

MEMORANDUM

NOT FOR CONSTRUCTION

Date: August 04, 2016

Re: US 301 (Five Chop Road) Replacement Bridge Over Four Hole Swamp
Project ID: 0040308
Final Bridge Geotechnical Engineering Report-95%

The Regional Production Group Three Geotechnical Design Section (RPG3 GDS) is 95% complete with the Final Road Geotechnical Report for the Replacement Bridge over Four Hole Swamp on US 301 (Five Chop Road) in Orangeburg County, South Carolina.

The purpose of this report is to present subsurface conditions encountered and provide recommendations for roadway and embankment design and construction. The recommendations are based on the geotechnical subsurface investigation and geotechnical analyses performed in accordance with the SCDOT Geotechnical Design Manual (GDM), 2010 version, and SCDOT Design Memorandums.

If you have questions or comments, please feel free to contact me at (803) 737-3987.

RSG:rsg
Attachment: Road Geotechnical Engineers Report
cc: Chris Lacey, RPG-3 Design Manager
File: PC/RSG



**95% FINAL ROAD GEOTECHNICAL ENGINEERS
REPORT**



July 2016

US 301 Replace Bridge over Four Hole Swamp
Orangeburg County, SC

NOT FOR CONSTRUCTION

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1.0 Project Description: The project consists of a lane widening and a bridge replacement over Four Hole Swamp along US Route 301 Southbound in Orangeburg County, South Carolina. The existing roadway is a 2-lane paved road of variable shoulder widths. The project will consist of removing the existing 247-foot concrete bridge supported by square cast-in-place concrete piles on unknown footings under the main super-structure and HP 10x72 battered piles under the widened portion of the super-structure, then constructing a multi-span, pre-stressed concrete flat slab bridge (Sta. 5949+30 to Sta. 5952+24) supported by HP 14x73 steel piles at the end bents and 48-inch steel pipe piles at the interior bents. The new 294-foot bridge will have a clear roadway width of 44-feet and approach slabs, 20 feet in length, are also planned. The proposed centerline finished grade elevation will be raised approximately 2.0 feet. A site map is provided in Appendix I.

The approach roadway section will be a 28-foot wide roadway including 2-foot paved shoulders on both sides of the alignment along with additional 8-foot grassed shoulders. Approach work will include constructing the necessary embankments for shoulders to accommodate the improved roadway and surface work to tie the new bridge to the existing roadway. The end slopes associated with the approach embankments are anticipated to be 2:1, the left side slopes associated with the approach embankments are anticipated to be 2:1 and the right side slopes associated with the approach embankments are anticipated to be 4:1. In addition, the existing approach embankments beneath the proposed bridge structure will be removed at the beginning and end of the bridge to elevations of about +108 and +103 feet MSL, respectively. Based on final right-of-way (ROW) plans, additional fill is not expected to exceed 2.5 feet at the shoulder breaks. It is our understanding that the new bridge will be placed on the existing horizontal alignment; therefore, the bridge will be closed and southbound traffic shifted to share the northbound lanes during construction. It is anticipated that temporary shoring will not be required during construction.

2.0 Objective: This report presents the subsurface conditions encountered during our exploration, seismic conditions of the site, and final roadway and approach embankment construction recommendations. Regional Production Group Three Geotechnical Design Section (RPG3 GDS) based the geotechnical recommendations herein on test logs RW-1 through RW-7, B-1, B-8 and B-9, HA-1 through HA-3, Bulk Samples 1 and 2 and an MASW obtained during the geotechnical exploration executed by ICA Engineering and test logs RW-3B, B-1A, DMT-1 and DMT-2 obtained during the geotechnical exploration executed by Professional Services Industries, Inc. (PSI). The geotechnical recommendations are also based on a geotechnical engineering evaluation of the subsurface soil explorations, a liquefaction assessment, a review of the bridge interior bent foundations and a review of embankment longitudinal slope stability performed by GeoStellar Engineering.

The exploration by ICA Engineering was conducted during the dates of April 3 through 25, 2014. The exploration by PSI was conducted during the dates of December 4 through 17, 2014. The

GDM did not provide sufficient guidance to identify the geologic formations and classify the soil strength parameters for this project; therefore, GeoStellar Engineering provided support in research and an engineering evaluation. The engineering evaluation by GeoStellar Engineering was performed during the dates of June 2015 through April 2016. The subsurface explorations performed by ICA Engineering and PSI and the engineering evaluation performed by GeoStellar were performed in general accordance with the 2010 Geotechnical Design Manual (GDM).

3.0 Subsurface Investigation: Test-holes were performed along the roadway near the slope crest and toe of the existing approach embankments. In addition to typical test-hole sampling, shear wave velocity measurements and bulk samples were obtained at this site. When we identified a potential weak subsurface soil condition we requested a second phase of test-holes. All test locations were surveyed and are presented in Table 1 below. The Boring Layouts and test-hole records from both subsurface investigations are provided in Appendix II.

Table 1 – Subsurface Test Locations

Test Number	Test Hole Location	Station (ft)	Offset (ft)	Elevation (ft.)	Soil Depth (ft)	Core Depth (ft)
RW-1	Road	5947+73	20-L	119.9	41.4	N/A
HA-1	Road	5948+00	50-R	112.9	10.5	N/A
RW-2	Road	5948+38	18-R	119.1	41.5	N/A
RW-3	Road	5948+83	19-R	119.9	33.7*	N/A
RW-3B	Road	5948+83	7-L	120.2	16.0	N/A
HA-2	Road	5949+00	60-R	112.1	7.5	N/A
B-1	Road/Bridge	5949+31	13-L	119.9	102.5	0
DMT-1	Road/Bridge	5949+26	8-L	119.9	15.0	N/A
B-1A	Road/Bridge	5949+32	9-R	119.9	120.0	N/A
Bulk-1	Road/Bridge	5949+31	13-L	119.9	5.0	N/A
B-8	Road/Bridge	5952+17	8-R	120.0	80.5	20.9
Bulk-2	Road/Bridge	5952+17	8-R	120.0	5.0	N/A
B-9	Road/Bridge	5952+28	8-L	120.0	101.5	0
HA-3	Road	5952+23	40-R	110.7	10.5	N/A
DMT-2	Road/Bridge	5952+32	8-L	120.0	15.0	N/A
RW-4	Road	5952+50	20-R	119.5	25.1*	N/A
RW-5	Road	5952+70	22-L	119.4	41.4	N/A
HA-4	Road	5952+54	42-R	112.8	3.5	N/A
RW-6	Road	5953+15	22-R	119.2	20.9*	N/A
RW-7	Road	5953+66	20-L	119.7	21.8*	N/A

*Depth of refusal.

In addition and as defined in Table 2 laboratory tests were performed on select split spoon samples, undisturbed samples, bulk samples and rock cores. Summaries of the laboratory test results are included in Appendix III.

Table 2 – Laboratory Tests

Test Type	Quantity
Atterberg Limits (ICA)	70
Atterberg Limits (PSI)	49
Full Sieve Analysis (ICA)	85
Full Sieve Analysis (PSI)	40
Hydrometer Analysis (ICA)	14
Hydrometer Analysis (PSI)	9
Moisture Content (ICA)	69
Moisture Content (PSI)	49
Corrosion Series (PSI)	4
Consolidation (PSI)	1
Triaxial Compression (PSI)	1
Unconfined Compression (ICA)	17
Direct Shear (ICA)	2

The project site is located within the USDA MLRA Atlantic Coast Flatwoods region (153A) of the Coastal Plain Province of the Atlantic Plain. This area is a relatively flat coastal plain crossed by many broad, shallow valleys which have widely meandering stream channels. The new bridge will cross over Four Hole Swamp which is a small black-water tributary to the Edisto River. The geology is defined as being located in the Middle Coastal Plain Province between the South Carolina geologic features referred to as the Orangeburg Scarp (OS) and the Surry Scarp (SS).

Three subsurface profiles are presented in Appendix IV. The first subsurface profile was prepared by ICA Engineering based on the initial subsurface investigation. The second subsurface profile was prepared by PSI based on the final subsurface investigation. The third subsurface profile was prepared by GeoStellar and is a compilation of both the initial and final subsurface investigations and interpretations based on consultations with William R. Doar, III, Senior Geologist for the Coastal Plains, South Carolina Geological Survey (SCGS). Table 3 outlines the generalized subsurface conditions encountered during the field exploration.

Table 3 – Generalized Subsurface Conditions

Geologic Formation	Elevations at Top of Layer (ft)	USCS Soil Type	SPT-N values (bpf)	Comments
Recent (Fill Embankment)	120	SM, SW-SM, SC, SP-SM	3 to 31	Very Loose to Medium Dense silty SANDs
Marietta Unit	105 - 112	SM, SW-SM, SC, SP-SM, SC-SM ,SP, ML, SW, CL	0 to 100	Very Loose to Medium Dense silty SANDs, Very Loose to Loose clayey SANDs, Very Soft sandy SILTs, Very Loose to Medium Dense SANDs with silt, Very Loose to Very Dense SANDs, and Very Soft lean CLAYs
Santee Limestone	92 - 101	SM, SW-SM, SC, SC-SM, SP, ML	6 to 50/2"	Medium Dense to Very Dense, silty SANDs, Firm to Very Hard sandy SILTs, Hard to Very Hard SILTs with sand, Very Dense SANDs with silt, Medium Dense to Very Dense clayey SANDs
Warley Hill	27 -51	SM, SW-SM, SC, SP-SM, SW, MH, CL	4 to 50/2"	Loose to Very Dense silty SANDs, Very Dense clayey SANDs, Very Soft Silty SAND, Very Soft sandy SILT, Loose to Very Dense SAND with silt, Very Loose SAND, Very Hard sandy lean CLAY
Congaree	8 - 14	SM, SW-SM, SP-SM, MH, CL, CH	30 to 50/3"	Dense to Very Dense silty SANDs, Medium Dense to Very Dense SAND with silt, Very Hard sandy SILT, Hard to Very Hard sandy lean CLAY, Hard sandy fat CLAY

Soil strength parameters were calculated using the SPT-Based Soil Shear Strength Loss Evaluation spreadsheet created by Preconstruction Support – Geotechnical Design Section (PCS-GDS). This method of evaluating soil strength parameters initially indicated that the potentially weak soil zones would liquefy during a seismic event; however, this potentially weak soil zone is overlain by extremely strong non-liquefiable soils more than 50 feet in depth. While these soils have a reduced strength parameter any settlement will not propagate to the surface. The calculation package for Soil Strength Parameters is provided in Appendix VI.

Groundwater is expected to fluctuate due to rainfall events, seasonal changes and construction practices. Groundwater levels were measured in test-holes at the time of boring (TOB) and 24-hours after drilling if possible. Test-holes cored in the roadway or bridge deck were not left open to measure groundwater depth. The depths to the ground water obtained are presented in Table 4. Hydrology data on the bridge plans indicate a 100-year high water elevation of 119.0 feet-msl. The groundwater measurements correspond to a high elevation of 109.6 feet-msl. **Groundwater elevation of 110 feet msl was used for design.**

Table 4 – Depth to Ground Water

Test-Hole No.	Location	Station	Existing Ground Elevation (ft msl)	TOB Depth* (ft)	24 hour Depth* (ft)
RW-1	Road	5947+73	119.9	4.8	8.8
HA-1	Road	5948+00	112.7	2.0	0.2
RW-2	Road	5948+38	119.1	7.7	8.0
RW-3	Road	5948+83	120.2	8.5	NA
RW-3B	Road	5948+83	120.2	6.7	NA
HA-2	Road	5949+00	112.1	1.2	0.2
B-1	Road/Bridge	5949+31	119.9	5.2	7.7
B-1A	Road/Bridge	5949+32	119.9	9.7	6.0
B-8	Road/Bridge	5952+17	120.0	12.0	10.4
B-9	Road/Bridge	5952+28	120.0	5.9	12.6
HA-3	Road	5952+23	110.7	2.6	0.0
RW-4	Road	5952+50	119.5	6.5	NA
RW-5	Road	5952+70	120.3	8.1	NA
HA-4	Road	5952+54	112.8	0.5	0.0
RW-6	Road	5953+15	119.2	8.0	NA
RW-7	Road	5953+66	119.7	3.5	7.9

*From existing ground line

4.0 Operational Classification: According to the GDM a Bridge Operational Classification (OC) and Roadway Structure Operational classification (ROC) shall be identified to determine resistance factors and performance limits for the project site. It is our understanding that the proposed bridge has an OC of “II”. Table 8-11 from the Design Memorandum DM0211 indicates an ROC of “II” for structures located within 150 feet of a bridge with OC of “II”. For roadway embankments located more than 150 feet from a bridge indicate a ROC of “IV”.

5.0 Seismic Conditions: A seismic Site Class evaluation was performed using the 2010 Geotechnical Design Manual (GDM). Based on the soil test boring logs and the shear wave velocity data obtained from the MASW/MAM, the seismic Site Class for the bridge was determined to be “D”. This Site Class was determined from data measured to a depth of approximately 100 feet below the existing ground surface. Based on Table 3.5 in the 2008 Seismic Design Specifications for Highway Bridges and the S_{DISEE} value provided below, the Seismic Design Category (SDC) for this bridge structure is “C”. The S_{DI} values were defined using the three-point method and the ADRS curves are provided in Appendix V.

The Site Class defined above and the corresponding seismic design parameters, defined in Table 5, were used for designing embankments, and determining the potential for liquefaction.

Table 5 – Seismic Design Parameters for Site Class D

	Acceleration, g
PGA_{FEE}	0.20
S_{DsFEE}	0.39
S_{DIFEE}	0.18
k_{hFEE}	0.19
M_{wFEE}	7.36
PGA_{SEE}	0.43
S_{DsSEE}	0.87
S_{DISEE}	0.49
k_{hSEE}	0.41
M_{wSEE}	7.37

Note 1: k_h and M_w are only used in the embankment design and should not be shown on the bridge plans

6.0 Liquefaction Study: We utilized the laboratory index testing and visual soil classifications to evaluate the soil behavior of the subsurface soils in all of the soil borings. The criteria in the 2010 SCDOT GDM Section 13.6 were used to determine soil behavior as either sand-like or clay-like. The laboratory index testing from both subsurface investigations was used to plot the fines content (FC), plasticity index (PI), and natural moisture content (NMC) vs. elevation and is included along with the combined subsurface profile in Appendix II. The general trend for each of the formations is shown in Table 6.

Table 6 – Project Site Soil Behavior Trends

Geologic Formation	Approximate Elevation (ft-msl)		USCS Soil Type	Soil Behavior
	Bottom	Top		
Recent (Fill Embankment)	110	120	SM,SW-SM,SP	Sand-Like
			SC	Clay-Like
Marietta Unit	100	110	SP, SM, SP-SM	Sand-Like
			SC,SC-SM, CL, ML	Clay-Like
Santee Limestone	30	100	ML, SM, SW-SM, SW	Sand-Like
			ML, MH, SC	Clay-Like
Warley Hill	10	30	SM, SW-SM, SP-SM, SW	Sand-Like
			SC	Clay-Like
Congaree	--	10	SM, SP-SM, SW-SM	Sand-Like
			ML, CL, CH	Clay-Like

The trends observed in Table 6 were used to interpret subsurface soil behavior for soils that did not have index testing performed. The interpretation of Sand-Like/Clay-Like for all soil samples was achieved by utilizing the plots of the FC, PI, and NMC versus elevation. Additionally, Soil Shear Strength Loss (SSL) and seismic settlements were evaluated using the procedures outlined by Idriss and Boulanger in the 2008 EERI Monograph MNO-12, “Soil Liquefaction during Earthquakes” and Chapter 13 – “Geotechnical Seismic Hazards” of the 2010 GDM. The interpreted results were then applied to all borings and used to develop a Subsurface Soil Profile of Sand-Like and Clay-Like soils and

evaluate potential for liquefaction-induced settlement as presented in Table 7. Results of the Soil Shear Strength Loss Evaluation are presented in Appendix VI.

Table 7 – Liquefaction-Induced Settlement (inches)

Location	Test-Hole Number	SEE	FEE
Roadway	RW-1	0.00	0.00
Roadway	RW-2	1.64	0.06
Roadway	RW-3	2.31	0.21
Roadway	RW-3B	0.00	0.00
Roadway/Bridge	B-1	0.00	0.00
Roadway/Bridge	B-1A	0.00	0.00
Roadway/Bridge	B-8	8.42 ¹	8.42 ¹
Roadway/Bridge	B-9	0.00	0.00
Roadway	RW-4	0.40	0.00
Roadway	RW-5	4.97	4.11
Roadway	RW-6	1.32	0.05
Roadway	RW-7	1.00	0.07

¹Possible erroneous data. Soil test boring B8 includes a note related to drilling method difficulties near the groundwater table.

7.0 Embankments: Approach embankments at the proposed bridge were evaluated for static and seismic settlement and slope stability.

7.1 Slope Stability: The computer software SLIDE 7.0 was used to evaluate slope stability using Modified Bishop, Janbu, and Spencer methods as required by the GDM choosing the lowest Factor of Safety (FOS). Based on requirements set forth in the GDM, the required Resistance Factors (RFs) are outlined in Appendix VII. As stated in the project description, all embankment slopes are to be constructed at 2:1 or flatter. As shown in Appendix VII, the calculated RFs for these slopes are below the required RFs for static conditions. Newmark Analyses for lateral displacements were performed for the Seismic model. The results were within the performance limits set forth in the 2010 GDM. The Newmark Displacement results are also presented in Appendix VII.

7.2 Settlement Analyses: The computer program FoSSA (2.0) was used to evaluate static settlement including the elastic compression of sand and the primary consolidation of clay following Hook’s Law and Terzaghi’s 1-D differential equation, respectively. The amount of settlement calculated is a function of the classification of the foundation soils as determined from test borings and the height of fill to be placed at that location. The performance criteria set forth in Chapter 10 of the GDM was used to establish acceptable limits of static settlements under Service limit state. These limits and the calculated settlements are presented in Appendix VIII. In summary elastic compression of the sand is immediate and will occur during construction. The primary consolidation of the clay layers has minimal expected consolidation and will occur over the course of construction activities. Detailed discussion of seismic settlements is presented in Section 6.0.

8.0 Embankment Recommendations

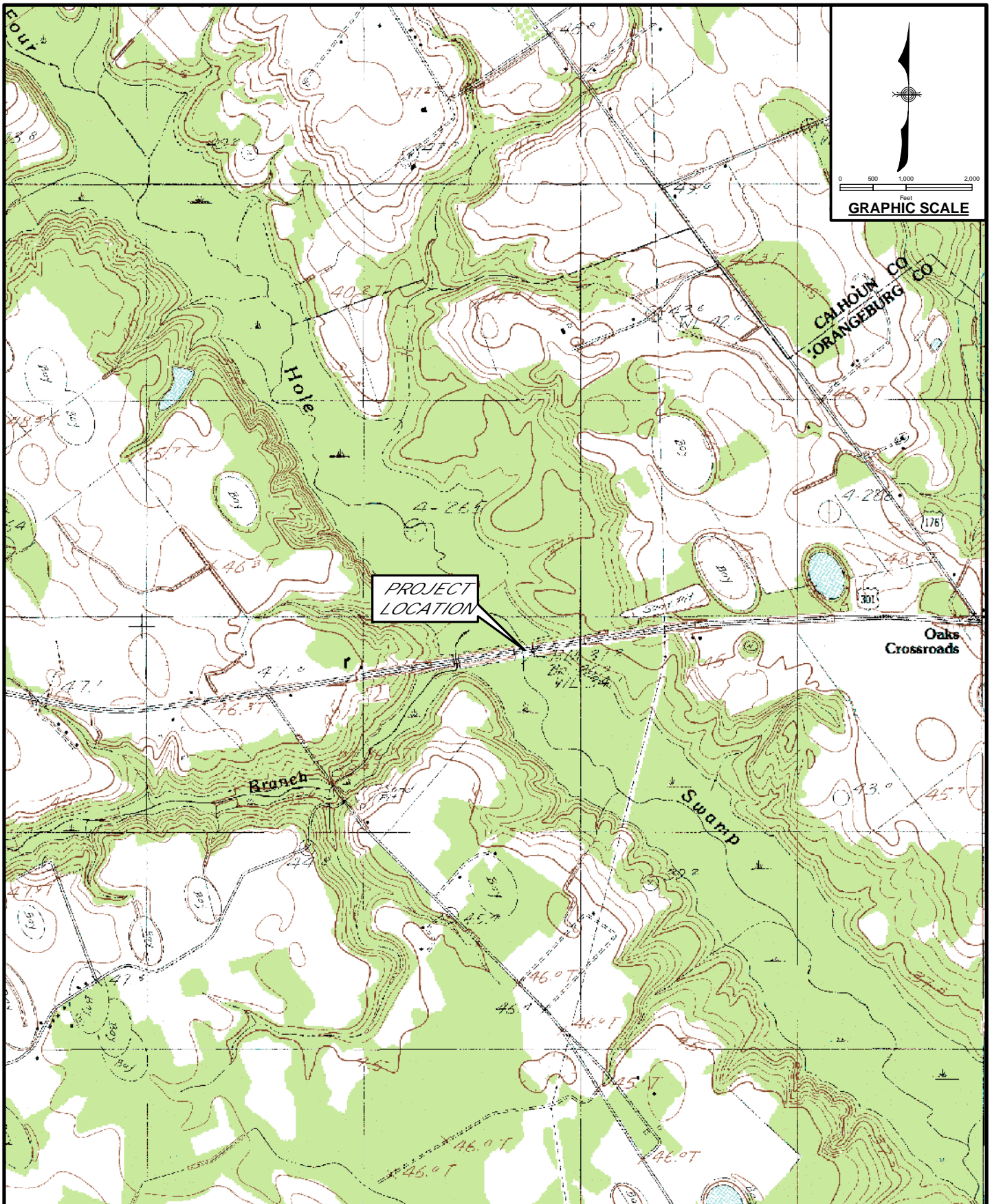
8.1 Undercutting: Areas requiring potential mucking were not visually observed during our site reconnaissance, or encountered within the test-holes performed during our field exploration. At this time, it is expected for mucking quantities to be minimal.

8.2 Borrow Material: Based on the Roadway plans dated August 29, 2014, provided by RPG3 Roadway Design Section, portions of the proposed alignment will require fill to achieve the proposed finished grade. Regardless of where the borrow materials are obtained (on-site or off-site), the borrow material must meet the 2007 Standard Specifications, Section 203 “Roadway and Drainage Excavation” for “Borrow Excavation.”

8.3 Construction: Construction of the embankment shall be in accordance with the 2007 Standard Specifications, Section 205 “Embankment Construction.” Construction of the embankments will begin with preparation of the sub-grade soils and then brought up to the elevation specified in the road plans

Appendix I

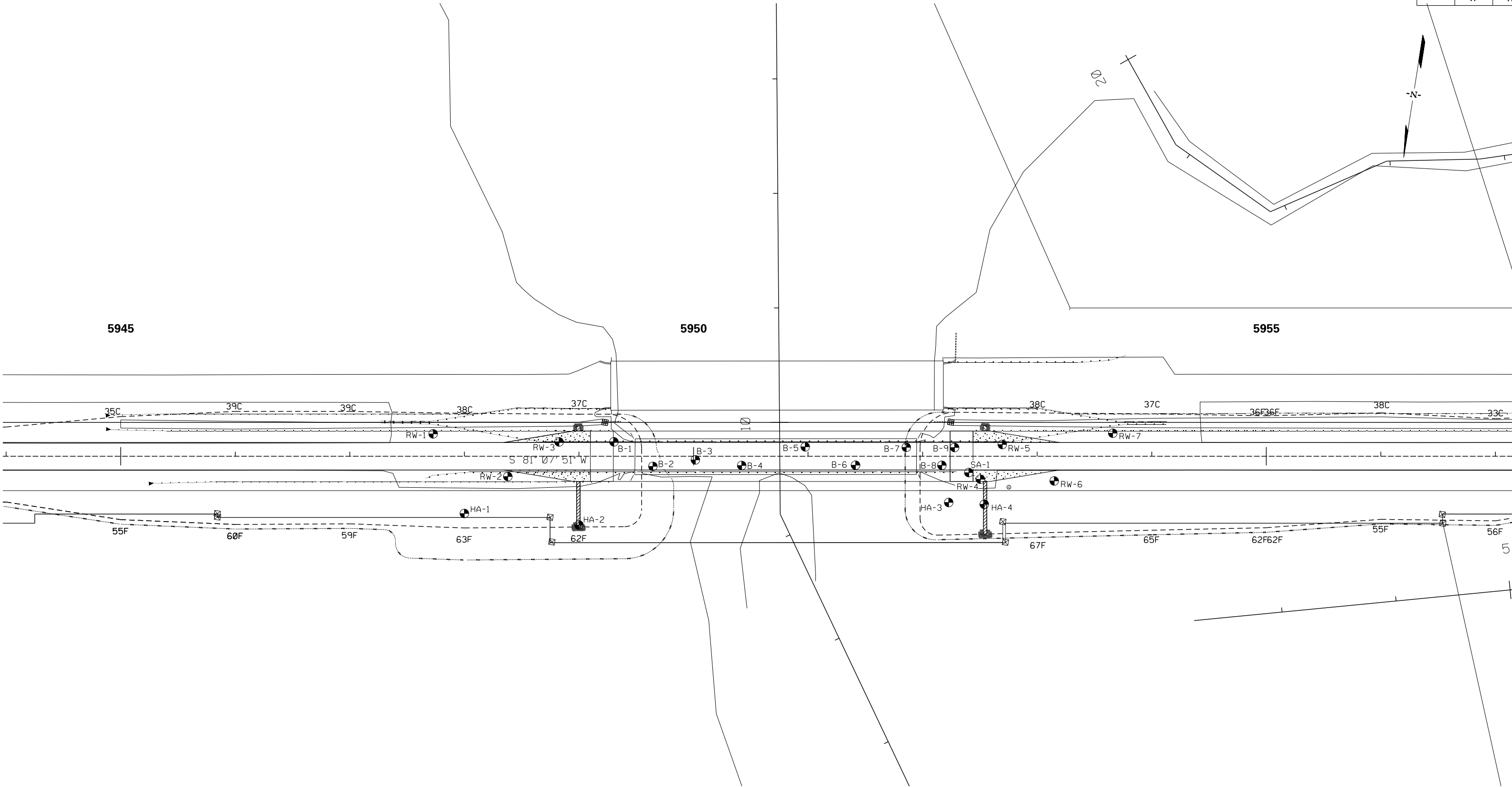
Site Map



Appendix II

Boring Layout
Soil Test Borings
DMT Logs

PIN	SHEET NO.	TOTAL SHEETS
40308 BR01	??	??



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REV.			
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REVIEWED			
QUAN.			
DR.	TAR		8-14
DES.	KRB		8-14
BY	CHK.	DATE	



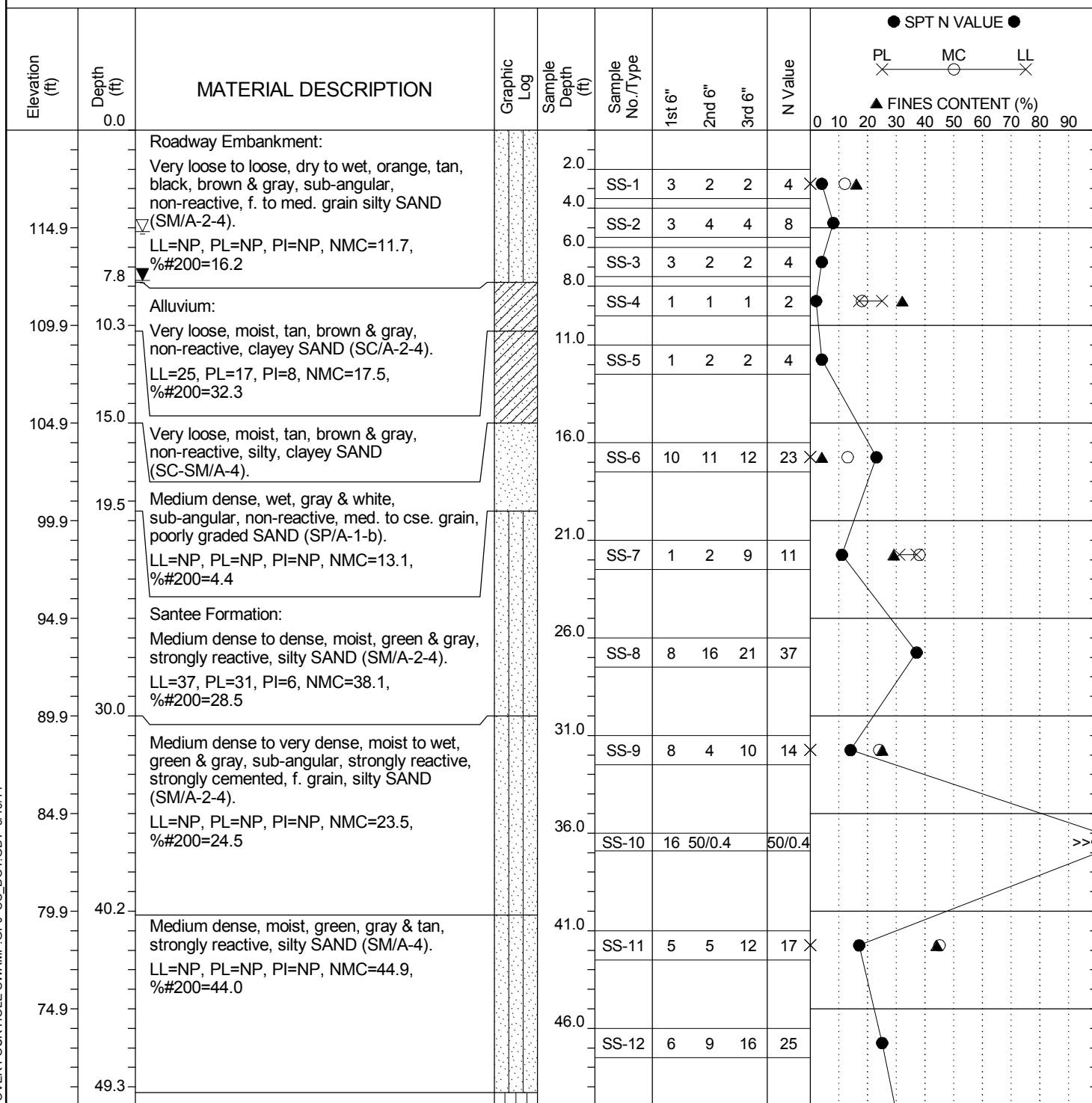
BRIDGE DESIGN
COLUMBIA, S.C.

**BRIDGE REPLACEMENT OVER
FOUR HOLE SWAMP**

FILE NO.	ROUTE	COUNTY	DRAWING NO.
38.040308	US 301	ORANGEBURG	??

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-1	Boring Location: 5949+31	Offset: 13' Lt.	Alignment: US 301
Elev.: 119.9 ft	Latitude: 33.45753	Longitude: 80.64727	Date Started: 4/22/14
Total Depth: 102.5 ft	Soil Depth: 102.5 ft	Core Depth: ft	Date Completed: 4/23/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.2 ft	24HR: 7.7 ft



LEGEND

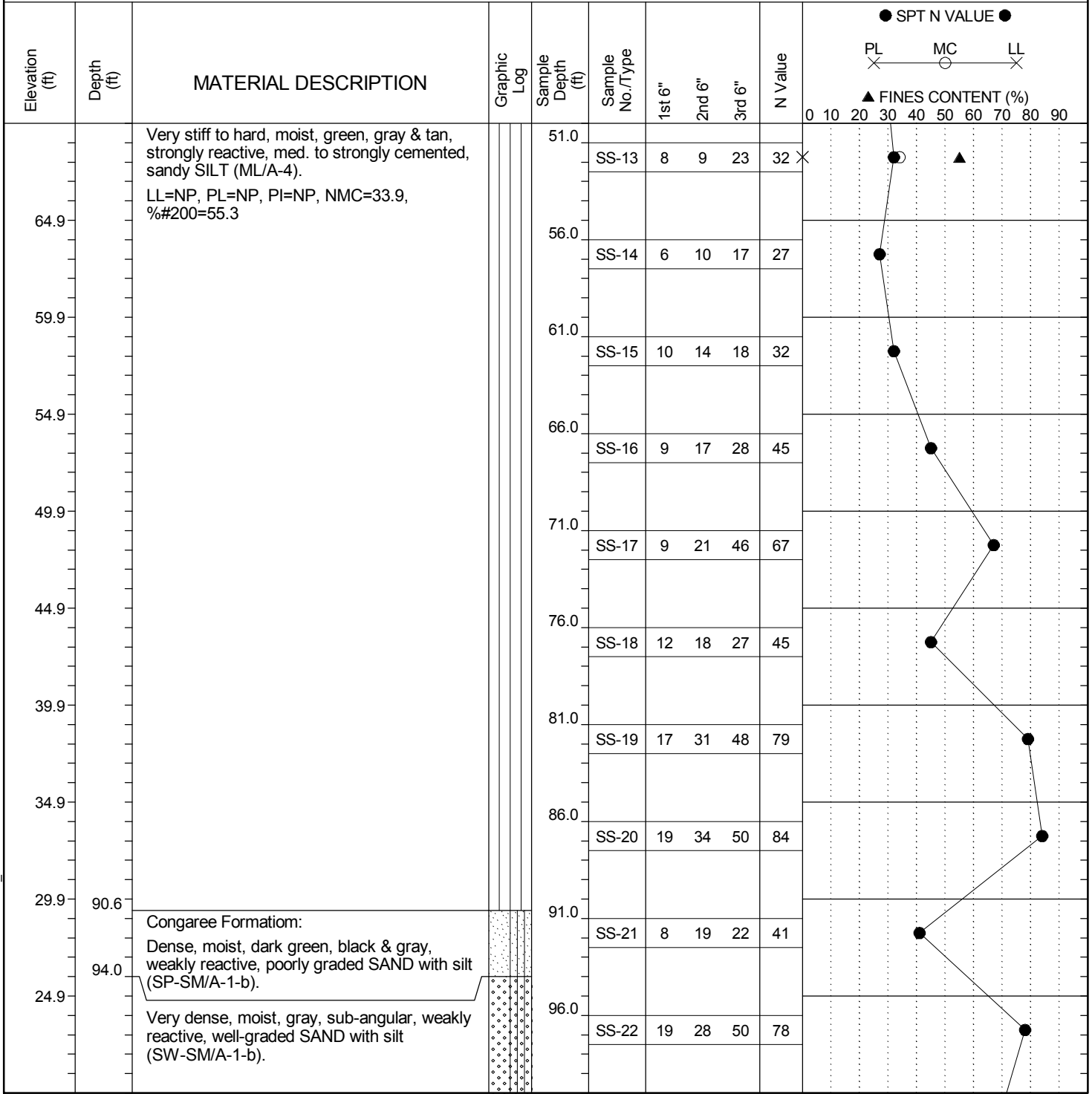
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

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Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.2 ft	24HR: 7.7 ft



LEGEND

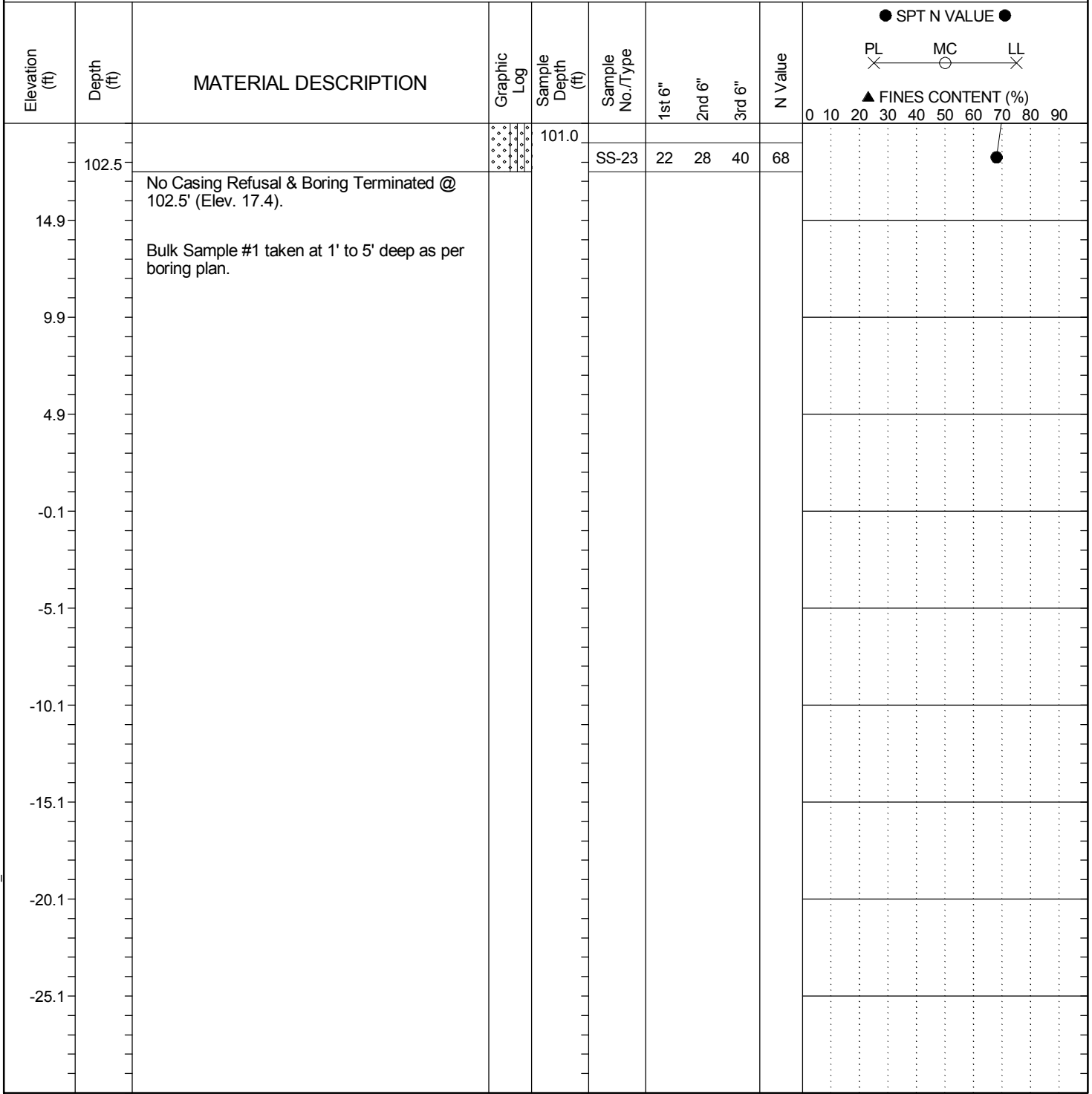
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
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AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Boring Log

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Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-1	Boring Location: 5949+31	Offset: 13' Lt.	Alignment: US 301
Elev.: 119.9 ft	Latitude: 33.45753	Longitude: 80.64727	Date Started: 4/22/14
Total Depth: 102.5 ft	Soil Depth: 102.5 ft	Core Depth: ft	Date Completed: 4/23/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.2 ft	24HR: 7.7 ft



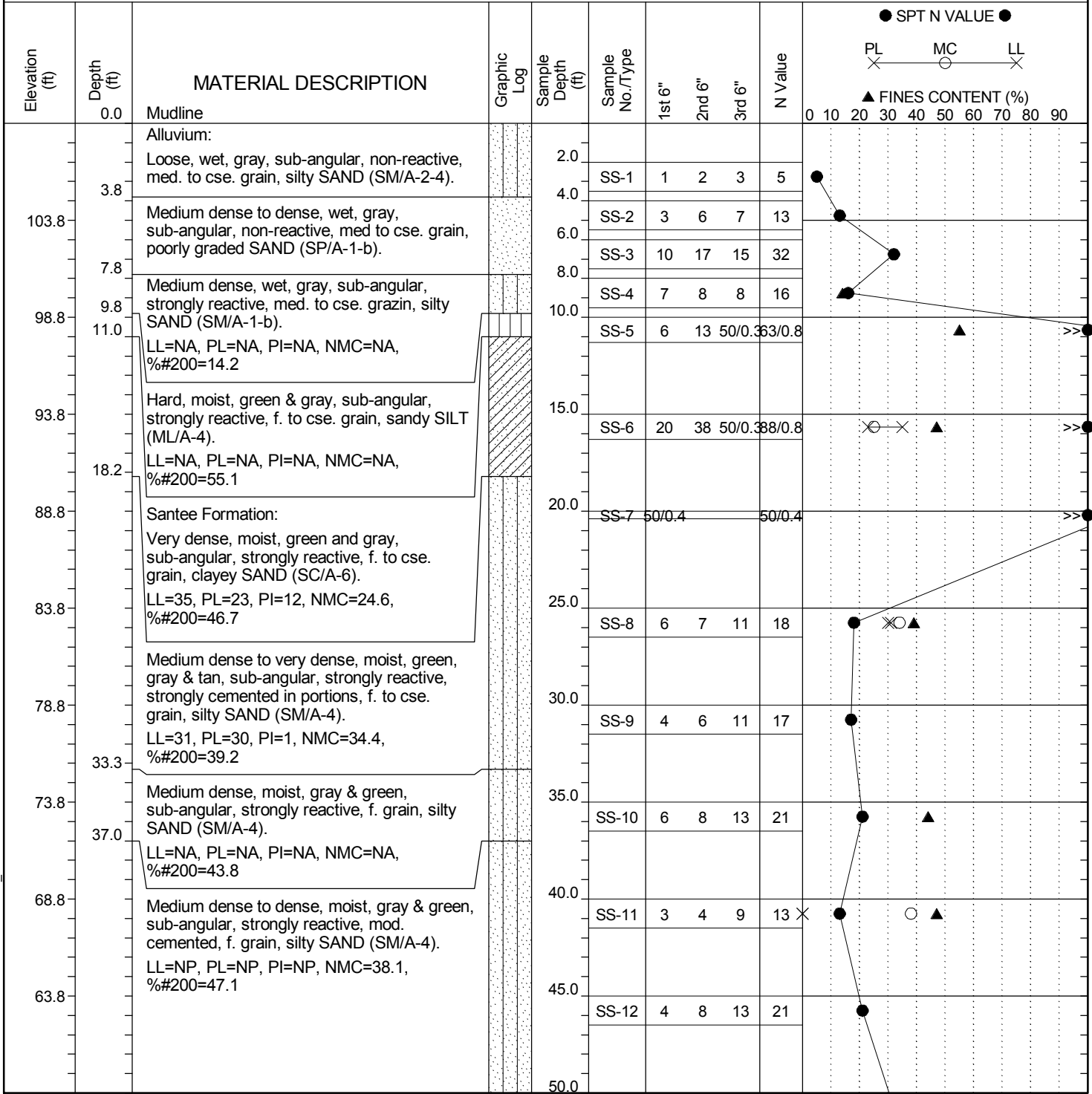
LEGEND

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

SC_DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-2	Boring Location: 5949+65	Offset: 9' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45757	Longitude: 80.6474	Date Started: 4/3/2014
Total Depth: 111.5 ft	Soil Depth: 111.5 ft	Core Depth: ft	Date Completed: 4/5/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



