

# Geotechnical Data Report

**S-17-51 (E. Academy Street)  
Emergency Bridge Replacement over Unnamed Stream  
Dillon County, South Carolina**

November 29, 2018  
SCDOT Project ID.: P038248  
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](http://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-17-51 (E. Academy Street) Emergency Bridge Replacement over Unnamed Stream  
Dillon County, South Carolina  
SCDOT Project ID.: P038248  
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: P038248, 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-17-51 (E. Academy Street) bridge over an unnamed stream in Dillon 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/CPT soundings, results of the geophysical testing, 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.



Terracon Consultants, Inc. 521 Clemson Road Columbia, South Carolina 29229  
P [803] 741 9000 F [803] 741 9900 terracon.com

Geotechnical



Environmental



Construction Materials



Facilities

## **2.0 PROJECT DESCRIPTION**

The project site is located at the bridge crossing of S-17-51 (E. Academy Street) and an unnamed stream in Dillon 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 deep foundations.

## **3.0 GEOTECHNICAL TESTING**

The geotechnical exploration for this project was performed between November 8 and 12, 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)
- Two (2) CPT Soundings (CPT-1 and CPT-2)
- Geophysical testing including one (1) Multi-channel Analysis of Surface Waves test array (MASW-1)

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
- Eight (8) Gradation Tests
- Four (4) 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-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038248



**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

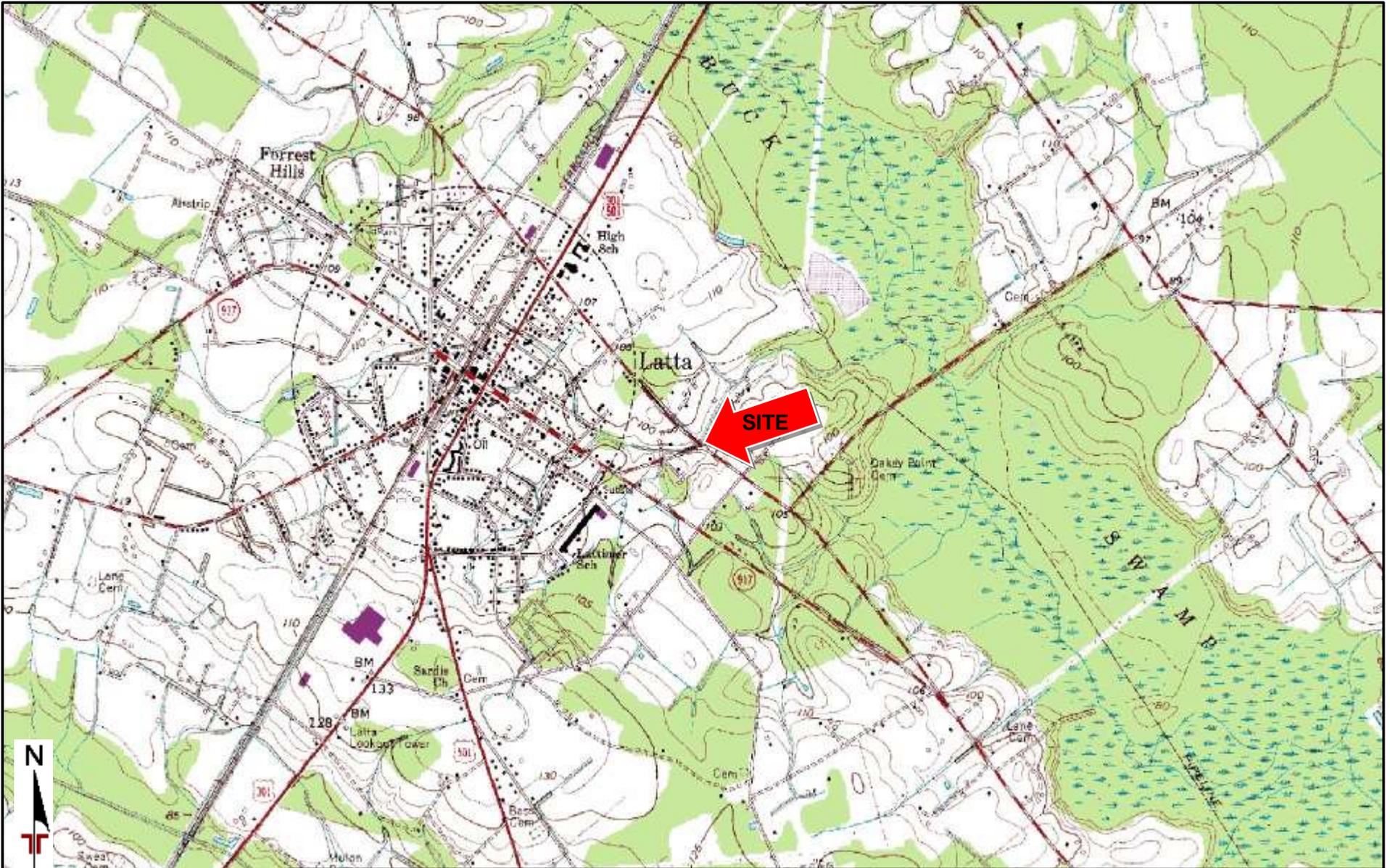
Jonathan N. Ard, P.E.  
Senior Engineer

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 – MASW Results**
- Exhibit A-5 – Field Exploration Description**
- Exhibit A-6 – Soil Description Terms**
- Exhibit A-7 – Soil Rock Symbol Log**
- Exhibit A-8 – Boring Logs**
- Exhibit A-9 – CPT Logs**
- Exhibit A-10 – Drill Rig Photograph Log**



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY  
 QUADRANGLES INCLUDE: LATTA, SC  
 (1/1/1980).

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

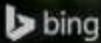
**Terracon**  
 521 Clemson Rd  
 Columbia, SC 29229-4307

**SITE LOCATION MAP**  
 S-17-51 (E. Academy Street) BRO Unnamed Stream  
 Dillon County, South Carolina

Exhibit  
**A-1**



	<b>BORING LOCATION</b>
	<b>CPT LOCATION</b>
	<b>MULTICHANNEL ANALYSIS OF SURFACE WAVES</b>



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.	7318P119E
Scale:	AS SHOWN
File Name:	A-1 & A-2
Date:	Nov. 2018

**Terracon**

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Columbia, SC 29229-4307

**EXPLORATION PLAN**

S-17-51 (E. Academy Street) BRO Unnamed Stream  
Dillion County, South Carolina

Exhibit

**A-2**

**Geotechnical Data Report**

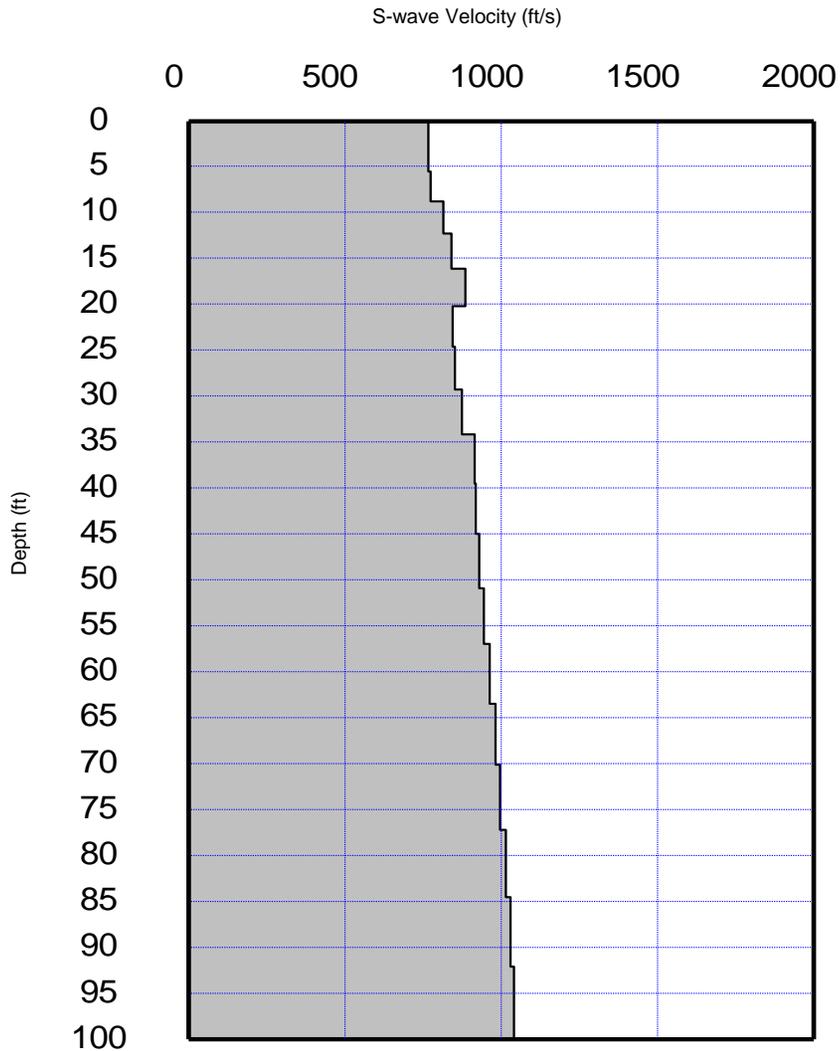
S-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038248

**Summary of Field Data**

Test No.	Ground Elevation (ft)	Test Depth (ft.)	Northing	Easting	Latitude	Longitude
B-1	96.90	100	913773.92	2476805.03	N34.334809	W79.420399
B-2	96.91	100	913787.52	2476756.26	N34.334848	W79.420560
CPT-1	96.33	37.8	913766.03	2476785.14	N34.334788	W79.420466
CPT-2	96.67	33.1	913808.48	2476770.84	N34.334905	W79.420511
MASW-1 <sup>1</sup>	97.81	N.A.	913896.87	2476629.88	N34.335154	W79.420973

1. Approximate center of array

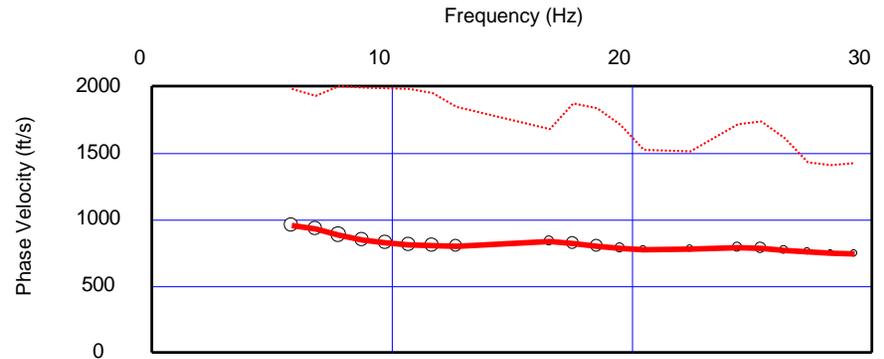
# ARRAY 1



Average Weighted Shear Wave Velocity (ft/s)<sup>1</sup> = **923**

1. measured between 0 ft and 100 ft.

Testing Results	
Depth(ft)	S-wave velocity(ft/s)
0.0	767.8
2.6	768.7
5.6	775.5
8.8	816.3
12.3	841.2
16.1	886.7
20.2	845.8
24.6	854.2
29.2	877.7
34.2	915.9
39.5	920.3
45.0	931.7
50.9	946.7
57.0	964.1
63.5	982.2
70.2	999.7
77.2	1015.9
84.5	1030.4
92.1	1043.9
115.8	1050.6



Project Mgr:	PAM	Project No.	7318P119E
Prepared by:	PDM	File Name:	MASW
Checked by:	PAM	Scale:	N/A
Approved by:	PAM	Date:	Nov. 2018

**Terracon**

2701 Wesport Road Charlotte, NC  
 PH: (704) 509-1777 Fax: (704) 509-1888

**GEOPHYSICAL TESTING RESULTS**  
**S-17-51 (E. Academy Street) RBO Unnamed Stream**  
**Dillon County, SC**

**EXHIBIT**  
  
**A-4**

## Geotechnical Data Report

S-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038248



## 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 test 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.

### Cone Penetration Test Soundings (CPT)

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

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
CPT-1	50 feet or refusal	N/A
CPT-2	50 feet or refusal	N/A

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

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S-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
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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 on Exhibit A-6.

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 clean sand and the borings were capped with cold-patch asphalt.

### Seismic Surface Wave Testing

Multi-Channel Analysis of Surface Waves (MASW testing) was performed to determine the shear wave velocity profile of the layered soil system. At the test location, both MASW readings (active) and Microtremor Array Measurement (MAM) readings (passive) were recorded. The MASW test was conducted using the 24-channel Geometrics Geode seismographs and 4.5-Hz geophones with a linear geometry at an interval of 10-ft. Surface waves were generated by a 20-pound sledgehammer striking a polyethylene plate at four locations. MAM testing was performed along the same survey line.

MASW (Active) Testing - Multi-Channel Analysis of Surface Waves (MASW) is a seismic method that uses the dispersive characteristics of Rayleigh-type surface waves to determine the variation of the shear-wave velocity of layered soils with depth.

MAM (Passive) Testing - Microtremor Array Measurement (MAM) “for lower frequency surface waves (passive waves) arising from microtremors and/or urban (traffic) noise and recorded them using a linear or two-dimensional (triangle, circle, semicircle, and “shapes”) array of geophones (Zywicki and Rix, 1999; Lie et al., 2000). Multiple noise records are required for analysis. The data filters out the Rayleigh waves through a technique called spatial auto-correction (SPAC). This allows the development of a dispersion curve that is defined as the lower envelope of the measured energy peaks. MAM testing results in lower peak energy selections than the active testing described above.

## SOIL DESCRIPTION TERMS

### Relative Density/Consistency Terms

<u>Relative Density<sup>1</sup></u>			<u>Consistency<sup>2</sup></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.

