECT COUNTY Greenville

SURFACE ELEVATION: 917.0

BORING S-23-40-2 Overflow



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



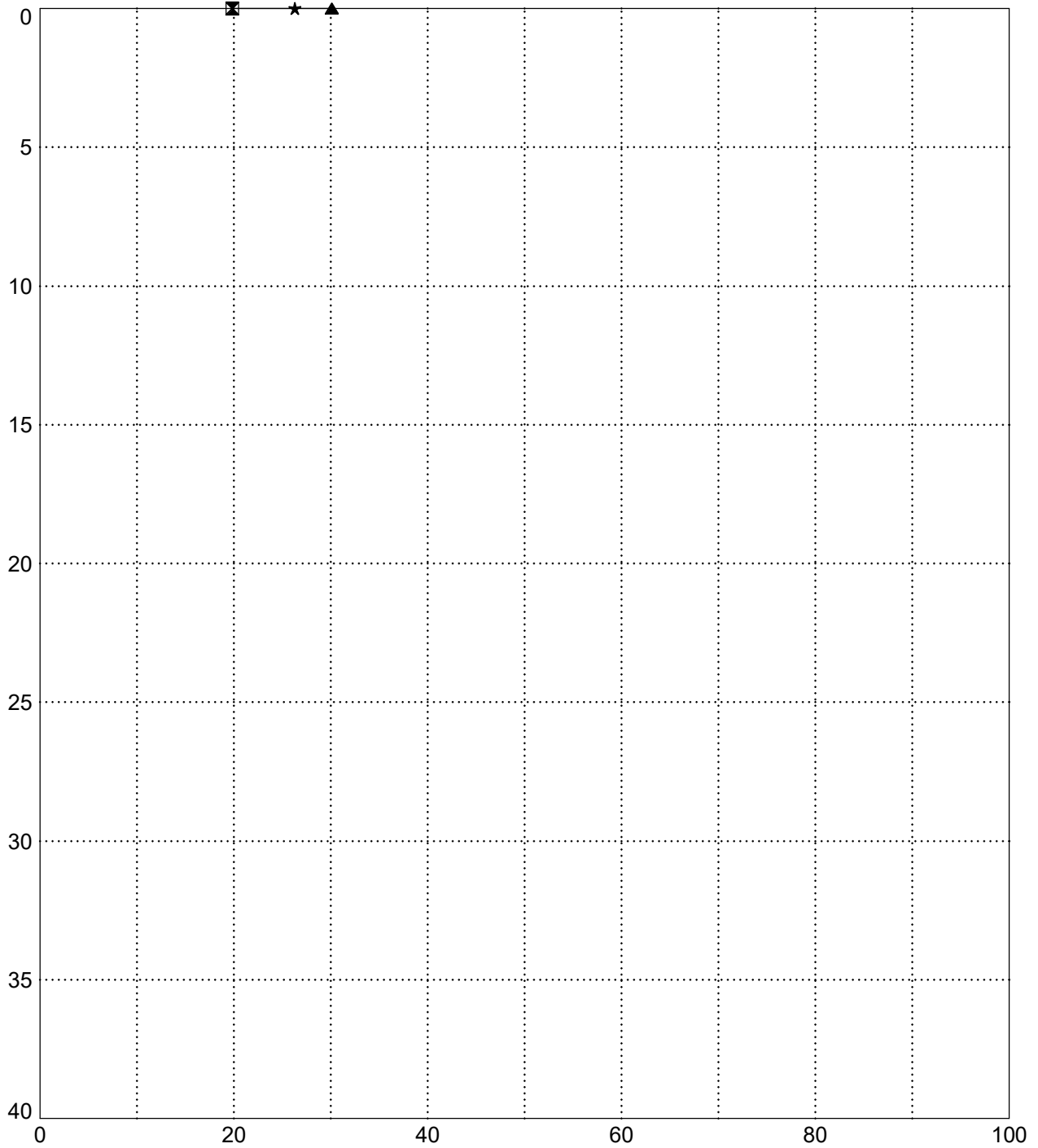
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PROJECT NAME S-23-40 BRO South Saluda Overflow

