

S-26-31 (Red Bluff Road) Bridge Replacement over Tod Swamp

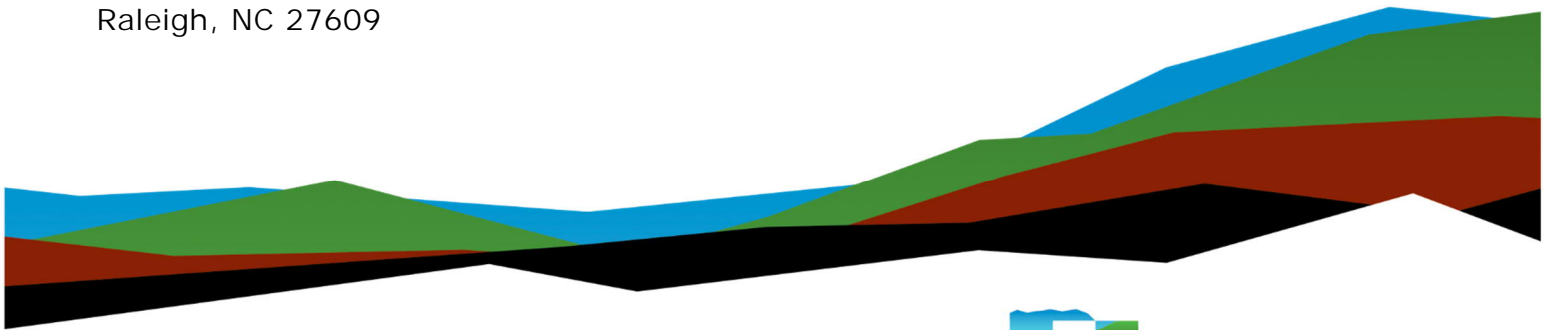
Horry County, SC

Geotechnical Subsurface Data Report

May 7, 2024 | SCDOT Project ID: P041157
Terracon Project No.: ER23P202- Rev1

Prepared for:

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



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

- Facilities
- Environmental
- Geotechnical
- Materials



1246 Howard Avenue
Myrtle Beach, SC
P (843) 286 - 2500
Terracon.com

May 7, 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-26-31 Bridge Replacement over Tod Swamp
Horry County, South Carolina
SCDOT Project ID.: P041157
Terracon Project No.: ER23P202-Rev 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 Task Order Number 001, dated May 25, 2023.

Introduction

HNTB Corporation (HNTB) has contracted Terracon to perform subsurface exploration, and laboratory testing for the replacement of the S-26-31 bridge over Tod Swamp in Horry County, South Carolina. The proposed bridge intends to replace the existing one. This GSDR was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM).

Project Description

The project site is located on the S-26-31 (Red Bluff Road) crossing over Tod Swamp in Horry County, South Carolina. Site location and exploration plans are presented in Appendix A of this report. Based on the undated conceptual plans provided by HNTB via e-mail on February 9, 2024, the replacement bridge will be constructed on essentially the same alignment as the current bridge. The existing bridge is a single-span structure and appears to be supported by timber pile foundations.

Geotechnical Testing

The geotechnical field exploration for this project was performed between December 19, 2023 and January 5, 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:

- Two (2) Standard Penetration Test (SPT) Borings (S-26-31-1 and S-26-31-2)
- One (1) offset boring SPT S-26-31-Bulk for bulk sample collection
- One (1) Downhole Shear Wave Velocity Test located in Boring S-26-31-1
- Two (2) Cone Penetration Test soundings (S-26-31-1C and S-26-31-2C)

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 Cox Surveying after completion. Photographs of the drill rig set up at each boring location are provided in Appendix A.

Laboratory Testing

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

- Eleven (11) Natural Moisture Content Tests
- Five (5) Atterberg Limits Tests
- Five (5) 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 Tests (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.



Kara Fugate, P.E.
Senior Engineer
SC Registration No. 41532

Wendy Parsons, P.E.
Geotechnical Department Manager
SC Registration No. 20962

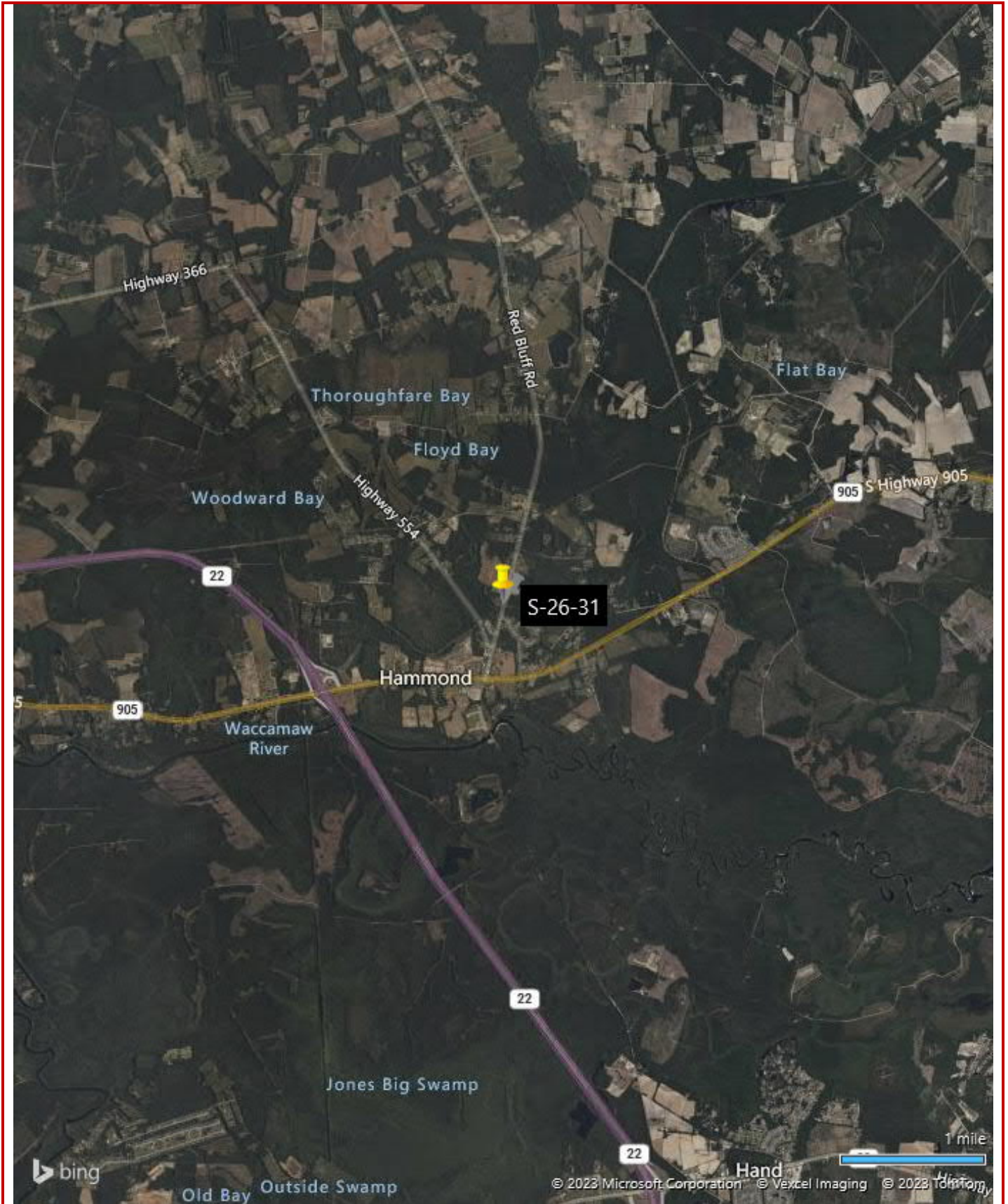
Reviewed by Terracon's Authorized Project Reviewer: Abdul Q. Fekrat, PhD, P.E.

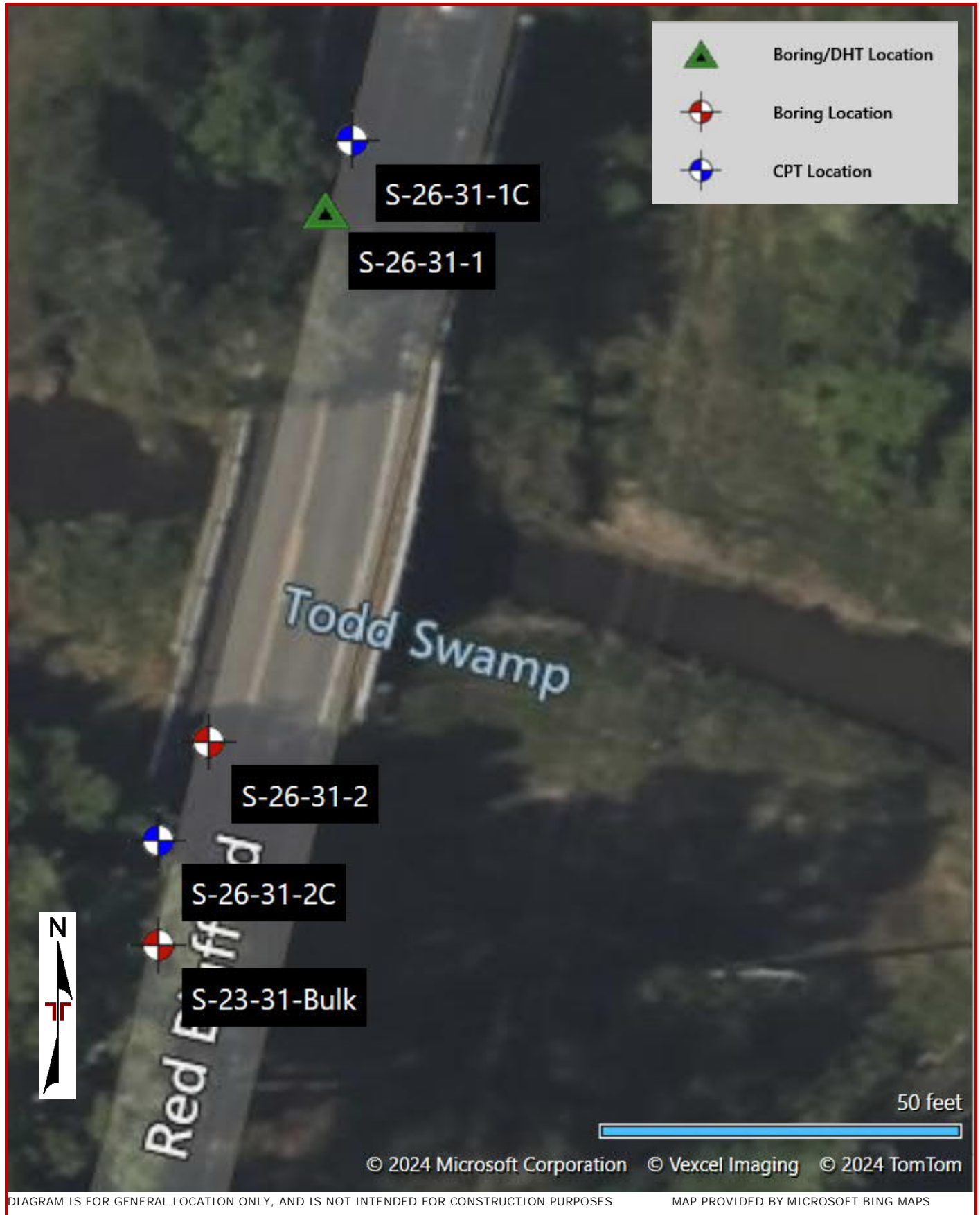
Appendix A

Field Exploration

- Exhibit A-1 – Site Location Map
- Exhibit A-2 – Exploration Plan
- Exhibit A-3 – Summary of Boring Data
- Exhibit A-4 - GeoScoping Form (2 Pages)
- Exhibit A-5 – Field Exploration Description (3 Pages)
- Exhibit A-6 – Soil Description Terms
- Exhibit A-7 – Soil and Rock Symbols
- Exhibit A-8 – Boring and Sounding Logs (11 Pages)
- Exhibit A-9 – Geophysical Testing Results
- Exhibit A-10 – Grout Logs (3 Pages)

Note: All exhibits are one page unless noted above.







Summary of Boring Data

Boring No.	Ground Elevation ft.	Test Depth ft.	Northing	Easting	Latitude	Longitude	Station ¹	Offset ¹
S-26-31-1	23.63	100	3754549.68	699855.61	33.912422	-78.838250	555+85	9.5R
S-26-31-2	23.51	100	3754527.17	699851.09	33.912219	-78.838303	556+65	8.5R
S-26-31-1C	23.58	109	3754552.59	699856.66	33.912448	-78.838238	555+65	9R
S-26-31-2C	23.50	100	3754522.94	699850.16	33.912182	-78.838315	556+75	8.5R
S-26-31-Bulk	23.56	6	3754518.28	699849.14	33.912142	-78.838327	556+85	8R

1. Plans provided after field exploration and surveying. These values are estimated based on overlay in Google Earth^(R).

GeoScoping Form

PROJECT INFORMATION			
Project ID:	P041157	Date of Trip:	12/19-1/4/2024
County:	Horry	Location:	Loris
Rd/ Route:	S-26-31	Local Name:	Red Bluff Road
Attendees:	K. Fugate		

EXISTING BRIDGE INFORMATION			
Bridge Length:	45 ft	Bridge Width:	25 ft
Superstructure Type:	Concrete framing and decking	Substructure Type:	Timber Piles
Begin Bridge Sta ¹ :	556+00	End Bridge Sta ¹ :	556+45
Begin Bridge Embankment Sta ¹ :	555+00	End Bridge Embankment Sta ¹ :	557+45
Structure Number:	06038	Posted Weight Limit:	44 tons
Crossing:	Tod Swamp	Skew:	N/A
Latitude:	33.912308°	Longitude:	-78.838262° Existing
Fill Height:	approx 6 ft	Approx Existing Slope Angle:	2H:1V
1. Begin and End Bridge Embankment 100 feet down station or up station from bridge, respectively. Sta estimated from overlay of bridge			

EXISTING ROADWAY EMBANKMENT INFORMATION			
Begin Project Sta:	551+00	Begin Bridge Embankment Sta:	551+70
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and sand		
Existing Fill Height:	6 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to swamp		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	clays over silts and sands	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	7 to 11 feet	Water Depth:	2 to 5 feet
Depth to Existing Ground:	approximately 13 feet at center of bridge		
Scour Condition at EB:	None Observed	Scour Condition at IB:	None Observed

End Project Sta:	560+40	End Bridge Embankment Sta:	562+00
Accessibility Issues:	None Observed		
Ground Cover:	Asphalt pavement and grassed shoulders		
Existing Fill Height:	6 feet, sloping	Approx Existing Slope Angle:	2H:1V
Local Development:	developed - residential		
Topography:	graded slope to swamp		
Traffic Control Necessary:	Yes, lane closure		
Surface Soils:	clays over silts and sands	Muck:	No
Exposed Rock in Stream Bed:	No	Exposed Rock in banks:	No
Wetlands on Site:	Yes	Wetland Adjacent:	Yes
Depth FG to Water:	7 to 11 feet	Water Depth:	2 to 5 feet
Depth to Existing Ground:	approximately 13 feet at center of bridge		
Scour Condition at EB:	None Observed	Scour Condition at IB:	None Observed

GeoScoping Form

UTILITIES INFORMATION	
Attached:	A PVC pipe was observed to be attached to the bridge deck on the west side of the bridge
Above Ground:	Overhead power was observed on the east side of the road
Underground:	An underground waterline was observed in the west 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 Cox Surveyors 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-26-31-1	100 feet	20 inches to 10 feet
S-26-31-2	100 feet	15 inches to 50 feet
S-26-31-Bulk	6 feet	Bulk Sample
S-26-31-1C	109 feet	CPT - No sampling
S-26-31-2C	100 feet	CPT - No sampling

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.

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.

Cone Penetration Test (CPT) Soundings

Cone Penetration Test soundings were conducted in accordance with ASTM D5778 *Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils*.

Downhole Shear Wave Velocity Test (DHT)

One downhole seismic test was performed in a cased borehole drilled for this project. After the test boring was completed, the boring was filled with a fluid water/cement/bentonite grout and then a threaded PVC pipe casing (capped at the bottom end) was inserted into the borehole, providing a uniform bond between the soil and pipe exterior.

The downhole seismic test consisted of placing two downhole triaxial geophones at selected depth intervals in the borehole casing. The geophone was connected to a recording device (Seismic Source Daq Link 5 Seismograph) at the surface and clamped to the side of the casing at the selected test depth. The geophones are equipped with a spring-arm that is released at the bottom of the boring. The spring expands and forces the geophone against the casing wall. The interval between each geophone and each test depth was 3 feet for the entire depth of the cased borehole. An instrumented hammer was then used to strike a steel plate with cleats at the bottom (often called a shear wave golf shoe) that penetrated the ground and prevented sliding when struck. The steel plate was oriented to generate

horizontal shear waves (SH) at the surface. An additional plate was also struck to better produce compression waves. The horizontal distance was measured and the plate was set exactly 10 feet from the borehole. The recorder was set to record the arrival times of the shear waves at the geophone locations. At least 15 blows (5 in each direction on the golf shoe, and 5 on the steel plate) were struck for each test depth to electronically stack and polarize the observed data, and to increase the signal-to-noise ratio. The data was stored on computer disks for processing and computation. The geophone was raised to the next depth interval and the process was repeated.

Shear Wave Velocity Test Results shows the downhole shear wave velocity and compressive wave velocity test results. The data was evaluated using the Fixed Interval method. S-wave arrival times using the Interval method were picked based on the onset of the signal (first break) as observed in the software package TomTime by GeoTom.