### Angularity<sup>1</sup>

<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 Reaction<sup>3</sup>

<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

### Cementation<sup>3</sup>

<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 Range<sup>1</sup>

<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<sup>1,2</sup>

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

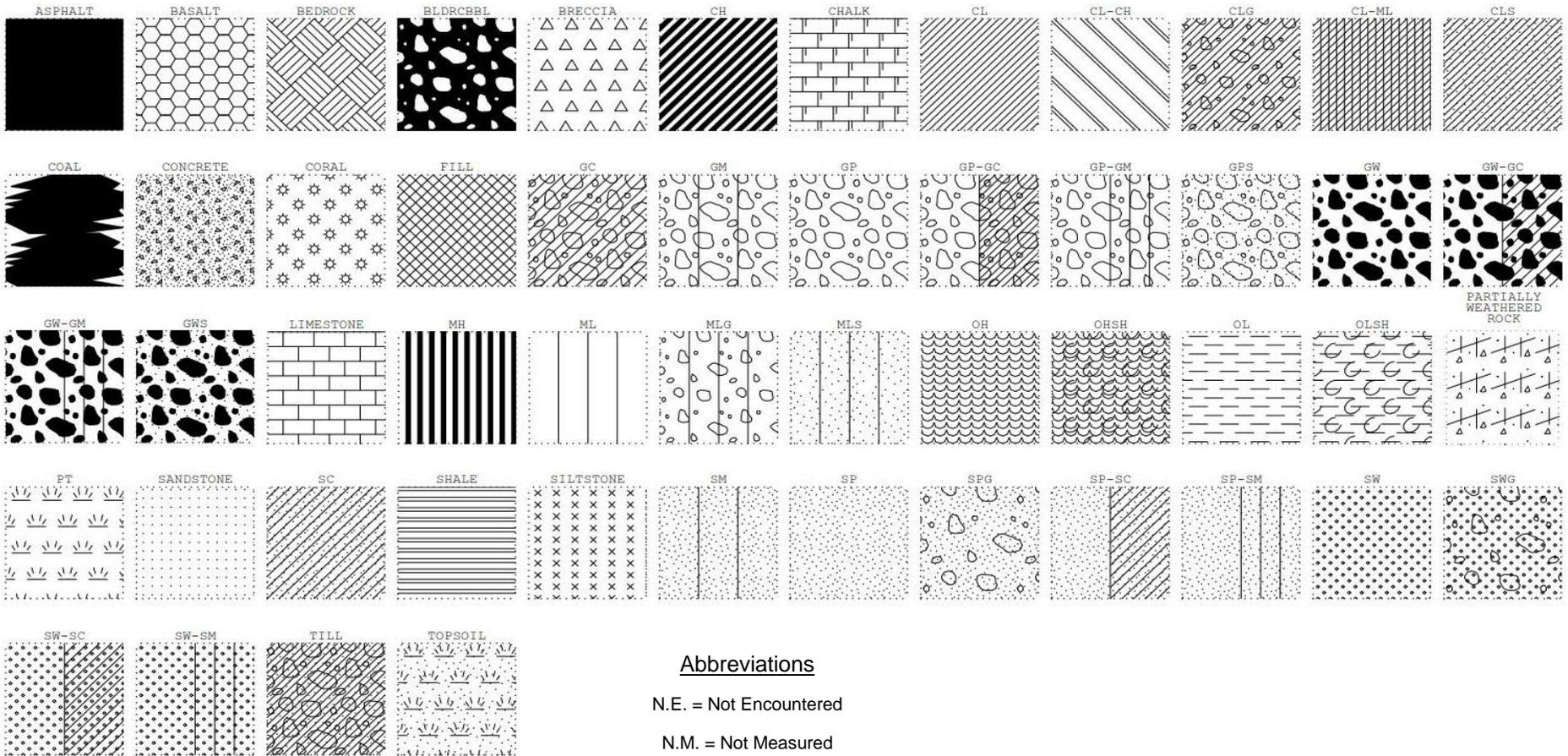
### AASHTO Soil Designation

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

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

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

<sup>3</sup> 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

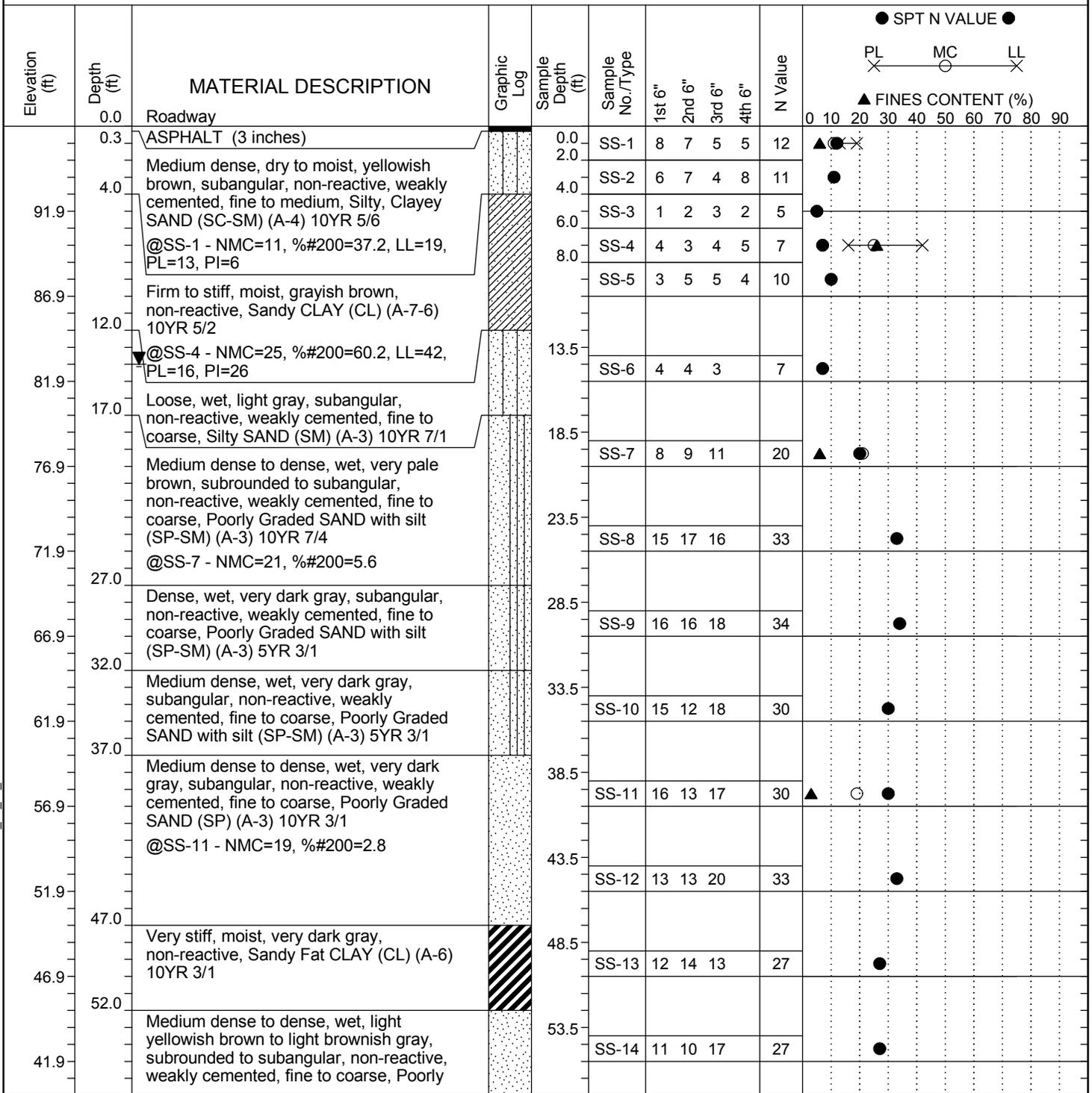
**Terracon**  
Consulting Engineers & Scientists

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

SOIL / ROCK / LOG SYMBOL LEGEND

# SCDOT Soil Test Log

<b>Project ID:</b> P038248	<b>County:</b> Dillon County	<b>Boring No.:</b> B-1
<b>Site Description:</b> S-17-51 (E. Academy Street) BRO Unnamed Stream	<b>Route:</b> S-17-51	
<b>Eng./Geo.:</b> KM	<b>Boring Location:</b>	<b>Offset:</b>
<b>Elev.:</b> 96.9 ft	<b>Latitude:</b> 34.334809	<b>Longitude:</b> -79.420399
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> N.A. ft
<b>Bore Hole Diameter (in):</b> 3	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Drill Machine:</b> CME-45C	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Core Size:</b> N.A.	<b>Driller:</b> SB	<b>Energy Ratio:</b> 97.1%
	<b>Groundwater:</b> TOB	<b>24HR:</b> 14 ft



## LEGEND

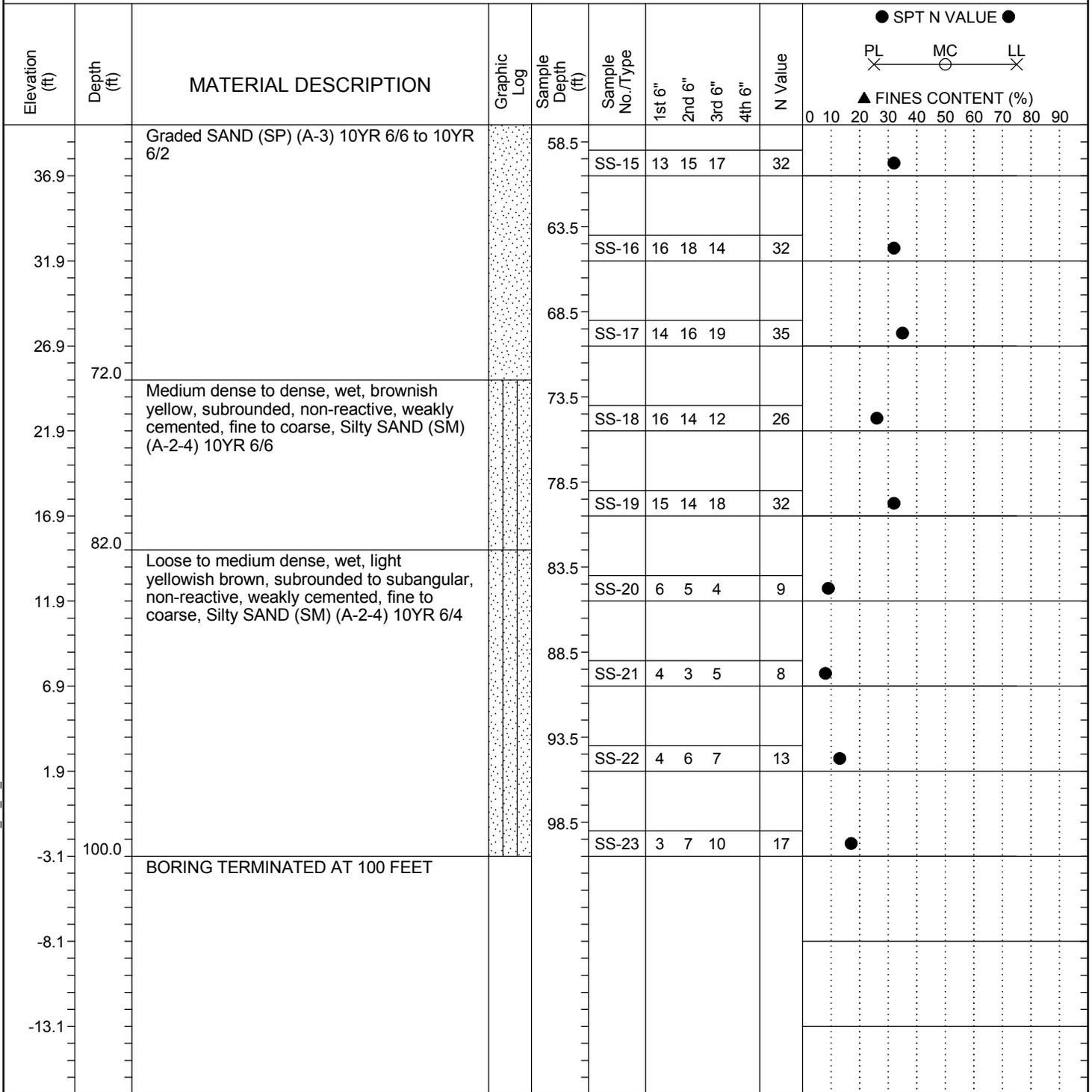
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC\_DOT\_7318P119E S-51 SCDOT.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 11/29/18

# SCDOT Soil Test Log

<b>Project ID:</b> P038248	<b>County:</b> Dillon County	<b>Boring No.:</b> B-1
<b>Site Description:</b> S-17-51 (E. Academy Street) BRO Unnamed Stream	<b>Route:</b> S-17-51	
<b>Eng./Geo.:</b> KM	<b>Boring Location:</b>	<b>Offset:</b>
<b>Elev.:</b> 96.9 ft	<b>Latitude:</b> 34.334809	<b>Longitude:</b> -79.420399
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> N.A. ft
<b>Bore Hole Diameter (in):</b> 3	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Drill Machine:</b> CME-45C	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Core Size:</b> N.A.	<b>Driller:</b> SB	<b>Energy Ratio:</b> 97.1%
	<b>Groundwater:</b> TOB	<b>24HR:</b> 14 ft



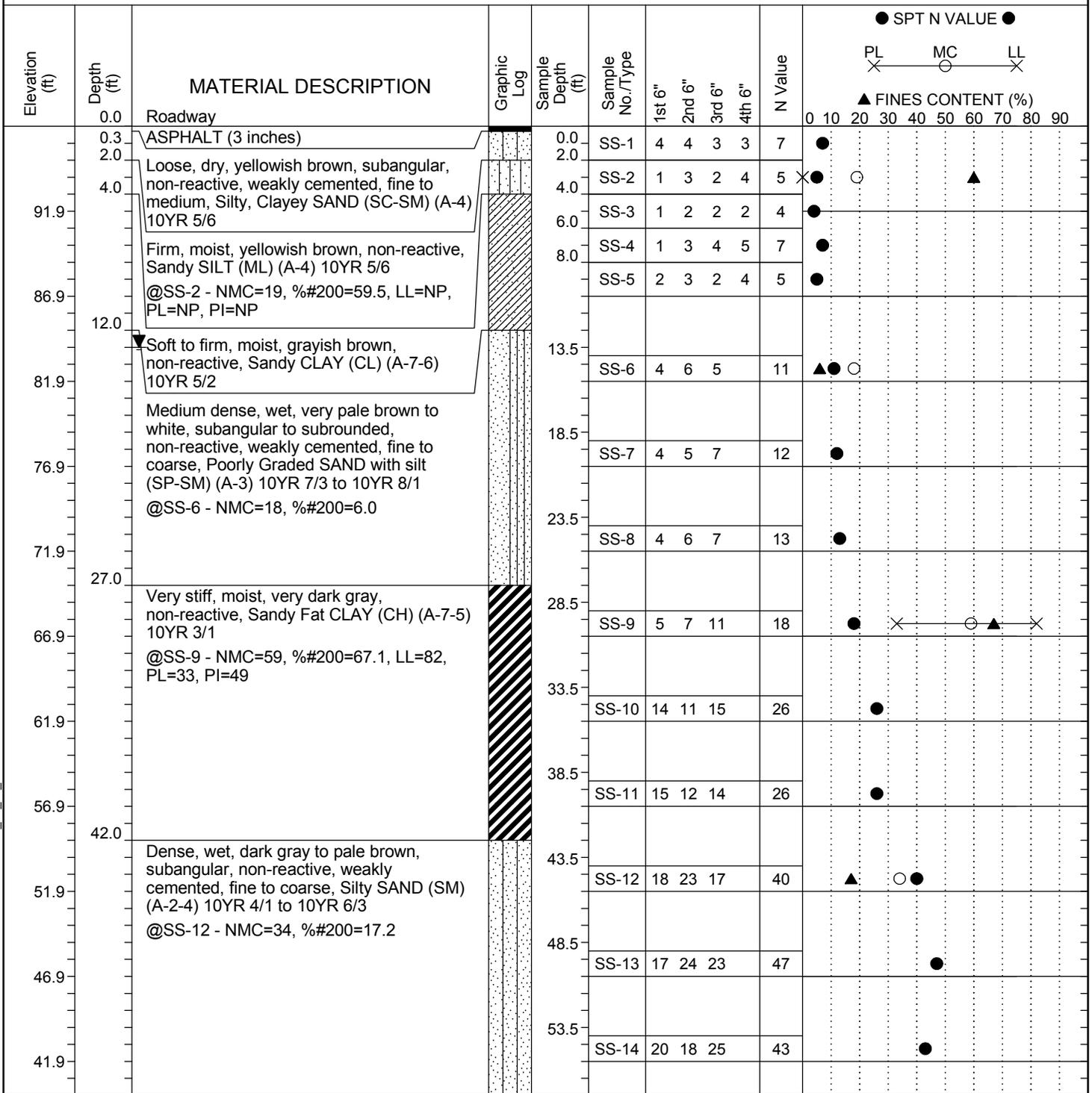
## LEGEND

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
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SC\_DOT\_7318P119E S-51 SCDOT.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 11/29/18

# SCDOT Soil Test Log

<b>Project ID:</b> P038248	<b>County:</b> Dillon County		<b>Boring No.:</b> B-2
<b>Site Description:</b> S-17-51 (E. Academy Street) BRO Unnamed Stream	<b>Route:</b> S-17-51		
<b>Eng./Geo.:</b> KM	<b>Boring Location:</b>	<b>Offset:</b>	<b>Alignment:</b> Main
<b>Elev.:</b> 96.9 ft	<b>Latitude:</b> 34.334848	<b>Longitude:</b> -79.42056	<b>Date Started:</b> 11/9/2018
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> N.A. ft	<b>Date Completed:</b> 11/12/2018
<b>Bore Hole Diameter (in):</b> 3	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)	<b>Liner Used:</b> Y (N)
<b>Drill Machine:</b> CME-45C	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic	<b>Energy Ratio:</b> 97.1%
<b>Core Size:</b> N.A.	<b>Driller:</b> SB	<b>Groundwater:</b> TOB N/M	<b>24HR:</b> 13 ft



## LEGEND

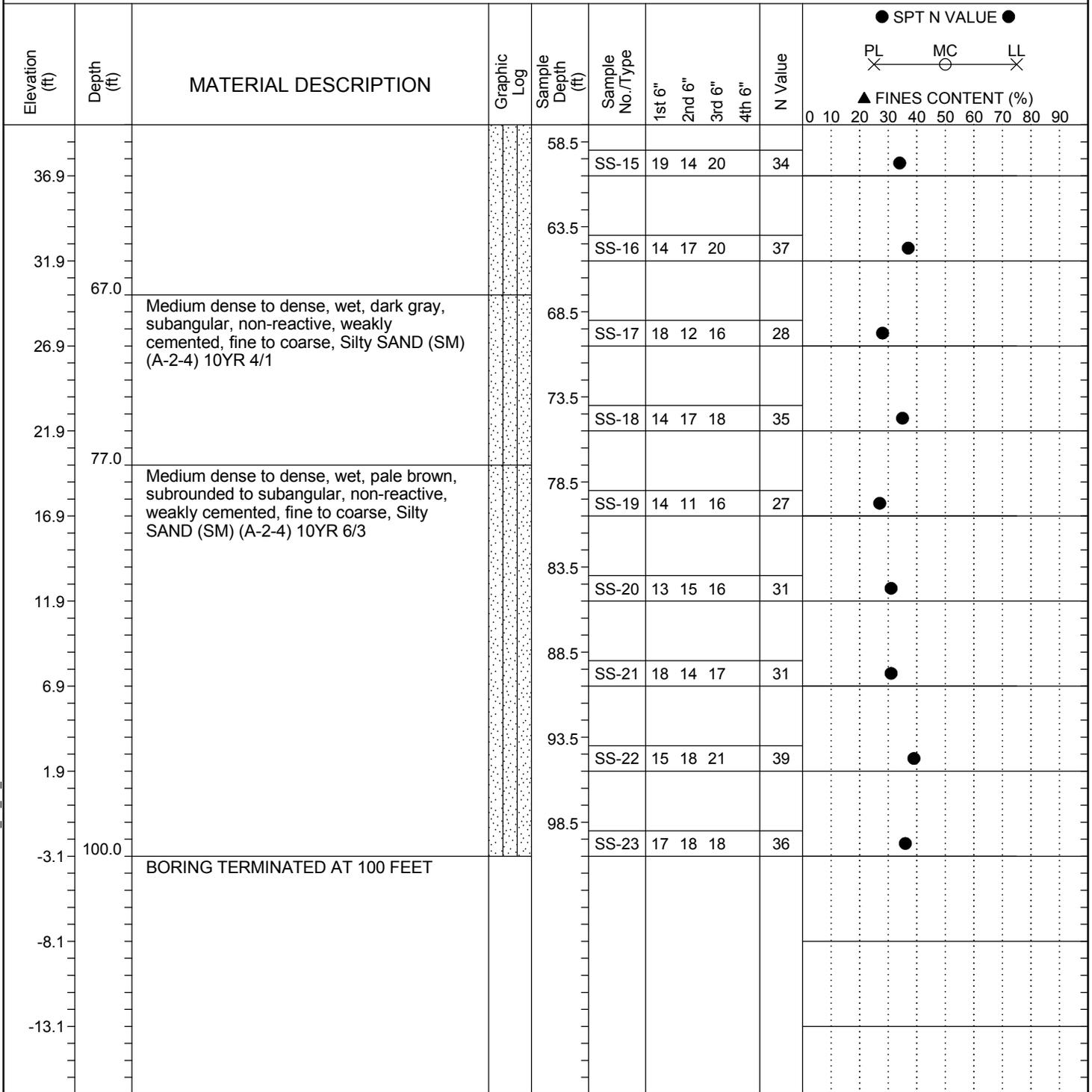
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SAMPLER TYPE		DRILLING METHOD	
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UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
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SC\_DOT\_7318P119E S-51 SCDOT.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 11/29/18