PROJECT COUNTY Greenville

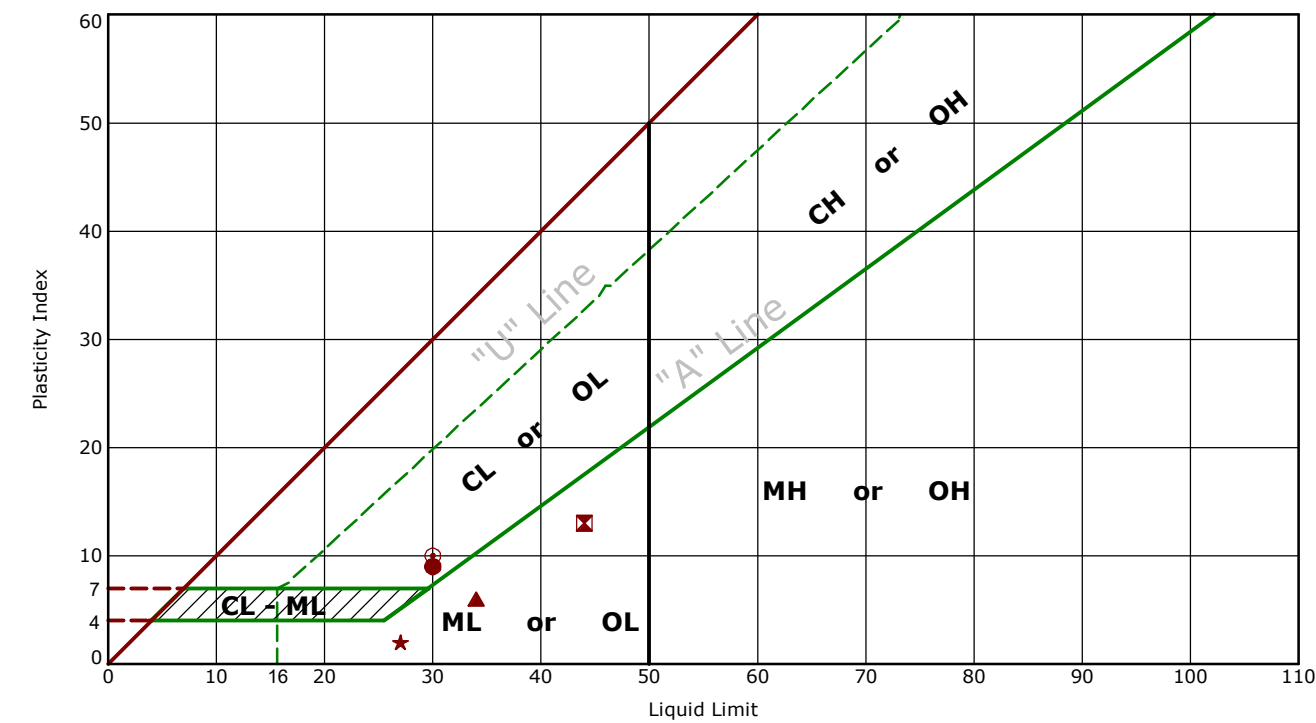
BORING S-23-40-1/2 Overflow Offset



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

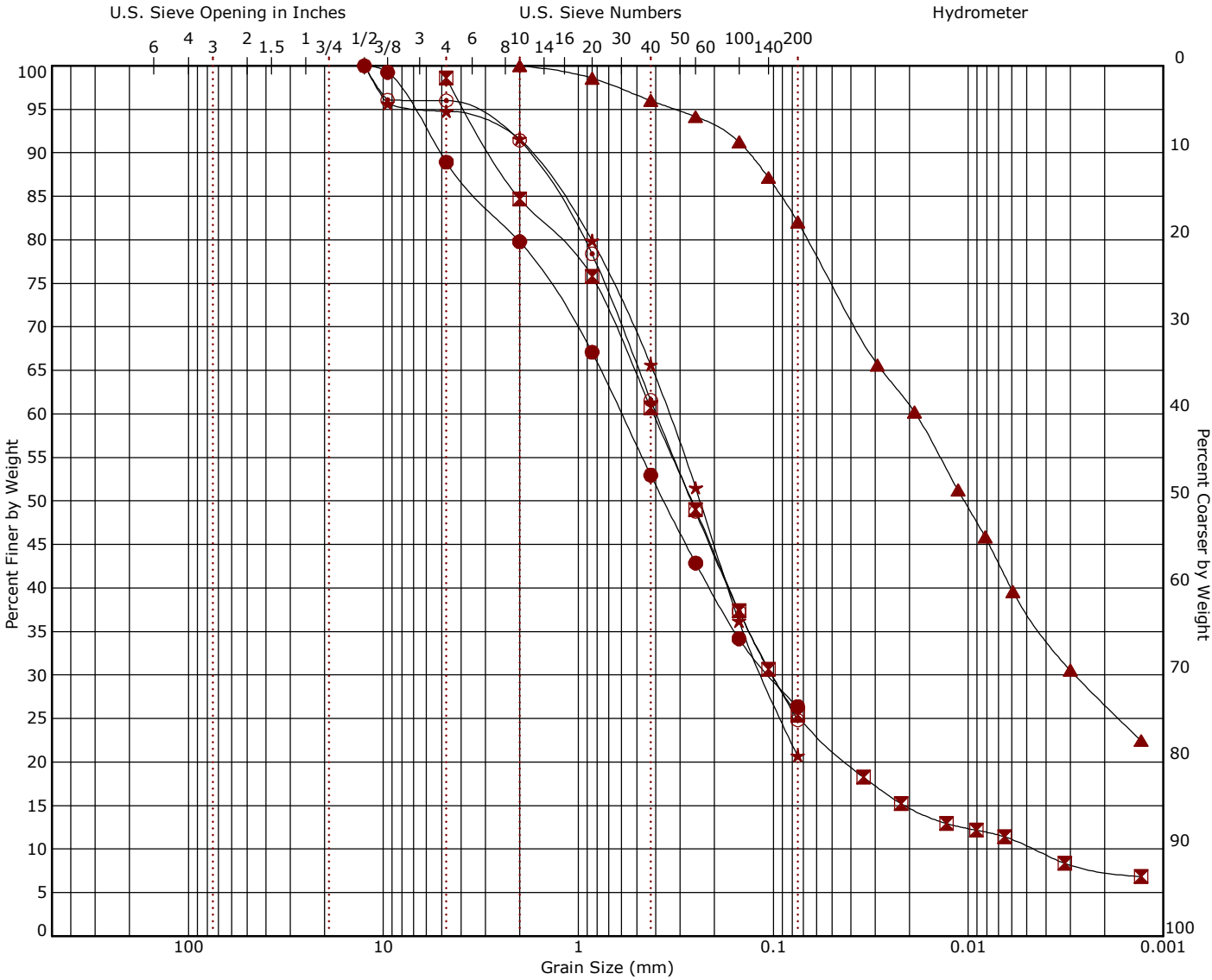
Atterberg Limit Results

ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	AASHTO	Description
●	S-23-40-1 Overflow	6 - 8	30	21	9	26.4	A-2-4 (0)	CLAYEY SAND
■	S-23-40-1 Overflow	13.5 - 15	44	31	13	82.1	A-7-5 (12)	SILT with SAND
▲	S-23-40-2 Overflow	8 - 10	34	28	6	27.1	A-2-4 (0)	SILTY SAND with GRAVEL
★	S-23-40-2 Overflow	13.5 - 15	27	25	2	50.2	A-4 (0)	SANDY SILT
⊙	S-23-40-1/2 Overflow Offset	0 - 5	30	20	10	26.3	A-2-4 (0)	CLAYEY SAND

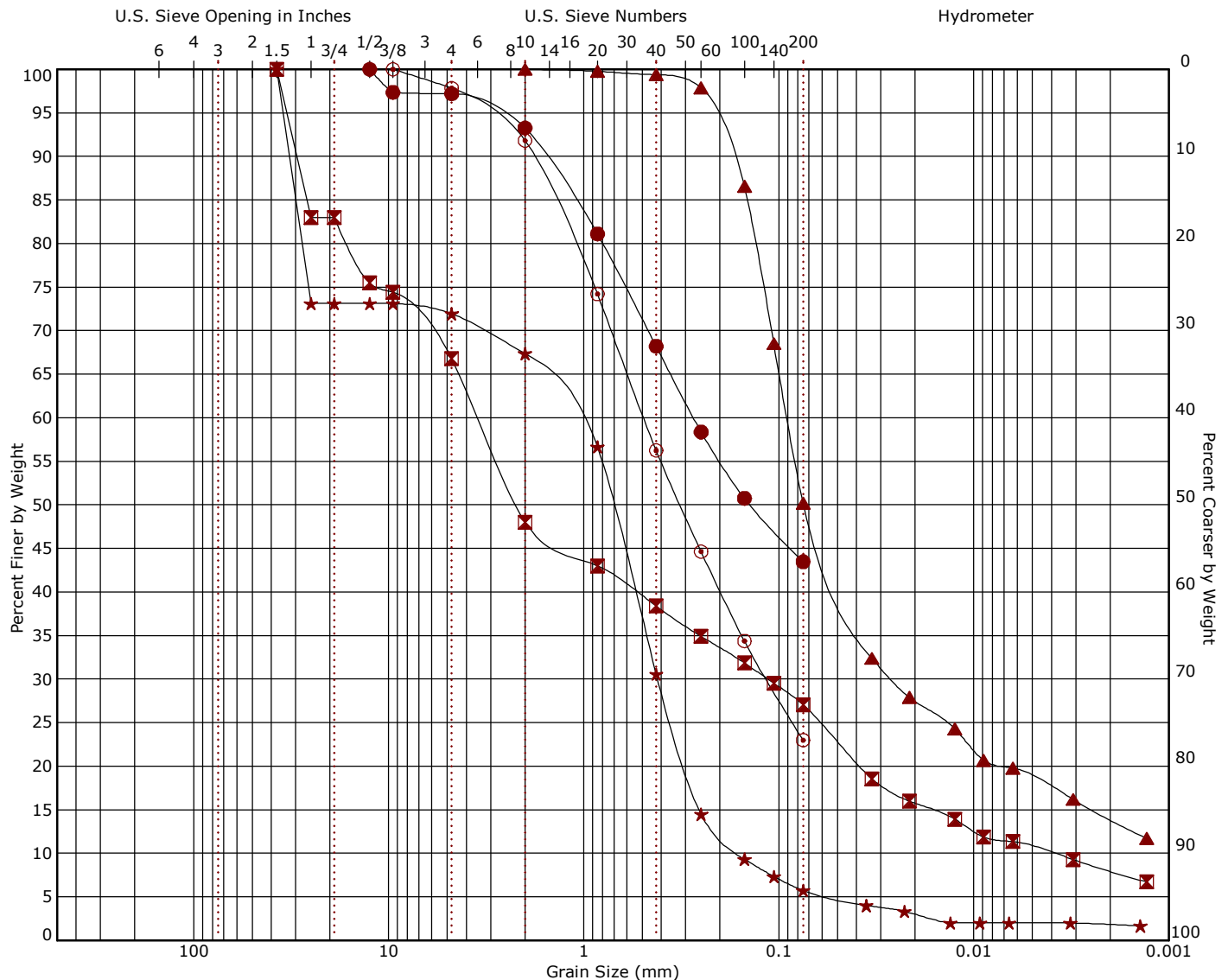
Grain Size Distribution
ASTM D422 / ASTM C136