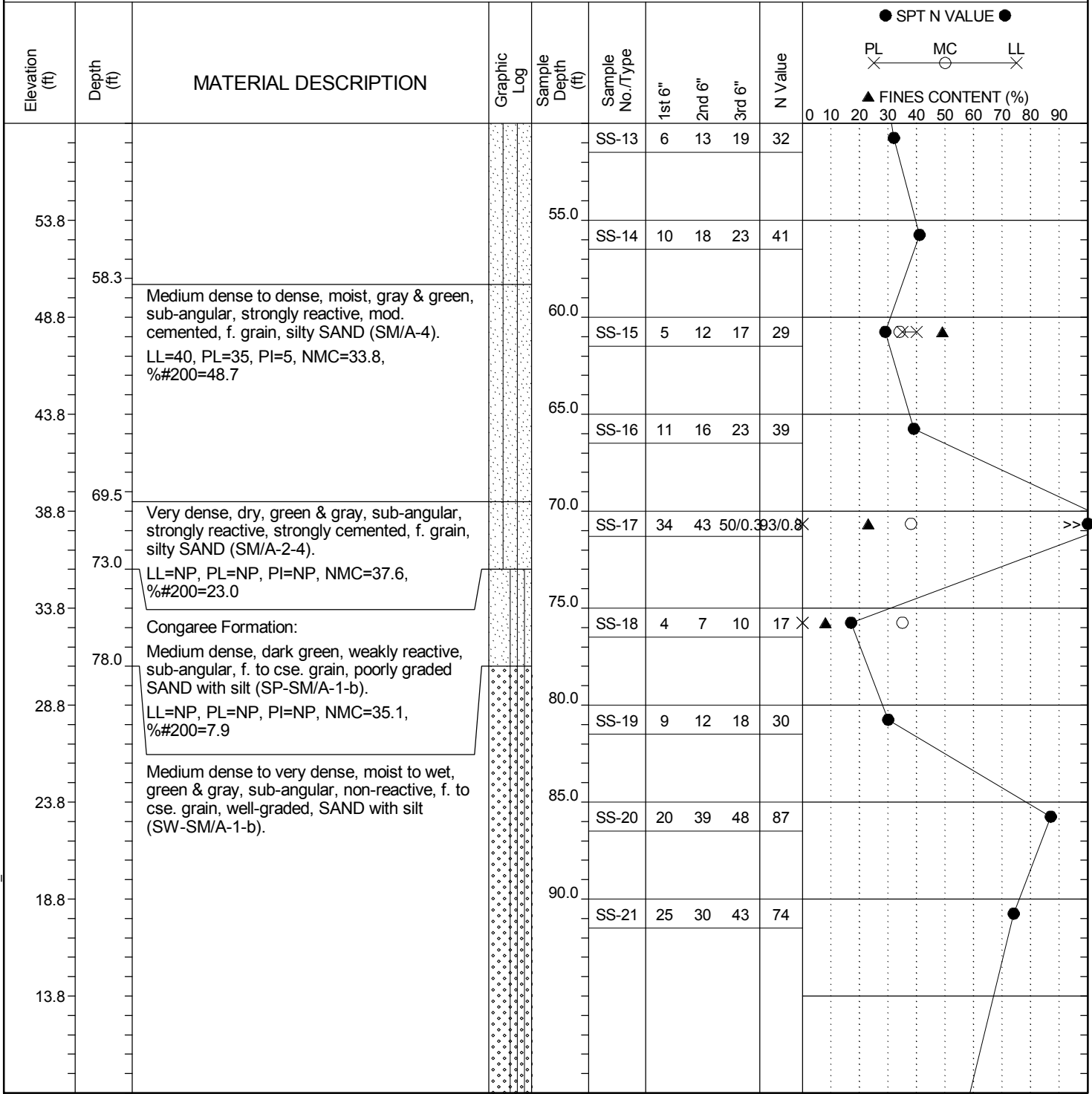
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
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SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-2	Boring Location: 5949+65	Offset: 9' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45757	Longitude: 80.6474	Date Started: 4/3/2014
Total Depth: 111.5 ft	Soil Depth: 111.5 ft	Core Depth: ft	Date Completed: 4/5/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

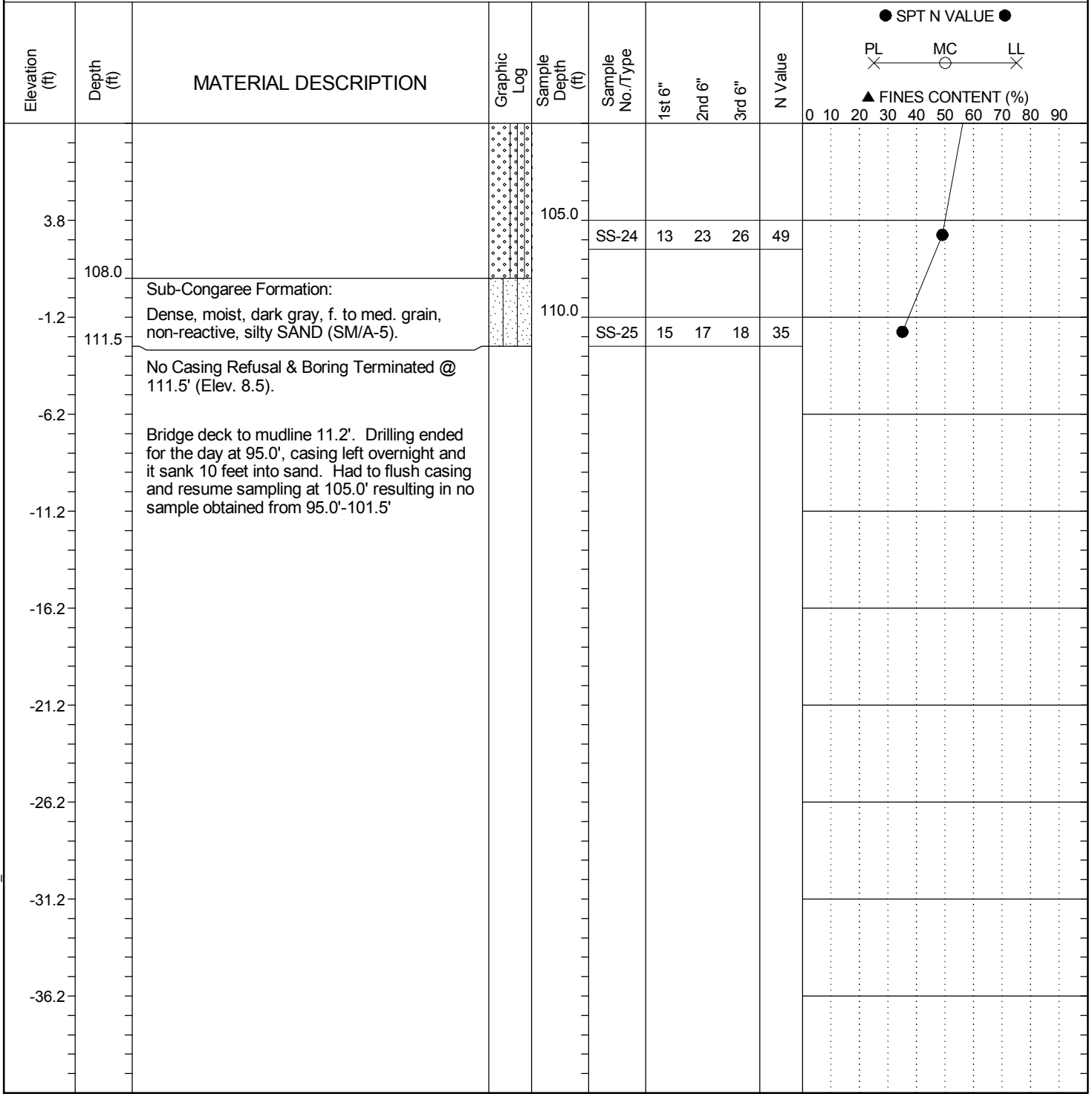
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-2	Boring Location: 5949+65	Offset: 9' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45757	Longitude: 80.6474	Date Started: 4/3/2014
Total Depth: 111.5 ft	Soil Depth: 111.5 ft	Core Depth: ft	Date Completed: 4/5/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



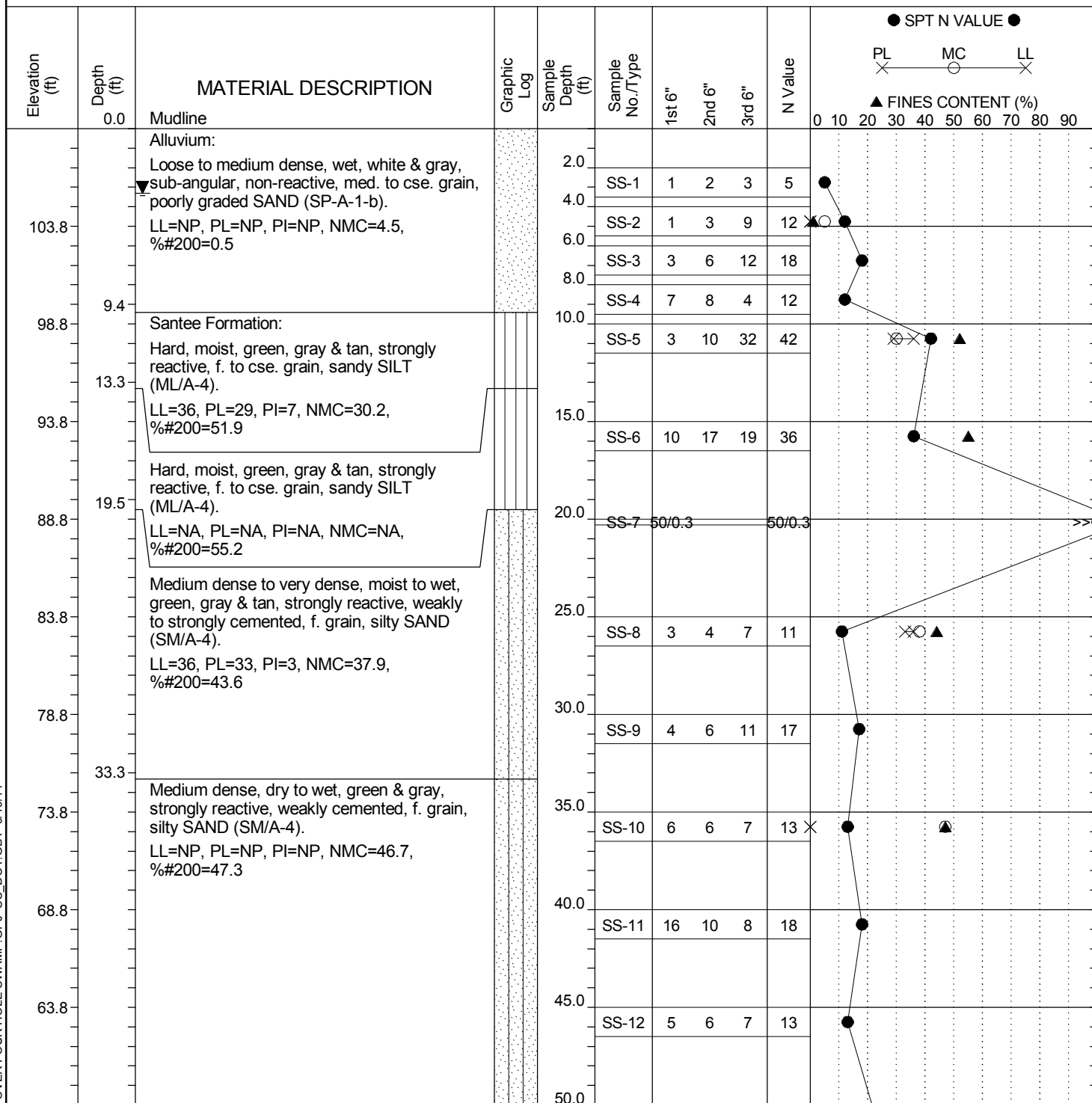
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-3	Boring Location: 5950+02	Offset: 3' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45751	Longitude: 80.64752	Date Started: 4/21/14
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/22/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 3.3 ft	24HR: 3.3 ft



LEGEND

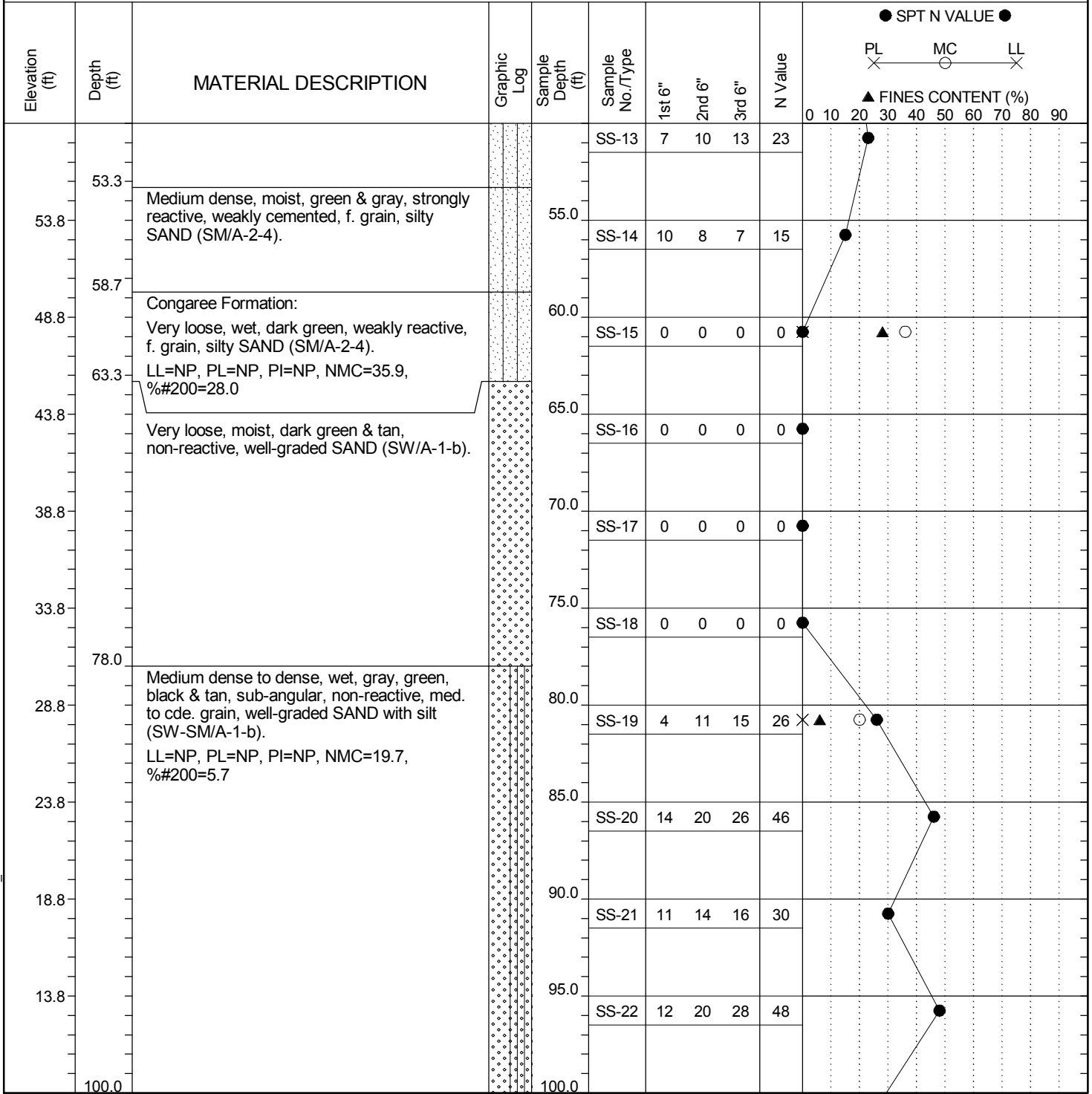
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-3	Boring Location: 5950+02	Offset: 3' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45751	Longitude: 80.64752	Date Started: 4/21/14
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/22/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 3.3 ft	24HR: 3.3 ft



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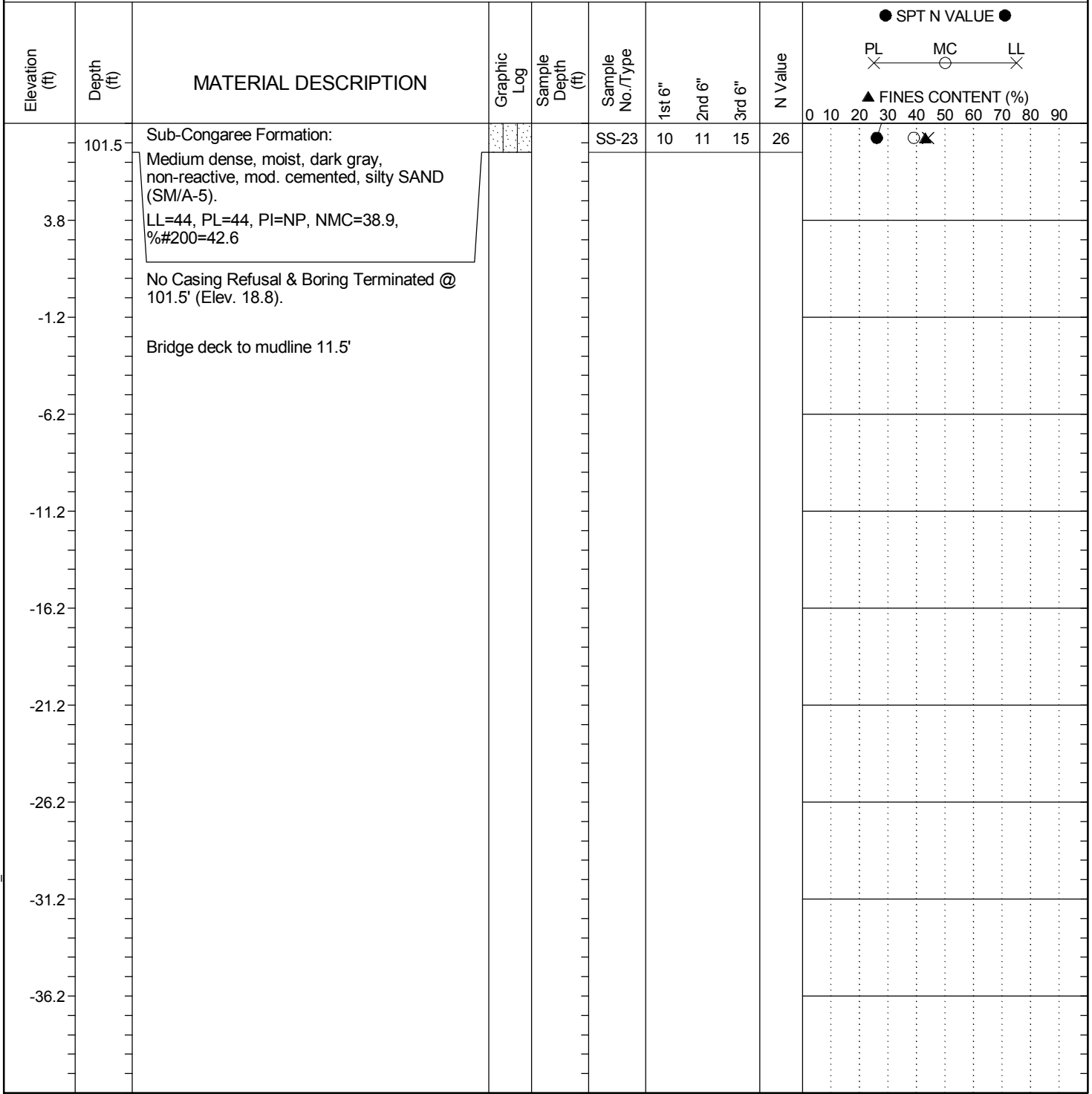
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SC_DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-3	Boring Location: 5950+02	Offset: 3' Rt.	Alignment: US 301
Elev.: 108.8 ft	Latitude: 33.45751	Longitude: 80.64752	Date Started: 4/21/14
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/22/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 3.3 ft	24HR: 3.3 ft



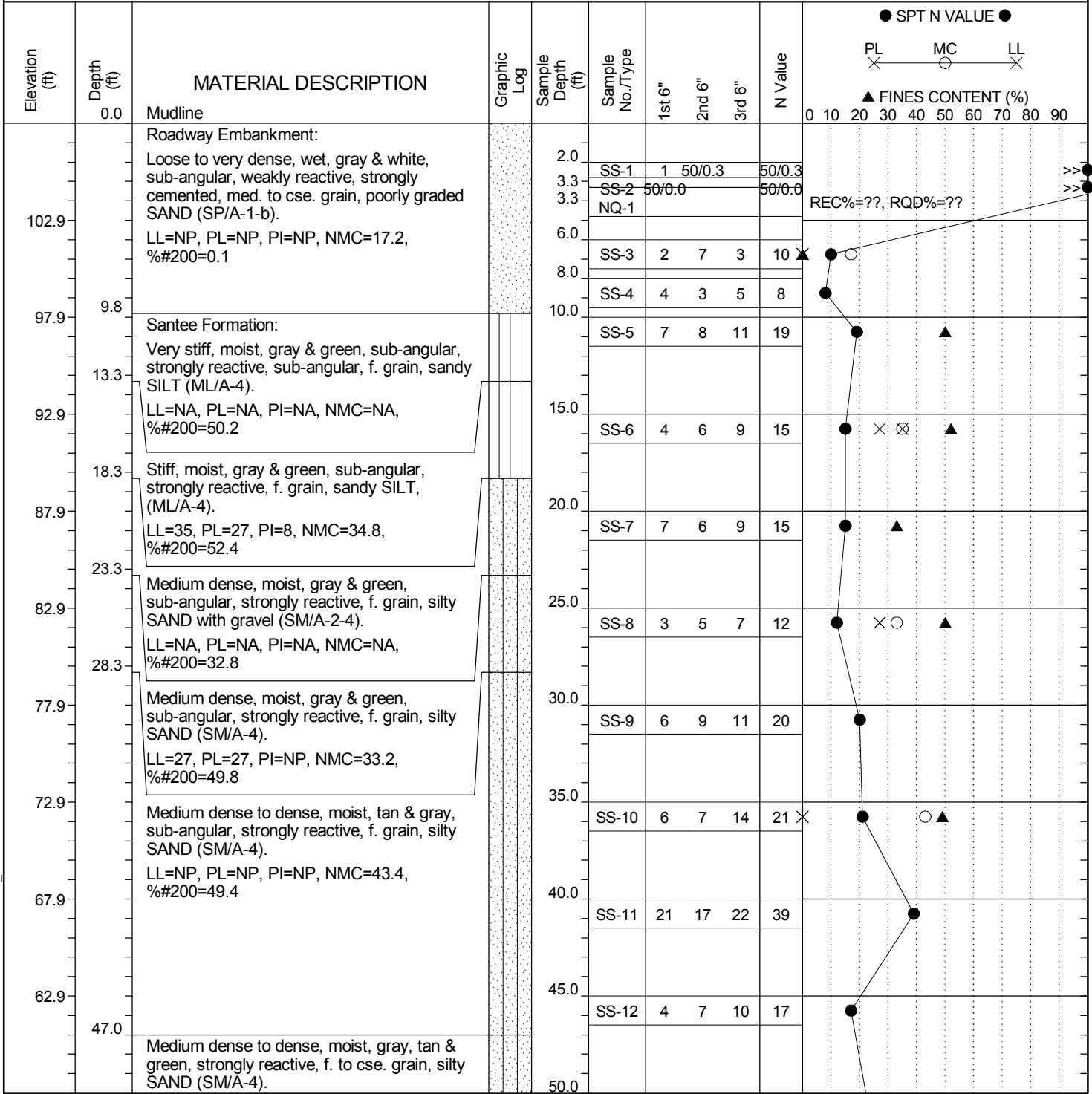
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-4	Boring Location: 5950+42	Offset: 8' Rt.	Alignment: US 301
Elev.: 107.9 ft	Latitude: 33.45754	Longitude: 80.64764	Date Started: 4/5/2014
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/6/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



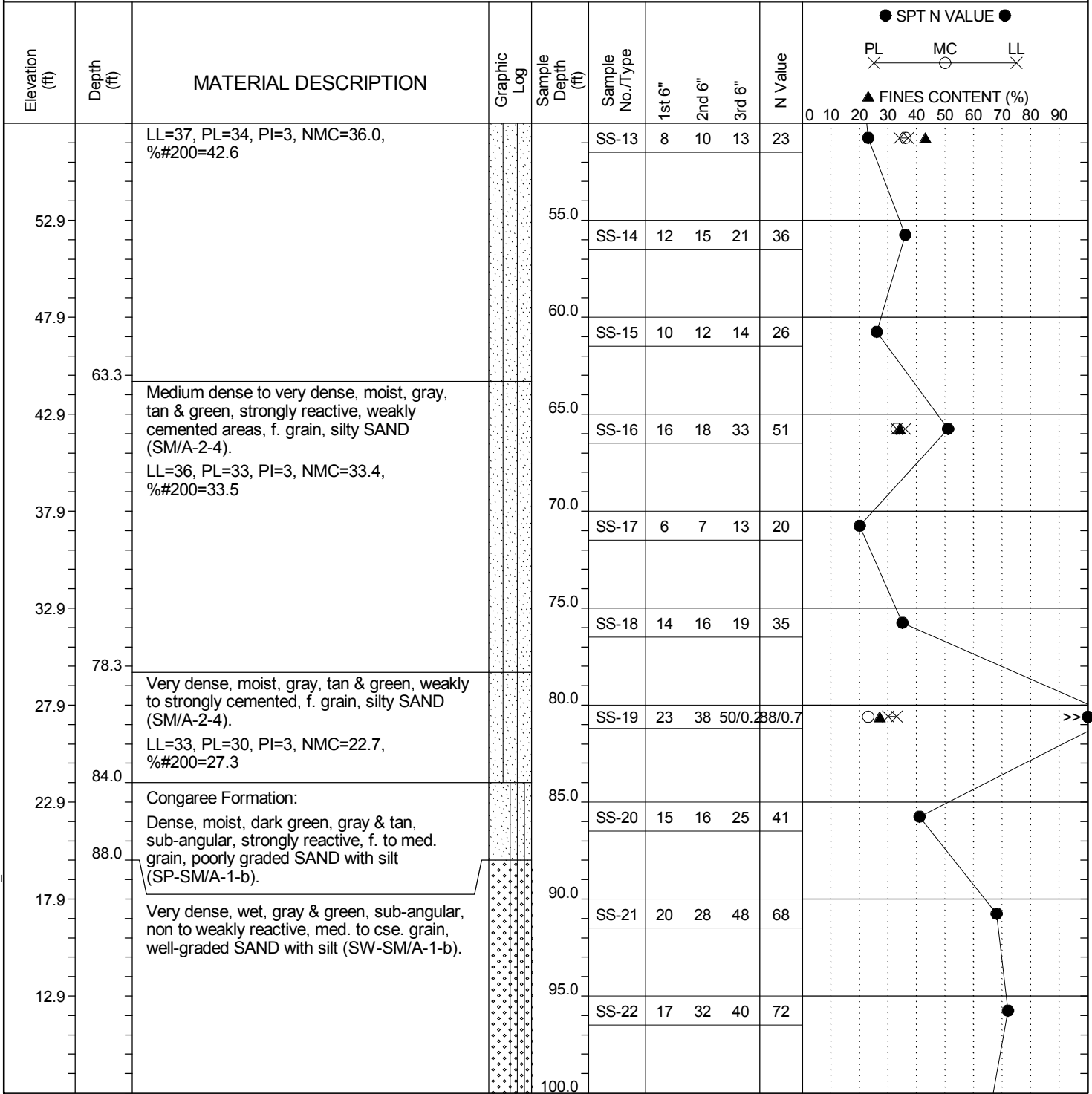
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-4	Boring Location: 5950+42	Offset: 8' Rt.	Alignment: US 301
Elev.: 107.9 ft	Latitude: 33.45754	Longitude: 80.64764	Date Started: 4/5/2014
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/6/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

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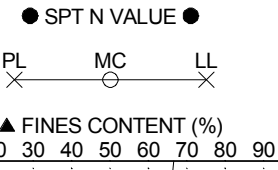
SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.:	38.040308	Project No. (PIN):	BR38(019)	County:	Orangeburg	Eng./Geo.:	R. DeLost	
Site Description:						Route:	US 301	
Boring No.:	B-4	Boring Location:	5950+42	Offset:	8' Rt.	Alignment:	US 301	
Elev.:	107.9 ft	Latitude:	33.45754	Longitude:	80.64764	Date Started:	4/5/2014	
Total Depth:	101.5 ft	Soil Depth:	101.5 ft	Core Depth:	ft	Date Completed:	4/6/2014	
Bore Hole Diameter (in):		4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:		CME 45C	Drill Method:		RW/DC	Hammer Type:		Automatic
Core Size:		NA	Driller:		M. Morgan	Groundwater:		TOB NA
						24HR		NA
						Energy Ratio:		79%

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	N Value	SPT N VALUE										
										0	10	20	30	40	50	60	70	80	90	
101.5	101.5	No Casing Refusal & Boring Terminated @ 101.5' (Elev. 18.7).	⊙		SS-23	16	31	35	66											
2.9		Bridge deck to mudline 12.3'.																		
-2.1																				
-7.1																				
-12.1																				
-17.1																				
-22.1																				
-27.1																				
-32.1																				
-37.1																				

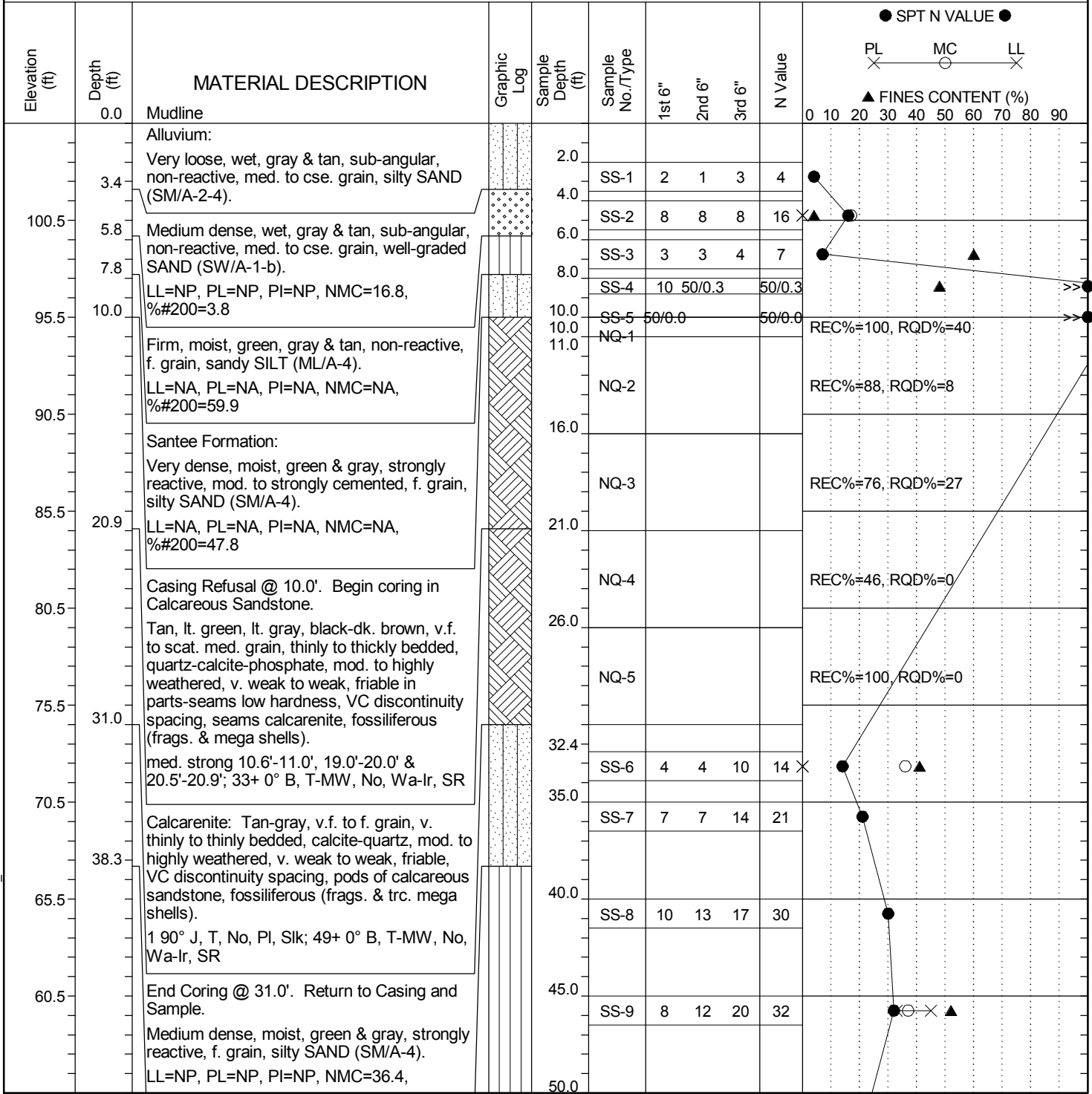


LEGEND

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-5	Boring Location: 5950+98	Offset: 8' Lt.	Alignment: US 301
Elev.: 105.5 ft	Latitude: 33.45747	Longitude: 80.64781	Date Started: 4/12/2014
Total Depth: 101.3 ft	Soil Depth: 80.3 ft	Core Depth: 21 ft	Date Completed: 4/13/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

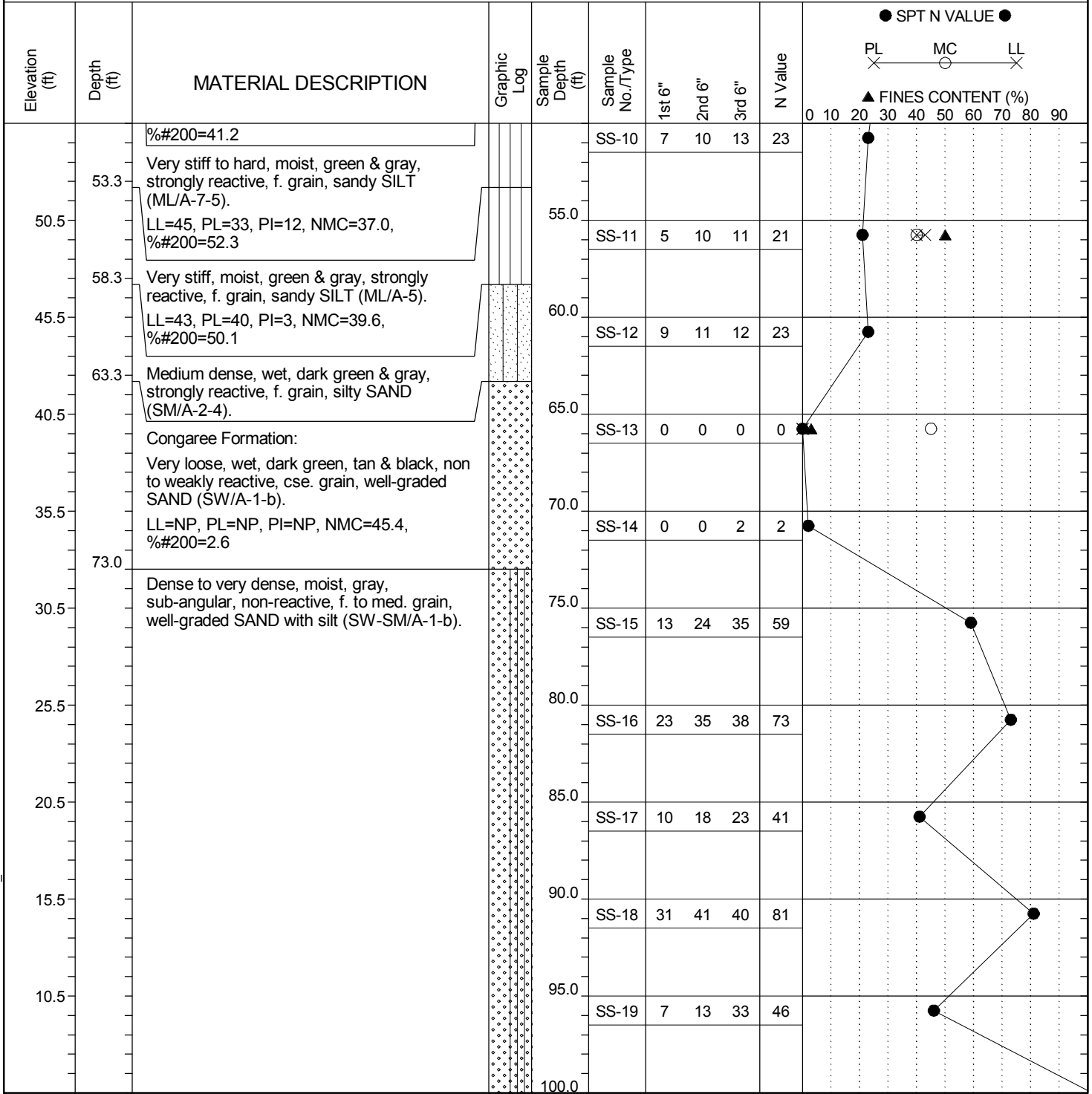
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-5	Boring Location: 5950+98	Offset: 8' Lt.	Alignment: US 301
Elev.: 105.5 ft	Latitude: 33.45747	Longitude: 80.64781	Date Started: 4/12/2014
Total Depth: 101.3 ft	Soil Depth: 80.3 ft	Core Depth: 21 ft	Date Completed: 4/13/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

Continued Next Page

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.:	38.040308	Project No. (PIN):	BR38(019)	County:	Orangeburg	Eng./Geo.:	R. DeLost
Site Description:	Bridge Replacement over Four Hole Swamp					Route:	US 301
Boring No.:	B-5	Boring Location:	5950+98	Offset:	8' Lt.	Alignment:	US 301
Elev.:	105.5 ft	Latitude:	33.45747	Longitude:	80.64781	Date Started:	4/12/2014
Total Depth:	101.3 ft	Soil Depth:	80.3 ft	Core Depth:	21 ft	Date Completed:	4/13/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 45C	Drill Method:	RW/RC/DC	Hammer Type:	Automatic	Energy Ratio:	79%
Core Size:	NQ2	Driller:	M. Morgan	Groundwater:	TOB NA	24HR:	NA

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	N Value	SPT N VALUE												
										PL	MC	LL	▲ FINES CONTENT (%)									
	101.3	No Casing Refusal & Boring Terminated @ 101.3' (Elev. 19.0).	⊙		SS-20	15	42	50/0.3	32/0.8													>>
	0.5	Bridge deck to mudline 14.8'.																				
	-4.5																					
	-9.5																					
	-14.5																					
	-19.5																					
	-24.5																					
	-29.5																					
	-34.5																					
	-39.5																					

LEGEND

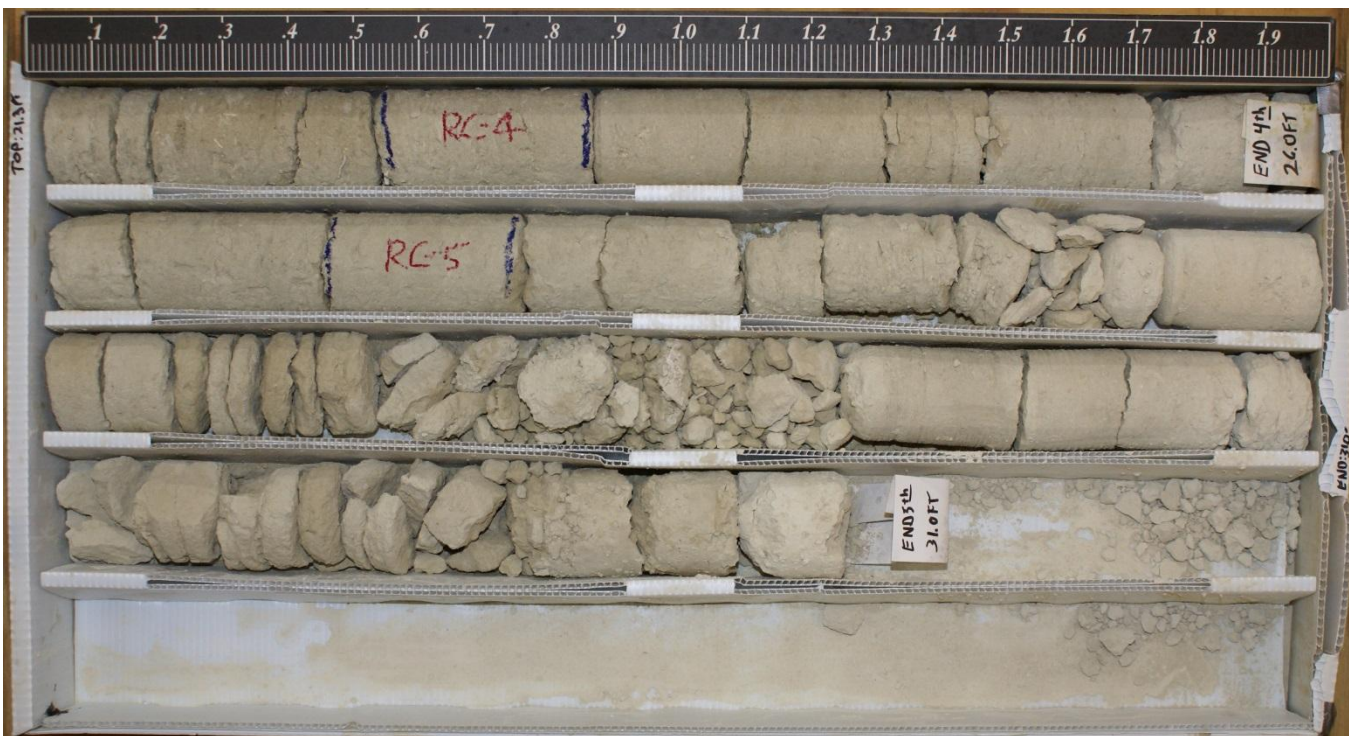
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