# SCDOT Soil Test Log

<b>Project ID:</b> P038248	<b>County:</b> Dillon County	<b>Boring No.:</b> B-2
<b>Site Description:</b> S-17-51 (E. Academy Street) BRO Unnamed Stream		<b>Route:</b> S-17-51
<b>Eng./Geo.:</b> KM	<b>Boring Location:</b>	<b>Offset:</b>
<b>Elev.:</b> 96.9 ft	<b>Latitude:</b> 34.334848	<b>Longitude:</b> -79.42056
<b>Total Depth:</b> 100 ft	<b>Soil Depth:</b> 100 ft	<b>Core Depth:</b> N.A. ft
<b>Bore Hole Diameter (in):</b> 3	<b>Sampler Configuration</b>	<b>Liner Required:</b> Y (N)
<b>Drill Machine:</b> CME-45C	<b>Drill Method:</b> RW	<b>Hammer Type:</b> Automatic
<b>Core Size:</b> N.A.	<b>Driller:</b> SB	<b>Energy Ratio:</b> 97.1%
<b>Groundwater:</b> TOB	N/M	<b>24HR:</b> 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
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SC\_DOT\_7318P119E S-51 SCDOT.GPJ SCDOT DATA TEMPLATE\_01\_30\_2015.GDT 11/29/18

# CPT LOG NO. CPT-1

**PROJECT:** S-17-51 (E. Academy Street) BRO  
Unnamed Stream

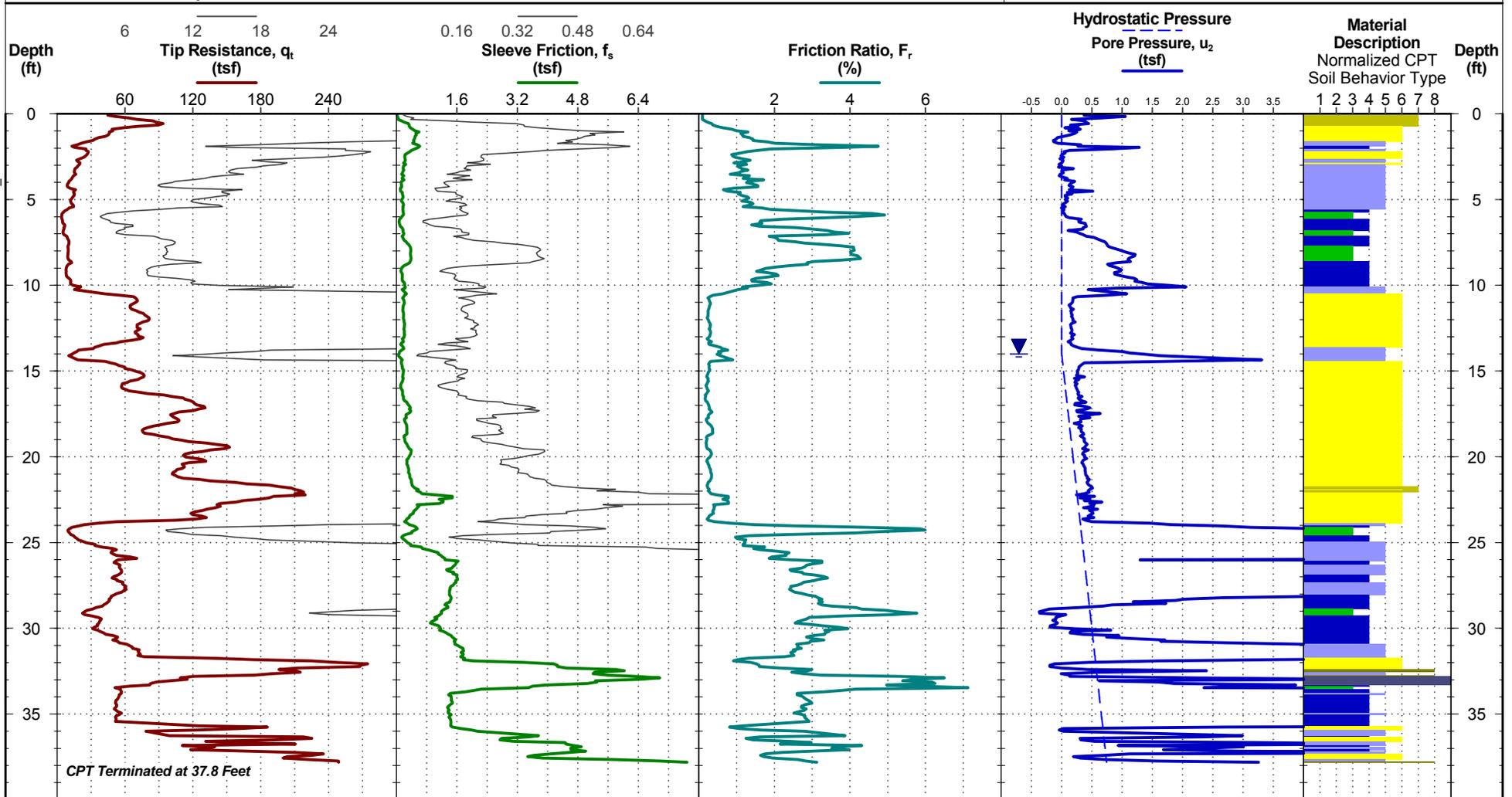
**CLIENT:** SCDOT  
Columbia, South Carolina

**TEST LOCATION:** See Exhibit A-2

**SITE:** Various Counties  
Dillion County, South Carolina

Latitude: 34.334788°  
Longitude: -79.420465°

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT: 7318P119E S-51 LAB DATA .GPJ TERRACON\_DATATEMPLATE.GDT 11/29/18



See Exhibit A-5 for description of field procedures.  
See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 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

**WATER LEVEL OBSERVATION**

▼ 14 ft measured water depth  
(used in normalizations and correlations;  
see Appendix C)

Probe no. 4815 with net area ratio of 0.88  
U2 pore pressure transducer location  
Manufactured by Geotech A.B.; calibrated 2/20/2017  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>  
Ring friction reducer with O.D. of 1.875 in



CPT Started: 11/14/2018

Rig: Pagani TG73-200

Project No.: 7318P119E

CPT Completed: 11/14/2018

Operator: BR

Exhibit: A-1

# CPT LOG NO. CPT-2

**PROJECT:** S-17-51 (E. Academy Street) BRO  
Unnamed Stream

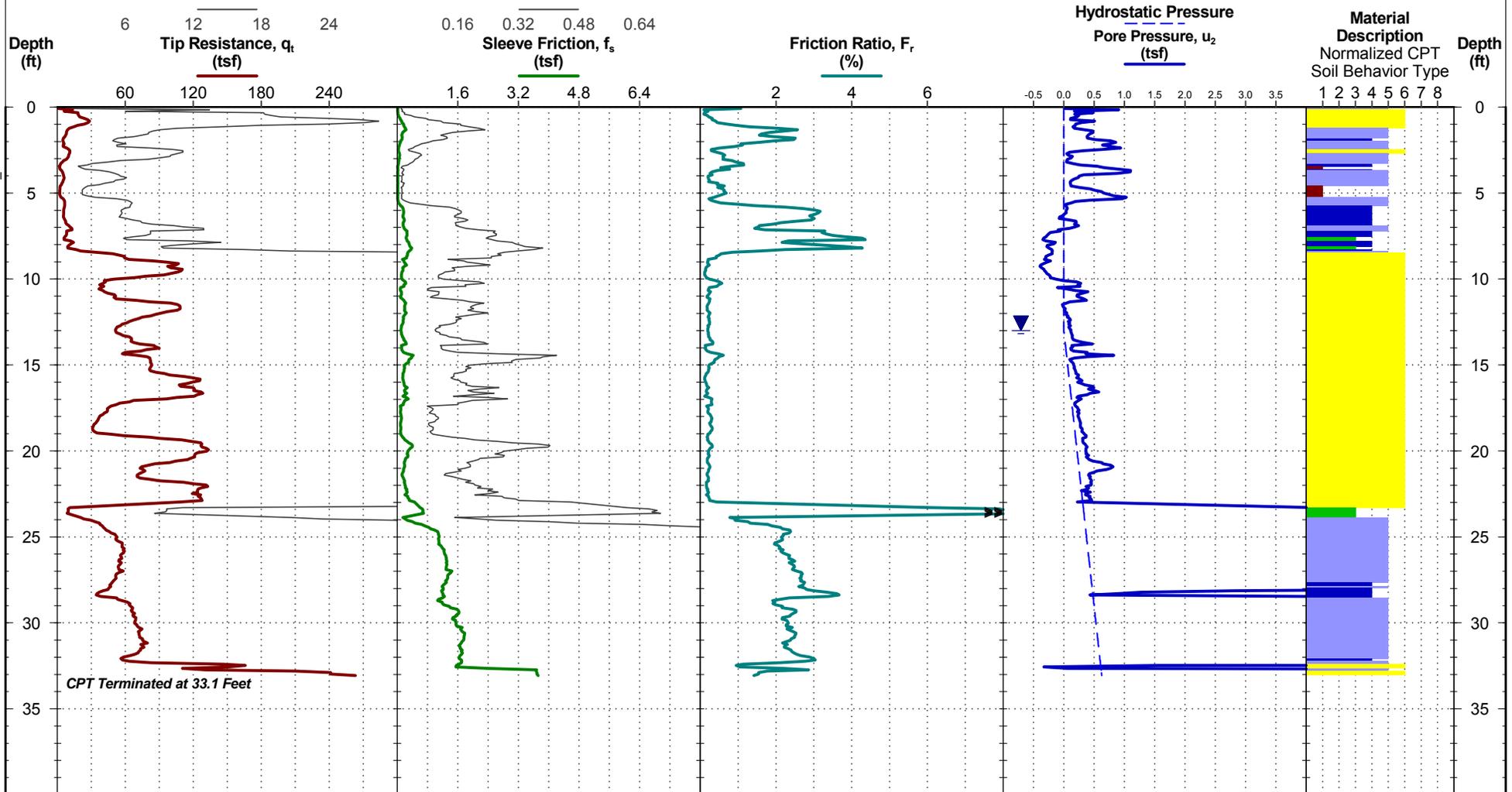
**CLIENT:** SCDOT  
Columbia, South Carolina

**TEST LOCATION:** See Exhibit A-2

**SITE:** Various Counties  
Dillion County, South Carolina

Latitude: 34.334905°  
Longitude: -79.420511°

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT: 7318P119E S-51 LAB DATA .GPU TERRACON\_DATATEMPLATE.GDT 11/29/18



See Exhibit A-5 for description of field procedures.  
See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 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

**WATER LEVEL OBSERVATION**

▼ 13 ft measured water depth  
(used in normalizations and correlations;  
see Appendix C)

Probe no. 4815 with net area ratio of 0.88  
U2 pore pressure transducer location  
Manufactured by Geotech A.B.; calibrated 2/20/2017  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>  
Ring friction reducer with O.D. of 1.875 in



CPT Started: 11/14/2018

Rig: Pagani TG73-200

Project No.: 7318P119E

CPT Completed: 11/14/2018

Operator: BR

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT CORRELATIVE PARAMETERS REPORT 7318P119E S-51 LAB DATA .GPJ TERRACON\_DATATEMPLATE.GDT 11/29/18

# CPT CORRELATIVE PARAMETER LOG NO. CPT-1

SEE CPT LOG NO. CPT-1 FOR DETAILED TEST RESULTS

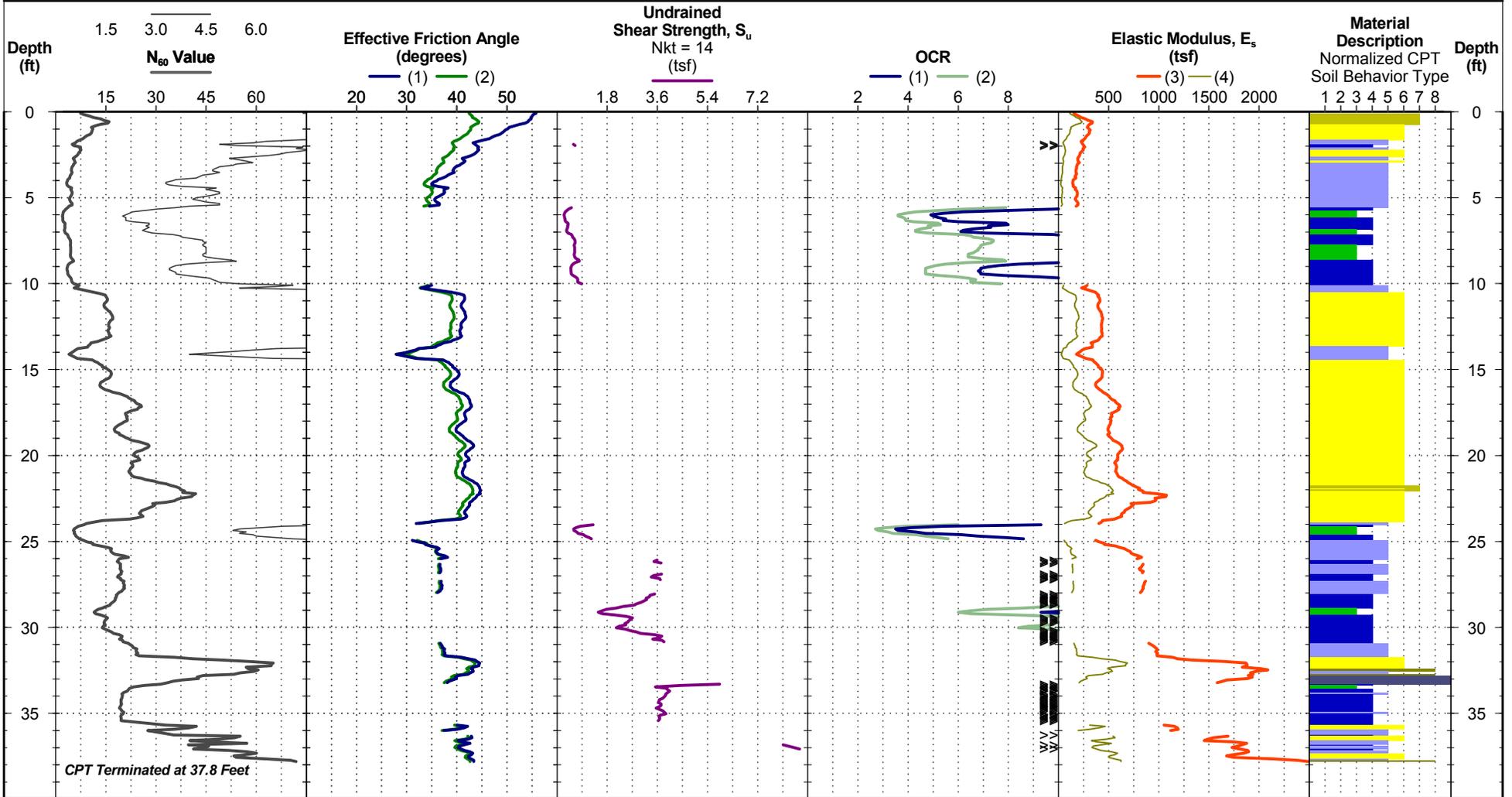
**PROJECT:** S-17-51 (E. Academy Street) BRO  
Unnamed Stream

**CLIENT:** SCDOT  
Columbia, South Carolina

**TEST LOCATION:** See Exhibit A-2

**SITE:** Various Counties  
Dillion County, South Carolina

Latitude: 34.334788°  
Longitude: -79.420465°



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

**WATER LEVEL OBSERVATION**

14 ft measured water depth  
(used in normalizations and correlations; see Appendix C)

Notes:  
Probe no. 4815 with net area ratio of 0.88  
Manufactured by Geotech A.B.; calibrated 2/20/2017  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>  
Ring friction reducer with O.D. of 1.875 in



