

Geotechnical Data Report

**S-35-33 (David Pond Road)
Emergency Bridge Replacement over Naked Creek
Marlboro County, South Carolina**

November 29, 2018
SCDOT Project ID.: P038249
Terracon Project No. 7318P119E

Prepared for:
South Carolina Department of Transportation
Columbia, South Carolina

Prepared by:
Terracon Consultants, Inc.
Columbia, South Carolina

Offices Nationwide
Employee-Owned

Established in 1965
terracon.com

Terracon

November 29, 2018



South Carolina Department of Transportation
955 Park Street, Room 421
Columbia, South Carolina 29201

Attn: Mr. Trapp Harris, P.E.
Geotechnical Design Engineer – Design-Build Section

Re: Geotechnical Data Report
S-35-33 (David Pond Road) Emergency BRO Naked Creek
Marlboro County, South Carolina
SCDOT Project ID.: P038249
Terracon Project Number: 7318P119E

Dear Mr. Harris:

Terracon Consultants Inc. (Terracon) has completed the geotechnical exploration and testing services for the above referenced project. These services were conducted in general accordance with the SCDOT Request for Subsurface Exploration and Laboratory Testing (SCDOT Project ID: P038249, authorized on November 5, 2018). This geotechnical data report presents the findings of the subsurface exploration and laboratory testing along with an overview of testing activities.

1.0 INTRODUCTION

The South Carolina Department of Transportation (SCDOT) has contracted Terracon to perform subsurface exploration and laboratory testing for the replacement of the S-35-33 (David Pond Road) bridge over Naked Creek in Marlboro County, SC. The purpose of this work is to develop information relative to subsurface soil and groundwater conditions at the bridge location. No geotechnical recommendations are associated with the requested scope of study.

The following sections of this report contain a summary of the activities for our field exploration and laboratory testing. The logs of the borings, the Site Location Map and the Exploration Plan are included in Appendix A. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included in Appendix B. Descriptions of the field exploration and laboratory testing are included in their respective appendices.



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Geotechnical



Environmental



Construction Materials



Facilities

2.0 PROJECT DESCRIPTION

The project site is located at the bridge crossing of S-35-33 (David Pond Road) and Naked Creek in Marlboro County, South Carolina. It is our understanding that the project will include the replacement of the previously damaged bridge with a new structure on the existing or similar horizontal alignment. The original structure appears to have been supported with round timber piles.

3.0 GEOTECHNICAL TESTING

The geotechnical exploration for this project was performed between November 21 and 27, 2018. The results of our field work and our associated laboratory testing is attached in Appendixes A and B of this report.

3.1 Field Exploration

Our field exploration at the site consisted of the following:

- Two (2) Standard Penetration Test (SPT) Borings (B-1 and B-2)

The tests were performed at the approximate locations provided by the SCDOT. A description of our testing methods and graphical logs outlining the soil conditions at each test location are presented in Appendix A. Test locations were established in the field by Terracon and surveyed by Construction Support Services, LLC, after completion. Photographs of the drill rig set up at each boring location are provided in Appendix A.

3.2 Laboratory Testing

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

- Eight (8) Natural Moisture Content Tests
- Five (5) Particle-Size Distribution (Gradation) Tests
- Two (2) No. 200 Wash
- Three (3) Atterberg Limits Tests

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

Geotechnical Data Report

S-35-33 RBO Naked Creek ■ Marlboro County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038249



4.0 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.

Phillip A. Morrison, P.E.
Geotechnical Department Manager
SC Registration No. 17275

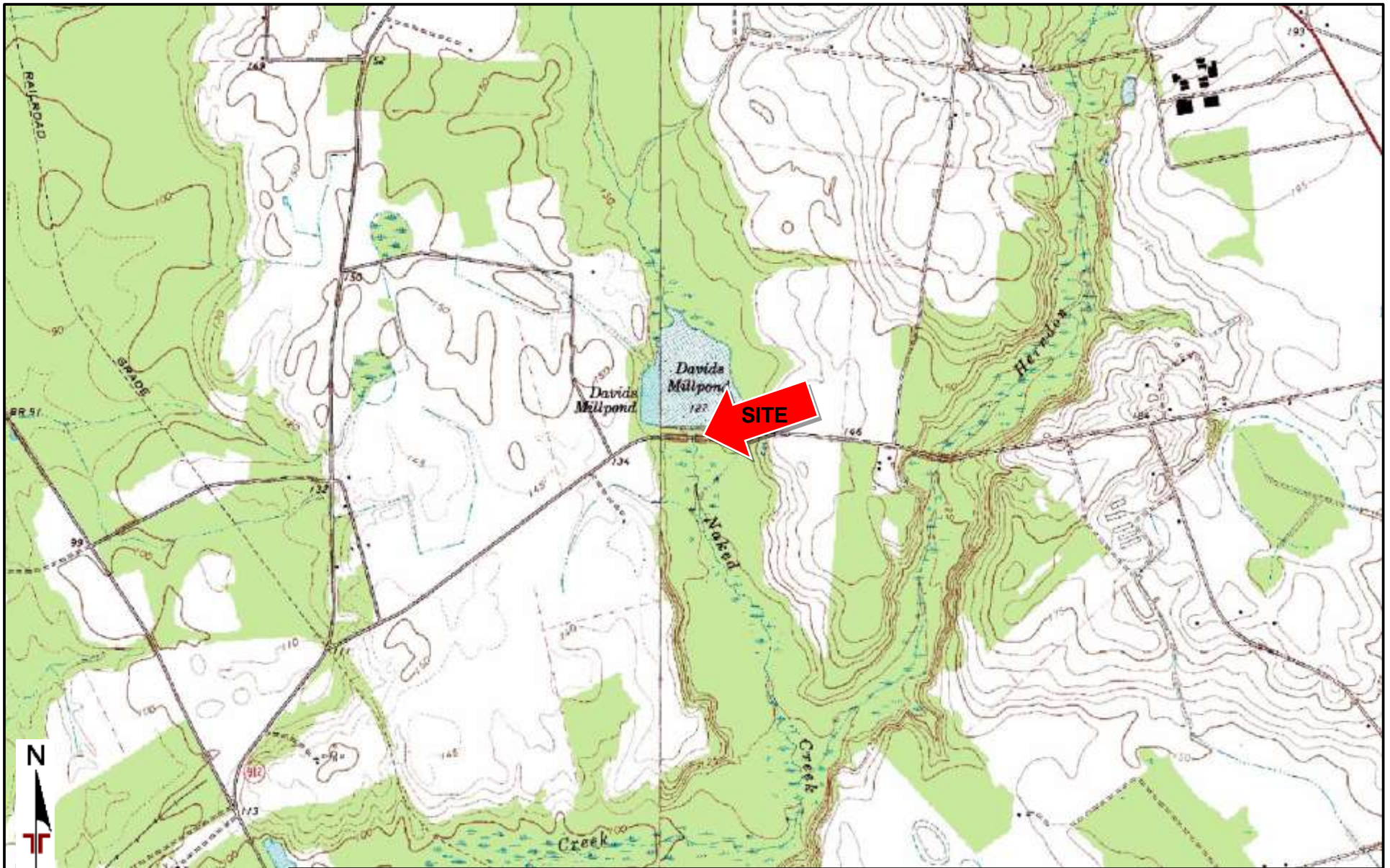
Thomas C. Smoak, P.E.
Project Engineer

Attachments:

- Appendix A
- Appendix B
- Appendix C

APPENDIX A
FIELD EXPLORATION

- Exhibit A-1 – Site Location Map**
- Exhibits A-2 – Exploration Plan**
- Exhibit A-3 – Summary of Field Data**
- Exhibit A-4 – Field Exploration Description**
- Exhibit A-5 – Soil Description Terms**
- Exhibit A-6 – Soil Rock Symbol Log**
- Exhibit A-7 – Boring Logs**
- Exhibit A-8 – Drill Rig Photograph Log**



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
 QUADRANGLES INCLUDE: WALLACE, SC (1/1/1971) and BENNETTSVILLE NORTH, SC (1/1/1972).

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


Project Manager:	PAM	Project No.	7318P119E
Drawn by:	PTK	Scale:	1"=2,000'
Checked by:	PAM	File Name:	A-1 & A-2
Approved by:	PAM	Date:	Nov. 2018

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SITE LOCATION MAP
 S-35-33 (David's Mill Pond Rd)
 RBO over Naked Creek
 Marlboro County, South Carolina

Exhibit
A-1



 **BORING LOCATION**



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AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager:	PAM
Drawn by:	PTK
Checked by:	PAM
Approved by:	PAM

Project No.	7318P119
Scale:	AS SHOWN
File Name:	A-1 & A-2
Date:	Nov. 2018

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Columbia, SC 29229-4307

EXPLORATION PLAN
S-35-33 (David's Mill Pond Rd) RBO over Naked Creek Marlboro County, South Carolina

Exhibit
A-2

Geotechnical Data Report

S-35-33 RBO Naked Creek ■ Marlboro County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038249



Summary of Field Data

Test No.	Ground Elevation (ft)	Test Depth (ft.)	Northing	Easting	Latitude	Longitude
B-1	124.69	100	1024917.08	2376461.29	N34.643971	W79.748331
B-2	122.53	100	1024929.37	2376563.53	N34.644002	W79.747990

Geotechnical Data Report

S-35-33 RBO Naked Creek ■ Marlboro County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038249



FIELD EXPLORATION DESCRIPTION

Overview

The general testing locations were provided by the SCDOT and located in the field by Terracon by taking measurements from existing structures. The borings were surveyed by Construction Support Services, LLC after testing and drilling was complete. The locations are shown on the appended Exploration Plan.

A field log of each test location was prepared by our field 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 2010
- ASTM D5783, "Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geo-environmental Exploration"
- ASTM D1586 "Test Method for Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D4220 "Standard Practices for Preserving and Transporting Soil"

Each boring was advanced using rotary wash drilling techniques to the planned termination depths. The sampling program is summarized in the following table:

Test ID	Total Depth	Interval of Continuous Sampling
B-1	100 feet or refusal and 20 feet of coring	0 to 10 feet
B-2	100 feet or refusal and 20 feet of coring	0 to 10 feet

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

Geotechnical Data Report

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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 on Exhibit A-5.

Consistent with SCDOT GDM, the borings were drilled using mud rotary drilling techniques. As the drilling method introduces water into the borehole, time-of-drilling water levels could not be recorded. As noted on the boring log, the water levels of the borings were recorded 1 day after the start of drilling activities. These water levels are indicated on the boring logs. At the conclusion of the work, the boreholes were backfilled with sand and the borings were capped with cold-patch asphalt.

SOIL DESCRIPTION TERMS

Relative Density/Consistency Terms

<u>Relative Density¹</u>			<u>Consistency²</u>		
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

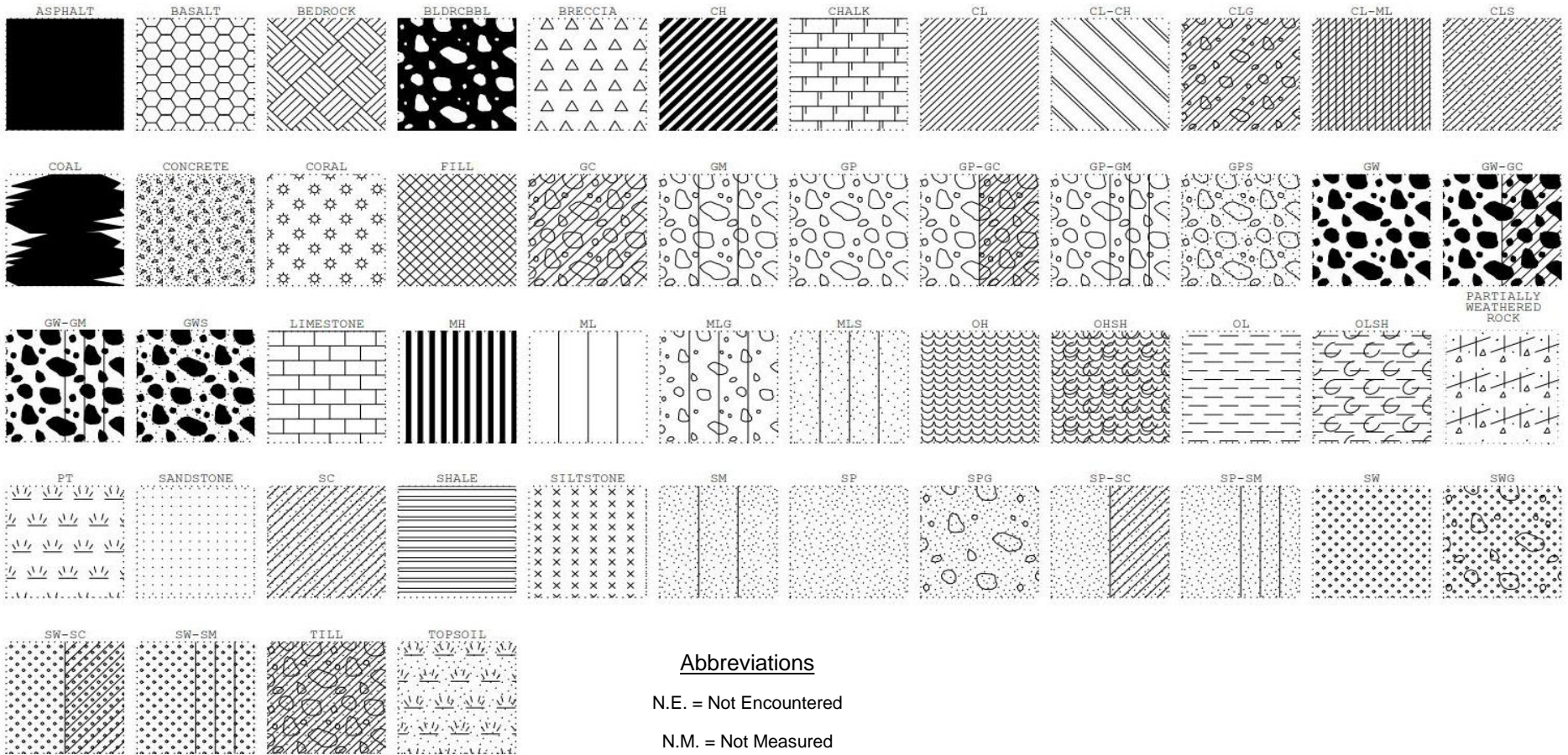
AASHTO Soil Designation

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

¹ Applies to coarse-grained soils (major portion retained on No. 200 sieve)

² Applies to fine-grained soils (major portion passing No. 200 sieve)

³ Use as required



Abbreviations

N.E. = Not Encountered

N.M. = Not Measured

Project Manager:	KJZ
Project No.	7318P119B
Drawn by:	KJZ
Scale:	N.T.S.
Checked by:	KJZ
File Name:	Soil - Rock - Log
Approved by:	PAM
Date:	JULY 2016

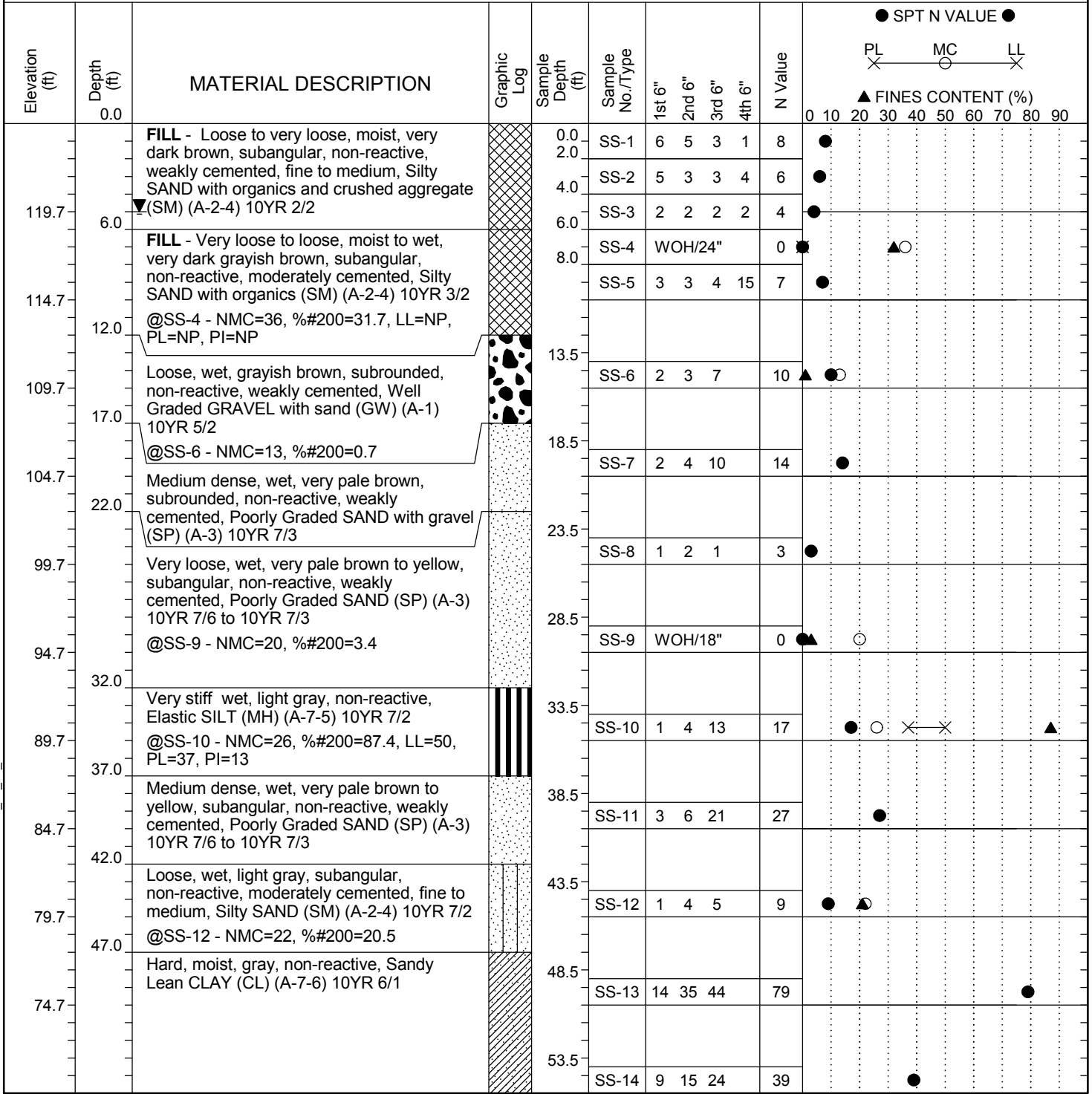
Terracon
Consulting Engineers & Scientists

521 Clemson Road Columbia, South Carolina 29229
PH. (803) 741-9000 FAX. (803) 741-9900

SOIL / ROCK / LOG SYMBOL LEGEND

SCDOT Soil Test Log

Project ID: P038249	County: Marlboro	Boring No.: B-1
Site Description: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek	Route: S-35-33	
Eng./Geo.: PM	Boring Location:	Offset:
Elev.: 124.7 ft	Latitude: 34.643971	Longitude: -79.748331
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: N.A. ft
Bore Hole Diameter (in): 3	Sampler Configuration	Liner Required: Y (N)
Drill Machine: CME-55/595	Drill Method: RW	Hammer Type: Automatic
Core Size: N.A.	Driller: WB	Energy Ratio: 88.3%
	Groundwater: TOB	24HR: 5 ft