CORE PHOTOGRAPHIC RECORD

Bridge Replacement over Four Hole Swamp



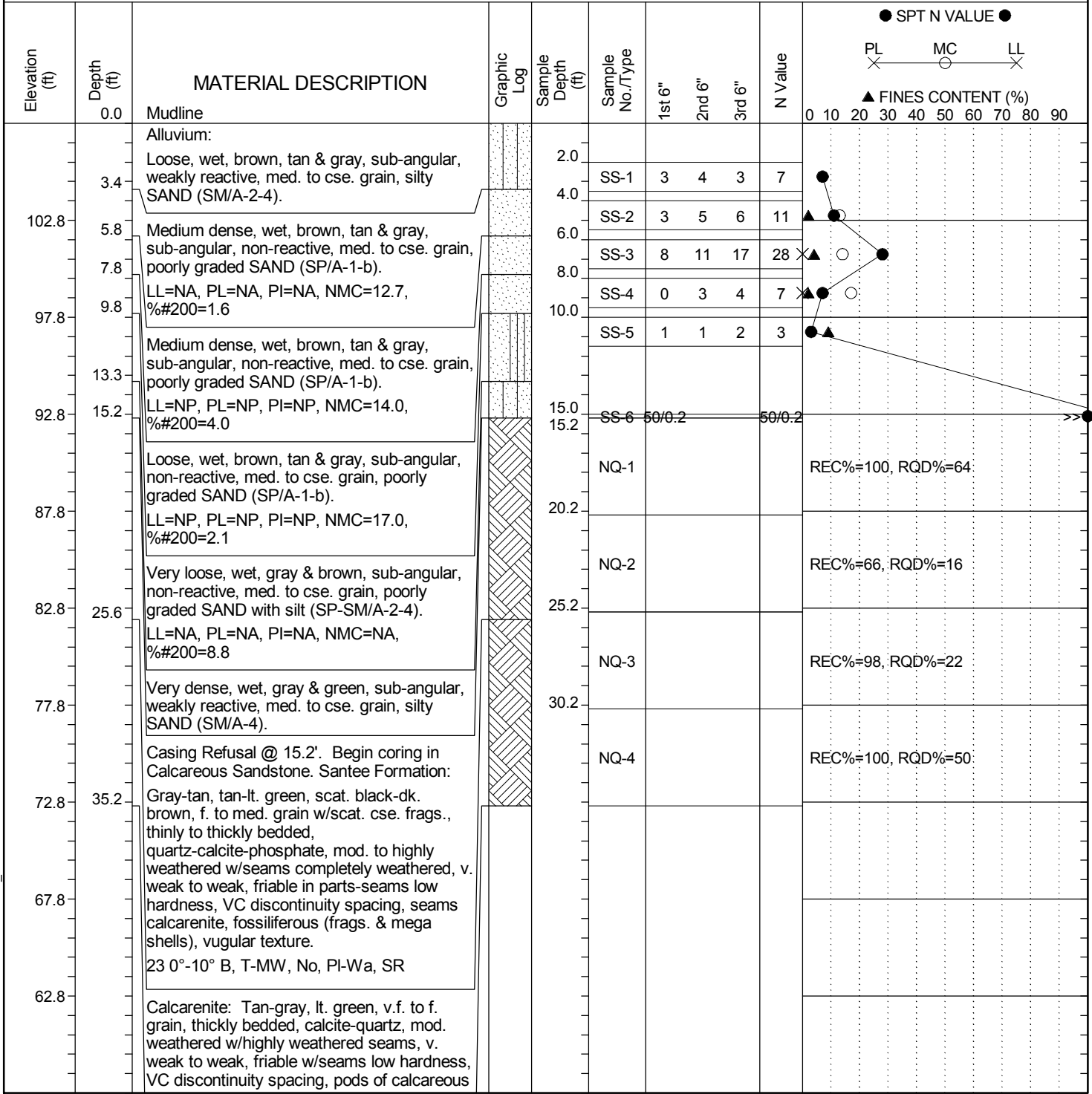
B5 – Box 1 of 2



B5 – Box 2 of 2

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-6	Boring Location: 5951+41	Offset: 8' Rt.	Alignment: US 301
Elev.: 107.8 ft	Latitude: 33.4575	Longitude: 80.64796	Date Started: 4/6/2014
Total Depth: 35.2 ft	Soil Depth: 15.2 ft	Core Depth: 20 ft	Date Completed: 4/8/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

Continued Next Page

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-6	Boring Location: 5951+41	Offset: 8' Rt.	Alignment: US 301
Elev.: 107.8 ft	Latitude: 33.4575	Longitude: 80.64796	Date Started: 4/6/2014
Total Depth: 35.2 ft	Soil Depth: 15.2 ft	Core Depth: 20 ft	Date Completed: 4/8/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	N Value	SPT N VALUE											
										PL	MC	LL	FINES CONTENT (%)								
52.8		sandstone, fossiliferous (frags. & trc. mega shells). med. strong 25.6'-26.5'; 27+ 0° B, T-MW, No, PI-Ir, SR Boring Terminated @ 35.2' (Elev. 85.0). Bridge deck to mudline 12.4'.																			
47.8																					
42.8																					
37.8																					
32.8																					
27.8																					
22.8																					
17.8																					
12.8																					

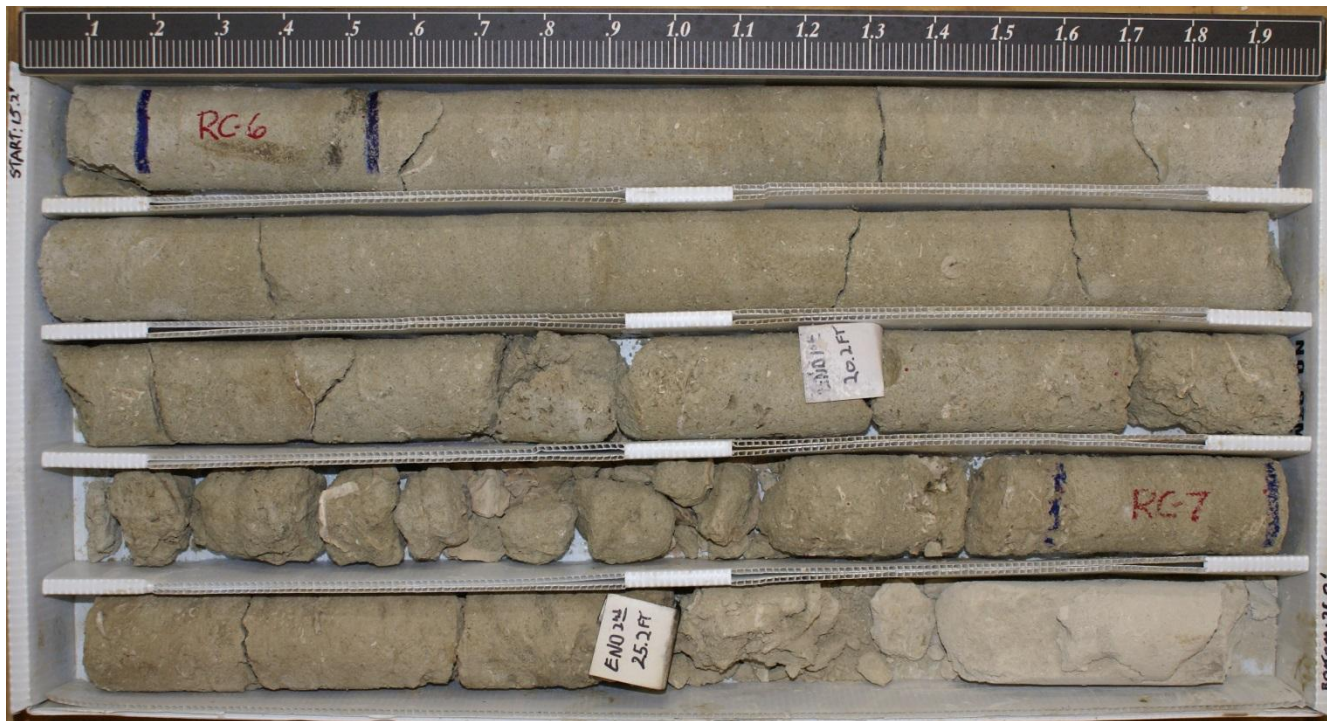
LEGEND

SAMPLER TYPE SS - Split Spoon ST - Shelby Tube 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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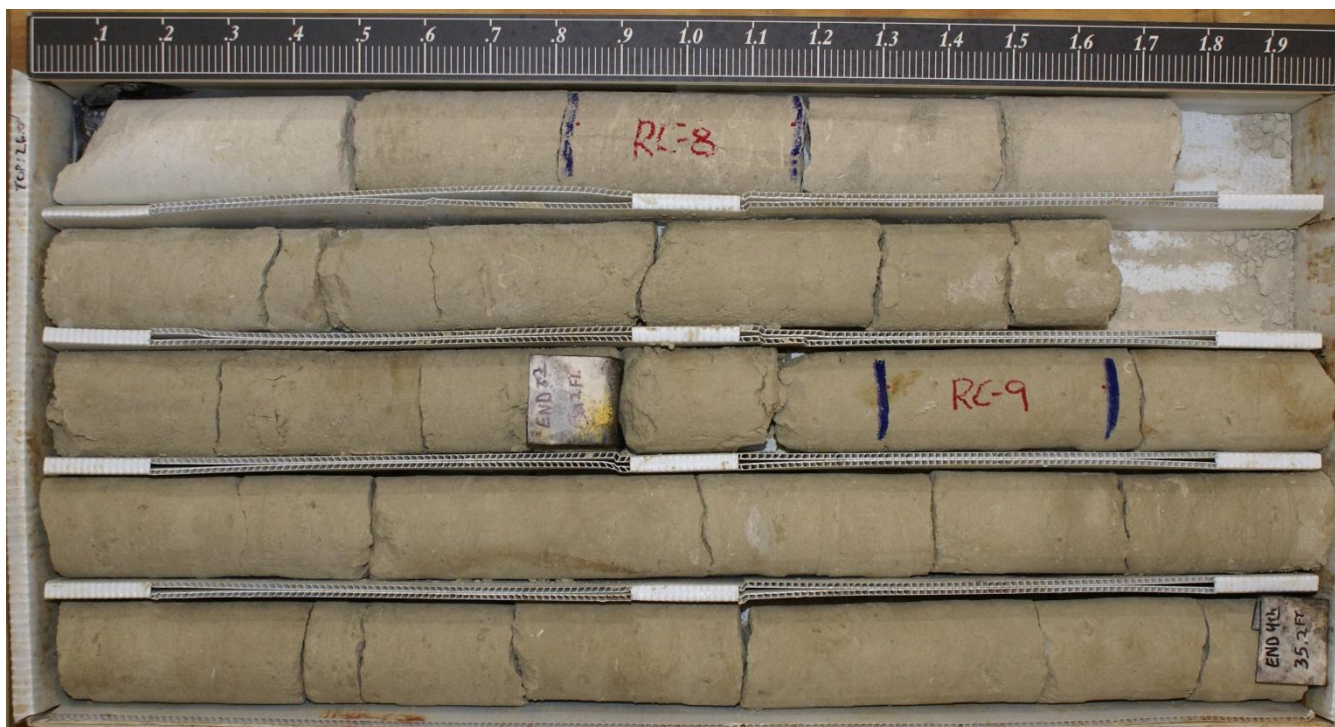
SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

CORE PHOTOGRAPHIC RECORD

Bridge Replacement over Four Hole Swamp



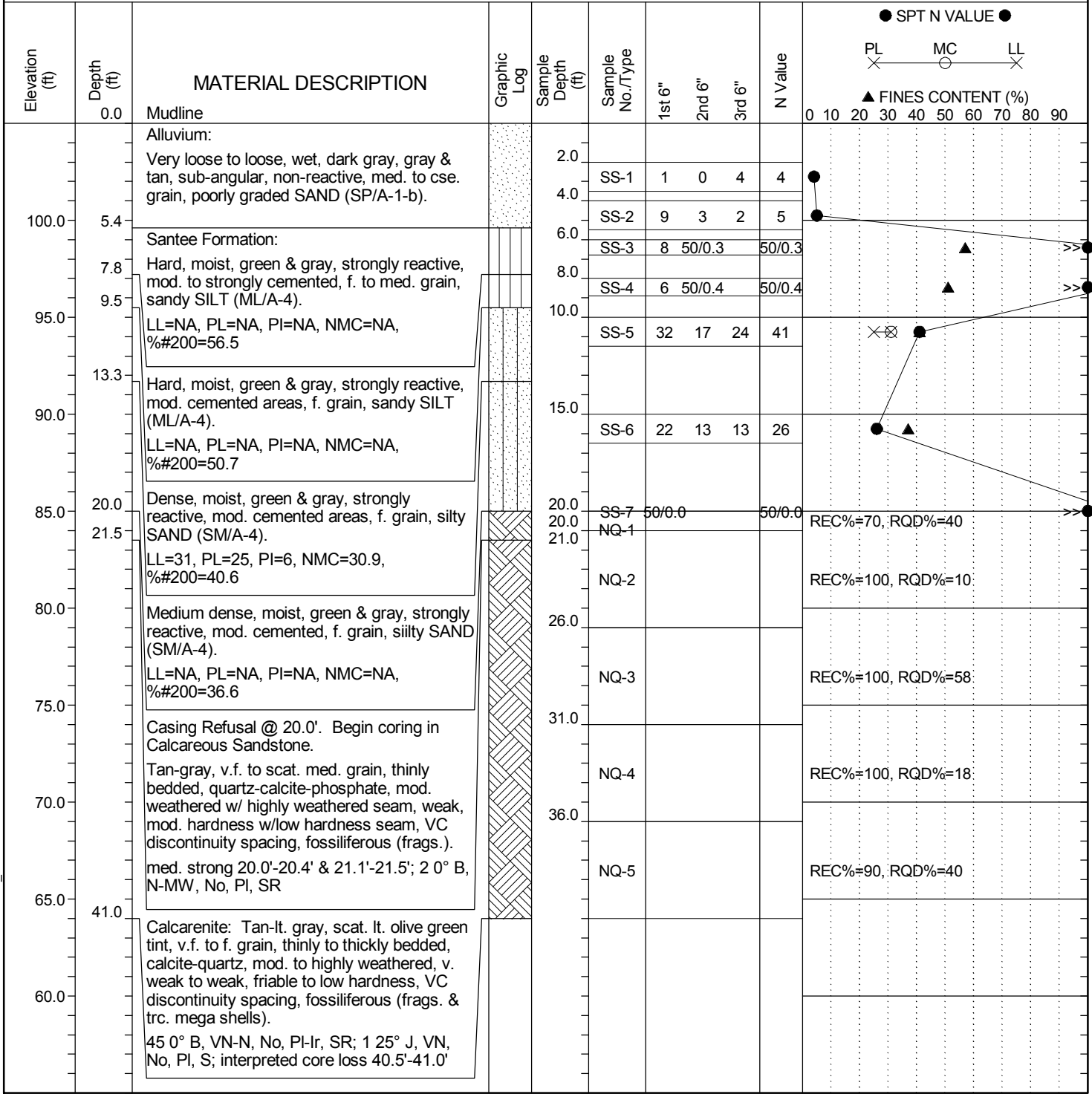
B6 – Box 1 of 2



B6 – Box 2 of 2

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-7	Boring Location: 5951+86	Offset: 8' Lt.	Alignment: US 301
Elev.: 105.0 ft	Latitude: 33.45744	Longitude: 80.6481	Date Started: 4/12/2014
Total Depth: 41 ft	Soil Depth: 20 ft	Core Depth: 21 ft	Date Completed: 4/12/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA



LEGEND

Continued Next Page

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-7	Boring Location: 5951+86	Offset: 8' Lt.	Alignment: US 301
Elev.: 105.0 ft	Latitude: 33.45744	Longitude: 80.6481	Date Started: 4/12/2014
Total Depth: 41 ft	Soil Depth: 20 ft	Core Depth: 21 ft	Date Completed: 4/12/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB NA	24HR: NA

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	N Value	SPT N VALUE												
										PL	MC	LL	FINES CONTENT (%)									
		Boring Terminated @ 41.0' (Elev. 79.1). Bridge deck to mudline 15.1'.																				
50.0																						
45.0																						
40.0																						
35.0																						
30.0																						
25.0																						
20.0																						
15.0																						
10.0																						

LEGEND

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

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

CORE PHOTOGRAPHIC RECORD

Bridge Replacement over Four Hole Swamp

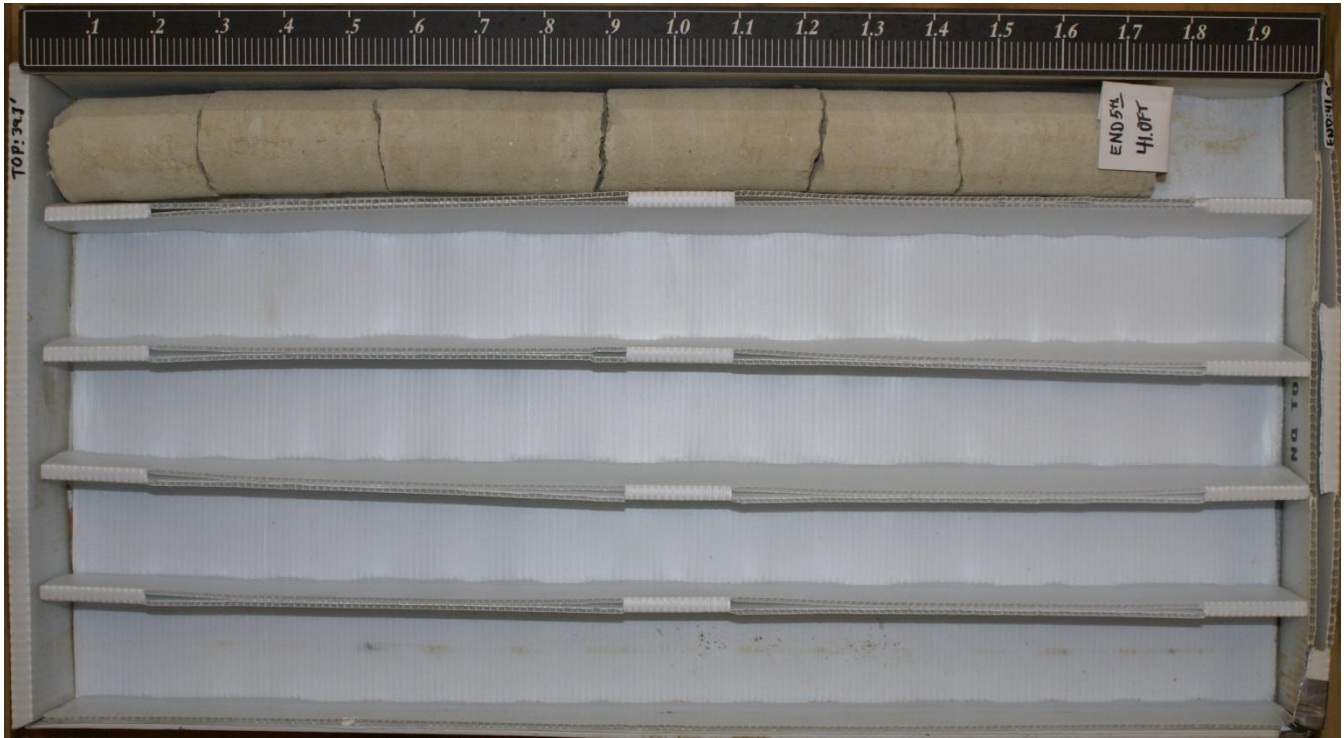


B7 – Box 1 of 3



B7 – Box 2 of 3

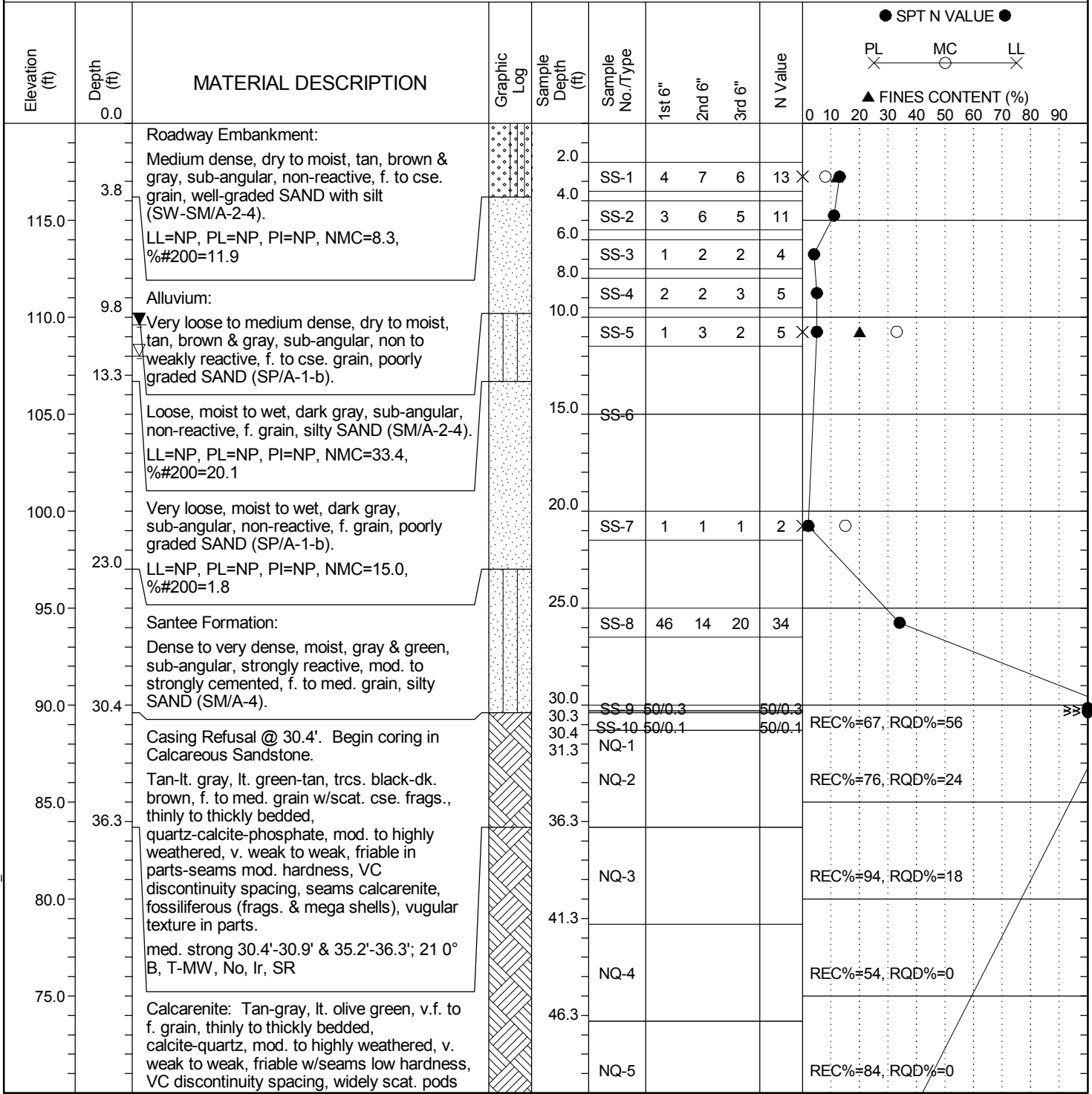
CORE PHOTOGRAPHIC RECORD
Bridge Replacement over Four Hole Swamp



B7 – Box 3 of 3

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-8	Boring Location: 5952+17	Offset: 8' Rt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45747	Longitude: 80.64821	Date Started: 4/8/2014
Total Depth: 101.4 ft	Soil Depth: 80.5 ft	Core Depth: 20.9 ft	Date Completed: 4/9/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB 12 ft.	24HR: 10.4 ft.



LEGEND

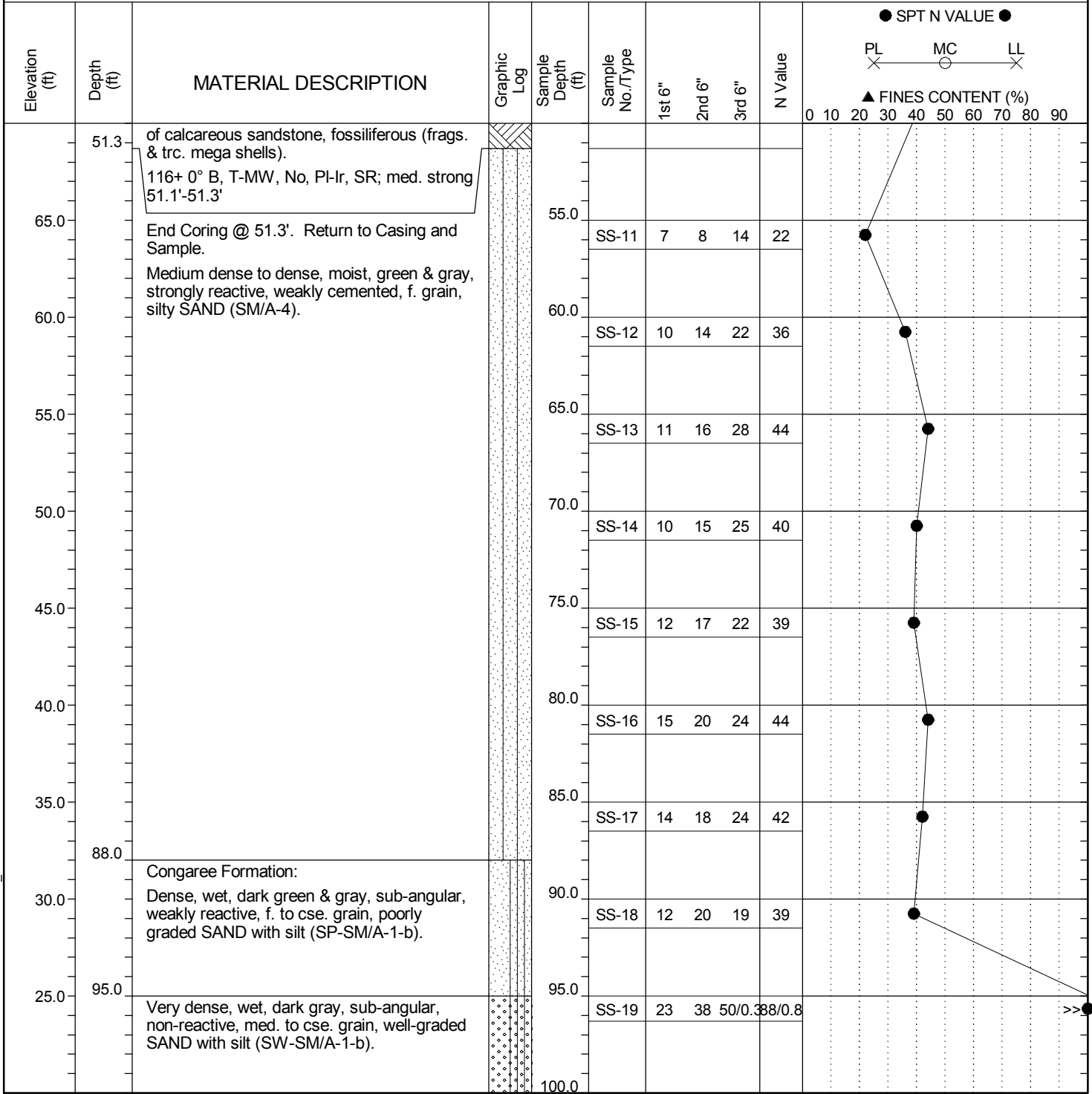
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-8	Boring Location: 5952+17	Offset: 8' Rt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45747	Longitude: 80.64821	Date Started: 4/8/2014
Total Depth: 101.4 ft	Soil Depth: 80.5 ft	Core Depth: 20.9 ft	Date Completed: 4/9/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB 12 ft.	24HR: 10.4 ft.



LEGEND

Continued Next Page

SC_DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC_DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp		Route: US 301	
Boring No.: B-8	Boring Location: 5952+17	Offset: 8' Rt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45747	Longitude: 80.64821	Date Started: 4/8/2014
Total Depth: 101.4 ft	Soil Depth: 80.5 ft	Core Depth: 20.9 ft	Date Completed: 4/9/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/RC/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NQ2	Driller: M. Morgan	Groundwater: TOB 12 ft.	24HR: 10.4 ft.

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	SPT N VALUE			N Value	● SPT N VALUE ● PL MC LL X ○ X ▲ FINES CONTENT (%) 0 10 20 30 40 50 60 70 80 90
						1st 6"	2nd 6"	3rd 6"		
101.4	101.4	No Casing Refusal & Boring Terminated @ 101.4' (Elev. 18.6).	(Symbolic)		SS-20	25	31	50/0.48	1/0.9	>>●
15.0	15.0	Could not obtain sample at 15.0' due to bore backfilling w/wash rotary, switched to mud rotary drilling. Bulk Sample #2 taken at 1' to 5' deep as per boring plan.								
10.0	10.0									
5.0	5.0									
0.0	0.0									
-5.0	-5.0									
-10.0	-10.0									
-15.0	-15.0									
-20.0	-20.0									
-25.0	-25.0									

LEGEND

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

CORE PHOTOGRAPHIC RECORD

Bridge Replacement over Four Hole Swamp



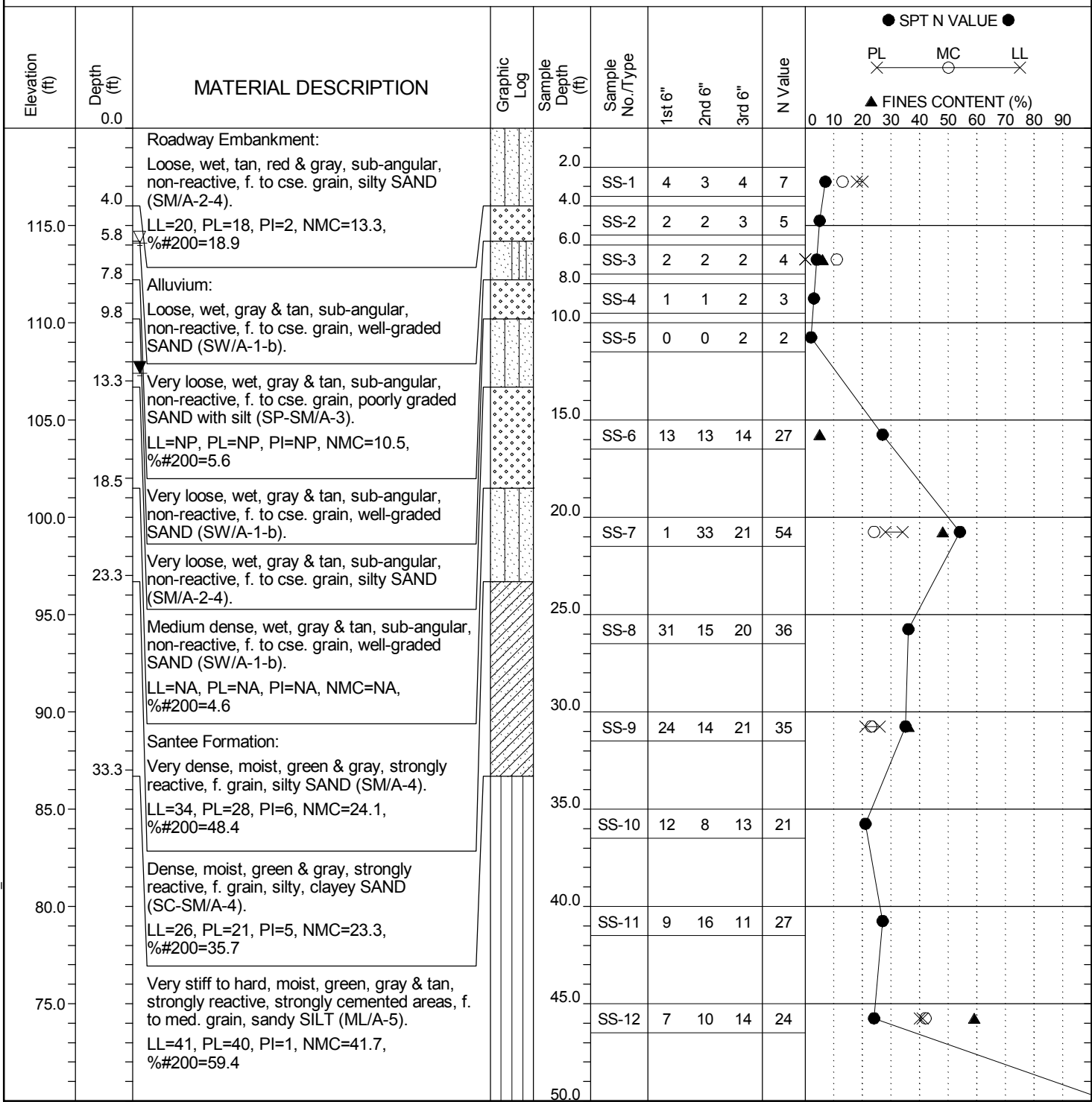
B8 – Box 1 of 2



B8 – Box 2 of 2

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-9	Boring Location: 5952+28	Offset: 8' Lt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45742	Longitude: 80.64824	Date Started: 4/11/2014
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/11/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.9 ft.	24HR: 12.6 ft.



LEGEND

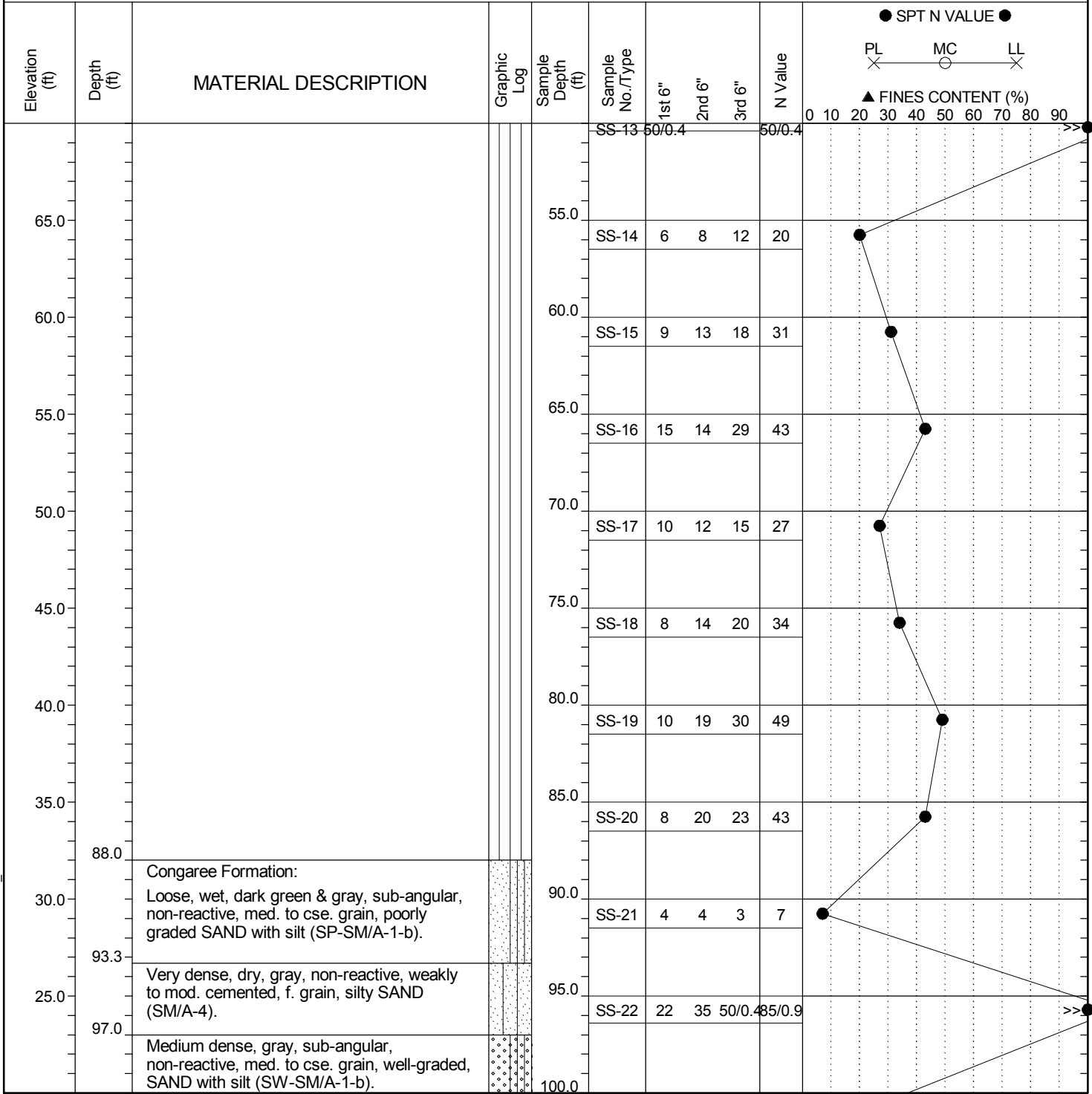
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-9	Boring Location: 5952+28	Offset: 8' Lt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45742	Longitude: 80.64824	Date Started: 4/11/2014
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/11/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.9 ft.	24HR: 12.6 ft.



LEGEND

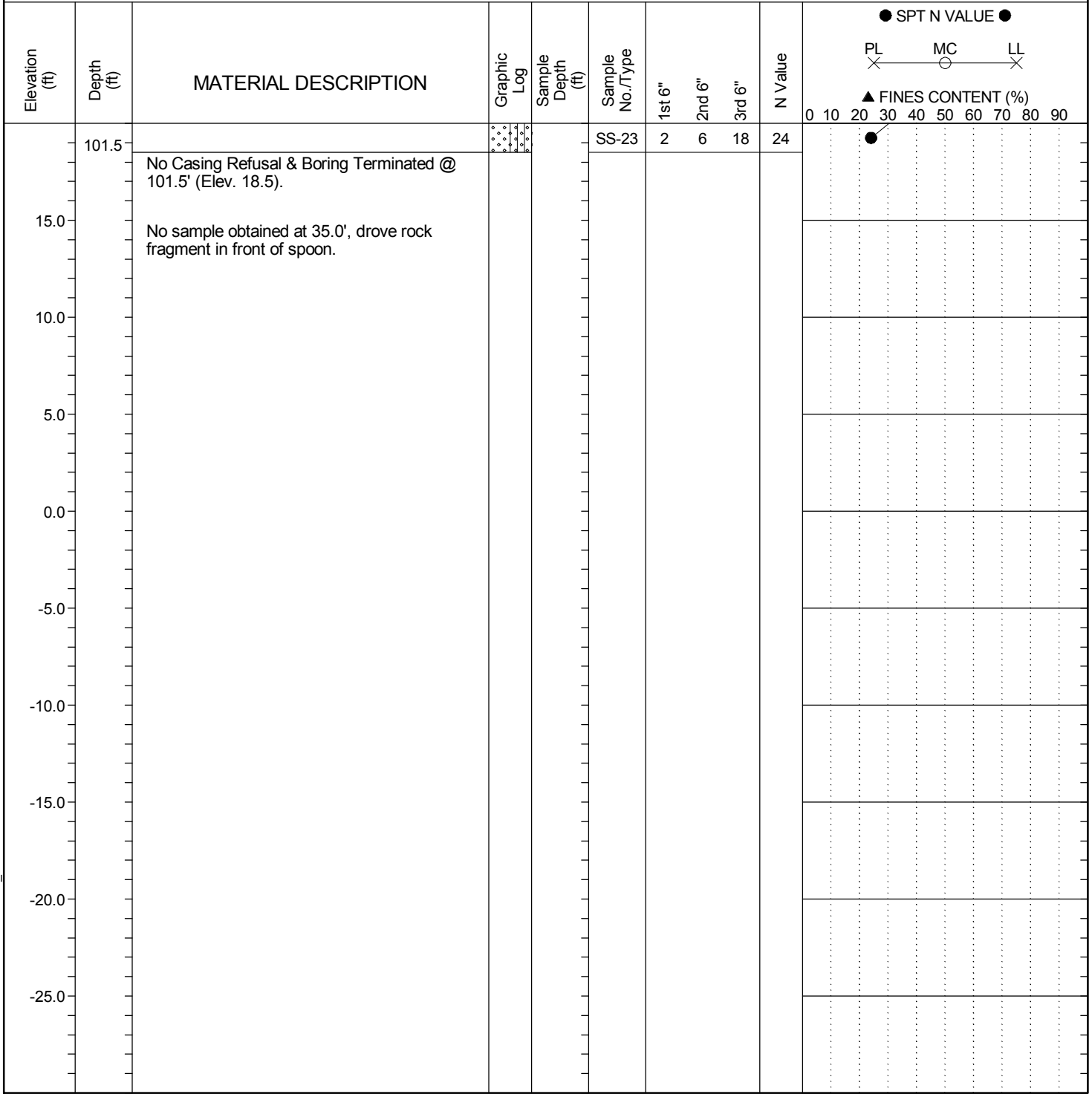
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SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

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

SCDOT Soil Test Boring Log

File No.: 38.040308	Project No. (PIN): BR38(019)	County: Orangeburg	Eng./Geo.: R. DeLost
Site Description: Bridge Replacement over Four Hole Swamp			Route: US 301
Boring No.: B-9	Boring Location: 5952+28	Offset: 8' Lt.	Alignment: US 301
Elev.: 120.0 ft	Latitude: 33.45742	Longitude: 80.64824	Date Started: 4/11/2014
Total Depth: 101.5 ft	Soil Depth: 101.5 ft	Core Depth: ft	Date Completed: 4/11/2014
Bore Hole Diameter (in): 4	Sampler Configuration	Liner Required: Y (N)	Liner Used: Y (N)
Drill Machine: CME 45C	Drill Method: RW/DC	Hammer Type: Automatic	Energy Ratio: 79%
Core Size: NA	Driller: M. Morgan	Groundwater: TOB 5.9 ft.	24HR 12.6 ft.