CPT Started: 11/14/2018

Rig: Pagani TG73-200

Project No.: 7318P119E

CPT Completed: 11/14/2018

Operator: BR

Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT CORRELATIVE PARAMETERS REPORT 7318P119E S-51 LAB DATA .GPJ TERRACON\_DATATEMPLATE.GDT 11/29/18

# CPT CORRELATIVE PARAMETER LOG NO. CPT-2

SEE CPT LOG NO. CPT-2 FOR DETAILED TEST RESULTS

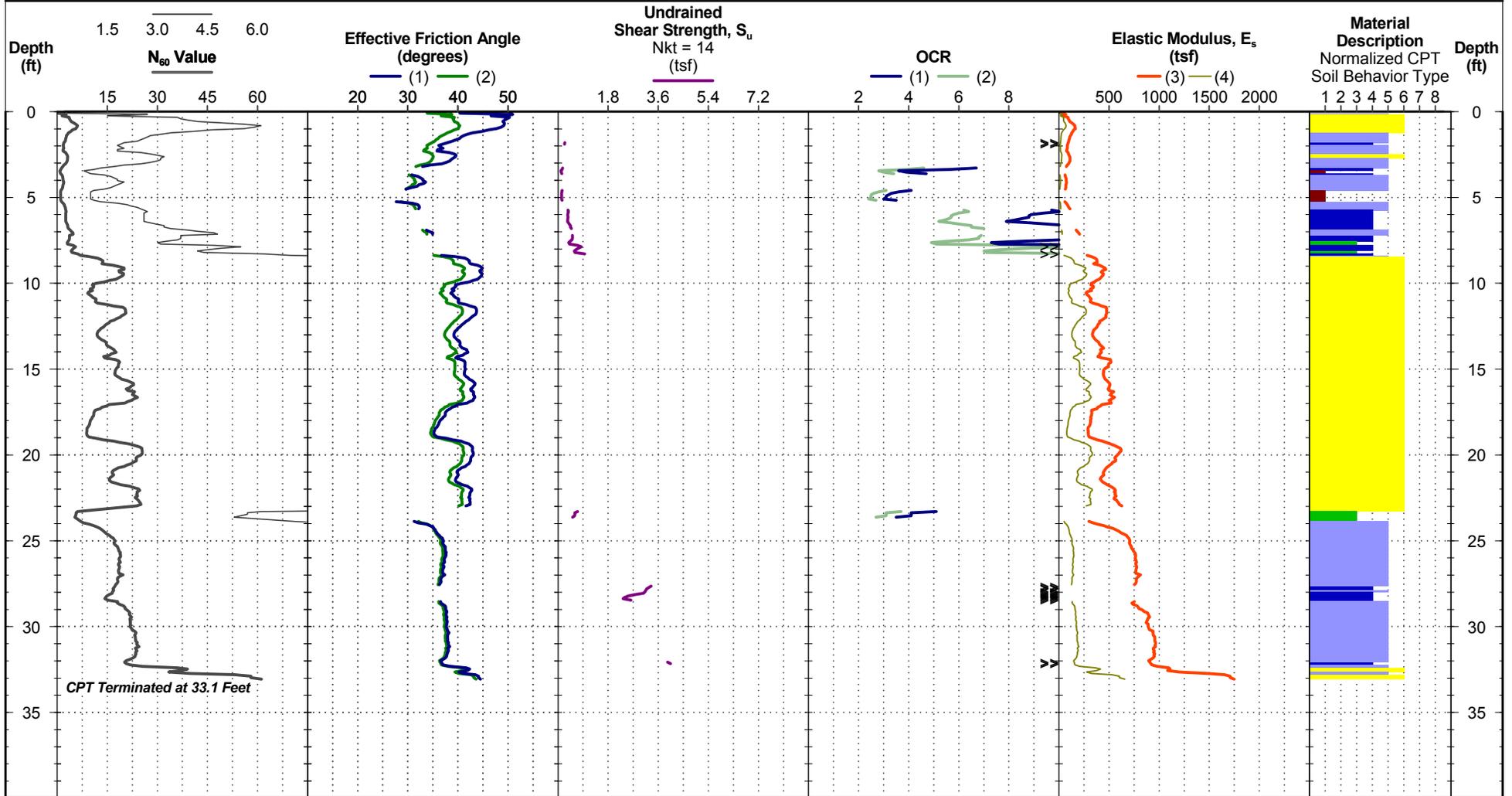
**PROJECT:** S-17-51 (E. Academy Street) BRO  
Unnamed Stream

**CLIENT:** SCDOT  
Columbia, South Carolina

**TEST LOCATION:** See Exhibit A-2

**SITE:** Various Counties  
Dillion County, South Carolina

Latitude: 34.334905°  
Longitude: -79.420511°



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

**WATER LEVEL OBSERVATION**

13 ft measured water depth  
(used in normalizations and correlations; see Appendix C)

Notes:  
Probe no. 4815 with net area ratio of 0.88  
Manufactured by Geotech A.B.; calibrated 2/20/2017  
Tip and sleeve areas of 10 cm<sup>2</sup> and 150 cm<sup>2</sup>  
Ring friction reducer with O.D. of 1.875 in



CPT Started: 11/14/2018

Rig: Pagani TG73-200

Project No.: 7318P119E

CPT Completed: 11/14/2018

Operator: BR

Exhibit: A-2

**Geotechnical Data Report**

S-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
November 29, 2018 ■ Terracon Project No. 73185119E



Drill rig on B-1



Drill rig on B-2

**Geotechnical Data Report**

S-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC  
November 29, 2018 ■ Terracon Project No. 73185119E



CPT rig on CPT-1



CPT rig on CPT-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-17-51 (E. Academy Street) RBO Unnamed Stream ■ Dillon County, SC

November 29, 2018 ■ Terracon Project No. 7318P119E/Project ID.: P038248



### 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                 |
| ■ 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	0 - 2	1.0	61.8	37.2	19	13	6	11
B-1	6 - 8	0.0	39.8	60.2	42	16	26	25
B-1	18.5 - 20	1.3	93.1	5.6				21
B-1	38.5 - 40	0.7	96.5	2.8				19
B-2	2 - 4	0.0	40.5	59.5	NP	NP	NP	19
B-2	13.5 - 15	1.9	92.1	6.0				18
B-2	28.5 - 30	1.3	31.5	67.1	82	33	49	59
B-2	43.5 - 45	3.2	79.6	17.2				34

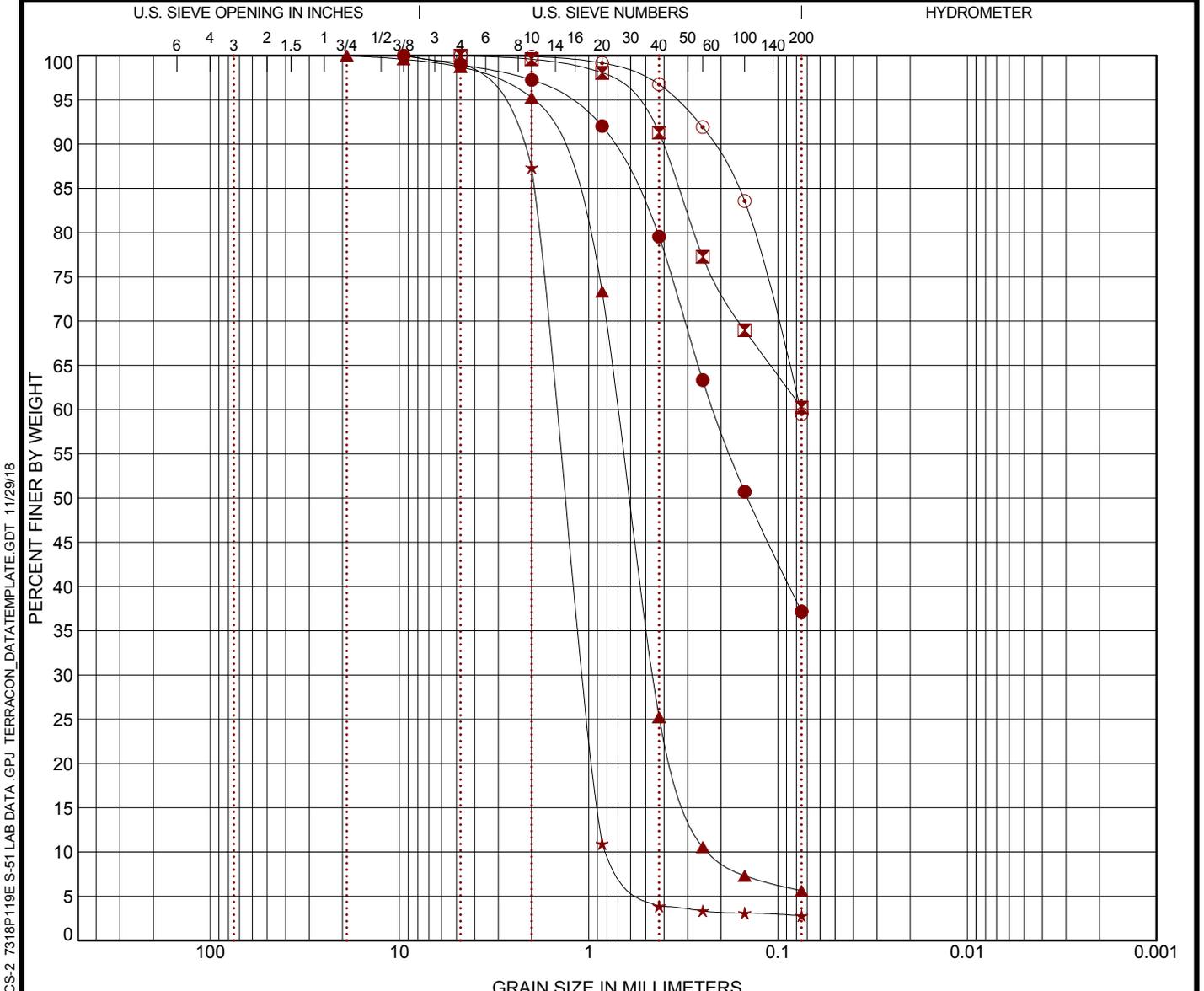
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SMART LAB SUMMARY-PORTRAIT\_7318P119E S-51 LAB DATA.GPJ TERRACON\_DATATEMPLATE.GDT\_11/29/18

PROJECT: S-17-51 (E. Academy Street) BRO Unnamed Stream	 <p style="font-size: small;">521 Clemson Rd Columbia, SC</p>	PROJECT NUMBER: 7318P119E
SITE: Various Counties Dillion 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	0 - 2	SILTY, CLAYEY SAND (SC-SM)				11	19	13	6		
⊠ B-1	6 - 8	SANDY CLAY (CL)				25	42	16	26		
▲ B-1	18.5 - 20	POORLY GRADED SAND WITH SILT (SP-SM)				21				1.29	3.06
★ B-1	38.5 - 40	POORLY GRADED SAND (SP)				19				0.97	1.90
⊙ B-2	2 - 4	SANDY SILT (ML)				19	NP	NP	NP		
Boring ID	Depth	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Gravel	%Sand	%Silt	%Fines	%Clay	
● B-1	0 - 2	9.5	0.218			1.0	61.8		37.2		
⊠ B-1	6 - 8	4.75				0.0	39.8		60.2		
▲ B-1	18.5 - 20	19	0.701	0.455	0.229	1.3	93.1		5.6		
★ B-1	38.5 - 40	9.5	1.472	1.052	0.776	0.7	96.5		2.8		
⊙ B-2	2 - 4	4.75	0.076			0.0	40.5		59.5		

PROJECT: S-17-51 (E. Academy Street) BRO Unnamed Stream  SITE: Various Counties Dillion County, South Carolina	521 Clemson Rd Columbia, SC	PROJECT NUMBER: 7318P119E  CLIENT: SCDOT Columbia, South Carolina  EXHIBIT: B-4
--	--------------------------------	--

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 7318P119E S-51 LAB DATA.GPJ TERRACON\_DATA\TEMPLATE.GDT 11/29/18

**APPENDIX C**  
**SUPPORTING DOCUMENTS**

**Exhibit C-1 – CPT General Notes**  
**Exhibit C-2 – Rig Calibration Documentation**

# CPT GENERAL NOTES

## DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

### To be reported per ASTM D5778:

Uncorrected Tip Resistance,  $q_c$   
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance,  $q_t$   
Cone resistance corrected for porewater and net area ratio effects  
 $q_t = q_c + U2(1 - a)$

Where  $a$  is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

### Pore Pressure, U1/U2

Pore pressure generated during penetration  
U1 - sensor on the face of the cone  
U2 - sensor on the shoulder (more common)

### Sleeve Friction, $f_s$

Frictional force acting on the sleeve divided by its surface area

### Normalized Friction Ratio, FR

The ratio as a percentage of  $f_s$  to  $q_t$ , accounting for overburden pressure

### To be reported per ASTM D7400, if collected:

Shear Wave Velocity,  $V_s$   
Measured in a Seismic CPT and provides direct measure of soil stiffness

## DESCRIPTION OF GEOTECHNICAL CORRELATIONS

### Normalized Tip Resistance, $Q_t$

$$Q_t = (q_t - \sigma_{v0}) / \sigma'_{v0}$$

### Over Consolidation Ratio, OCR

$$\text{OCR (1)} = 0.25(Q_t)^{1.25}$$

$$\text{OCR (2)} = 0.33(Q_t)$$

### Undrained Shear Strength, $S_u$

$$S_u = Q_t \times \sigma'_{v0} / N_{kq}$$

$N_{kq}$  is a geographical factor (shown on  $S_u$  plot)

### Sensitivity, $St$

$$St = (q_t - \sigma_{v0} / N_{kq}) \times (1 / fs)$$

### Effective Friction Angle, $\phi'$

$$\phi' (1) = \tan^{-1}(0.373[\log(q_t / \sigma'_{v0}) + 0.29])$$

$$\phi' (2) = 17.6 + 11[\log(Q_t)]$$

### Unit Weight

$$UW = (0.27[\log(FR)] + 0.36[\log(q_t / \text{atm})] + 1.236) \times UW_{\text{water}}$$

$\sigma_{v0}$  is taken as the incremental sum of the unit weights

### Small Strain Shear Modulus, $G_0$

$$G_0 (1) = \rho V_s^2$$

$$G_0 (2) = 0.015 \times 10^{(0.55k + 1.68)} (q_t - \sigma_{v0})$$

### Soil Behavior Type Index, $I_c$

$$I_c = [(3.47 - \log(Q_t))^2 + (\log(FR) + 1.22)^2]^{0.5}$$

### SPT $N_{60}$

$$N_{60} = (q_t / \text{atm}) / 10^{(1.1268 - 0.2817k)}$$

### Elastic Modulus, $E_s$ (assumes $q_t / q_{t, \text{ultimate}} \sim 0.3$ , i.e. FS = 3)

$$E_s (1) = 2.6 \Psi G_0 \text{ where } \Psi = 0.56 - 0.33 \log Q_{t, \text{clean sand}}$$

$$E_s (2) = G_0$$

$$E_s (3) = 0.015 \times 10^{(0.55k + 1.68)} (q_t - \sigma_{v0})$$

$$E_s (4) = 2.5q_t$$

### Constrained Modulus, $M$

$$M = \alpha_M (q_t - \sigma_{v0})$$

For  $I_c > 2.2$  (fine-grained soils)

$$\alpha_M = Q_t \text{ with maximum of } 14$$

For  $I_c < 2.2$  (coarse-grained soils)

$$\alpha_M = 0.0188 \times 10^{(0.55k + 1.68)}$$

### Hydraulic Conductivity, $k$

$$\text{For } 1.0 < I_c < 3.27 \quad k = 10^{(0.952 - 3.04k)}$$

$$\text{For } 3.27 < I_c < 4.0 \quad k = 10^{(-4.52 - 1.37k)}$$

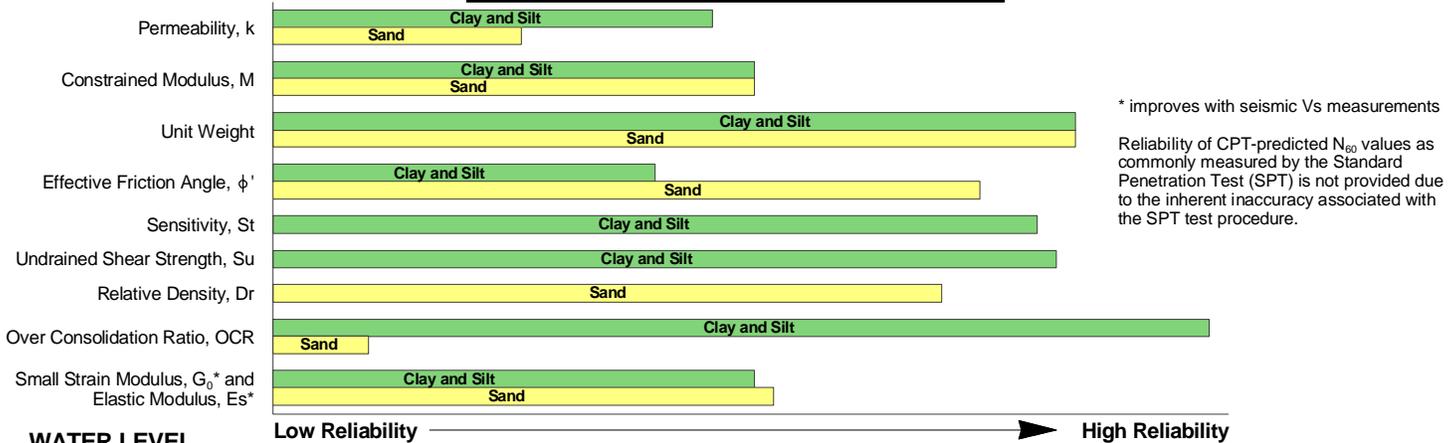
### Relative Density, $Dr$

$$Dr = (Q_t / 350)^{0.15} \times 100$$

## REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include tip resistance, sleeve resistance, and porewater pressure. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