LEGEND

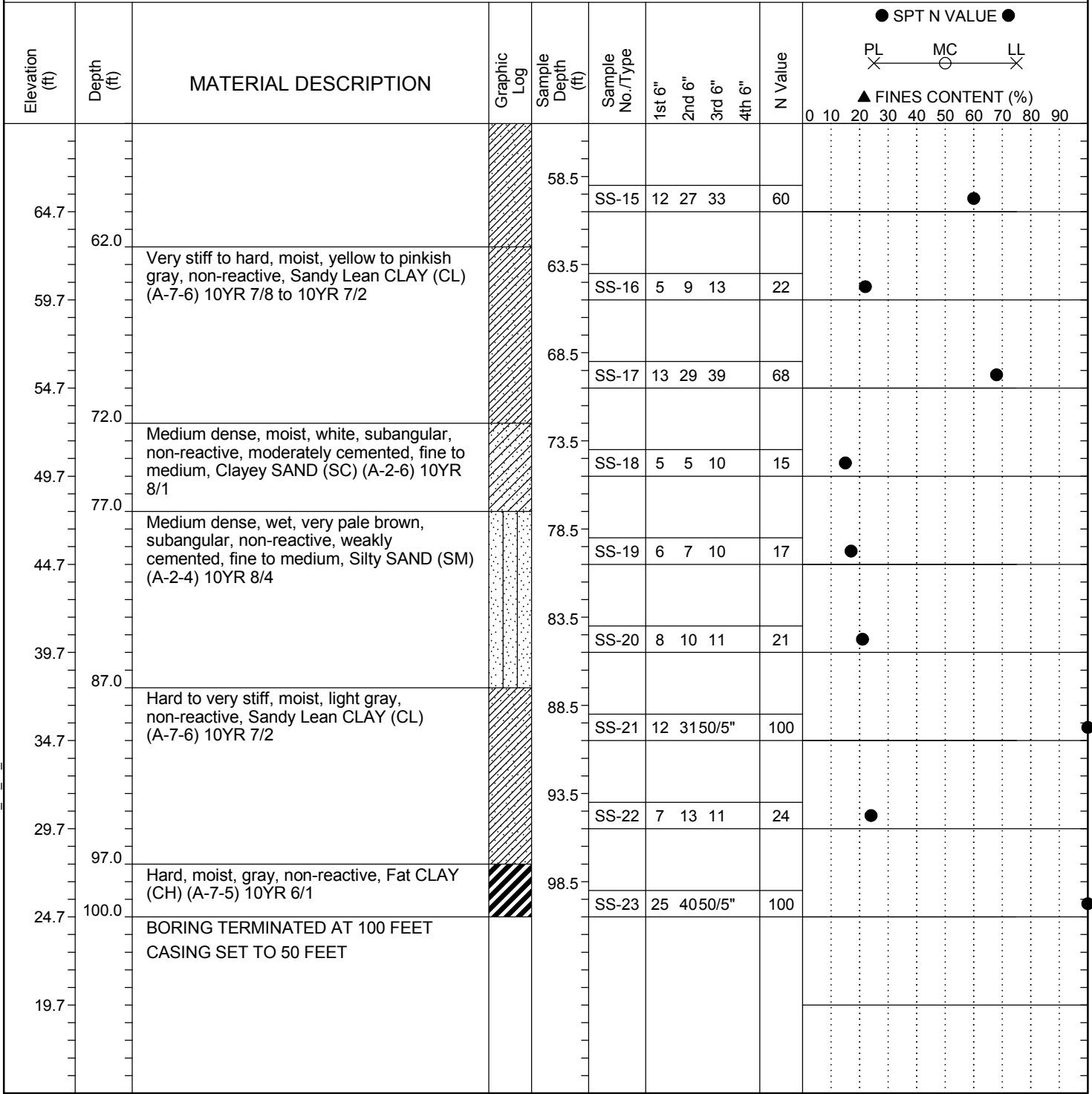
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SAMPLER TYPE SS - Split Spoon UD - Undisturbed Sample AWG - Rock Core, 1-1/8" NQ - Rock Core, 1-7/8" CU - Cuttings CT - Continuous Tube		DRILLING METHOD HSA - Hollow Stem Auger CFA - Continuous Flight Augers DC - Driving Casing RW - Rotary Wash RC - Rock Core	
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SC_DOT_7318P119E S-35-33 SCDOT DATA TEMPLATE_01_30_2015.GDT 11/29/18

SCDOT Soil Test Log

Project ID: P038249	County: Marlboro		Boring No.: B-1
Site Description: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek		Route: S-35-33	
Eng./Geo.: PM	Boring Location:		Offset:
Elev.: 124.7 ft		Latitude: 34.643971	Longitude: -79.748331
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: N.A. ft	Date Started: 11/20/2018
Bore Hole Diameter (in): 3		Sampler Configuration	Liner Required: Y (N)
Drill Machine: CME-55/595		Drill Method: RW	Energy Ratio: 88.3%
Core Size: N.A.	Driller: WB	Groundwater: TOB N.M.	24HR 5 ft



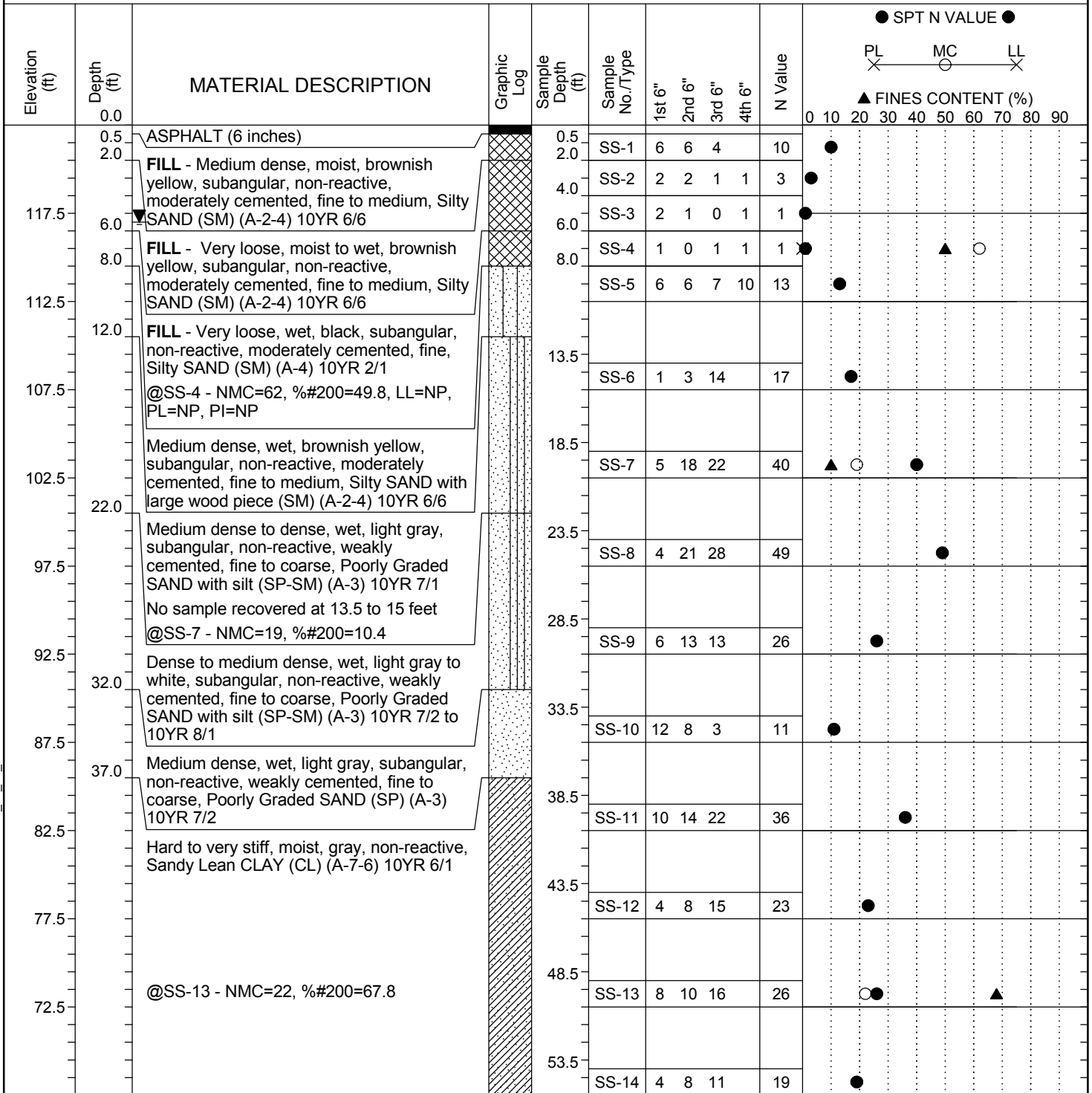
LEGEND

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_7318P119E S-35-33 SCDOT DATA TEMPLATE_01_30_2015.GDT 11/29/18

SCDOT Soil Test Log

Project ID: P038249	County: Marlboro	Boring No.: B-2
Site Description: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek	Route: S-35-33	
Eng./Geo.: PM	Boring Location:	Offset:
Elev.: 122.5 ft	Latitude: 34.644002	Longitude: -79.74799
Total Depth: 100 ft	Soil Depth: 100 ft	Core Depth: N.A. ft
Bore Hole Diameter (in): 3	Sampler Configuration	Liner Required: Y (N)
Drill Machine: CME-55/727	Drill Method: RW	Hammer Type: Automatic
Core Size: N.A.	Driller: AM	Energy Ratio: 93.2%
	Groundwater: TOB	24HR: 5.5 ft



LEGEND

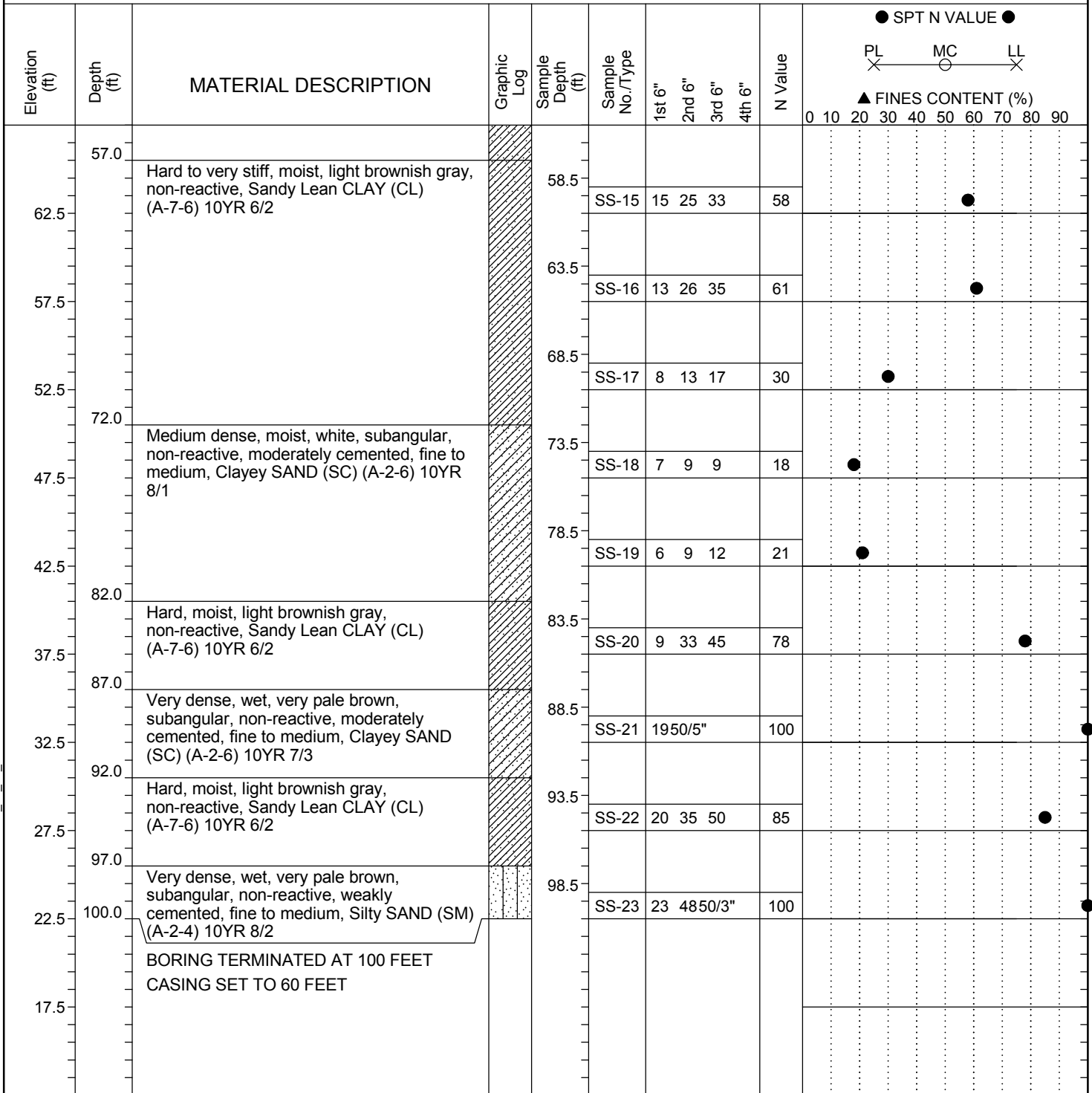
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC_DOT_7318P119E S-35-33 SCDOT DATA TEMPLATE_01_30_2015.GDT 11/29/18

SCDOT Soil Test Log

Project ID:	P038249		County:	Marlboro	Boring No.:	B-2	
Site Description:	S-35-33 (David's Mill Pond Rd) RBO over Naked Creek				Route:	S-35-33	
Eng./Geo.:	PM	Boring Location:		Offset:		Alignment:	Main
Elev.:	122.5 ft	Latitude:	34.644002	Longitude:	-79.74799	Date Started:	11/26/2018
Total Depth:	100 ft	Soil Depth:	100 ft	Core Depth:	N.A. ft	Date Completed:	11/27/2018
Bore Hole Diameter (in):	3	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME-55/727	Drill Method:	RW	Hammer Type:	Automatic	Energy Ratio:	93.2%
Core Size:	N.A.	Driller:	AM	Groundwater:	TOB N.M.	24HR	5.5 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_7318P119E S-35-33 SCDOT.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 11/29/18

Geotechnical Data Report

S-35-33 RBO Naked Creek ■ Marlboro County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038249



Drill rig on B-1



Drill rig on B-2

APPENDIX B
LABORATORY TESTING

Exhibit B-1 – Laboratory Testing Description
Exhibit B-2 – Summary of Laboratory Data
Laboratory Data Sheets

Geotechnical Data Report

S-35-33 RBO Naked Creek ■ Marlboro County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038249



LABORATORY TESTING DESCRIPTION

The samples collected during the field exploration were taken to our laboratory for additional testing. The laboratory testing program was developed by the SCDOT. Using the provided testing program, the laboratory tests were conducted on selected soil samples from the borings. 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:

- | | |
|---|----------------------------|
| ■ Particle-Size Distribution (Gradation) of Soils | ASTM D6913 |
| ■ Materials Finer Than 75- μ m (No. 200) Sieve | AASHTO T11/(ASTM D1140) |
| ■ Liquid Limit, Plastic Limit and Plasticity Index of Soils | AASHTO T89/90/(ASTM D4318) |
| ■ Determination of Moisture Content of Soils | AASHTO T265/(ASTM D2216) |

Summary of Laboratory Results

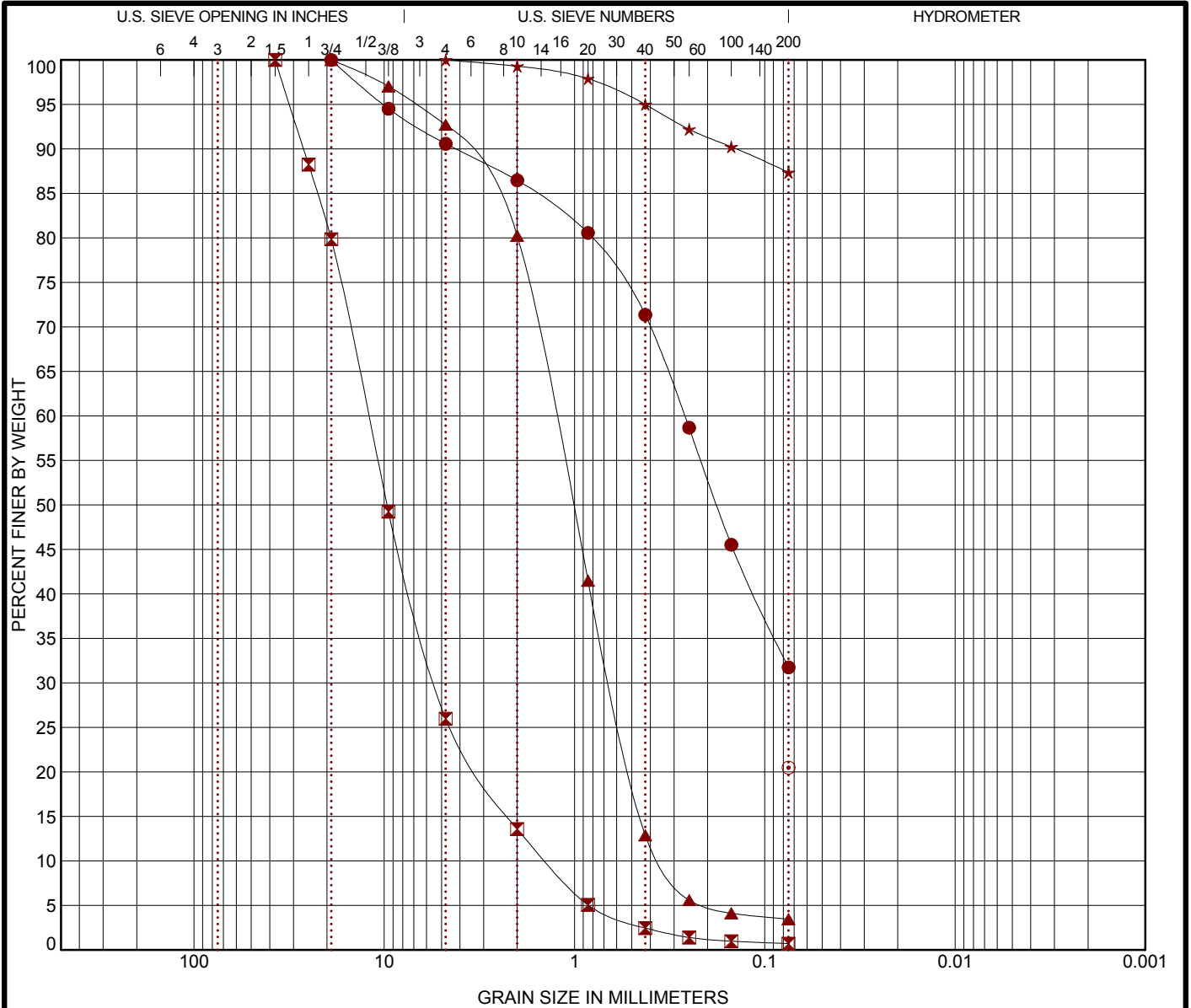
BORING ID	Depth (Ft.)	% Gravel	% Sand	% Fines	Liquid Limit	Plastic Limit	Plasticity Index	Water Content (%)
B-1	6 - 8	9.4	58.8	31.7	NP	NP	NP	36
B-1	13.5 - 15	74.0	25.3	0.7				13
B-1	28.5 - 30	7.3	89.3	3.4				20
B-1	33.5 - 35	0.0	12.6	87.4	50	37	13	26
B-1	43.5 - 45			20.5				22
B-2	6 - 8	0.0	50.2	49.8	NP	NP	NP	62
B-2	18.5 - 20			10.4				19
B-2	48.5 - 50			67.8				22