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

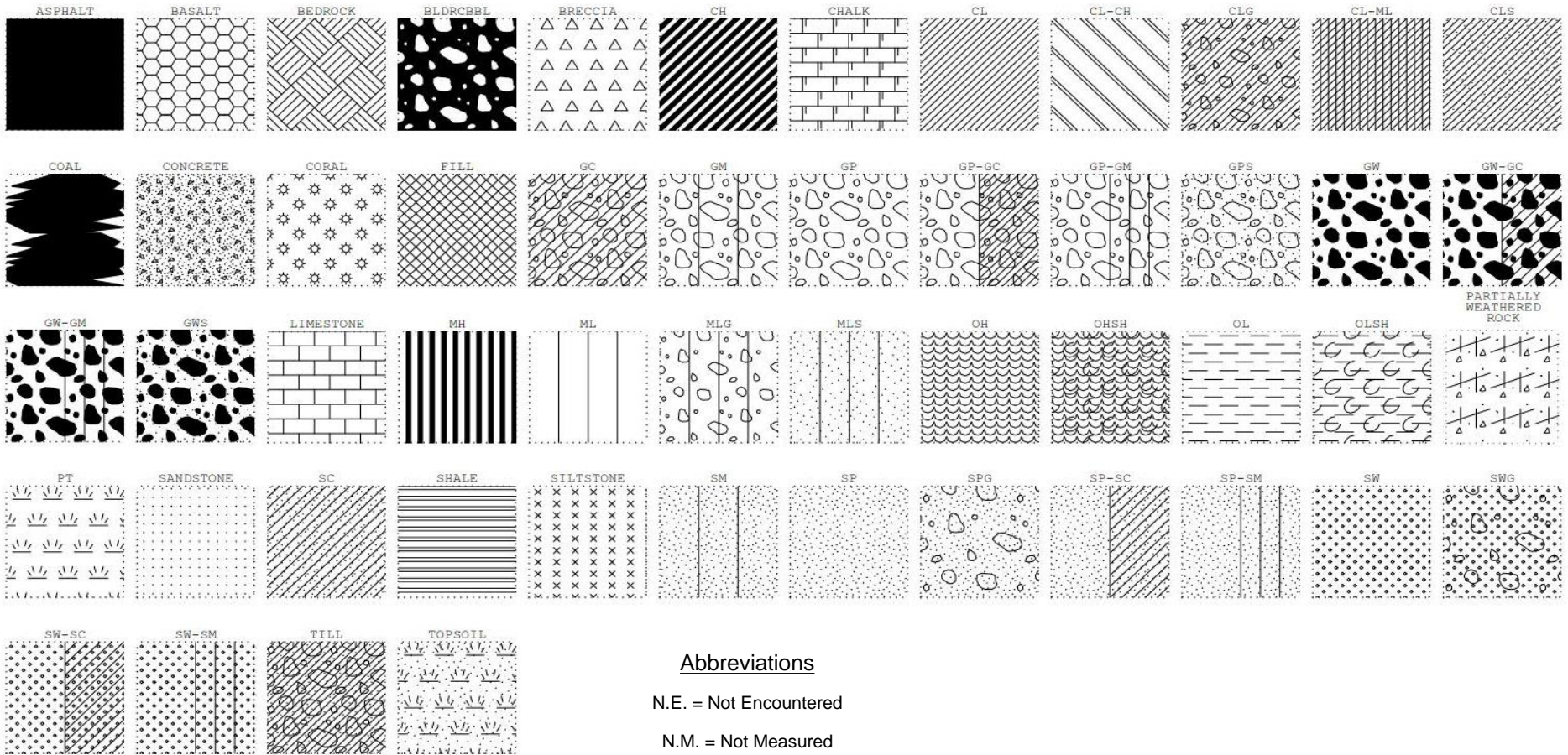
AASHTO Soil Designation

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



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

Project Manager:
KEF
Drawn by:
KEF
Checked by:
WHP
Approved by:
WHP

Project No.
ER23P202
Scale:
N.T.S.
File Name:
Soil - Rock - Log
Date:
Feb 2024

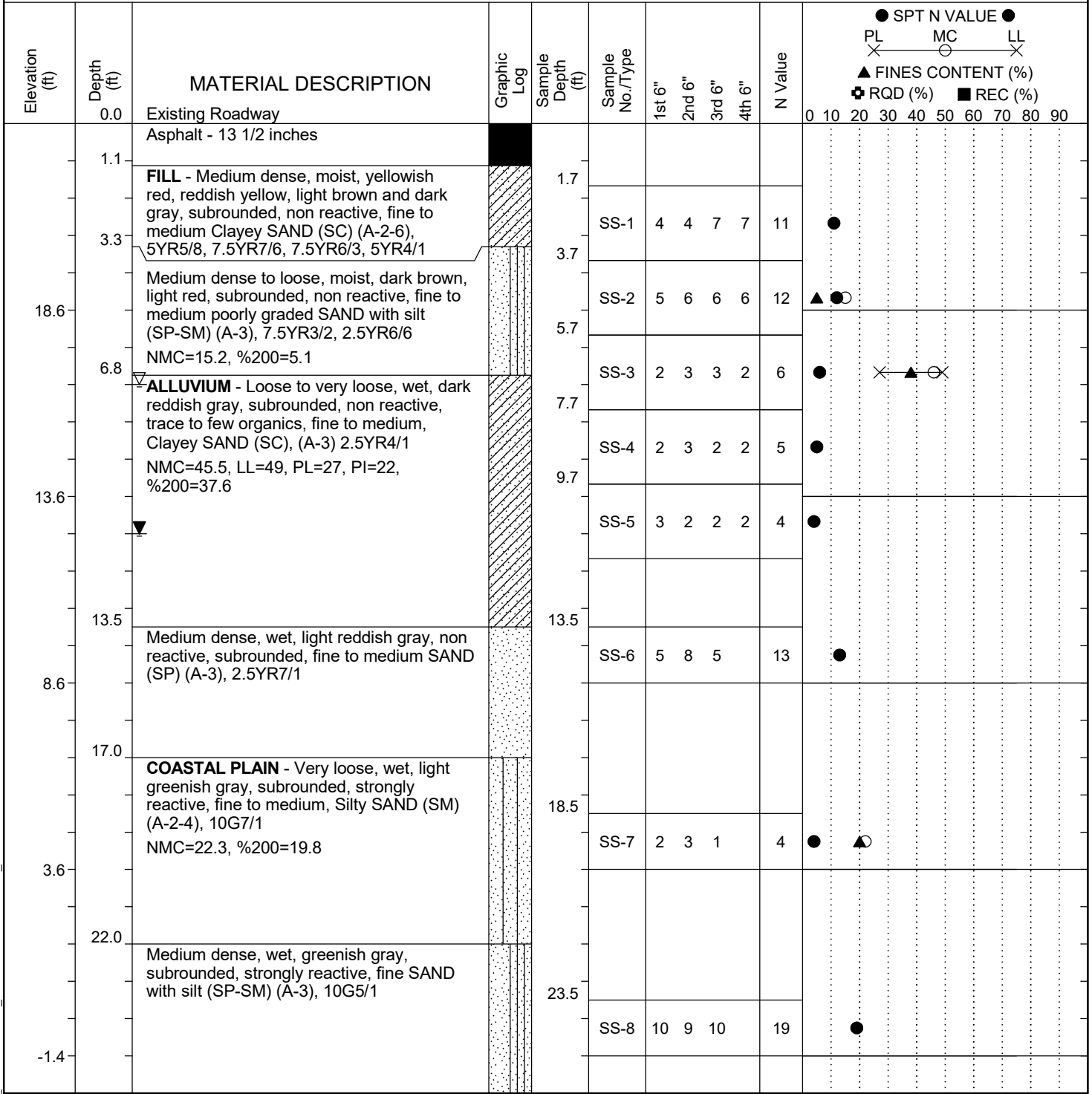


1246 Howard Ave Myrtle Beach, SC 29577
PH. (843) 286-2500

SOIL AND ROCK SYMBOLS

SCDOT Soil Test Log

Project ID: P041157	County: Horry	Boring No.: S-26-31-1
Site Description: S-26-31 BRO Tod Swamp	Route: S-26-31	
Eng./Geo.: K. Fugate	Boring Location: 555+85	Offset: 9.5R
Alignment: Existing		
Elev.: 23.6 ft	Latitude: 33.912422	Longitude: -78.83825
Date Started: 12/18/2023		
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: 0 ft
Date Completed: 12/21/2023		
Bore Hole Diameter (in): 4.5	Sampler Configuration	Liner Required: Y (N)
Liner Used: Y (N)		
Drill Machine: D-50-479	Drill Method: RW	Hammer Type: Automatic
Energy Ratio: 93.9%		
Core Size: N/A	Driller: Chris Costner	Groundwater: TOB 7 ft
		24HR: 11 ft



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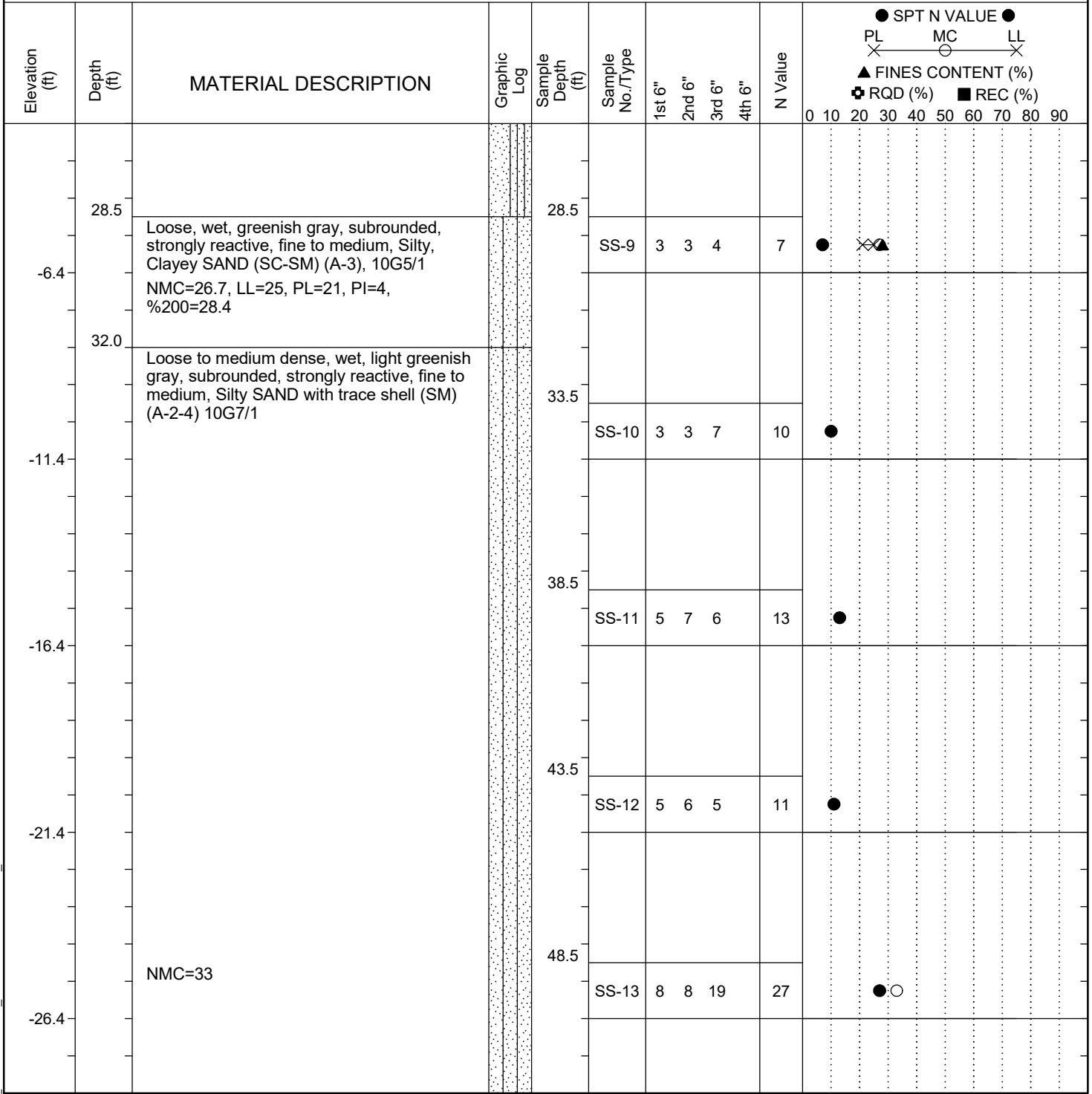
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC.DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT_3/25/24

SCDOT Soil Test Log

Project ID: P041157	County: Horry	Boring No.: S-26-31-1
Site Description: S-26-31 BRO Tod Swamp	Route: S-26-31	
Eng./Geo.: K. Fugate	Boring Location: 555+85	Offset: 9.5R
Alignment: Existing		
Elev.: 23.6 ft	Latitude: 33.912422	Longitude: -78.83825
Date Started: 12/18/2023		
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: 0 ft
Date Completed: 12/21/2023		
Bore Hole Diameter (in): 4.5	Sampler Configuration	Liner Required: Y (N)
Liner Used: Y (N)		
Drill Machine: D-50-479	Drill Method: RW	Hammer Type: Automatic
Energy Ratio: 93.9%		
Core Size: N/A	Driller: Chris Costner	Groundwater: TOB 7 ft
24HR: 11 ft		



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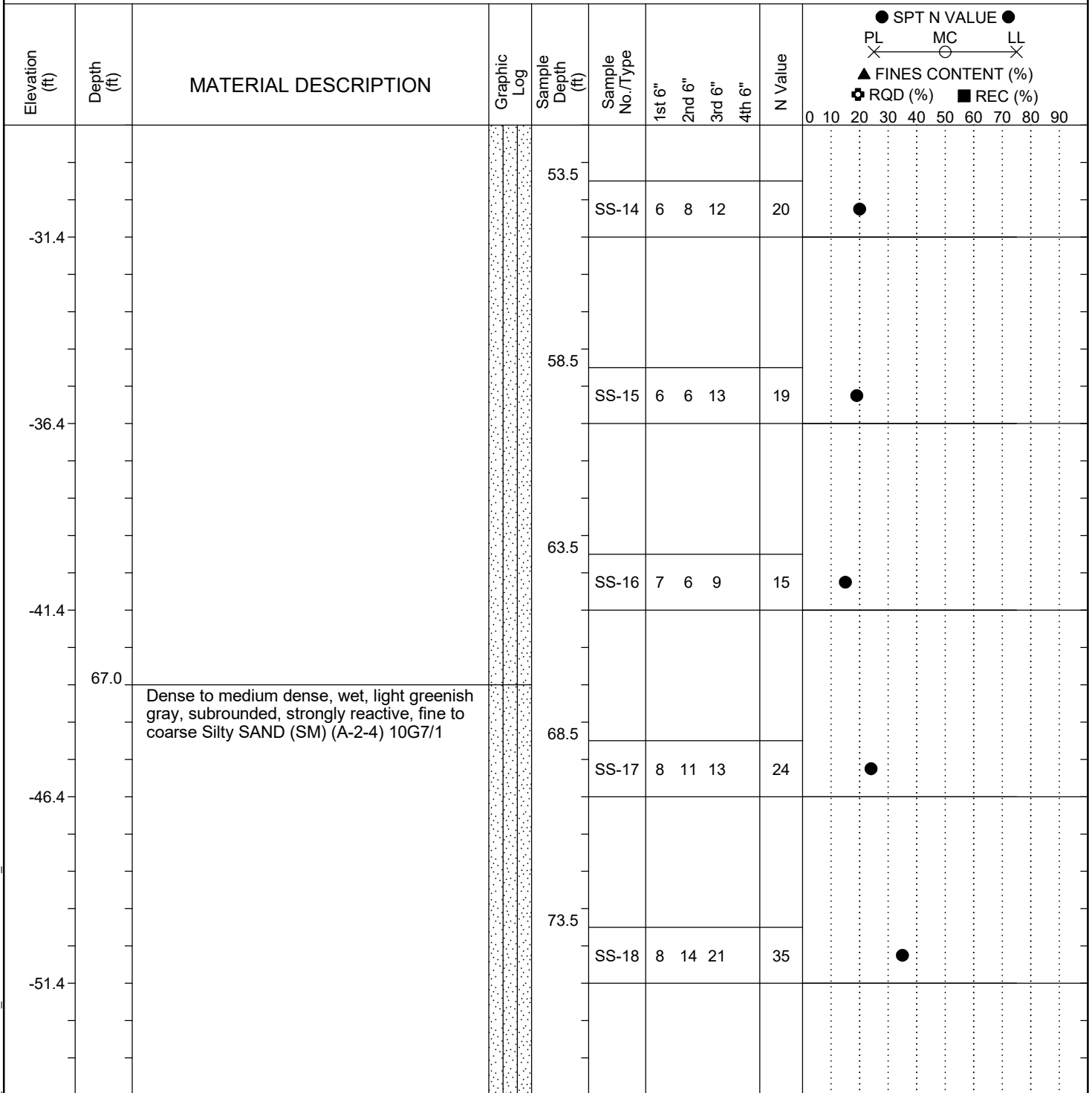
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SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT_3/25/24

SCDOT Soil Test Log

Project ID: P041157			County: Horry			Boring No.: S-26-31-1		
Site Description: S-26-31 BRO Tod Swamp					Route: S-26-31			
Eng./Geo.: K. Fugate		Boring Location: 555+85		Offset: 9.5R		Alignment: Existing		
Elev.: 23.6 ft		Latitude: 33.912422		Longitude: -78.83825		Date Started: 12/18/2023		
Total Depth: 100 ft		Soil Depth: 100 ft		Core Depth: 0 ft		Date Completed: 12/21/2023		
Bore Hole Diameter (in): 4.5		Sampler Configuration			Liner Required: Y (N)		Liner Used: Y (N)	
Drill Machine: D-50-479		Drill Method: RW		Hammer Type: Automatic		Energy Ratio: 93.9%		
Core Size: N/A		Driller: Chris Costner		Groundwater: TOB 7 ft		24HR		11 ft



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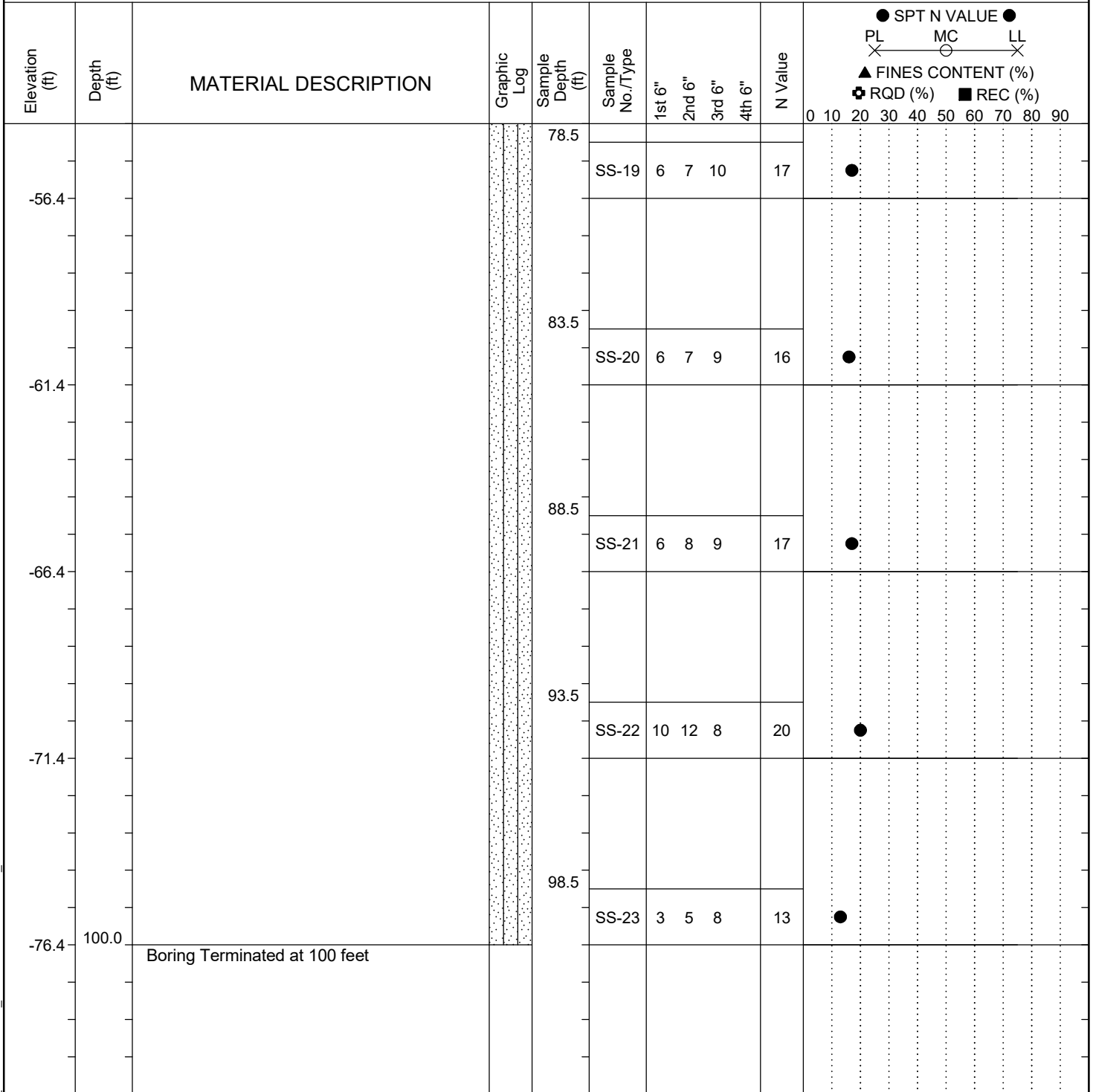
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SC.DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT 3/25/24

SCDOT Soil Test Log

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Eng./Geo.: K. Fugate		Boring Location: 555+85		Offset: 9.5R	Alignment: Existing
Elev.: 23.6 ft	Latitude: 33.912422	Longitude: -78.83825	Date Started: 12/18/2023		
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: 0 ft	Date Completed: 12/21/2023		
Bore Hole Diameter (in): 4.5		Sampler Configuration		Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: D-50-479	Drill Method: RW	Hammer Type: Automatic		Energy Ratio: 93.9%	
Core Size: N/A	Driller: Chris Costner	Groundwater: TOB	7 ft	24HR	11 ft



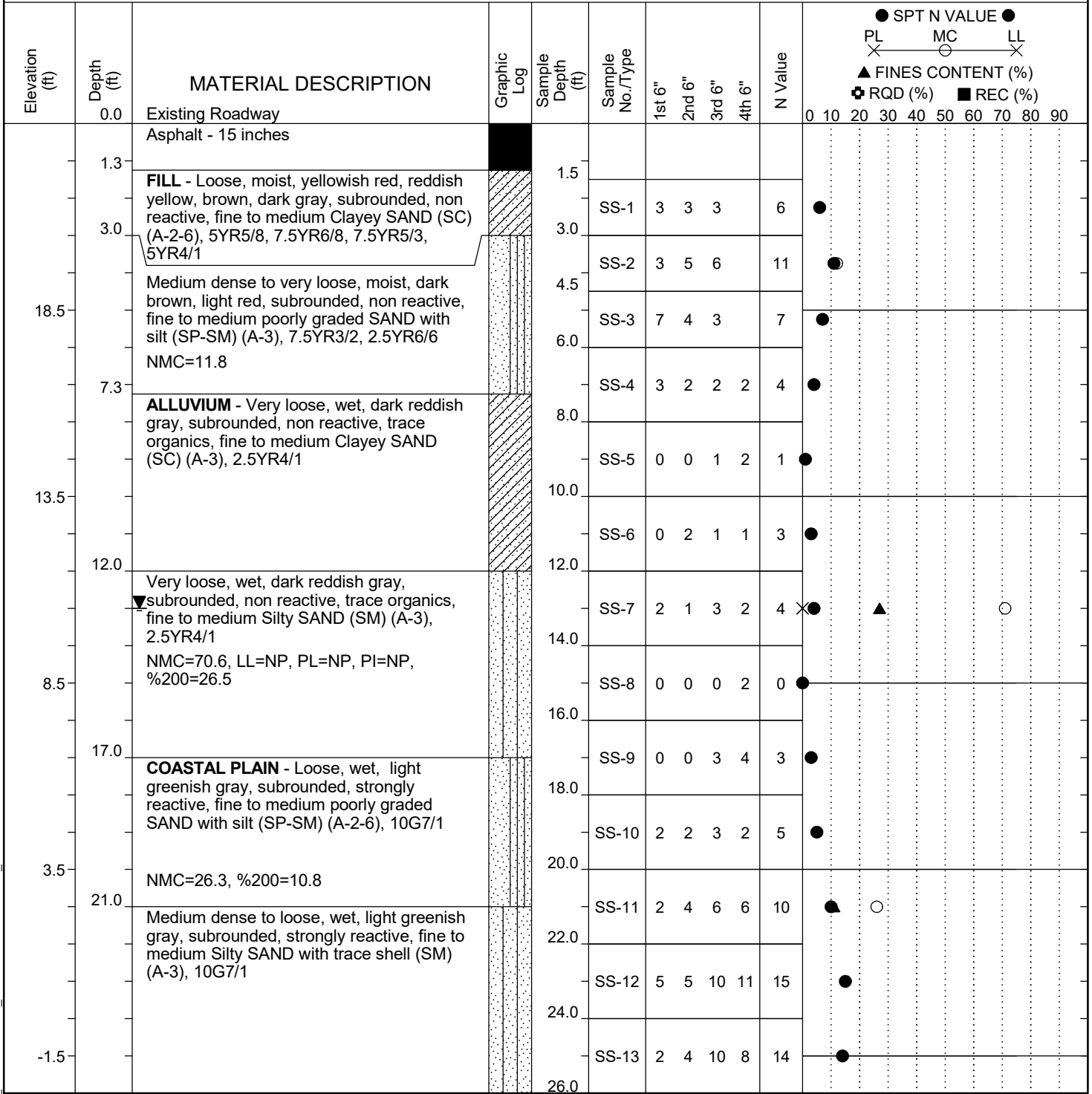
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UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT 3/25/24