## RELATIVE RELIABILITY OF CPT CORRELATIONS



## WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated."

*Measured - Depth to water directly measured in the field*

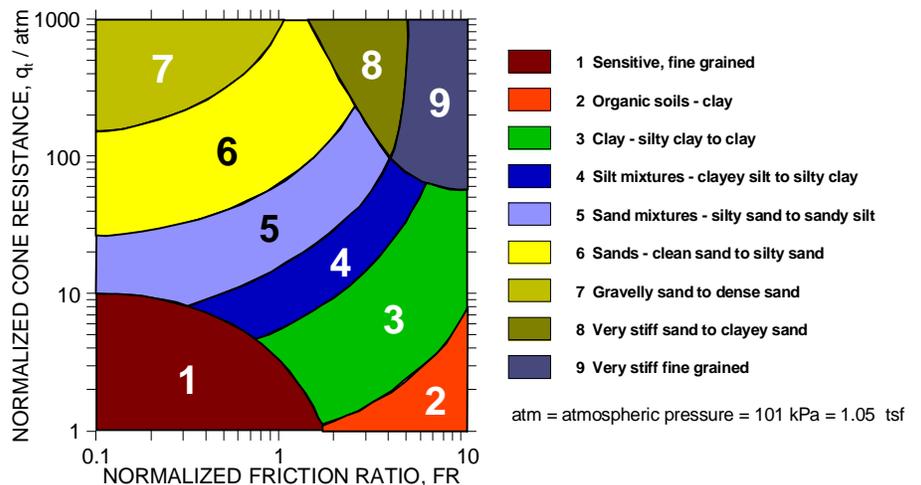
*Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions*

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

## CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance ( $q_t$ ), friction resistance ( $f_s$ ), and porewater pressure (U2). The normalized friction ratio (FR) is used to classify the soil behavior type.

Typically, silts and clays have high FR values and generate large excess penetration porewater pressures; sands have lower FRs and do not generate excess penetration porewater pressures. Negative pore pressure measurements are indicative of fissured fine-grained material. The adjacent graph (Robertson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.



## REFERENCES

- Kulhawy, F.H., Mayne, P.W., (1997). "Manual on Estimating Soil Properties for Foundation Design," Electric Power Research Institute, Palo Alto, CA.
- Mayne, P.W., (2013). "Geotechnical Site Exploration in the Year 2013," Georgia Institute of Technology, Atlanta, GA.
- Robertson, P.K., Cabal, K.L. (2012). "Guide to Cone Penetration Testing for Geotechnical Engineering," Signal Hill, CA.
- Schmertmann, J.H., (1970). "Static Cone to Compute Static Settlement over Sand," *Journal of the Soil Mechanics and Foundations Division*, 96(SM3), 1011-1043.

# DRILL RIG SPT HAMMER ENERGY CALIBRATION REPORT

**Drill Rig Model CME-45C SN 406484**

**Terracon Drill Rig No. 543**

**Gaston Solar Facility**

May 29, 2018

Project No. 73185061

**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

## 1.0 PROJECT INFORMATION

ITEM	DESCRIPTION
Drill Rig Identification	CME-45C, SN 406484 (see photograph on cover page)
Drill Rig Owner	Terracon
Drill Rig Operator	Spencer Blair
Testing Date	May 24, 2018
Testing Location	Gaston Solar Facility
Terracon Project Number	73185061
Boring Identification	SB-2
Energy Measurement Depths	30.0 ft.; 35.0 ft.; 40.0 ft.; 45.0 ft.; 50.0 ft.
Hammer Type	Automatic
Boring Method	Hollow Stem Auger
Drill Rods	<ul style="list-style-type: none"> <li>■ AWJ</li> <li>■ 1¾" outside diameter</li> <li>■ 3/16" wall thickness</li> </ul>
SPT Calibration Testing Equipment	<ul style="list-style-type: none"> <li>■ 2 foot AWJ rod instrumented w/ 2 strain gauges and 2 accelerometers</li> <li>■ Model PAX Pile Driving Analyzer™ (PDA)</li> </ul>
SPT Calibration Personnel	R. Wakeford & Z. McIntosh

## 2.0 TEST RESULTS

**Table 1:**  
 SPT Hammer Energy Calibration Testing Summary.

Boring	Start Depth <sup>1</sup> (ft)	Rod Length <sup>2</sup> (ft)	Rod Sections <sup>3</sup>			Measured Blow Counts (blows/6 inches)				SPT N <sub>meas</sub> (bpf)	Soil Type <sup>4</sup>
			2 ft	5 ft	10 ft	1 <sup>st</sup> Inc.	2 <sup>nd</sup> Inc.	3 <sup>rd</sup> Inc.	4 <sup>th</sup> Inc.		
SB-2	28.5	30.0	0	6	0	9	12	15	-	27	SM
	33.5	35.0	0	7	0	6	5	9	-	14	SM
	38.5	40.0	0	8	0	9	14	19	-	33	SM
	43.5	45.0	0	9	0	8	12	12	-	24	SM
	48.5	50.0	0	10	0	9	16	15	-	31	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 <sup>1</sup> (ft)	SPT N <sub>m</sub> (bpf)	No. of Blows <sup>2</sup>	EMX <sup>3</sup> (kip-ft)			ETR <sup>3</sup> (%)		
				Max.	Min.	Ave.	Std. Dev.	Ave.	Std. Dev.
SB-2	28.5	27	27	0.37	0.31	0.34	0.016	97.9	4.464
	33.5	14	14	0.36	0.33	0.34	0.008	98.5	2.171
	38.5	33	33	0.35	0.34	0.34	0.003	97.1	0.776
	43.5	24	24	0.34	0.33	0.33	0.004	95.4	1.005
	48.5	31	31	0.36	0.33	0.34	0.006	96.7	1.763
<b>Average:</b>				<b>0.35</b>	<b>0.33</b>	<b>0.34</b>	<b>0.007</b>	<b>97.1</b>	<b>2.036</b>

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 <sup>1</sup> (ft)	SPT N <sub>meas</sub> (bpf)	No. of Blows <sup>2</sup>	BPM <sup>3</sup>			
				Max.	Min.	Ave.	Std. Dev.
SB-2	28.5	27	27	55.4	54.8	55.1	0.183
	33.5	14	14	55.4	55.0	55.2	0.107
	38.5	33	33	55.0	54.5	54.7	0.123
	43.5	24	24	46.4	45.6	46.0	0.257
	48.5	31	31	55.2	54.7	55.0	0.128
<b>Average:</b>				<b>53.5</b>	<b>52.9</b>	<b>53.2</b>	<b>0.159</b>

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

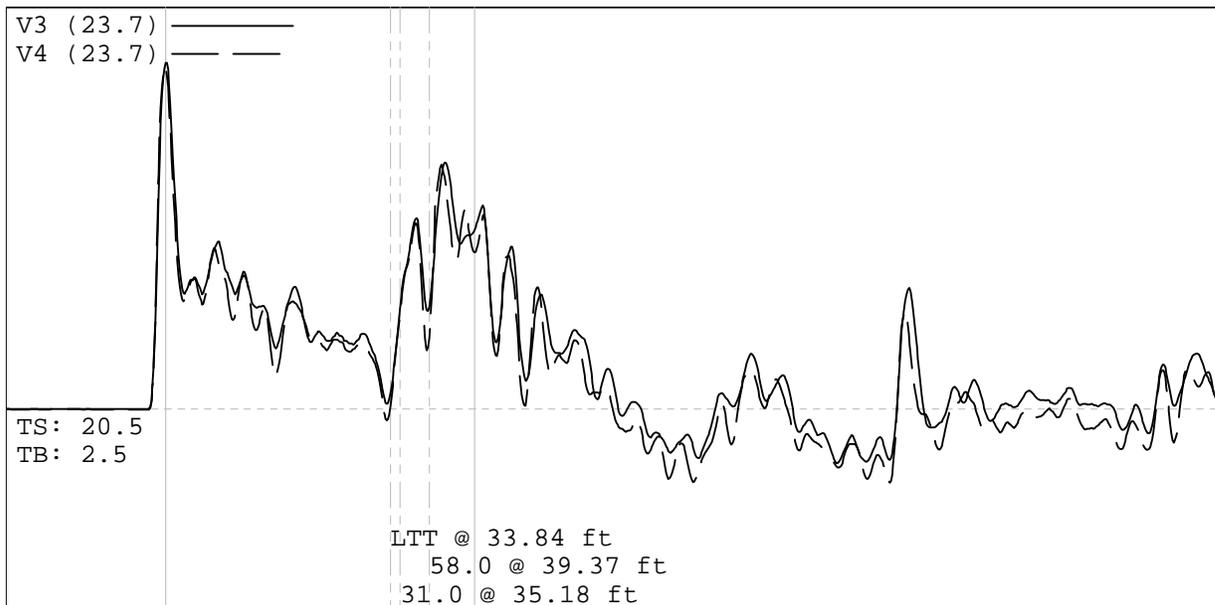
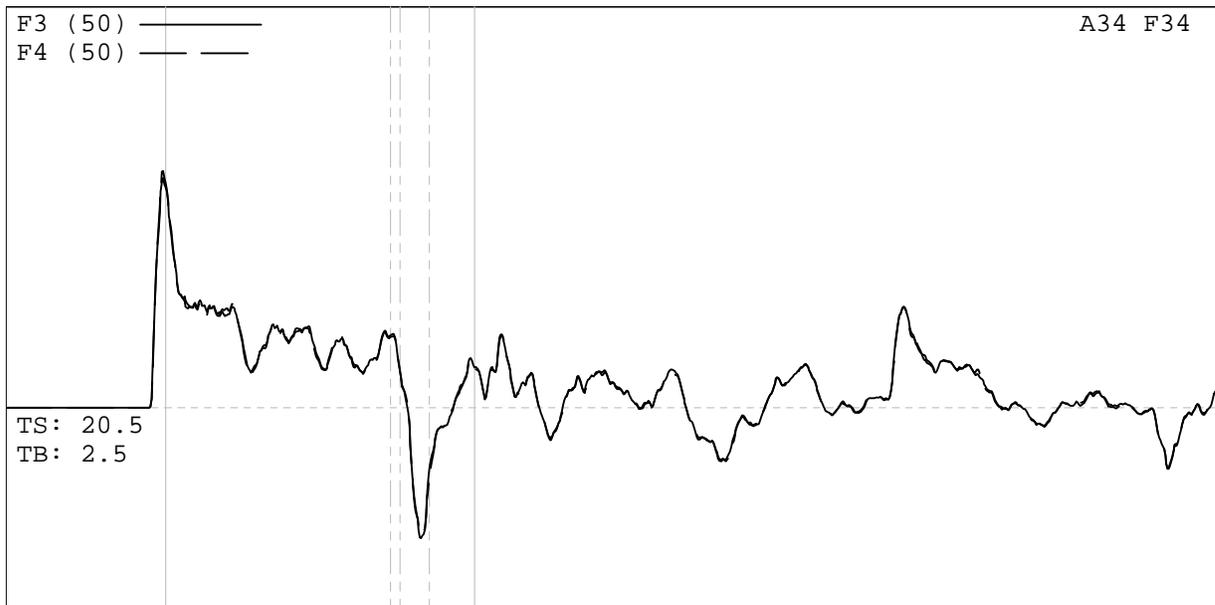
### 3.1 Energy Transfer Ratio (ETR) and Hammer Efficiency Correction (CE)

Based on our testing and subsequent analysis, drill rig CME-45C (No. 543) has an **ETR of 97.1% ± 2.04%**. Based on this ETR, the hammer efficiency correction (**C<sub>E</sub>**) is **1.62**.

## **Exhibit A-1   Representative Blow**

GASTON 2 SOLAR FACILITY

SPT CAL 38.5-40



Project Information

PROJECT: GASTON 2 SOLAR FACILITY  
 PILE NAME: SPT CAL 38.5-40  
 DESCR: CME 45C 38.5-40  
 OPERATOR: ZM  
 FILE: SPT CAL\_38.5\_40\_Log  
 5/24/2018 11:54:19 AM  
 Blow Number 9

Quantity Results

ETR 98.2 (%)  
 CSX 24.6 ksi  
 CSB 0.0 ksi  
 BPM 55.1 bpm  
 EMX 0.344 k-ft  
 DMX 0.69 in  
 SFR kips  
 MEX 820 µE  
 VMX 20.3 f/s

Pile Properties

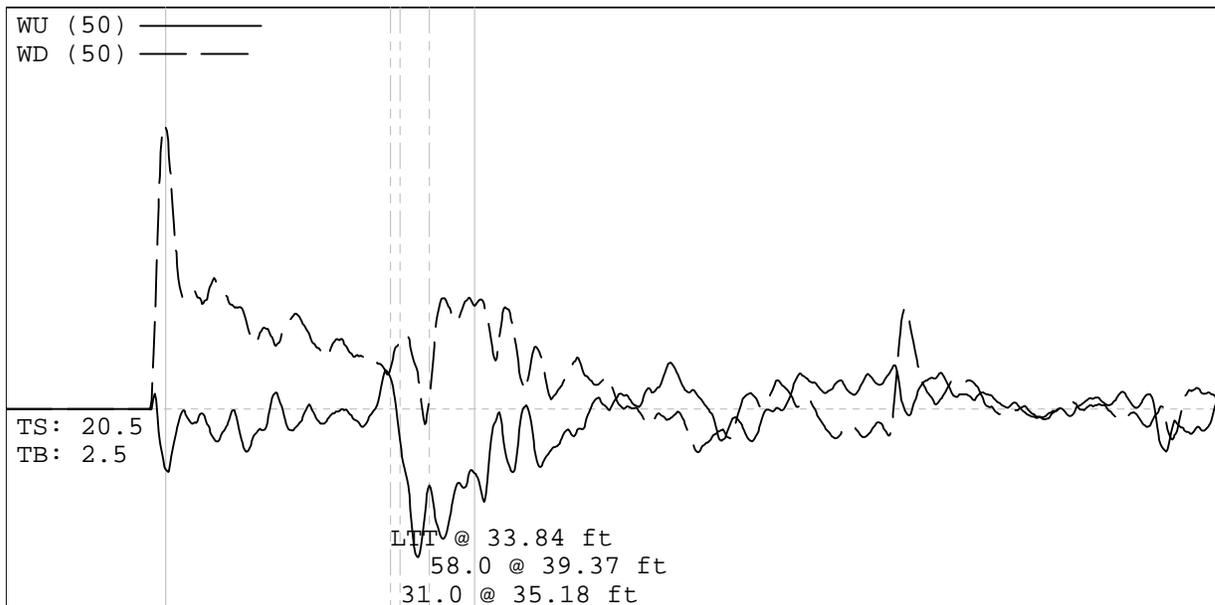
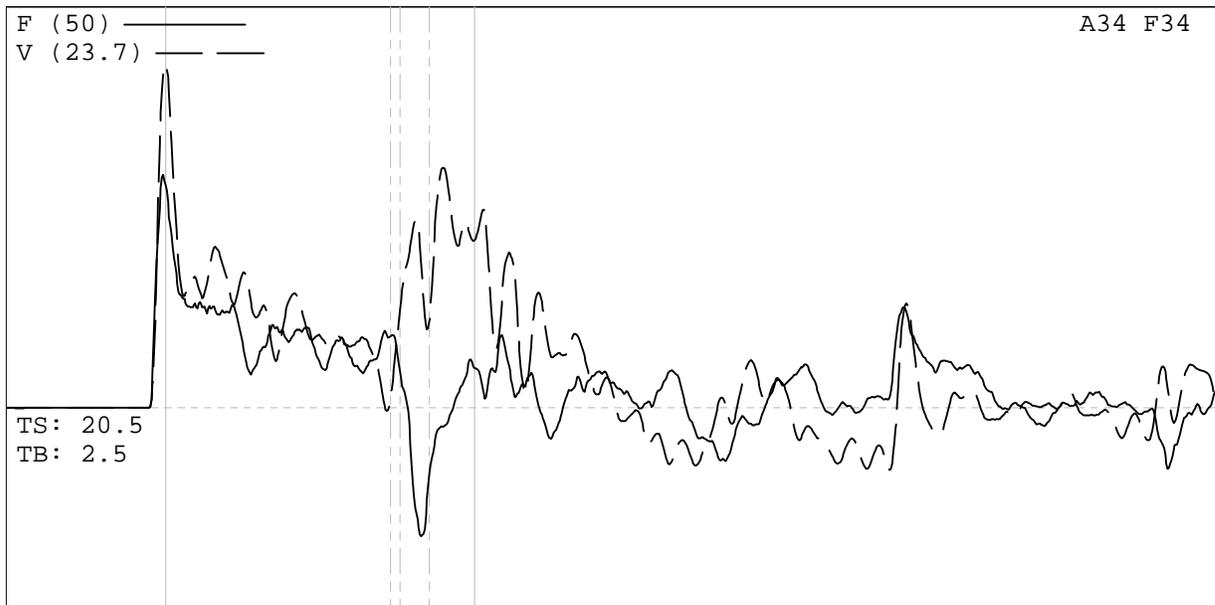
LE 43.70 ft  
 AR 1.18 in<sup>2</sup>  
 EM 30000 ksi  
 SP 0.492 k/ft<sup>3</sup>  
 WS 16807.9 f/s  
 EA/C 2.1 ksec/ft  
 2L/C 5.22 ms  
 JC []  
 LP 37.50 ft