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART LAB SUMMARY-PORTRAIT_7318P119E S-35-33 LAB DATA.GPJ TERRACON_DATATEMPLATE.GDT 11/29/18

PROJECT: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek	521 Clemson Rd Columbia, SC	PROJECT NUMBER: 7318P119E
SITE: Marlboro County, South Carolina Marlboro County, South Carolina		CLIENT: SCDOT Columbia, South Carolina
		EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY	
	coarse	fine	coarse	medium	fine		

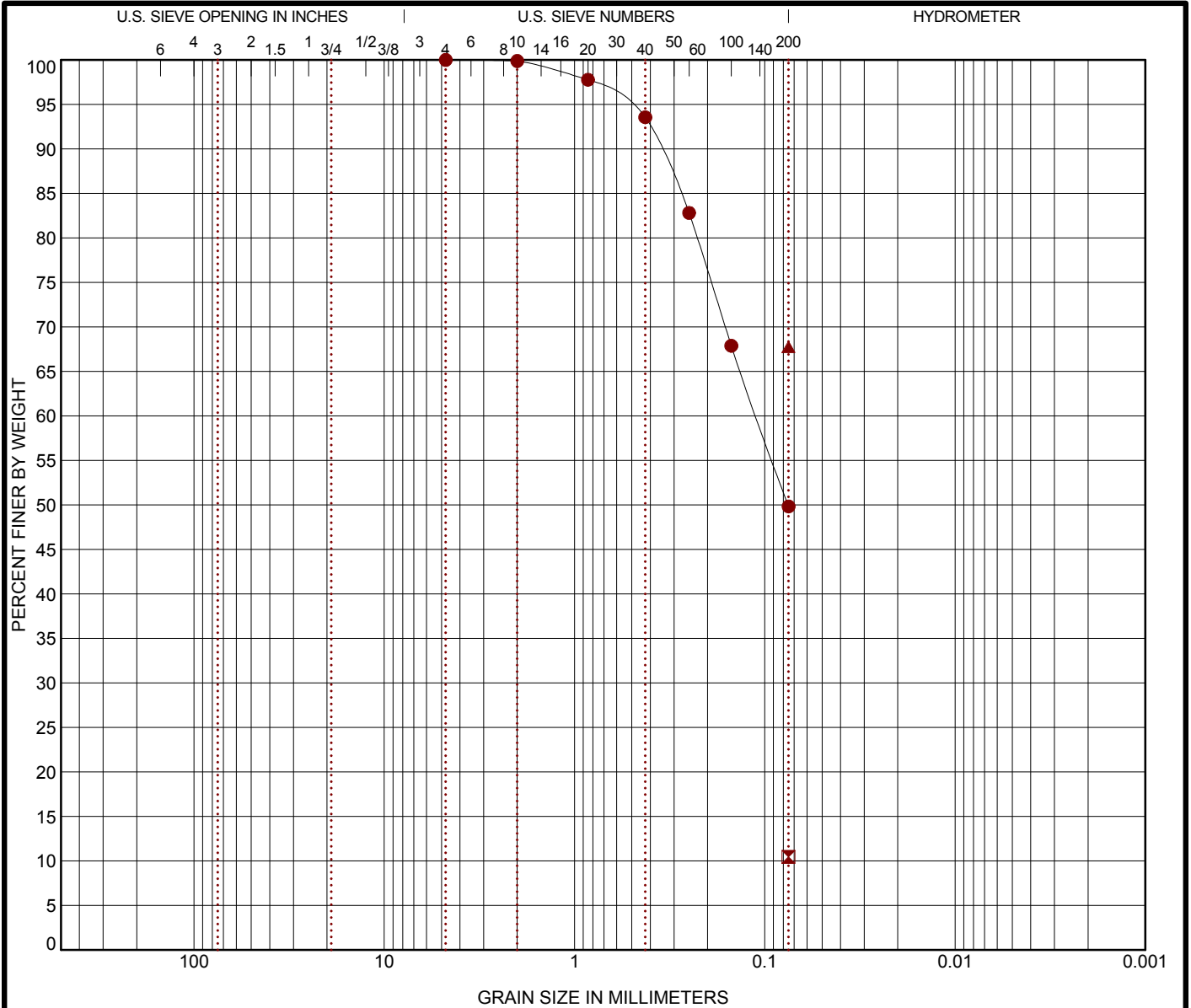
Boring ID	Depth	USCS Classification				WC (%)	LL	PL	PI	Cc	Cu
● B-1	6 - 8	SILTY SAND (SM)				36	NP	NP	NP		
⊠ B-1	13.5 - 15	WELL GRADED GRAVEL WITH SAND (GW)				13				1.69	8.67
▲ B-1	28.5 - 30	POORLY GRADED SAND (SP)				20				0.94	3.71
★ B-1	33.5 - 35	ELASTIC SILT (MH)				26	50	37	13		
⊙ B-1	43.5 - 45	SILTY SAND (SM)				22					
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Gravel	%Sand	%Silt	%Fines	%Clay	
● B-1	6 - 8	19	0.264			9.4	58.8		31.7		
⊠ B-1	13.5 - 15	37.5	12.121	5.356	1.398	74.0	25.3		0.7		
▲ B-1	28.5 - 30	19	1.279	0.644	0.345	7.3	89.3		3.4		
★ B-1	33.5 - 35	4.75				0.0	12.6		87.4		
⊙ B-1	43.5 - 45	0.075							20.5		

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 7318P119E S-35-33 LAB DATA.GPJ TERRACON_DATATEMPLATE.GDT 11/29/18

PROJECT: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek	<p style="font-size: small;">521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7318P119E CLIENT: SCDOT Columbia, South Carolina EXHIBIT: B-4
SITE: Marlboro County, South Carolina Marlboro County, South Carolina		

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY			
	coarse	fine	coarse	medium	fine				

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● B-2	6 - 8	SILTY SAND (SM)	62	NP	NP	NP		
⊠ B-2	18.5 - 20	POORLY GRADED SAND WITH SILT (SP-SM)	19					
▲ B-2	48.5 - 50	SANDY CLAY (CL)	22					

Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Gravel	%Sand	%Silt	%Fines	%Clay
● B-2	6 - 8	4.75	0.111			0.0	50.2		49.8	
⊠ B-2	18.5 - 20	0.075							10.4	
▲ B-2	48.5 - 50	0.075							67.8	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 7318P119E S-35-33 LAB DATA.GPJ TERRACON_DATATEMPLATE.GDT 11/29/18

PROJECT: S-35-33 (David's Mill Pond Rd) RBO over Naked Creek	<p style="font-size: small;">521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7318P119E CLIENT: SCDOT Columbia, South Carolina EXHIBIT: B-5
SITE: Marlboro County, South Carolina Marlboro County, South Carolina		

APPENDIX C
SUPPORTING DOCUMENTS

Exhibit C-1 – Rig Calibration Documentation

DRILL RIG SPT HAMMER ENERGY CALIBRATION REPORT

Drill Rig Model CME-55 LCX SN 399875

Terracon Drill Rig # 595

November 2, 2018



Prepared for:

Terracon Consultants, Inc.
Columbia, SC

Prepared by:

Terracon Consultants, Inc.
North Charleston, South
Carolina

Offices Nationwide
Employee-Owned

Established in 1965
terracon.com

Terracon

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities



November 2, 2018

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

Attn: Mr. Phillip Morrison, P.E.
P: 803-212-0062
E: pamorrison@terracon.com

Re: SPT Hammer Energy Calibration Report
Terracon Rig # 595, CME-55 LCX, SN:399875

Dear Mr. Morrison:

This report provides the Energy Transfer Ratio (ETR) for the SPT hammer found on drill rig model CME-55 LCX, Drill Rig # 595 (Serial Number 399875).

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

Sincerely,

Terracon Consultants, Inc.

Ryan Wakeford
Staff Engineer

Susheel R. Kolwalkar, Ph.D., P.E.
Senior Engineer

Zachary J. McIntosh
Field Engineer

Attachments :

- Exhibit A-1: Representative Blow
- Exhibit A-2: PDA Equipment Calibrations
- Exhibit A-3: SPT Calibration Data Plots and Tables
- Exhibit A-4: Field Log



Terracon Consultants, Inc. 1450 Fifth Street West North Charleston, South Carolina 29405
P [843] 884 1234 F [843] 884 9234 terracon.com

Geotechnical



Environmental



Construction Materials



Facilities

1.0 PROJECT INFORMATION

ITEM	DESCRIPTION
Drill Rig Identification	CME-55 LCX, SN 399875, DR # 595 (see photograph on cover page)
Drill Rig Owner	Terracon
Drill Rig Operator	Abel Mcguire
Testing Date	October 24, 2018
Testing Location	SC Community Living Center, Florence, SC
Boring Identification	B-1
Energy Measurement Depths	23.5 ft, 28.5 ft.; 33.5 ft.
Hammer Type	Automatic
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> ■ AWJ ■ 1¾" outside diameter ■ 3/16" wall thickness
SPT Calibration Testing Equipment	<ul style="list-style-type: none"> ■ 2 foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers ■ Model PAX Pile Driving Analyzer™ (PDA)
ASTM Methods Used	<p>ASTM D1586-11 – Standard Test Method for Standard Penetration Test and Split Barrel Sampling of Soils</p> <p>ASTM D4633-16 – Standard Methods for Energy Measurement for Dynamic Penetrometers</p>
SPT Calibration Personnel	R. Wakeford

2.0 TEST RESULTS

Table 1: 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-1	23.5	25.0	0	3	1	5	8	12	-	20	SM	
	28.5	30.0	0	4	1	7	10	12	-	22	SM	
	33.5	35.0	0	5	1	5	7	14	-	21	SM	

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 provided by Terracon personnel

Table 2: Energy Measurement and Analysis Summary

Boring	Start Depth ¹ (ft)	SPT N _m (bpf)	No. of Blows ²	EMX ³ (kip-ft)			ETR ³ (%)		
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
B-1	23.5	20	20	0.32	0.29	0.31	0.008	87.3	2.299
	28.5	22	22	0.31	0.27	0.29	0.007	84.2	2.063
	33.5	21	21	0.34	0.32	0.33	0.008	93.4	2.241
Average:				0.32	0.29	0.31	0.008	88.3	2.20

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 first increment if refusal were encountered
3. EMX = Maximum Transferred Energy, ETR = Energy Transfer Ratio.

Table 3: 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-1	23.5	20	20	51.7	50.8	51.2	0.188
	28.5	22	22	51.8	51.1	51.4	0.174
	33.5	21	21	51.8	51.1	51.4	0.169
Average:				51.8	51.0	51.4	0.177

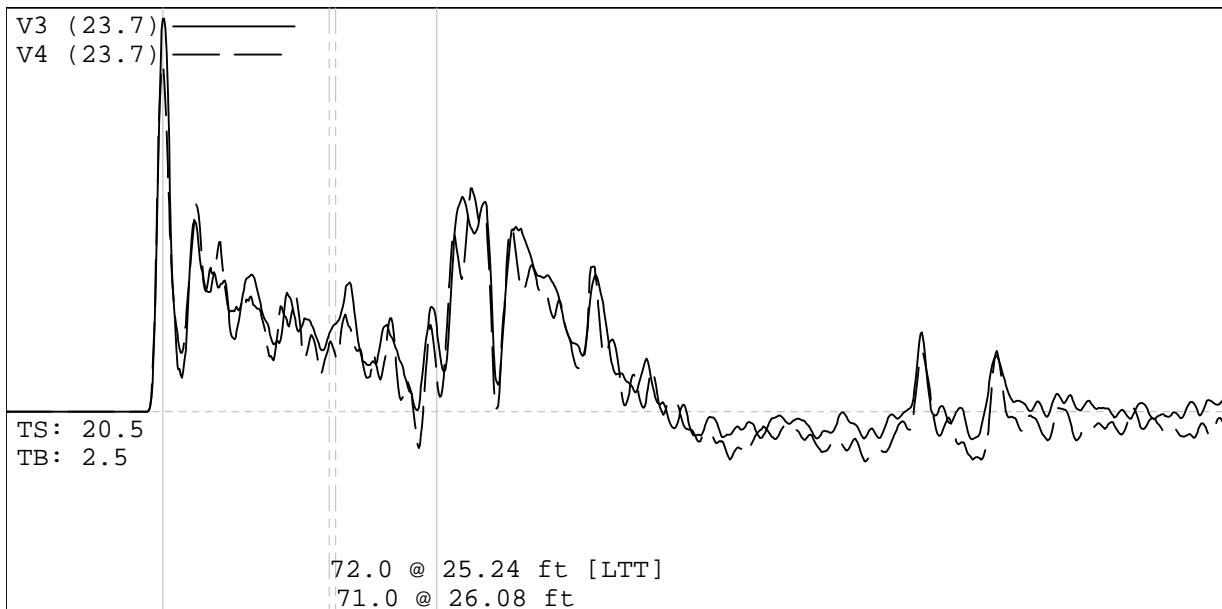
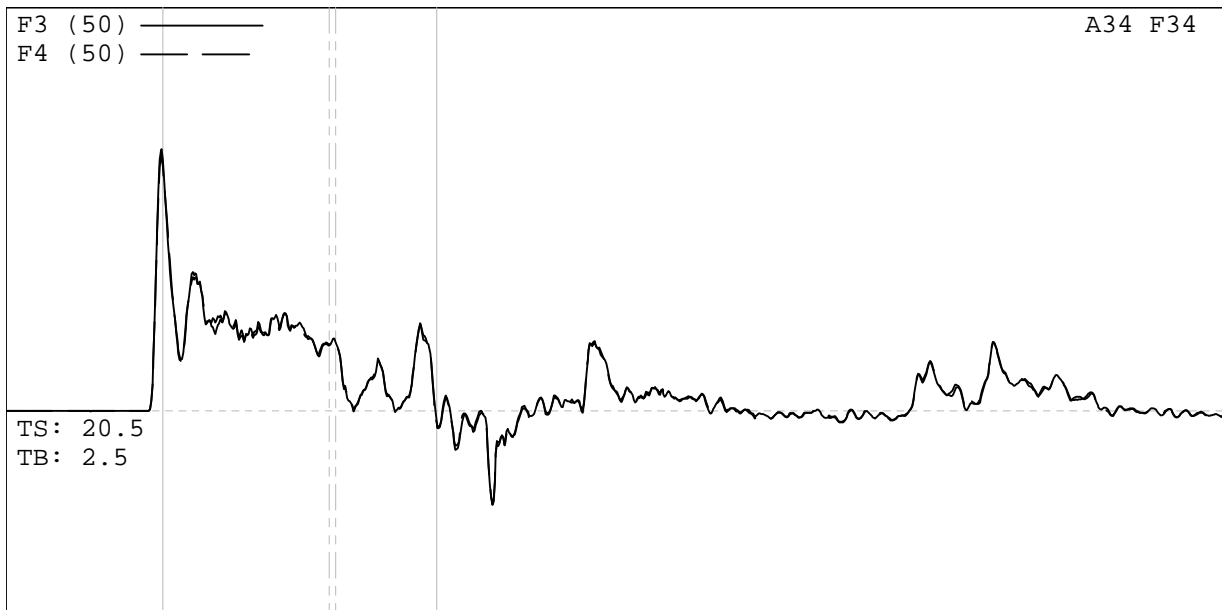
1. Boring ID and depth from existing ground surface to start of SPT.
2. Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
3. BPM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

3.0 CONCLUSIONS

3.1 Energy Transfer Ratio (ETR) and Hammer Efficiency Correction (CE)

Based on our testing and subsequent analysis, drill rig CME-55 LCX (No. 595) has an **ETR of 88.3% ± 2.20%**. Based on this ETR, the hammer efficiency correction (**C_E**) is **1.47**.

Exhibit A-1 Representative Blow



Project Information

PROJECT: SC COMMUNITY LIVING CENTER
 PILE NAME: CME 55 LCX DR#595_2
 DESCR: STB-1 33.5-35
 OPERATOR: RW
 FILE: CME 55 LCX 33.5-35
 10/24/2018 2:42:04 PM
 Blow Number 16

Quantity Results

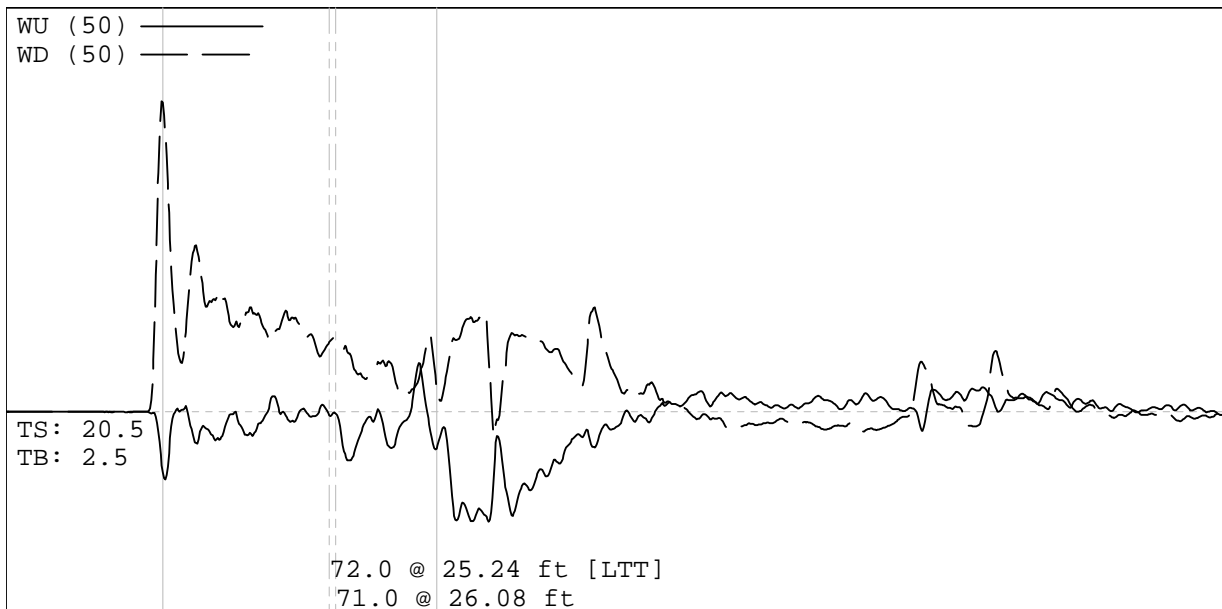
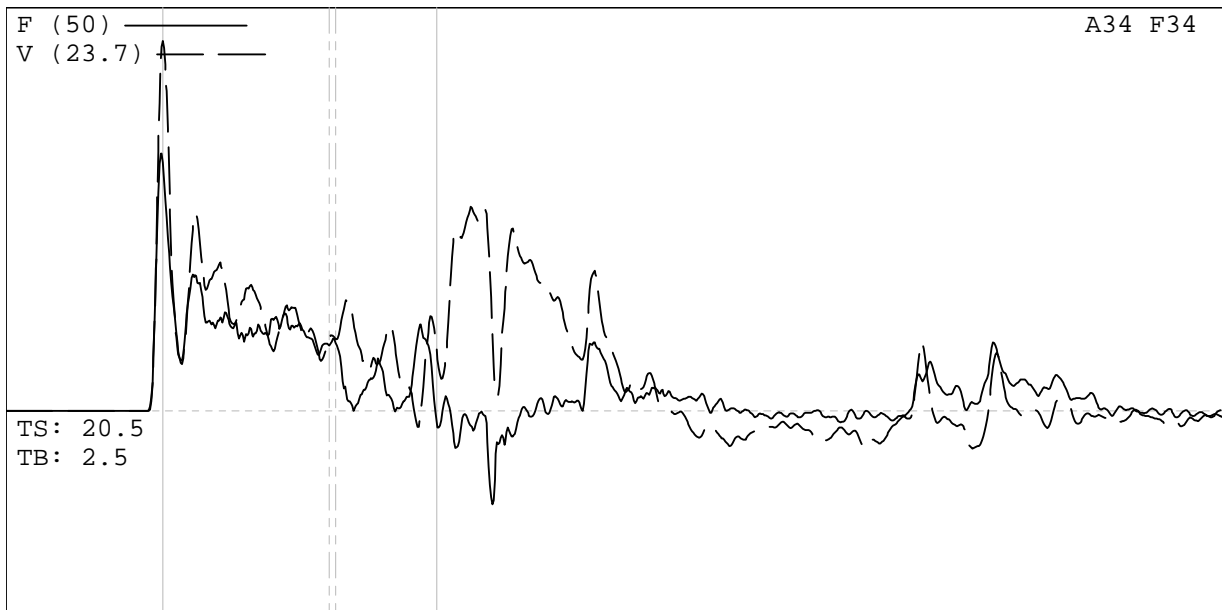
ETR 93.3 (%)
 CSX 27.0 ksi
 CSB 0.0 ksi
 BPM 51.5 bpm
 EMX 0.3 k-ft
 DMX 0.59 in
 SFR kips
 MEX 901 µE
 VMX 21.8 f/s