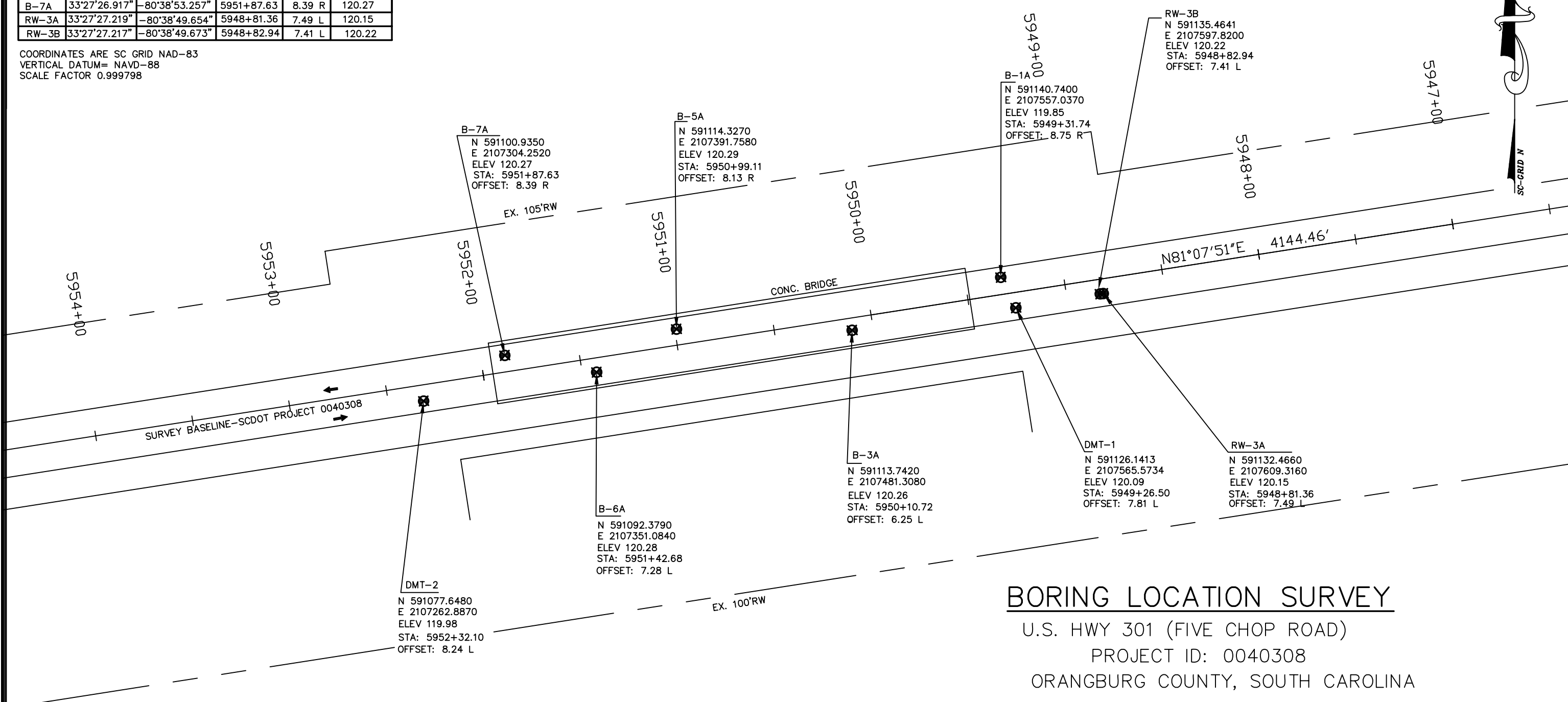
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC.DOT BRIDGE OVER FOUR HOLE SWAMP.GPJ SC.DOT.GDT 9/19/14

BORING	LAT	LONG	STATION	OFFSET	ELEVATION
DMT-1	33°27'27.148"	-80°38'50.180"	5949+26.50	7.81 L	120.09
DMT-2	33°27'26.688"	-80°38'53.746"	5952+32.10	8.24 L	119.98
B-1A	33°27'27.303"	-80°38'50.271"	5949+31.74	8.75 R	119.85
B-3A	33°27'27.038"	-80°38'51.166"	5950+10.72	6.25 L	120.26
B-5A	33°27'27.047"	-80°38'52.223"	5950+99.11	8.13 R	120.29
B-6A	33°27'26.831"	-80°38'52.704"	5951+42.68	7.28 L	120.28
B-7A	33°27'26.917"	-80°38'53.257"	5951+87.63	8.39 R	120.27
RW-3A	33°27'27.219"	-80°38'49.654"	5948+81.36	7.49 L	120.15
RW-3B	33°27'27.217"	-80°38'49.673"	5948+82.94	7.41 L	120.22

COORDINATES ARE SC GRID NAD-83
 VERTICAL DATUM= NAVD-88
 SCALE FACTOR 0.999798

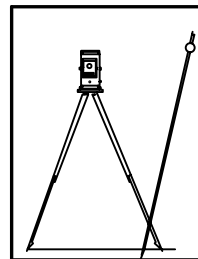


BORING LOCATION SURVEY

U.S. HWY 301 (FIVE CHOP ROAD)
 PROJECT ID: 0040308
 ORANGBURG COUNTY, SOUTH CAROLINA



I HEREBY STATE THAT TO THE BEST OF MY PROFESSIONAL KNOWLEDGE, INFORMATION AND BELIEF, THE SURVEY SHOWN HEREON WAS MADE IN ACCORDANCE WITH THE REQUIREMENTS OF THE STANDARD OF PRACTICE MANUAL FOR SURVEYING IN SOUTH CAROLINA, AND MEETS OR EXCEEDS THE REQUIREMENTS FOR A CLASS " " SURVEY AS SPECIFIED THEREIN, ALSO THERE ARE NO ENCROACHMENTS, PROJECTIONS, OR SETBACKS AFFECTING THE PROPERTY OTHER THAN THOSE SHOWN.
 PROPERTY NOT TO BE IN A FLOOD ZONE. UNLESS NOTED HEREON THIS MAP DOES NOT ADDRESS ENVIRONMENTAL CONCERNS OR SUBSURFACE INVESTIGATION.



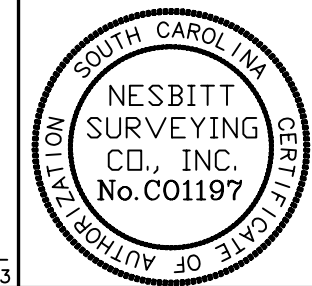
NESBITT SURVEYING CO., INC.

4340 ALLIGATOR ROAD
 U.S. HIGHWAY 76 & ALLIGATOR ROAD
 TIMMONSVILLE, S.C. 29161
 PHONE (843) 346-3302
 FAX (843)-346-5802

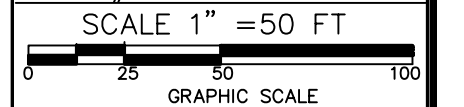
FILE#

email davidn@nesbittsurveying.com

DAVID A. NESBITT RLS NO 7623

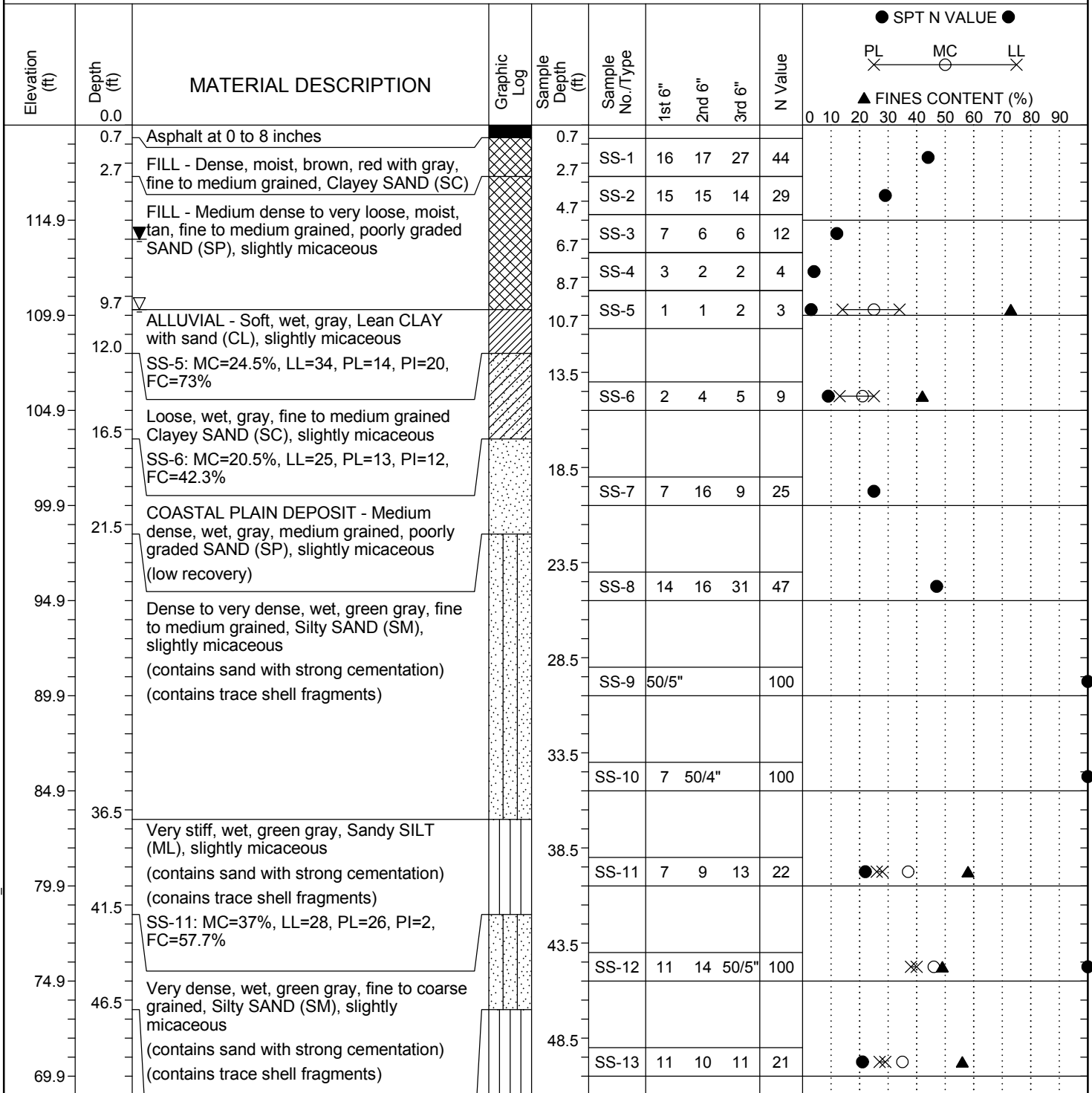


DATE: DECEMBER 18, 2014
 JOB NO: 14670
 REVISED 2-5-15 TO SHOW
 BORING RW3A & RW3B
 ROUTE NO.. US 301
 SCDOT #: 0040308



SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description:	Bridge Replacement Over Four Hole Swamp					Route:	US301
Boring No.:	B-1A	Boring Location:	5949+31.74	Offset:	8.75 R	Alignment:	Proposed
Elev.:	119.9 ft	Latitude:	33.4575	Longitude:	-80.6472	Date Started:	12/4/2014
Total Depth:	120 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.7 ft	24HR	6 ft



LEGEND

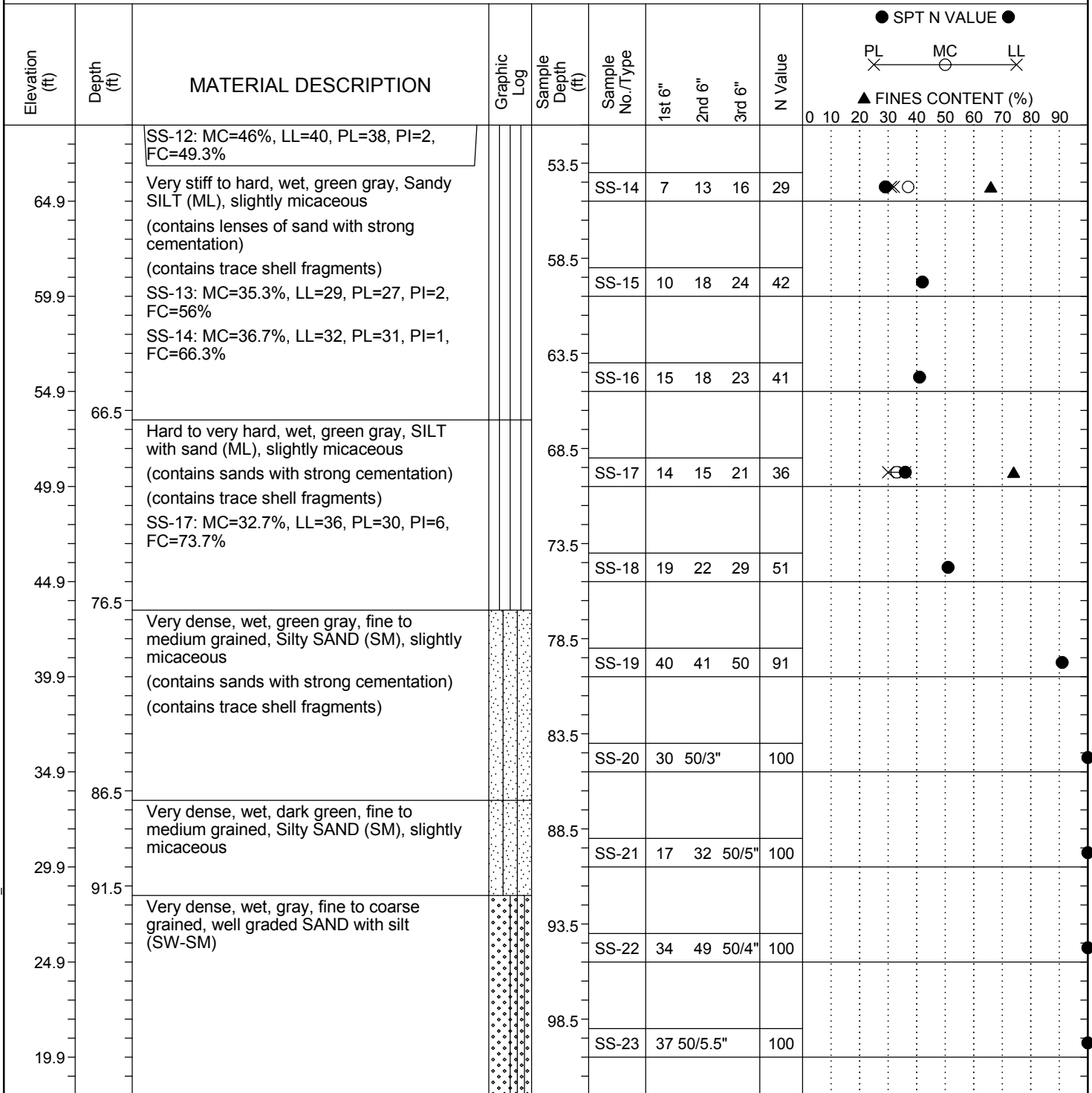
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Route:	US301	
Boring No.:	B-1A	Boring Location:	5949+31.74	Offset:	8.75 R	Alignment:	Proposed	
Elev.:	119.9 ft	Latitude:	33.4575	Longitude:	-80.6472	Date Started:	12/4/2014	
Total Depth:	120 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014	
Bore Hole Diameter (in):		4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.7 ft	24HR	6 ft



LEGEND

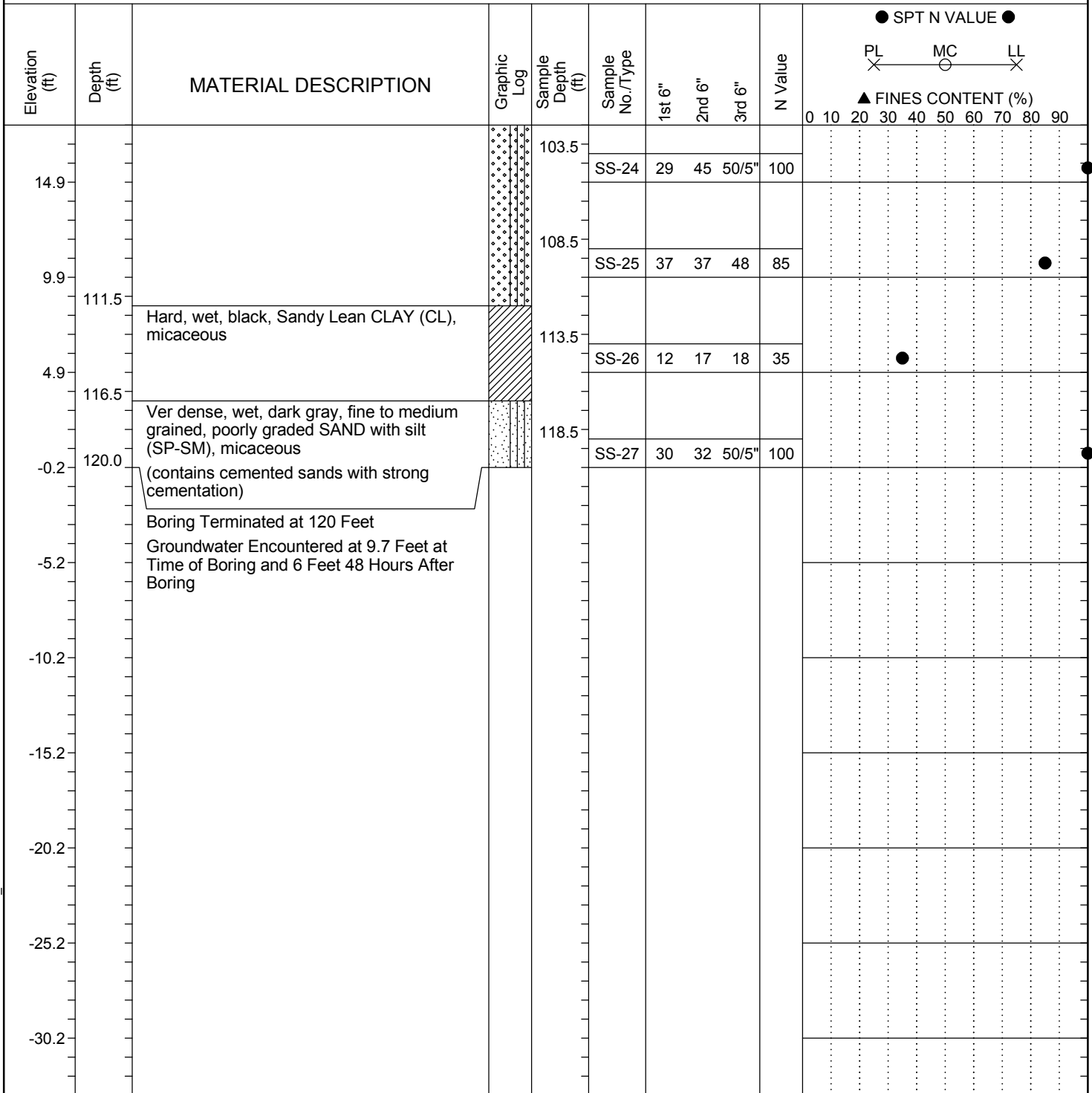
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-1A	Boring Location:	5949+31.74	Offset:	8.75 R	Alignment:	Proposed	
Elev.:	119.9 ft	Latitude:	33.4575	Longitude:	-80.6472	Date Started:	12/4/2014	
Total Depth:	120 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014	
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)	
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.7 ft	24HR 6 ft	



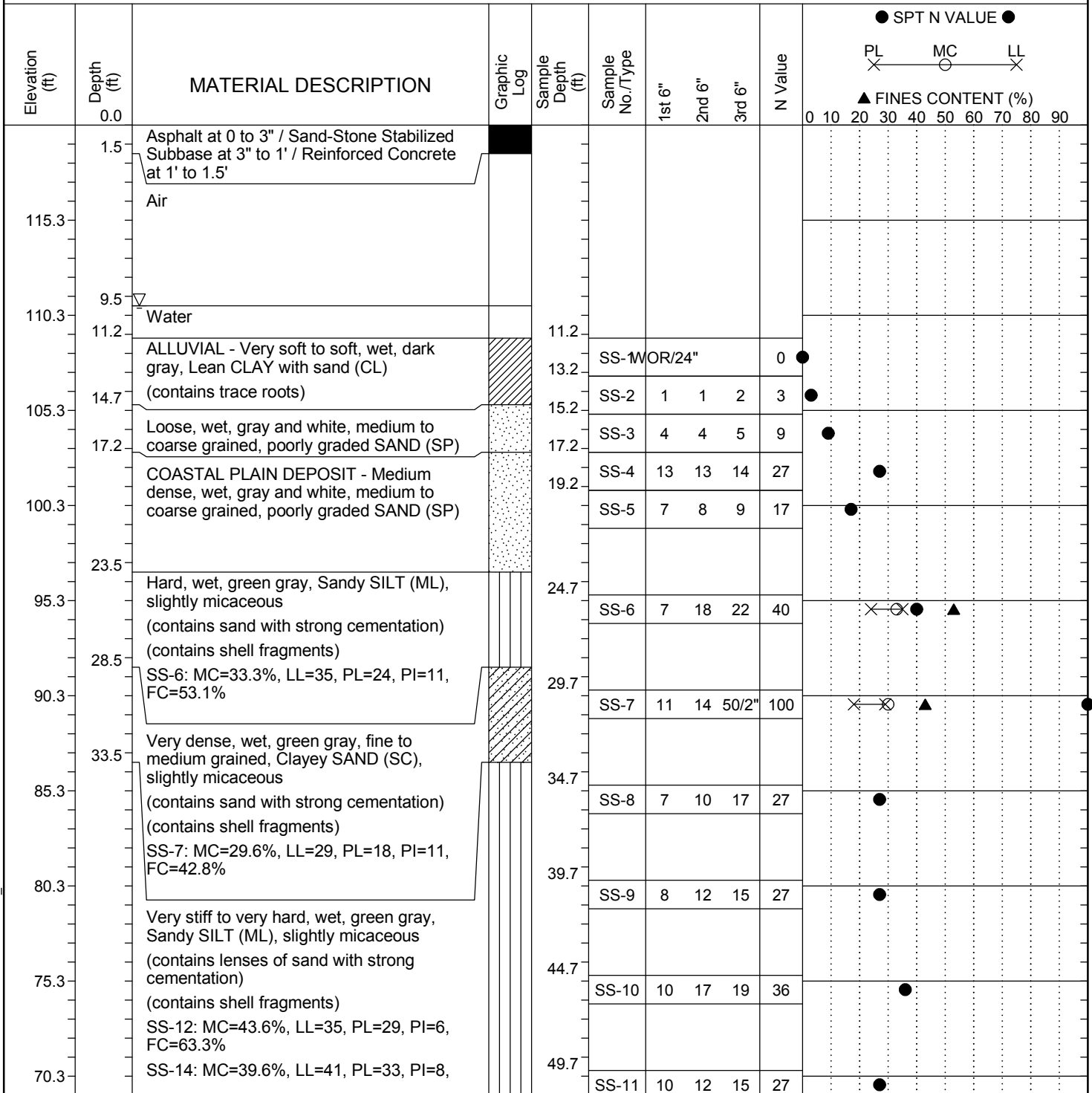
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-3A	Boring Location:	5950+10.72	Offset:	6.25 L	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6475	Date Started:	12/8/2014	
Total Depth:	131.2 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/8/2014	
Bore Hole Diameter (in):		4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.5 ft	24HR	



LEGEND

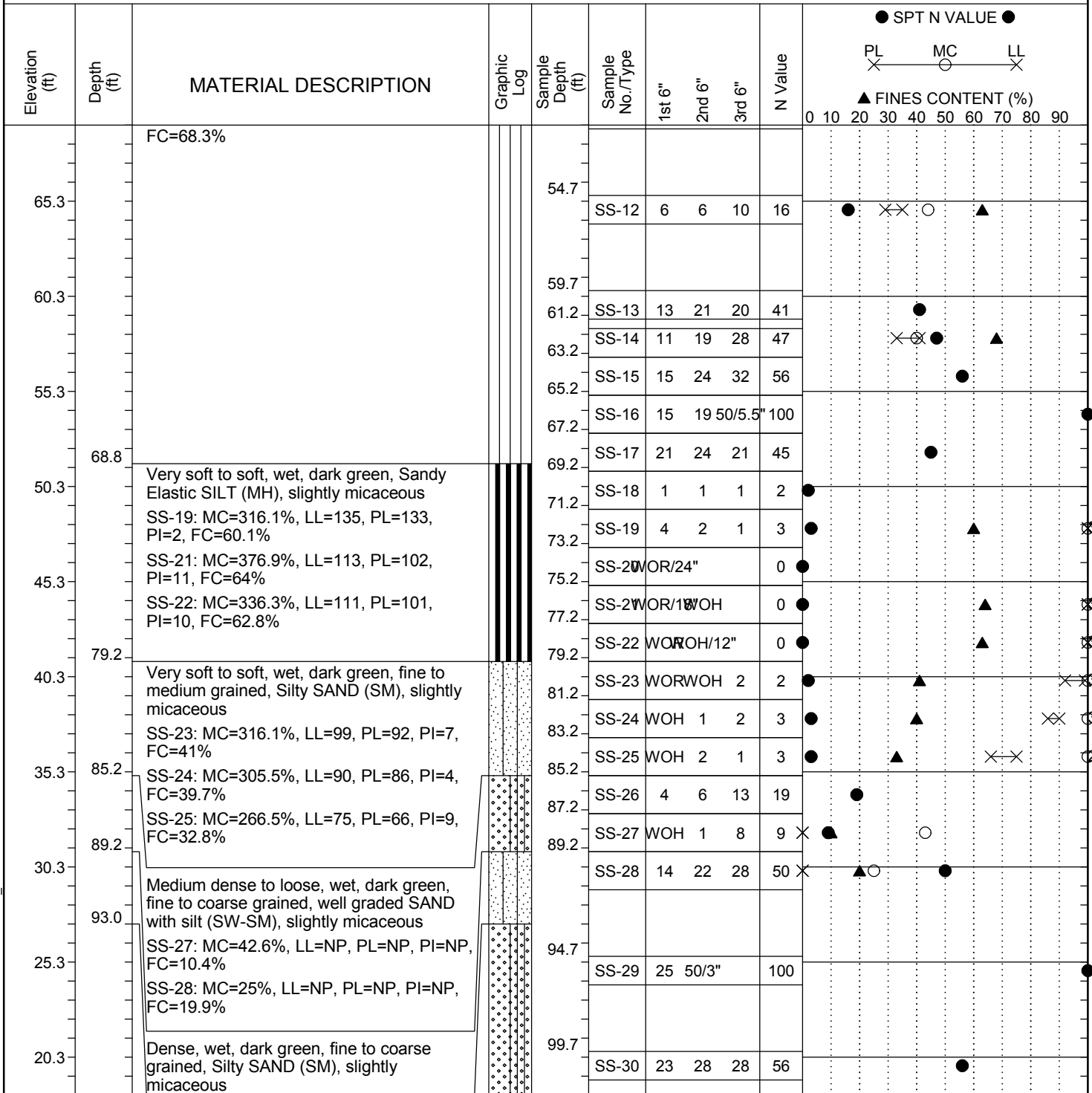
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description:						Route:	US301
Boring No.:	B-3A	Boring Location:	5950+10.72	Offset:	6.25 L	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6475	Date Started:	12/8/2014
Total Depth:	131.2 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/8/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.5 ft	24HR	



LEGEND

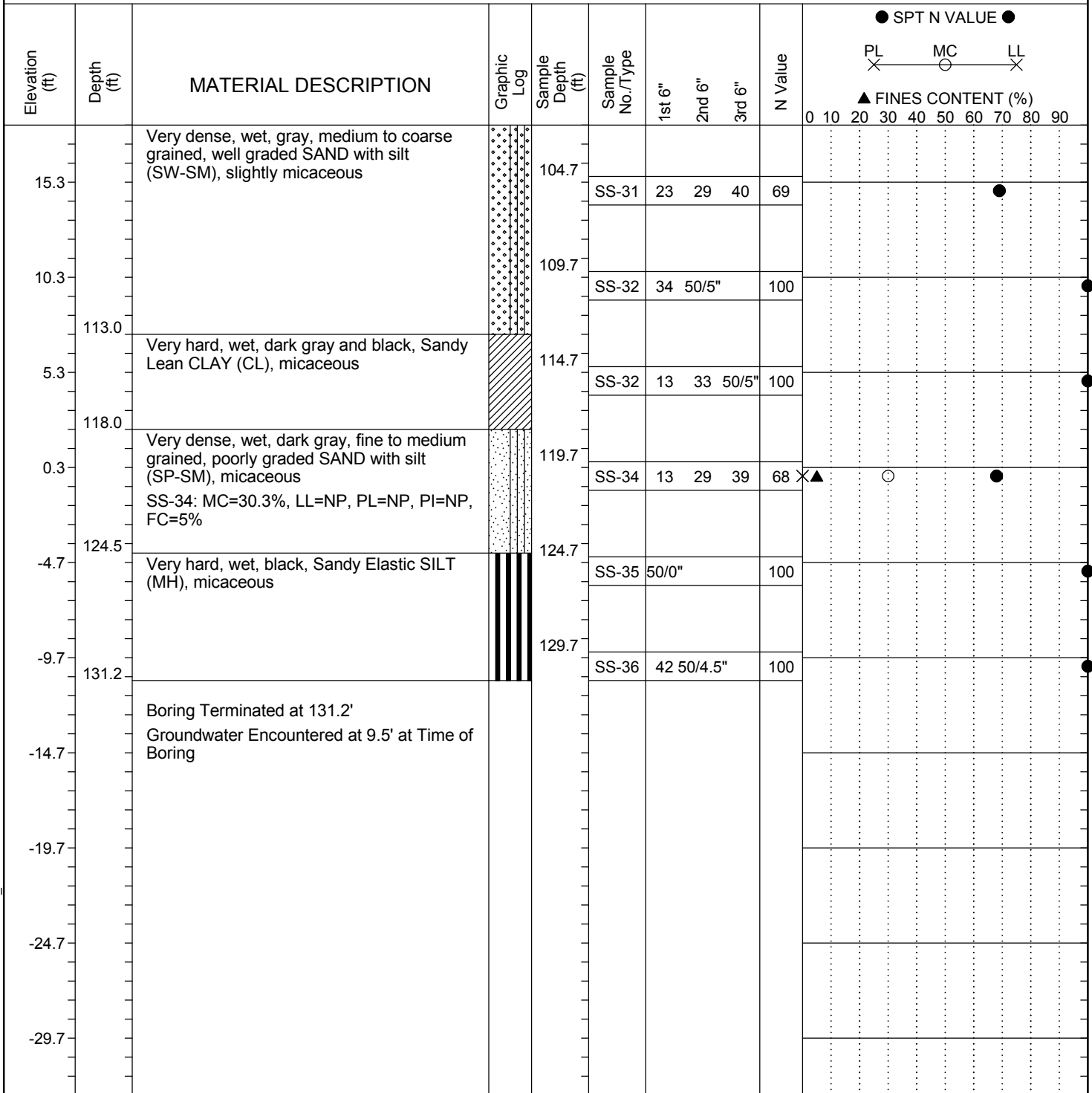
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-3A	Boring Location:	5950+10.72	Offset:	6.25 L	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6475	Date Started:	12/8/2014	
Total Depth:	131.2 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/8/2014	
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)	
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.5 ft	24HR	



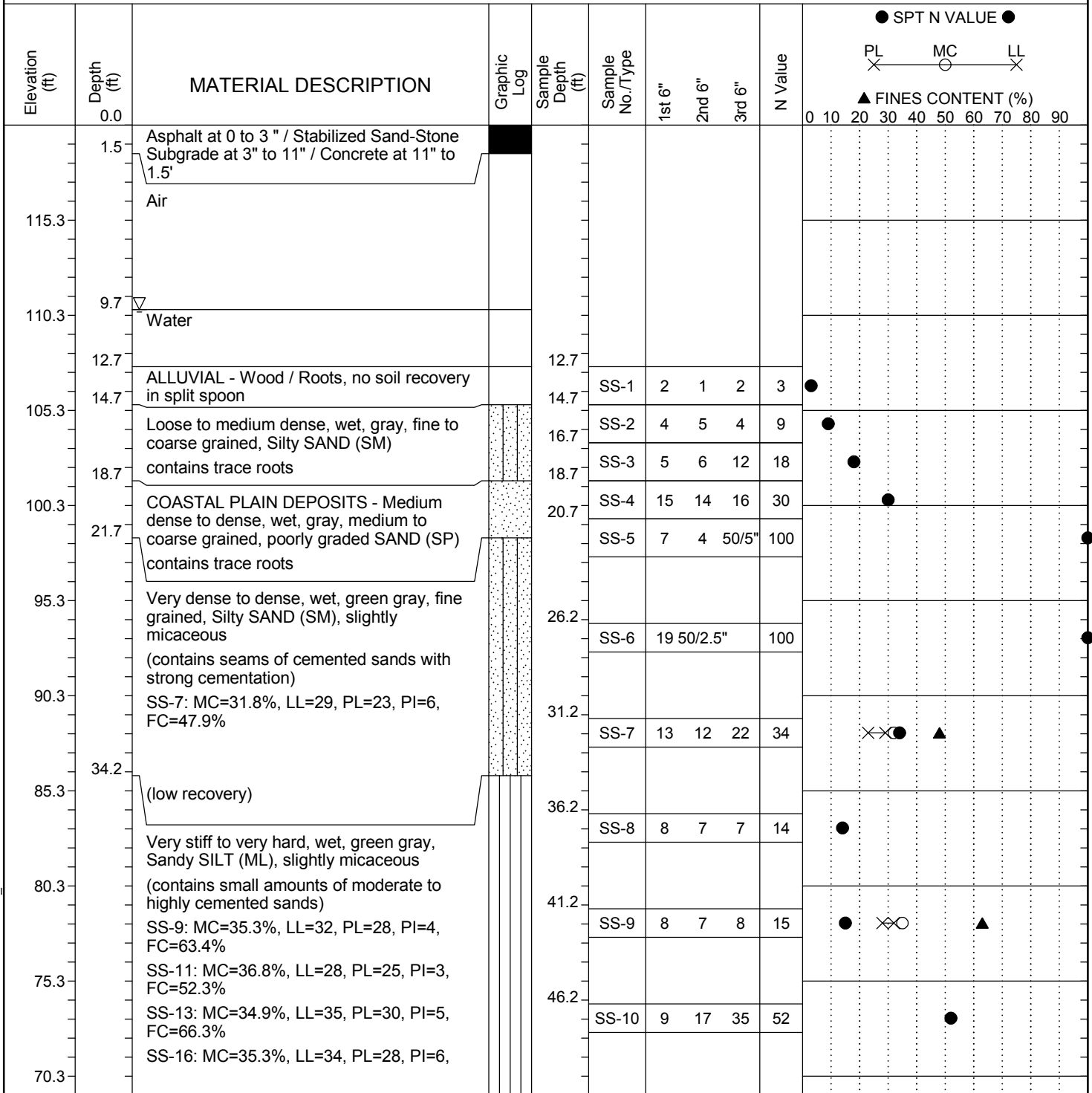
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description:						Route:	US301
Boring No.:	B-5A	Boring Location:	5950+99.11	Offset:	8.13 R	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/5/2014
Total Depth:	132.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.7 ft	24HR



LEGEND

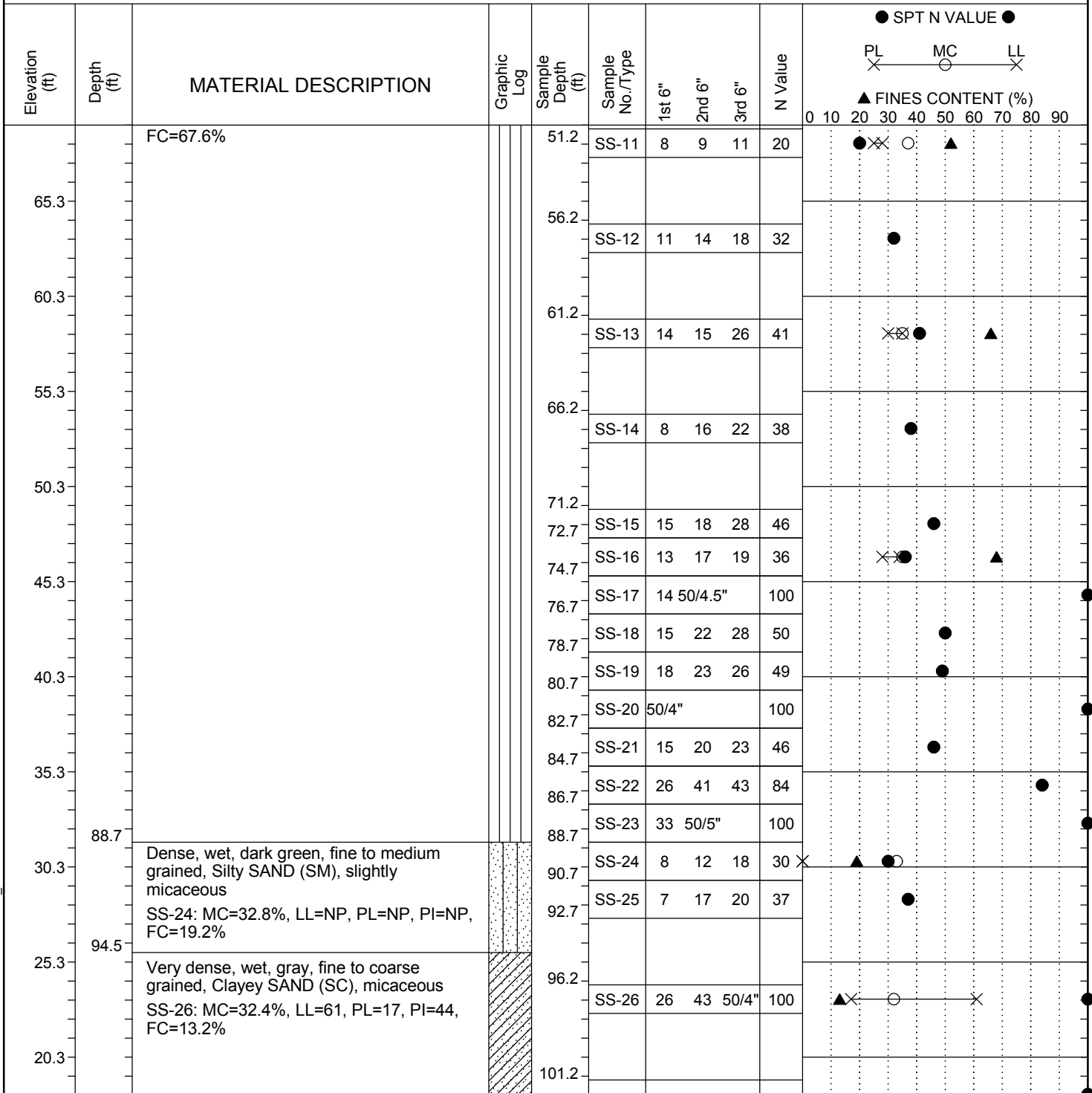
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description:						Route:	US301
Boring No.:	B-5A	Boring Location:	5950+99.11	Offset:	8.13 R	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/5/2014
Total Depth:	132.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.7 ft	24HR	