Sensors

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

GASTON 2 SOLAR FACILITY

SPT CAL 38.5-40



Project Information

PROJECT: GASTON 2 SOLAR FACILITY  
 PILE NAME: SPT CAL 38.5-40  
 DESCR: CME 45C 38.5-40  
 OPERATOR: ZM  
 FILE: SPT CAL\_38.5\_40\_Log  
 5/24/2018 11:54:19 AM  
 Blow Number 9

Quantity Results

ETR 98.2 (%)  
 CSX 24.6 ksi  
 CSB 0.0 ksi  
 BPM 55.1 bpm  
 EMX 0.344 k-ft  
 DMX 0.69 in  
 SFR kips  
 MEX 820 µE  
 VMX 20.3 f/s

Pile Properties

LE 43.70 ft  
 AR 1.18 in<sup>2</sup>  
 EM 30000 ksi  
 SP 0.492 k/ft<sup>3</sup>  
 WS 16807.9 f/s  
 EA/C 2.1 ksec/ft  
 2L/C 5.22 ms  
 JC []  
 LP 37.50 ft

Sensors

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



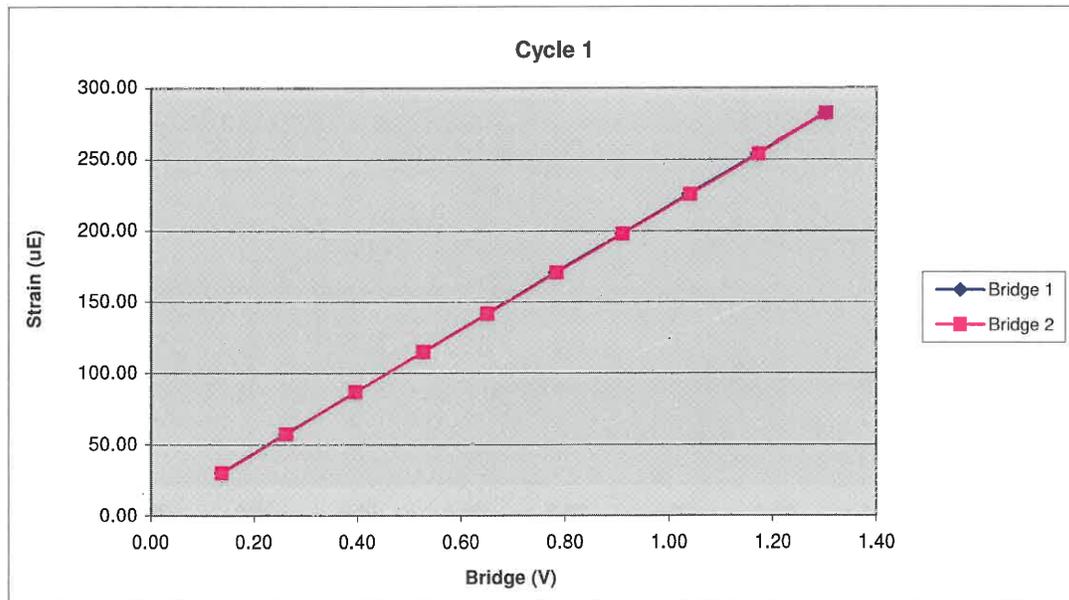
Tested by

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

267AWJ		Cycle 1		
Sample	Force (lb)	Strain ( $\mu$ 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 ( $\mu$ E/V)	216.43	Strain Calibration ( $\mu$ E/V)	216.02
Offset	0.60	Offset	0.51
Correlation	0.999996	Correlation	0.999993

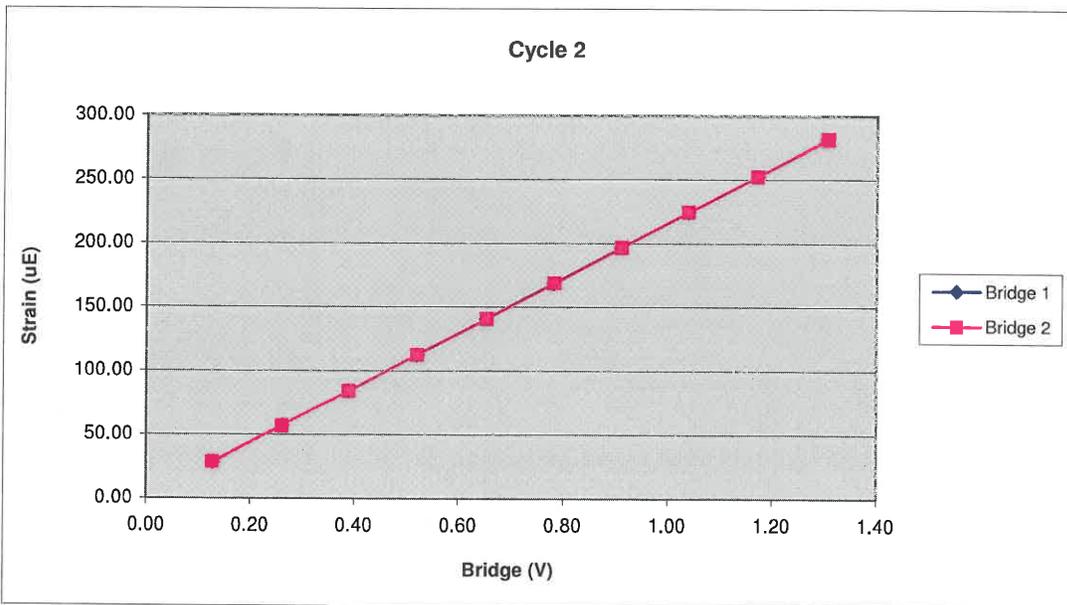
Force Strain Calibration	
EA (Kips)	35284.30
Offset	-29.01
Correlation	0.999989



267AWJ		Cycle 2		
Sample	Force (lb)	Strain ( $\mu$ 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 ( $\mu$ E/V)	215.81	Strain Calibration ( $\mu$ E/V)	215.58
Offset	0.30	Offset	0.38
Correlation	0.999997	Correlation	0.999996

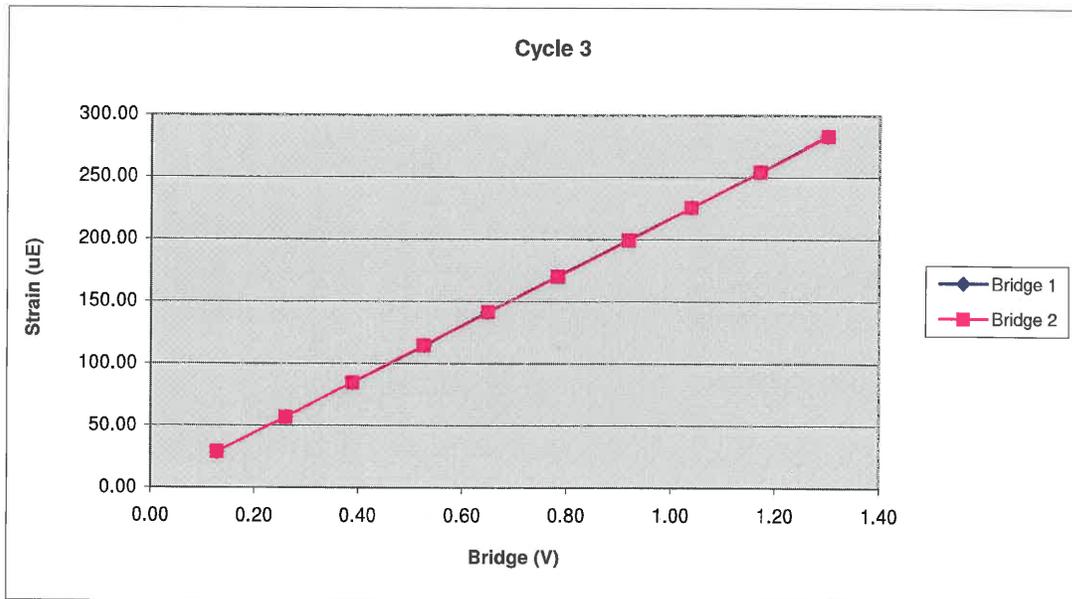
Force Strain Calibration	
EA (Kips)	35375.85
Offset	-19.88
Correlation	0.999997



267AWJ		Cycle 3		
Sample	Force (lb)	Strain ( $\mu$ E)	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 ( $\mu$ E/V)	217.34	Strain Calibration ( $\mu$ E/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

<b>Calibration Factors</b>	<b>267AWJ</b>		
<b>Bridge 1 (<math>\mu\text{E}/\text{V}</math>)</b>	<b>216.53</b>	<b>Bridge 2 (<math>\mu\text{E}/\text{V}</math>)</b>	<b>216.20</b>
<b>EA Factor (Kips)</b>	<b>35248.70</b>	<b>Area (in<sup>2</sup>)</b>	<b>1.17</b>

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]

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

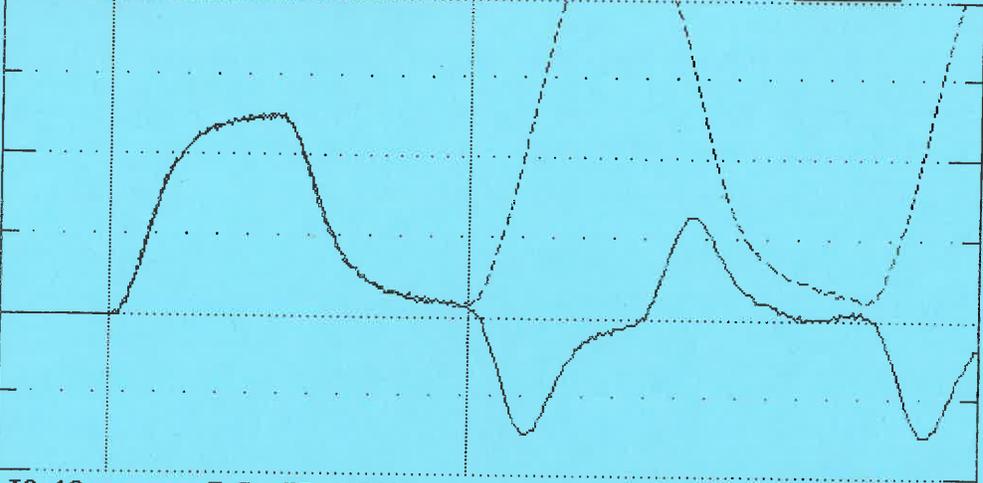
LE 17.0 ft  
AR 1.7 in2  
EM 30000 Ksi  
SP 0.492 K/ft3  
WS 16810 ft/s  
WC 7234 ft/s

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: [Signature]

<-AT:PIEZORESISTIVE

OP: laine [ver:5.01]

AT:PIEZOELECTRIC->

Smart Sensor

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

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

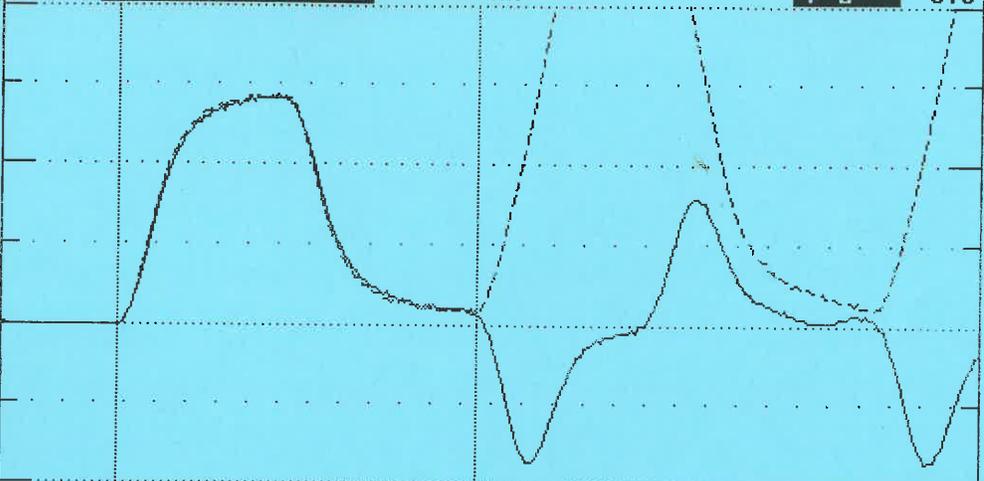
LE 17.0 ft  
AR 1.7 in2  
EM 30000 Ksi  
SP 0.492 K/ft3  
WS 16810 ft/s  
WC 7234 ft/s