Pile Properties

LE 38.70 ft
 AR 1.18 in^2
 EM 30000 ksi
 SP 0.492 k/ft3
 WS 16807.9 f/s
 EA/C 2.1 ksec/ft
 2L/C 4.60 ms
 JC []
 LP 34.64 ft

Sensors

F3: [AWJ 2] 216.2 (1)
 F4: [AWJ 1] 216.53 (1)
 A3: [K5418] 382 mv/5000g's (1)
 A4: [K5431] 344 mv/5000g's (1)
 CLIP: OK



Project Information

PROJECT: SC COMMUNITY LIVING CENTER
 PILE NAME: CME 55 LCX DR#595_2
 DESCR: STB-1 33.5-35
 OPERATOR: RW
 FILE: CME 55 LCX 33.5-35
 10/24/2018 2:42:04 PM
 Blow Number 16

Quantity Results

ETR 93.3 (%)
 CSX 27.0 ksi
 CSB 0.0 ksi
 BPM 51.5 bpm
 EMX 0.3 k-ft
 DMX 0.59 in
 SFR kips
 MEX 901 µE
 VMX 21.8 f/s

Pile Properties

LE 38.70 ft
 AR 1.18 in²
 EM 30000 ksi
 SP 0.492 k/ft³
 WS 16807.9 f/s
 EA/C 2.1 ksec/ft
 2L/C 4.60 ms
 JC []
 LP 34.64 ft

Sensors

F3: [AWJ 2] 216.2 (1)
 F4: [AWJ 1] 216.53 (1)
 A3: [K5418] 382 mv/5000g's (1)
 A4: [K5431] 344 mv/5000g's (1)
 CLIP: OK

Exhibit A-2 PDA Equipment Calibrations

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model PAX

Serial Number 3766L

was calibrated on 30 April 2018

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

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

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics
2018-03-06 07:55

FS — BN 675
10 SL 693/ 3440/ 2

PJ:
PN: HOPBAR

A 4 -- US
F 2 3.3

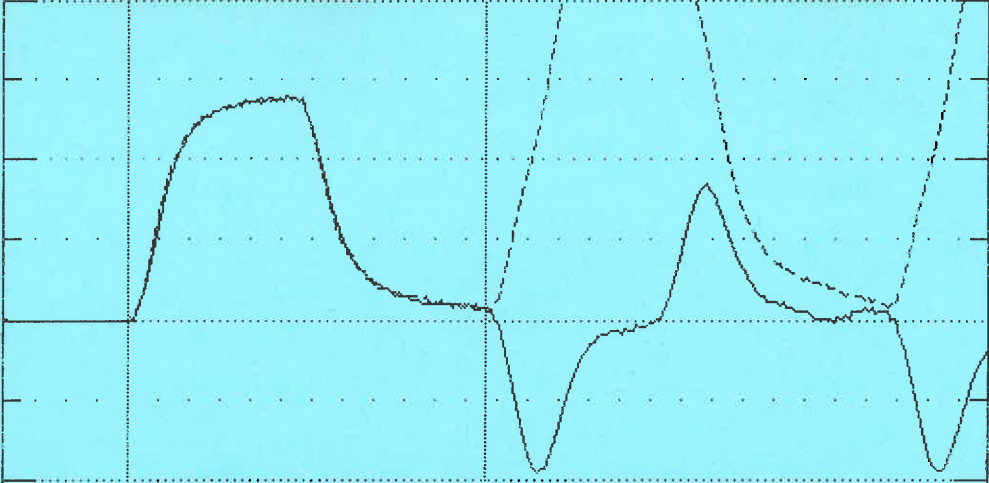
LE 17.0 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 7312 ft/s

JC 0.40
FM 1.00
VM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -42
UT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 344



TS 12 E B PD: k5431 LP 0.00 ft
TB 8.0 T1 9.6 2L/C 4.7 VA 1000 UE 1024 LI 1.0

UMX= 4.5 FMX= 70 AMX= 159
EMX= 0.3 MEX= 137 FVP= 0.99

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCEPT

ACCELEROMETER CALIBRATION N.I.S.T. Traceable
SERIAL NUMBER: K5431
CALIBRATION FACTOR: .0688 MV/G
PAK (*5000): 344 DATE: 6MAR18
PDA OPERATOR: [Signature]

<-AT:PIEZORESISTIVE

OP: laine [ver:5.01]

AT:PIEZOELECTRIC->

Smart Sensor

Smart Chip Programmed By X.W. on 6MAR18 CRC Value 738E

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics
2018-03-28 07:35

FS — BN 106
10 SL 510/ 3440/ 2

PJ:
PN: HOPBAR

A 4 -- US
F 2 3.3

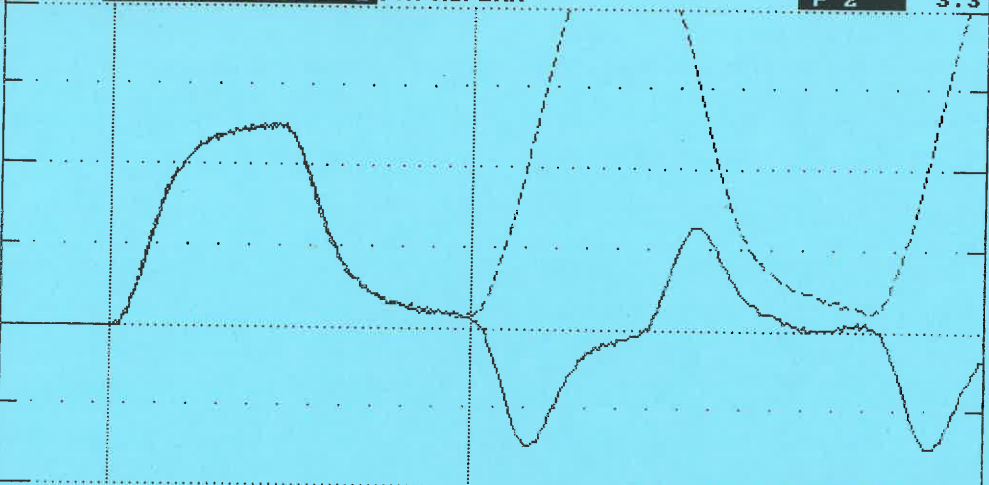
LE 17.0 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 7234 ft/s

JC 0.40
FM 1.00
UM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -40
UT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 382



TS 12 E B PD: k5418 LP 0.00 ft
TB 8.0 T1 9.4 2L/C 4.7 UA 1000 UE 1024 LI 1.0

ACCEPT SQ-OFF FL-OFF PR-OFF

VMX= 4.1 FMX= 63 AMX= 120
EMX= 0.2 MEX= 123 FVP= 1.00

ACCEPT

ACCELEROMETER CALIBRATION N.I.S.T. Traceable
SERIAL NUMBER: K5418
CALIBRATION FACTOR: .0764 mV/g
PAK (*5000): 382 DATE: 28/MAR/18
PDA OPERATOR: Joe

<-AT:PIEZORESISTIVE

OP: laine [ver:5.01]

AT:PIEZOELECTRIC->

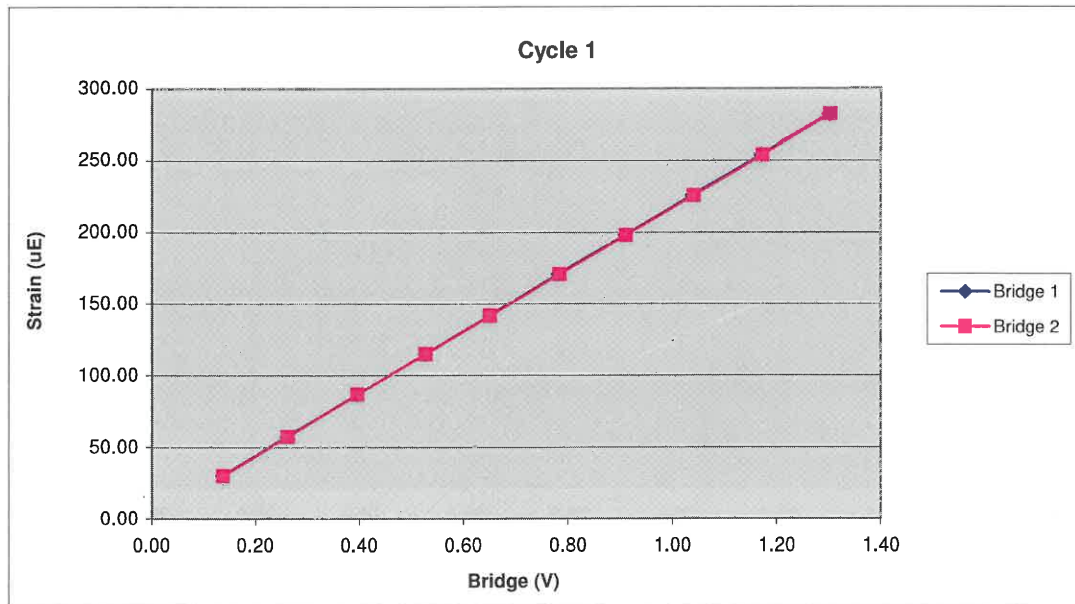
Smart Sensor

Smart Chip Programmed By A.W. on 28/MAR/18 CRC Value 63AE

267AWJ		Cycle 1		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1034.65	29.80	0.14	0.14
3	1995.74	57.07	0.26	0.26
4	3021.54	86.56	0.40	0.40
5	4013.51	114.64	0.53	0.53
6	4945.09	141.59	0.65	0.65
7	5967.55	170.38	0.78	0.78
8	6935.72	197.78	0.91	0.91
9	7944.21	225.43	1.04	1.04
10	8935.59	253.69	1.17	1.17
11	9924.61	282.06	1.30	1.30

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7636.82	Force Calibration (lb/V)	7622.38
Offset	-7.82	Offset	-11.05
Correlation	0.999996	Correlation	0.999997
Strain Calibration (μ E/V)	216.43	Strain Calibration (μ E/V)	216.02
Offset	0.60	Offset	0.51
Correlation	0.999996	Correlation	0.999993

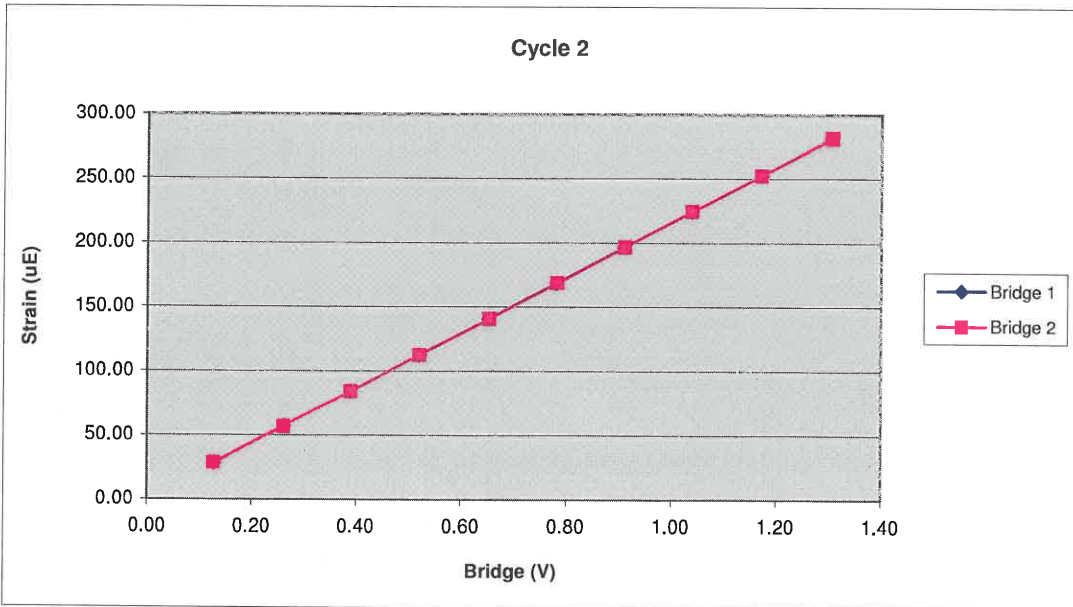
Force Strain Calibration	
EA (Kips)	35284.30
Offset	-29.01
Correlation	0.999989



267AWJ		Cycle 2		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	979.97	28.37	0.13	0.13
3	2002.82	57.00	0.26	0.26
4	2963.52	84.19	0.39	0.39
5	3965.12	112.62	0.52	0.52
6	4973.02	141.14	0.65	0.65
7	5964.01	169.18	0.78	0.78
8	6938.87	197.15	0.91	0.91
9	7932.41	224.93	1.04	1.04
10	8939.72	253.23	1.17	1.17
11	9962.18	281.86	1.30	1.31

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7634.65	Force Calibration (lb/V)	7626.42
Offset	-9.30	Offset	-6.45
Correlation	0.999997	Correlation	0.999997
Strain Calibration (μ E/V)	215.81	Strain Calibration (μ E/V)	215.58
Offset	0.30	Offset	0.38
Correlation	0.999997	Correlation	0.999996

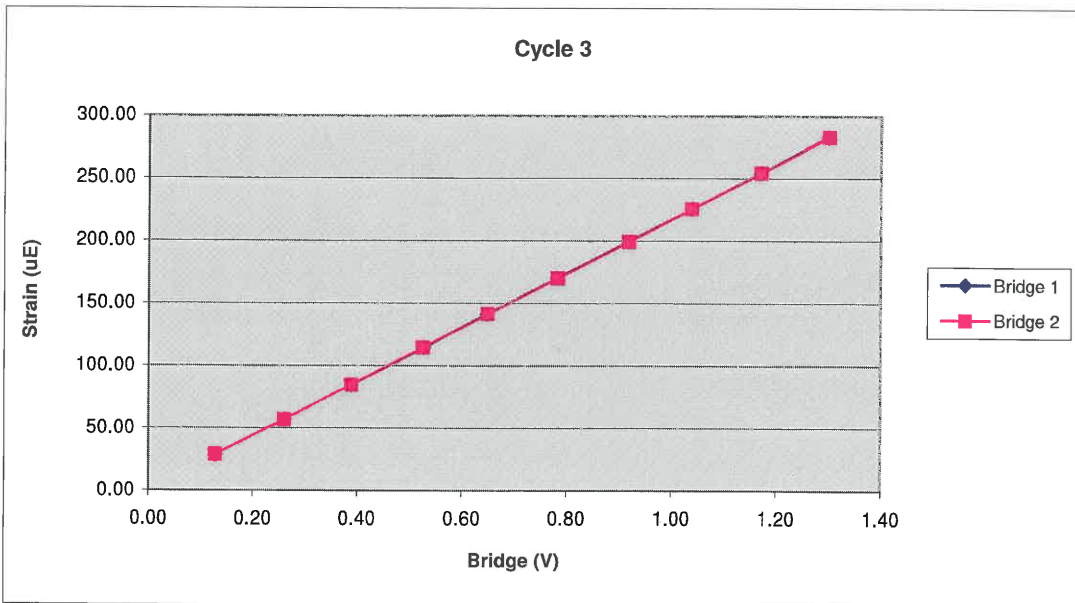
Force Strain Calibration	
EA (Kips)	35375.85
Offset	-19.88
Correlation	0.999997



267AWJ		Cycle 3		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	982.53	28.74	0.13	0.13
3	1993.97	56.89	0.26	0.26
4	2965.68	84.76	0.39	0.39
5	4014.49	114.61	0.53	0.53
6	4944.11	141.53	0.65	0.65
7	5962.04	170.43	0.78	0.78
8	6994.93	199.62	0.92	0.92
9	7922.38	225.92	1.04	1.04
10	8918.48	254.51	1.17	1.17
11	9909.26	283.02	1.30	1.30


Bridge 1		Bridge 2	
Force Calibration (lb/V)	7625.63	Force Calibration (lb/V)	7613.58
Offset	-4.78	Offset	-1.05
Correlation	0.999999	Correlation	0.999998
Strain Calibration ($\mu\text{E}/\text{V}$)	217.34	Strain Calibration ($\mu\text{E}/\text{V}$)	217.00
Offset	0.23	Offset	0.33
Correlation	0.999995	Correlation	0.999998

Force Strain Calibration	
EA (Kips)	35085.96
Offset	-12.70
Correlation	0.999996



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

Calibration Factors	267AWJ		
Bridge 1 ($\mu\text{E}/\text{V}$)	216.53	Bridge 2 ($\mu\text{E}/\text{V}$)	216.20
EA Factor (Kips)	35248.70	Area (in^2)	1.17