LEGEND

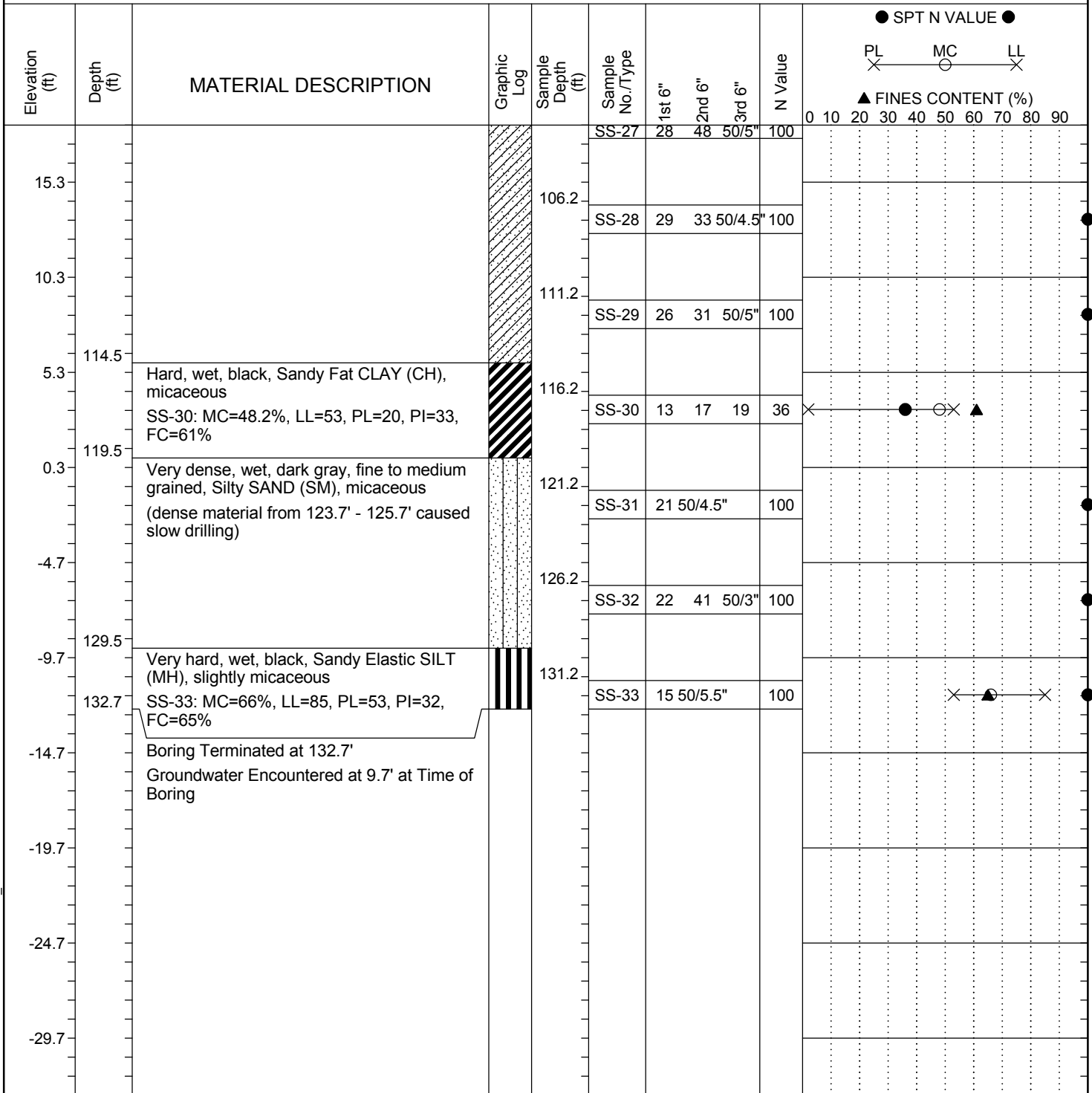
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SC.DOT 0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-5A	Boring Location:	5950+99.11	Offset:	8.13 R	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/5/2014	
Total Depth:	132.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/4/2014	
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)	
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.7 ft	24HR	



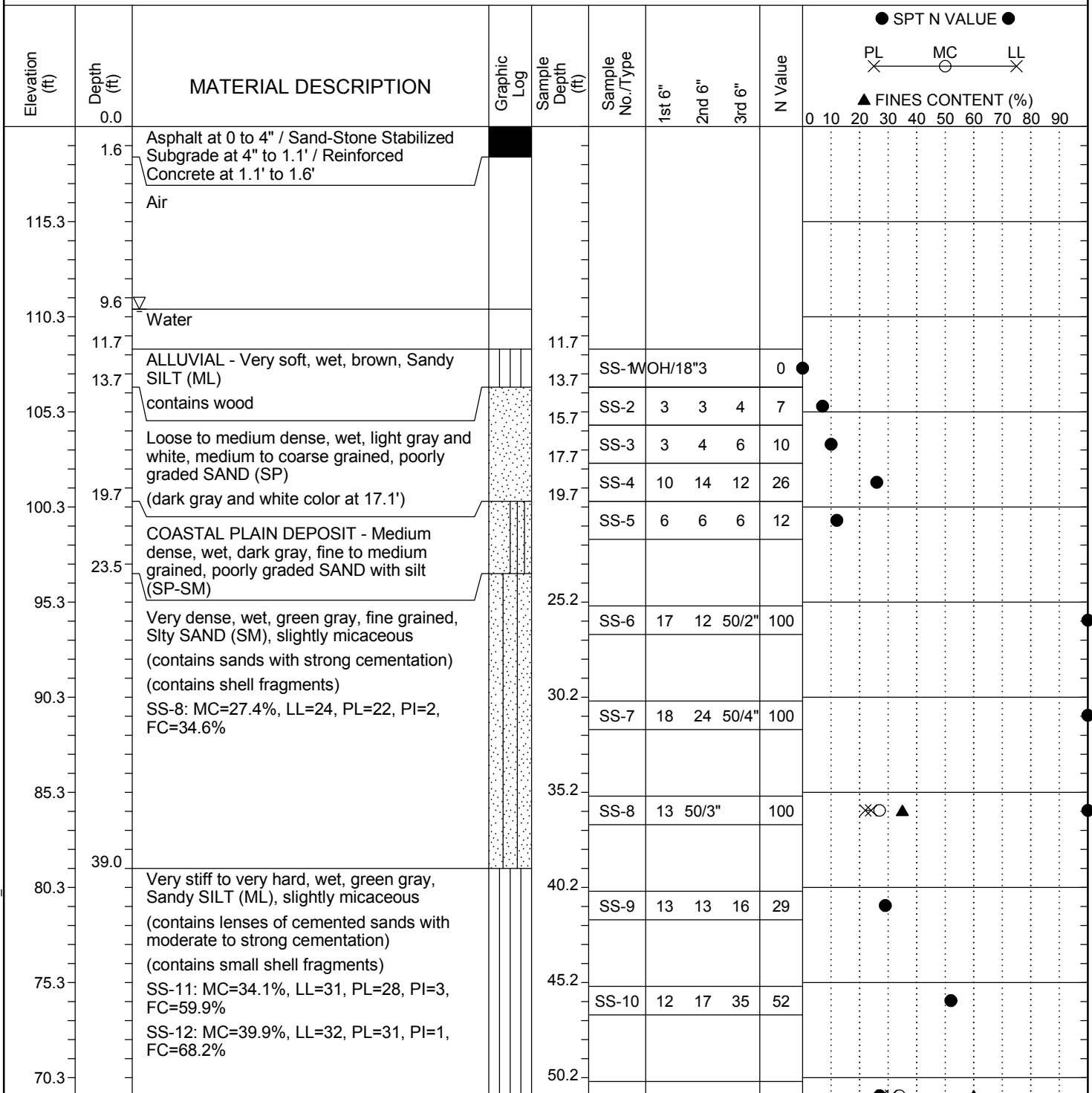
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-6A	Boring Location:	5951+42.68	Offset:	7.28 L	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/7/2014	
Total Depth:	131.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/7/2014	
Bore Hole Diameter (in):		4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.6 ft	24HR	



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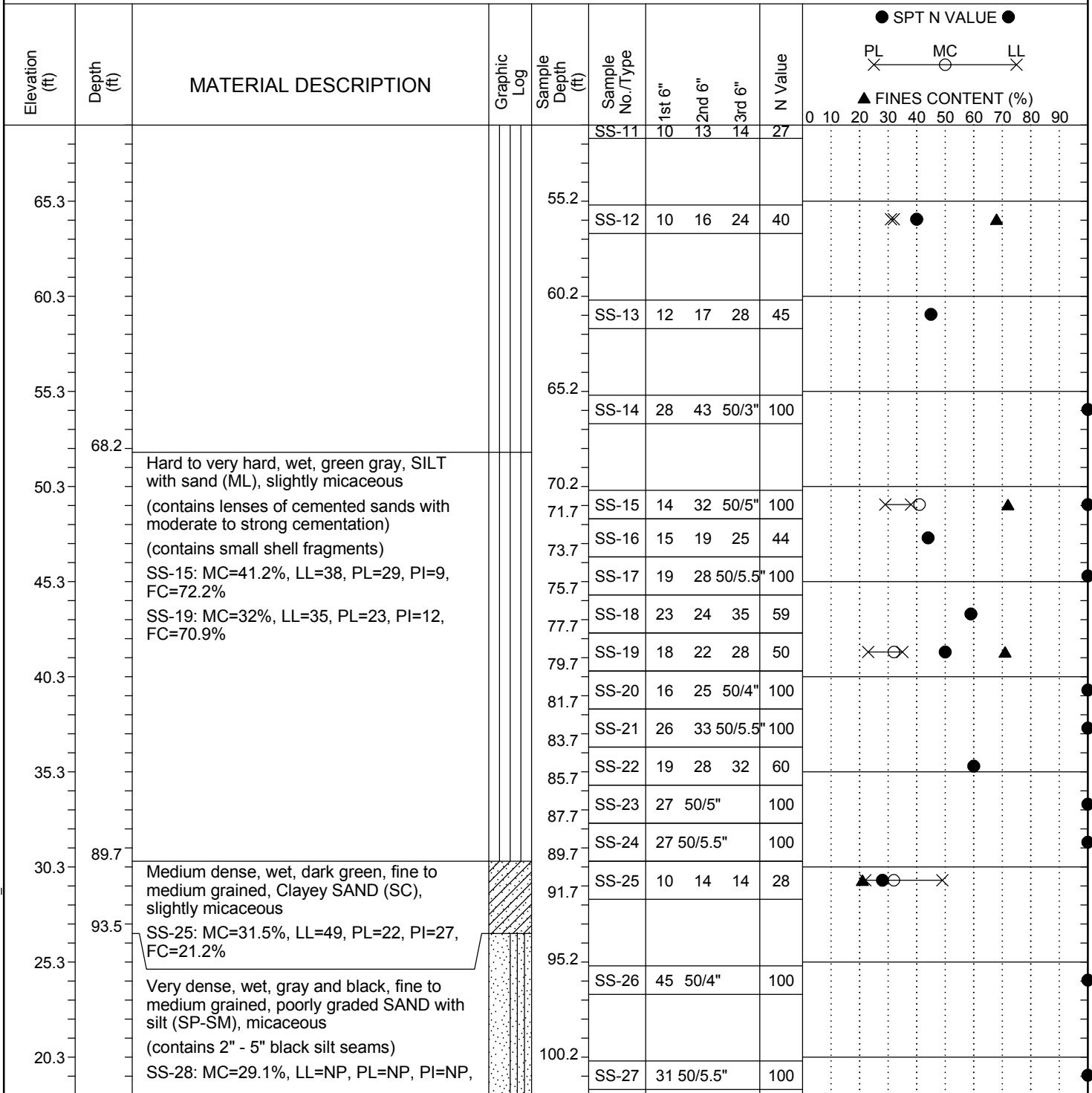
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SC.DOT 0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description: Bridge Replacement Over Four Hole Swamp						Route:	US301
Boring No.:	B-6A	Boring Location:	5951+42.68	Offset:	7.28 L	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/7/2014
Total Depth:	131.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/7/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.6 ft	24HR	



LEGEND

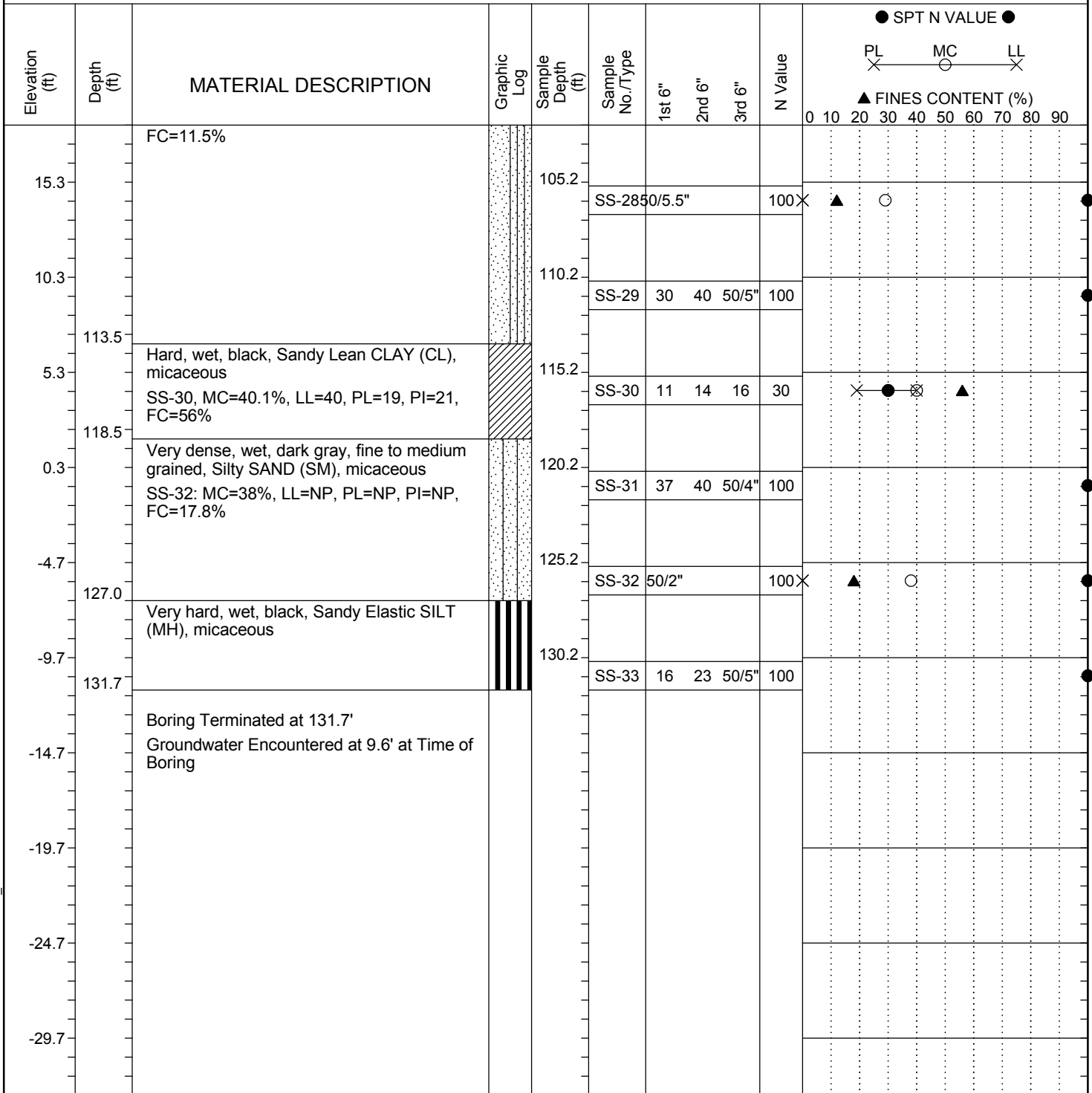
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-6A	Boring Location:	5951+42.68	Offset:	7.28 L	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6478	Date Started:	12/7/2014	
Total Depth:	131.7 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/7/2014	
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)	
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.6 ft	24HR	



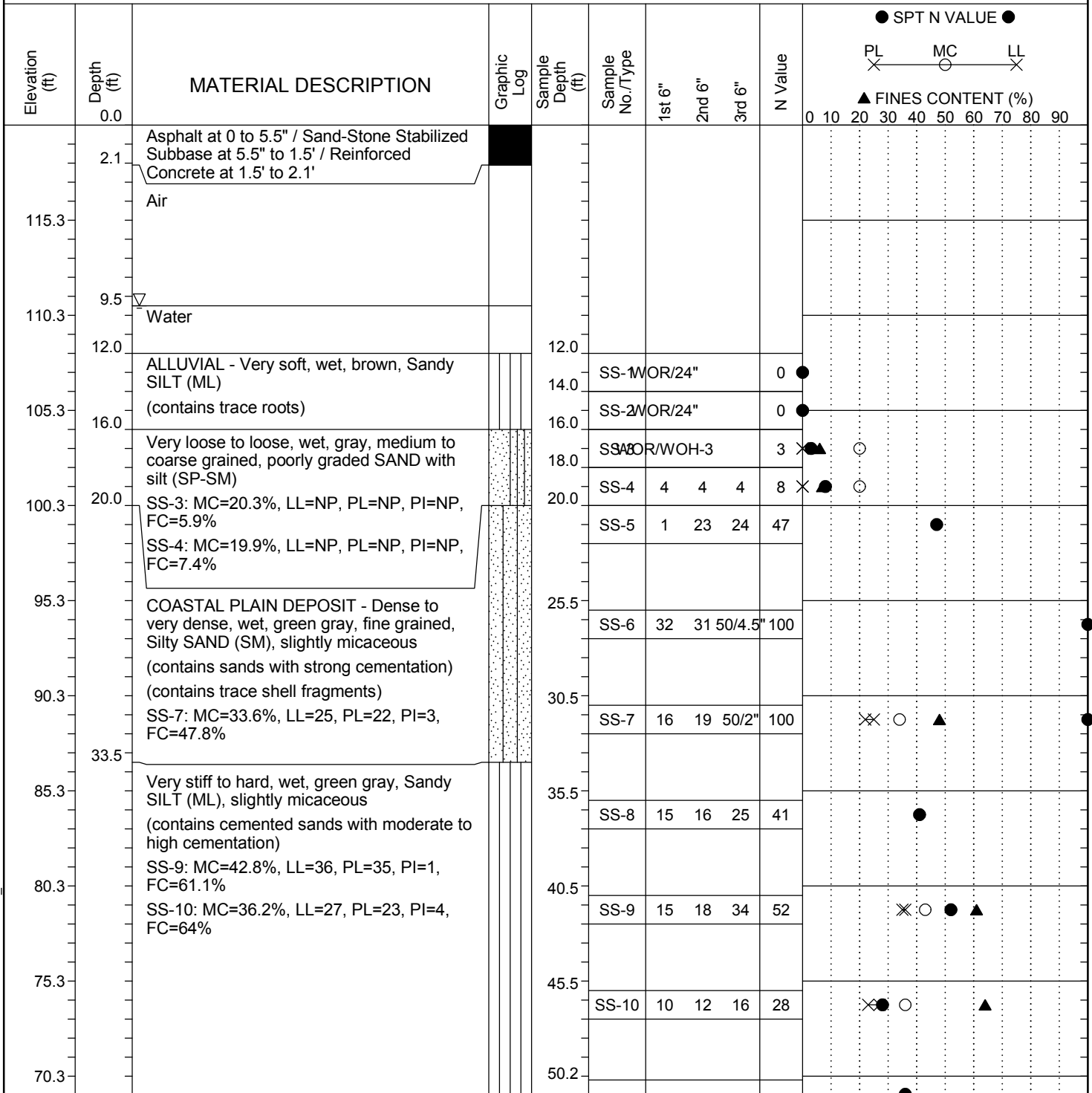
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description: Bridge Replacement Over Four Hole Swamp						Route:	US301
Boring No.:	B-7A	Boring Location:	5951+87.63	Offset:	8.39 R	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6481	Date Started:	12/6/2014
Total Depth:	132 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/6/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.5 ft	24HR	



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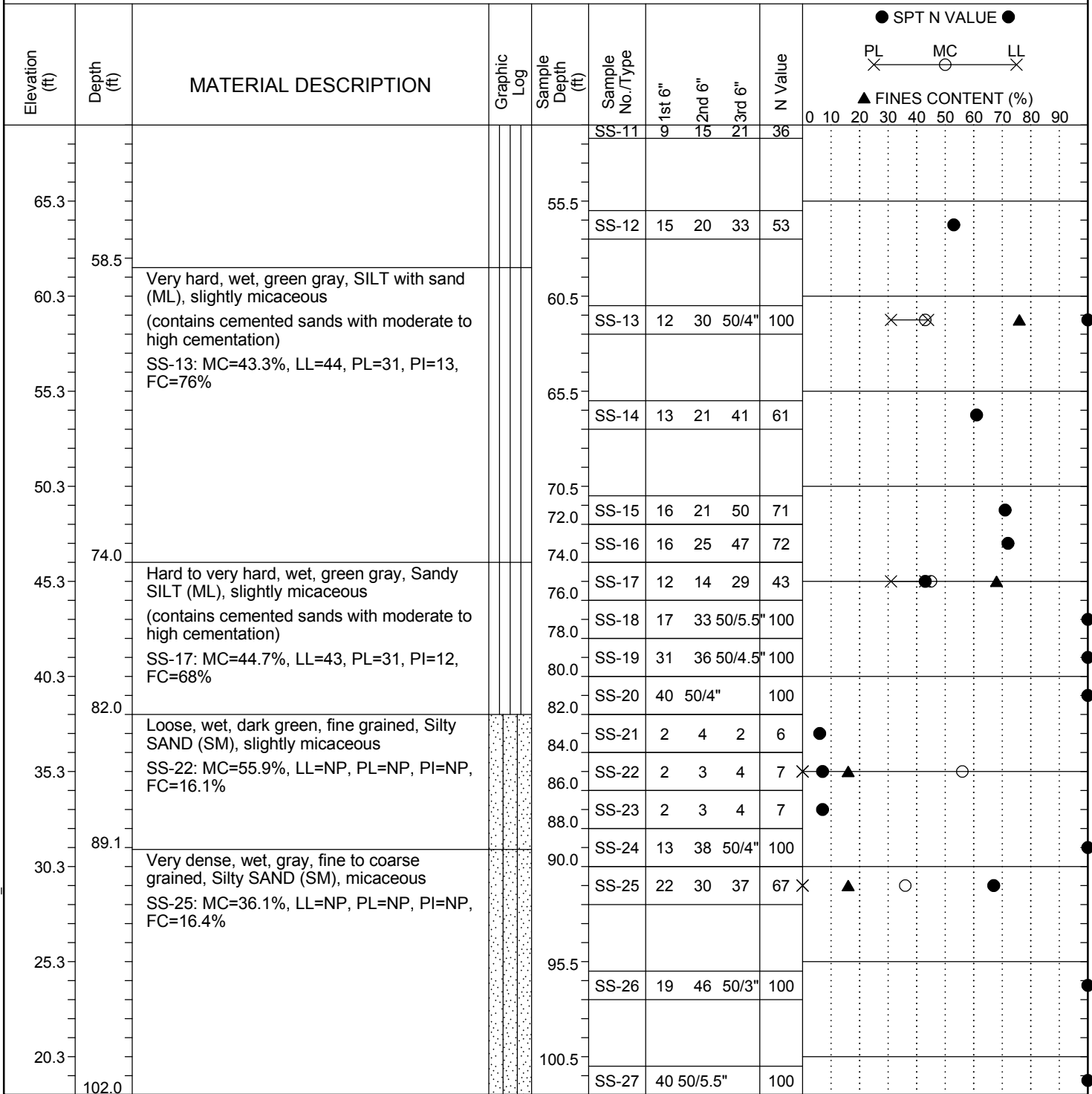
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston
Site Description:						Route:	US301
Boring No.:	B-7A	Boring Location:	5951+87.63	Offset:	8.39 R	Alignment:	Proposed
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6481	Date Started:	12/6/2014
Total Depth:	132 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/6/2014
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 9.5 ft	24HR	



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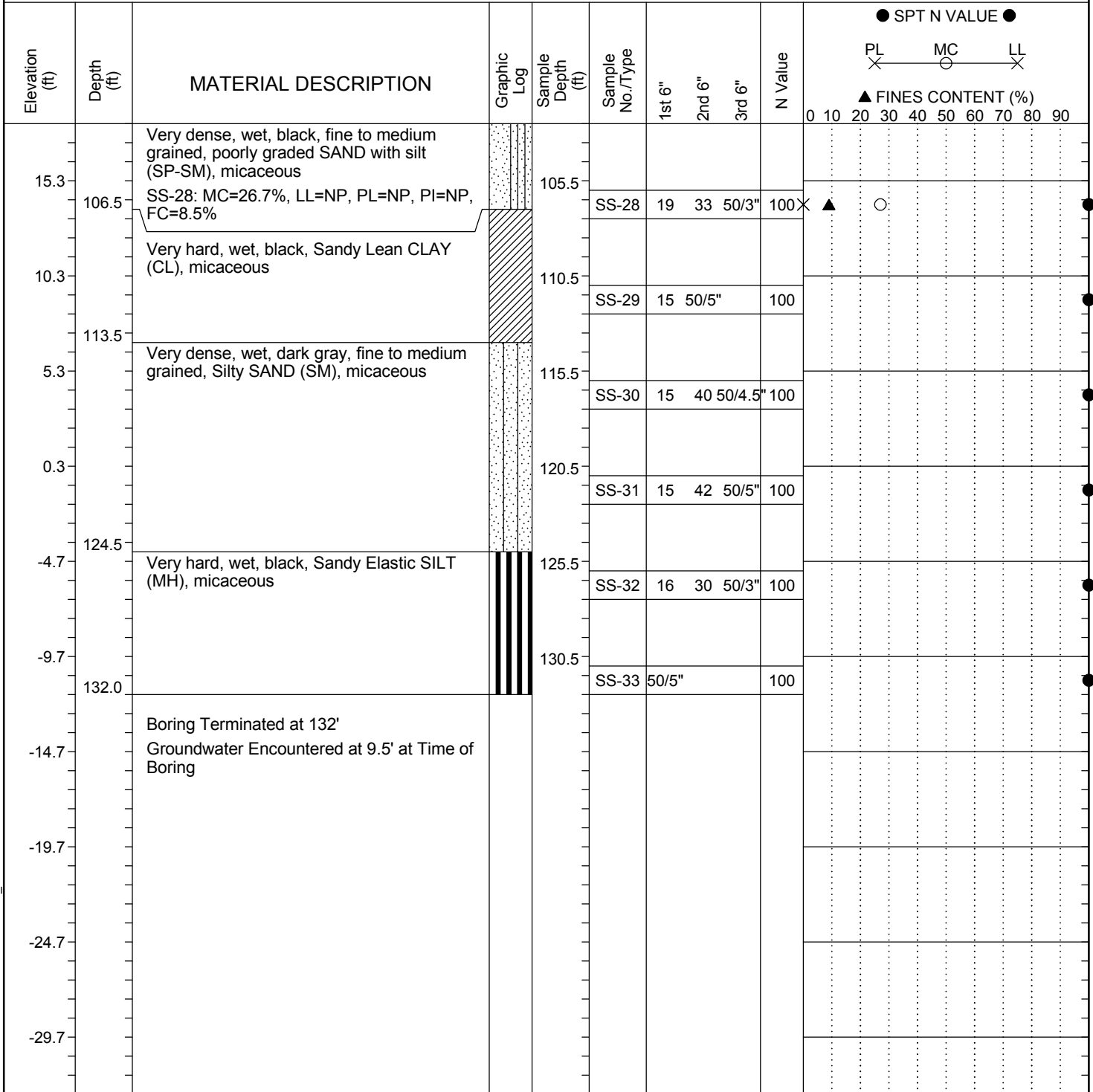
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SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	B. Livingston	
Site Description:						Bridge Replacement Over Four Hole Swamp	Route:	US301
Boring No.:	B-7A	Boring Location:	5951+87.63	Offset:	8.39 R	Alignment:	Proposed	
Elev.:	120.3 ft	Latitude:	33.4575	Longitude:	-80.6481	Date Started:	12/6/2014	
Total Depth:	132 ft	Soil Depth:	120 ft	Core Depth:	ft	Date Completed:	12/6/2014	
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)	
Drill Machine:	CME 55	Drill Method:	Mud Rotary	Hammer Type:	Safety Hammer	Energy Ratio:	76.4%	
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	9.5 ft	24HR	



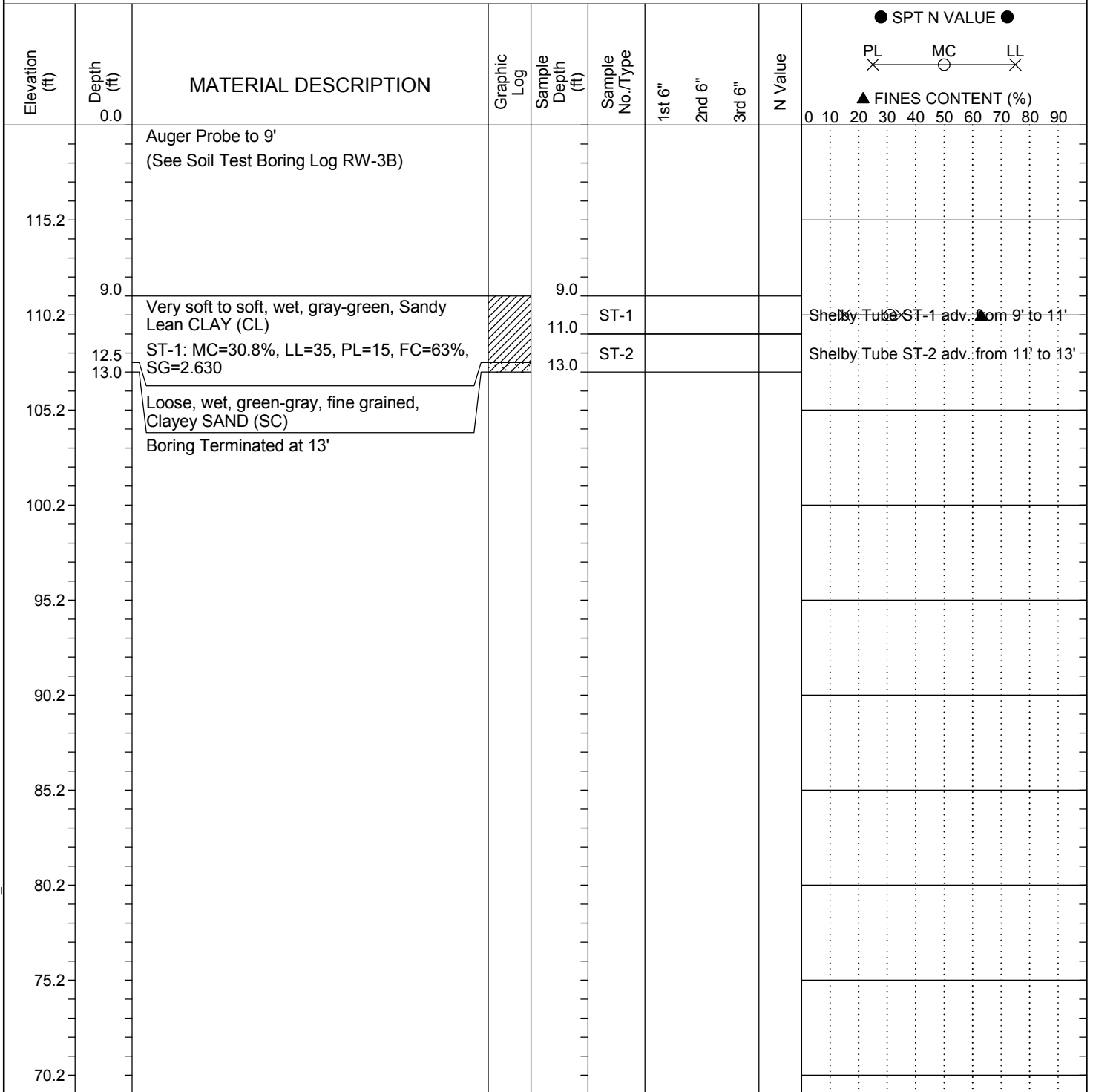
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT_0451644 SCDOT FIVE CHOP ROAD.GPJ SC_DOT.GDT 2/24/15

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	R. Cannarella
Site Description: Bridge Replacement Over Four Hole Swamp						Route:	US301
Boring No.:	RW-3A	Boring Location:	5948+81.36	Offset:	7.49 L	Alignment:	Proposed
Elev.:	120.2 ft	Latitude:		Longitude:		Date Started:	01/29/2015
Total Depth:	13 ft	Soil Depth:	13 ft	Core Depth:	ft	Date Completed:	1/29/2015
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME 45D	Drill Method:	HSA	Hammer Type:	Safety Hammer	Energy Ratio:	91.3%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB	24HR	

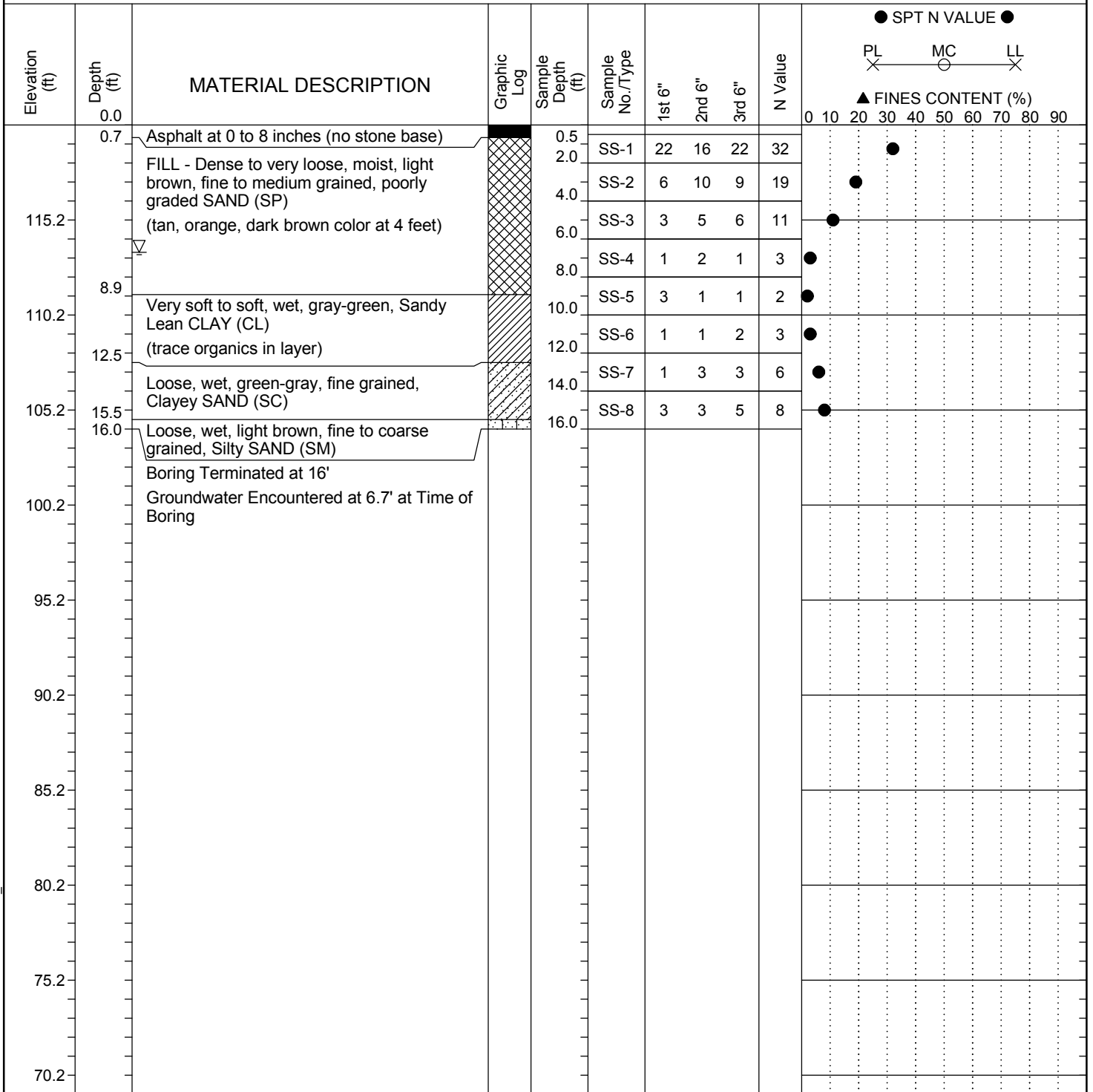


LEGEND

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

SCDOT Soil Test Boring Log

File No.:	38-40308.2	Project No. (PIN):	0040308	County:	Orangeburg	Eng./Geo.:	R. Cannarella
Site Description: Bridge Replacement Over Four Hole Swamp						Route:	US301
Boring No.:	RW-3B	Boring Location:	5948+82.94	Offset:	7.41L	Alignment:	Proposed
Elev.:	120.2 ft	Latitude:		Longitude:		Date Started:	01/29/2015
Total Depth:	16 ft	Soil Depth:	16 ft	Core Depth:	ft	Date Completed:	1/29/2015
Bore Hole Diameter (in):	4	Sampler Configuration		Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine:	CME45D	Drill Method:	HSA	Hammer Type:	Safety Hammer	Energy Ratio:	91.3%
Core Size:		Driller:	Carolina Drilling	Groundwater:	TOB 6.7 ft	24HR	



LEGEND

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

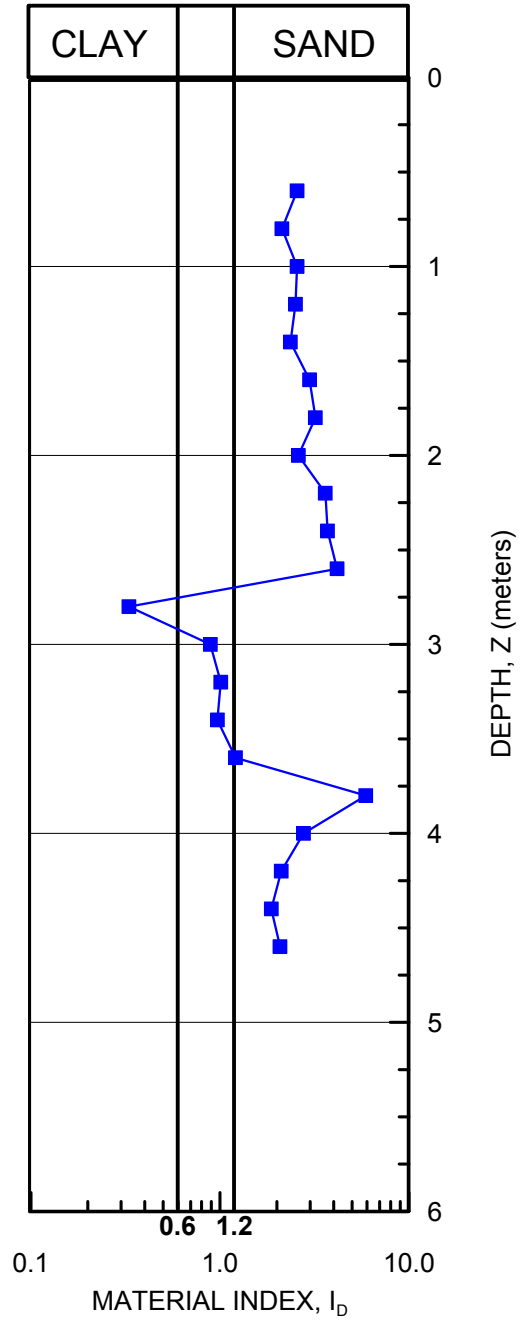
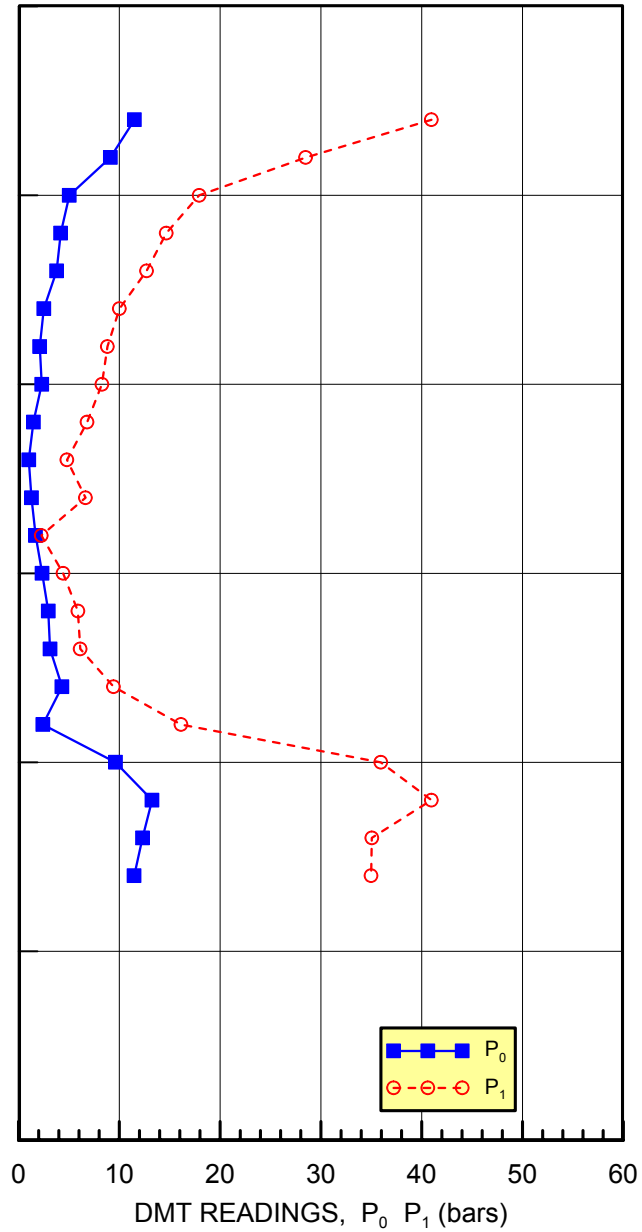
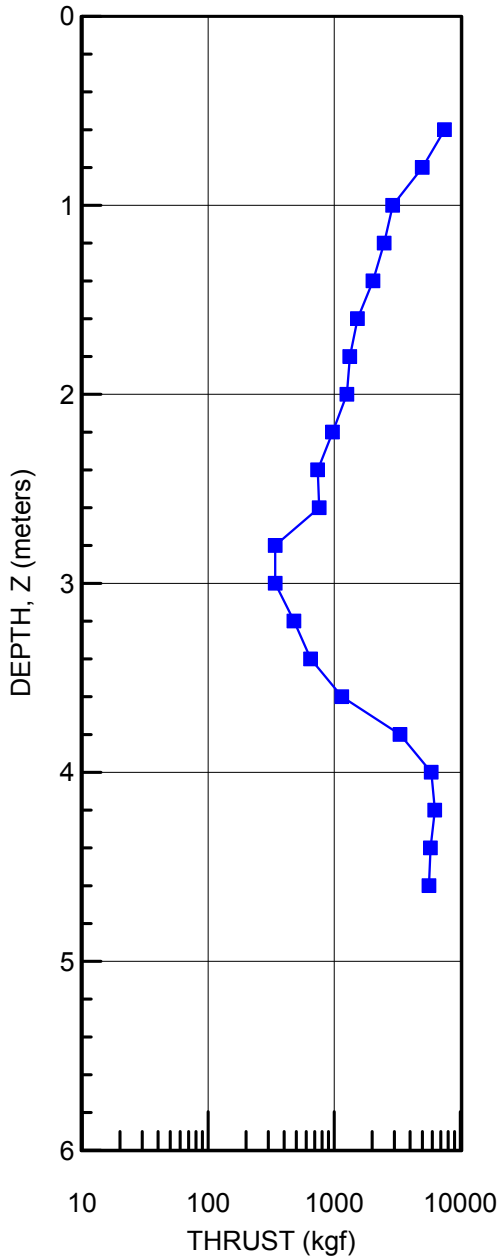
Ground Surface Elev.: ~37.3 m
Water Depth: ~2.9 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmeizer
SOUNDING DATE: 12/9/14