SCDOT Soil Test Log

Project ID: P041157		County: Horry		Boring No.: S-26-31-2	
Site Description: S-26-31 BRO Tod Swamp				Route: S-26-31	
Eng./Geo.: K. Fugate		Boring Location: 556+65		Offset: 8.5R	Alignment: Existing
Elev.: 23.5 ft	Latitude: 33.912219	Longitude: -78.838303	Date Started: 01/4/2024		
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: 0 ft	Date Completed: 1/4/2024		
Bore Hole Diameter (in): 4.5		Sampler Configuration		Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: D-50-479	Drill Method: RW	Hammer Type: Automatic		Energy Ratio: 93.9%	
Core Size: N/A	Driller: S. Truesdale	Groundwater: TOB	13 ft	24HR	13 ft



LEGEND

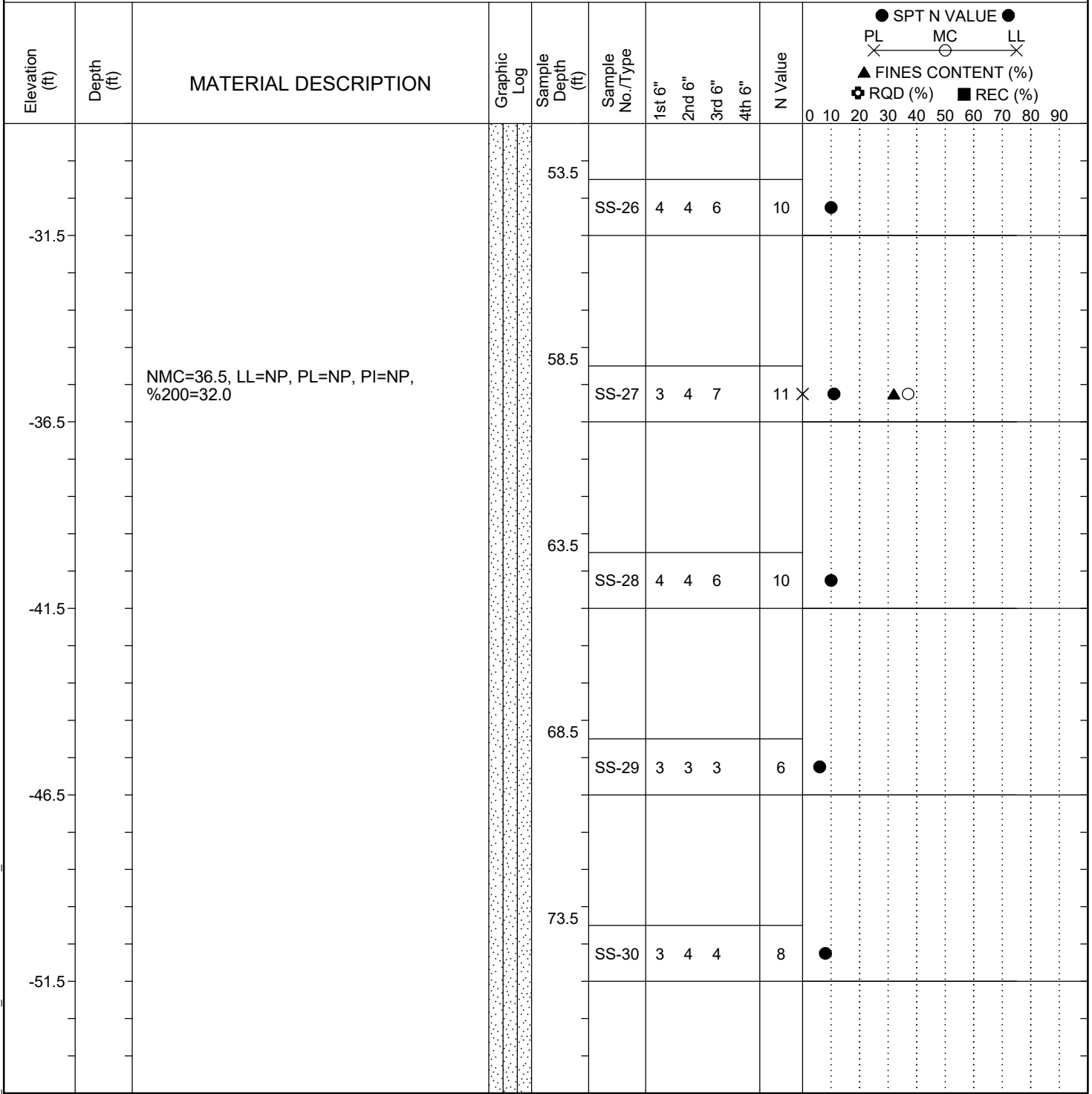
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UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT_3/26/24

SCDOT Soil Test Log

Project ID: P041157			County: Horry			Boring No.: S-26-31-2		
Site Description: S-26-31 BRO Tod Swamp						Route: S-26-31		
Eng./Geo.: K. Fugate		Boring Location: 556+65		Offset: 8.5R		Alignment: Existing		
Elev.: 23.5 ft		Latitude: 33.912219		Longitude: -78.838303		Date Started: 01/4/2024		
Total Depth: 100 ft		Soil Depth: 100 ft		Core Depth: 0 ft		Date Completed: 1/4/2024		
Bore Hole Diameter (in): 4.5		Sampler Configuration			Liner Required: Y (N)		Liner Used: Y (N)	
Drill Machine: D-50-479		Drill Method: RW		Hammer Type: Automatic		Energy Ratio: 93.9%		
Core Size: N/A		Driller: S. Truesdale		Groundwater: TOB		13 ft		24HR 13 ft



LEGEND

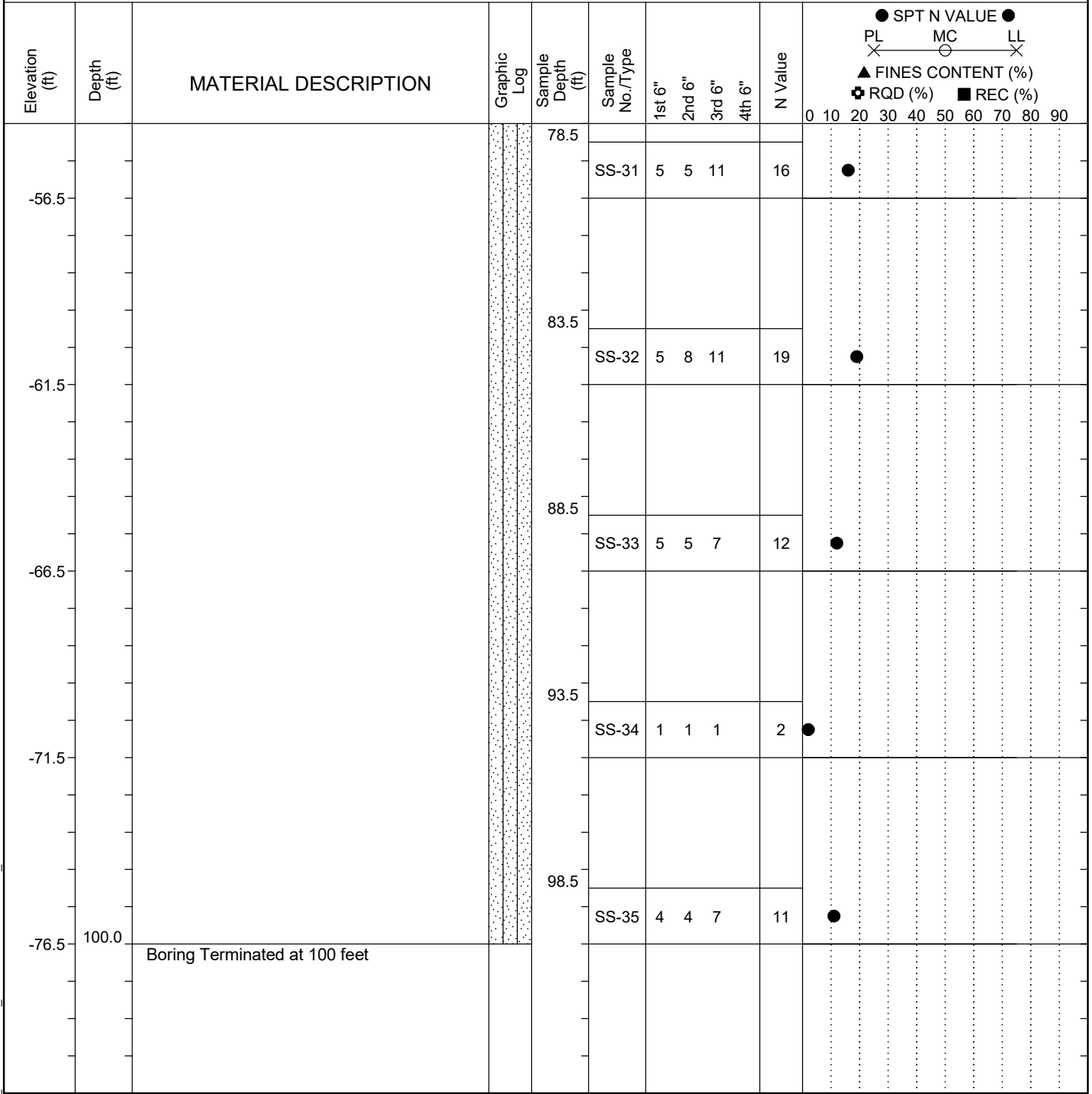
Continued Next Page

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

SC.DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT 3/26/24

SCDOT Soil Test Log

Project ID: P041157			County: Horry			Boring No.: S-26-31-2		
Site Description: S-26-31 BRO Tod Swamp					Route: S-26-31			
Eng./Geo.: K. Fugate		Boring Location: 556+65		Offset: 8.5R		Alignment: Existing		
Elev.: 23.5 ft		Latitude: 33.912219		Longitude: -78.838303		Date Started: 01/4/2024		
Total Depth: 100 ft		Soil Depth: 100 ft		Core Depth: 0 ft		Date Completed: 1/4/2024		
Bore Hole Diameter (in): 4.5		Sampler Configuration			Liner Required: Y (N)		Liner Used: Y (N)	
Drill Machine: D-50-479		Drill Method: RW		Hammer Type: Automatic		Energy Ratio: 93.9%		
Core Size: N/A		Driller: S. Truesdale		Groundwater: TOB		13 ft		24HR 13 ft



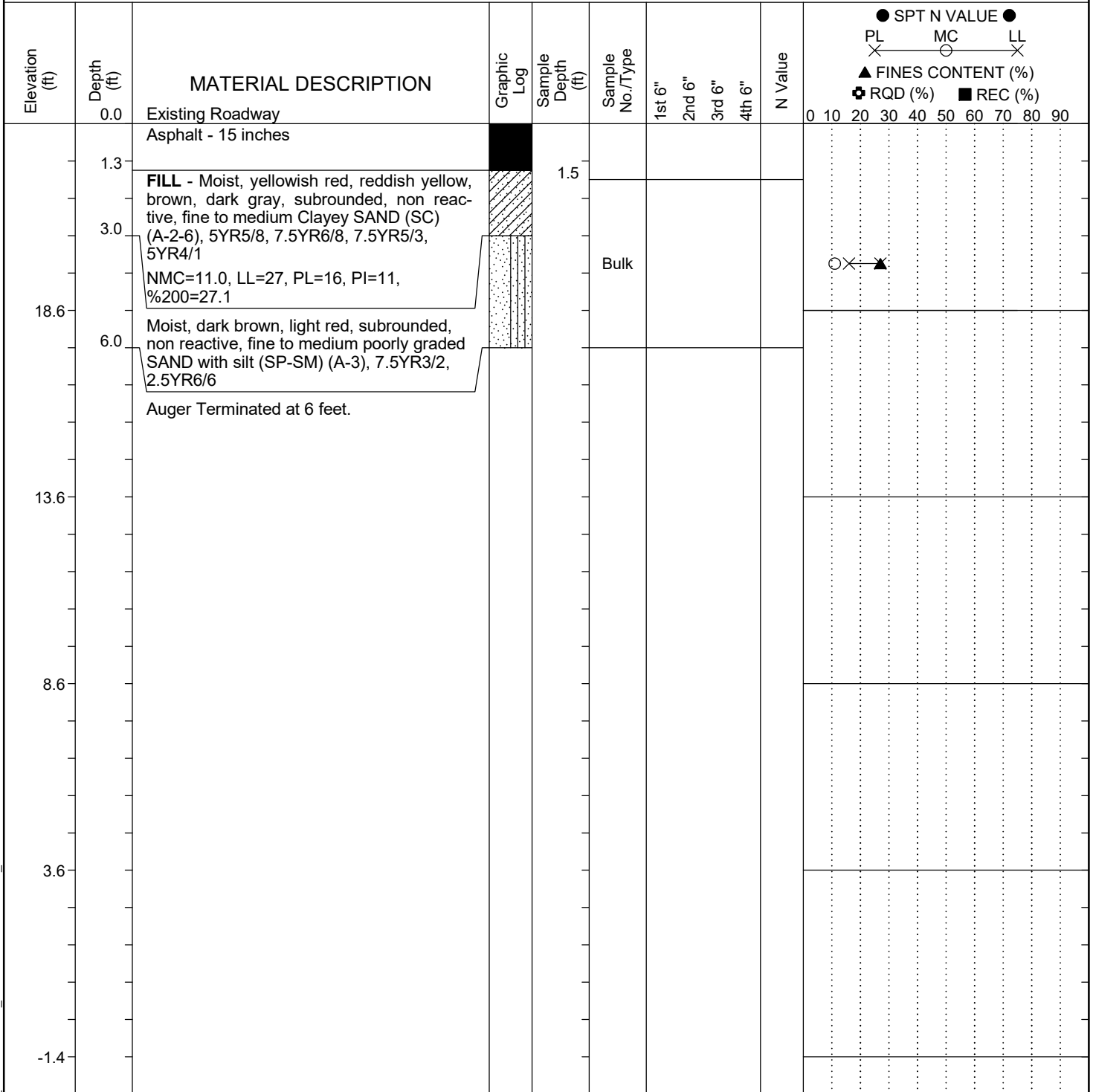
LEGEND

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

SC.DOT_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT 3/26/24

SCDOT Soil Test Log

Project ID: P041157	County: Horry			Boring No.: S-26-31-Bulk	
Site Description: S-26-31 BRO Tod Swamp			Route: S-26-31		
Eng./Geo.: K. Fugate		Boring Location: 556+85		Offset: 8R	Alignment: Existing
Elev.: 23.6 ft	Latitude: 33.912142	Longitude: -78.838327	Date Started: 1/4/2024		
Total Depth: 6 ft	Soil Depth: 6 ft	Core Depth: 0 ft	Date Completed: 1/4/2024		
Bore Hole Diameter (in): 6		Sampler Configuration		Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: D-50-479		Drill Method: HSA	Hammer Type:		Energy Ratio:
Core Size: N/A	Driller: S. Truesdale	Groundwater: TOB	Not Encountered	HR	



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_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT_DATATEMPLATE.GDT 3/25/24

CPT Sounding ID S-26-31-1C

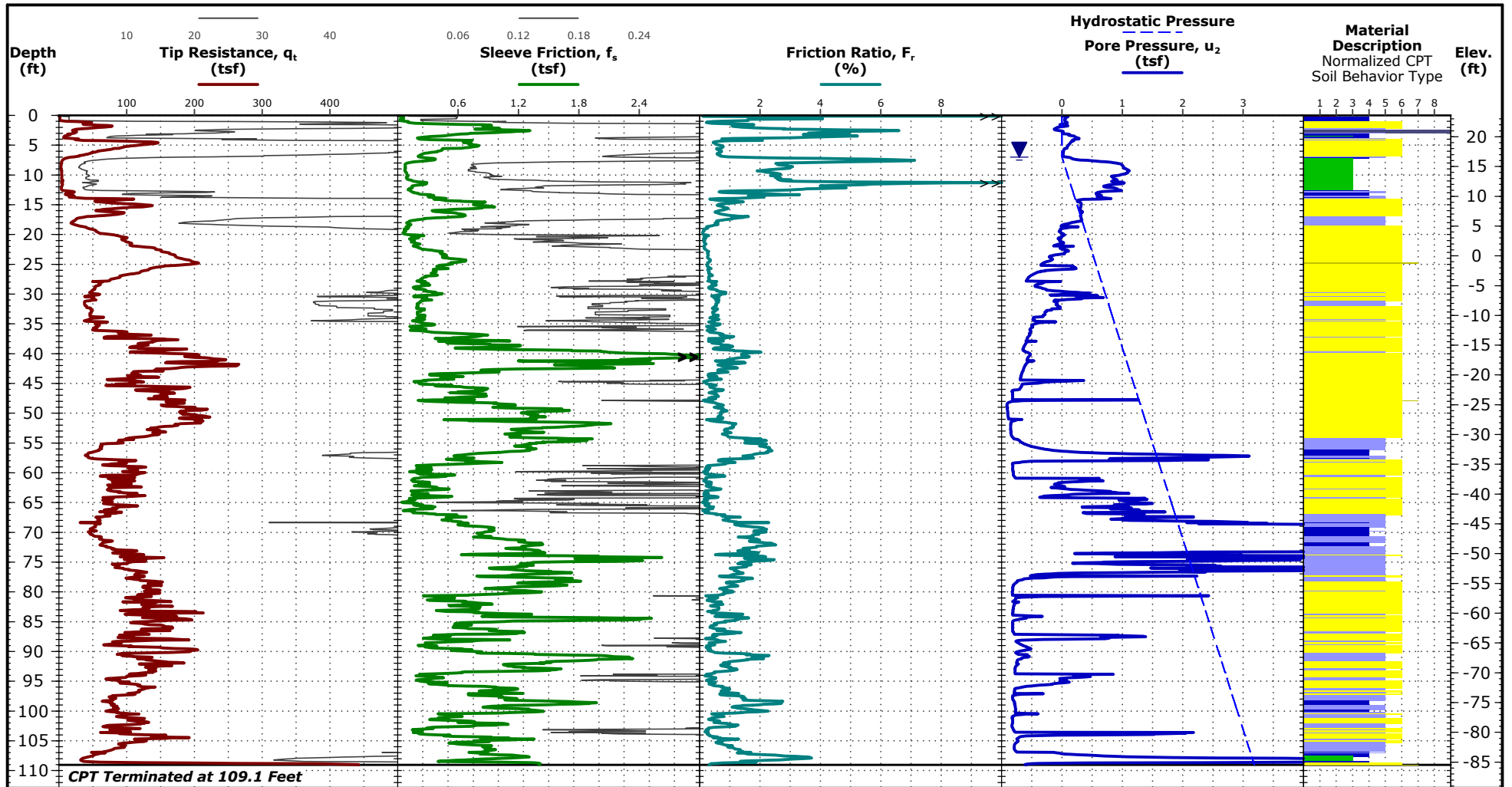


1246 Howard Ave
 Myrtle Beach, SC

CPT Started: 12/27/2023
 CPT Completed: 12/27/2023

Elevation: 23.58 (ft)

Latitude: 33.912448° Longitude: -78.838238°
 Sta: 555+65 Offset: 9' R



See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data, if any.
 See [Supporting Information](#) for explanation of symbols and abbreviations.