Calibrated by: 
Calibrated Date: 12/5/2016

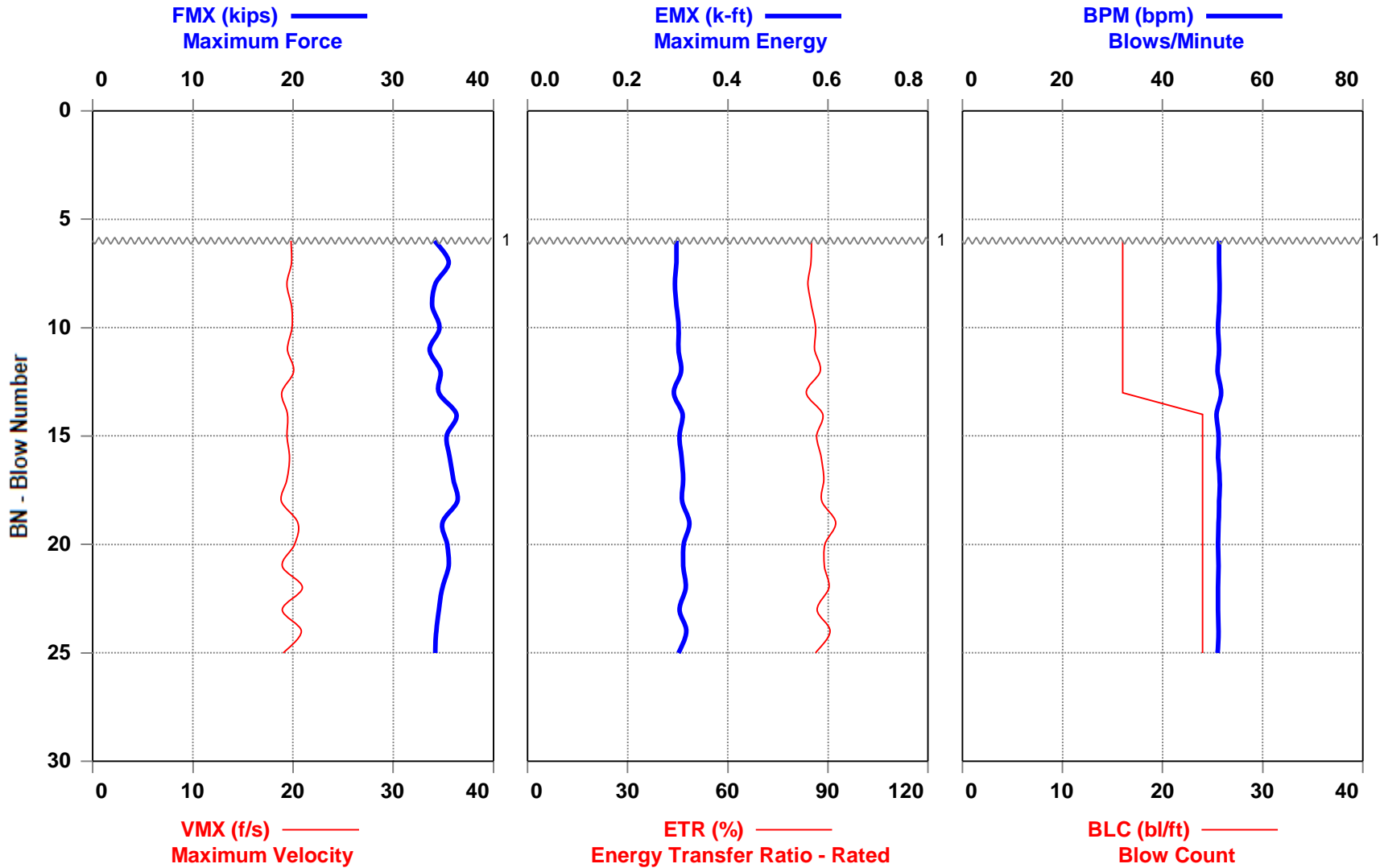
Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Exhibit A-3 SPT Calibration Data Plots and Tables



SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595
STB-1 23.5-25



1 - Blows 1-5 = Seating Blows, Blow 6 = First Blow of N-Value

SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595

STB-1 23.5-25

OP: RW

Date: 24-October-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 28.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
6	24.06	16	34	19.8	0.298	85.0	51.3	0.96	28.9
7	24.13	16	36	19.9	0.297	84.9	51.3	1.03	30.1
8	24.19	16	34	19.4	0.294	84.0	51.4	0.96	29.0
9	24.25	16	34	19.8	0.298	85.1	51.3	0.90	28.7
10	24.31	16	35	19.9	0.302	86.3	51.1	0.84	29.4
11	24.38	16	34	19.5	0.301	86.1	51.3	0.82	28.5
12	24.44	16	35	20.1	0.307	87.7	51.0	0.79	29.4
13	24.50	16	35	18.9	0.292	83.5	51.7	0.75	29.3
14	24.54	24	36	19.5	0.309	88.4	50.8	0.70	30.8
15	24.58	24	35	19.4	0.303	86.6	51.2	0.63	30.0
16	24.63	24	36	19.6	0.308	88.0	51.1	0.62	30.2
17	24.67	24	36	19.4	0.311	88.7	51.4	0.61	30.5
18	24.71	24	36	18.8	0.308	88.1	51.3	0.62	30.8
19	24.75	24	35	20.5	0.323	92.3	51.2	0.65	29.6
20	24.79	24	35	20.2	0.312	89.1	51.1	0.62	30.0
21	24.83	24	36	18.9	0.311	88.9	51.2	0.68	30.1
22	24.88	24	35	20.9	0.316	90.2	51.1	0.71	29.6
23	24.92	24	35	19.0	0.304	86.8	51.1	0.77	29.3
24	24.96	24	34	20.8	0.317	90.6	51.2	0.87	29.1
25	25.00	24	34	19.0	0.302	86.2	51.0	0.93	29.0
Average			35	19.7	0.306	87.3	51.2	0.77	29.6
Std. Dev.			1	0.6	0.008	2.2	0.2	0.13	0.7
Maximum			36	20.9	0.323	92.3	51.7	1.03	30.8
Minimum			34	18.8	0.292	83.5	50.8	0.61	28.5

Total number of blows analyzed: 20

BL# Sensors

6-25 F3: [AWJ 2] 216.2 (1.00); F4: [AWJ 1] 216.5 (1.00); A3: [K5418] 382.0 (1.00);
A4: [K5431] 344.0 (1.00)

BL# Comments

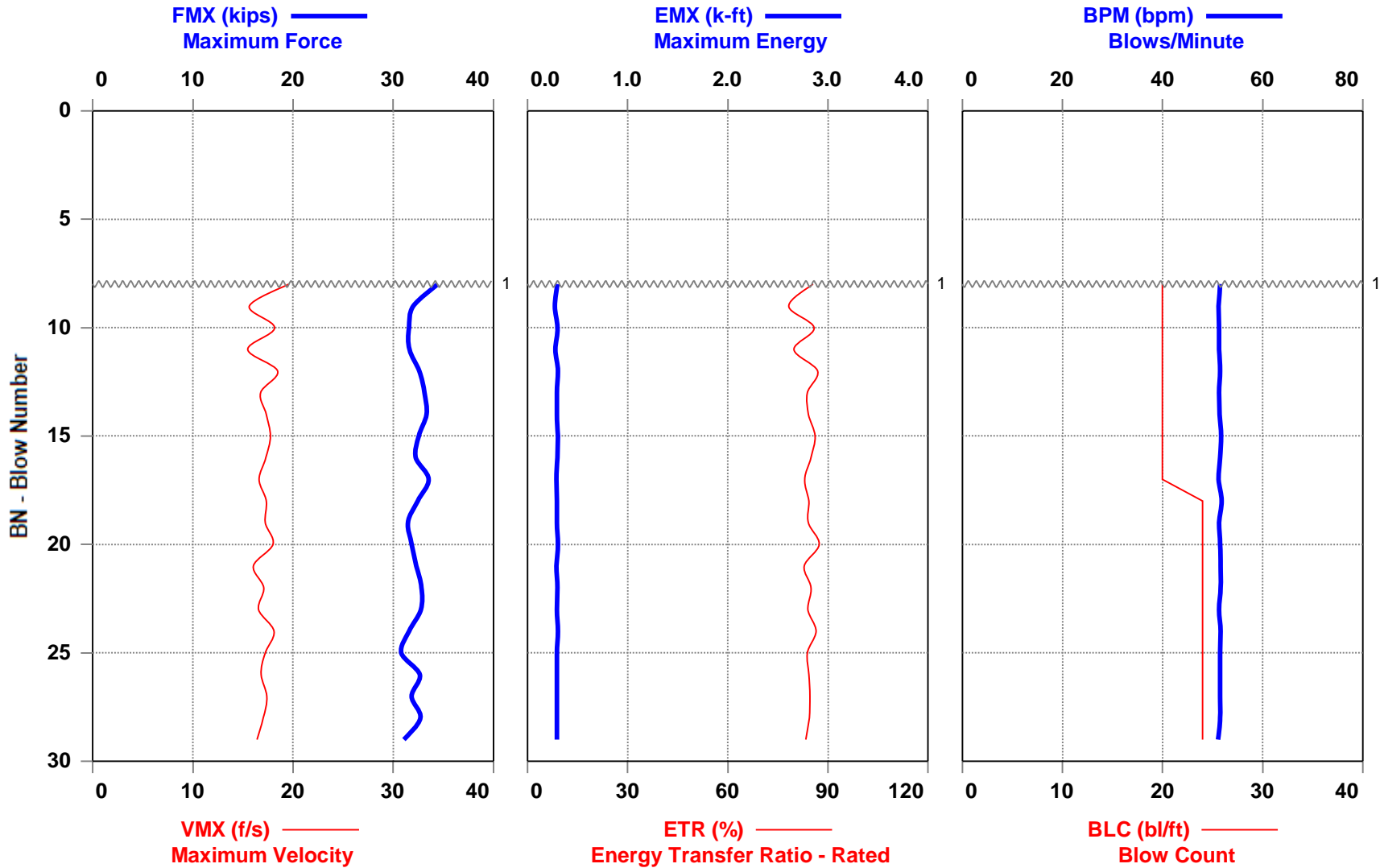
6 Blows 1-5 = Seating Blows, Blow 6 = First Blow of N-Value

Time Summary

Drive 28 seconds 2:20 PM - 2:20 PM BN 1 - 25



SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595
STB-1 28.5-30



1 - Blows 1-7 = Seating Blows, Blow 8 = First Blow of N-Value

SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595

STB-1 28.5-30

OP: RW

Date: 24-October-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 33.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
8	29.05	20	34	19.6	0.299	85.5	51.5	0.76	29.2
9	29.10	20	32	15.7	0.274	78.2	51.2	0.63	27.1
10	29.15	20	32	18.2	0.301	85.9	51.3	0.74	26.7
11	29.20	20	32	15.5	0.280	79.9	51.3	0.72	26.8
12	29.25	20	33	18.5	0.304	86.9	51.5	0.80	27.6
13	29.30	20	33	16.7	0.293	83.8	51.3	0.81	28.1
14	29.35	20	33	17.3	0.295	84.2	51.4	0.76	28.3
15	29.40	20	33	17.7	0.302	86.2	51.7	0.74	27.6
16	29.45	20	32	17.3	0.297	84.9	51.5	0.71	27.4
17	29.50	20	34	16.6	0.290	83.0	51.2	0.69	28.4
18	29.54	24	32	17.3	0.295	84.2	51.8	0.69	27.5
19	29.58	24	31	17.2	0.294	84.1	51.3	0.67	26.7
20	29.63	24	32	18.0	0.306	87.3	51.5	0.69	27.0
21	29.67	24	32	16.0	0.290	82.9	51.6	0.65	27.4
22	29.71	24	33	17.1	0.297	85.0	51.6	0.59	27.8
23	29.75	24	33	16.6	0.294	84.0	51.3	0.54	27.8
24	29.79	24	32	18.1	0.302	86.4	51.6	0.54	26.8
25	29.83	24	31	17.2	0.293	83.8	51.5	0.59	26.1
26	29.88	24	33	16.8	0.295	84.3	51.5	0.58	27.7
27	29.92	24	32	17.4	0.296	84.6	51.5	0.59	27.0
28	29.96	24	33	17.0	0.295	84.4	51.5	0.60	27.7
29	30.00	24	31	16.4	0.292	83.3	51.1	0.57	26.3
Average			32	17.2	0.295	84.2	51.4	0.67	27.4
Std. Dev.			1	0.9	0.007	2.0	0.2	0.08	0.7
Maximum			34	19.6	0.306	87.3	51.8	0.81	29.2
Minimum			31	15.5	0.274	78.2	51.1	0.54	26.1

Total number of blows analyzed: 22

BL# Sensors

8-29 F3: [AWJ 2] 216.2 (1.00); F4: [AWJ 1] 216.5 (1.00); A3: [K5418] 382.0 (1.00); A4: off

BL# Comments

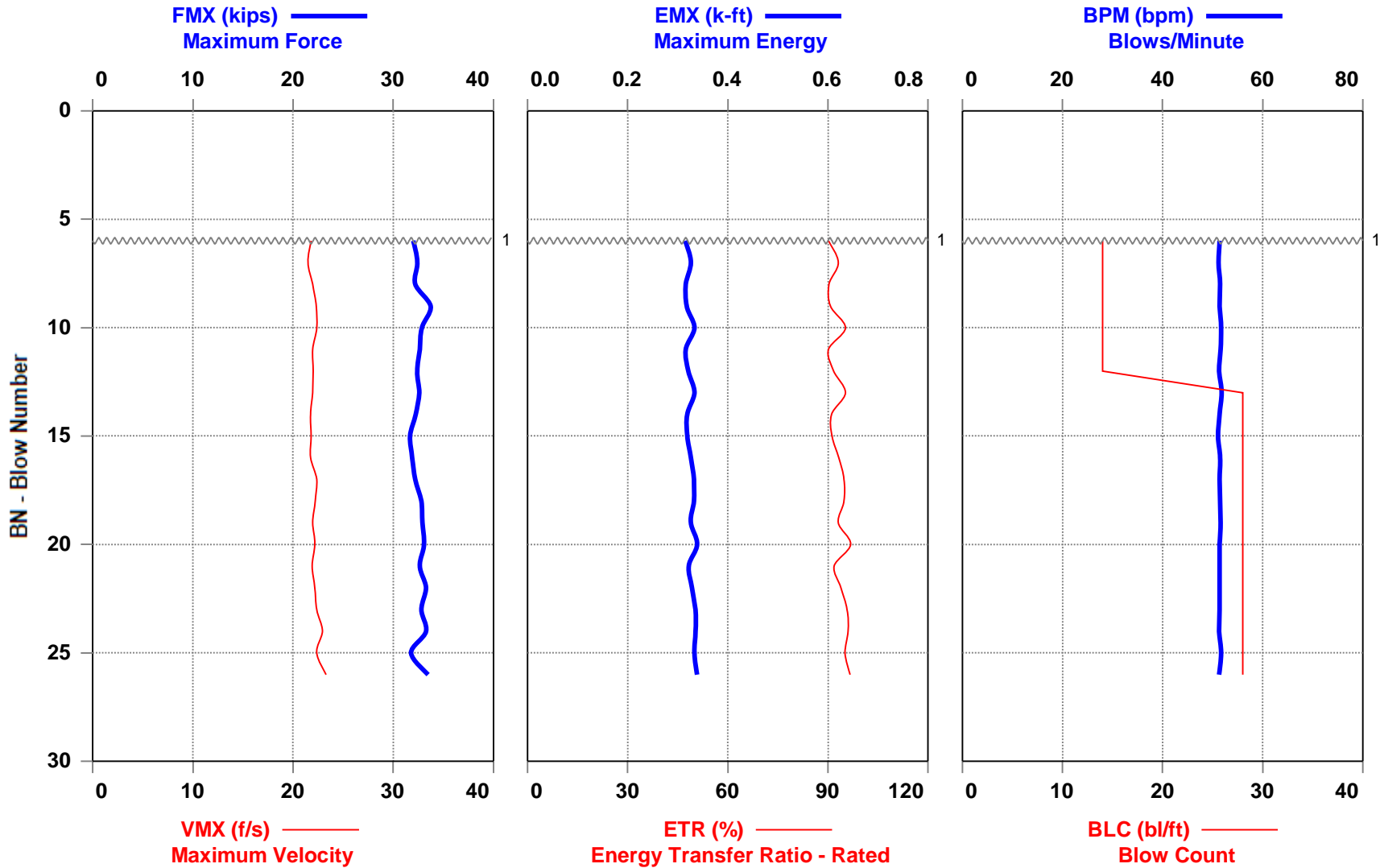
8 Blows 1-7 = Seating Blows, Blow 8 = First Blow of N-Value

Time Summary

Drive 32 seconds 2:30 PM - 2:30 PM BN 1 - 29



SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595
STB-1 33.5-35



1 - Blows 1-5 = Seating Blows, Blow 6 = First Blow of N-Value

SC COMMUNITY LIVING CENTER - CME 55 LCX DR#595

STB-1 33.5-35

OP: RW

Date: 24-October-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 38.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
6	34.07	14	32	21.8	0.315	90.1	51.4	1.03	27.1
7	34.14	14	32	21.5	0.326	93.1	51.2	1.15	27.5
8	34.21	14	32	21.9	0.316	90.3	51.5	1.05	27.3
9	34.29	14	34	22.3	0.318	90.7	51.4	1.04	28.6
10	34.36	14	33	22.4	0.333	95.2	51.7	1.10	27.9
11	34.43	14	33	22.0	0.316	90.2	51.6	0.94	27.7
12	34.50	14	32	22.0	0.321	91.7	51.3	0.88	27.4
13	34.54	28	33	21.9	0.333	95.2	51.8	0.81	27.6
14	34.57	28	32	21.8	0.319	91.1	51.4	0.67	27.3
15	34.61	28	32	21.8	0.319	91.2	51.1	0.59	26.9
16	34.64	28	32	21.8	0.326	93.3	51.5	0.59	27.0
17	34.68	28	32	22.4	0.332	94.9	51.4	0.55	27.3
18	34.71	28	33	22.2	0.332	94.8	51.5	0.56	27.8
19	34.75	28	33	22.0	0.326	93.1	51.6	0.54	27.9
20	34.79	28	33	22.2	0.339	96.8	51.4	0.57	28.0
21	34.82	28	33	21.9	0.322	91.9	51.4	0.54	27.7
22	34.86	28	33	22.2	0.329	93.9	51.4	0.53	28.2
23	34.89	28	33	22.4	0.335	95.8	51.4	0.54	27.8
24	34.93	28	33	22.9	0.336	96.0	51.3	0.53	28.2
25	34.96	28	32	22.3	0.333	95.2	51.7	0.54	26.9
26	35.00	28	33	23.3	0.338	96.6	51.3	0.51	28.4
Average			33	22.1	0.327	93.4	51.4	0.73	27.6
Std. Dev.			1	0.4	0.008	2.2	0.2	0.23	0.5
Maximum			34	23.3	0.339	96.8	51.8	1.15	28.6
Minimum			32	21.5	0.315	90.1	51.1	0.51	26.9

Total number of blows analyzed: 21

BL# Sensors

6-26 F3: [AWJ 2] 216.2 (1.00); F4: [AWJ 1] 216.5 (1.00); A3: [K5418] 382.0 (1.00);
A4: [K5431] 344.0 (1.00)

BL# Comments

6 Blows 1-5 = Seating Blows, Blow 6 = First Blow of N-Value

Time Summary

Drive 29 seconds 2:41 PM - 2:42 PM BN 1 - 26

Exhibit A-4 Field Log

Terracon

SPT HAMMER CALIBRATION FIELD WORKSHEET

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

PROJECT NAME: Florence SL Community Living Center
 PROJECT NO.: 73185069
 BORING NO.: B-1
 CLIENT: _____

DATE: 10/24/18
 TERRACON REP: _____
 PDA MODEL/SN: _____
 TERRACON RIG #: DR 595

DRILL RIG DATA

Type/Transport: Truck
 Manufacturer: CME 55 LCX
 Model No.: 55 LCX
 Serial No.: 399875
 Year Built: 2-17
 Modifications: N/A
 Maint. Schedule: As Needed

SPT HAMMER DATA

Type: Auto
 Manufacturer: CME
 Lifting Mechanism: Chain
 Model No.: _____
 Serial No.: _____
 Hammer Weight: 140
 Hammer Operator(s): AJL

PDA INPUT DATA

Operator: OP RW
 Project No./Location: PJ 73185069 Florence
 Rig Model & SN: PN 55 LCX 399875
 Hammer Type, LM, Rods: PD Auto, Chain, AWT
 Drill Rod Area (in²): AR 1.18

Elastic Modulus (ksi): EM 3000
 Specific Weight (kips/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: <u>AW5-2</u>		<u>216.2</u>
F2/F4: <u>AW5-1</u>		<u>216.53</u>
A1/A3: <u>K5418</u>		<u>382</u>
A2/A4: <u>K5431</u>		<u>344</u>

NOTES: .85
 SPLIT SPOON SAMPLER LENGTH 34" = 2.83

¹ LE is Measured from the Center of the Strain Gauges to the bottom of Split Spoon Sampler

SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		¹ LE (ft)	Rods & Lengths	PDA Blows		SPT Blows			
			Start	End			Start	End	1st 6"	2nd 6"	3rd 6"	N
2:25	Sandy clay		23.5	25	28.7	10'3x5'	1	26	5	8	12	20
2:35			28.5	30	33.7	10'4x5'	1	30	7	10	12	22
2:45			33.5	35	38.7	10'5x5'	1	27	5	7	14	21
3:00			38.5	40	43.7	10'6x6'	1		29	39	34	73
3:10			43.5	45	48.7	10'7x6'	1		11	35	56	80

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

①

DRILL RIG SPT HAMMER ENERGY CALIBRATION REPORT

Drill Rig Model CME-55 SN 359485

Terracon Drill Rig # 727

September 18, 2018

Prepared for:

Terracon Consultants, Inc.
Columbia, SC

Prepared by:

Terracon Consultants, Inc.
North Charleston, South Carolina



Offices Nationwide
Employee-Owned

Established in 1965
terracon.com

Terracon

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities



September 18, 2018

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

Attn: Mr. Phillip Morrison, P.E.
P: 803-212-0062
E: pamorrison@terracon.com

Re: SPT Hammer Energy Calibration Report
Terracon Rig # 727, CME-55, SN:359485

Dear Mr. Morrison:

This report provides the Energy Transfer Ration (ETR) for the SPT hammer found on drill rig model CME-55, Drill Rig # 727 (Serial Number 359485).