		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-23-40-1 Overflow	6 - 8	CLAYEY SAND				SC	A-2-4 (0)	30	21	9		
☒	S-23-40-1 Overflow	8 - 10	SILTY SAND				SM	A-2-4 (0)				5.35	88.08
▲	S-23-40-1 Overflow	13.5 - 15	SILT with SAND				ML	A-7-5 (12)	44	31	13		
★	S-23-40-1 Overflow	23.5 - 25	SILTY SAND				SM	A-2-4 (0)					
◎	S-23-40-1 Overflow	28.5 - 30	SILTY SAND				SM	A-2-4 (0)					
Boring ID		Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay	
●	S-23-40-1 Overflow	6 - 8	12.5	0.6	0.104		0.0	11.1	62.6	26.4			
☒	S-23-40-1 Overflow	8 - 10	4.75	0.412	0.102	0.005			73.2		15.1	10.3	
▲	S-23-40-1 Overflow	13.5 - 15	2	0.019	0.003		0.0	0.0	17.9		44.7	37.4	
★	S-23-40-1 Overflow	23.5 - 25	12.5	0.344	0.114		0.0	5.2	74.0	20.7			
◎	S-23-40-1 Overflow	28.5 - 30	12.5	0.398	0.1		0.0	4.0	71.2	24.8			