Notes
 Test Location: See [Exploration Plan](#)

CPT Equipment
 CPT Rig: 2021 International CV
 Operator: AF/AM
 CPT sensor calibration reports available upon request
 Probe No. 5890 with net area ratio of 0.842
 Manufactured by Geotech A.B.- Calibrated 3/28/2023
 Tip and sleeve areas of 15 cm² and 225 cm²

Water Level Observation
 7 ft estimated water depth
 (used in normalizations and correlations)

- Normalized Soil Behavior Type (Robertson 1990)**
- 1 Sensitive, fine grained
 - 2 Organic soils - clay
 - 3 Clay - silty clay to clay
 - 4 Silt mixtures - clayey silt to silty clay
 - 5 Sand mixtures - silty sand to sandy silt
 - 6 Sands - clean sand to silty sand
 - 7 Gravelly sand to dense sand
 - 8 Very stiff sand to clayey sand
 - 9 Very stiff fine grained

CPT Sounding ID S-26-31-2C

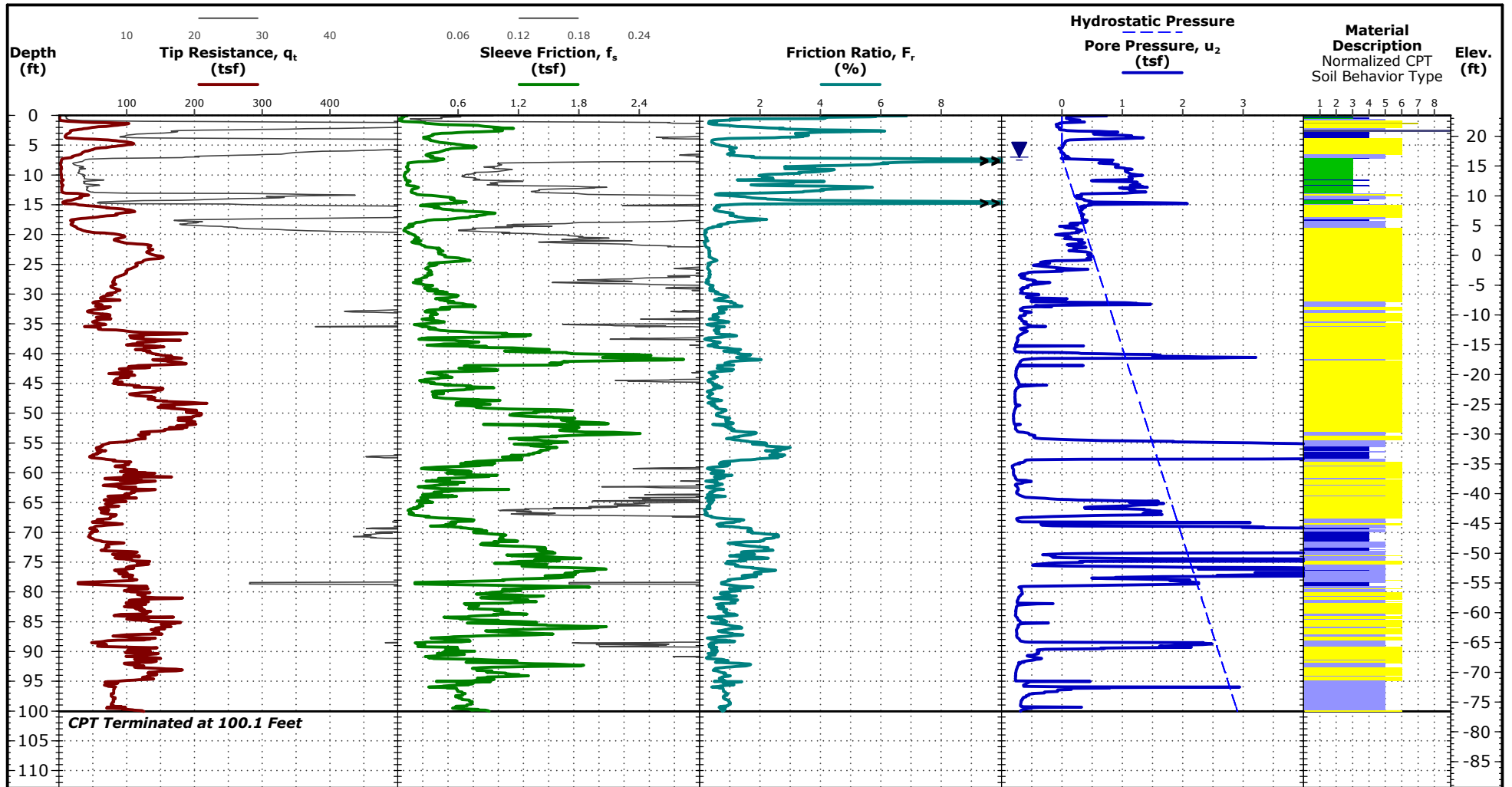


1246 Howard Ave
 Myrtle Beach, SC

Latitude: 33.912182° Longitude: -78.838315°
 Sta: 556+75 Offset: 8.5'R

Elevation: 23.50 (ft)

CPT Started: 12/27/2023
 CPT Completed: 12/27/2023



See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data, if any.
 See [Supporting Information](#) for explanation of symbols and abbreviations.

Notes

Test Location: See [Exploration Plan](#)

CPT Equipment

CPT Rig: 2021 International CV
 Operator: AF/AM
 CPT sensor calibration reports available upon request
 Probe No. 5890 with net area ratio of 0.842
 Manufactured by Geotech A.B.- Calibrated 3/28/2023
 Tip and sleeve areas of 15 cm² and 225 cm²

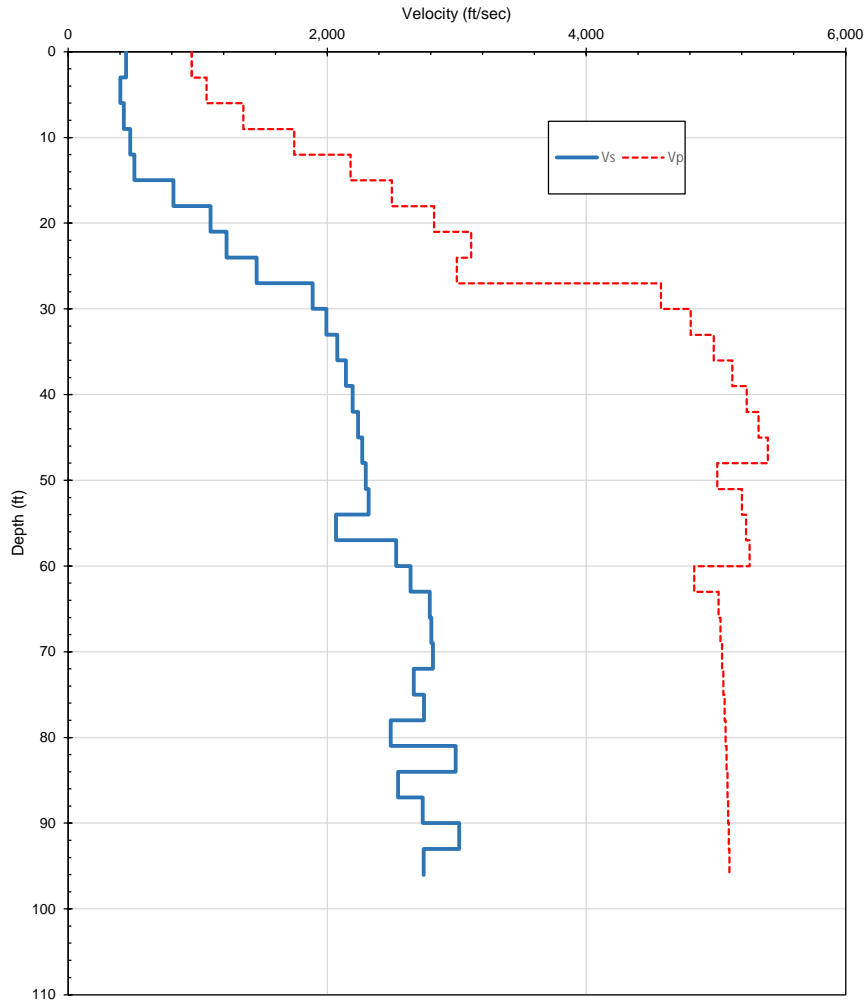
Water Level Observation

▼ 7 ft estimated water depth
 (used in normalizations and correlations)

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- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained


Downhole Seismic Velocity Fixed Interval Method



Depth (ft)	Vp (ft/sec)	Vs (ft/sec)	Δt (ft)	Δt (sec)	Est. In-Situ Unit Wt. (pcf)
3	954	448	3	0.00670	115
6	1068	403	3	0.00745	
9	1351	431	3	0.00696	
12	1745	480	3	0.00625	95
15	2179	512	3	0.00586	115
18	2498	815	3	0.00368	
21	2824	1100	3	0.00273	
24	3109	1223	3	0.00245	115
27	2999	1455	3	0.00206	
30	4574	1887	3	0.00159	
33	4803	1994	3	0.00150	
36	4982	2077	3	0.00144	
39	5124	2143	3	0.00140	
42	5237	2196	3	0.00137	
45	5327	2237	3	0.00134	
48	5399	2271	3	0.00132	
51	5008	2298	3	0.00131	
54	5198	2320	3	0.00129	
57	5232	2067	3	0.00145	
60	5259	2532	3	0.00118	
63	4832	2643	3	0.00114	
66	5019	2791	3	0.00108	
69	5033	2804	3	0.00107	
72	5046	2815	3	0.00107	
75	5056	2668	3	0.00112	
78	5066	2746	3	0.00109	
81	5074	2491	3	0.00120	
84	5081	2990	3	0.00100	
87	5087	2546	3	0.00118	
90	5092	2736	3	0.00110	
93	5097	3017	3	0.00099	
96	5101	2745	3	0.00109	
Unit Weight of Soil estimated from SPT results					
Sum of Data Over Profile			96	0.07247	
Weighted Average Shear Wave Velocity Over Profile				1,325 ft/sec	
Est. Weighted Average Shear Wave Velocity Over 100-Ft				1,346 ft/sec	

Project Mgr:	KF
Prepared by:	RK
Checked by:	
Approved by:	

Project No.	ER23P202
Scale:	NA
Date:	3/28/2024


Terracon
 Consulting Engineers and Scientists

1246 Howard Ave Myrtle Beach, South Carolina
 Ph: (843) 286-2500 Fax: (864) 292-6361

GEOPHYSICAL TESTING RESULTS

DOWNHOLE SEISMIC TEST

S-26-31 (Red Bluff Road) Bridge Replacement over Tod Swamp

HORRY COUNTY, SOUTH CAROLINA

P041157

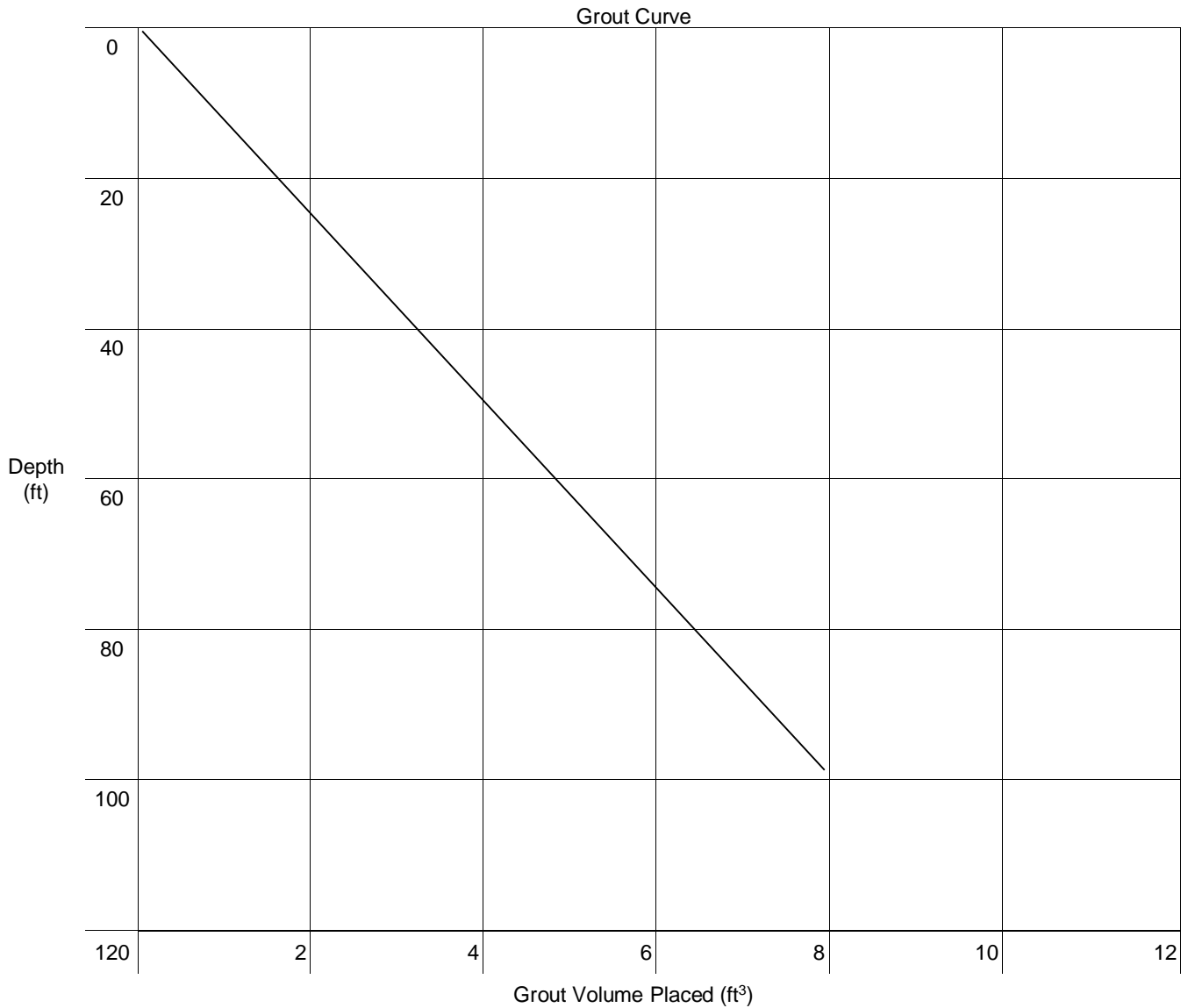
TEST NO.
S-26-31-1

EXHIBIT
A-9



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name:	S-26-31 BRO Tod Swamp	Test Hole No.:	S-26-31-1
Project ID:	P041157	Station:	555+85
Consultant Firm:	Terracon Consultants, Inc.	Offset:	9.5 R
Grouted By:	Fugate	Date	1/5/24
Notes:	Mix design: 1 pound cement mix, 1 pound bentonite, 6 pounds water		

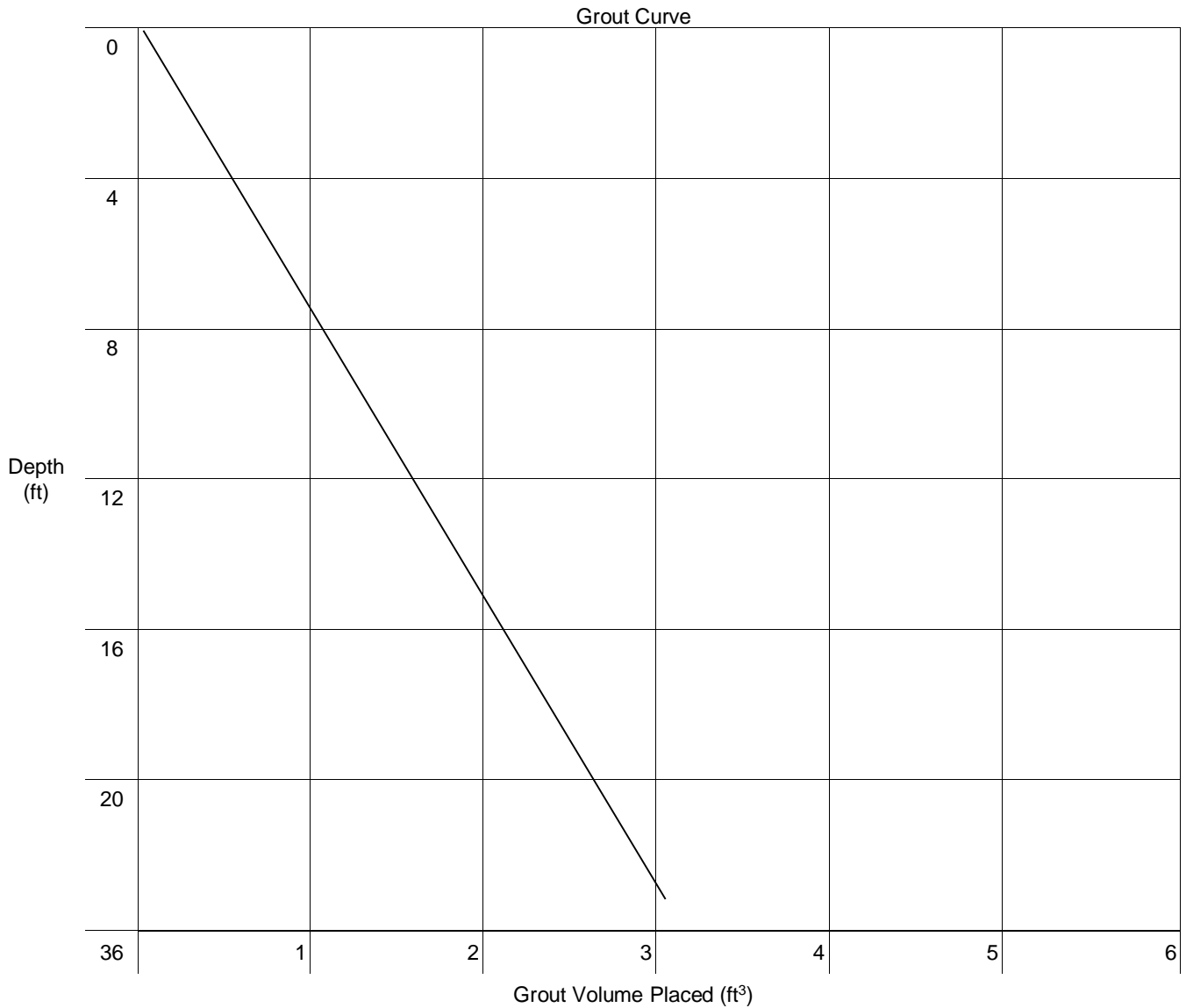


Number of Bags On-Site	15	ea.
Depth of Test Hole Grouted	100	ft.
Diameter of Test Hole	0.375	ft.
Area of Test Hole	0.11	ft ²
Volume of Test Hole	9.0	ft ³
Volume of Casing (If applicable)	1.16	ft ³
Theoretical Volume of Test Hole	9.84	ft ³
Number of Bags Used	17	ea.
Volume Placed	7.9	ft ³



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name: S-26-31 BRO Tod Swamp
Project ID: P041157 Test Hole No.: S-26-31-2
Consultant Firm: Terracon Consultants, Inc. Station: 556+65
Grouted By: Fugate Date 1/5/2024 Offset: 8.5R
Notes: Mix design: 1 pound cement mix, 6 pounds water



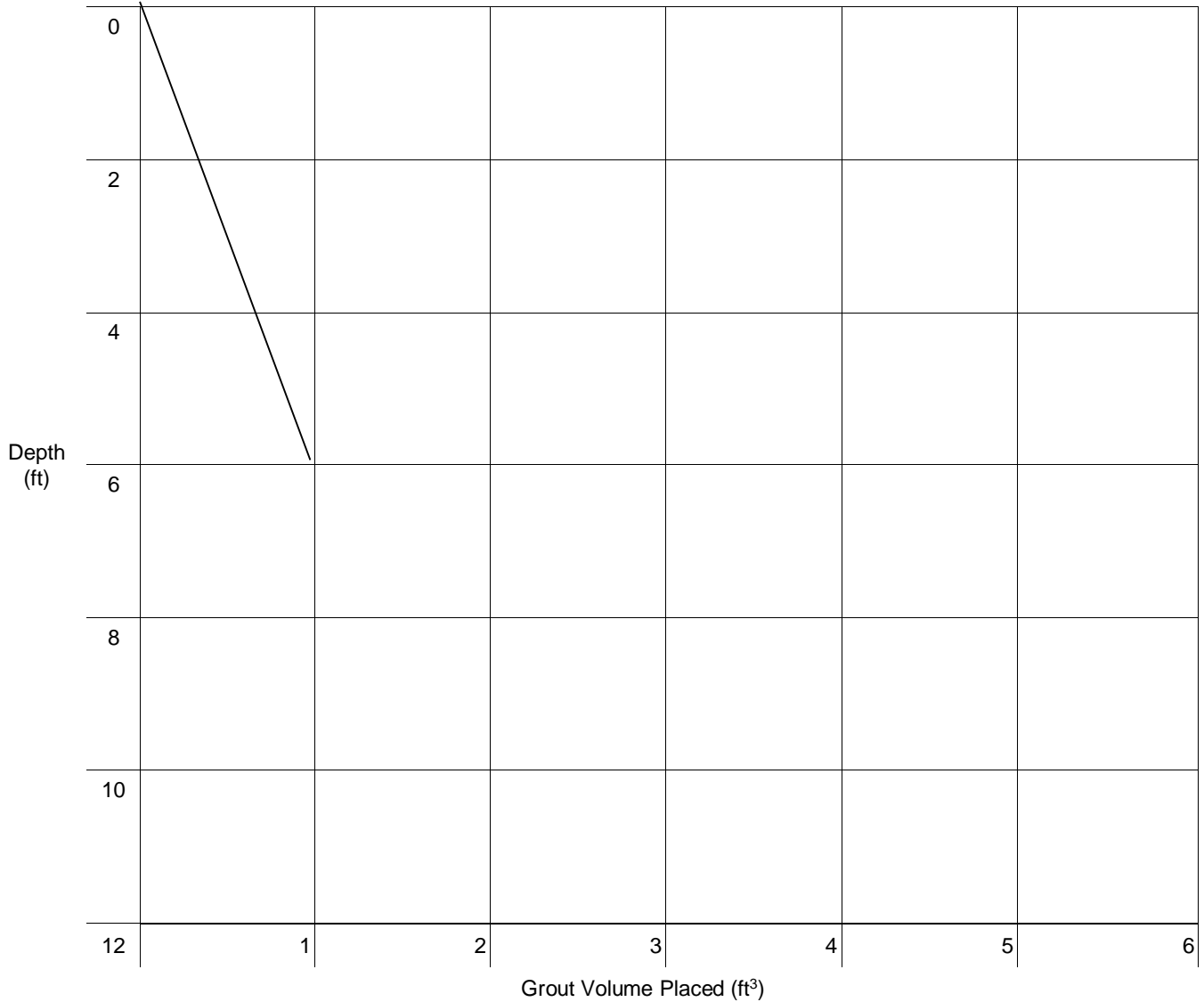
Number of Bags On-Site	<u>15</u>	ea.
Depth of Test Hole Grouted	<u>35</u>	ft.
Diameter of Test Hole	<u>0.375</u>	ft.
Area of Test Hole	<u>0.11</u>	ft ²
Volume of Test Hole	<u>3.9</u>	ft ³
Volume of Casing (If applicable)	<u>-</u>	ft ³
Theoretical Volume of Test Hole	<u>3.9</u>	ft ³
Number of Bags Used	<u>6.5</u>	ea.
Volume Placed	<u>3.04</u>	ft ³



GROUT LOG OF TEST HOLES FOR GEOTECHNICAL ON-CALL

Project Name: S-26-31 BRO Tod Swamp S-26-31-
Project ID: P041157 Test Hole No.: Bulk
Consultant Firm: Terracon Consultants, Inc. Station: 556+85
Grouted By: Fugate Date 1/5/2024 Offset: 8R
Notes: Mix design: 1 pound cement mix, 6
pounds water

Grout Curve



Number of Bags On-Site	<u>15</u>	ea.
Depth of Test Hole Grouted	<u>6</u>	ft.
Diameter of Test Hole	<u>0.5</u>	ft.
Area of Test Hole	<u>0.20</u>	ft ²
Volume of Test Hole	<u>1.0</u>	ft ³
Volume of Casing (If applicable)	<u>-</u>	ft ³
Theoretical Volume of Test Hole	<u>1.0</u>	ft ³
Number of Bags Used	<u>2</u>	ea.
Volume Placed	<u>1.0</u>	ft ³

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.