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

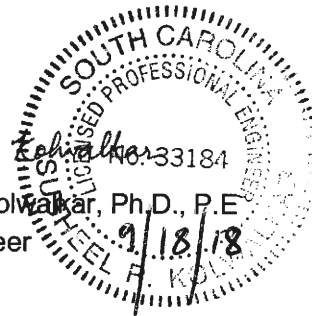
Sincerely,

Terracon Consultants, Inc.

Ryan Wakeford
Staff Engineer

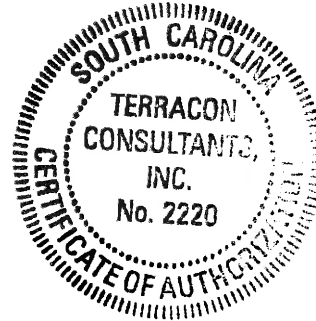
Zachary J. McIntosh
Field Engineer

Susheel Kolwalkar
Susheel R. Kolwalkar, Ph.D., P.E.
Senior Engineer



Attachments :

- Exhibit A-1: Representative Blow
- Exhibit A-2: PDA Equipment Calibrations
- Exhibit A-3: SPT Calibration Data Plots and Tables
- Exhibit A-4: Field Log



Terracon Consultants, Inc. 1450 Fifth Street West North Charleston, South Carolina 29405
P [843] 884 1234 F [843] 884 9234 terracon.com



Geotechnical

Environmental

Construction Materials

Facilities

1.0 PROJECT INFORMATION

ITEM	DESCRIPTION
Drill Rig Identification	CME-55, SN 359485, DR # 727 (see photograph on cover page)
Drill Rig Owner	Terracon
Drill Rig Operator	Will B.
Testing Date	September 17, 2018
Testing Location	Terracon Parking Lot, Columbia, SC
Boring Identification	SB-1
Energy Measurement Depths	28.5 ft.; 33.5 ft.; 38.5 ft.; 43.5 ft.; 48.5 ft.
Hammer Type	Automatic
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> ■ AWJ ■ 1¾" outside diameter ■ 3/16" wall thickness
SPT Calibration Testing Equipment	<ul style="list-style-type: none"> ■ 2 foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers ■ Model PAX Pile Driving Analyzer™ (PDA)
ASTM Methods Used	<p>ASTM D1586-11 – Standard Test Method for Standard Penetration Test and Split Barrel Sampling of Soils</p> <p>ASTM D4633-16 – Standard Methods for Energy Measurement for Dynamic Penetrometers</p>
SPT Calibration Personnel	R. Wakeford & Z. McIntosh

2.0 TEST RESULTS

Table 1: 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.		
SB-1	28.5	30.0	0	6	0	6	7	11	-	18	SC
	33.5	35.0	0	7	0	5	6	10	-	16	SC
	38.5	40.0	0	8	0	3	5	6	-	11	SC
	43.5	45.0	0	9	0	5	6	10	-	16	SC
	48.5	50.0	0	10	0	2	6	5	-	11	SC

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 provided by Terracon personnel

Table 2: Energy Measurement and Analysis Summary

Boring	Start Depth ¹ (ft)	SPT N _m (bpf)	No. of Blows ²	EMX ³ (kip-ft)				ETR ³ (%)	
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
SB-1	28.5	18	18	0.34	0.32	0.32	0.005	92.6	1.434
	33.5	16	16	0.33	0.32	0.32	0.004	92.1	1.281
	38.5	11	11	0.34	0.33	0.34	0.006	95.7	1.644
	43.5	16	16	0.34	0.31	0.32	0.009	92.2	2.577
	48.5	11	11	0.34	0.31	0.33	0.008	93.2	2.262
Average:				0.34	0.31	0.33	0.006	93.2	1.840

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 first increment if refusal were encountered
3. EMX = Maximum Transferred Energy, ETR = Energy Transfer Ratio.

Table 3: Hammer Blow Rate Summary

Boring	Start Depth ¹ (ft)	SPT N _{meas} (bpf)	No. of Blows ²	BPM ³			
				Max.	Min.	Ave.	Std. Dev.
SB-1	28.5	18	18	54.3	52.8	53.6	0.381
	33.5	16	16	54.8	54.0	54.4	0.236
	38.5	11	11	55.5	53.9	54.5	0.520
	43.5	16	16	55.6	53.4	54.2	0.517
	48.5	11	11	55.2	53.8	54.4	0.469
Average:				55.1	53.6	54.2	0.425

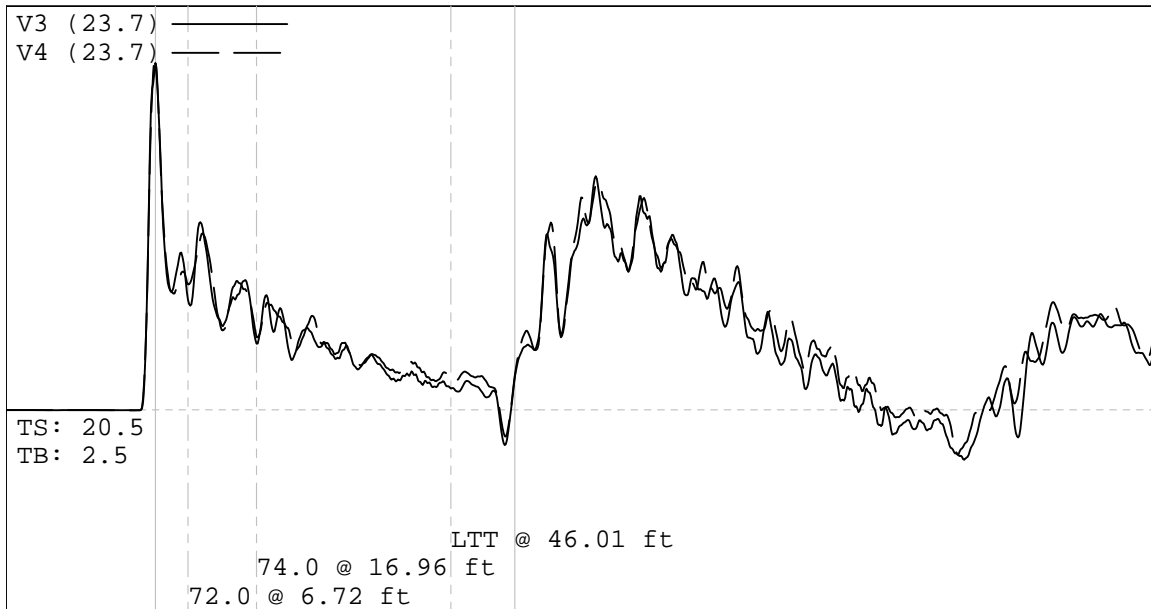
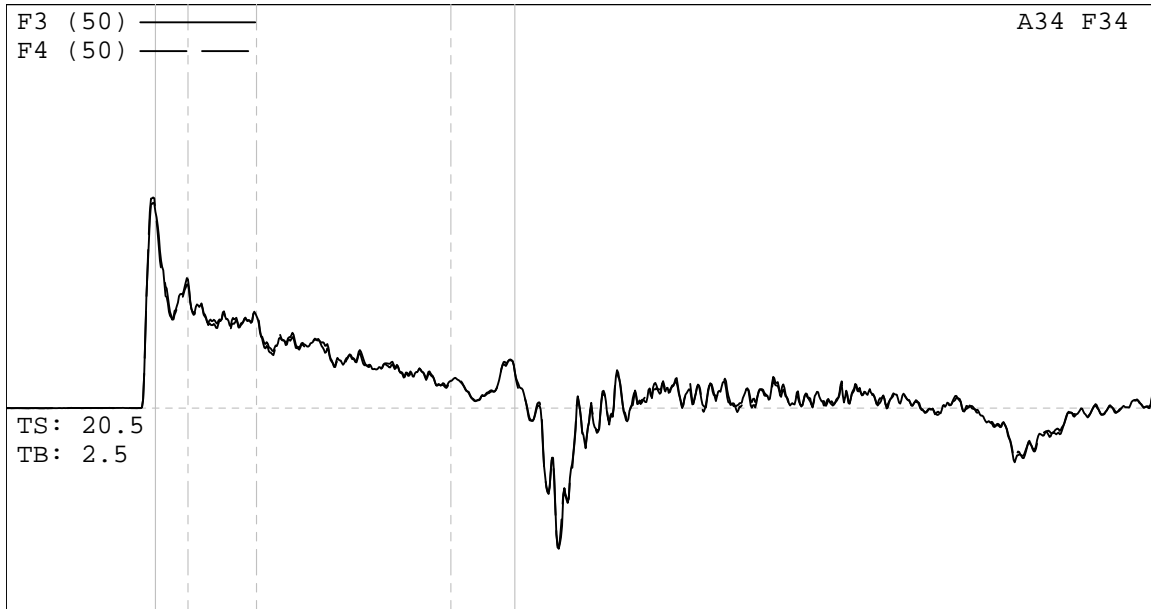
1. Boring ID and depth from existing ground surface to start of SPT.
2. Number of blows used in energy calibration analysis. Limited to measurements recorded during the second and third 6-inch sampling intervals at each depth or during the 1st increment if refusal conditions were encountered.
3. BPM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

3.0 CONCLUSIONS

3.1 Energy Transfer Ratio (ETR) and Hammer Efficiency Correction (CE)

Based on our testing and subsequent analysis, drill rig CME-55 (No. 727) has an **ETR of 93.2% ± 1.84%**. Based on this ETR, the hammer efficiency correction (C_E) is **1.55**.

Exhibit A-1 Representative Blow



Project Information

PROJECT: COLUMBIA SPT RIG CAL
 PILE NAME: CME 55 SERIAL # 359485
 DESCR: STB-1 48.5-50
 OPERATOR: ZM
 FILE: CME 55 SERIAL # 359485_6_Log.W01
 9/17/2018 11:34:31 AM
 Blow Number 11

Quantity Results

ETR 94.9 (%)
 CSX 21.8 ksi
 CSB 0.0 ksi
 BPM 54.3 bpm
 EMX 0.332 k-ft
 DMX 1.20 in
 SFR kips
 MEX 728 µE
 VMX 20.4 f/s

Pile Properties

LE 53.70 ft
 AR 1.18 in²
 EM 30000 ksi
 SP 0.492 k/ft³
 WS 16807.9 f/s
 EA/C 2.1 ksec/ft
 2L/C 6.40 ms
 JC []
 LP 49.80 ft

Sensors

F3: [AWJ 1] 216.53 (1)
 F4: [AWJ 2] 216.2 (1)
 A3: [K0059] 317 mv/5000g's (1)
 A4: [K5418] 382 mv/5000g's (1)
 CLIP: OK

Exhibit A-2 PDA Equipment Calibrations

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model PAX

Serial Number 3766L

was calibrated on 30 April 2018

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.



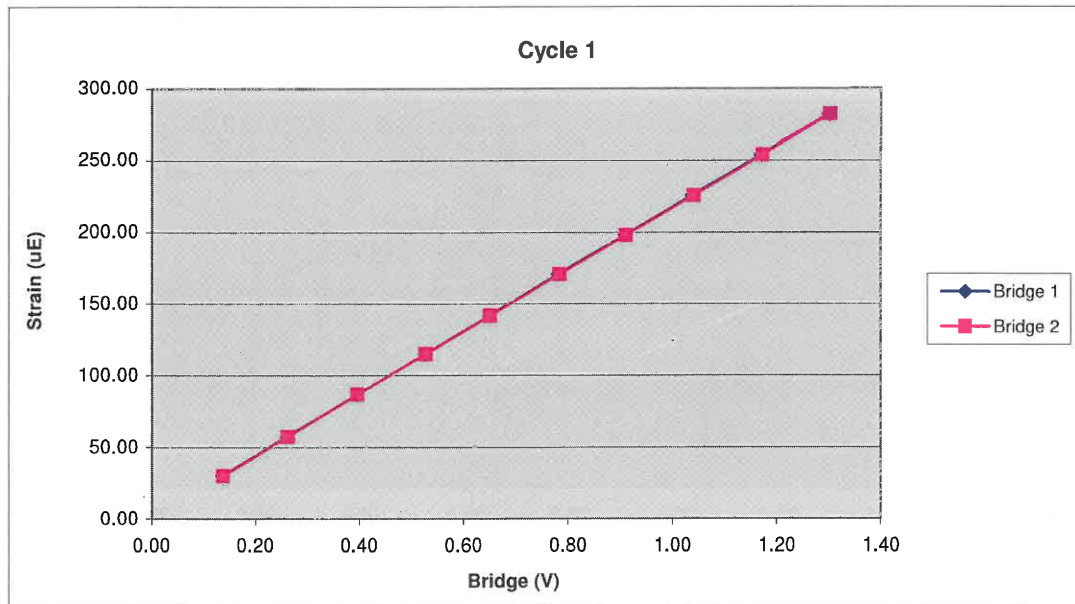
Tested by


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

267AWJ		Cycle 1		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1034.65	29.80	0.14	0.14
3	1995.74	57.07	0.26	0.26
4	3021.54	86.56	0.40	0.40
5	4013.51	114.64	0.53	0.53
6	4945.09	141.59	0.65	0.65
7	5967.55	170.38	0.78	0.78
8	6935.72	197.78	0.91	0.91
9	7944.21	225.43	1.04	1.04
10	8935.59	253.69	1.17	1.17
11	9924.61	282.06	1.30	1.30

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7636.82	Force Calibration (lb/V)	7622.38
Offset	-7.82	Offset	-11.05
Correlation	0.999996	Correlation	0.999997
Strain Calibration ($\mu\text{E}/\text{V}$)	216.43	Strain Calibration ($\mu\text{E}/\text{V}$)	216.02
Offset	0.60	Offset	0.51
Correlation	0.999996	Correlation	0.999993

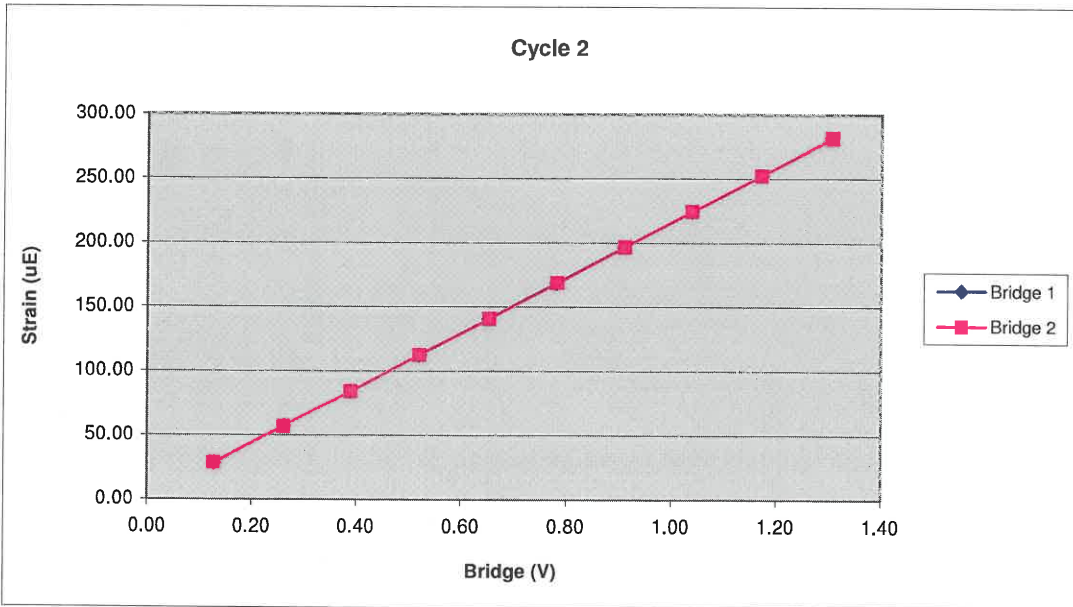
Force Strain Calibration	
EA (Kips)	35284.30
Offset	-29.01
Correlation	0.999989



267AWJ		Cycle 2		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	979.97	28.37	0.13	0.13
3	2002.82	57.00	0.26	0.26
4	2963.52	84.19	0.39	0.39
5	3965.12	112.62	0.52	0.52
6	4973.02	141.14	0.65	0.65
7	5964.01	169.18	0.78	0.78
8	6938.87	197.15	0.91	0.91
9	7932.41	224.93	1.04	1.04
10	8939.72	253.23	1.17	1.17
11	9962.18	281.86	1.30	1.31

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7634.65	Force Calibration (lb/V)	7626.42
Offset	-9.30	Offset	-6.45
Correlation	0.999997	Correlation	0.999997
Strain Calibration (μ E/V)	215.81	Strain Calibration (μ E/V)	215.58
Offset	0.30	Offset	0.38
Correlation	0.999997	Correlation	0.999996

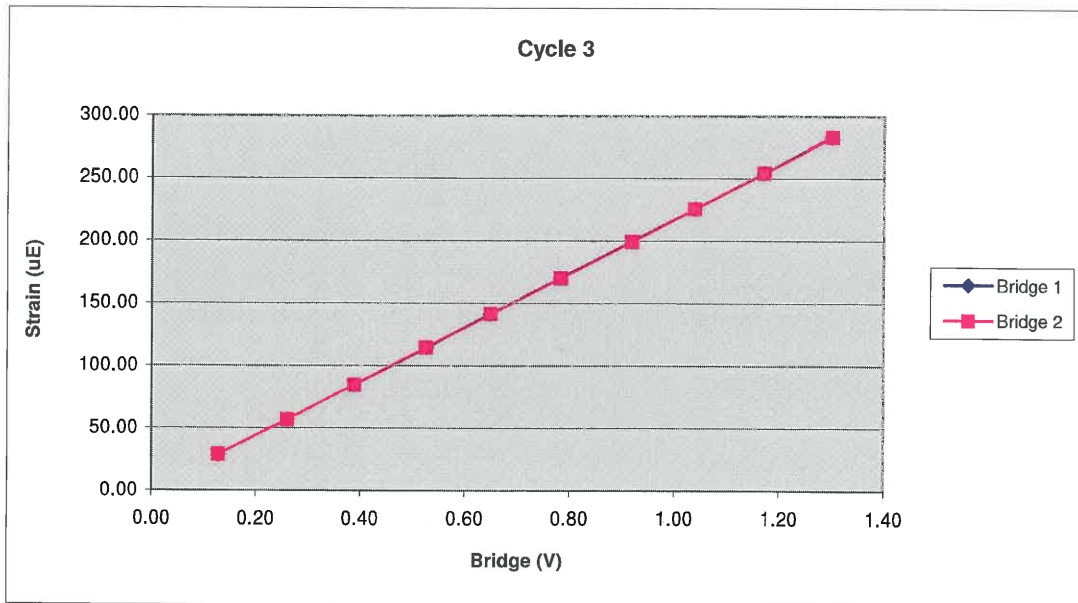
Force Strain Calibration	
EA (Kips)	35375.85
Offset	-19.88
Correlation	0.999997



267AWJ		Cycle 3		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	982.53	28.74	0.13	0.13
3	1993.97	56.89	0.26	0.26
4	2965.68	84.76	0.39	0.39
5	4014.49	114.61	0.53	0.53
6	4944.11	141.53	0.65	0.65
7	5962.04	170.43	0.78	0.78
8	6994.93	199.62	0.92	0.92
9	7922.38	225.92	1.04	1.04
10	8918.48	254.51	1.17	1.17
11	9909.26	283.02	1.30	1.30


Bridge 1		Bridge 2	
Force Calibration (lb/V)	7625.63	Force Calibration (lb/V)	7613.58
Offset	-4.78	Offset	-1.05
Correlation	0.999999	Correlation	0.999998
Strain Calibration ($\mu\text{E}/\text{V}$)	217.34	Strain Calibration ($\mu\text{E}/\text{V}$)	217.00
Offset	0.23	Offset	0.33
Correlation	0.999995	Correlation	0.999998

Force Strain Calibration	
EA (Kips)	35085.96
Offset	-12.70
Correlation	0.999996



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

Calibration Factors	267AWJ		
Bridge 1 ($\mu\text{E}/\text{V}$)	216.53	Bridge 2 ($\mu\text{E}/\text{V}$)	216.20
EA Factor (Kips)	35248.70	Area (in²)	1.17

Calibrated by: 
Calibrated Date: 12/5/2016

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

QBTA: ON [ALT-F1/BB=60]

File Dynamics, Inc.