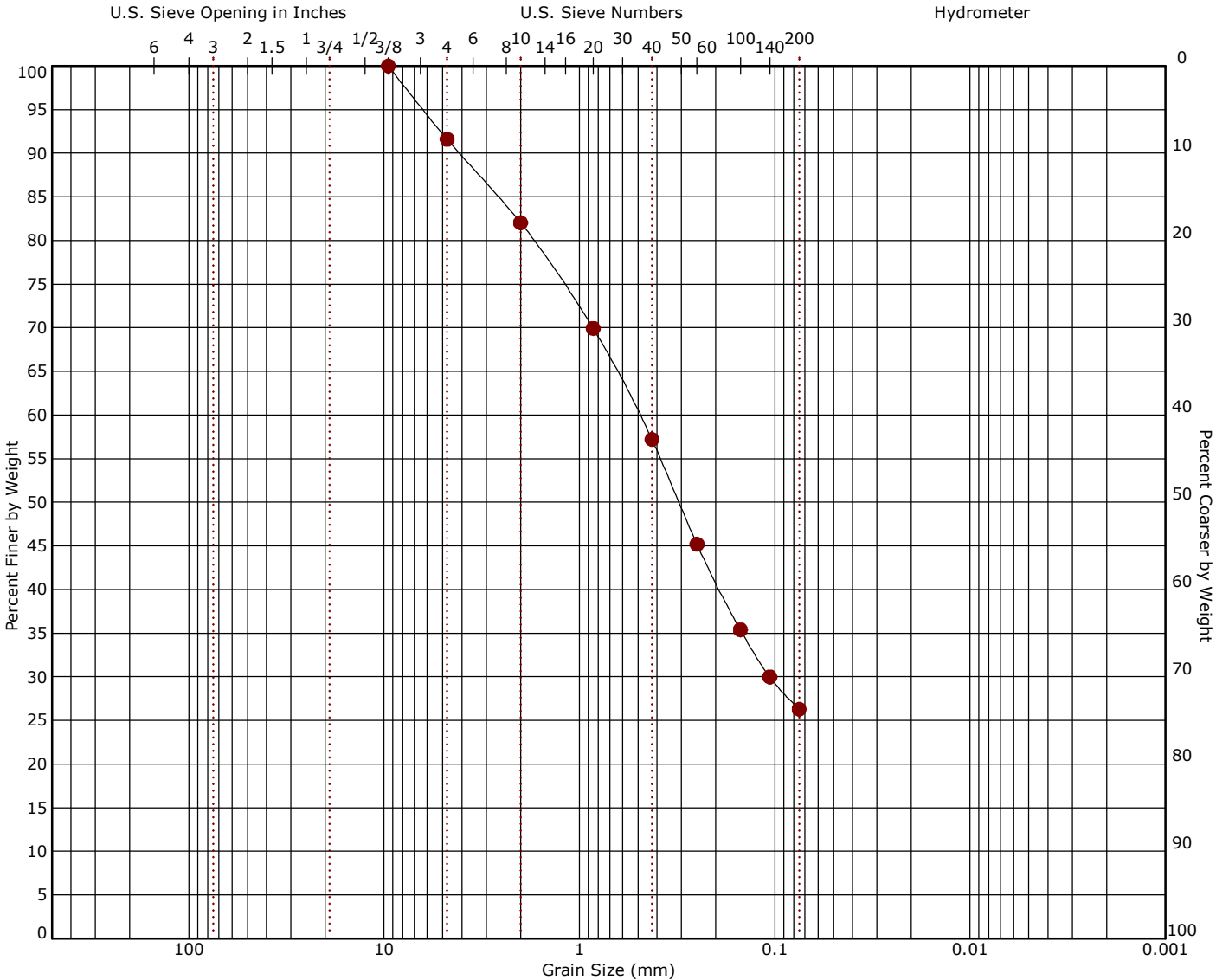
Grain Size Distribution

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-23-40-2 Overflow	4 - 6	SILTY SAND			SM	A-4 (0)					
 S-23-40-2 Overflow	8 - 10	SILTY SAND with GRAVEL			SM	A-2-4 (0)	34	28	6	0.94	875.82
 S-23-40-2 Overflow	13.5 - 15	SANDY SILT			ML	A-4 (0)	27	25	2		
 S-23-40-2 Overflow	18.5 - 20	POORLY GRADED SAND with SILT and GRAVEL			SP-SM	A-1-b (0)				0.98	6.92
 S-23-40-2 Overflow	33.5 - 35	SILTY SAND			SM	A-2-4 (0)					
Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
 S-23-40-2 Overflow	4 - 6	12.5	0.273			0.0	2.8	53.7	43.5		
 S-23-40-2 Overflow	8 - 10	37.5	3.474	0.114	0.004	0.0	33.2	39.7		16.4	10.7
 S-23-40-2 Overflow	13.5 - 15	2	0.09	0.026		0.0	0.0	49.8		31.6	18.6
 S-23-40-2 Overflow	18.5 - 20	37.5	1.109	0.417	0.16	0.0	28.1	66.2		3.7	2.0
 S-23-40-2 Overflow	33.5 - 35	9.5	0.491	0.115		0.0	2.2	74.8	23.0		

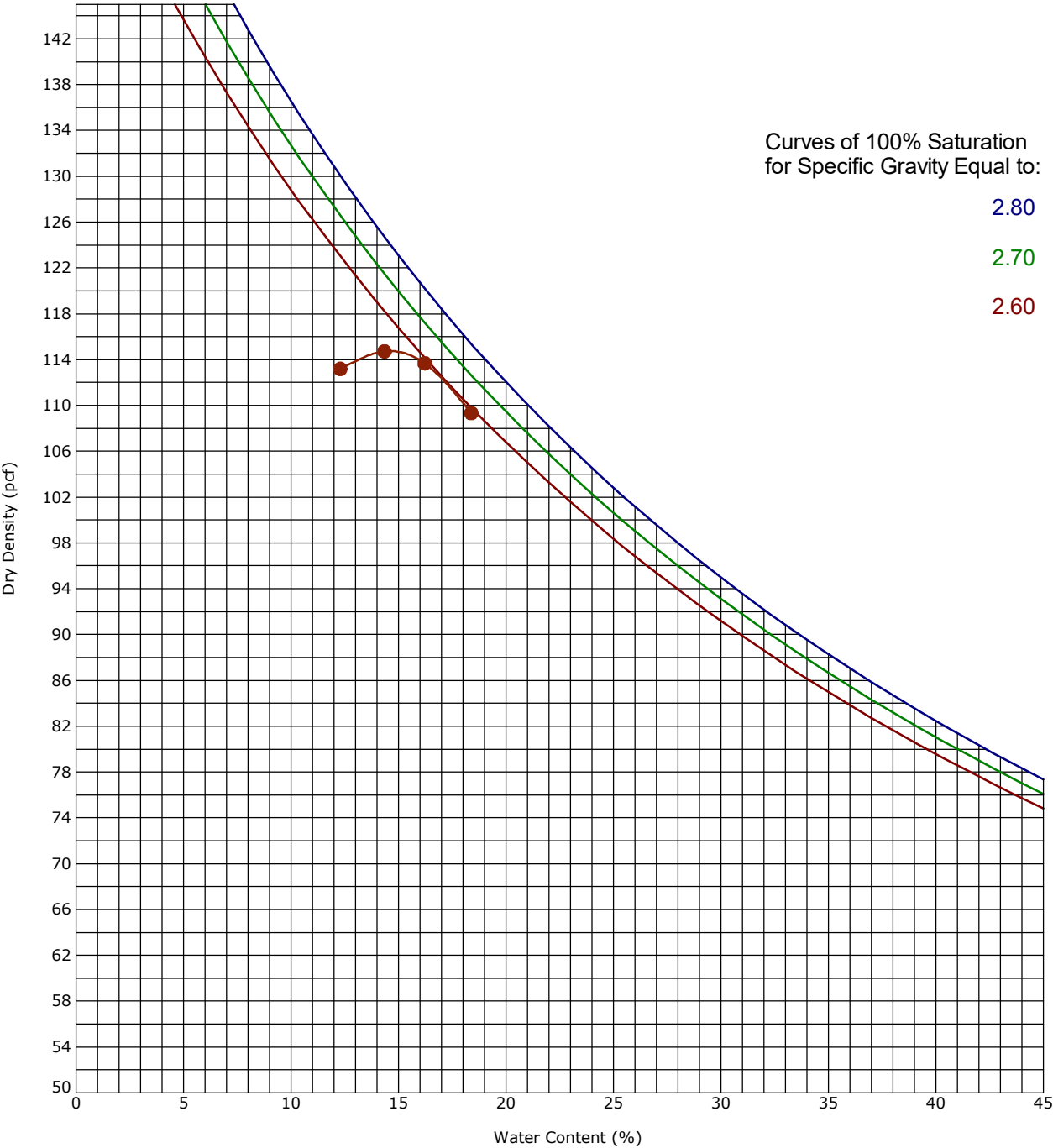
Grain Size Distribution
ASTM D422 / ASTM C136