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) |
| ■ 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 |

Appendix B
Laboratory Testing

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

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|---|-------------------------|----------------------------|
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| ■ | Wash 200 | AASHTO T11/(ASTM D1140) |
| ■ | 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	% Fines	% Gravel	% Sand	% Silt	% Clay	Water Content (%)
S-26-31-1	3.7					5.1	0.1	94.8			15.2
S-26-31-1	5.7	CLAYEY SAND(SC) / A-7-6 (3)	49	27	22	37.6	5.1	57.4	34.8	2.7	45.5
S-26-31-1	18.5-20					19.8	5.4	74.8			22.3
S-26-31-1	28.5-30	SILTY, CLAYEY SAND(SC-SM) / A-2-4 (0)	25	21	4	28.4	0.8	70.8	27.6	0.8	26.7
S-26-31-1	48.5-50										33.0
S-26-31-2	3-4.5										11.8
S-26-31-2	12-14	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	26.5	1.2	72.1	25.3	1.2	70.6
S-26-31-2	20-22					10.8	0.7	88.6			26.3
S-26-31-2	34-36					21.9	8.2	69.9			31.2
S-26-31-2	58.5-60	SILTY SAND(SM) / A-2-4 (0)	NP	NP	NP	32.0	2.8	64.2	30.8	1.2	36.5
S-26-31-Bulk	1.5	CLAYEY SAND(SC) / A-2-6 (0)	27	16	11	27.1	1.2	71.7			11.0



INDEX PROPERTIES VERSUS DEPTH

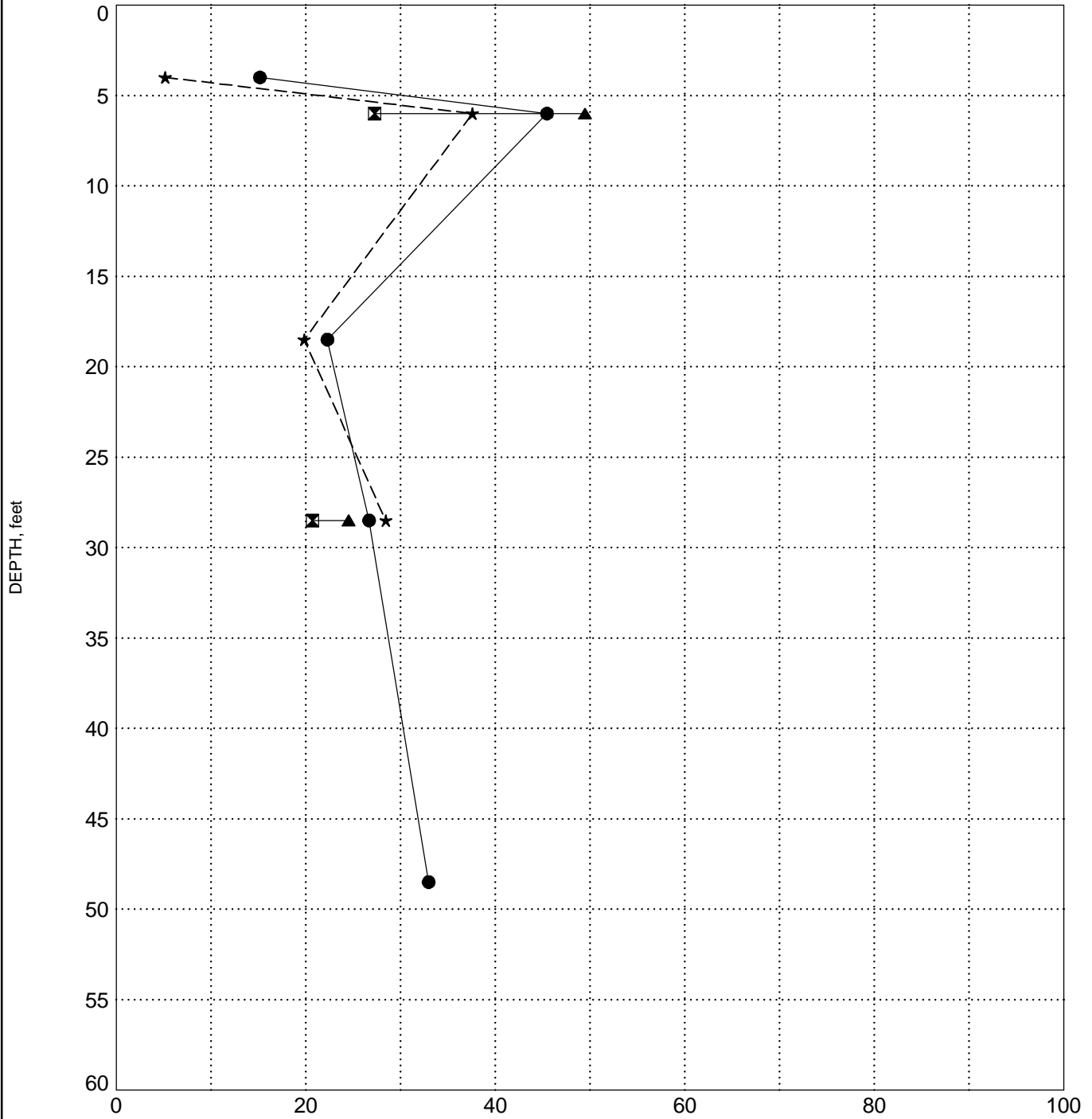
PROJECT ID P041157

PROJECT NAME S-26-31 Red Bluff Road

PROJECT COUNTY Horry

BORING S-26-31-1

SURFACE ELEVATION: 23.6



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

INDEX PROPS_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT DATA TEMPLATE_01_30_2015.GDT 2/21/24



INDEX PROPERTIES VERSUS DEPTH

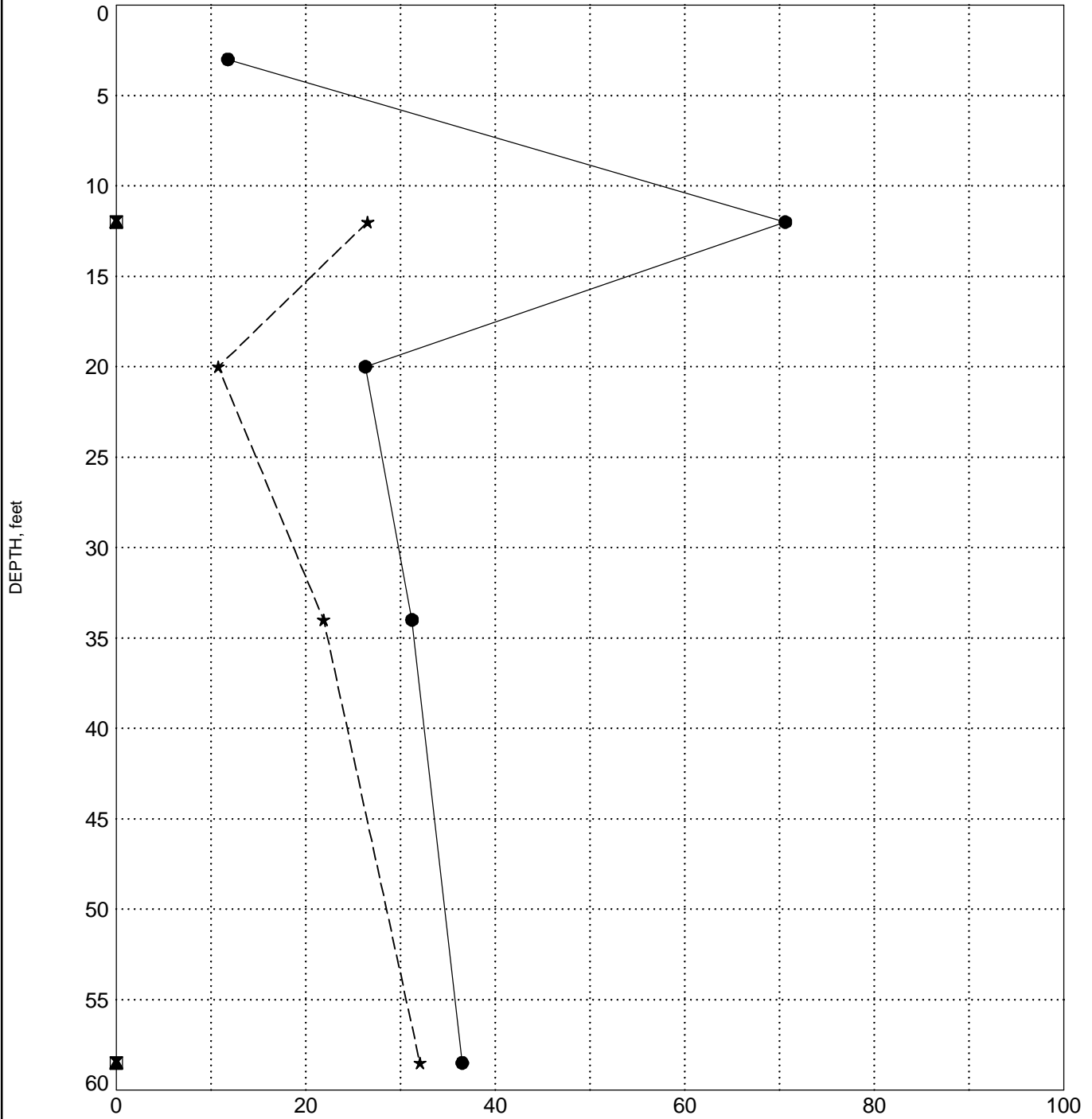
PROJECT ID P041157

PROJECT NAME S-26-31 Red Bluff Road

PROJECT COUNTY Horry

BORING S-26-31-2

SURFACE ELEVATION: 23.5



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

INDEX PROPS_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT DATA TEMPLATE_01_30_2015.GDT 2/21/24



INDEX PROPERTIES VERSUS DEPTH

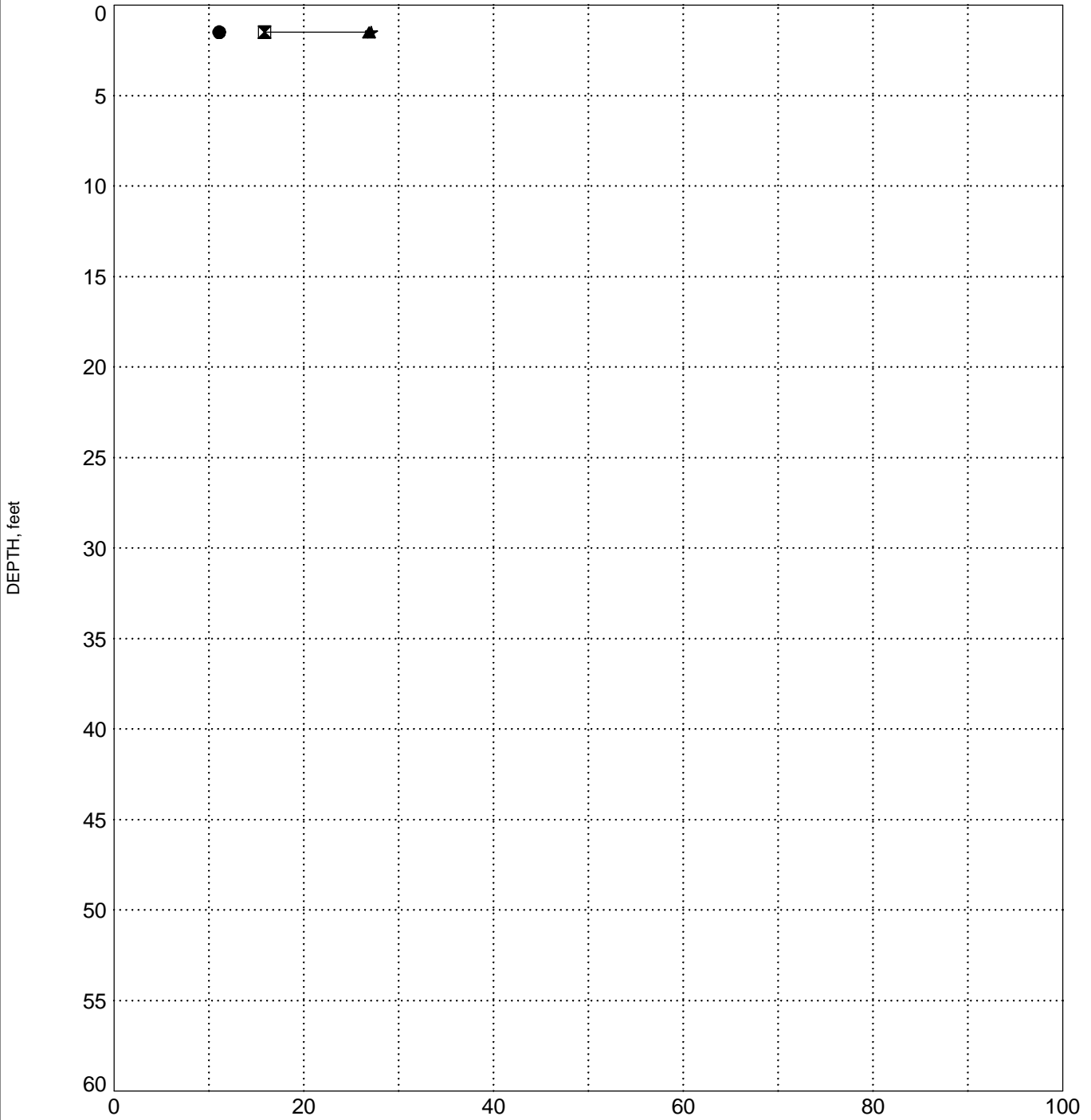
PROJECT ID P041157

PROJECT NAME S-26-31 Red Bluff Road

PROJECT COUNTY Horry

SURFACE ELEVATION: 23.6

BORING S-26-31-Bulk

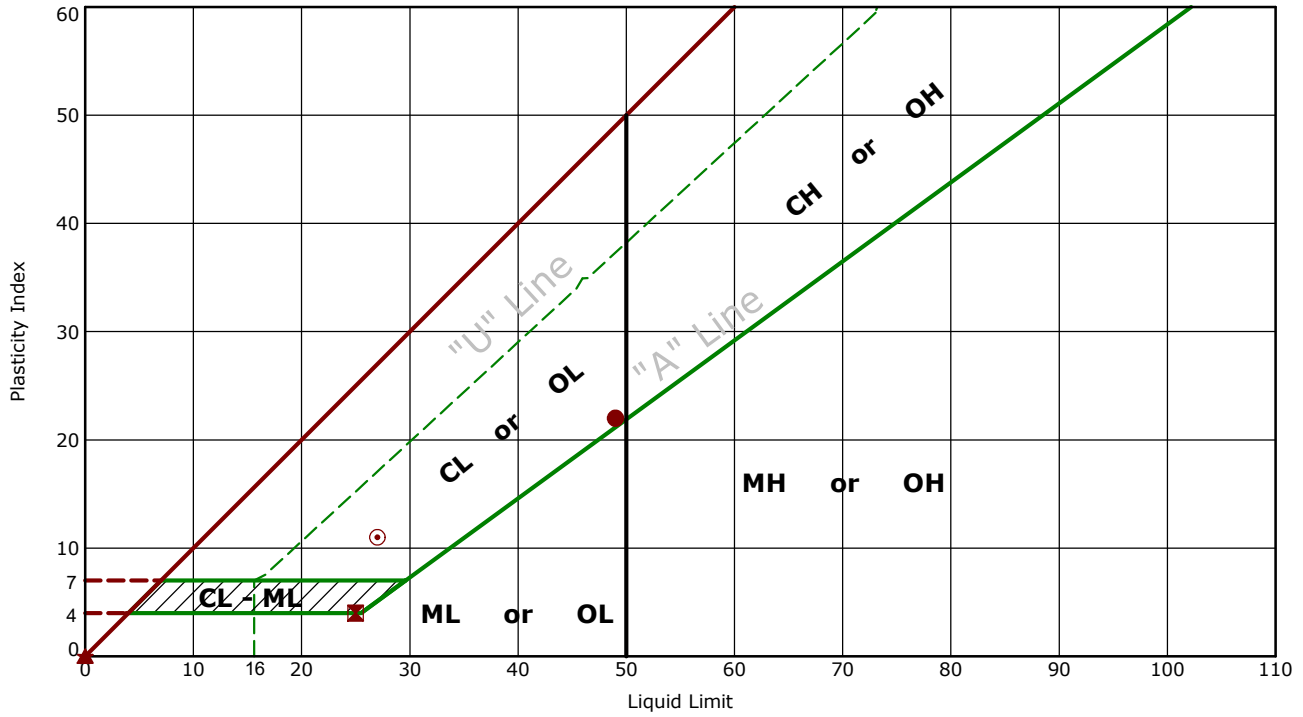


LEGEND	
●	Water Content
☒	Plastic Limit
▲	Liquid Limit
★	Fines

INDEX PROPS_SCDOT_GINTPROJECT_20190606.GPJ_SCDOT DATA TEMPLATE_01_30_2015.GDT 2/21/24

Atterberg Limit Results

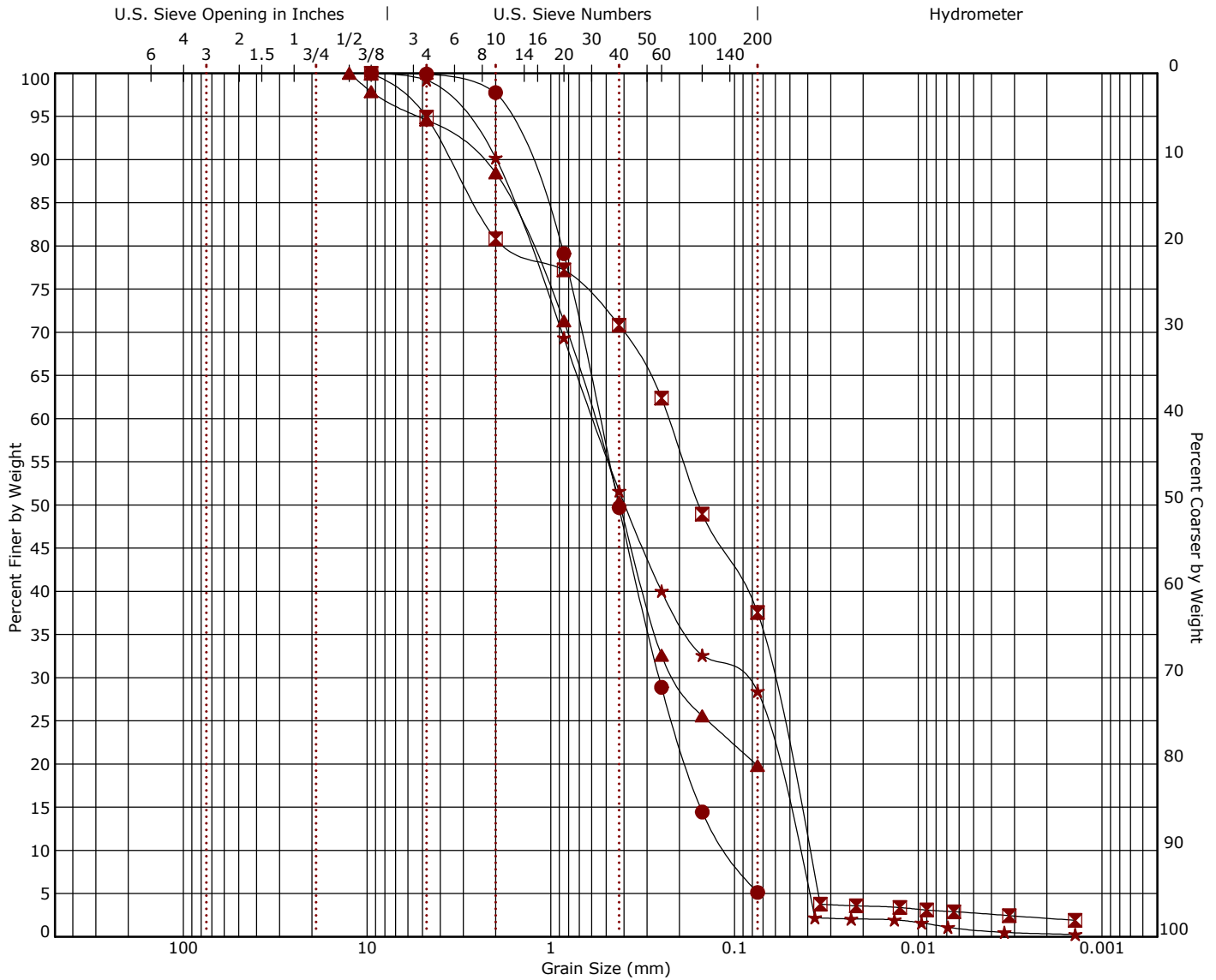
ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	AASHTO	Description
●	S-26-31-1	5.7 - 7.7	49	27	22	37.6	A-7-6 (3)	CLAYEY SAND
■	S-26-31-1	28.5 - 30	25	21	4	28.4	A-2-4 (0)	SILTY, CLAYEY SAND
▲	S-26-31-2	12 - 14	NP	NP	NP	26.5	A-2-4 (0)	SILTY SAND
★	S-26-31-2	58.5 - 60	NP	NP	NP	32.0	A-2-4 (0)	SILTY SAND
⊙	S-26-31-Bulk	1.5	27	16	11	27.1	A-2-6 (0)	CLAYEY SAND