TG F2 DPF

File Dynamics
2018-03-28 07:36

FS — BN 108
10 SL 512/ 3440/ 2

PJ:
PN: HOPBAR

A 4 -- US
F 2 3.3

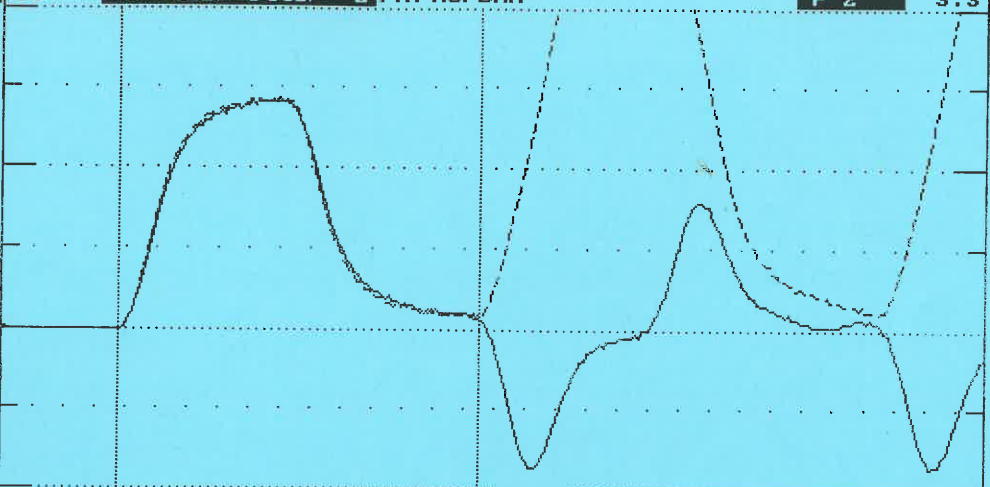
LE 17.0 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 7234 ft/s

JC 0.40
FM 1.00
UM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -40
UT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 317



TS 12 E B PD: k0059 LP 0.00 ft
TB 8.0 T1 9.5 2L/C 4.7 VA 1000 UE 1024 LI 1.0

ACCEPT SQ-OFF FL-OFF PR-OFF	UMX= 4.7	FMX= 72	AMX= 149
	EMX= 0.3	MEX= 141	FVP= 0.99

ACCEPT

ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: K0059

CALIBRATION FACTOR: .0634 MV/G

PAK (*5000): 317 DATE: 28 MAR 18

PDA OPERATOR: JWA

<-AT:PIEZORESISTIVE

OP: laine [ver:5.01]

AT:PIEZOELECTRIC->

Smart Sensor

Smart Chip Programmed By J.W. on 28 MAR 18 CRC Value A7E0

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics
2018-03-28 07:35

FS — BN 106
10 SL 510/ 3440/ 2

PJ:
PN: HOPBAR

A 4 -- US
F 2 3.3

LE 17.0 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16810 ft/s
WC 7234 ft/s

JC 0.40
FM 1.00
UM 1.00

EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90

DL -40
UT -1 IP 0.00
PK 1 TM-PEAK

F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 382

TS 12 E B PD: k5418 LP 0.00 ft
TB 8.0 T1 9.4 2L/C 4.7 UA 1000 UE 1024 LI 1.0

VMX= 4.1 FMX= 63 AMX= 120
EMX= 0.2 MEX= 123 FVP= 1.00

ACCEPT SQ-OFF FL-OFF PR-OFF

ACCEPT



ACCELEROMETER CALIBRATION N.I.S.T. Traceable

SERIAL NUMBER: K5418

CALIBRATION FACTOR: .0764 mV/g

PAK (*5000): 382 DATE: 28/MAR/18

PDA OPERATOR: [Signature]

<-AT:PIEZORESISTIVE

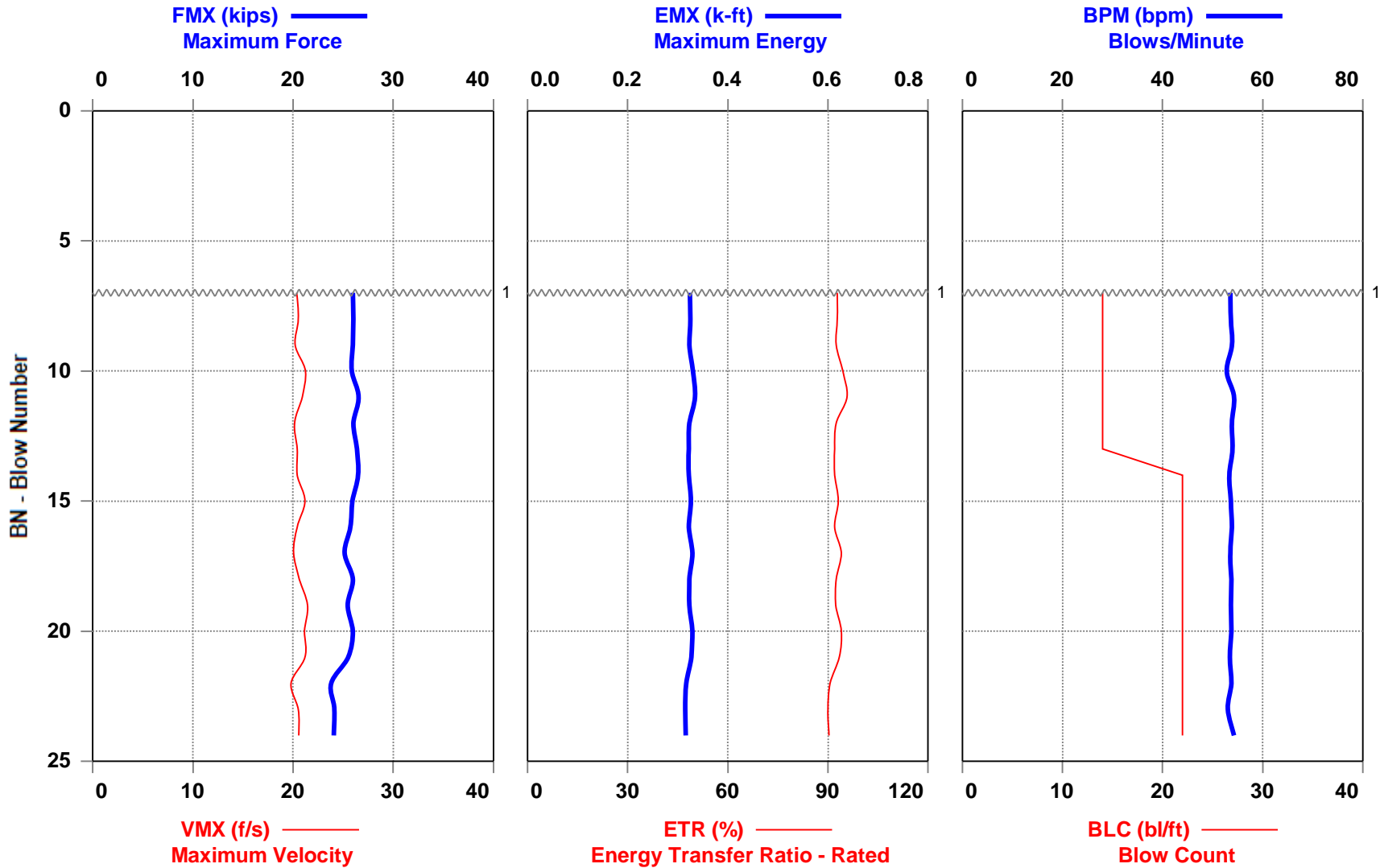
OP: laine [ver:5.011

AT:PIEZOELECTRIC->

Smart Sensor

Smart Chip Programmed By A.W. on 28/MAR/18 CRC Value 63AE

Exhibit A-3 SPT Calibration Data Plots and Tables



1 - Blows 1-6 = Seating blows, Blow 7 = First blow of N value

COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485

STB-1 28.5-30

OP: ZM

Date: 17-September-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 33.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
7	29.07	14	26	20.4	0.325	92.7	53.5	0.86	22.0
8	29.14	14	26	20.5	0.325	92.8	53.6	0.86	22.1
9	29.21	14	26	20.2	0.324	92.5	53.9	0.86	22.0
10	29.29	14	26	21.2	0.330	94.4	52.8	0.86	21.9
11	29.36	14	27	20.9	0.335	95.7	54.3	0.87	22.5
12	29.43	14	26	20.2	0.324	92.5	53.8	0.86	22.1
13	29.50	14	26	20.4	0.322	91.9	54.0	0.87	22.4
14	29.55	22	26	20.4	0.322	92.1	53.3	0.67	22.5
15	29.59	22	26	21.2	0.326	93.1	53.6	0.69	22.0
16	29.64	22	26	20.4	0.322	92.1	53.8	0.67	21.8
17	29.68	22	25	20.0	0.329	94.0	53.5	0.69	21.3
18	29.73	22	26	20.6	0.324	92.5	53.7	0.62	22.0
19	29.77	22	25	21.4	0.323	92.4	53.6	0.65	21.6
20	29.82	22	26	21.2	0.329	94.0	53.7	0.65	22.0
21	29.86	22	26	21.2	0.327	93.4	53.4	0.64	21.6
22	29.91	22	24	19.8	0.317	90.7	53.7	0.62	20.2
23	29.95	22	24	20.5	0.315	89.9	53.0	0.59	20.5
24	30.00	22	24	20.6	0.316	90.4	54.3	0.59	20.4
Average			26	20.6	0.324	92.6	53.6	0.73	21.7
Std. Dev.			1	0.5	0.005	1.4	0.4	0.11	0.7
Maximum			27	21.4	0.335	95.7	54.3	0.87	22.5
Minimum			24	19.8	0.315	89.9	52.8	0.59	20.2

Total number of blows analyzed: 18

BL# Sensors

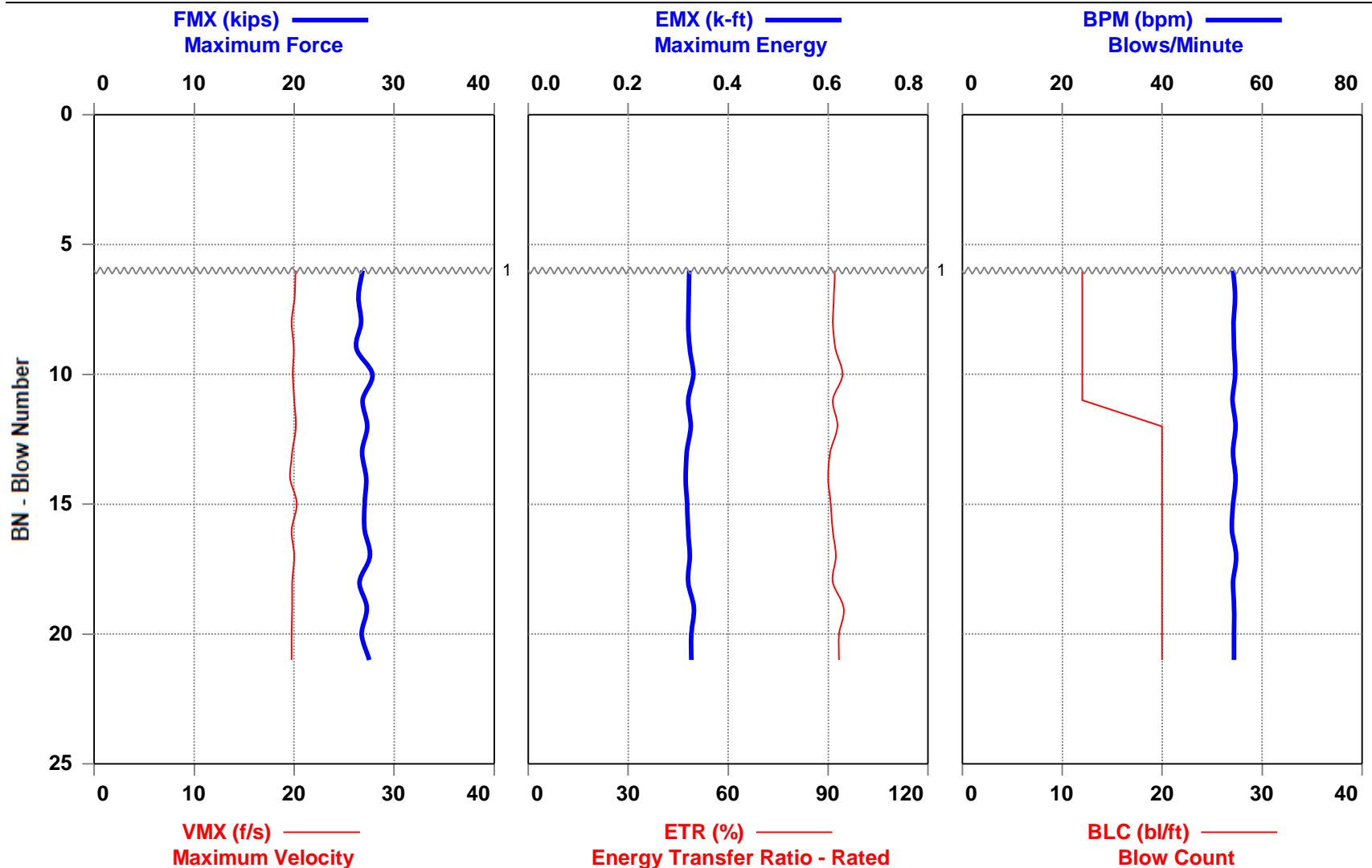
7-24 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K0059] 317.0 (1.00);
A4: [K5418] 382.0 (1.00)

BL# Comments

7 Blows 1-6 = Seating blows, Blow 7 = First blow of N value

Time Summary

Drive 25 seconds 10:58 AM - 10:58 AM BN 1 - 24



1 - Blows 1-5 = Seating blows, Blow 6 = First blow of N value

COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485

STB-1 33.5-35

OP: ZM

Date: 17-September-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 38.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
6	34.08	12	27	20.1	0.322	92.0	54.2	1.14	22.8
7	34.17	12	26	20.1	0.321	91.7	54.6	1.09	22.4
8	34.25	12	27	19.8	0.320	91.4	54.3	1.05	22.6
9	34.33	12	26	20.0	0.323	92.2	54.4	1.01	22.2
10	34.42	12	28	19.9	0.330	94.3	54.6	1.14	23.6
11	34.50	12	27	20.0	0.320	91.5	54.1	1.00	22.8
12	34.55	20	27	20.2	0.325	92.8	54.7	0.89	23.2
13	34.60	20	27	19.8	0.317	90.7	54.2	0.85	22.7
14	34.65	20	27	19.6	0.315	90.0	54.7	0.81	23.0
15	34.70	20	27	20.3	0.318	90.8	54.2	0.75	22.9
16	34.75	20	27	19.7	0.320	91.3	54.0	0.81	22.9
17	34.80	20	28	20.0	0.323	92.3	54.8	0.77	23.4
18	34.85	20	27	19.8	0.320	91.4	54.2	0.77	22.5
19	34.90	20	27	19.8	0.331	94.7	54.4	0.81	23.1
20	34.95	20	27	19.7	0.327	93.3	54.4	0.74	22.7
21	35.00	20	28	19.7	0.326	93.2	54.4	0.71	23.3
	Average		27	19.9	0.322	92.1	54.4	0.89	22.9
	Std. Dev.		0	0.2	0.004	1.2	0.2	0.15	0.4
	Maximum		28	20.3	0.331	94.7	54.8	1.14	23.6
	Minimum		26	19.6	0.315	90.0	54.0	0.71	22.2

Total number of blows analyzed: 16

BL# Sensors

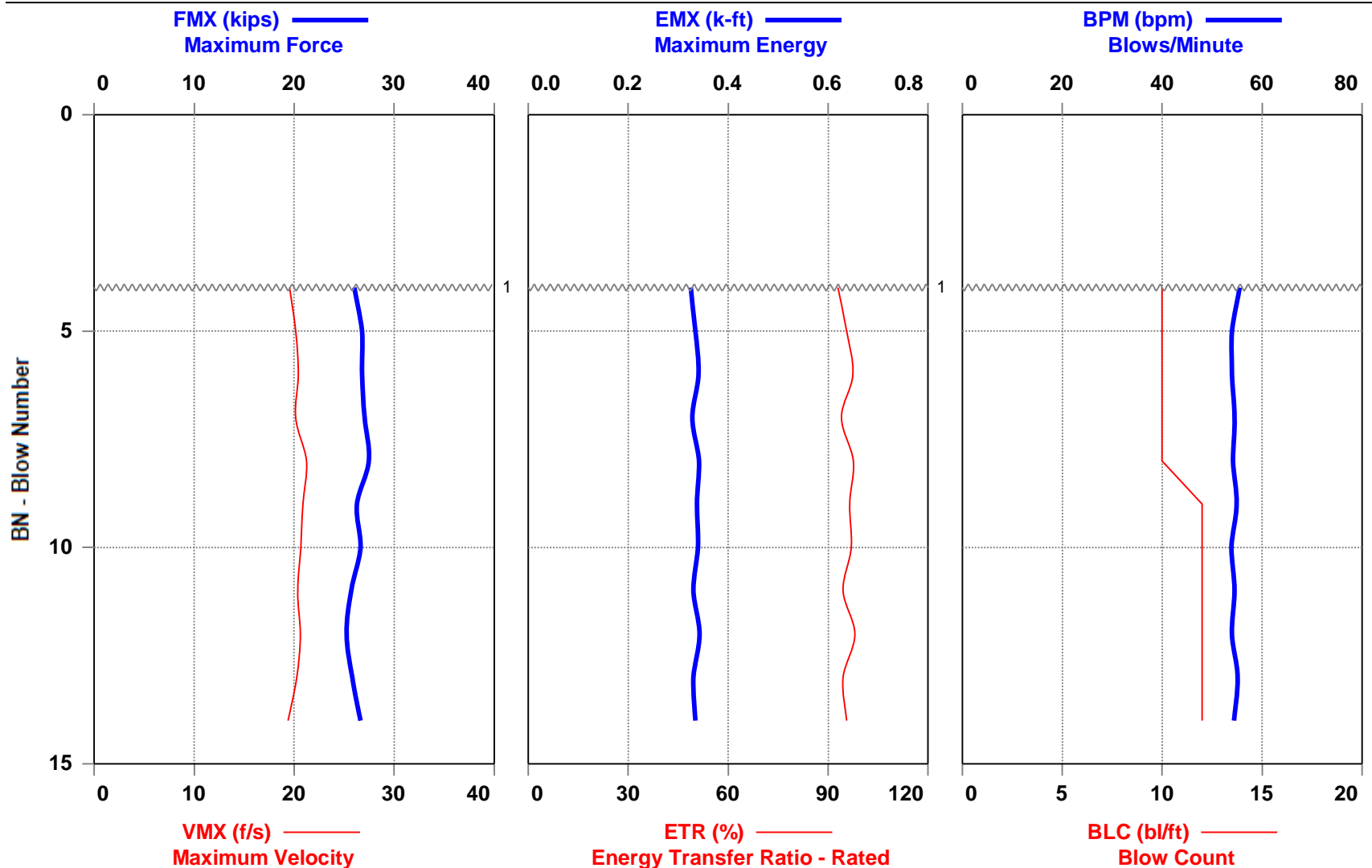
6-21 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K0059] 317.0 (1.00);
A4: [K5418] 382.0 (1.00)