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->

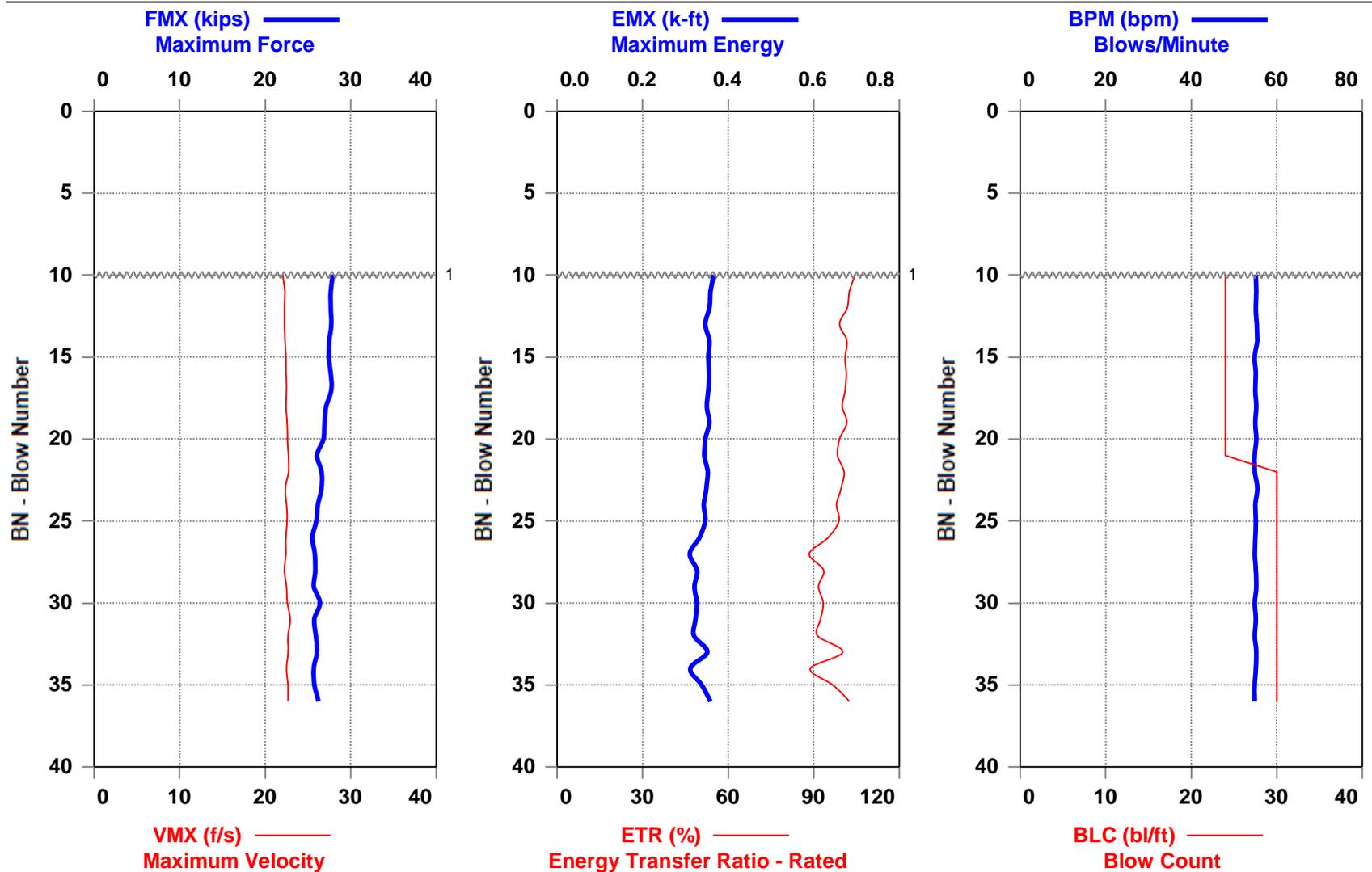
Smart Sensor

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

## **Exhibit A-3    SPT Calibration Data Plots and Tables**



GASTON 2 SOLAR FACILITY - SPT CAL 28.5-30  
CME 45C 28.5-30



1 - Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 28.5-30

CME 45C 28.5-30

OP: ZM

Date: 24-May-2018

AR: 1.18 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

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
10	29.04	24	28	22.0	0.366	104.5	55.1	0.93	23.6
11	29.08	24	28	22.3	0.359	102.5	55.2	0.85	23.4
12	29.13	24	28	22.3	0.356	101.7	55.1	0.76	23.4
13	29.17	24	28	22.2	0.347	99.1	55.3	0.67	23.5
14	29.21	24	28	22.3	0.356	101.6	55.4	0.74	23.3
15	29.25	24	27	22.4	0.353	101.0	54.8	0.68	23.3
16	29.29	24	28	22.5	0.355	101.4	55.1	0.70	23.4
17	29.33	24	28	22.5	0.354	101.0	55.0	0.64	23.5
18	29.38	24	27	22.4	0.350	100.0	55.2	0.62	23.0
19	29.42	24	27	22.6	0.356	101.6	55.0	0.64	22.8
20	29.46	24	27	22.6	0.347	99.1	55.2	0.64	22.7
21	29.50	24	26	22.7	0.344	98.4	54.8	0.60	22.1
22	29.53	30	27	22.7	0.352	100.6	54.9	0.63	22.5
23	29.57	30	27	22.4	0.349	99.6	55.4	0.60	22.5
24	29.60	30	26	22.5	0.343	98.0	55.0	0.56	22.2
25	29.63	30	26	22.6	0.346	98.8	55.1	0.59	22.0
26	29.67	30	26	22.4	0.333	95.1	55.0	0.53	21.6
27	29.70	30	26	22.4	0.310	88.5	54.8	0.48	21.9
28	29.73	30	26	22.3	0.327	93.5	55.1	0.50	21.9
29	29.77	30	26	22.5	0.321	91.6	55.2	0.49	21.8
30	29.80	30	26	22.6	0.327	93.3	54.8	0.49	22.4
31	29.83	30	26	22.9	0.323	92.3	55.1	0.49	21.8
32	29.87	30	26	22.6	0.320	91.3	54.8	0.48	21.9
33	29.90	30	26	22.7	0.351	100.2	55.2	0.63	22.1
34	29.93	30	26	22.5	0.311	88.8	55.1	0.47	21.7
35	29.97	30	26	22.6	0.338	96.7	54.8	0.52	21.8
36	30.00	30	26	22.7	0.359	102.5	54.9	0.69	22.2
Average			27	22.5	0.343	97.9	55.1	0.62	22.5
Std. Dev.			1	0.2	0.015	4.4	0.2	0.11	0.7
Maximum			28	22.9	0.366	104.5	55.4	0.93	23.6
Minimum			26	22.0	0.310	88.5	54.8	0.47	21.6

Total number of blows analyzed: 27

BL# Sensors

10-36 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K5418] 382.0 (1.00);  
A4: [K0059] 317.0 (1.00)

BL# Comments

10 Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 28.5-30  
OP: ZM

CME 45C 28.5-30  
Date: 24-May-2018

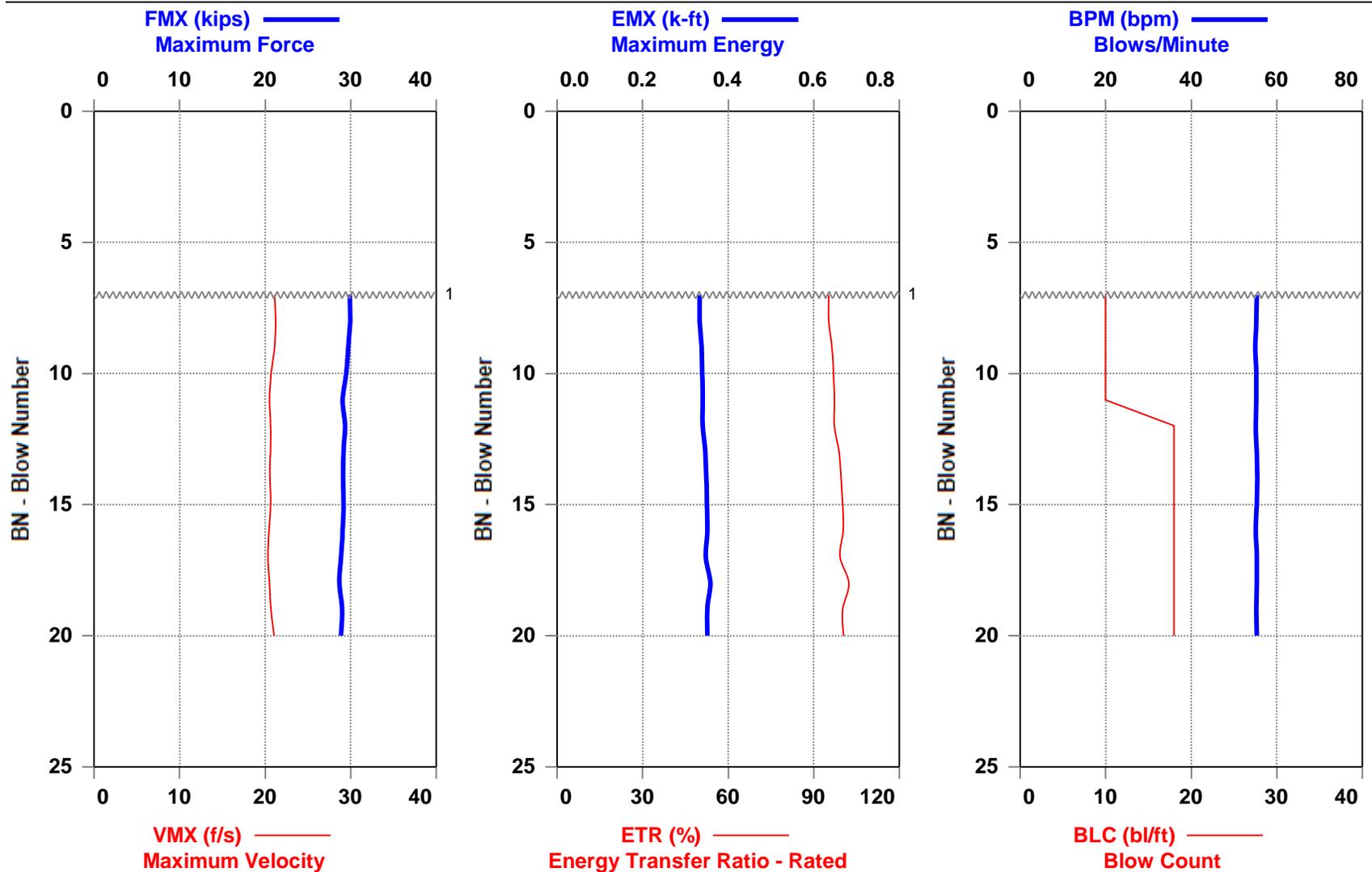
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Time Summary

Drive 38 seconds 11:32 AM - 11:33 AM BN 1 - 36



GASTON 2 SOLAR FACILITY - SPT CAL 33.5-35  
CME 45C 33.5-35



1 - Blows 1-6 = Seating Blows, Blow 7 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 33.5-35

CME 45C 33.5-35

OP: ZM

Date: 24-May-2018

AR: 1.18 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

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
7	34.10	10	30	21.1	0.333	95.3	55.3	1.21	25.3
8	34.20	10	30	21.2	0.333	95.3	55.2	1.21	25.4
9	34.30	10	30	21.1	0.337	96.4	55.0	1.23	25.2
10	34.40	10	29	20.7	0.339	97.0	55.2	1.20	25.0
11	34.50	10	29	20.5	0.341	97.3	55.2	1.22	24.6
12	34.56	18	29	20.6	0.340	97.2	55.1	1.02	24.8
13	34.61	18	29	20.6	0.346	98.9	55.3	0.95	24.7
14	34.67	18	29	20.5	0.349	99.6	55.4	0.91	24.7
15	34.72	18	29	20.7	0.350	100.1	55.3	0.88	24.7
16	34.78	18	29	20.5	0.351	100.3	55.1	0.85	24.6
17	34.83	18	29	20.3	0.347	99.2	55.3	0.77	24.5
18	34.89	18	29	20.5	0.358	102.3	55.3	0.82	24.3
19	34.94	18	29	20.7	0.351	100.2	55.2	0.76	24.6
20	35.00	18	29	21.0	0.351	100.4	55.3	0.73	24.5
	Average		29	20.7	0.345	98.5	55.2	0.98	24.8
	Std. Dev.		0	0.3	0.007	2.1	0.1	0.19	0.3
	Maximum		30	21.2	0.358	102.3	55.4	1.23	25.4
	Minimum		29	20.3	0.333	95.3	55.0	0.73	24.3

Total number of blows analyzed: 14

BL# Sensors

7-20 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K5418] 382.0 (1.00);  
A4: [K0059] 317.0 (1.00)

BL# Comments

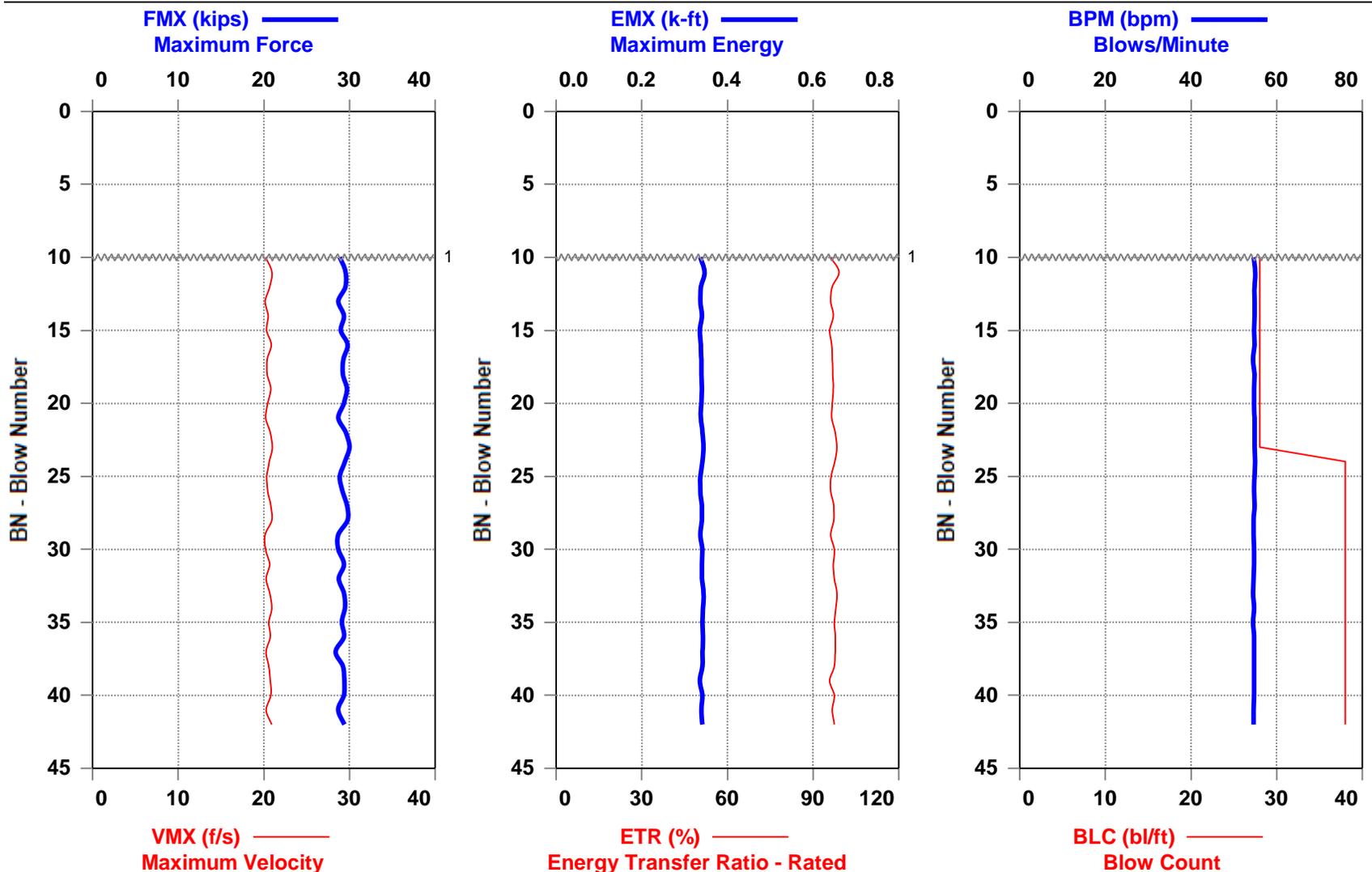
7 Blows 1-6 = Seating Blows, Blow 7 = First Blow of N Value

Time Summary

Drive 20 seconds 11:48 AM - 11:48 AM BN 1 - 20



GASTON 2 SOLAR FACILITY - SPT CAL 38.5-40  
CME 45C 38.5-40



1 - Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 38.5-40

CME 45C 38.5-40

OP: ZM

Date: 24-May-2018

AR: 1.18 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

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
10	37.54	28	29	20.2	0.336	96.1	54.6	0.58	24.5
11	37.57	28	30	20.9	0.347	99.1	55.0	0.59	25.0
12	37.61	28	30	20.7	0.338	96.7	54.8	0.57	25.0
13	37.64	28	29	20.2	0.337	96.1	54.8	0.56	24.3
14	37.68	28	29	20.5	0.340	97.1	54.8	0.56	24.9
15	37.71	28	29	20.3	0.335	95.9	54.7	0.56	24.6
16	37.75	28	30	20.9	0.338	96.5	54.8	0.55	25.2
17	37.79	28	29	20.4	0.339	96.7	54.5	0.56	24.8
18	37.82	28	29	20.4	0.339	96.9	54.8	0.56	24.8
19	37.86	28	30	20.8	0.340	97.1	54.7	0.55	25.2
20	37.89	28	29	20.4	0.339	96.7	54.7	0.56	24.8
21	37.93	28	29	20.2	0.338	96.5	54.8	0.55	24.3
22	37.96	28	30	20.7	0.342	97.7	54.9	0.56	25.1
23	38.00	28	30	21.0	0.344	98.3	54.8	0.56	25.4
24	38.03	38	29	20.6	0.342	97.7	55.0	0.56	25.0
25	38.05	38	29	20.3	0.337	96.3	54.8	0.55	24.5
26	38.08	38	29	20.4	0.337	96.2	54.7	0.54	24.7
27	38.11	38	30	20.8	0.340	97.1	54.8	0.54	25.2
28	38.13	38	30	20.9	0.340	97.2	54.6	0.53	25.2
29	38.16	38	29	20.2	0.336	96.1	54.6	0.53	24.3
30	38.18	38	29	20.2	0.341	97.5	54.7	0.53	24.3
31	38.21	38	29	20.7	0.340	97.1	54.7	0.52	24.9
32	38.24	38	29	20.3	0.341	97.4	54.6	0.51	24.4
33	38.26	38	29	20.7	0.344	98.4	54.5	0.51	24.9
34	38.29	38	29	20.9	0.343	98.0	54.7	0.51	25.0
35	38.32	38	29	20.6	0.341	97.5	54.5	0.50	24.7
36	38.34	38	29	20.8	0.342	97.8	54.7	0.50	24.9
37	38.37	38	28	20.2	0.342	97.7	54.7	0.50	24.0
38	38.39	38	29	20.6	0.341	97.5	54.7	0.49	24.8
39	38.42	38	29	20.7	0.335	95.8	54.7	0.48	24.9
40	38.45	38	29	20.8	0.341	97.5	54.7	0.49	24.9
41	38.47	38	29	20.3	0.339	96.7	54.6	0.48	24.3
42	38.50	38	29	20.9	0.341	97.5	54.6	0.49	24.9
Average			29	20.6	0.340	97.1	54.7	0.53	24.8
Std. Dev.			0	0.3	0.003	0.8	0.1	0.03	0.3
Maximum			30	21.0	0.347	99.1	55.0	0.59	25.4
Minimum			28	20.2	0.335	95.8	54.5	0.48	24.0

Total number of blows analyzed: 33

BL# Sensors

10-42 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K5418] 382.0 (1.00);  
A4: [K0059] 317.0 (1.00)