Grain Size Distribution

ASTM D422 / ASTM C136



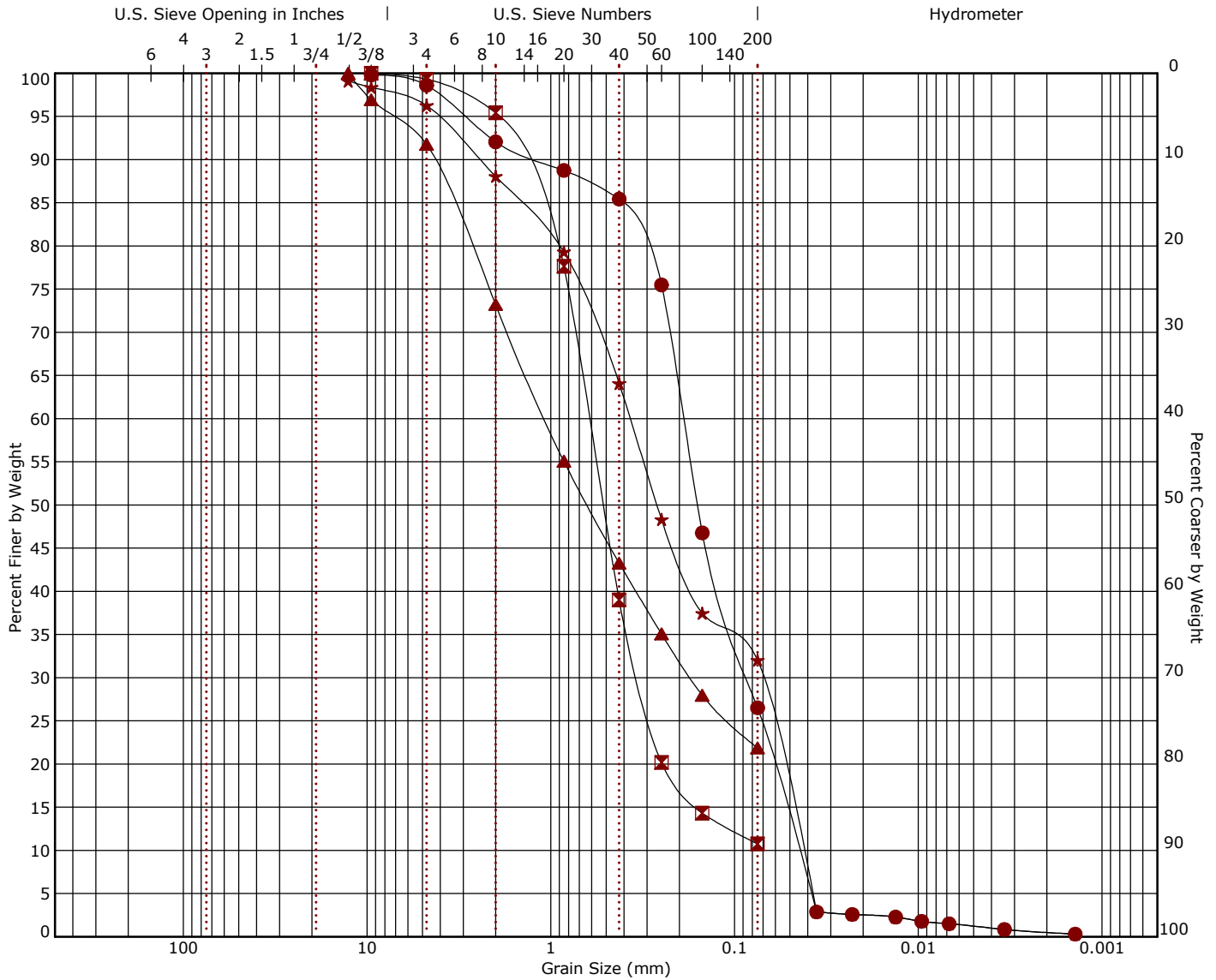
Cobbles | **Gravel** (coarse | fine) | **Sand** (coarse | medium | fine) | **Silt or Clay**

Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
● S-26-31-1	3.7 - 5.7						1.13	5.03
☒ S-26-31-1	5.7 - 7.7	CLAYEY SAND	SC	49	27	22	0.44	5.77
▲ S-26-31-1	18.5 - 20							
★ S-26-31-1	28.5 - 30	SILTY, CLAYEY SAND	SC-SM	25	21	4	0.35	13.01

Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-26-31-1	3.7 - 5.7	9.5	0.542	0.257	0.108	0.0	0.1	94.8	5.1		
☒ S-26-31-1	5.7 - 7.7	9.5	0.228	0.063	0.04	0.0	5.1	57.4	37.6	34.8	2.7
▲ S-26-31-1	18.5 - 20	12.5	0.585	0.207		0.0	5.4	74.8	19.8		
★ S-26-31-1	28.5 - 30	9.5	0.589	0.097	0.045	0.0	0.8	70.8	28.4	27.6	0.8

Grain Size Distribution

ASTM D422 / ASTM C136



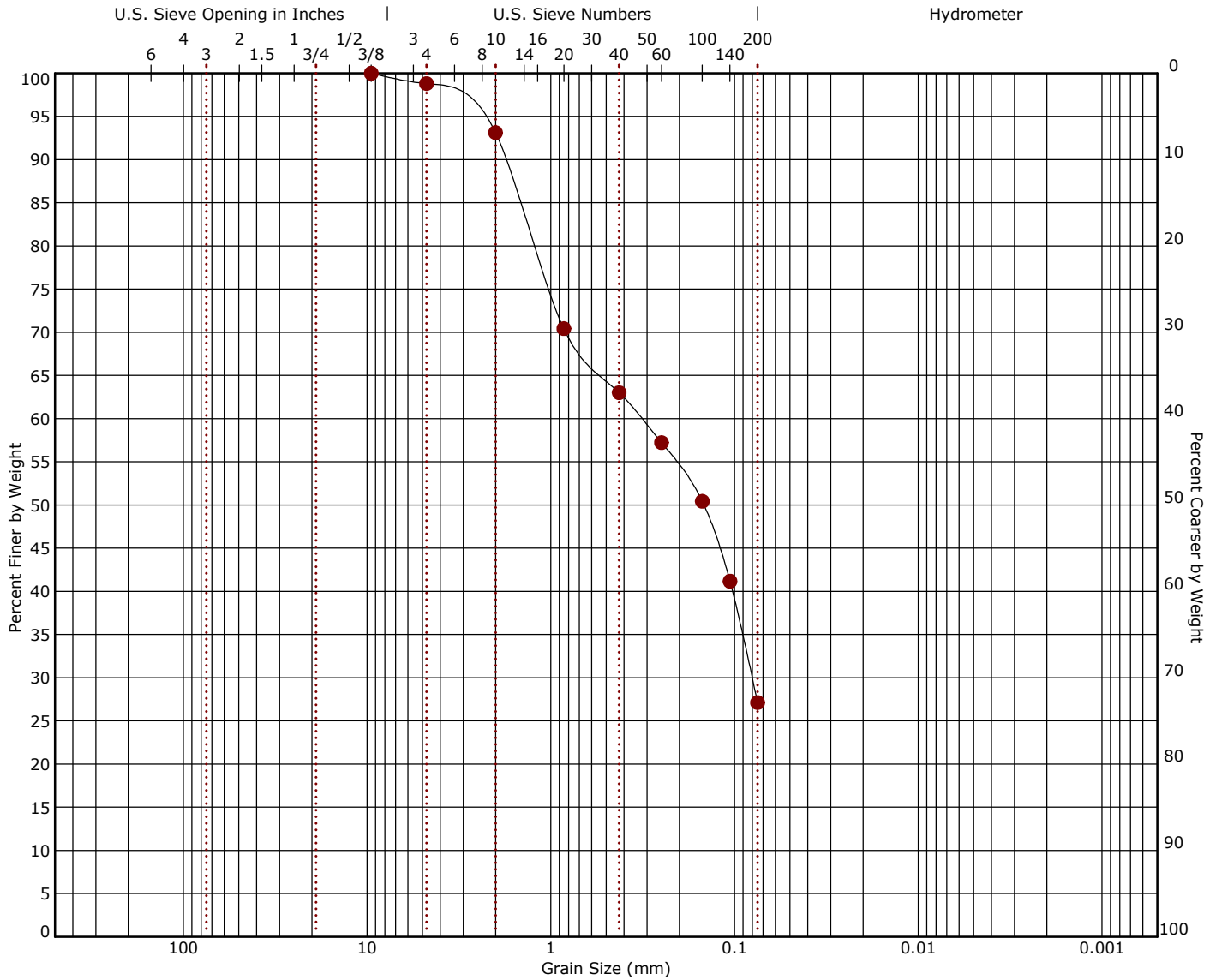
Cobbles | **Gravel** (coarse | fine) | **Sand** (coarse | medium | fine) | **Silt or Clay**

Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
● S-26-31-2	12 - 14	SILTY SAND	SM	NP	NP	NP	0.84	4.24
☒ S-26-31-2	20 - 22						2.71	9.56
▲ S-26-31-2	34 - 36							
★ S-26-31-2	58.5 - 60	SILTY SAND	SM	NP	NP	NP	0.32	8.64

Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-26-31-2	12 - 14	9.5	0.19	0.085	0.045		1.2	72.1	26.5	25.3	1.2
☒ S-26-31-2	20 - 22	9.5	0.619	0.33		0.0	0.7	88.6	10.8		
▲ S-26-31-2	34 - 36	12.7	1.072	0.174		0.0	8.2	69.9	21.9		
★ S-26-31-2	58.5 - 60	12.7	0.37	0.071	0.043		2.8	64.2	32.0	30.8	1.2

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles | **Gravel** (coarse | fine) | **Sand** (coarse | medium | fine) | **Silt or Clay**

Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
● S-26-31-Bulk	1.5	CLAYEY SAND	SC	27	16	11		

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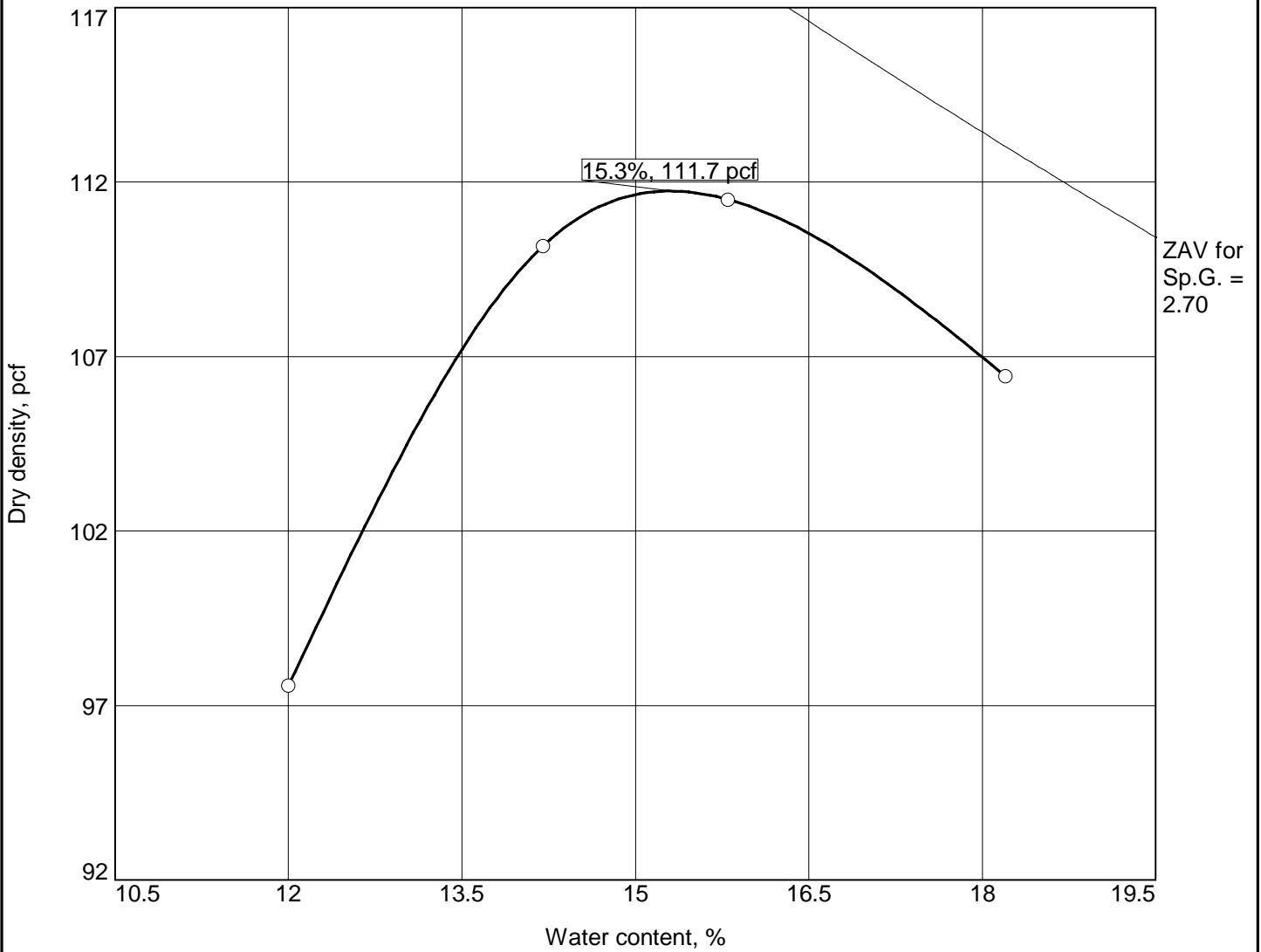
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Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● S-26-31-Bulk	1.5	9.5	0.322	0.081		0.0	1.2	71.7	27.1		

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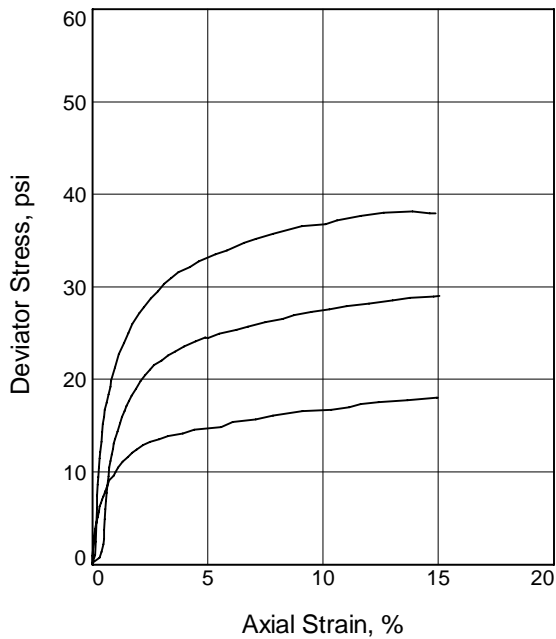
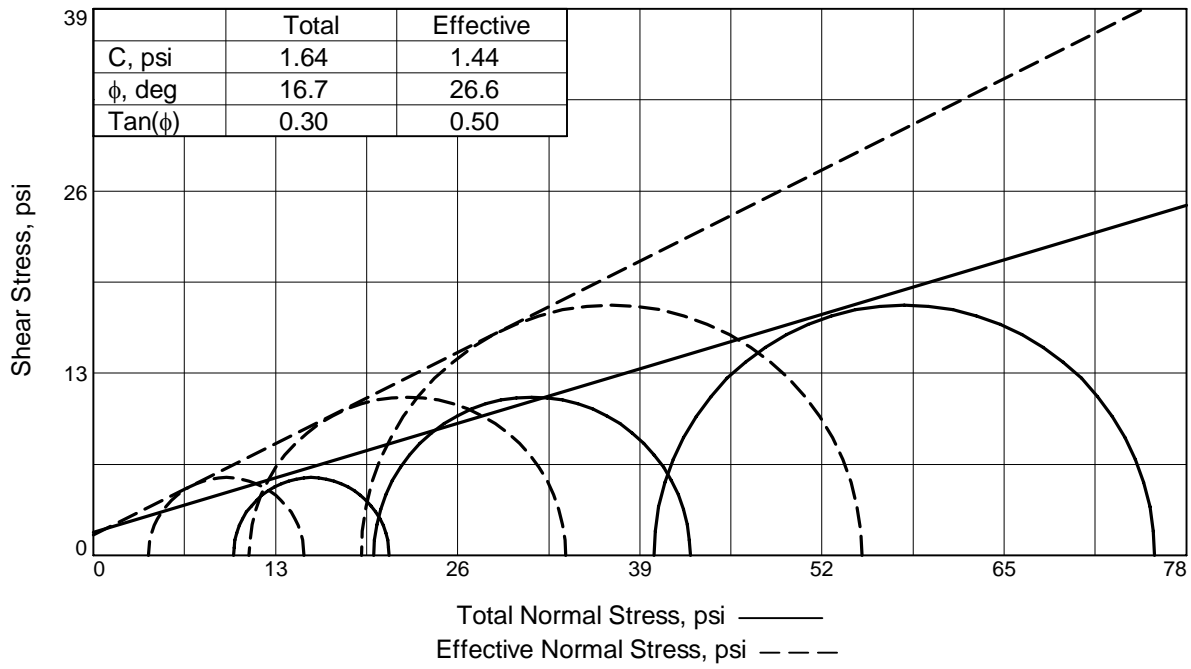
COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
1.5-6 ft	SC	A-2-6(0)	11.1	2.7	27	16	0.0	27.1

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 111.7 pcf Optimum moisture = 15.3 %	SC Clayey Sand
Project No. ER23P202T Client: HNTB North Carolina PC Project: SCDOT Bridge Package 18 S-26-31 (Red Bluff Road) BRO Tod Swamp ○ Source of Sample: Bulk Sample Number: 1	Remarks:
Terracon Consultants, Inc.	