DILATOMETER RESULTS

SOUNDING
DMT-1



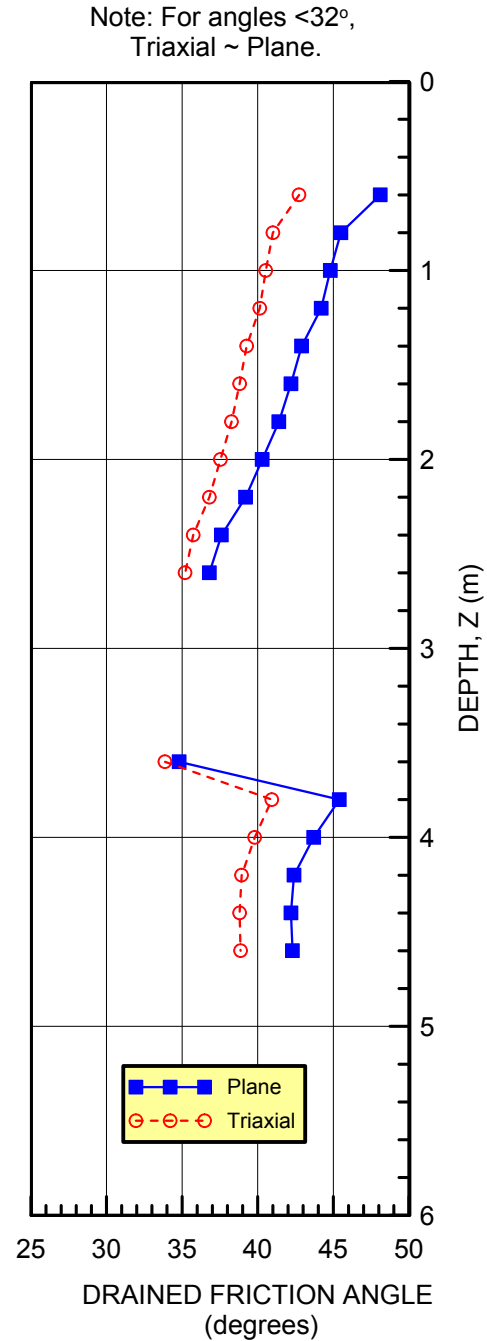
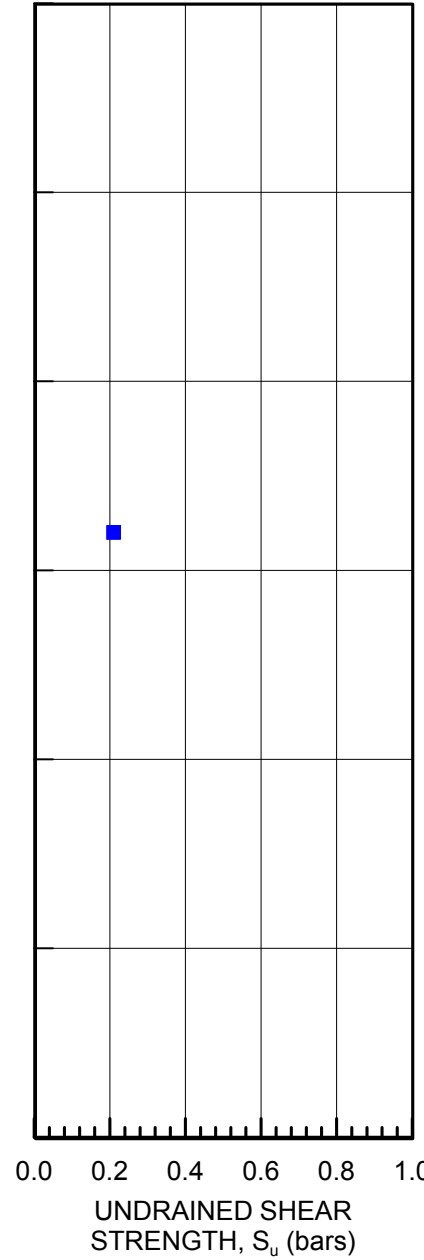
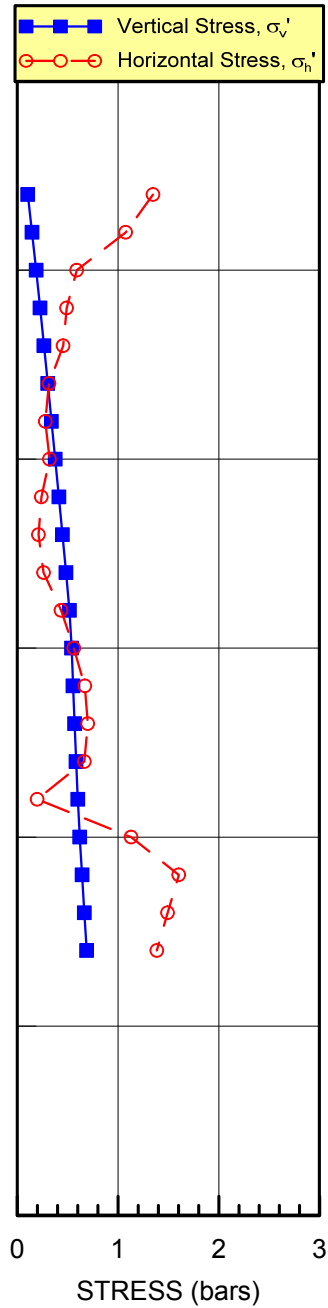
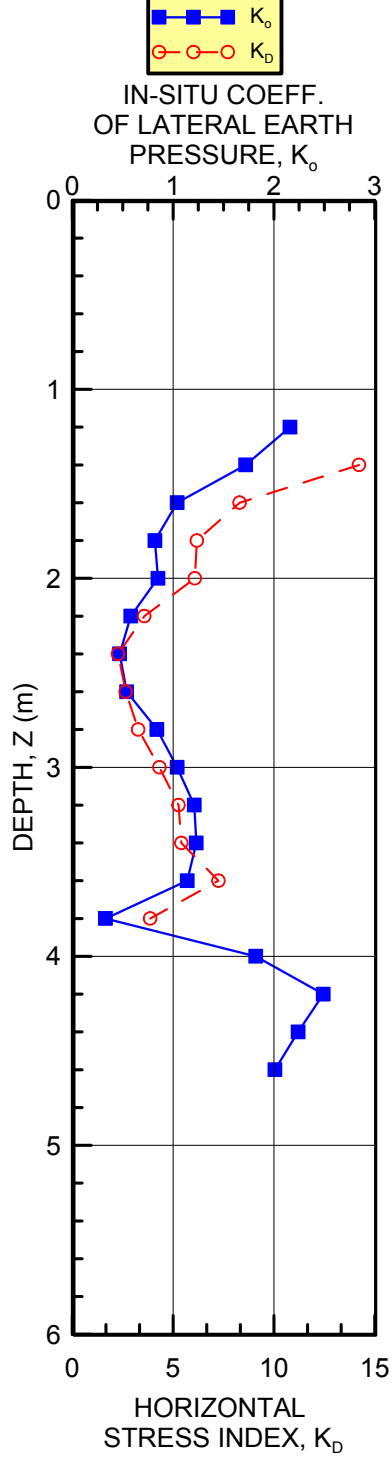
Ground Surface Elev: ~37.3 m
Water Depth: ~2.9 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmeizger
SOUNDING DATE: 12/9/14

INTERPRETED DMT STRENGTH PARAMETERS

SOUNDING
DMT-1



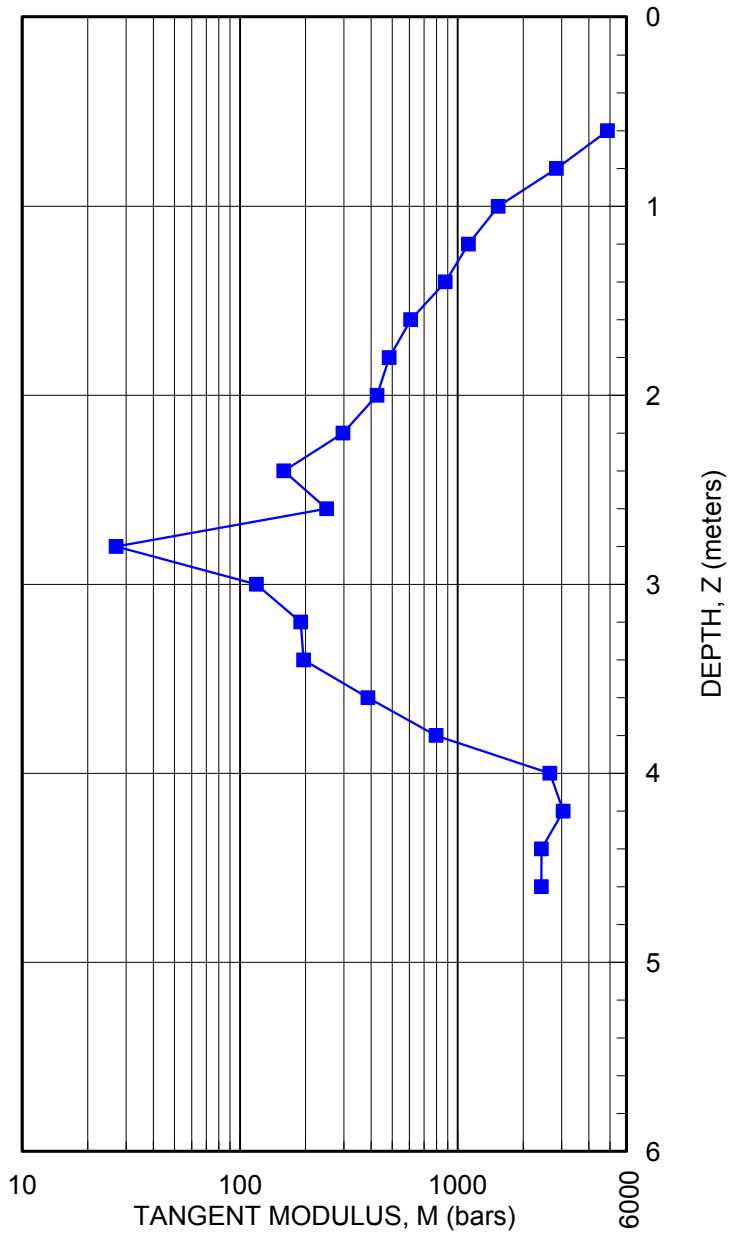
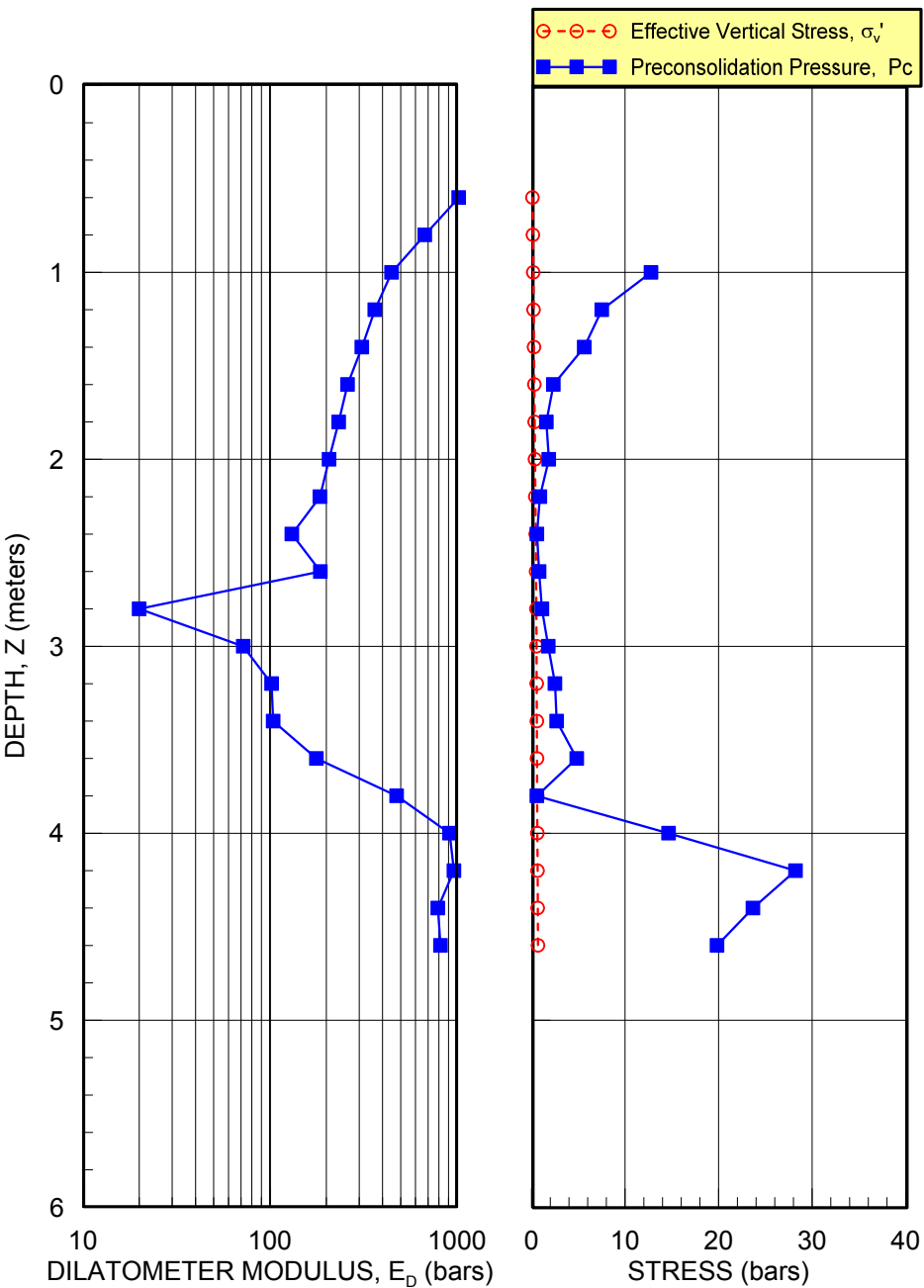
Ground Surface Elev.: ~37.3 m
Water Depth: ~2.9 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmeijer
SOUNDING DATE: 12/9/14

INTERPRETED DMT DEFORMATION PARAMETERS

SOUNDING
DMT-1



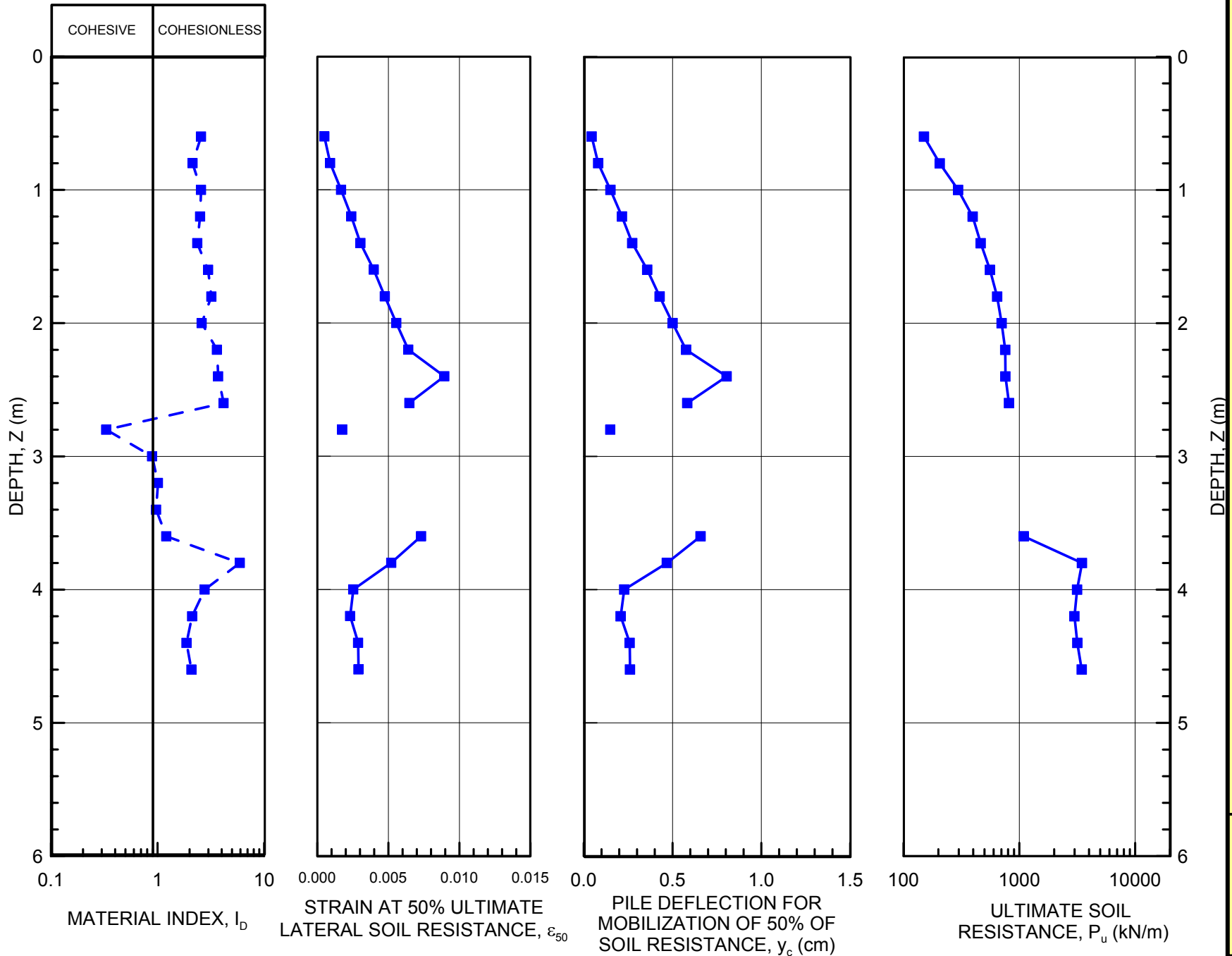
Pile Width/Diameter = 14 inches 36 cm

Ground Surface Elev: ~37.3 m
Water Depth: ~2.9 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmezer
SOUNDING DATE: 12/9/14

SOUNDING
DMT-1



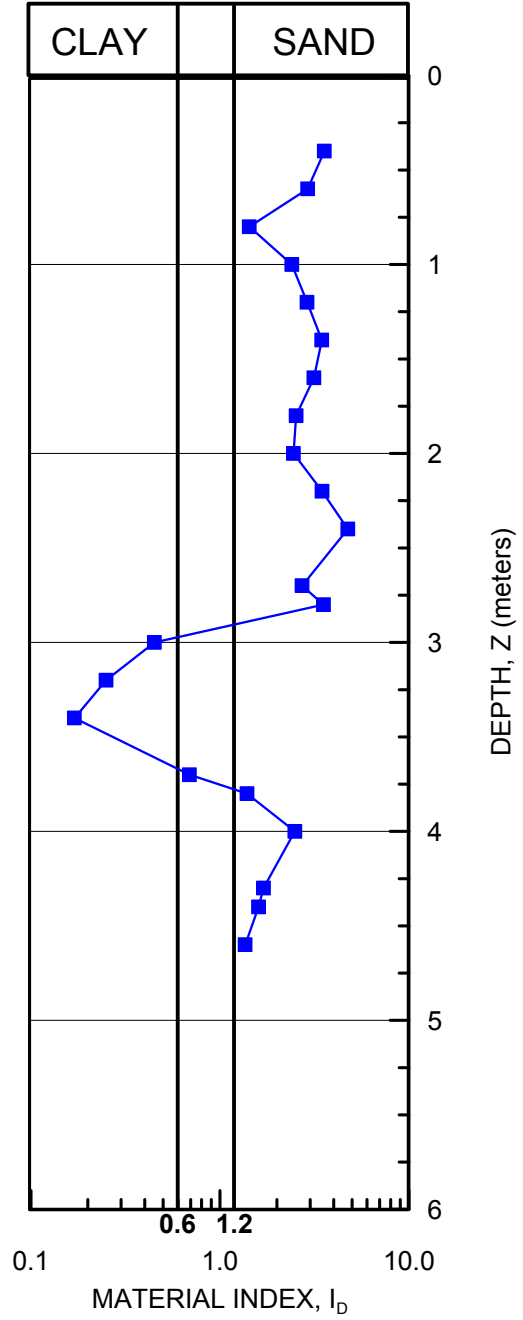
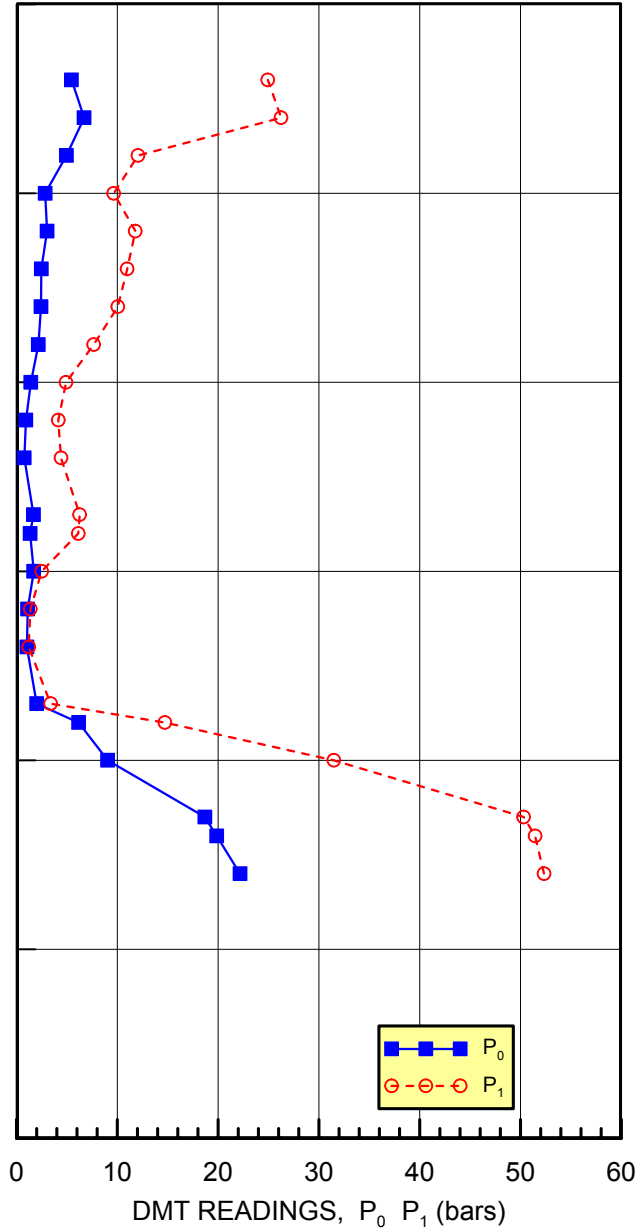
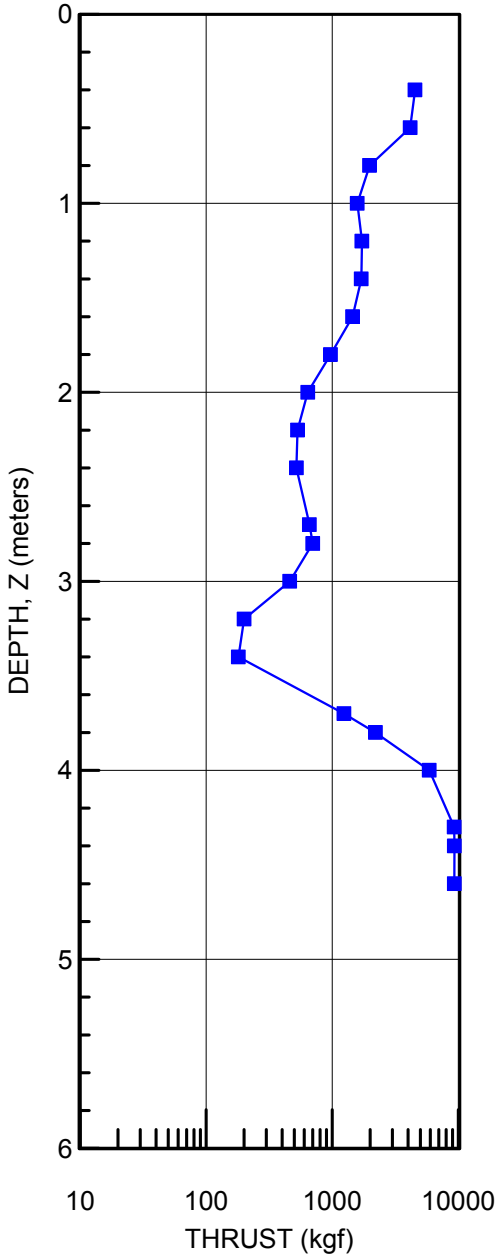
Ground Surface Elev.: ~37.4 m
Water Depth: ~3.7 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmezer
SOUNDING DATE: 12/9/14

DILATOMETER RESULTS

SOUNDING
DMT-2



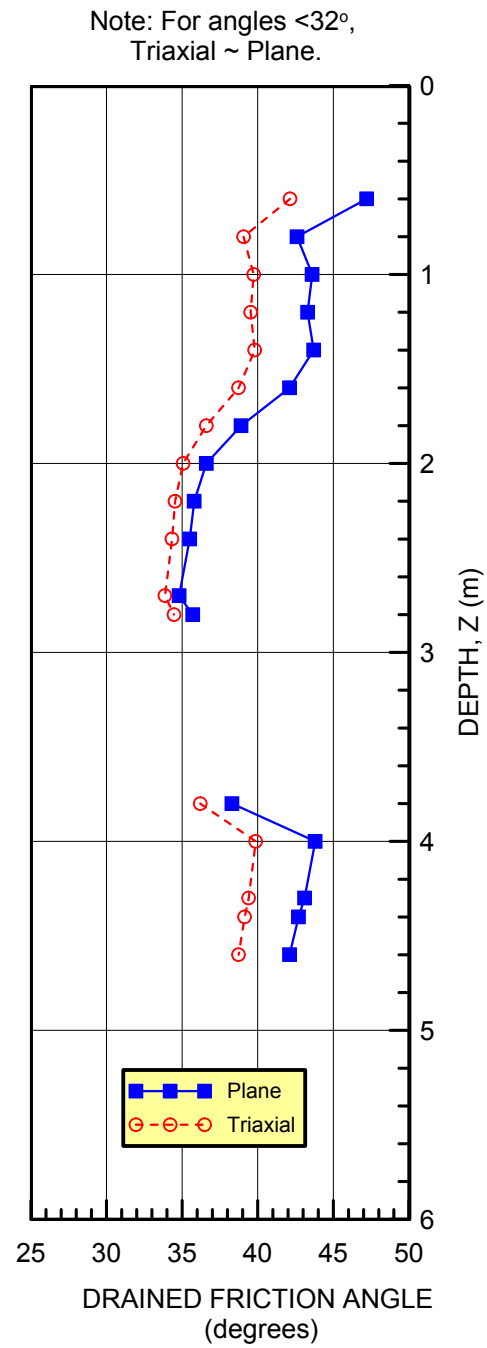
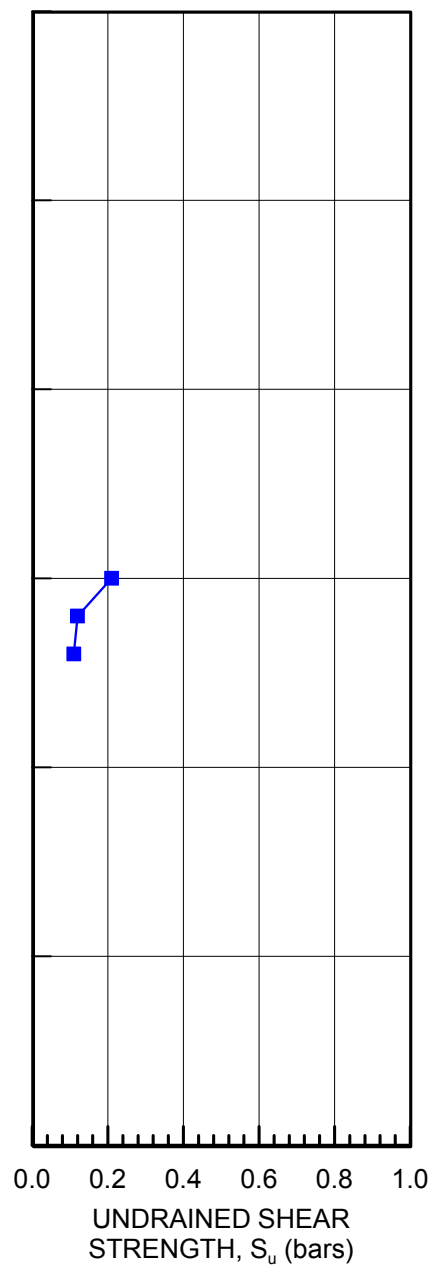
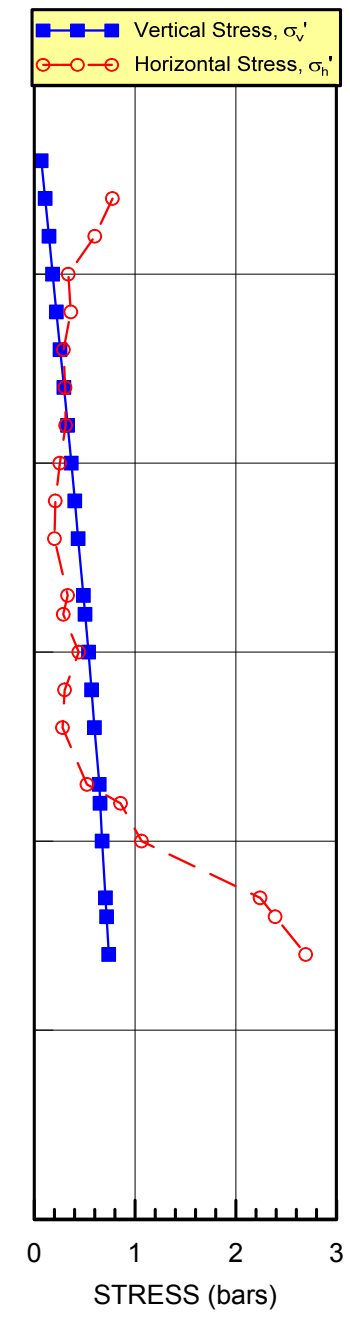
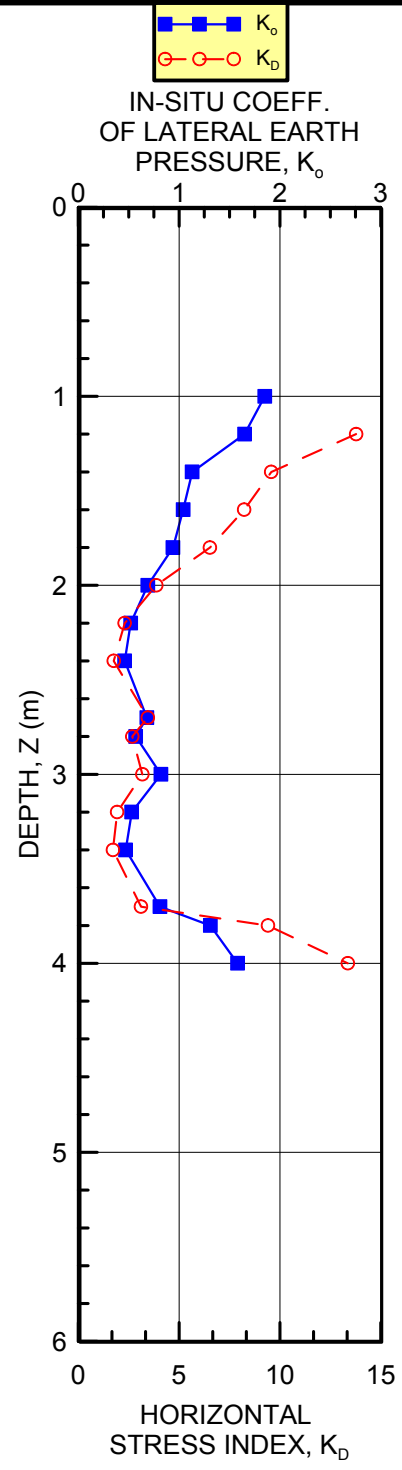
Ground Surface Elev: ~37.4 m
Water Depth: ~3.7 m

INTERPRETED DMT STRENGTH PARAMETERS

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmezzger
SOUNDING DATE: 12/9/14

SOUNDING
DMT-2



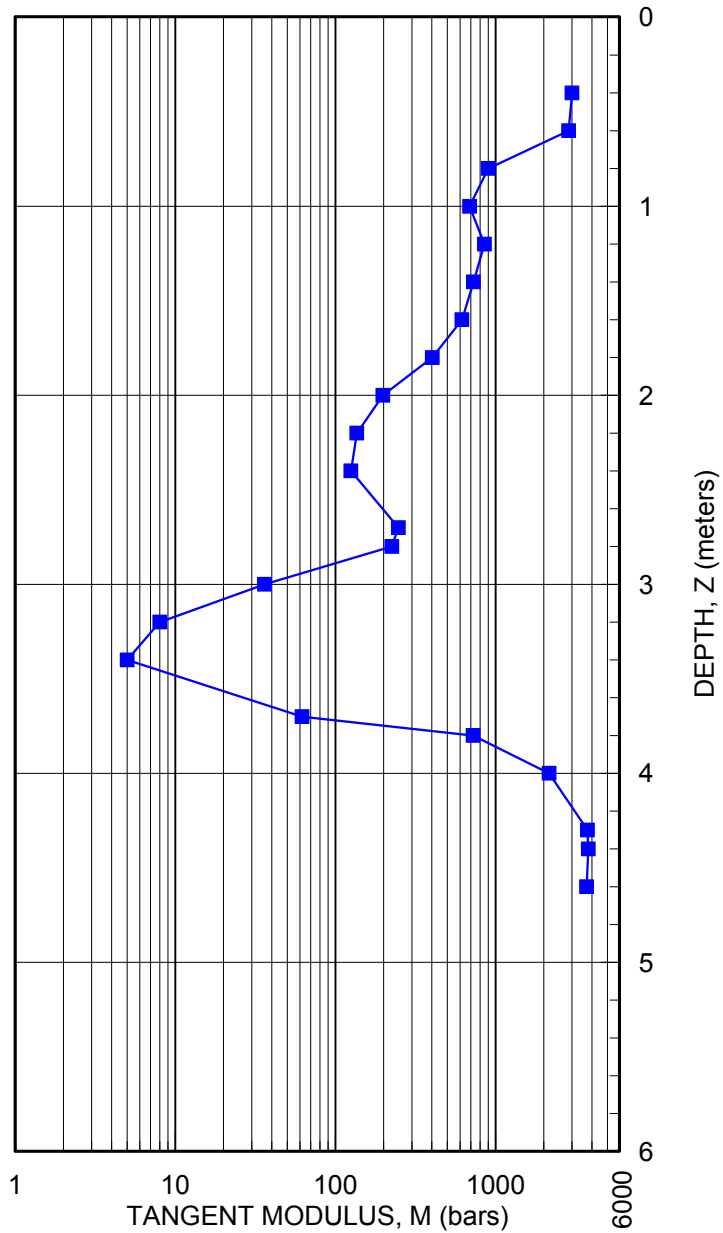
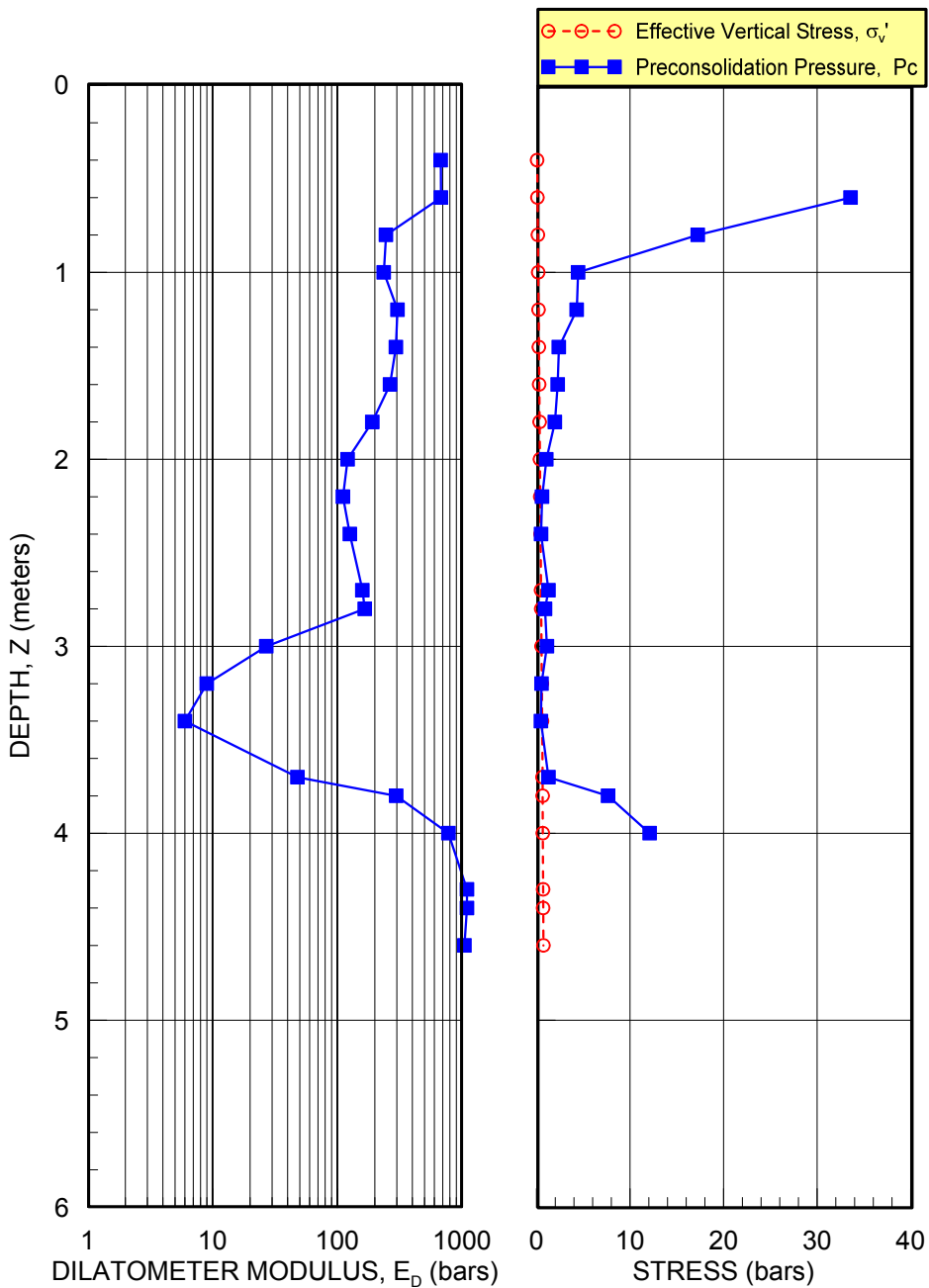
Ground Surface Elev.: ~37.4 m
Water Depth: ~3.7 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmeijer
SOUNDING DATE: 12/9/14

INTERPRETED DMT DEFORMATION PARAMETERS

SOUNDING
DMT-2



Pile Width/Diameter = 14 inches 36 cm

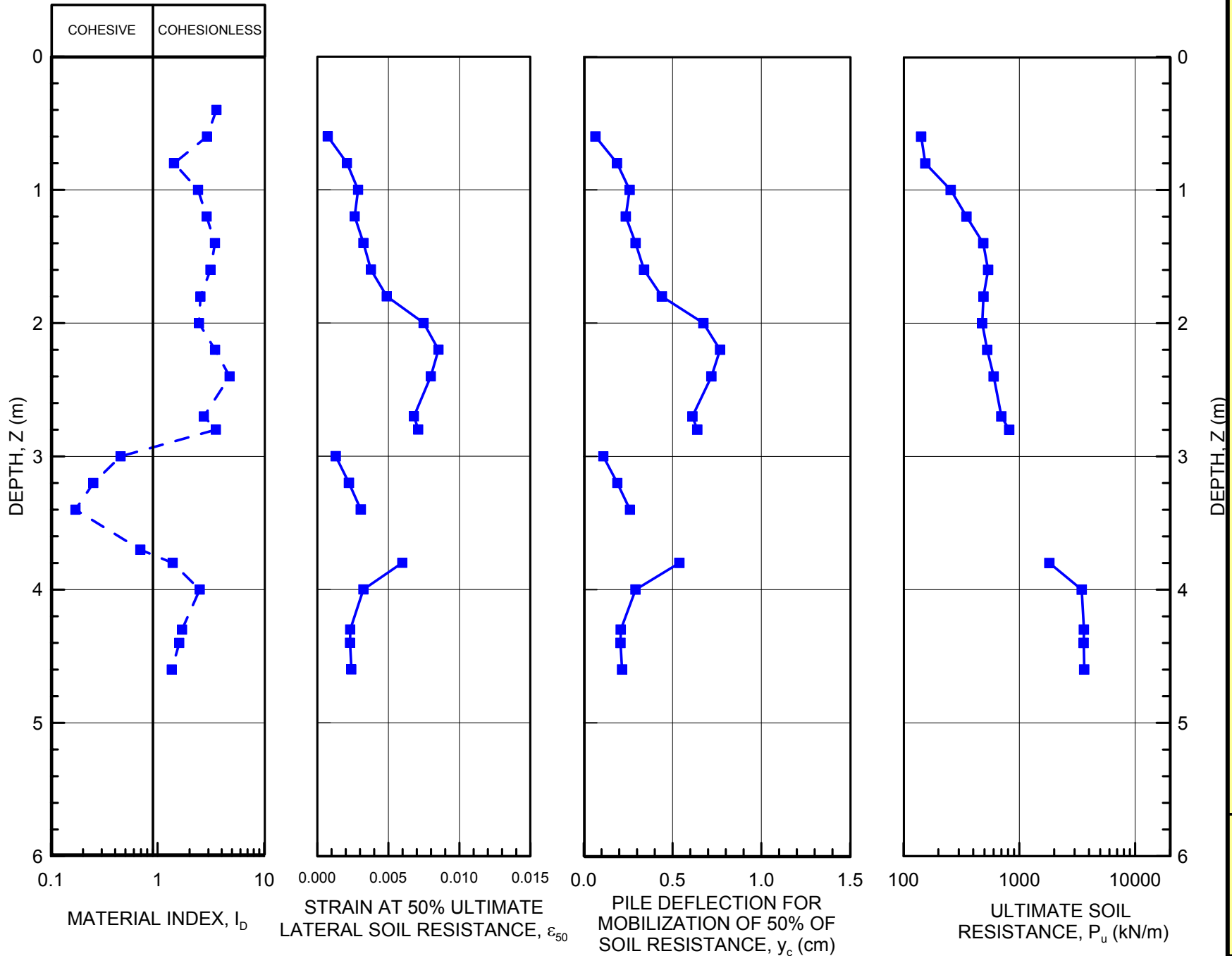
Ground Surface Elev: ~37.4 m
Water Depth: ~3.7 m

PROJECT: US Route 301 Bridge over Four Hole Swamp
LOCATION: Orangeburg, SC

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Fallmezzger
SOUNDING DATE: 12/9/14

SOUNDING
DMT-2

INTERPRETED P-y PARAMETERS FOR LATERAL LOAD ANALYSES



Appendix III

Summary of Lab Data

PSI Professional Service Industries, Inc.