GASTON 2 SOLAR FACILITY - SPT CAL 38.5-40  
OP: ZM

CME 45C 38.5-40  
Date: 24-May-2018

---

BL# Comments

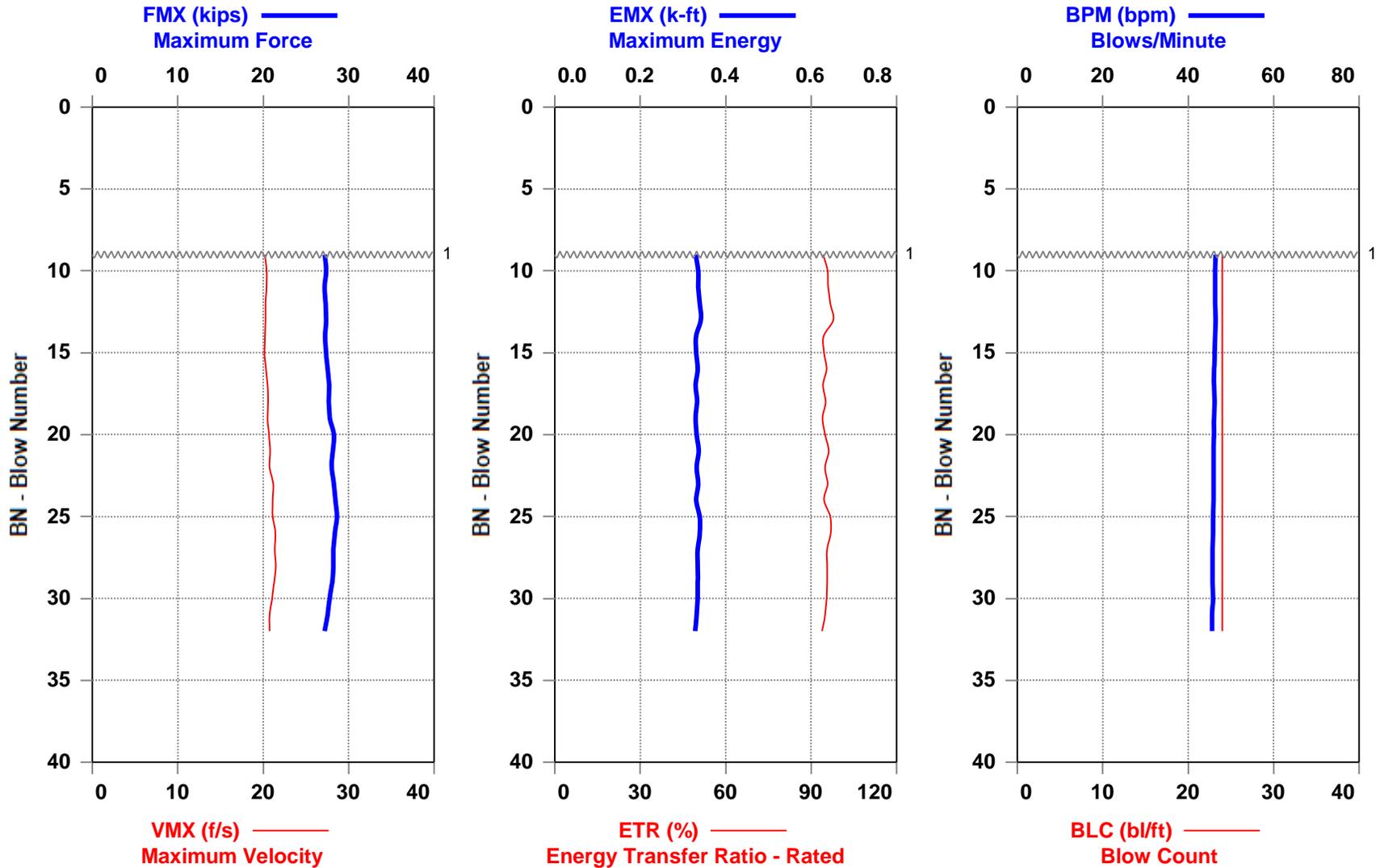
10 Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

Time Summary

Drive 44 seconds 11:54 AM - 11:54 AM BN 1 - 42



GASTON 2 SOLAR FACILITY - SPT CAL 43.5-45  
CME 45C 43.5-45



1 - Blows 1-8 = Seating Blows, Blow 9 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 43.5-45

CME 45C 43.5-45

OP: ZM

Date: 24-May-2018

AR: 1.18 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

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
9	44.04	24	27	20.2	0.330	94.2	46.4	0.67	23.0
10	44.08	24	27	20.4	0.335	95.8	46.3	0.65	23.2
11	44.13	24	27	20.4	0.336	95.9	46.3	0.65	23.0
12	44.17	24	27	20.3	0.339	96.8	46.3	0.69	23.1
13	44.21	24	27	20.3	0.342	97.7	46.4	0.75	23.2
14	44.25	24	27	20.2	0.330	94.4	46.3	0.64	23.1
15	44.29	24	27	20.1	0.331	94.6	46.2	0.63	23.2
16	44.33	24	28	20.3	0.334	95.4	46.1	0.65	23.3
17	44.38	24	28	20.5	0.330	94.2	46.0	0.63	23.5
18	44.42	24	28	20.6	0.333	95.0	46.2	0.62	23.5
19	44.46	24	28	20.5	0.329	94.0	46.0	0.62	23.6
20	44.50	24	28	20.7	0.332	94.9	46.0	0.62	23.9
21	44.54	24	28	20.8	0.337	96.2	45.9	0.62	23.9
22	44.58	24	28	20.7	0.332	94.8	45.9	0.62	23.7
23	44.63	24	28	21.2	0.335	95.7	45.9	0.62	24.0
24	44.67	24	28	21.1	0.331	94.5	45.9	0.61	24.1
25	44.71	24	29	21.1	0.339	96.7	45.8	0.60	24.3
26	44.75	24	28	21.4	0.339	96.9	45.8	0.78	24.0
27	44.79	24	28	21.4	0.334	95.5	45.7	0.61	23.9
28	44.83	24	28	21.5	0.335	95.7	45.7	0.60	23.9
29	44.88	24	28	21.3	0.335	95.6	45.7	0.59	23.8
30	44.92	24	28	21.0	0.334	95.4	45.8	0.63	23.5
31	44.96	24	28	20.8	0.332	94.9	45.6	0.60	23.3
32	45.00	24	27	20.7	0.329	93.9	45.6	0.57	23.0
	Average		28	20.7	0.334	95.4	46.0	0.64	23.5
	Std. Dev.		0	0.4	0.003	1.0	0.3	0.05	0.4
	Maximum		29	21.5	0.342	97.7	46.4	0.78	24.3
	Minimum		27	20.1	0.329	93.9	45.6	0.57	23.0

Total number of blows analyzed: 24

BL# Sensors

9-32 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K5418] 382.0 (1.00);  
A4: [K0059] 317.0 (1.00)

BL# Comments

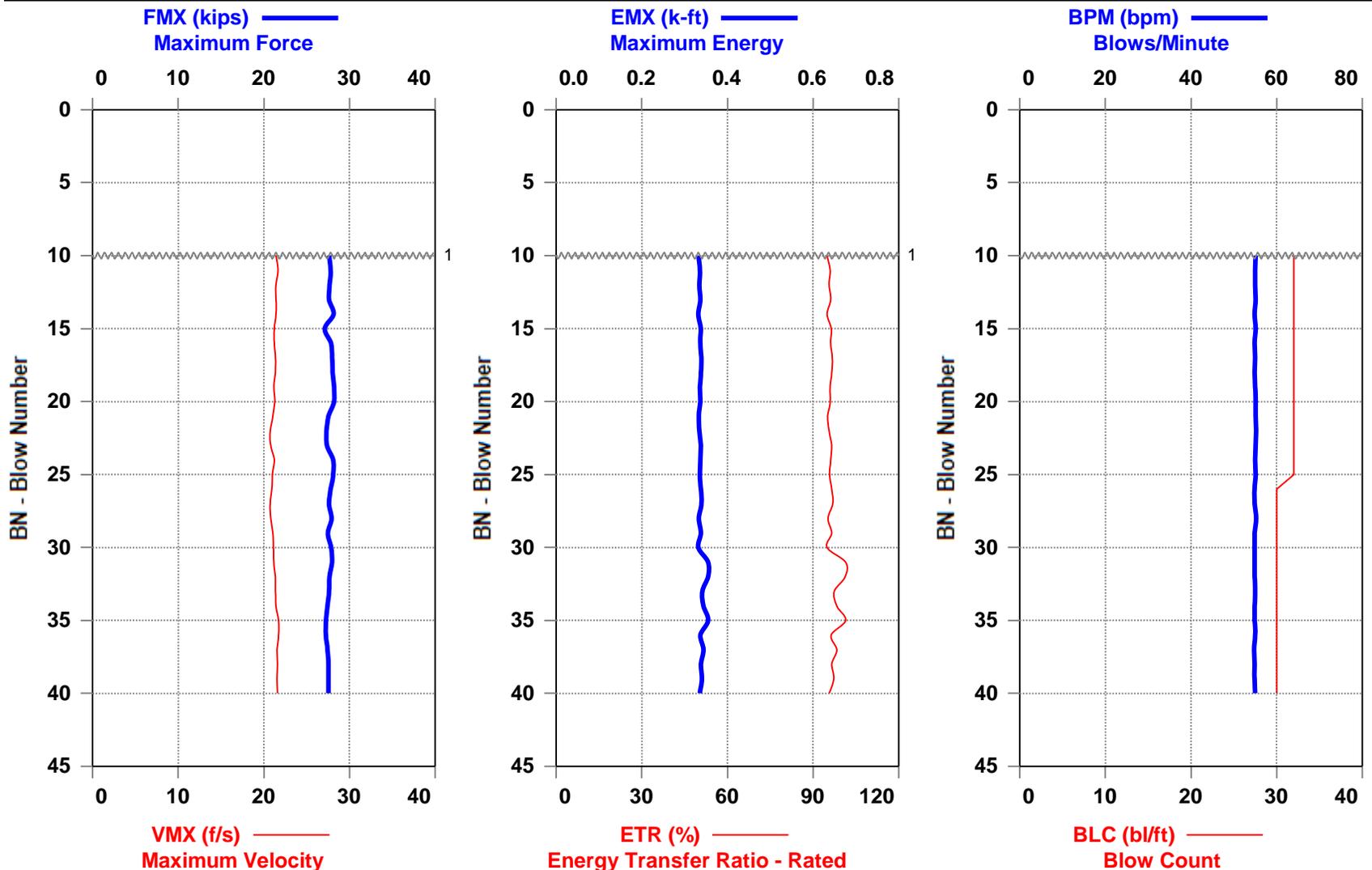
9 Blows 1-8 = Seating Blows, Blow 9 = First Blow of N Value

Time Summary

Drive 40 seconds 12:01 PM - 12:02 PM BN 1 - 32



GASTON 2 SOLAR FACILITY - SPT CAL 48.5-50  
CME 45C 48.5-50



1 - Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 48.5-50

CME 45C 48.5-50

OP: ZM

Date: 24-May-2018

AR: 1.18 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

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
10	49.03	32	28	21.4	0.332	94.8	55.1	0.63	23.4
11	49.06	32	28	21.7	0.336	96.0	55.0	0.63	23.6
12	49.09	32	28	21.4	0.334	95.5	55.0	0.62	23.5
13	49.13	32	28	21.4	0.337	96.2	55.1	0.63	23.4
14	49.16	32	28	21.4	0.332	94.9	54.8	0.62	23.8
15	49.19	32	27	21.2	0.337	96.4	55.1	0.63	23.0
16	49.22	32	28	21.2	0.336	96.1	54.8	0.63	23.6
17	49.25	32	28	21.4	0.339	96.8	55.0	0.64	23.7
18	49.28	32	28	21.3	0.338	96.6	54.9	0.63	23.8
19	49.31	32	28	21.2	0.336	96.0	55.0	0.63	23.9
20	49.34	32	28	21.3	0.336	96.0	55.1	0.63	23.9
21	49.38	32	28	21.0	0.333	95.1	55.1	0.63	23.4
22	49.41	32	27	20.8	0.334	95.5	55.2	0.64	23.2
23	49.44	32	27	20.8	0.338	96.4	55.1	0.65	23.2
24	49.47	32	28	21.2	0.337	96.2	55.0	0.65	23.8
25	49.50	32	28	21.0	0.335	95.8	55.1	0.64	23.8
26	49.53	30	28	20.9	0.338	96.5	54.8	0.63	23.6
27	49.57	30	28	20.7	0.339	96.9	54.9	0.64	23.4
28	49.60	30	28	20.8	0.333	95.2	55.2	0.61	23.6
29	49.63	30	27	21.0	0.338	96.5	54.9	0.65	23.3
30	49.67	30	28	21.1	0.332	94.8	54.9	0.58	23.6
31	49.70	30	28	21.1	0.355	101.4	54.9	0.88	23.7
32	49.73	30	28	21.3	0.354	101.2	54.9	0.82	23.4
33	49.77	30	28	21.4	0.341	97.5	55.0	0.68	23.4
34	49.80	30	27	21.4	0.344	98.3	54.9	0.71	23.2
35	49.83	30	27	21.7	0.355	101.4	54.9	0.83	23.1
36	49.87	30	27	21.7	0.337	96.4	55.0	0.59	23.1
37	49.90	30	27	21.6	0.344	98.2	54.7	0.69	23.3
38	49.93	30	28	21.6	0.338	96.6	54.8	0.59	23.3
39	49.97	30	28	21.5	0.340	97.2	54.8	0.58	23.4
40	50.00	30	28	21.6	0.335	95.7	55.0	0.58	23.4
	Average		28	21.3	0.339	96.7	55.0	0.65	23.5
	Std. Dev.		0	0.3	0.006	1.7	0.1	0.07	0.3
	Maximum		28	21.7	0.355	101.4	55.2	0.88	23.9
	Minimum		27	20.7	0.332	94.8	54.7	0.58	23.0

Total number of blows analyzed: 31

BL# Sensors

10-40 F3: [AWJ 1] 216.5 (1.00); F4: [AWJ 2] 216.2 (1.00); A3: [K5418] 382.0 (1.00);  
A4: [K0059] 317.0 (1.00)

BL# Comments

10 Blows 1-9 = Seating Blows, Blow 10 = First Blow of N Value

GASTON 2 SOLAR FACILITY - SPT CAL 48.5-50  
OP: ZM

CME 45C 48.5-50  
Date: 24-May-2018

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Time Summary

Drive 42 seconds 12:10 PM - 12:11 PM BN 1 - 40

## **Exhibit A-4    Field Log**

# Terracon

## SPT HAMMER CALIBRATION FIELD WORKSHEET

ARRIVAL TIME: 10:30  
 DEPART TIME: 12:30  
 TOTAL TRAVEL: 3 hr  
 TOTAL TIME: 5 hr  
 CLIENT REP: \_\_\_\_\_  
 MILEAGE: \_\_\_\_\_

PROJECT NAME: Gaston Solar Facility  
 PROJECT NO.: 73185061  
 BORING NO.: B-18  
 CLIENT: \_\_\_\_\_

DATE: 5/24  
 TERRACON REP: Columbia  
 PDA MODEL/SN: PAX 2756  
 TERRACON RIG # DR#: 543

### DRILL RIG DATA

Type/Transport: Truck  
 Manufacturer: CME-45L  
 Model No.: CME-45C  
 Serial No.: 406484  
 Year Built: 4-18  
 Modifications: N/A  
 Maint. Schedule: As Needed

### SPT HAMMER DATA

Type: Auto  
 Manufacturer: \_\_\_\_\_  
 Lifting Mechanism: Chain w/ Hydraulic  
 Model No.: \_\_\_\_\_  
 Serial No.: \_\_\_\_\_  
 Hammer Weight: 140 lbs  
 Hammer Operator(s): Francer and Brian

### PDA INPUT DATA

Operator: **OP** ZM  
 Project No./Location: **PJ** Croston  
 Rig Model & SN: **PN** CME-45C  
 Hammer Type, LM, Rods: **PD** Auto, Chain, AWJ  
 Drill Rod Area (in<sup>2</sup>): **AR** 1.18

Elastic Modulus (ksi): **EM** 3000  
 Specific Weight (kips/ft<sup>3</sup>): **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>AWJ-1</u>	<u>216.53</u>
F2/F4:	<u>AWJ-2</u>	<u>216.20</u>
A1/A3:	<u>K5418</u>	<u>382</u>
A2/A4:	<u>K0059</u>	<u>317</u>

NOTES: Instrumentation to Bottom of Rod Length 25.85 + 2.85  
 \_\_\_\_\_ Inches 28.7 Feet  
 SPLIT SPOON SAMPLER LENGTH 0.85  
 Gauge to Bottom of Cal. Rod length 28.7  
<sup>1</sup> LE is Measured from the Center of the Strain Gauges to the bottom of Split Spoon Sampler

### SPT TESTING INFORMATION

Start Time	Soil	Stick Up Length (ft)	Depth (ft)		'LE (ft)	Rods & Lengths	PDA Blows		SPT Blows				
			Start	End			Start	End	1st 6"	2nd 6"	3rd 6"	4th 6"	
						2ft (5ft) 10ft							
10:50		32"	23.5	25	28.7	Sea 2ft (5ft) 10ft							N
11:20		41.5'	24.5	26	30.7	1x2ft 5x5ft 10ft	1	19	5	5	8	13	
11:32	Sand	36"	28.5	30	33.7	2ft 5x5ft 10ft	1	37	9	12	15	27	
11:48	White Sand	36"	33.5	35	38.7	2ft 7x5ft 10ft	1	21	6	5	9	14	
11:53	Orange Sand	37"	38.5	40	43.7	2ft 8x5ft 10ft	1	43	9	14	19	33	
12:01	White Sand	36"	43.5	45	48.7	2ft 9x5ft 10ft	1	33	8	12	12	24	
12:10	Sand	36"	48.5	50	53.7	2ft 10x5ft 10ft	1	41	9	16	15	31	
						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....)