Sample No.		1	2	3
Initial	Water Content, %	17.3	17.3	17.3
	Dry Density, pcf	106.1	106.1	106.1
	Saturation, %	79.4	79.4	79.4
	Void Ratio	0.5879	0.5879	0.5879
	Diameter, in.	2.80	2.80	2.80
	Height, in.	5.60	5.60	5.60
At Test	Water Content, %	21.2	20.8	20.2
	Dry Density, pcf	106.7	107.7	108.4
	Saturation, %	98.8	99.5	98.4
	Void Ratio	0.5795	0.5646	0.5544
	Diameter, in.	2.80	2.78	2.78
	Height, in.	5.59	5.58	5.57
Strain rate, in./min.	0.001	0.001	0.001	
Back Pressure, psi	50.0	50.0	50.0	
Cell Pressure, psi	60.0	70.0	90.0	
Fail. Stress, psi	11.1	22.6	35.7	
Excess Pore Pr., psi	6.1	8.9	20.9	
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{\sigma}_1$ Failure, psi	15.0	33.7	54.9	
$\bar{\sigma}_3$ Failure, psi	3.9	11.1	19.1	

Type of Test:

CU with Pore Pressures

Sample Type: Remolded

Description: clayey sand

LL= 27

PL= 11

PI= 16

Assumed Specific Gravity= 2.7

Remarks: Three Specimen Series

Client: HNTB North Carolina PC

Project: SCDOT Bridge Package 18

S-26-31 (Red Bluff Road) BRO Tod Swamp

Source of Sample: Bulk

Depth: 1.5 ft

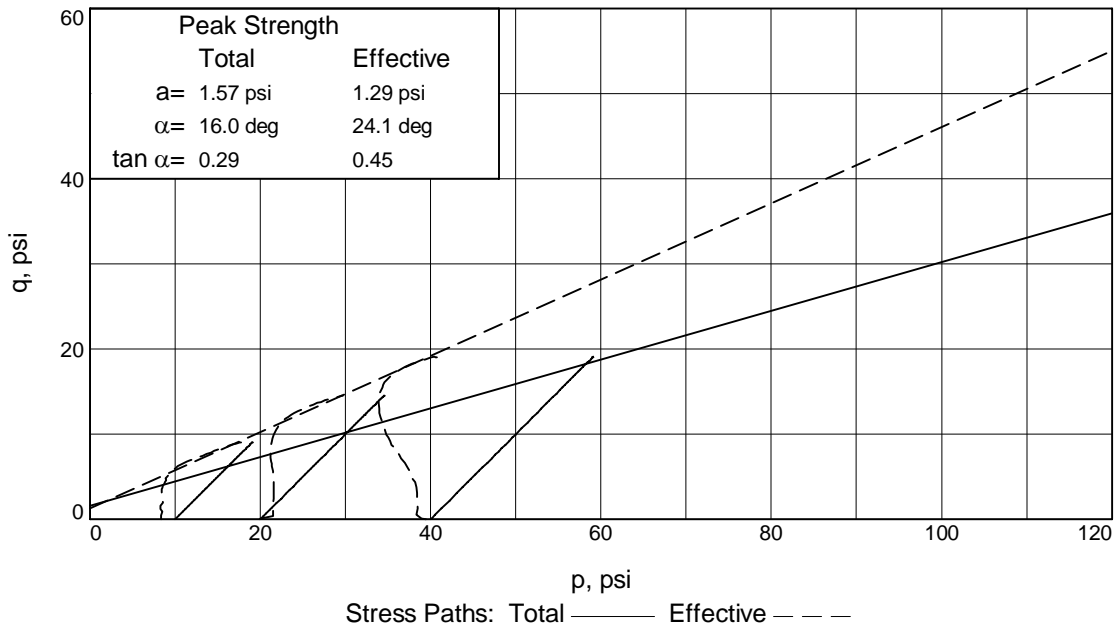
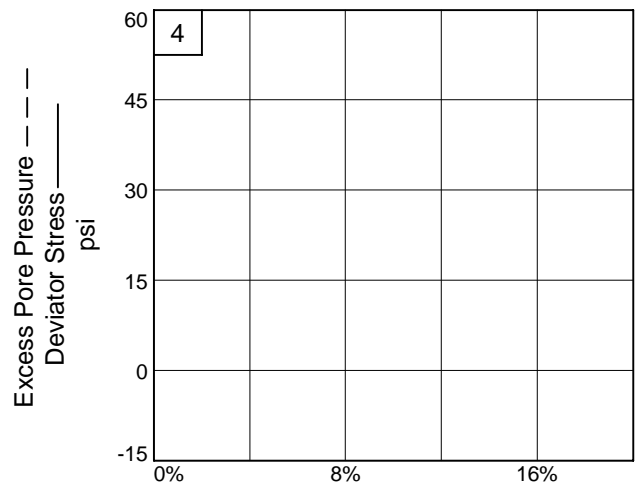
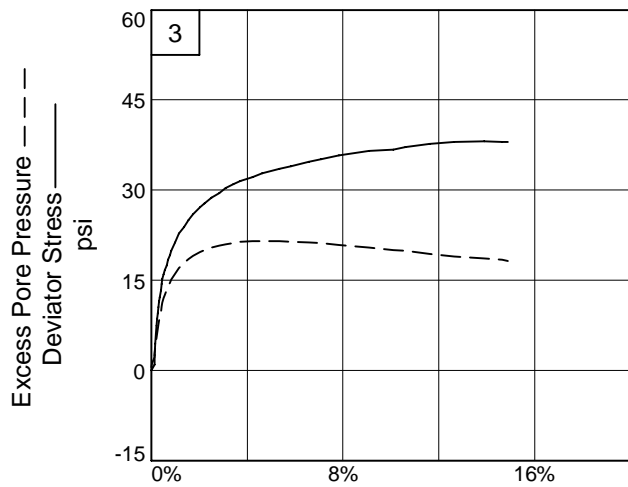
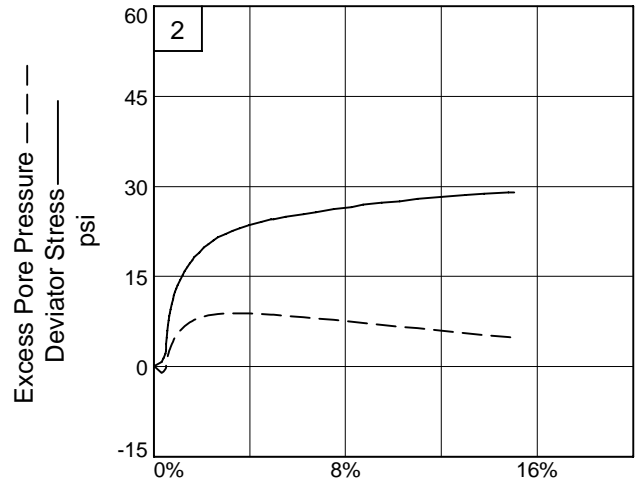
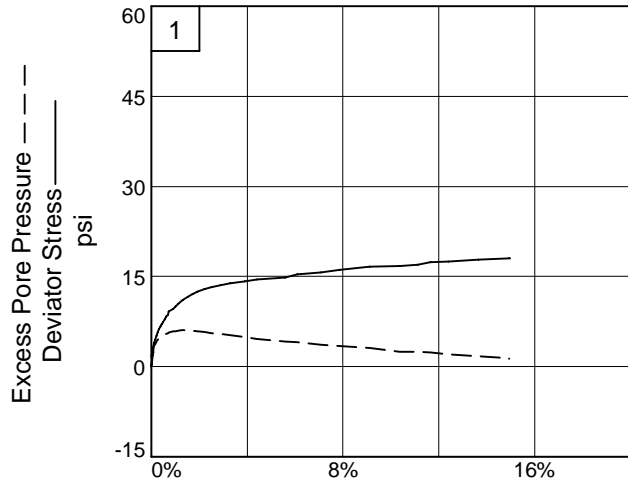
Sample Number: 1

Proj. No.: ER23P202T

Date Sampled: N/A

TRIAxIAL SHEAR TEST REPORT

Terracon Consultants, Inc.



Client: HNTB North Carolina PC

Project: SCDOT Bridge Package 18 S-26-31 (Red Bluff Road) BRO Tod Swamp

Source of Sample: Bulk **Depth:** 1.5 ft **Sample Number:** 1

Project No.: ER23P202T

Terracon Consultants, Inc.

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



Client

HNTB North Carolina PC

Project

SCDOT Bridge Package 18
S-26-31 (Red Bluff Road) BRO Tod Swamp

Sample Submitted By: Terracon (ER)

Date Received: 1/16/2024

Lab No.: 24-0023

Results of Corrosion Analysis

Sample Number	--
Sample Location	S-26-31-1
Sample Depth (ft.)	0.0-10.0
pH Analysis, ASTM G51	7.40
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	157
Sulfides, AWWA 4500-S D, (mg/Kg)	Nil
Chlorides, ASTM D512, (mg/kg)	380
Red-Ox, ASTM G200, (mV)	+720
Total Salts, AWWA 2520 B, (mg/Kg)	1405
Saturated Minimum Resistivity, ASTM G-57, (ohm-cm)	1649

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.

Appendix C

Supporting Documents

3-Point Acceleration Design Response Spectrum provided
by SCDOT

Rig Calibration Report (18 Pages)

3-Point Acceleration Design Response Spectrum

SCDOT v3.2 - 06/01/2023

Project ID: P041157	Latitude: 33.9122
Route: S-26-31	Longitude: 78.8382
County: 26 - Horry	
Project: Red Bluff Road over Tod Swamp	

Designer: N. Harman - Support
Date: 4/18/2024

Design EQ	PGA	S _{DS}	S _{D1}	M _W	R	PGV	D ₃₅₋₉₅	T' _o
	g	g	g	-	km	inches/sec	sec	sec
FEE	0.13	0.23	0.08	7.30	120.33	2.91	37.84	0.22
SEE	0.41	0.83	0.30	7.30	98.70	11.55	34.60	0.21

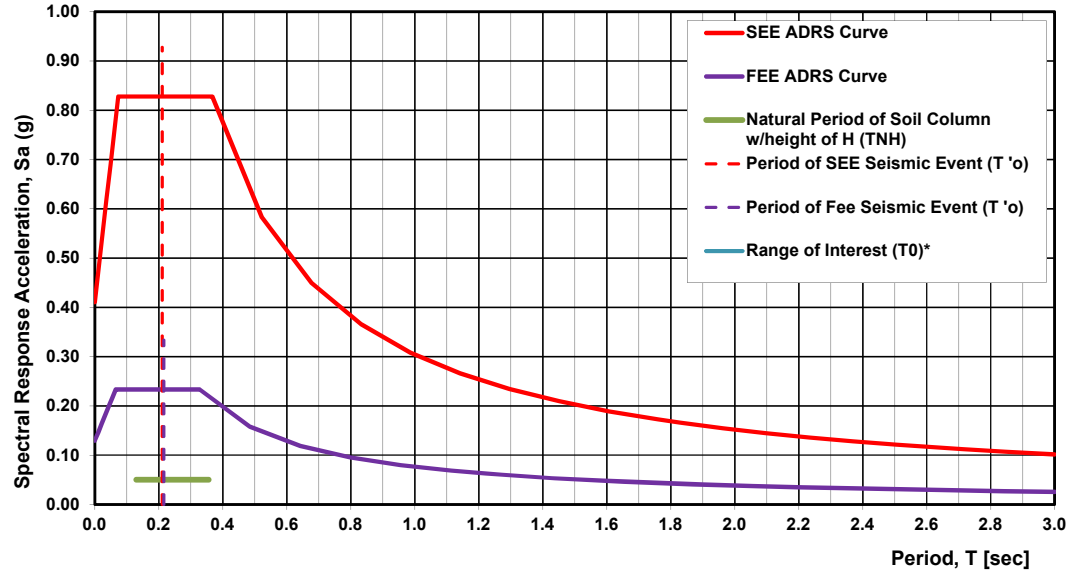
Fundamental Period of Structure, T _o	Range of Interest		V* _{s,H}	H	T _{NH}	
	sec				sec	
sec	0.5*T _o	2.0*T _o	ft/sec	ft	(4*H)/V* _{s,H}	(6*H)/V* _{s,H}
0.00	0.00	0.00	1011.09	60.00	0.13	0.36
0.00	0.00	0.00				

H = B-C Boundary

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

South Carolina Coastal Plain
*Same Geologic Condition as used in SCENARIO_PC (2006)

SC Seismic ADRS Curve



FEE Data		SEE Data	
T	S _a	T	S _a
0.00	0.129	0.00	0.411
0.01	0.147	0.01	0.480
0.02	0.164	0.02	0.550
0.03	0.181	0.04	0.619
0.04	0.199	0.05	0.689
0.05	0.216	0.06	0.758
To	0.233	To	0.828
0.09	0.233	0.10	0.828
0.11	0.233	0.12	0.828
0.13	0.233	0.15	0.828
0.15	0.233	0.17	0.828
0.17	0.233	0.20	0.828
0.20	0.233	0.22	0.828
0.22	0.233	0.24	0.828
0.24	0.233	0.27	0.828
0.26	0.233	0.29	0.828
0.28	0.233	0.32	0.828
0.31	0.233	0.34	0.828
0.33	0.233	Ts	0.828
0.49	0.158	0.52	0.582
0.64	0.119	0.68	0.449
0.80	0.096	0.83	0.366
0.96	0.080	0.99	0.308
1.11	0.069	1.14	0.266
1.27	0.060	1.30	0.235
1.43	0.054	1.45	0.210
1.59	0.048	1.61	0.189
1.74	0.044	1.76	0.173
1.90	0.040	1.92	0.159
2.06	0.037	2.07	0.147
2.21	0.035	2.23	0.137
2.37	0.032	2.38	0.128
2.53	0.030	2.54	0.120
2.69	0.028	2.69	0.113
2.84	0.027	2.85	0.107
3.00	0.026	3.00	0.101

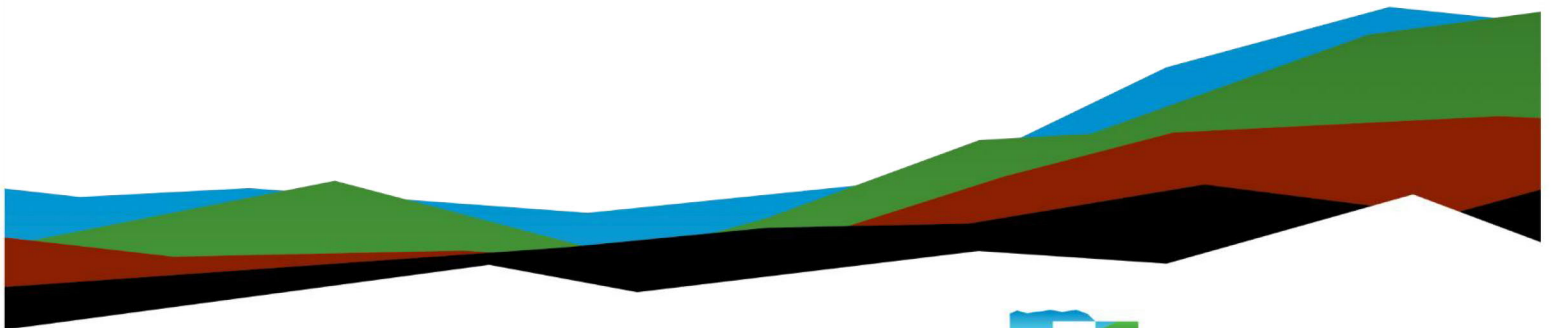
SPT Automatic Hammer Energy Measurement Report

Drill Rig Model: Diedrich D-50

Drill Rig Serial Number: D50-479

Asset Number: DR#1109

July 3, 2023



Prepared for:

Terracon Consultants, Inc.
Columbia, South Carolina



Nationwide
Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

July 03, 2023

Terracon Consultants Inc.
521 Clemson Rd.
Columbia, SC 29229

Attn: Chris Costner
E: chris.costner@terracon.com

Re: SPT Automatic Hammer Energy Measurement Report
Rig Serial Number: D50-479 Terracon Project Number: DUXX0500


Dear Mr. Costner:

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)
Diedrich D50	D50-479	2021	DR#1109	93.9% ± 2.3%	1.57

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



James P. Smith
National Manager of Equipment & Training



Rob Kramer
Geophysical Services Manager, COG

Attachments:

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

MEASUREMENT SUMMARY

ITEM	DESCRIPTION
Drill Rig Owner	Terracon Consultant, Inc. – Columbia, SC
Drill Rig Operator	Shiver Truesdale; Terracon Exploration
Testing Date	07/03/2023
Testing Location	Columbia, SC
Boring Identification	B-1
Hammer Type	140 pounds (automatic)
Boring Method	Rotary Wash
Drill Rods	<ul style="list-style-type: none"> ■ AWJ ■ 1-¾" 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	Micah Hatch– Department Manager, Terracon Consultants, Inc.

Exhibit A

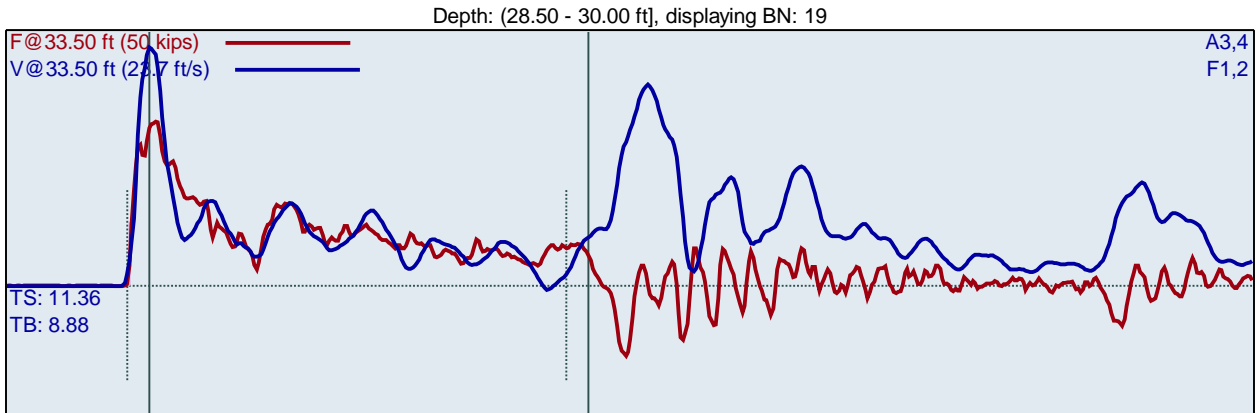
PDA SPT Analyzer Results

Diedrich D50 (SN 479)
M. Hatch
B-13 (PN 73235076)

28.5-30
Interval start: 7/3/2023

AR: 1.18 in²
LE: 33.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [512AWJ] 207.75 PDICAL (1) FF1
F2 : [512AWJ2] 208.76 PDICAL (1) FF1

A3 (PR): [K5998] 403.535 mv/6.4v/5000g (1) VF1
A4 (PR): [K10493] 411.89 mv/6.4v/5000g (1) VF1

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
3	6	32	23.8	48.1	315	89.9
4	6	34	23.8	47.8	319	91.3
5	6	32	23.5	48.4	316	90.4
6	6	32	23.3	47.8	324	92.5
7	6	32	23.0	48.3	325	92.8
8	6	32	22.2	48.2	316	90.4
9	6	32	22.0	47.7	324	92.7
10	6	32	22.7	48.5	324	92.7
11	6	32	21.6	47.9	326	93.3
12	6	31	21.3	48.4	326	93.1
13	9	32	21.7	47.7	329	94.1
14	9	32	22.1	48.0	326	93.3
15	9	32	21.8	47.9	331	94.7
16	9	31	21.7	48.2	329	93.9
17	9	32	21.8	48.1	334	95.4
18	9	33	22.2	47.5	338	96.5
19	9	32	22.1	48.4	340	97.1
20	9	32	22.2	48.1	326	93.2
21	9	32	22.7	47.8	332	94.8
Average		32	22.1	48.1	329	93.9
Std Dev		0	0.4	0.3	6	1.6
Maximum		33	23.0	48.5	340	97.1
Minimum		31	21.3	47.5	316	90.4

N-value: 15

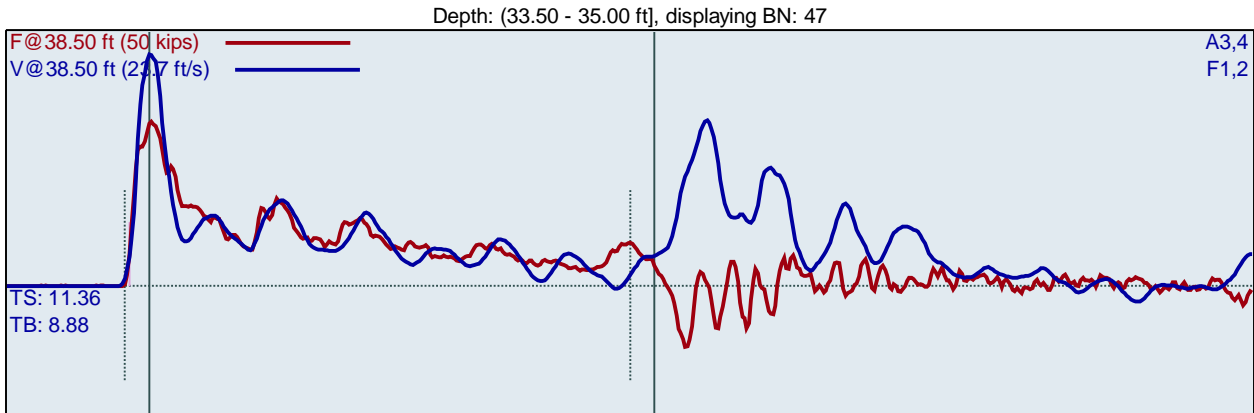
Sample Interval Time: 22.48 seconds.

Diedrich D50 (SN 479)
M. Hatch
B-13 (PN 73235076)

28.5-30
Interval start: 7/3/2023

AR: 1.18 in²
LE: 38.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



F1 : [512AWJ] 207.75 PDICAL (1) FF1
F2 : [512AWJ2] 208.76 PDICAL (1) FF1

A3 (PR): [K5998] 403.535 mv/6.4v/5000g (1) VF1
A4 (PR): [K10493] 411.89 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
23	7	32	19.5	48.3	314	89.7
24	7	31	19.4	48.4	305	87.0
25	7	31	19.9	48.1	311	88.9
26	7	31	19.4	48.2	310	88.6
27	7	31	19.5	48.0	311	88.8
28	7	31	19.9	48.1	310	88.7
29	9	31	19.6	48.0	314	89.8
30	9	32	19.8	48.3	314	89.7
31	9	30	19.2	48.0	309	88.3
32	9	31	19.7	48.2	313	89.5
33	9	31	19.6	47.9	313	89.5
34	9	30	19.3	48.0	310	88.7
35	9	32	21.2	48.3	319	91.2
36	9	32	21.3	48.3	321	91.7
37	9	33	22.0	48.1	327	93.5
38	12	32	20.4	48.2	302	86.2
39	12	32	21.6	47.9	319	91.2
40	12	32	21.1	47.9	321	91.7
41	12	31	20.4	48.0	311	88.9
42	12	31	20.9	48.1	324	92.6
43	12	32	21.8	48.0	322	92.1
44	12	32	22.3	48.1	323	92.3
45	12	32	21.4	48.1	317	90.6
46	12	32	21.8	48.2	323	92.4
47	12	32	21.5	48.2	322	92.0
48	12	33	22.0	48.2	320	91.4
49	12	32	21.8	47.7	322	92.1

Average	32	20.9	48.1	318	90.7
Std Dev	1	1.0	0.2	6	1.7
Maximum	33	22.3	48.3	327	93.5
Minimum	30	19.2	47.7	302	86.2

N-value: 21

Sample Interval Time: 32.40 seconds.