BL# Comments

6 Blows 1-5 = Seating blows, Blow 6 = First blow of N value

Time Summary

Drive 22 seconds 11:05 AM - 11:05 AM BN 1 - 21



1 - Blows 1-3 = Seating blows, Blow 4 = First blow of N value

COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485

STB-1 38.5-40

OP: ZM

Date: 17-September-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 43.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
4	39.10	10	26	19.5	0.325	92.9	55.5	1.42	22.0
5	39.20	10	27	20.2	0.334	95.6	54.0	1.30	22.7
6	39.30	10	27	20.4	0.341	97.4	54.0	1.26	22.7
7	39.40	10	27	20.1	0.329	93.9	54.5	1.20	22.9
8	39.50	10	27	21.2	0.341	97.6	54.2	1.20	23.3
9	39.58	12	26	20.9	0.338	96.4	54.9	1.04	22.3
10	39.67	12	27	20.7	0.339	96.9	53.9	1.11	22.6
11	39.75	12	26	20.3	0.331	94.5	54.5	1.11	21.8
12	39.83	12	25	20.6	0.343	98.0	54.0	1.17	21.4
13	39.92	12	26	20.2	0.331	94.5	55.1	1.10	21.9
14	40.00	12	27	19.4	0.334	95.5	54.4	1.12	22.6
Average			26	20.3	0.335	95.8	54.5	1.18	22.4
Std. Dev.			1	0.5	0.006	1.6	0.5	0.10	0.5
Maximum			27	21.2	0.343	98.0	55.5	1.42	23.3
Minimum			25	19.4	0.325	92.9	53.9	1.04	21.4

Total number of blows analyzed: 11

BL# Sensors

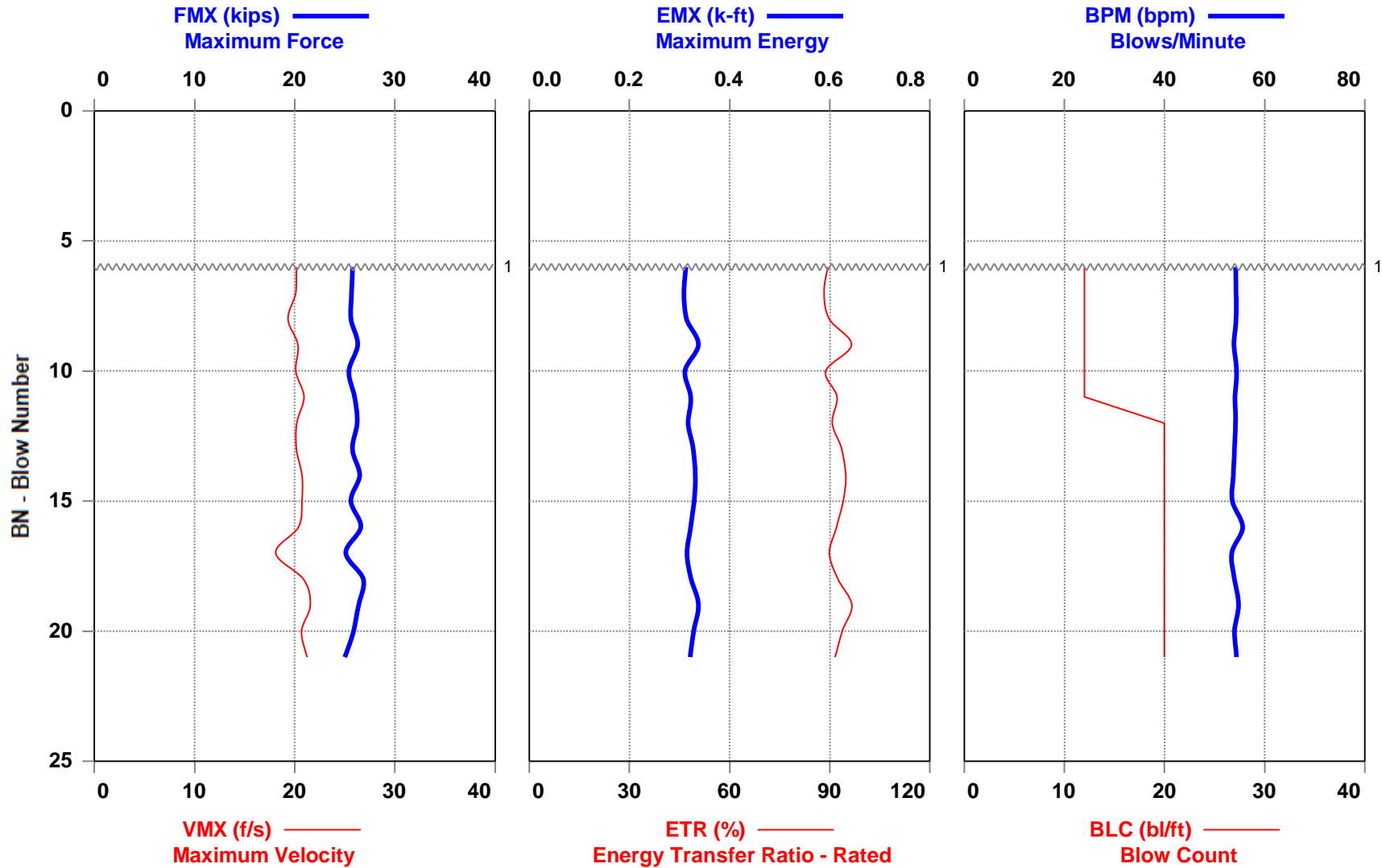
4-14 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K0059] 317.0 (1.00);
A4: [K5418] 382.0 (1.00)

BL# Comments

4 Blows 1-3 = Seating blows, Blow 4 = First blow of N value

Time Summary

Drive 14 seconds 11:14 AM - 11:14 AM BN 1 - 14



1 - Blows 1-5 = Seating blows, Blow 6 = First blow of N value

COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485

STB-1 43.5-45

OP: ZM

Date: 17-September-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 48.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
6	44.08	12	26	20.2	0.313	89.4	54.2	1.01	21.9
7	44.17	12	26	20.1	0.309	88.2	54.3	1.00	21.8
8	44.25	12	26	19.3	0.314	89.8	54.3	1.00	21.7
9	44.33	12	26	20.3	0.338	96.4	53.9	1.20	22.3
10	44.42	12	25	20.1	0.311	88.8	54.4	1.00	21.5
11	44.50	12	26	20.9	0.323	92.2	54.1	1.00	22.0
12	44.55	20	26	20.2	0.318	90.7	54.2	0.79	22.2
13	44.60	20	26	20.2	0.327	93.5	54.0	0.93	21.8
14	44.65	20	26	20.7	0.332	94.8	53.7	0.77	22.4
15	44.70	20	26	20.7	0.329	94.0	53.5	0.78	21.7
16	44.75	20	27	20.4	0.322	92.0	55.6	0.72	22.5
17	44.80	20	25	18.1	0.315	89.9	53.4	0.69	21.3
18	44.85	20	27	20.9	0.323	92.4	54.0	0.62	22.8
19	44.90	20	26	21.6	0.338	96.6	54.8	0.75	22.3
20	44.95	20	26	20.7	0.328	93.7	54.0	0.70	21.9
21	45.00	20	25	21.3	0.321	91.6	54.4	0.65	21.2
Average			26	20.4	0.322	92.1	54.2	0.85	22.0
Std. Dev.			1	0.8	0.009	2.5	0.5	0.16	0.4
Maximum			27	21.6	0.338	96.6	55.6	1.20	22.8
Minimum			25	18.1	0.309	88.2	53.4	0.62	21.2

Total number of blows analyzed: 16

BL# Sensors

6-21 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K0059] 317.0 (1.00);
A4: [K5418] 382.0 (1.00)

BL# Comments

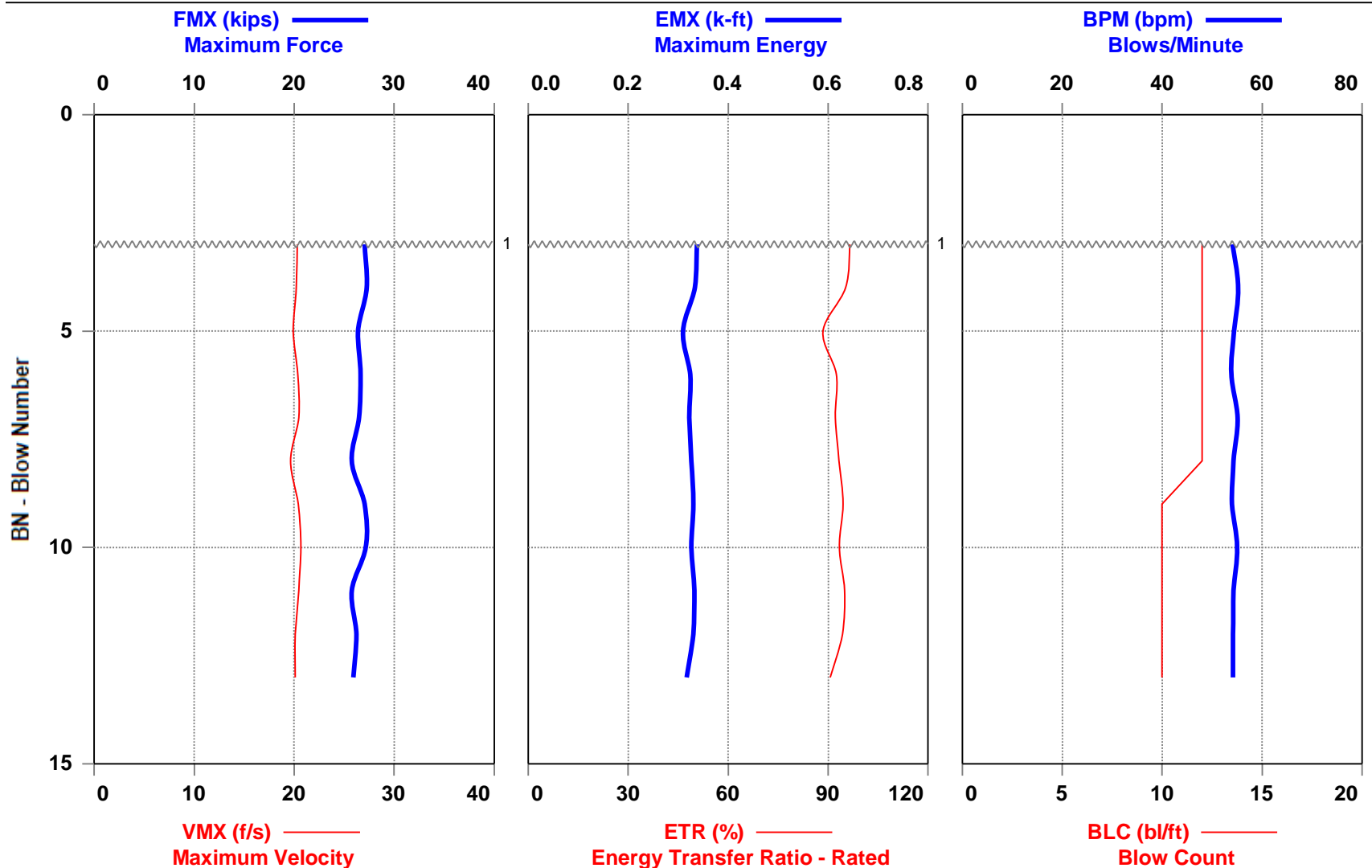
6 Blows 1-5 = Seating blows, Blow 6 = First blow of N value

Time Summary

Drive 22 seconds 11:25 AM - 11:26 AM BN 1 - 21



COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485
STB-1 48.5-50



1 - Blows 1-2 = Seating blows, Blow 3 = First blow of N value

COLUMBIA SPT RIG CAL - CME 55 SERIAL # 359485

STB-1 48.5-50

OP: ZM

Date: 17-September-2018

AR: 1.18 in²

SP: 0.492 k/ft³

LE: 53.70 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.00

FMX: Maximum Force

BPM: Blows/Minute

VMX: Maximum Velocity

DMX: Maximum Displacement

EMX: Maximum Energy

CSX: Compression Stress Maximum

ETR: Energy Transfer Ratio - Rated

BL#	Depth ft	BLC bl/ft	FMX kips	VMX f/s	EMX k-ft	ETR (%)	BPM bpm	DMX in	CSX ksi
3	49.08	12	27	20.3	0.338	96.5	54.1	1.27	22.9
4	49.17	12	27	20.2	0.333	95.3	55.2	1.03	23.1
5	49.25	12	26	19.9	0.310	88.4	54.4	1.00	22.4
6	49.33	12	27	20.4	0.324	92.5	53.8	1.00	22.6
7	49.42	12	26	20.5	0.322	92.1	55.1	1.00	22.4
8	49.50	12	26	19.7	0.326	93.3	54.3	1.03	21.8
9	49.60	10	27	20.4	0.331	94.5	54.0	1.20	22.9
10	49.70	10	27	20.7	0.327	93.4	55.0	1.20	23.0
11	49.80	10	26	20.4	0.332	94.9	54.3	1.20	21.8
12	49.90	10	26	20.1	0.330	94.3	54.2	1.20	22.2
13	50.00	10	26	20.1	0.317	90.6	54.2	1.21	22.0
Average			27	20.2	0.326	93.2	54.4	1.12	22.5
Std. Dev.			1	0.3	0.008	2.2	0.4	0.10	0.5
Maximum			27	20.7	0.338	96.5	55.2	1.27	23.1
Minimum			26	19.7	0.310	88.4	53.8	1.00	21.8

Total number of blows analyzed: 11

BL# Sensors

3-13 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K0059] 317.0 (1.00);
A4: [K5418] 382.0 (1.00)

BL# Comments

3 Blows 1-2 = Seating blows, Blow 3 = First blow of N value

Time Summary

Drive 13 seconds 11:34 AM - 11:34 AM BN 1 - 13

Exhibit A-4 Field Log

Terracon

SPT HAMMER CALIBRATION FIELD WORKSHEET

ARRIVAL TIME: 10:20
 DEPART TIME: 12:00
 TOTAL TRAVEL: 5 Hours
 TOTAL TIME: 7 Hours
 CLIENT REP: N/A
 MILEAGE: 188

PROJECT NAME: Columbia, SC
 PROJECT NO.: N/A
 BORING NO.: STB-1
 CLIENT: Terracon

DATE: 9-17-18
 TERRACON REP: Columbia
 PDA MODEL/SN: PAX 3766
 TERRACON RIG # DR#: PR 717

DRILL RIG DATA

Type/Transport: Truck
 Manufacturer: CME-SS
 Model No.:
 Serial No.: 259489
 Year Built: 2008
 Modifications: N/A
 Maint. Schedule: As needed

SPT HAMMER DATA

Type: Auto
 Manufacturer: CME
 Lifting Mechanism: Chain
 Model No.:
 Serial No.:
 Hammer Weight: 140 lbs
 Hammer Operator(s): Will & Jason

PDA INPUT DATA

Operator: **OP** ZM
 Project No./Location: **PJ** Columbia, SC
 Rig Model & SN: **PN** CME-SS
 Hammer Type, LM, Rods: **PD** Auto, Chain, AWT
 Drill Rod Area (in²): **AR** 1.18

Elastic Modulus (ksi): **EM** 3000
 Specific Weight (kips/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:	<u>AWT-1</u>	<u>216.53</u>
F2/F4:	<u>AWT-2</u>	<u>216.20</u>
A1/A3:	<u>K0059</u>	<u>317</u>
A2/A4:	<u>K5918</u>	<u>350</u>

NOTES: Instrumentation to Bottom of Rod Length
10.2" Inches 0.875' Feet
 SPLIT SPOON SAMPLER LENGTH 0.83'
 Gauge to Bottom of Cal. Rod length 371' + Rod
¹ LE is Measured from the Center of the Strain Gauges to the bottom of Split Spoon Sampler

SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		¹ LE (ft)	Rods & Lengths			PDA Blows		SPT Blows			
			Start	End		2ft	5ft	10ft	Start	End	1st 6"	2nd 6"	3rd 6"	4th 6"
						2ft	5ft	10ft						
<u>10:55</u>	<u>SC</u>	<u>52.5</u>	<u>23.5</u>	<u>25</u>	<u>28.7</u>	2ft	<u>5ft x 7</u>	10ft	<u>1</u>	<u>39</u>	<u>8</u>	<u>12</u>	<u>18</u>	<u>30</u>
<u>11:00</u>	<u>SC</u>	<u>57</u>	<u>28.5</u>	<u>30</u>	<u>33.7</u>	2ft	<u>5ft x 6</u>	10ft	<u>1</u>	<u>25</u>	<u>6</u>	<u>7</u>	<u>11</u>	<u>18</u>
<u>11:07</u>	<u>SC</u>	<u>53.75</u>	<u>33.5</u>	<u>35</u>	<u>38.7</u>	2ft	<u>5ft x 7</u>	10ft	<u>1</u>	<u>22</u>	<u>5</u>	<u>6</u>	<u>10</u>	<u>16</u>
<u>11:16</u>	<u>SC</u>	<u>56</u>	<u>38.5</u>	<u>40</u>	<u>43.7</u>	2ft	<u>5ft x 8</u>	10ft	<u>1</u>	<u>15</u>	<u>3</u>	<u>5</u>	<u>6</u>	<u>11</u>
<u>11:28</u>	<u>SC</u>	<u>58</u>	<u>43.5</u>	<u>45</u>	<u>48.7</u>	2ft	<u>5ft x 9</u>	10ft	<u>4</u>	<u>25</u>	<u>5</u>	<u>6</u>	<u>10</u>	<u>16</u>
<u>11:36</u>	<u>SC</u>	<u>42.5</u>	<u>48.5</u>	<u>50</u>	<u>53.7</u>	2ft	<u>5ft x 10</u>	10ft	<u>2</u>	<u>15</u>	<u>2</u>	<u>6</u>	<u>5</u>	<u>11</u>
						2ft	5ft	10ft						
						2ft	5ft	10ft						

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
 Drilling Method: (ie. Hollow Stem Augers, Mud Rotary....)

Red
 CD: 1 3/4"