Project Name: Bridge Replacement over Four Hole Swamp

Location : Orangeburg County

Soil Classification Summary

Boring No.	Sample No.	Depth (ft)	Grain Size Data				Hydrometer Test Data							Atterberg			Classification	
			Natural Moisture (%)	% Gravel	% Sand	% Silt Clay	% Passing 32.9 µm	% Passing 21.1 µm	% Passing 12.4 µm	% Passing 8.9 µm	% Passing 6.4 µm	% Passing 3.2 µm	% Passing 1.3 µm	LL	PL	PI	ASTM	AASHTO
B-1A	SS-5	8.7	24.5		27.0	73.0								34	14	20	CL	
B-1A	SS-6	13.5	20.5		57.7	42.3								25	13	12	SC	
B-1A	SS-11	38.5	37		42.3	57.7								28	26	2	ML	
B-1A	SS-12	43.5	46.0	8.3	42.4	49.3								40	38	2	SM	
B-1A	SS-13	48.5	35.3		44.0	56.0								29	27	2	ML	
B-1A	SS-14	53.5	36.7		33.7	66.3								32	31	1	ML	
B-1A	SS-17	68.5	32.7		26.3	73.7								36	30	6	ML	
B-3A	SS-6	24.7	33.3		46.9	53.1								35	24	11	ML	
B-3A	SS-7	31.2	29.6	1.0	56.2	42.8								29	18	11	SC	
B-3A	SS-12	54.7	43.6		36.7	63.3								35	29	6	ML	
B-3A	SS-14	61.7	39.6	3.3	28.4	68.3								41	33	8	ML	
B-3A	SS-19	71.2	316.1		39.9	60.1								135	133	2	MH	
B-3A	SS-21	75.2	376.9		35.7	64.3	44.7	40.6	34.4	30.0	25.9	19.7	9.7	113	102	11	MH	
B-3A	SS-22	77.2	336.3		37.2	62.8								111	101	10	MH	
B-3A	SS-23	79.2	316.1		59.0	41.0	24.5	22.4	18.3	16.0	13.7	9.3	3.5	99	92	7	SM	
B-3A	SS-24	81.2	305.5		60.3	39.7								90	86	4	SM	
B-3A	SS-25	83.2	266.5		67.2	32.8								75	66	9	SM	
B-3A	SS-27	87.2	42.6	0.6	89.0	10.4								NP	NP	NP	SW-SM	
B-3A	SS-28	89.2	25.0	3.2	76.9	19.9								NP	NP	NP	SM	
B-3A	SS-34	120.7	30.3		95.0	5.0								NP	NP	NP	SP-SM	
B-5A	SS-7	31.2	31.8	0.5	51.6	47.9								29	33	6	SM	
B-5A	SS-9	41.2	35.3		36.6	63.4								32	28	4	ML	
B-5A	SS-11	51.2	36.8		47.7	52.3								28	25	3	ML	
B-5A	SS-13	61.2	34.9	2.1	31.6	66.3								35	30	5	ML	
B-5A	SS-16	72.7	35.3	0.1	32.3	67.6								34	28	6	ML	
B-5A	SS-24	88.7	32.8	0.3	80.5	19.2								NP	NP	NP	SM	
B-5A	SS-26	96.2	32.4	1.2	85.6	13.2								61	17	44	SC	
B-5A	SS-30	116.2	48.2		38.9	61.1	31.5	25.2	18.7	15.4	13.8	8.9	7.6	53	20	33	CH	
B-5A	SS-33	132.7	66.0		35.0	65.1	46.4	40.7	38.6	35.0	33.2	27.5	15.7	85	53	32	MH	
B-6A	SS-8	35.2	27.4	17.8	47.6	34.6								24	22	2	SM	
B-6A	SS-11	50.2	34.1		40.1	59.9								31	28	3	ML	

PSI Professional Service Industries, Inc.

Project Name: Bridge Replacement over Four Hole Swamp

Location : Orangeburg County

Soil Classification Summary

Boring No.	Sample No.	Depth (ft)	Grain Size Data				Hydrometer Test Data							Atterberg			Classification	
			Natural Moisture (%)	% Gravel	% Sand	% Silt Clay	% Passing 32.9 µm	% Passing 21.1 µm	% Passing 12.4 µm	% Passing 8.9 µm	% Passing 6.4 µm	% Passing 3.2 µm	% Passing 1.3 µm	LL	PL	PI	ASTM	AASHTO
B-6A	SS-12	55.2	39.9		31.8	68.2								32	31	1	ML	
B-6A	SS-15	70.2	41.2		27.8	72.2								38	29	9	ML	
B-6A	SS-19	77.7	32.0		29.1	70.9								35	23	12	ML	
B-6A	SS-25	89.7	31.5	0.2	78.6	21.2								49	22	27	SC	
B-6A	SS-28	105.2	29.1		88.5	11.5								NP	NP	NP	SP-SM	
B-6A	SS-30	115.2	40.1		43.6	56.4	26.7	20.7	14.8	12.8	11.0	7.0	4.6	40	19	21	CL	
B-6A	SS-32	125.2	38.0	6.5	75.7	17.8								NP	NP	NP	SM	
B-7A	SS-3	16.0	20.3		94.1	5.9								NP	NP	NP	SP-SM	
B-7A	SS-4	18.0	19.9	0.7	91.9	7.4								NP	NP	NP	SP-SM	
B-7A	SS-7	30.5	33.6	3.3	48.9	47.8								25	22	3	SM	
B-7A	SS-9	40.5	42.8	0.7	38.2	61.1								36	35	1	ML	
B-7A	SS-10	45.5	36.2		36.1	63.9	32.7	30.8	25.2	23.4	17.8	10.3	4.5	27	23	4	ML	
B-7A	SS-13	60.5	43.3		23.9	76.2	47.4	41.7	35.9	30.5	23.2	10.3	4.5	44	31	13	ML	
B-7A	SS-17	74.0	44.7		31.7	68.3	44.5	39.0	31.5	28.0	20.9	9.9	6.2	43	31	12	ML	
B-7A	SS-22	84.0	55.9	1.1	82.8	16.1								NP	NP	NP	SM	
B-7A	SS-25	90.0	36.1	0.8	82.8	16.4								NP	NP	NP	SM	
B-7A	SS-28	105.5	26.7		91.5	8.5								NP	NP	NP	SP-SM	

PSI Professional Service Industries, Inc.

Project Name: Bridge Replacement over Four Hole Swamp

Location : Orangeburg County

Boring No.	RW-3A		Grain Size Data							Hydrometer Test Data								
Sample No.	Depth (ft)	Natural Moisture (%)	% < #4	% < #10	% < #20	% < #40	% < #60	% < #140	% < #200	0.0332 mm	0.0213 mm	0.0125 mm	0.0089 mm	.0064 mm	.0046 mm	.0032 mm	.0014 mm	.0010 mm
ST-1	9.00' - 11.00'	30.8	100.0	96.7	94.8	92.5	90.1	67.3	63.1	56.2	51.5	46.8	42.1	37.4	32.7	25.7	11.6	6.9

Atterberg			Classification		Direct Shear	
LL	PL	PI	ASTM	AASHTO	Effective Phi Angle	Cohesion (TSF)
35	15	20	CL	A-6(10)	28.9	0.162

PSI Professional Service Industries, Inc.

Project Name: Bridge Replacement over Four Hole Swamp

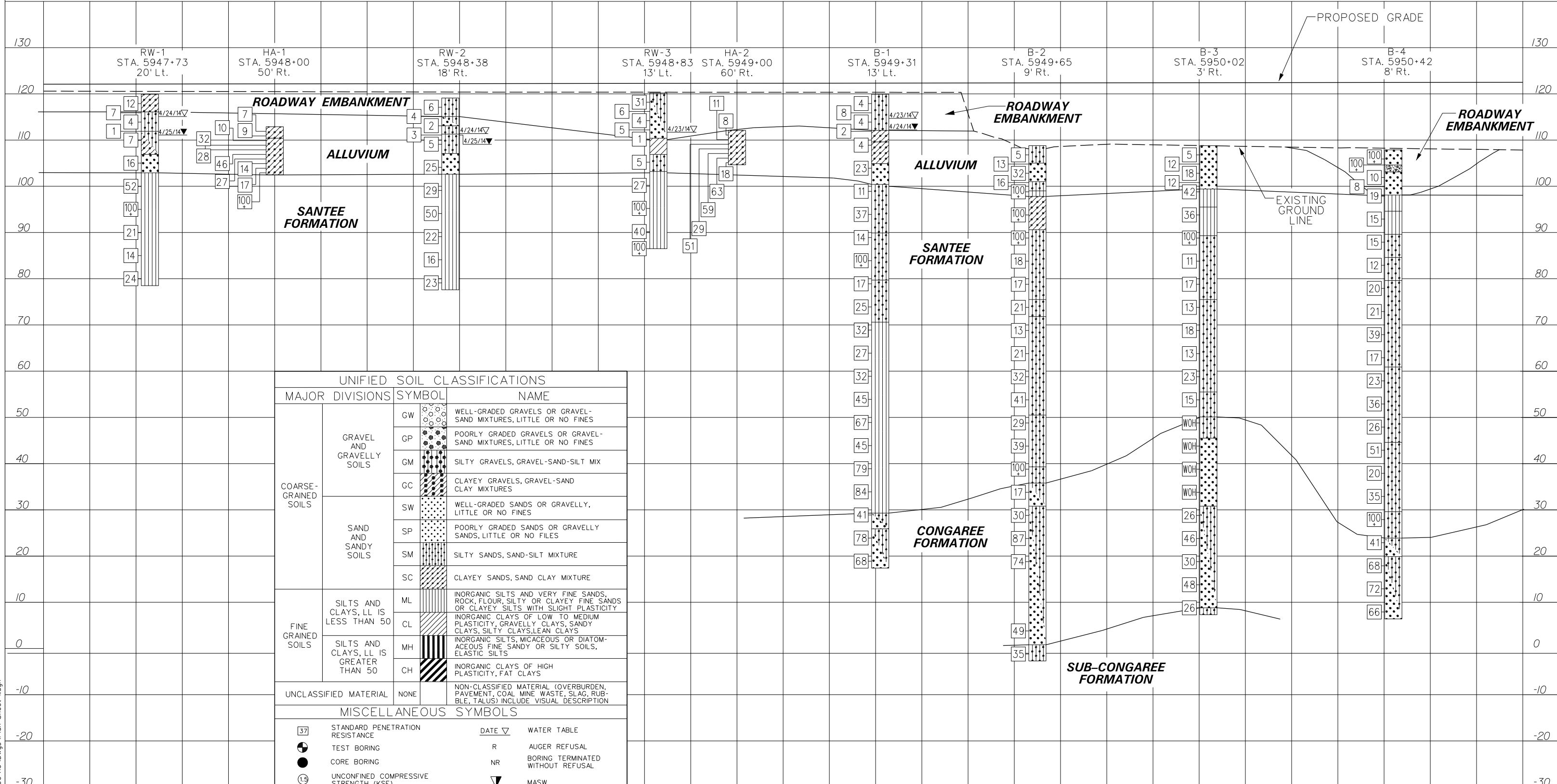
Location : Orangeburg County

SUMMARY OF LABORATORY CORROSION SERIES TEST RESULTS				
Sample	pH	Resistivity ($\rho, \Omega \cdot \text{cm}$)	Chloride Content (ppm)	Sulfate Content (ppm)
B-1A SS-7	3.9	2600	*	*
B-1A Composite (SS-9/SS-10)	7.7	1500	5	555
B-3A Composite (SS-3/SS-4)	7.5	7600	2	111
B-5A SS-9	7.6	1800	4	396

*Insufficieint Sample

Appendix IV

Subsurface Profile



UNIFIED SOIL CLASSIFICATIONS			
MAJOR DIVISIONS		SYMBOL	NAME
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIX
		GC	CLAYEY GRAVELS, GRAVEL-SAND CLAY MIXTURES
	SAND AND SANDY SOILS	SW	WELL-GRADED SANDS OR GRAVELLY, LITTLE OR NO FINES
		SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FILES
		SM	SILTY SANDS, SAND-SILT MIXTURE
		SC	CLAYEY SANDS, SAND CLAY MIXTURE
FINE GRAINED SOILS	SILTS AND CLAYS, LL IS LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK, FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
	SILTS AND CLAYS, LL IS GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
UNCLASSIFIED MATERIAL		NONE	NON-CLASSIFIED MATERIAL (OVERBURDEN, PAVEMENT, COAL MINE WASTE, SLAG, RUBBLE, TALUS) INCLUDE VISUAL DESCRIPTION
MISCELLANEOUS SYMBOLS			
(37)	STANDARD PENETRATION RESISTANCE	DATE	WATER TABLE
(+)	TEST BORING	R	AUGER REFUSAL
(●)	CORE BORING	NR	BORING TERMINATED WITHOUT REFUSAL
(15)	UNCONFINED COMPRESSIVE STRENGTH, (KSF)	▼	MASW

5950 00	5950 50		BRIDGE DESIGN COLUMBIA, S.C.	-40		
REV.						
REV.						
REV.						
REVIEWED			BRIDGE REPLACEMENT OVER FOUR HOLE SWAMP	-50		
QUAN.						
DR.	TAR	8-14				
DES.	KRB	8-14				
BY	CHK.	DATE	FILE NO.	ROUTE	COUNTY	DRAWING NO.
			38.040308	US 301	ORANGEBURG	??

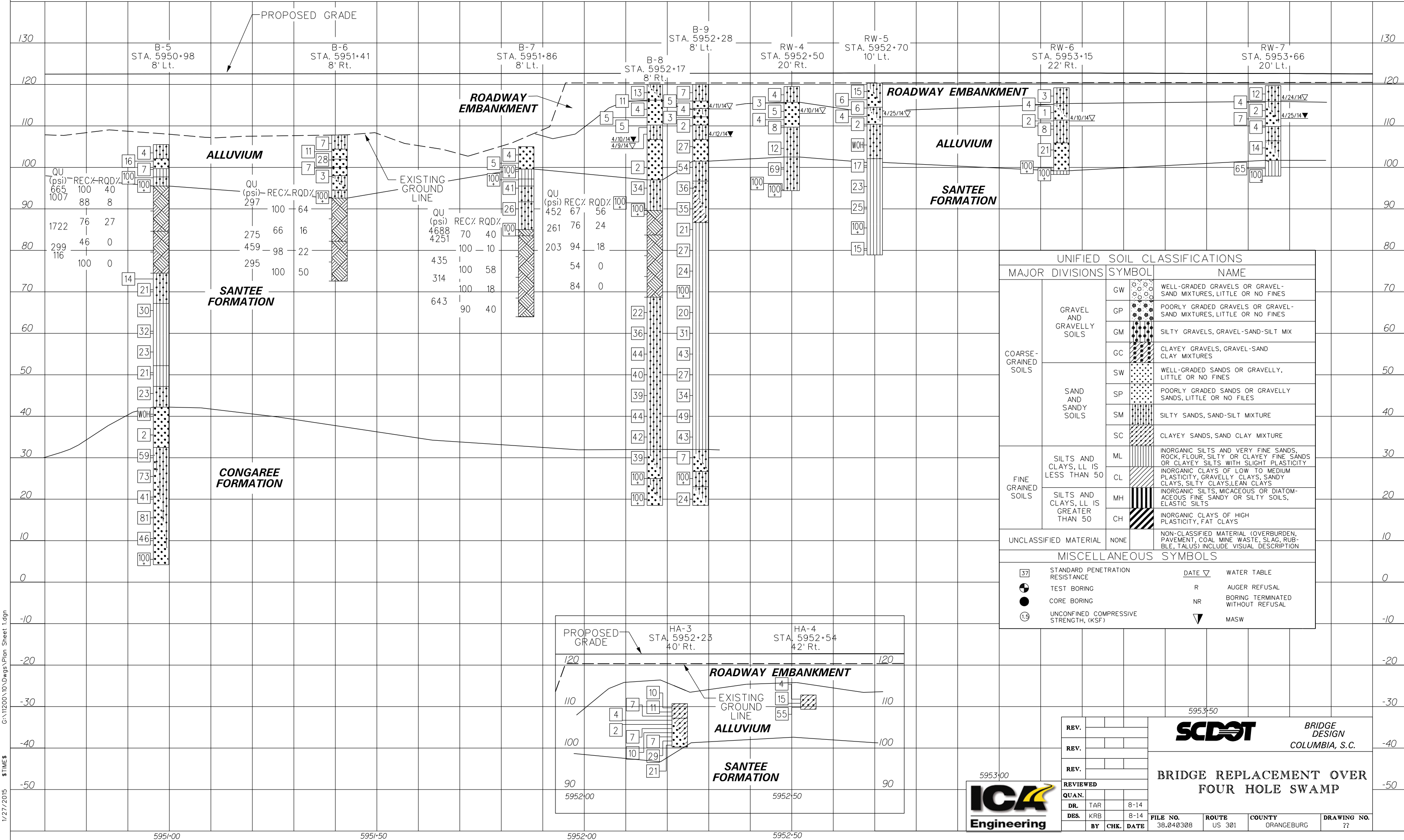


5948-00

5948-50

5949-00

5949-50



UNIFIED SOIL CLASSIFICATIONS		
MAJOR DIVISIONS	SYMBOL	NAME
COARSE-GRAINED SOILS	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIX
	GC	CLAYEY GRAVELS, GRAVEL-SAND CLAY MIXTURES
SAND AND SANDY SOILS	SW	WELL-GRADED SANDS OR GRAVELLY, LITTLE OR NO FINES
	SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FILES
	SM	SILTY SANDS, SAND-SILT MIXTURE
	SC	CLAYEY SANDS, SAND CLAY MIXTURE
	FINE GRAINED SOILS	ML
CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
FINE GRAINED SOILS	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
	NONE	NON-CLASSIFIED MATERIAL (OVERBURDEN, PAVEMENT, COAL MINE WASTE, SLAG, RUBBLE, TALUS) INCLUDE VISUAL DESCRIPTION

MISCELLANEOUS SYMBOLS		
37	STANDARD PENETRATION RESISTANCE	DATE ▽ WATER TABLE
●	TEST BORING	R AUGER REFUSAL
●	CORE BORING	NR BORING TERMINATED WITHOUT REFUSAL
1.5	UNCONFINED COMPRESSIVE STRENGTH, (KSF)	▽ MASW

REV.					BRIDGE DESIGN COLUMBIA, S.C.
REV.					
REV.					
REVIEWED					BRIDGE REPLACEMENT OVER FOUR HOLE SWAMP
QUAN.					
DR.	TAR	8-14			
DES.	KRB	8-14		FILE NO. 38.040308	ROUTE US 301
BY	CHK.	DATE		COUNTY ORANGEBURG	DRAWING NO. ??

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 1/27/2015 8:15 AM

SUBSURFACE DIAGRAM



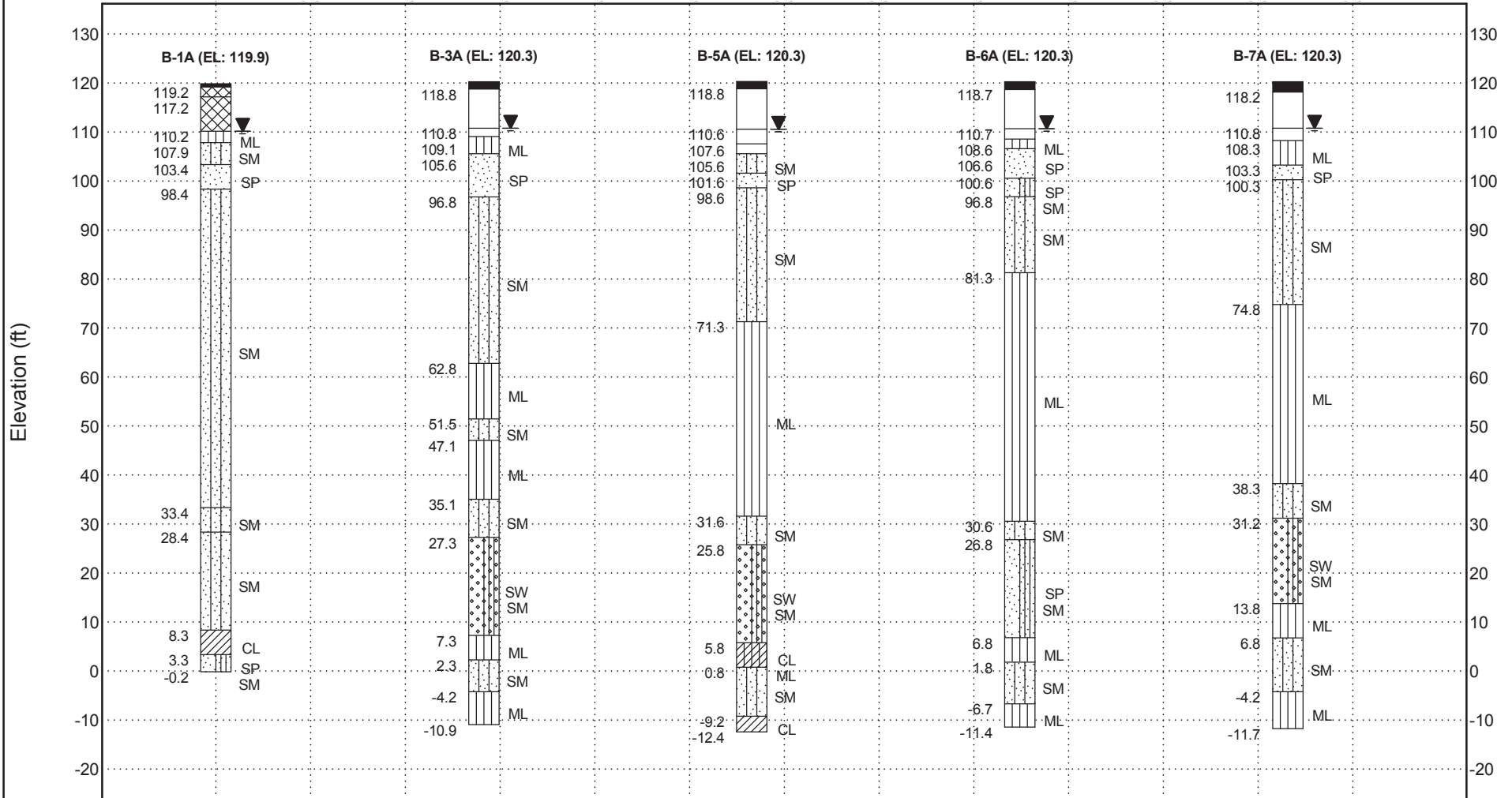
PROJECT NAME: Bridge Replacement Over Four Hole Swamp

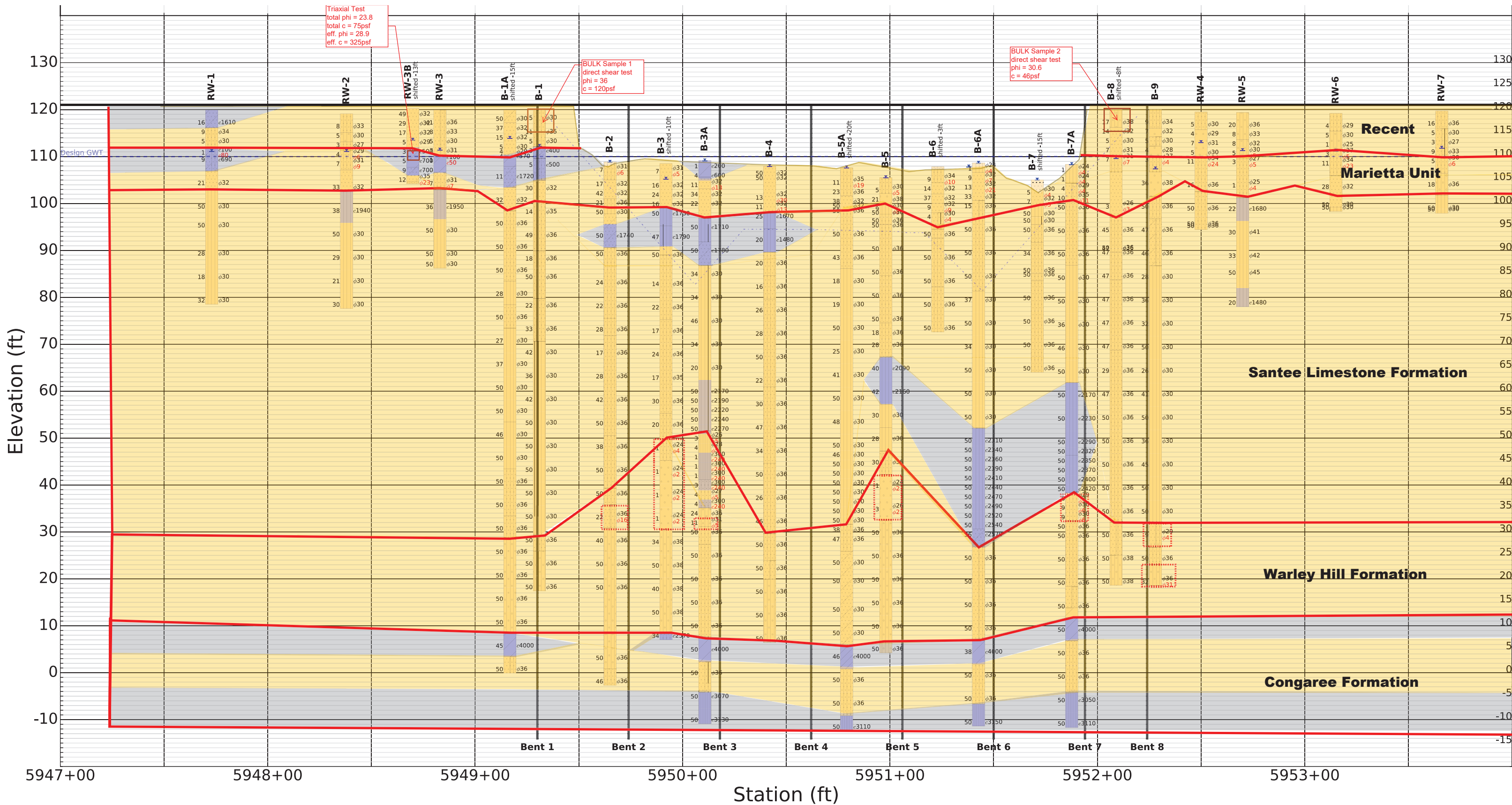
PROJECT NUMBER: 0040308

PROJECT LOCATION: Orangeburg

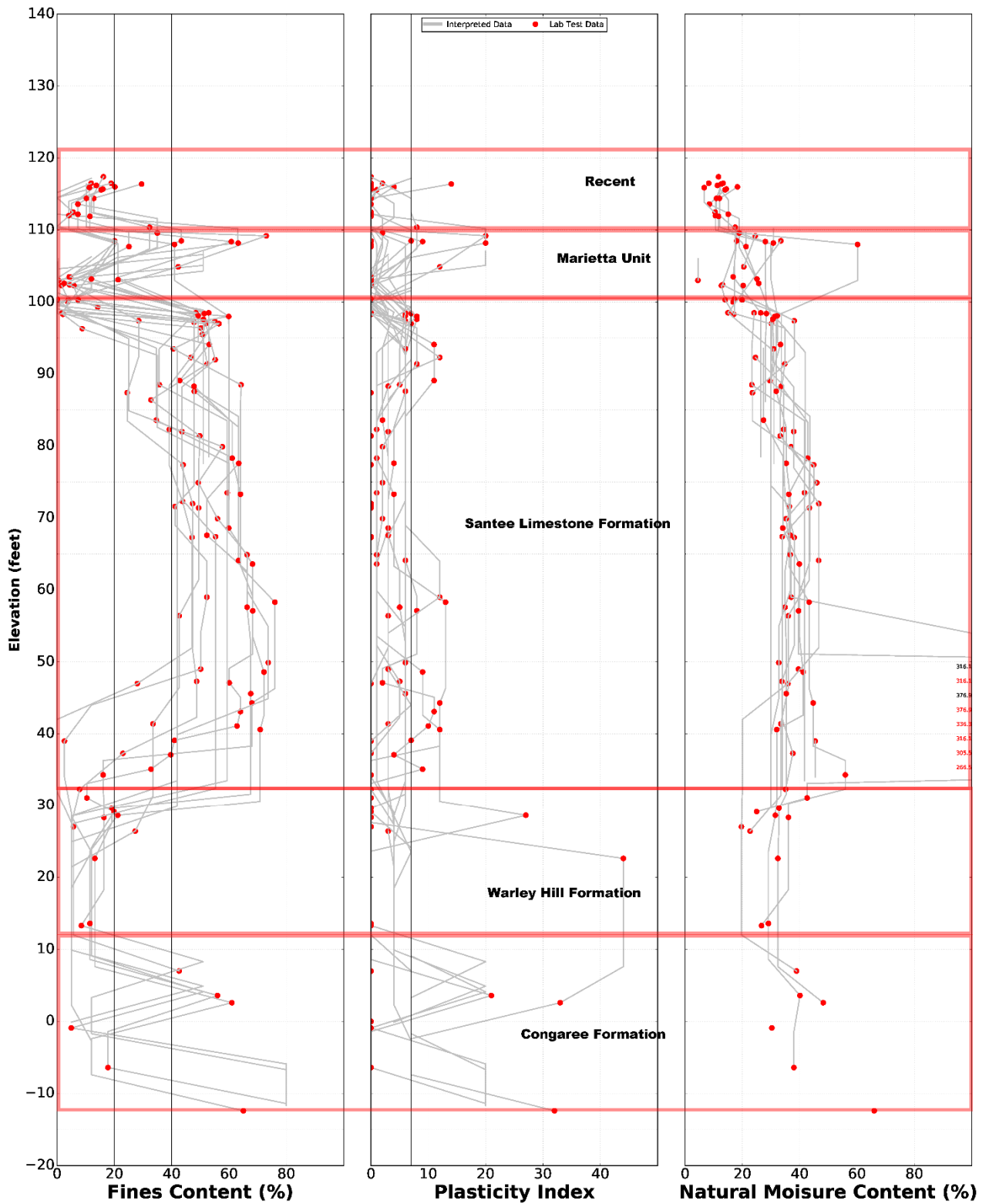


STRATIGRAPHY & GW - A SIZE - PSIHOUSTON.GDT - 1/9/15 11:22 - P:\511-PROJECTS\511-PROJECTS\0-2014\0451 COLUMBIA JOBS\0451644\286-1179 LOGS.GPJ



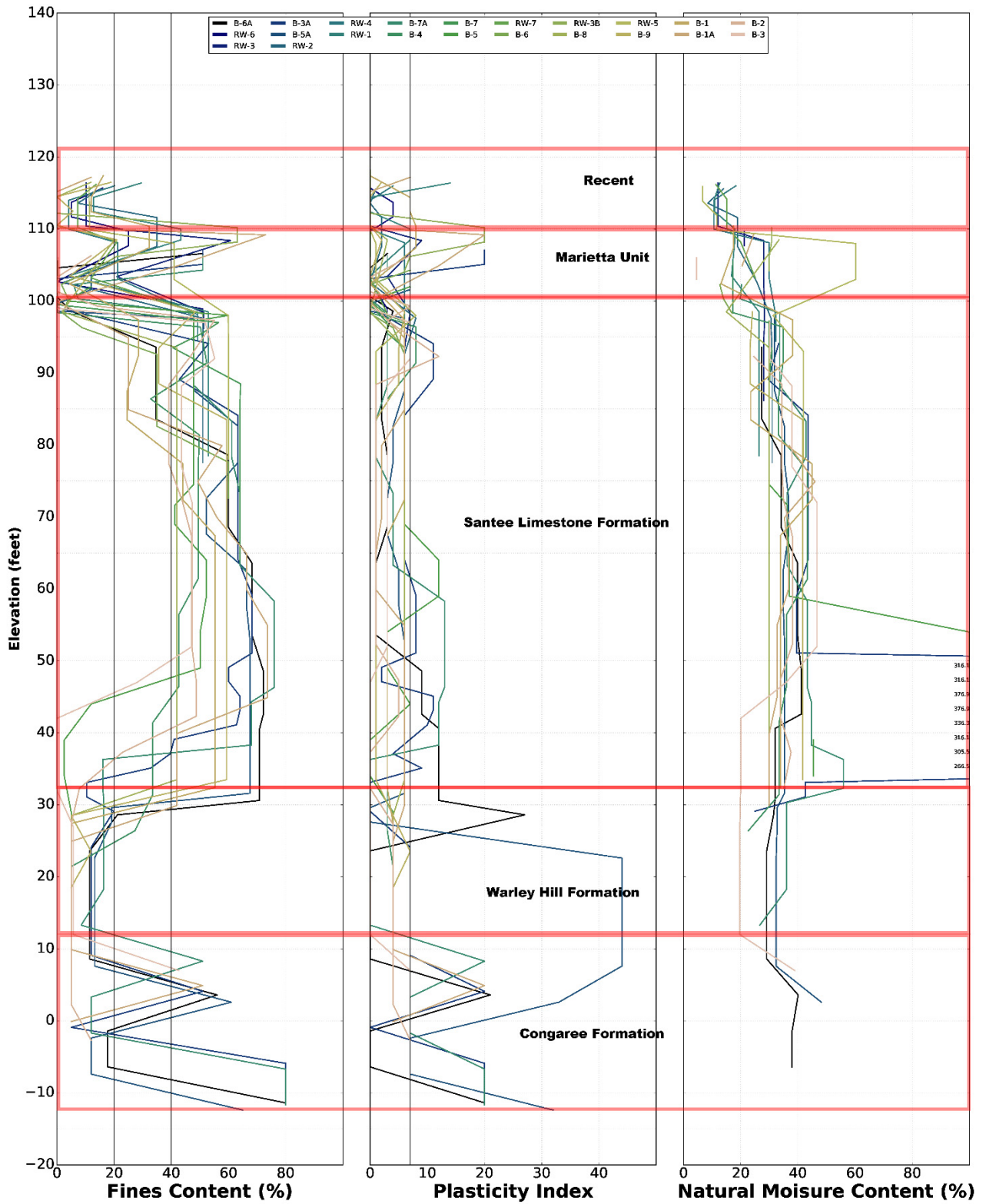


US 301 RBO Four Hole Swamp Subsurface Profile



Index Properties – Laboratory Data

US 301 RBO Four Hole Swamp
Orangeburg County, South Carolina



Index Properties – Interpretation

US 301 RBO Four Hole Swamp

Orangeburg County, South Carolina

GeoStellar Engineering, LLC

Figure 5

Appendix V

Three-Point ADRS Curves

MASW Profile

**SC Seismic Hazard Map
Three-Point ADRS Curves**

PIN No:	40308	File No:	38.040308	Latitude:	33.457
Route:	US 301	County:	Orangeburg	Longitude:	80.6470
Project:	RBO Four Hole Swamp				

Designer:	M. Jackson - Midlands RPG
Date:	9/4/2014

Design EQ	PGA	S _{DS}	S _{D1}	M _w	R (km)	Geologic Condition	Site Class	Damping
FEE	0.20	0.39	0.18	7.36	64.1	Geologically Realistic (Q = 100)	D	5%
SEE	0.43	0.87	0.49	7.37	63.3	Geologically Realistic (Q = 100)	D	

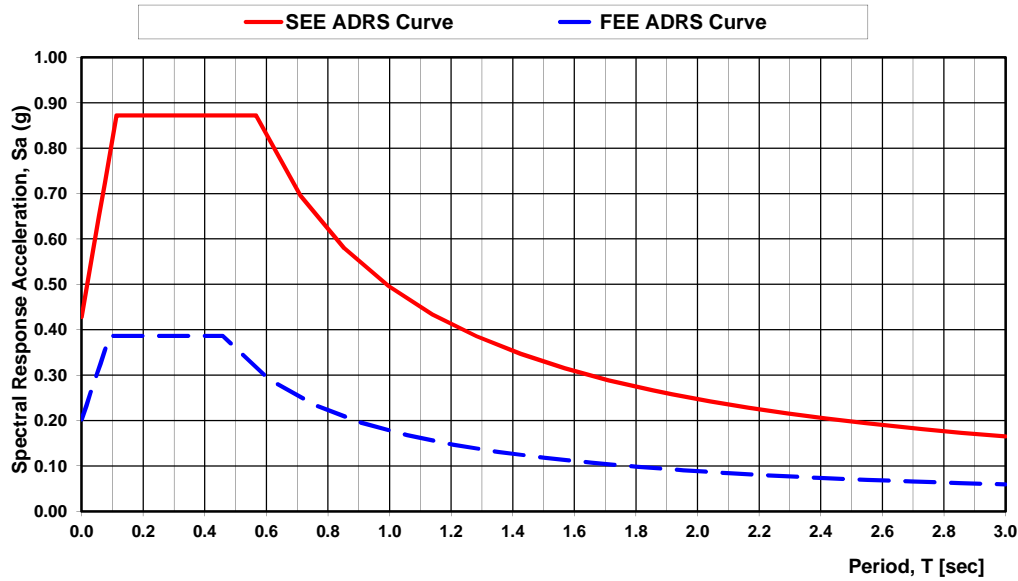
FEE ADRS Curve
Three-Point Method

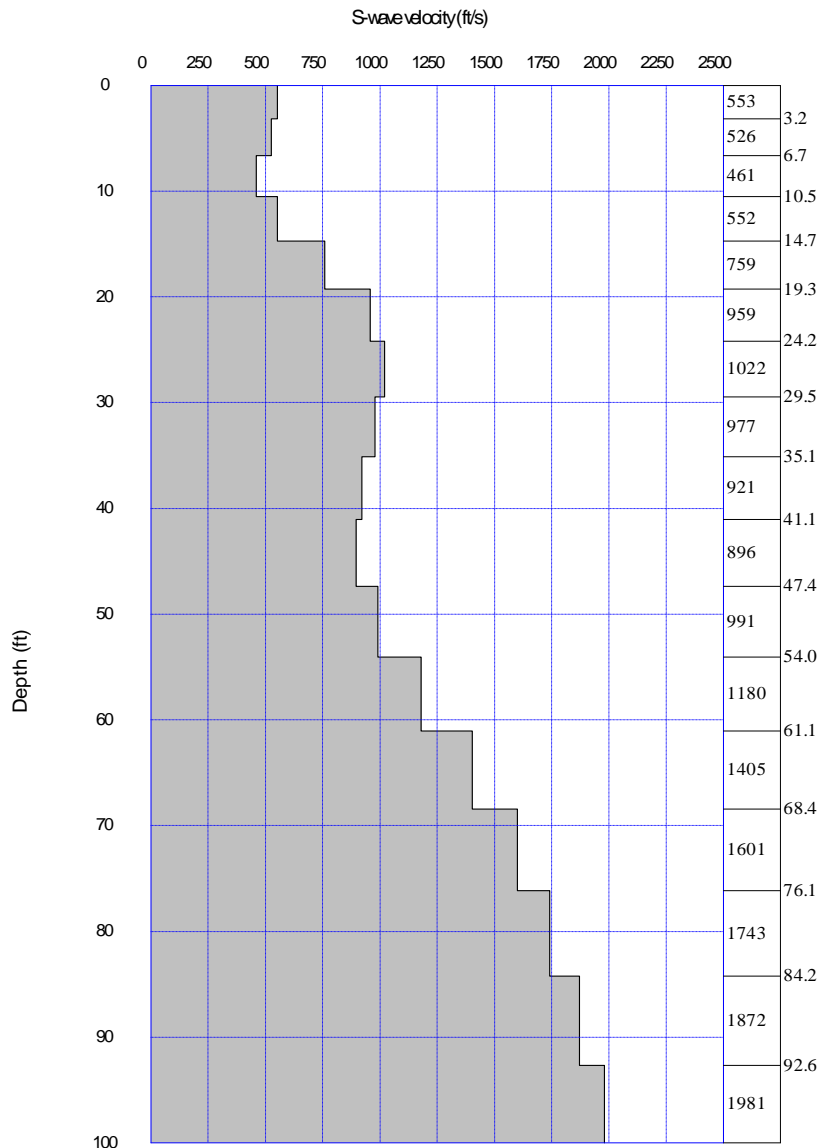
SEE ADRS Curve
Three-Point Method

T	S _a
0.00	0.20
0.02	0.23
0.03	0.26
0.05	0.29
0.06	0.32
0.08	0.36
To	0.39
0.12	0.39
0.15	0.39
0.18	0.39
0.21	0.39
0.24	0.39
0.28	0.39
0.31	0.39
0.34	0.39
0.37	0.39
0.40	0.39
0.43	0.39
Ts	0.39
0.61	0.29
0.76	0.23
0.91	0.20
1.06	0.17
1.21	0.15
1.36	0.13
1.51	0.12
1.65	0.11
1.80	0.10
1.95	0.09
2.10	0.08
2.25	0.08
2.40	0.07
2.55	0.07
2.70	0.07
2.85	0.06
3.00	0.06

T	S _a
0.00	0.43
0.02	0.50
0.04	0.58
0.06	0.65
0.08	0.72
0.09	0.80
To	0.87
0.11	0.87
0.15	0.87
0.19	0.87
0.23	0.87
0.26	0.87
0.30	0.87
0.34	0.87
0.38	0.87
0.42	0.87
0.45	0.87
0.49	0.87
0.53	0.87
Ts	0.87
0.57	0.87
0.71	0.70
0.85	0.58
1.00	0.50
1.14	0.43
1.28	0.39
1.43	0.35
1.57	0.32
1.71	0.29
1.85	0.27
2.00	0.25
2.14	0.23
2.28	0.22
2.43	0.20
2.57	0.19
2.71	0.18
2.86	0.17
3.00	0.16

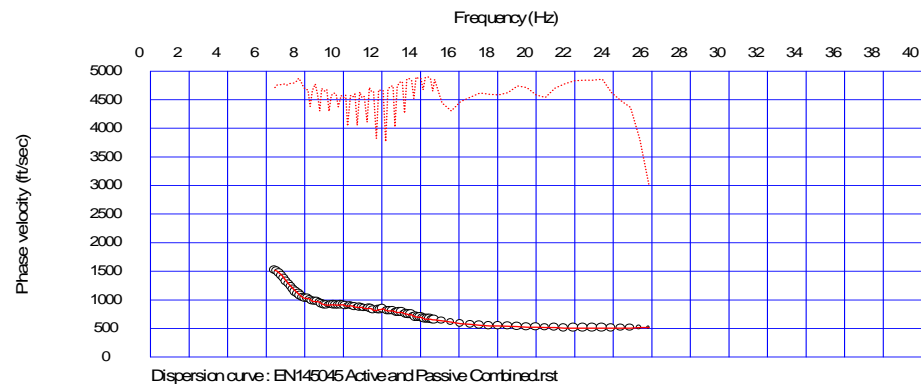
**SC Seismic Hazard Map Three-Point ADRS Curve From
Ground Surface**





S-wave velocity model (inverted): EN145045 Active and Passive Combined.rst
 Average Vs 100ft = 1005.4 ft/sec

Testing Results	
Depth(ft)	S-wave velocity(ft/s)
0.0	553.1
3.2	526.7
6.7	461.6
10.5	552.7
14.7	759.5
19.3	959.8
24.2	1022.2
29.5	977.8
35.1	921.2
41.1	896.1
47.4	991.6
54.0	1180.6
61.1	1405.0
68.4	1601.4
76.1	1743.3
84.2	1872.3
92.6	1981.6



Dispersion curve: EN145045 Active and Passive Combined.rst

Project Mgr:	BTS
Prepared by:	BTS
Checked by:	BTS
Approved by:	BTS

Project No.	EN145045
Scale:	NA
Date:	4/18/2014

Terracon

1450 FIFTH STREET WEST NORTH CHARLESTON, SC
 PH: (843) 884-1234 Fax: (843) 884-9234

GEOPHYSICAL TESTING RESULTS
MASW SHEAR WAVE VELOCITY
 XXXXX
 Orangeburg County, South Carolina

TEST NO
X

Appendix VI

Soil Strength Parameters

SSL Spreadsheets

PROJECT ID	0040308
DATE	03/16/15
COMPUTED BY	RSG
CHECKED BY	SMS

PROJECT NAME: US 301 RBO Four Hole Swamp

CALCULATION: Soil Strength Parameters

PROBLEM: Determine the proper soil strength parameters to utilize in embankment and foundation design.