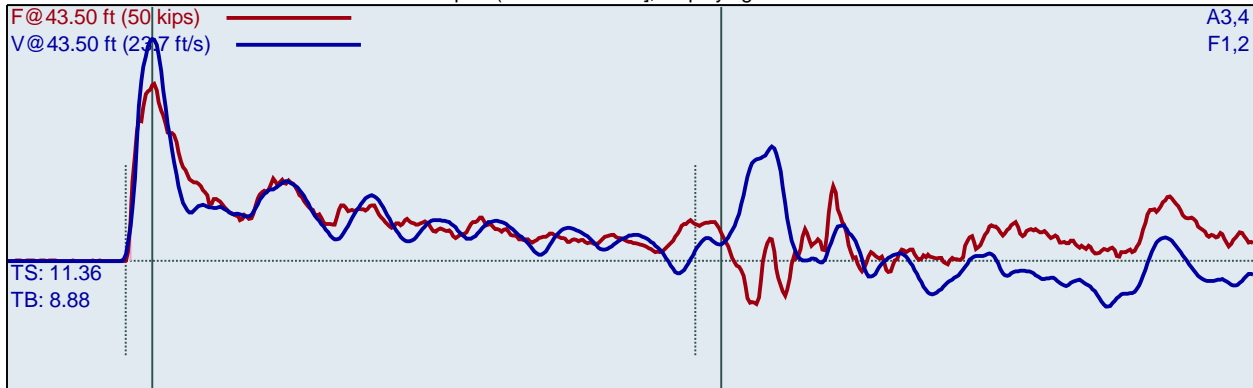
Diedrich D50 (SN 479)
M. Hatch
B-13 (PN 73235076)

28.5-30
Interval start: 7/3/2023

AR: 1.18 in²
LE: 43.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (38.50 - 40.00 ft), displaying BN: 114



F1 : [512AWJ] 207.75 PDICAL (1) FF1
F2 : [512AWJ2] 208.76 PDICAL (1) FF1

A3 (PR): [K5998] 403.535 mv/6.4v/5000g (1) VF1
A4 (PR): [K10493] 411.89 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
51	17	35	21.7	47.4	339	96.8
52	17	35	21.7	48.4	336	96.0
53	17	35	21.7	48.2	336	96.1
54	17	34	21.7	48.2	337	96.3
55	17	34	21.7	48.1	339	96.9
56	17	34	21.2	48.1	337	96.2
57	17	34	21.2	48.3	336	95.9
58	17	33	21.2	48.4	322	92.1
59	17	35	22.2	48.1	343	98.0
60	17	33	21.2	48.0	324	92.6
61	17	34	21.8	48.3	337	96.3
62	17	34	21.7	48.0	331	94.5
63	17	33	21.3	48.2	335	95.6
64	17	34	21.8	48.2	336	95.9
65	17	34	22.1	48.0	329	94.0
66	17	33	21.4	48.3	336	96.1
67	19	34	21.7	48.5	331	94.7
68	19	33	21.3	47.8	336	95.9
69	19	33	21.2	48.2	334	95.3
70	19	35	22.9	47.8	344	98.4
71	19	34	22.1	48.1	339	96.9
72	19	33	20.9	48.3	333	95.0
73	19	33	20.8	48.1	331	94.4
74	19	34	20.7	47.9	329	94.1
75	19	34	20.9	48.2	331	94.6
76	19	34	21.1	47.7	343	97.9
77	19	35	20.9	48.3	332	94.9
78	19	35	21.1	48.3	336	96.1
79	19	34	20.5	48.1	338	96.5
80	19	34	20.6	48.4	338	96.7
81	19	34	20.4	48.3	326	93.2

82	19	33	20.2	48.0	336	96.0
83	19	34	20.3	48.3	333	95.1
84	19	33	20.1	47.7	325	92.8
85	19	33	19.9	48.4	330	94.4
86	31	35	20.5	47.9	332	94.9
87	31	34	20.5	48.1	330	94.3
88	31	33	20.3	47.8	324	92.5
89	31	33	20.8	48.3	336	95.9
90	31	33	20.6	48.0	331	94.6
91	31	34	20.4	48.4	338	96.7
92	31	33	20.2	48.5	329	94.0
93	31	34	20.6	48.0	336	96.1
94	31	34	20.7	48.6	334	95.3
95	31	34	20.5	48.6	334	95.4
96	31	34	20.3	48.5	331	94.5
97	31	33	20.3	48.4	331	94.6
98	31	34	20.3	48.5	332	94.9
99	31	33	20.5	48.4	333	95.2
100	31	33	20.0	48.0	338	96.5
101	31	34	21.1	48.3	332	94.8
102	31	33	20.0	48.1	334	95.4
103	31	34	20.2	48.8	329	93.9
104	31	33	20.0	48.3	331	94.4
105	31	33	20.1	48.1	330	94.3
106	31	35	20.4	47.9	334	95.5
107	31	34	20.2	48.3	331	94.5
108	31	34	20.1	48.0	335	95.7
109	31	34	20.0	48.3	327	93.3
110	31	34	20.0	47.9	330	94.2
111	31	34	20.3	47.6	331	94.6
112	31	34	20.5	47.2	333	95.1
113	31	35	20.4	47.6	336	95.9
114	31	35	20.6	47.7	335	95.7
115	31	34	20.6	47.2	335	95.7
116	31	34	20.6	47.2	339	96.7
Average		34	20.6	48.1	333	95.2
Std Dev		1	0.6	0.4	4	1.2
Maximum		35	22.9	48.8	344	98.4
Minimum		33	19.9	47.2	324	92.5

N-value: 50

Sample Interval Time: 81.06 seconds.

Summary of SPT Test Results

Project: Diedrich D50 (SN 479), Test Date: 7/3/2023

FMX: Maximum Force		N		Average	Average	EFV: Maximum Energy		Average	
VMX: Maximum Velocity		Value	Value	FMX	VMX	ETR: Energy Transfer Ratio - Rated		ETR	
BPM: Blows/Minute	Instr. Length ft	Blows Applied /6"		kips	ft/s	BPM bpm	EFV ft-lb	%	
	33.50	6-6-9	15	23	32	22.1	48.1	329	93.9
	38.50	7-9-12	21	32	32	20.9	48.1	318	90.7
	43.50	17-19-31	50	78	34	20.6	48.1	333	95.2
Overall Average Values:				33	20.9	48.1	328	93.9	
Standard Deviation:				1	0.9	0.3	8	2.3	
Overall Maximum Value:				35	23.0	48.8	344	98.4	
Overall Minimum Value:				30	19.2	47.2	302	86.2	

Exhibit B

PDA Equipment Calibration

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model SPT

Serial Number: 4510 TB

was calibrated on 25 August 2022
using a PDA Calibration Box whose output was calibrated with test equipment
traceable to NIST.

This certificate is valid for 2 years from above date.



Tested by:

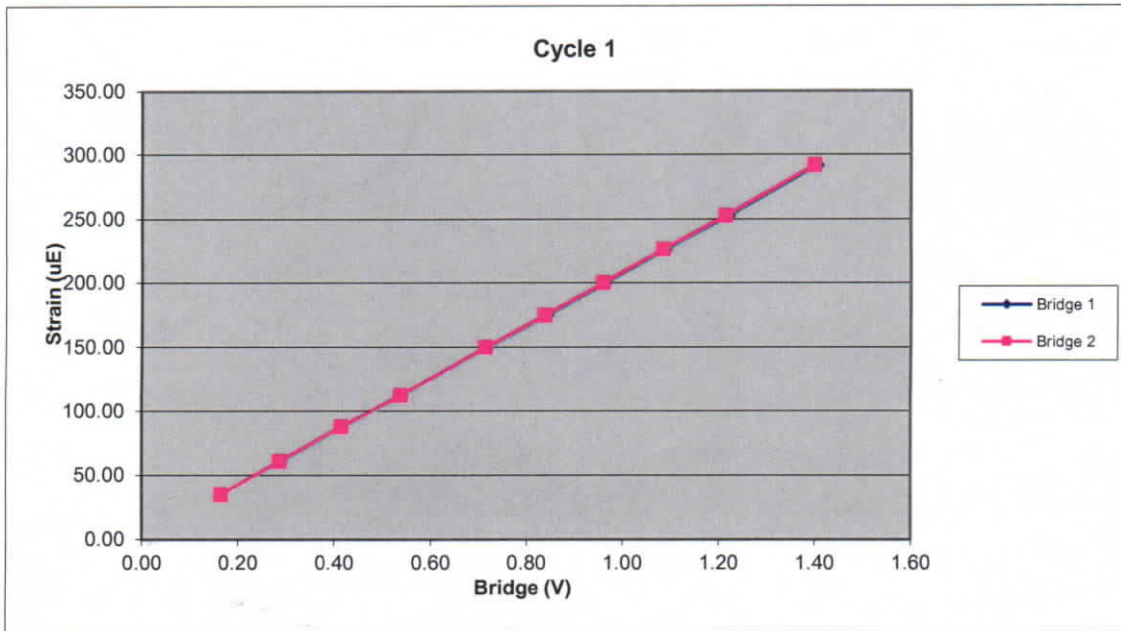


MJG
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

512AWJ		Cycle 1		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1203.06	34.31	0.16	0.16
3	2126.16	60.40	0.29	0.29
4	3077.44	86.97	0.42	0.42
5	3982.41	111.72	0.54	0.54
6	5285.39	149.30	0.72	0.72
7	6200.50	174.57	0.84	0.84
8	7099.62	199.59	0.96	0.96
9	8021.85	226.03	1.09	1.08
10	8981.90	252.42	1.22	1.21
11	10350.08	291.62	1.40	1.40

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7371.63	Force Calibration (lb/V)	7404.01
Offset	-2.95	Offset	-5.32
Correlation	1.000000	Correlation	0.999999
Strain Calibration (μ E/V)	207.13	Strain Calibration (μ E/V)	208.04
Offset	0.34	Offset	0.27
Correlation	0.999991	Correlation	0.999992

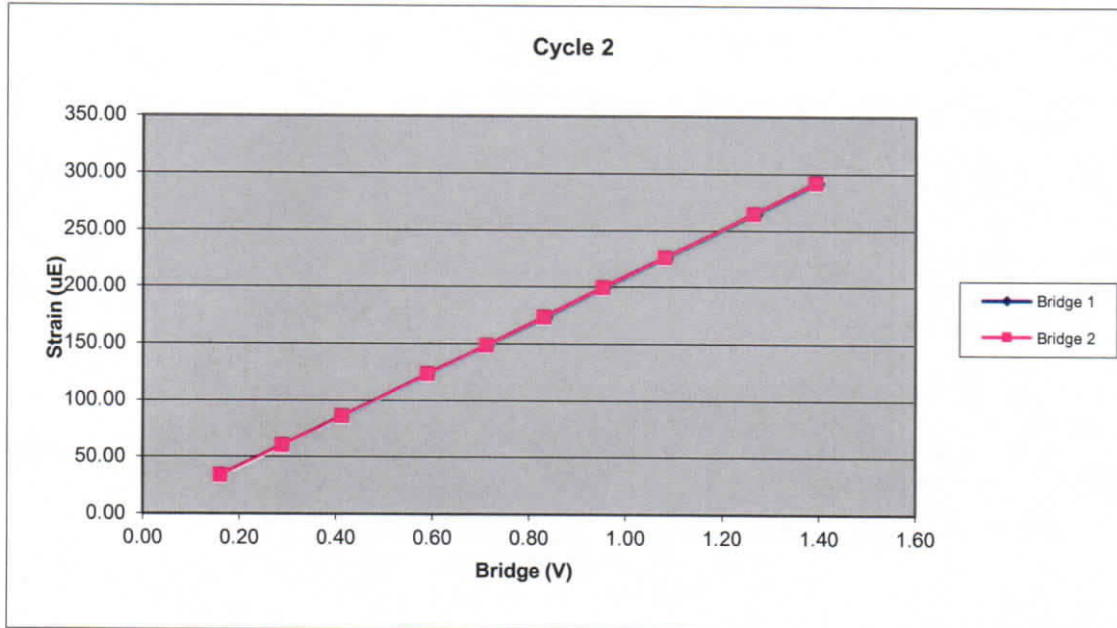
Force Strain Calibration	
EA (Kips)	35589.20
Offset	-14.99
Correlation	0.999992



512AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1195.16	33.02	0.16	0.16
3	2140.49	59.36	0.29	0.29
4	3060.77	84.68	0.41	0.41
5	4361.31	122.48	0.59	0.59
6	5276.03	147.78	0.71	0.71
7	6152.73	172.65	0.83	0.83
8	7048.15	198.82	0.96	0.95
9	8008.49	225.14	1.08	1.08
10	9364.20	264.06	1.27	1.26
11	10320.35	291.14	1.40	1.39

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7383.19	Force Calibration (lb/V)	7408.85
Offset	1.99	Offset	1.61
Correlation	0.999999	Correlation	1.000000
Strain Calibration ($\mu\text{E}/\text{V}$)	209.13	Strain Calibration ($\mu\text{E}/\text{V}$)	209.86
Offset	-1.28	Offset	-1.29
Correlation	0.999988	Correlation	0.999991

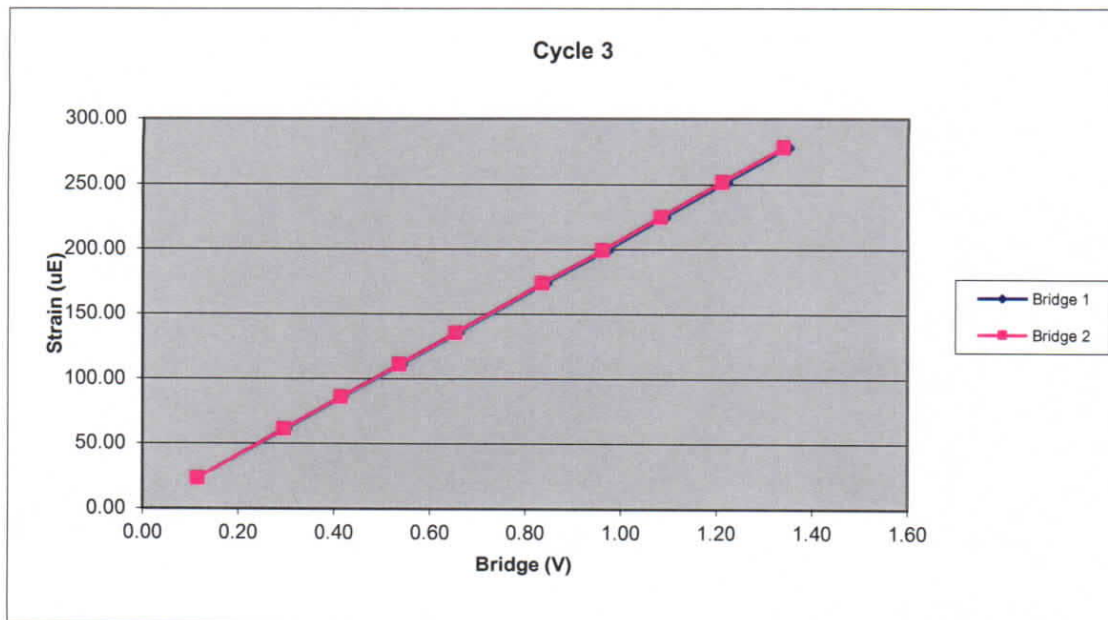
Force Strain Calibration	
EA (Kips)	35302.85
Offset	47.38
Correlation	0.999989



512AWJ		Cycle 3		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	843.37	22.72	0.11	0.11
3	2199.17	60.67	0.30	0.29
4	3069.54	85.62	0.42	0.41
5	3979.10	110.64	0.54	0.54
6	4849.18	135.11	0.66	0.65
7	6197.28	173.33	0.84	0.84
8	7134.13	198.98	0.97	0.96
9	8033.64	224.83	1.09	1.08
10	8976.83	251.64	1.22	1.21
11	9937.94	277.86	1.35	1.34

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7369.64	Force Calibration (lb/V)	7419.12
Offset	-2.56	Offset	0.17
Correlation	0.999999	Correlation	0.999999
Strain Calibration ($\mu E/V$)	206.99	Strain Calibration ($\mu E/V$)	208.38
Offset	-1.03	Offset	-0.95
Correlation	0.999995	Correlation	0.999995

Force Strain Calibration	
EA (Kips)	35602.66
Offset	34.21
Correlation	0.999994



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

Calibration Factors	512AWJ		
Bridge 1 ($\mu\text{E/V}$)	207.75	Bridge 2 ($\mu\text{E/V}$)	208.76
EA Factor (Kips)	35498.24	Area (in²)	1.18

Calibrated by: 
Calibrated Date: 8/31/2022

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 03Aug2022

Serial No: K5998 Temperature: 74.7 °F
 Model: PR Humidity: 53%
 Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR

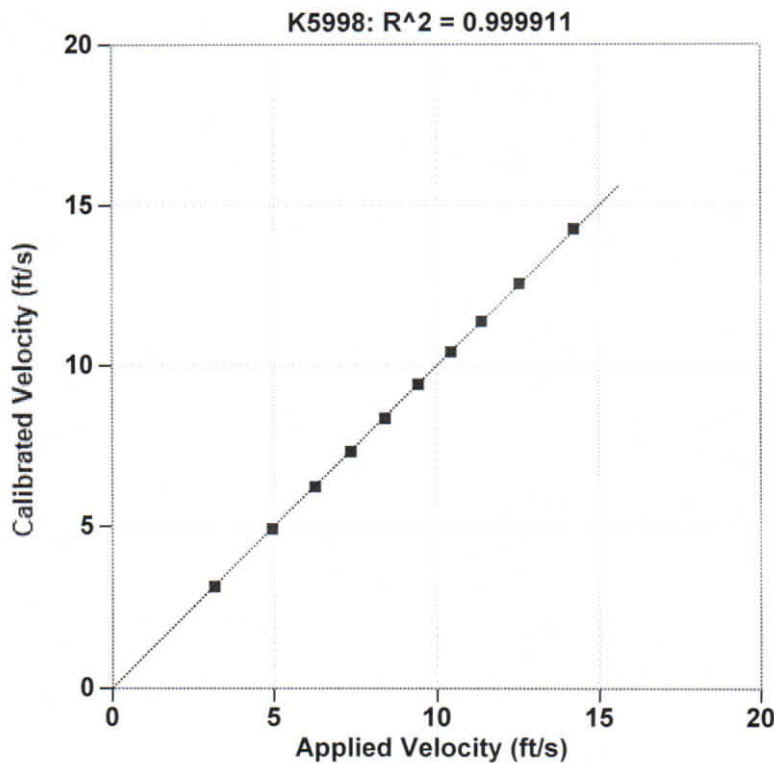
403.5 mv/5000g
 (80.7 $\mu\text{v/g}$)
 R²: 0.999911 [Chip programmed]

Operator: William Johnson

Ref Acc 1: 72505! Cal on: 24Mar2022
 1035 g's/volt
 Ref Acc 2: 72517! Cal on: 24Mar2022
 1049 g's/volt

William Johnson
 Signed

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



Reference Velocity	S/N K5998 Velocity
ft/s	ft/s
3.158	3.142
4.952	4.919
6.268	6.242
7.350	7.338
8.411	8.359
9.429	9.410
10.433	10.412
11.368	11.386
12.542	12.568
14.216	14.271

Maximum Acceleration: 959 g's

Accelerometer Calibration Certificate

Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.
 Calibration performed on 03Aug2022

Serial No: K10493 Temperature: 74.7 °F
 Model: PR Humidity: 53%
 Calibrated on: Channel 3 on 8G 5161 LE

PDA CALIBRATION FACTOR

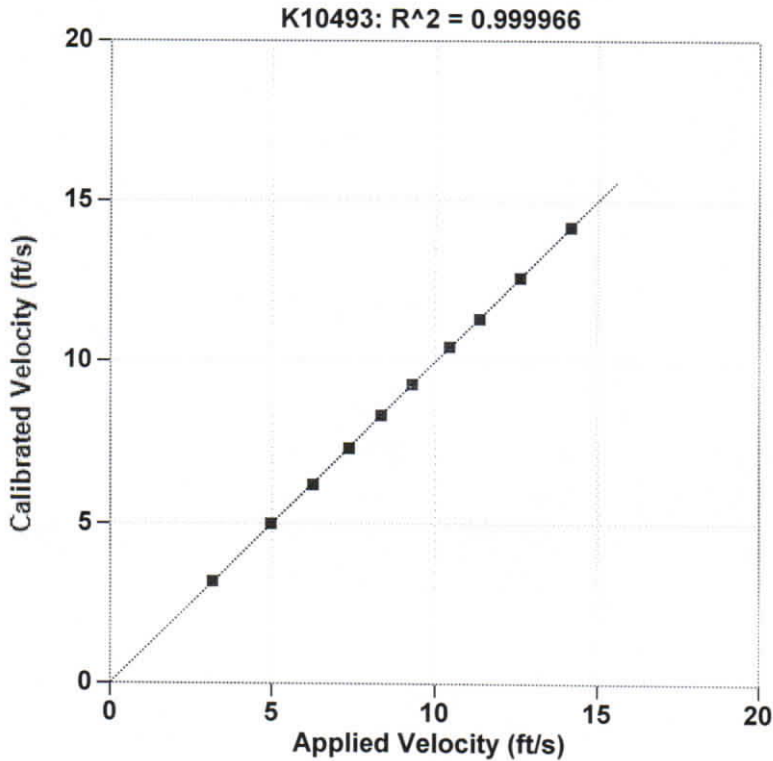
411.9 mv/5000g
 (82.4 $\mu\text{v/g}$)
 R²: 0.999966 [Chip programmed]

Operator: William Johnson

Ref Acc 1: 72505! Cal on: 24Mar2022
 1035 g's/volt
 Ref Acc 2: 72517! Cal on: 24Mar2022
 1049 g's/volt


 Signed

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



Reference Velocity ft/s	S/N K10493 Velocity ft/s
3.172	3.199
4.972	4.995
6.253	6.217
7.351	7.341
8.342	8.345
9.293	9.296
10.433	10.456
11.350	11.329
12.605	12.608
14.169	14.170

Maximum Acceleration: 952 g's