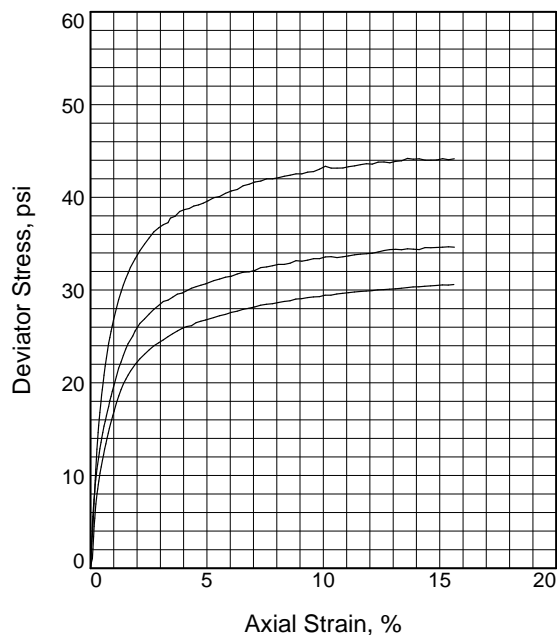
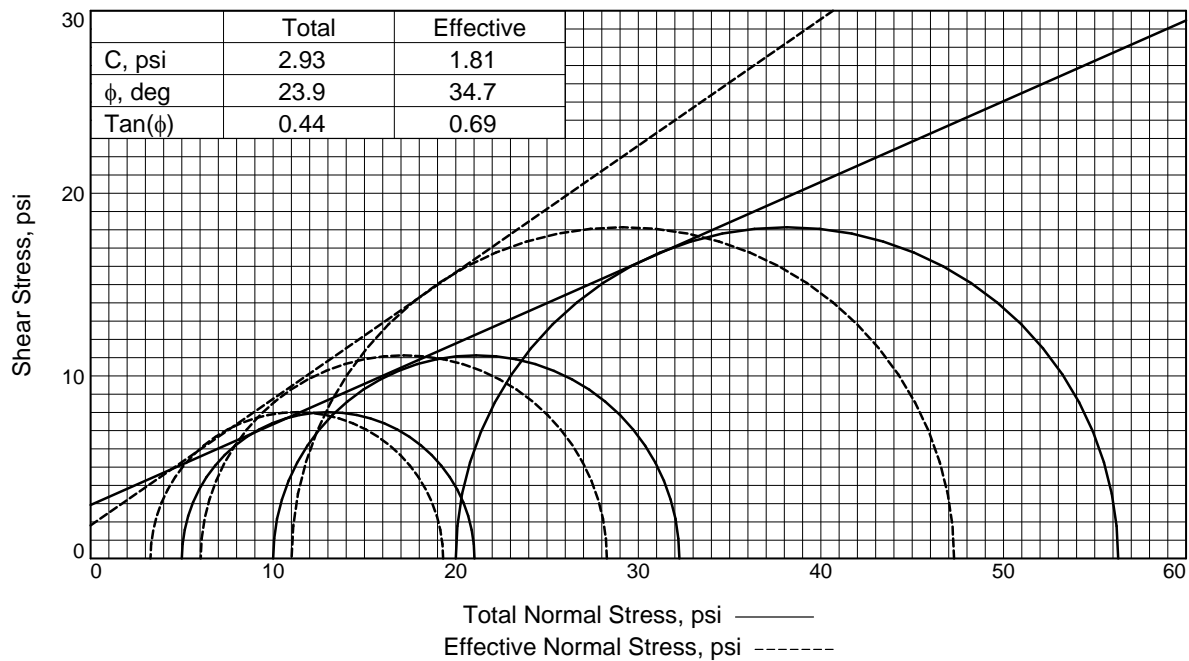
Cobbles		Gravel		Sand			Silt or Clay				
		coarse	fine	coarse	medium	fine					
Boring ID	Depth (Ft)	USCS Classification			USCS	AASHTO	LL	PL	PI	Cc	Cu
<div><div></div><div>S-23-40-1/2 Overflow Offset</div></div>	0 - 5	CLAYEY SAND			SC	A-2-4 (0)	30	20	10		
Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
<div><div></div><div>S-23-40-1/2 Overflow Offset</div></div>	0 - 5	9.5	0.495	0.106		0.0	8.4	65.3	26.3		

Moisture-Density Relationship

ASTM D698-Method B



Boring ID		Depth (Ft)		Description of Materials			
S-23-40-1/2 Overflow Offset		0 - 5		CLAYEY SAND(SC)			
Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)
26	0.0	30	20	10	ASTM D698-Method B	114.7	14.6



Sample No.		1	2	3
Initial	Water Content, %	14.4	14.4	14.4
	Dry Density, pcf	109.4	109.6	109.6
	Saturation, %	71.7	72.3	72.0
	Void Ratio	0.5409	0.5376	0.5382
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.62	5.62	5.62
At Test	Water Content, %	18.8	19.1	18.6
	Dry Density, pcf	111.9	111.2	112.2
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5069	0.5152	0.5027
	Diameter, in.	2.77	2.79	2.77
	Height, in.	5.58	5.58	5.58
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		16.0	22.2	36.3
Excess Pore Pr., psi		1.7	4.0	9.0
Ult. Stress, psi		30.5	34.6	44.2
Excess Pore Pr., psi		-4.4	-2.6	5.0
$\bar{\sigma}_1$ Failure, psi		19.3	28.3	47.3
$\bar{\sigma}_3$ Failure, psi		3.3	6.0	11.0

Type of Test:

CU with Pore Pressures

Sample Type: Remolded

Description: Clayey Sand (SC)

LL= 30

PL= 20

PI= 10

Specific Gravity= 2.7

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

Figure _____

Client: HNTB North Carolina PC

Project: S-23-40 BRO South Saluda Overflow

Source of Sample: S-23-40-1/2 Overflow Offset **Depth:** 0-5'

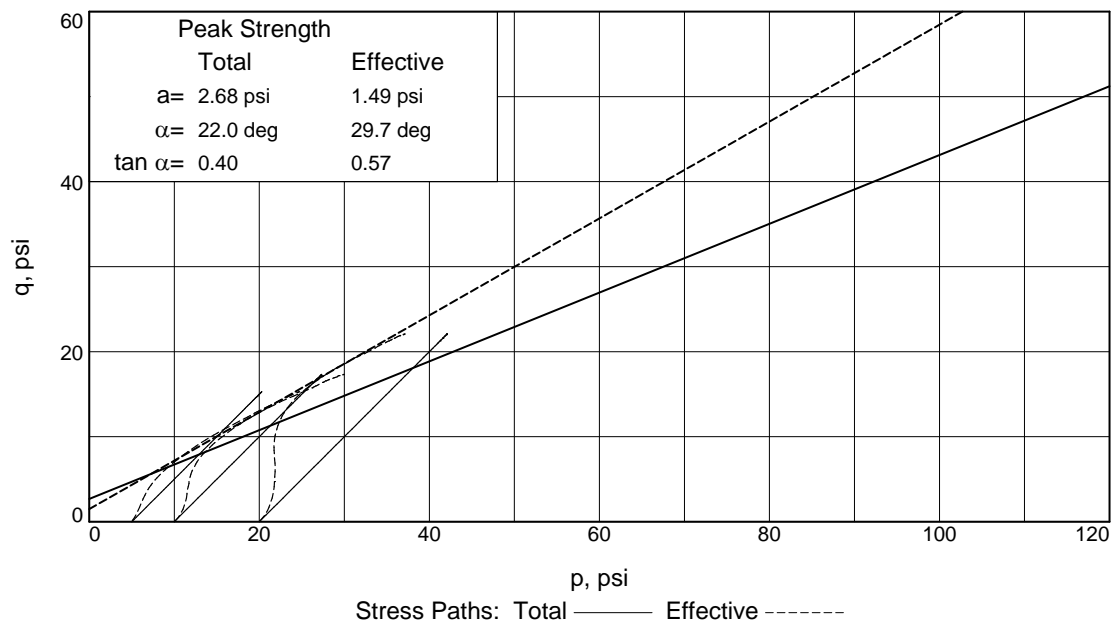
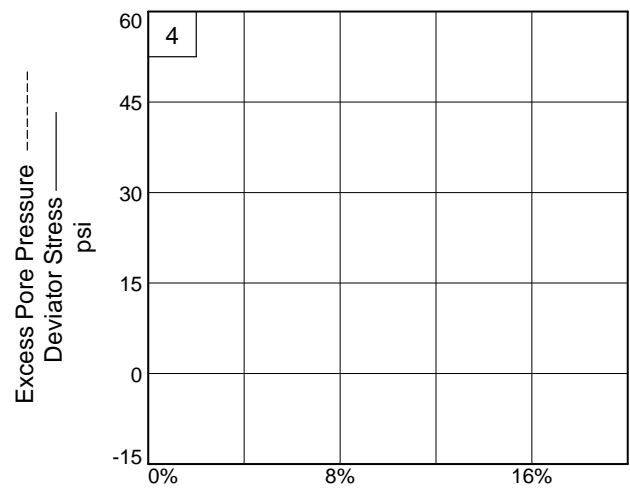
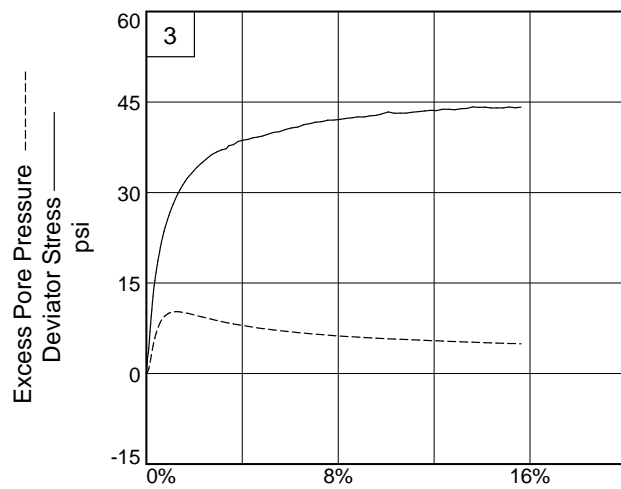
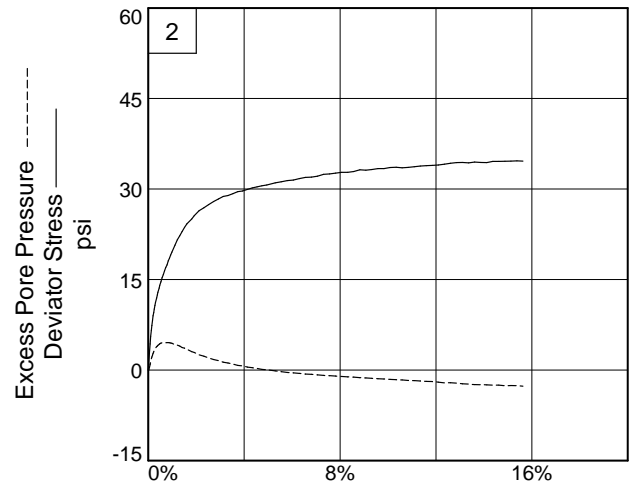
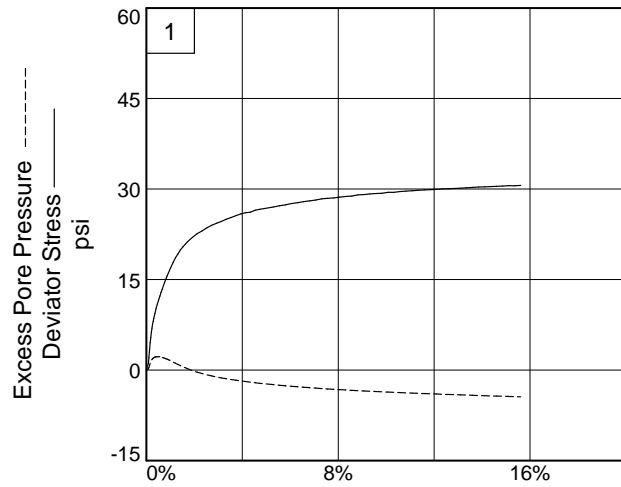
Proj. No.: 8623P180

Date Sampled: N/A

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.

Chattanooga, TN



Client: HNTB North Carolina PC

Project: S-23-40 BRO South Saluda Overflow

Source of Sample: S-23-40-1/2 Overflow 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-23-40 BRO South Saluda Overflow

Sample Submitted By: Terracon (86)

Date Received: 8/29/2024

Lab No.: 24-0289

Results of Corrosion Analysis

Sample Number	S-23-40-1 Overflow
Sample Location	--
Sample Depth (ft.)	2.0-15.0
pH Analysis, AASHTO T289	5.27
Water Soluble Sulfate (SO ₄), AASHTO T290 (mg/kg)	61
Chlorides, AASHTO T291, (mg/kg)	79
Saturated Minimum Resistivity, AASHTO T288, (ohm-cm)	8710

Analyzed By _____

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

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.

Appendix C – Supporting Documents

S-23-40 BRO South Saluda River Overflow | Greenville County, SC
Terracon Project No. 8623P180 | SCDOT Project ID: P043137



Appendix C

Supporting Documents

Rig Calibration Report – DR#1327 (8 Pages)

Note: All exhibits are one page unless noted above.

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

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

Facilities | Environmental | Geotechnical | Materials |



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	ASTM D1586, Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils ASTM D4633-16, Standard Method for Energy Measurement for Dynamic Penetrometers
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

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 Inc.	2 nd Inc.	3 rd Inc.	4 th 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	
1. Depth from existing ground surface to start of SPT 2. Total rod length from instrumentation to bottom of sampler 3. Two-foot section is instrumented and is located at top of drill rods 4. Soil type visually classified by Terracon												

- 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

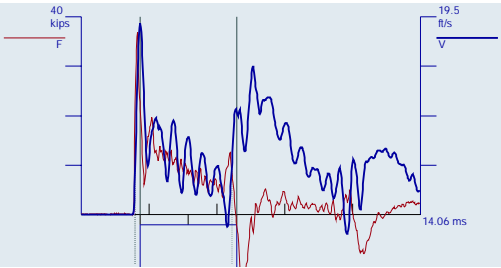
1. Boring ID and depth from existing ground surface to start of SPT.
2. Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
3. BPM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



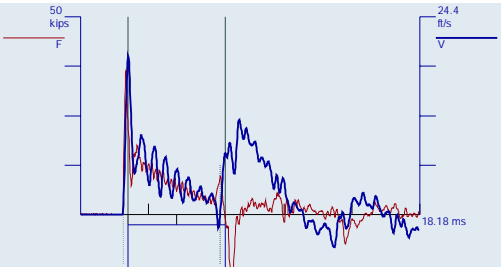
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CSX 32.1 ksi
DMX 1.11 in
EFV 331 ft-lb
ETR 94.7 %
BPM 53.8 bpm
RAT 1.0
VMX 18.9 ft/s
FMX 37 kips
DFN 1.00 in
MEX 1070 µE
AMX 3001 g/s
FVP 0.6
LE 33.70 ft
AR 1.15 in²
EM 30000 ksi
SP 0.492 k/ft³
WS 16807.9 ft/s
WC 16766.2 ft/s
JC 0.90
JF 1.00

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

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

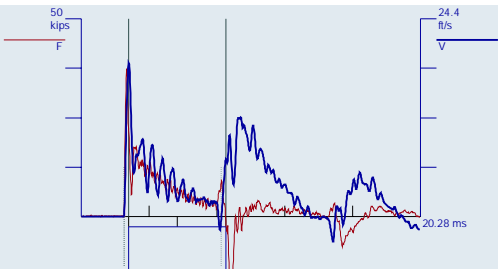
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Version: 2022.35.2



BN 25
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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 in²
EM 30000 ksi
SP 0.492 k/ft³
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

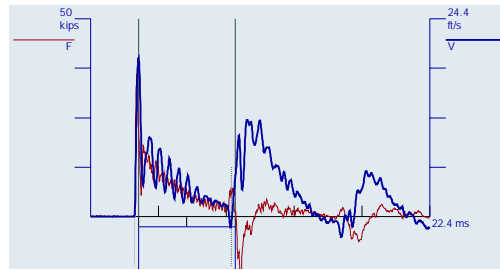


BN 14
 05Sep2024 10:32:57 AM

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 in²
 EM 30000 ksi
 SP 0.492 k/ft³
 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 mm/6.4v/5000g (1) VF1
 A4 (PR): [K14006] 375.226 mm/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 in²
 EM 30000 ksi
 SP 0.492 k/ft³
 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 mm/6.4v/5000g (1) VF1
 A4 (PR): [K14006] 375.226 mm/6.4v/5000g (1) VF1



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



Exhibit B

SPT Analyzer Literature and Equipment Calibrations

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.

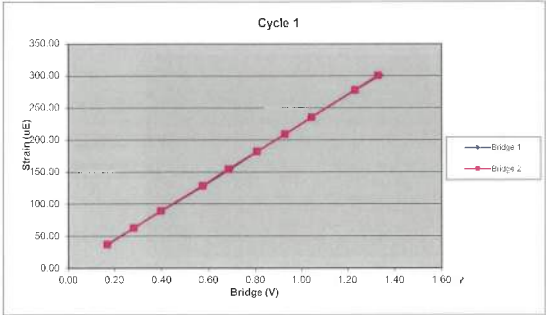
www.pile.com | +1 (216) 831-6131 | info@pile.com



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	7067.05	208.93	0.93	0.93
9	7958.18	235.42	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	-0.83
Correlation	0.999989	Correlation	0.999992

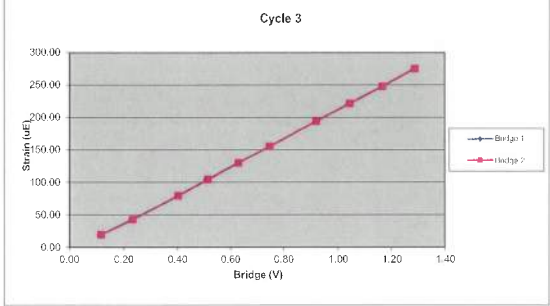
Force Strain Calibration	
EA (Kips)	33651.50
Offset	33.98
Correlation	0.999994



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

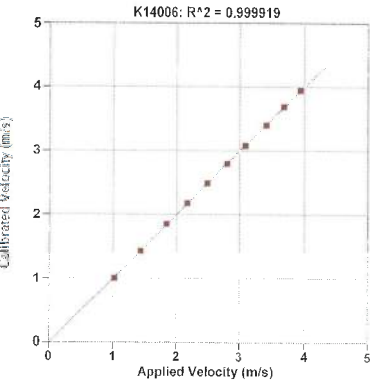
PDA CALIBRATION FACTOR
375.2 mv/5000g
(75.0 μ v/g)
R²: 0.999919 [Chip programmed]

Operator: 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).



Version 2020 09 11 16:42:17

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

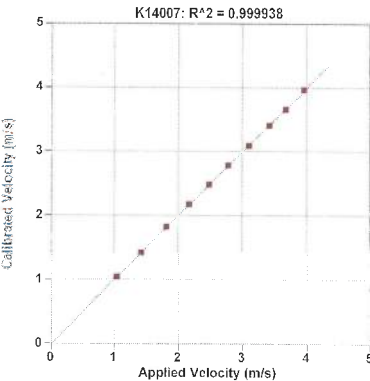
PDA CALIBRATION FACTOR
407.2 mv/5000g
(81.4 μ v/g)
R²: 0.999938 [Chip programmed]

Operator: 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

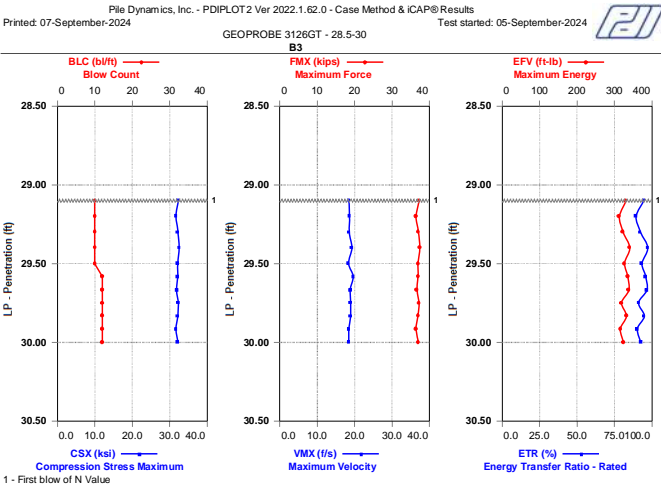
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).



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Exhibit C
SPT Analyzer Results



Case Method & iCAP® Results

GEOPROBE 3126GT - 28.5-30

B3

Date: 05-September-2024

OP: RW
AR: 1.15 in²
LE: 33.70 ft
WS: 16.807 g f/s
SP: 0.492 klf/ft
EM: 30,000 ksi
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

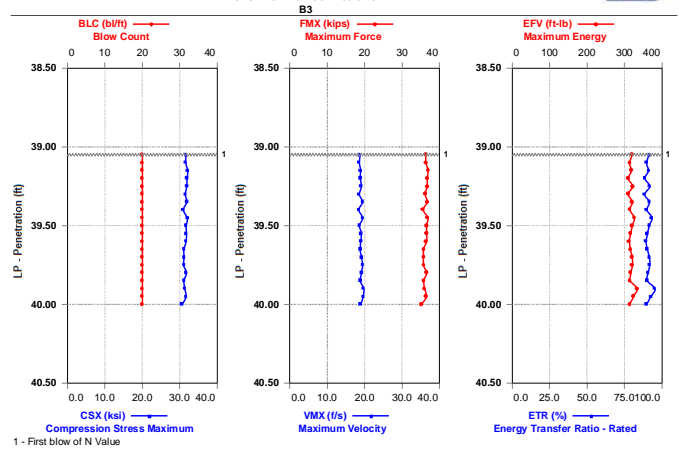
5-15 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 38.5-40

B3

Date: 05-September-2024

OP: RW
AR: 1.15 in²
LE: 43.70 ft
WS: 16.807 g f/s
SP: 0.492 klf/ft
EM: 30,000 ksi
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

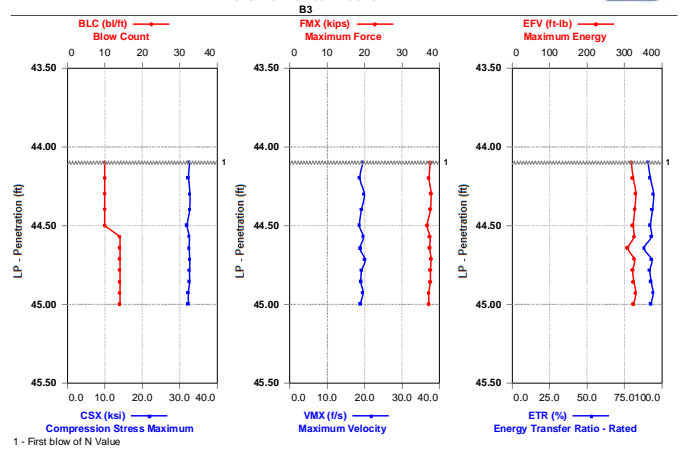
7-26 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);
A4: [K14006] 375.2 (1.00)

BL# Comments

7 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 43.5-45

B3

Date: 05-September-2024

OP: RW
AR: 1.15 in²
LE: 48.70 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
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	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	0.85	32.5
Std. Dev.		0	0.5	5.5	5.5	1.6	0.1	0.15	0.17	0.2	0.2
Maximum		38	20.1	330.1	330.1	94.3	53.6	1.30	1.20	0.86	32.8
Minimum		37	18.6	309.1	309.1	88.3	53.2	0.89	0.85	0.85	32.0

Total number of blows analyzed: 12

BL# Sensors

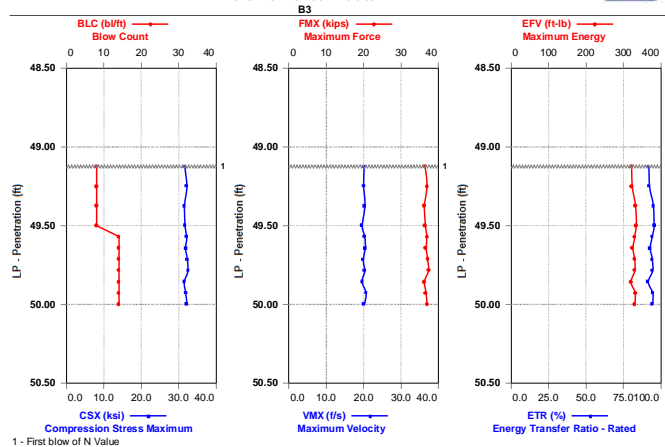
5-16 F1: [746AWJ1] 222.1 (1.00); F2: [746AWJ2] 222.2 (1.00); A3: [K14007] 407.2 (1.00);
A4: [K14006] 375.2 (1.00)

BL# Comments

5 First blow of N Value

Time Summary

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



Case Method & iCAP® Results

GEOPROBE 3126GT - 48.5-50

B3

Date: 05-September-2024

OP: RW
AR: 1.15 in²
LE: 53.70 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
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	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	0.86	31.9
Std. Dev.		0	0.3	4.5	4.5	1.3	0.2	0.36	0.31	0.3	0.3
Maximum		37	20.7	334.0	334.0	95.4	53.8	1.81	1.50	0.86	32.4
Minimum		36	19.6	319.8	319.8	91.4	53.1	0.87	0.86	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 Calibration Agency Site
BORING NO.: 8-3
CLIENT:

ARRIVAL TIME:
DEPART TIME:
TOTAL TRAVEL:
TOTAL TIME:
CLIENT REP:
MILEAGE:

DATE: 9/5/24
TERRACON REP: WJ
PDA MODEL/SN: SPT 412 TR
TERRACON RIG #: 1327

DRILL RIG DATA

Type/Transport: Truck
Manufacturer: GOMME
Model No.: 3126 GS
Serial No.: 712654224106
Year Built: 2024
Modifications: N/A
Maint. Schedule: 50 hrs

SPT HAMMER DATA

Type: 410
Manufacturer: GOMME
Lifting Mechanism: Chain
Model No.: 40431
Serial No.: 10001
Hammer Weight: 140
Hammer Operator(s): B. R. MEAT

PDA INPUT DATA

Operator: OP (W)
Project No./Location: 7324515/
Rig Mode & SN: PN 60000/3126 GS
Hammer Type, LM, Rods: PD 4120/4WJ
Drill Rod Area (in²): AR 1.15

Elastic Modulus (ksi): EM 3000
Specific Weight (kip/ft³): SP 0.492
Wave Speed (ft/sec): WS 16808
Increment Length (ft): LI 0.5
Sampling Freq. (kHz): FR 50

TRANSducer INFORMATION

Gage SN Calibration
F1/F3: 746 AWJ1 222.05
F2/F4: 746 AWJ2 222.19
A1/A3: K14002 407.23
A2/A4: K14006 375.23

NOTES: 286.25 + 1.875
34.56 + 25 + 10.5 = 28.74

SPLIT SPOON SAMPLER LENGTH 38' + 0.88' = 38.88'
'LE is Measured from the Center of the Strain Gages to the bottom of Split Spoon Sampler

SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		Rods & Lengths	PDA Blows		SPT Blows			
			Start	End		Start	End	1st 6"	2nd 6"	3rd 6"	4th 6"
9:55	CL		27.5	28.5	5'x5	1	30	5	10	4	24
10:05	SP		28.5	30	5'x6	3	18	4	5	6	11
10:10	CL		33.5	35	5'x7	1	18	8	0	0	0
10:15	SP		38.5	40	5'x8	3	30	7	10	10	20
10:25	SP		43.5	45	5'x9	1	18	4	5	2	12
10:35	SP		48.5	50	5'x10	1	17	4	4	2	11
10:50	SC		53.5	55	5'x11	1	6	2	1	2	3
11:10	SC		58.5	60	5'x12	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

Exhibit E

Copy of Certificate of Proficiency



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, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2005



This documents that
Ryan Wakeford
Terracon Consultants, Inc.
has on March 15, 2019 achieved the rank of
INTERMEDIATE

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

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

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

Frank T. Peters, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2898