PROJECT INFORMATION

Project Type: Bridge Replacement

Existing Alignment: 2-lane paved road of variable shoulder widths

Proposed Alignment: 2-lane paved road of variable shoulder widths

Proposed Bridge Dimensions: 47.25 x 294 feet

Stations: 5941+40 to 5960+00, (Bridge 5949+30.00 to 5952+24.00)

End Bent Pile Type: HP 14x73 steel H-Piles

Interior Bent Pile Type: 48-inch steel pipe piles with 1.5 inch wall thickness

Grades: Bridge grades will be raised approximately 2 feet

End Slopes: 2:1

Side Slopes: Right 4:1, Left 2:1

Added Fill: Not expected to exceed 2.5 feet at the shoulder breaks

Travel ways: 12 feet wide

Medians: NA

Project Features: It is our understanding that the proposed bridge will be constructed on the existing alignment and traffic of the existing bridge will be shifted to share the northbound lanes during construction of the proposed bridge.

GIVEN/ASSUMPTIONS

- Based on soil properties, soil strata layers only have friction angles or cohesion, unless a triaxial test is available and then the c and the phi from this test is used.
- Field-tests conducted are SPT and DMT.
- Field Sampling consisted of split spoon, bulk and UD.
- Lab testing consists of classification series, hydrometer analysis, direct shear, corrosion series, and Standard Proctor.
- Liquefiable soils were determined from SSL_Idriss and Boulanger-07302012 spreadsheet for the SPT's.
- Settlement due to liquefaction was determined from the Idriss and Boulanger spreadsheet.
- SEE: M=7.3, PGA=0.43; FEE: M=7.3, PGA=0.20
- Parameters were limited if necessary by maximum values outlined in the SCDOT GDM.
- Others listed as used.

METHODOLOGY

SPTs

We evaluated Strength Parameters using the SSL_Idriss and Boulanger Spreadsheet (SSL). We derived input for this spreadsheet based on the soil lithology and blow counts presented on the boring logs. In turn, the spreadsheet calculated the liquefiable layers and the strength parameters for both the static and seismic conditions.

CPTs

There were no CPTs performed for this project.

DMTs

DMT's were not used in the determination of soil strength parameters at this site. However, the P_1 values on the DMT logs were compared to soil strength parameters determined with the SSL spreadsheet as a check to ensure agreement.

RESULTS and DISCUSSION

The results of the subsurface investigation indicated that the entire bridge site could be divided into five general geologic layers. The five soil layers consist of Recent Fill Embankment, Marietta Unit, Santee Limestone Formation, Warley Hill Formation and Congaree formation.

SPT CORRECTIONS, SOIL SHEAR STRENGTH, AND SEISMIC HAZARD EVALUATION

The SPT testing results were first corrected and then correlated to static soil shear strengths. Seismic soil shear strengths were evaluated by first screening for soils susceptible to soil shear strength loss (SSL) and then evaluating if soil SSL could be triggered by the SEE design events. If soil SSL was not triggered by the SEE design event, it was assumed that the FEE design event would also not trigger soil SSL. Seismic soil shear strengths were determined based on correlations with SPT results after evaluating if the soils are subject to cyclic softening, full cyclic liquefaction, or limited cyclic liquefaction.

SPT CORRECTIONS

The SPT penetration field results, N_{Meas} , were corrected for energy losses in order to obtain N_{60} and N_{60}^* . The energy corrected N_{60}^* blow counts were then normalized to a reference overburden pressure of 1 tsf (1atm) to obtain a normalized $N_{1,60}^*$. The SPT N_{60} and $N_{1,60}^*$ were used to evaluate the static soil shear strengths. The energy corrections and overburden corrections used are in accordance with the 2010 SCDOT GDM, Section 7.8.1.1 and Section 13.11.1.2. The SPT $N_{1,60}^*$ values were also corrected for fines content to equivalent clean sand SPT $N_{1,60,CS}^*$ blow counts that were used to evaluate soil shear strength loss (SSL). The fines content correction used was in accordance with the 2010 SCDOT GDM, Table 13-6.

STATIC SOIL SHEAR STRENGTH

The SPT N_{60} blow counts were used to obtain total soil shear strength (cohesion, c) for cohesive soils and SPT $N^*_{1,60}$ was used to obtain effective shear strength (internal friction angle, ϕ') for cohesionless soils based on correlations obtained from the 2010 SCDOT GDM, Sections 7.10 and 7.11. Effective (drained) soil shear strengths of clay-like soils typically used in long-term drained analyses were computed by observing the soil behavior trends. Laboratory index testing from the subsurface investigations were used to plot fines content (FC), plasticity index (PI) and natural moisture content (NMC) versus elevation. The trends observed were used to interpret subsurface soil behavior for soils that did not have any index testing performed. The interpreted results were then applied to all borings and used to develop a Subsurface Soil Profile of Sand-Like and Clay-Like soils.

An internal angle of friction was assigned for sand-like soils and a cohesion was assigned for clay-like soils by using the appropriate SCDOT correlations. The computed shear strength parameters (internal angle of friction or cohesion) were further evaluated and limited to the maximum allowable total and effective soil shear strength in accordance with 2010 SCDOT GDM, Tables 7-15 and 7-16, respectively, unless laboratory shear strength data was available. The majority of the SPT blow counts, $N^*_{1,60}$ for cohesionless soils substantially exceeded a corrected blow count of 16.6 blows/foot which corresponds to an effective internal angle of friction, ϕ' , of 36° and consequently may be a lower bound value that has been limited to the maximum allowable internal angle of friction (typically 36°). The corrected SPT blow counts, N^*_{60} , $N^*_{1,60}$, $N^*_{1,60,CS}$ and soil shear strength correlations for SPT soil borings are included in the attachments.

SEISMIC SOIL SHEAR STRENGTH

Seismic soil shear strength parameters of the subsurface soils were evaluated by first screening the SPT soil borings to determine if the soils encountered are susceptible to soil shear strength loss (SSL). Soils identified as susceptible to soil SSL were then evaluated to determine if the seismic demand (SEE) was capable of triggering soil SSL.

Soil borings were screened for soil SSL susceptibility based on classification of the soils as either No Strength Loss (NSL) or Possible Strength Loss (PSL). PSL soils were further classified as either Sand-Like, NS Clay-Like soils or HS Clay-Like soils. The soil SSL screening for Sand-Like, NS Clay-Like soils and HS Clay-Like soils was based on fines content corrected SPT blow counts, $N^*_{1,60,CS}$, USCS soil classification, and depth to ground water table in accordance with the GDM Subsection 13.6.

Sand-Like, NS Clay-Like and HS Clay-Like soils were then evaluated to determine if the seismic demand (SEE) would trigger soil SSL. Soil SSL triggering was evaluated using seismic design parameters from the ADRS Three-Point Method and the SSL triggering method for level ground sites in accordance with GDM Subsection 13.7. Sand-like soils were assigned liquefaction resistance age correction factors (K_{DR}) based on the Shear Wave Velocity Evaluation. Sand-Like soils that indicate triggering of soil SSL will undergo full or limited cyclic liquefaction and NS/HS Clay-Like soils that indicate triggering of soil SSL will undergo cyclic softening. The SSL screening, triggering, and seismic soil shear strengths for the borings listed below are provided in the attachments.

SEISMIC HAZARD EVALUATION

Seismic settlements were evaluated using the procedures outlined by Idriss and Boulanger in the 2008 EERI Monograph MNO-12, “Soil Liquefaction during Earthquakes” and Chapter 13 – “Geotechnical Seismic Hazards” of the 2010 GDM. The results of the seismic settlement evaluation are provided in the attachments.

ATTACHMENTS

Strength Parameters for Service Limit State and Extreme Event I (SEE)

RW-1_SPT-SSL_Idriss and Boulanger-07302012
RW-2_SPT-SSL_Idriss and Boulanger-07302012
RW-3_SPT-SSL_Idriss and Boulanger-07302012
RW-3B_SPT-SSL_Idriss and Boulanger-07302012
B-1_SPT-SSL_Idriss and Boulanger-07302012
B-1A_SPT-SSL_Idriss and Boulanger-07302012
B-2_SPT-SSL_Idriss and Boulanger-07302012
B-3_SPT-SSL_Idriss and Boulanger-07302012
B-3A_SPT-SSL_Idriss and Boulanger-07302012
B-4_SPT-SSL_Idriss and Boulanger-07302012
B-5_SPT-SSL_Idriss and Boulanger-07302012
B-5A_SPT-SSL_Idriss and Boulanger-07302012
B-6_SPT-SSL_Idriss and Boulanger-07302012
B-6A_SPT-SSL_Idriss and Boulanger-07302012
B-7_SPT-SSL_Idriss and Boulanger-07302012
B-7A_SPT-SSL_Idriss and Boulanger-07302012
B-8_SPT-SSL_Idriss and Boulanger-07302012
B-9_SPT-SSL_Idriss and Boulanger-07302012
RW-4_SPT-SSL_Idriss and Boulanger-07302012
RW-5_SPT-SSL_Idriss and Boulanger-07302012
RW-6_SPT-SSL_Idriss and Boulanger-07302012
RW-7_SPT-SSL_Idriss and Boulanger-07302012

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/9/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-1	Station:	5947+73.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

Soil Shear Strength Summary

Boring Number = RW-1
 Boring Station = 5947+73.00
 Boring Offset = 20' Lt
 Ground Elevation at Boring (ft msl) = 119.9
 Water Table Depth (Dw) (ft) = 8.8
 Water Table Elevation (msl ft) = 111.1

Design EQ = SEE
 Site Class = D
 PGA (g) = 0.43
 Mw = 7.37
 R (km) = 63.3
 D_{as-95} (sec) = 30.12

No. of Soil Layers = 5 each
 No. of Split Spoon Samples = 11 each
 Total Profile Thickness = 41 feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ_{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths		
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)	
	0	119.9																		
1	3.5	116.4	12.0	11.5	19.6	24.9	1	SM/SC/SC-SM	NS Clay-Like	No Strength Loss		29.5						1730		1730
2	5.5	114.4	7.0	7.2	12.2	14.6	2	SM/SC/SC-SM		No Liquefaction		12.8						34		34
3	7.5	112.4	4.0	4.3	6.5	9.0	2	SM/SC/SC-SM		No Liquefaction		12.8						30		30
4	9.9	110.0	1.0	1.1	1.5	7.0	3	SM/SC/SC-SM	NS Clay-Like	Strength Loss		43.4						100		80
5	11.4	108.5	7.0	8.1	10.7	16.2	3	SM/SC/SC-SM	NS Clay-Like	No Strength Loss		43.4						700		700
6	16.4	103.5	16.0	19.5	23.0	23.0	4	SP/SW		No Liquefaction		4.3						32		32
7	21.4	98.5	50.0	63.0	63.0	46.0	5	ML		No Liquefaction		52.9						30		30
8	25.4	94.5	50.0	64.0	64.0	46.0	5	ML		No Liquefaction		52.9						30		30
9	31.4	88.5	21.0	27.2	27.2	32.7	5	ML		No Liquefaction		52.9						30		30
10	36.4	83.5	14.0	18.3	18.3	23.8	5	ML		No Liquefaction		52.9						30		30
11	41.4	78.5	24.0	31.4	31.4	36.9	5	ML		No Liquefaction		52.9						30		30

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/8/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-2	Station:	5948+38.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D	
Design Earthquake:	SEE	FEE
S_{D1} =	0.490	0.180
$k_{max} = PGA$ =	0.430	0.200
$\beta = S_{D1}/PGA$ =	1.140	0.900
α_w =	1.000	1.000
$k_h = k_{avg}$ =	0.430	0.200
M_w =	7.37	7.36
R =	63.3	64.1
\bar{V}_s =	1,005.40	1,005.40
Z_{HR} =	494.50	494.50
ϵ =	0.000	0.000
D_{a5-95}	30.12	30.07

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$0.50 \leq \beta \leq 1.5$$

$$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308		
Project:	Bridge Replacement over Four Hole Swamp				
Route:	US 301	County:	38 - Orangeburg	Location:	RW-2

Latitude:	33.4570
Longitude:	80.6470

Designer:	R. Gardner - Midlands RPG
Date:	10/8/2014
Station:	5948+38.00

Boring Number = RW-2
 Boring Station = 5948+38.00
 Boring Offset = 18' Rt
 Ground Elevation at Boring (ft msl) = 119.1
 Water Table Depth (Dw) (ft) = 8
 Water Table Elevation (msl ft) = 111.1

Design EQ = SEE
 Site Class = D
 PGA (g) = 0.43
 M_w = 7.37
 R (km) = 63.3
 D_{a5-95} (sec) = 30.12

No. of Soil Layers = 6 each
 No. of Split Spoon Samples = 11 each
 Total Profile Thickness = 42 feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
0		119.1														
1	3.5	115.6	6.0	1.32	1.00	0.73	1.00	400.0	1.70	15.4	3.4	5.8	9.8	13.2	1	SM/SC/SC-SM
2	5.5	113.6	4.0	1.32	1.00	0.78	1.00	642.5	1.70	7.3	0.2	4.1	7.0	7.1	2	SW-SM/SW-SC/SP-SM/SP-SC
3	7.5	111.6	2.0	1.32	1.00	0.82	1.00	872.5	1.51	12.0	2.1	2.1	3.3	5.3	3	SM/SC/SC-SM
4	9.5	109.6	3.0	1.32	1.00	0.85	1.00	1,008.9	1.41	35.0	5.5	3.4	4.7	10.2	4	SM/SC/SC-SM
5	11.5	107.6	5.0	1.32	1.00	0.88	1.00	1,111.6	1.34	35.0	5.5	5.8	7.7	13.2	4	SM/SC/SC-SM
6	16.5	102.6	25.0	1.32	1.00	0.93	1.00	1,399.6	1.20	2.5	0.0	30.5	36.5	36.5	5	SP/SW
7	21.5	97.6	29.0	1.32	1.00	0.96	1.00	1,637.6	1.00	51.1	5.5	36.6	36.6	42.1	6	ML
8	26.5	92.6	50.0	1.32	1.00	0.98	1.00	1,875.6	1.00	51.1	5.5	64.2	64.2	46.0	6	ML
9	31.5	87.6	22.0	1.32	1.00	0.99	1.00	2,113.6	1.00	51.1	5.5	28.6	28.6	34.1	6	ML
10	36.5	82.6	16.0	1.32	1.00	0.99	1.00	2,351.6	1.00	51.1	5.5	20.9	20.9	26.4	6	ML
11	41.5	77.6	23.0	1.32	1.00	1.00	1.00	2,589.6	1.00	51.1	5.5	30.1	30.1	35.6	6	ML

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number =	RW-2
Boring Station =	5948+38.00
Boring Offset =	18' Rt
Ground Elevation at Boring (ft msl) =	119.1
Water Table Depth (Dw) (ft) =	8
Water Table Elevation (msl ft) =	111.1

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.3
D _{as-95} (sec) =	30.12

No. of Soil Layers =	6	each
No. of Split Spoon Samples =	11	each
Total Profile Thickness =	42	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ϕ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths			
																ϕ' (degrees)	τ = c (psf)	ϕ' (degrees)	τ = c (psf)		
	0	119.1																			
1	3.5	115.6	6.0	5.8	9.8	13.2	1	SM/SC/SC-SM		No Liquefaction		15.4				33		33			
2	5.5	113.6	4.0	4.1	7.0	7.1	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		7.3				30		30			
3	7.5	111.6	2.0	2.1	3.3	5.3	3	SM/SC/SC-SM		No Liquefaction		12.0				27		27			
4	9.5	109.6	3.0	3.4	4.7	10.2	4	SM/SC/SC-SM	Sand-Like	Full Liquefaction	27.0	35.0				29		6			
5	11.5	107.6	5.0	5.8	7.7	13.2	4	SM/SC/SC-SM	Sand-Like	Full Liquefaction	35.4	35.0				31		9			
6	16.5	102.6	25.0	30.5	36.5	36.5	5	SP/SW		No Liquefaction		2.5				32		32			
7	21.5	97.6	29.0	36.6	36.6	42.1	6	ML	NS Clay-Like	No Strength Loss		51.1					1900		1900		
8	26.5	92.6	50.0	64.2	64.2	46.0	6	ML	NS Clay-Like	No Strength Loss		51.1					2000		2000		
9	31.5	87.6	22.0	28.6	28.6	34.1	6	ML	NS Clay-Like	No Strength Loss		51.1						2100		2100	
10	36.5	82.6	16.0	20.9	20.9	26.4	6	ML	NS Clay-Like	No Strength Loss		51.1						1600		1600	
11	41.5	77.6	23.0	30.1	30.1	35.6	6	ML	NS Clay-Like	No Strength Loss		51.1						2200		2200	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/8/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-3	Station:	5948+83.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$0.50 \leq \beta \leq 1.5$$

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

$$R \geq 20 \text{ km}; \epsilon = 0$$

Soil Shear Strength Summary

Boring Number = **RW-3**
 Boring Station = **5948+83.00**
 Boring Offset = **19' Lt**
 Ground Elevation at Boring (ft msl) = **119.9**
 Water Table Depth (Dw) (ft) = **9.9**
 Water Table Elevation (msl ft) = **110**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.3**
 D_{as-95} (sec) = **30.12**

No. of Soil Layers = **4** each
 No. of Split Spoon Samples = **10** each
 Total Profile Thickness = **34** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
	0	119.9																	
1	3.5	116.4	31.0	29.8	50.6	46.0	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
2	5.5	114.4	6.0	6.1	10.4	11.7	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		10.3				33		33	
3	7.5	112.4	4.0	4.3	6.4	7.7	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		10.3				30		30	
4	9.5	110.4	5.0	5.6	7.4	8.7	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		10.3				31		31	
5	11.5	108.4	1.0	1.2	1.2	6.7	2	CL	HS Clay-Like	Strength Loss		60.8					100		50
6	16.5	103.4	5.0	6.1	7.0	9.1	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	36.4	12.0				31		5	
7	21.5	98.4	27.0	34.0	34.0	39.5	4	ML	NS Clay-Like	No Strength Loss		51.4					1900		1900
8	26.5	93.4	50.0	64.2	64.2	46.0	4	ML	NS Clay-Like	No Strength Loss		51.4				30		4815	4815
9	31.5	88.4	40.0	51.9	51.9	46.0	4	ML	NS Clay-Like	No Strength Loss		51.4				30		3893	3893
10	33.7	86.2	50.0	65.1	65.1	46.0	4	ML	NS Clay-Like	No Strength Loss		51.4				30		4882	4882

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	2/25/2015
Project:	Bridge Replacement over Four Hole Swamp						
Location:		Station:	5948+82.94	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.: 40308	File No.: 38.040308	Latitude: 33.4570	Designer: R. Gardner - Midlands RPG
Project: Bridge Replacement over Four Hole Swamp		Longitude: 80.6470	Date: 2/25/2015
Route: US 301	County: 38 - Orangeburg	Location: 0	Station: 5948+82.94

Design EQ =	SEE	Boring Number =	RW-B	Hammer Type =	Safety
Site Class =	D	Boring Station =	5948+82.94	Energy Ratio =	91.3
PGA (g) =	0.43	Boring Offset =	7' Lt	Energy Correction (C _e) =	1.52
M _w =	7.4	Ground Elevation at Boring (ft msl) =	120.2	Borehole Diameter (in) =	4
R (km) =	63.3	Water Table Depth (D _w) (ft) =	6.7	Borehole Correction (CB) =	1.00
D ₈₅₋₉₅ (sec) =	30.12	Water Table Elevation (msl ft) =	113.5		

No. of Soil Layers =	4	each	Sampler Configuration:	N
No. of Split Spoon Samples =	8	each	Liner Required =	N
Total Profile Thickness =	16	feet	Liner Used =	N

N-value Summary				SSL Screening Summary			SSL Triggering Summary				Seismic Analysis Summary		Geotechnical Seismic Hazards Summary		
SPT Sample Number	Depth ^o (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR _{eq} [*] /CRR _{eq} [*]	φ _{SL}	(D/C)SL ≤ φ _{SL}	R _u	φ' (degrees)	τ (psf)	ΔLDI _i (feet)	ΣΔLDI _i (feet)	ΔS _i (inches)
	0	120.2													
1	2	118.2	46.0	SP/SW	NSL-S				No Liquefaction		32.0				
2	4	116.2	36.5	SP/SW	NSL-S				No Liquefaction		32.0				
3	6	114.2	22.0	SP/SW	NSL-S				No Liquefaction		32.0				
4	8	112.2	11.3	SP/SW	NSL-S				No Liquefaction		33.2				
5	10	110.2	8.1	CL	PSL	HS Clay-Like	0.77	0.90	No Strength Loss		500.00				
6	12	108.2	9.5	CL	PSL	HS Clay-Like	0.65	0.90	No Strength Loss		700.00				
7	14	106.2	12.8	SM/SC/SC-SM	NSL-C				No Strength Loss		700.00				
8	16	104.2	16.1	SM/SC/SC-SM	NSL-S				No Liquefaction		34.7				
												0.00			
												LDI Total	S Total		
												(feet)	(inches)		

^oDepth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	Bridge Replacement over Four Hole Swamp			Longitude:	80.6470	Date:	2/25/2015
Route:	US 301	County:	38 - Orangeburg	Location:	0	Station:	5948+82.94

Boring Number =	RW-B	Design EQ =	SEE	No. of Soil Layers =	4	each
Boring Station =	5948+82.94	Site Class =	D	No. of Split Spoon Samples =	8	each
Boring Offset =	7' Lt	PGA (g) =	0.43	Total Profile Thickness =	16	feet
Ground Elevation at Boring (ft msl) =	120.2	M _w =	7.37			
Water Table Depth (Dw) (ft) =	6.7	R (km) =	63.3			
Water Table Elevation (msl ft) =	113.5	D _{a5-95} (sec) =	30.12			

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ _{'vo} (psf)	C _N	Fines Content (FC)	ΔN _{1,60}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
0		120.2														
1	2	118.2	32.0	1.52	1.00	0.69	1.00	240.0	1.70	0.0	0.0	33.6	57.1	46.0	1	SP/SW
2	4	116.2	19.0	1.52	1.00	0.74	1.00	480.0	1.70	0.0	0.0	21.5	36.5	36.5	1	SP/SW
3	6	114.2	11.0	1.52	1.00	0.79	1.00	720.0	1.67	0.0	0.0	13.2	22.0	22.0	1	SP/SW
4	8	112.2	6.0	1.52	1.00	0.83	1.00	887.9	1.50	0.0	0.0	7.5	11.3	11.3	1	SP/SW
5	10	110.2	2.0	1.52	1.00	0.86	1.00	983.1	1.00	63.1	5.5	2.6	2.6	8.1	2	CL
6	12	108.2	3.0	1.52	1.00	0.88	1.00	1,075.8	1.00	63.1	5.5	4.0	4.0	9.5	2	CL
7	14	106.2	6.0	1.52	1.00	0.91	1.00	1,181.0	1.30	12.0	2.1	8.3	10.8	12.8	3	SM/SC/SC-SM
8	16	104.2	8.0	1.52	1.00	0.92	1.00	1,286.2	1.25	12.0	2.1	11.2	14.0	16.1	4	SM/SC/SC-SM

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **RW-B**
 Boring Station = **5948+82.94**
 Boring Offset = **7' Lt**
 Ground Elevation at Boring (ft msl) = **120.2**
 Water Table Depth (Dw) (ft) = **6.7**
 Water Table Elevation (msl ft) = **113.5**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 M_w = **7.37**
 R (km) = **63.3**
 D₈₅₋₉₅ (sec) = **30.12**

No. of Soil Layers = **4** each
 No. of Split Spoon Samples = **8** each
 Total Profile Thickness = **16** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths		
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)	
	0	120.2																		
1	2	118.2	32.0	33.6	57.1	46.0	1	SP/SW		No Liquefaction		0.0				32		32		
2	4	116.2	19.0	21.5	36.5	36.5	1	SP/SW		No Liquefaction		0.0				32		32		
3	6	114.2	11.0	13.2	22.0	22.0	1	SP/SW		No Liquefaction		0.0				32		32		
4	8	112.2	6.0	7.5	11.3	11.3	1	SP/SW		No Liquefaction		0.0				33		33		
5	10	110.2	2.0	2.6	2.6	8.1	2	CL	HS Clay-Like	No Strength Loss		63.1	0.001	42.3	0.3		500		500	
6	12	108.2	3.0	4.0	4.0	9.5	2	CL	HS Clay-Like	No Strength Loss		63.1					700		700	
7	14	106.2	6.0	8.3	10.8	12.8	3	SM/SC/SC-SM		No Strength Loss		12.0					700		700	
8	16	104.2	8.0	11.2	14.0	16.1	4	SM/SC/SC-SM		No Liquefaction		12.0					35		35	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/23/2014
Project:	RBO Four Hole Swamp						
Location:	EB1 B-1	Station:	5949+31	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.: 40308		File No.: 38.040308		Latitude: 33.4570		Designer: R. Gardner - Midlands RPG	
Project: RBO Four Hole Swamp				Longitude: 80.6470		Date: 9/23/2014	
Route: US 301	County: 38 - Orangeburg	Location: EB1 B-1				Station: 5949+31	

Boring Number =	B-1	Design EQ =	SEE
Boring Station =	5949+31.00	Site Class =	D
Boring Offset =	13 ft LT	PGA (g) =	0.43
Ground Elevation at Boring (ft msl) =	119.9	M _w =	7.37
Water Table Depth (Dw) (ft) =	7.7	R (km) =	63.5
Water Table Elevation (msl ft) =	112.2	D _{a5-95} (sec) =	30.15

No. of Soil Layers =	10	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	103	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	119.9														
1	2.5	117.4	4.0	1.32	1.00	0.70	1.00	287.5	1.70	16.2	3.6	3.7	6.3	9.9	1	SM/SC/SC-SM
2	5.5	114.4	8.0	1.32	1.00	0.78	1.00	632.5	1.70	16.2	3.6	8.2	13.9	17.5	1	SM/SC/SC-SM
3	7.5	112.4	4.0	1.32	1.00	0.82	1.00	862.5	1.52	16.2	3.6	4.3	6.5	10.2	1	SM/SC/SC-SM
4	9.5	110.4	2.0	1.32	1.00	0.85	1.00	980.2	1.43	32.3	5.4	2.2	3.2	8.6	2	SM/SC/SC-SM
5	12.5	107.4	4.0	1.32	1.00	0.89	1.00	1,125.5	1.33	32.3	5.4	4.7	6.2	11.7	3	SM/SC/SC-SM
6	17.5	102.4	23.0	1.32	1.00	0.93	1.00	1,423.5	1.19	4.4	0.0	28.3	33.6	33.6	4	SP/SW
7	22.5	97.4	11.0	1.32	1.00	0.96	1.00	1,686.5	1.09	28.5	5.3	13.9	15.2	20.5	5	SM/SC/SC-SM
8	27.5	92.4	37.0	1.32	1.00	0.98	1.00	1,949.5	1.01	28.5	5.3	47.6	48.2	46.0	5	SM/SC/SC-SM
9	32.5	87.4	14.0	1.32	1.00	0.99	1.00	2,212.5	0.95	24.5	5.0	18.2	17.3	22.3	6	SM/SC/SC-SM
10	36.4	83.5	50.0	1.32	1.00	0.99	1.00	2,417.6	0.91	24.5	5.0	65.3	59.4	46.0	6	SM/SC/SC-SM
11	42.5	77.4	17.0	1.32	1.00	1.00	1.00	2,738.5	0.85	44.0	5.5	22.3	19.0	24.5	7	SM/SC/SC-SM
12	47.5	72.4	25.0	1.32	1.00	1.00	1.00	3,010.5	0.82	44.0	5.5	32.8	26.8	32.3	7	SM/SC/SC-SM
13	52.5	67.4	32.0	1.32	1.00	1.00	1.00	3,248.5	1.00	55.3	5.5	42.1	42.1	46.0	8	ML
14	57.5	62.4	27.0	1.32	1.00	1.00	1.00	3,486.5	1.00	55.3	5.5	35.5	35.5	41.0	8	ML
15	62.5	57.4	32.0	1.32	1.00	1.00	1.00	3,724.5	1.00	55.3	5.5	42.1	42.1	46.0	8	ML
16	67.5	52.4	45.0	1.32	1.00	1.00	1.00	3,962.5	1.00	55.3	5.5	59.2	59.2	46.0	8	ML
17	72.5	47.4	67.0	1.32	1.00	1.00	1.00	4,200.5	1.00	55.3	5.5	88.2	88.2	46.0	8	ML
18	77.5	42.4	45.0	1.32	1.00	1.00	1.00	4,438.5	1.00	55.3	5.5	59.2	59.2	46.0	8	ML
19	82.5	37.4	50.0	1.32	1.00	1.00	1.00	4,676.5	1.00	55.3	5.5	65.8	65.8	46.0	8	ML
20	87.5	32.4	50.0	1.32	1.00	1.00	1.00	4,883.5	1.00	55.3	5.5	65.8	65.8	46.0	8	ML
21	92.5	27.4	41.0	1.32	1.00	1.00	1.00	5,171.5	0.62	5.0	0.0	54.0	33.6	33.6	9	SW-SM/SW-SC/SP-SM/SP-SC
22	67.5	52.4	50.0	1.32	1.00	1.00	1.00	3,962.5	0.71	5.0	0.0	65.8	46.8	46.0	10	SW-SM/SW-SC/SP-SM/SP-SC
23	102.5	17.4	50.0	1.32	1.00	1.00	1.00	5,747.5	0.59	5.0	0.0	65.8	38.8	38.8	10	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-1**
 Boring Station = **5949+31.00**
 Boring Offset = **13 ft LT**
 Ground Elevation at Boring (ft msl) = **119.9**
 Water Table Depth (Dw) (ft) = **7.7**
 Water Table Elevation (msl ft) = **112.2**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **10** each
 No. of Split Spoon Samples = **23** each
 Total Profile Thickness = **103** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
	0	119.9																	
1	2.5	117.4	4.0	3.7	6.3	9.9	1	SM/SC/SC-SM		No Liquefaction		16.2				30		30	
2	5.5	114.4	8.0	8.2	13.9	17.5	1	SM/SC/SC-SM		No Liquefaction		16.2				35		35	
3	7.5	112.4	4.0	4.3	6.5	10.2	1	SM/SC/SC-SM		No Liquefaction		16.2				30		30	
4	9.5	110.4	2.0	2.2	3.2	8.6	2	SM/SC/SC-SM		No Strength Loss		32.3					400		400
5	12.5	107.4	4.0	4.7	6.2	11.7	3	SM/SC/SC-SM		No Strength Loss		32.3					500		500
6	17.5	102.4	23.0	28.3	33.6	33.6	4	SP/SW		No Liquefaction		4.4				32		32	
7	22.5	97.4	11.0	13.9	15.2	20.5	5	SM/SC/SC-SM		No Liquefaction		28.5				36		36	
8	27.5	92.4	37.0	47.6	48.2	46.0	5	SM/SC/SC-SM		No Liquefaction		28.5				36		36	
9	32.5	87.4	14.0	18.2	17.3	22.3	6	SM/SC/SC-SM		No Liquefaction		24.5				36		36	
10	36.4	83.5	50.0	65.3	59.4	46.0	6	SM/SC/SC-SM		No Liquefaction		24.5				36		36	
11	42.5	77.4	17.0	22.3	19.0	24.5	7	SM/SC/SC-SM		No Liquefaction		44.0				36		36	
12	47.5	72.4	25.0	32.8	26.8	32.3	7	SM/SC/SC-SM		No Liquefaction		44.0				36		36	
13	52.5	67.4	32.0	42.1	42.1	46.0	8	ML		No Liquefaction		55.3				30		30	
14	57.5	62.4	27.0	35.5	35.5	41.0	8	ML		No Liquefaction		55.3				30		30	
15	62.5	57.4	32.0	42.1	42.1	46.0	8	ML		No Liquefaction		55.3				30		30	
16	67.5	52.4	45.0	59.2	59.2	46.0	8	ML		No Liquefaction		55.3				30		30	
17	72.5	47.4	67.0	88.2	88.2	46.0	8	ML		No Liquefaction		55.3				30		30	
18	77.5	42.4	45.0	59.2	59.2	46.0	8	ML		No Liquefaction		55.3				30		30	
19	82.5	37.4	50.0	65.8	65.8	46.0	8	ML		No Liquefaction		55.3				30		30	
20	87.5	32.4	50.0	65.8	65.8	46.0	8	ML		No Liquefaction		55.3				30		30	
21	92.5	27.4	41.0	54.0	33.6	33.6	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				30		30	
22	67.5	52.4	50.0	65.8	46.8	46.0	10	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
23	102.5	17.4	50.0	65.8	38.8	38.8	10	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	1/21/2015
Project:	RBO Four Hole Swamp						
Location:	EB1 B-1A	Station:	5949+31.75	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp			Longitude:	80.6470
Route:	US 301	County:	38 - Orangeburg	Location:	EB1 B-1A

Designer:	R. Gardner - Midlands RPG
Date:	1/21/2015
Station:	5949+31.75

Boring Number =	B-1A
Boring Station =	5949+31.75
Boring Offset =	8.75 ft RT
Ground Elevation at Boring (ft msl) =	119.9
Water Table Depth (Dw) (ft) =	6
Water Table Elevation (msl ft) =	113.9

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	15	each
No. of Split Spoon Samples =	28	each
Total Profile Thickness =	120	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	119.9														
1	2.7	117.2	44.0	1.27	1.00	0.71	1.00	310.5	1.70	12.0	2.1	39.7	67.5	46.0	1	SM/SC/SC-SM
2	4.7	115.2	29.0	1.27	1.00	0.76	1.00	550.5	1.70	0.0	0.0	28.0	47.6	46.0	2	SP/SW
3	6.7	113.2	12.0	1.27	1.00	0.80	1.00	746.8	1.64	0.0	0.0	12.2	20.0	20.0	2	SP/SW
4	8.7	111.2	4.0	1.27	1.00	0.84	1.00	862.0	1.52	0.0	0.0	4.3	6.5	6.5	2	SP/SW
5	9.7	110.2	3.0	1.27	1.00	0.85	1.00	919.6	1.47	73.0	5.5	3.3	4.8	10.3	2	SP/SW
6	10.7	109.2	3.0	1.27	1.00	0.87	1.00	960.7	1.00	42.3	5.5	3.3	3.3	8.8	3	CL
7	15	104.9	9.0	1.27	1.00	0.91	1.00	1,179.4	1.30	12.0	2.1	10.5	13.7	15.7	4	SM/SC/SC-SM
8	20	99.9	25.0	1.27	1.00	0.95	1.00	1,474.9	1.16	57.7	5.5	30.2	35.2	40.7	5	SP/SW
9	25	94.9	47.0	1.27	1.00	0.97	1.00	1,737.9	1.07	57.7	5.5	58.1	62.3	46.0	6	SM/SC/SC-SM
10	30	89.9	50.0	1.27	1.00	0.98	1.00	2,000.9	1.00	57.7	5.5	62.6	62.6	46.0	6	SM/SC/SC-SM
11	35	84.9	50.0	1.27	1.00	0.99	1.00	2,271.4	0.94	57.7	5.5	63.0	59.2	46.0	6	SM/SC/SC-SM
12	40	79.9	22.0	1.27	1.00	0.99	1.00	2,501.9	1.00	49.3	5.5	27.9	27.9	33.4	7	ML
13	45	74.9	50.0	1.27	1.00	1.00	1.00	2,772.4	0.85	56.0	5.5	63.5	53.9	46.0	8	SM/SC/SC-SM
14	50	69.9	21.0	1.27	1.00	1.00	1.00	3,010.4	1.00	66.3	5.5	26.7	26.7	32.2	9	ML
15	55	64.9	29.0	1.27	1.00	1.00	1.00	3,248.4	1.00	73.7	5.5	36.9	36.9	42.4	9	ML
16	60	59.9	42.0	1.27	1.00	1.00	1.00	3,486.4	1.00	73.7	5.5	53.4	53.4	46.0	9	ML
17	65	54.9	41.0	1.27	1.00	1.00	1.00	3,724.4	1.00	73.7	5.5	52.2	52.2	46.0	9	ML
18	70	49.9	36.0	1.27	1.00	1.00	1.00	3,962.4	1.00	51.0	5.5	45.8	45.8	46.0	10	ML
19	75	44.9	51.0	1.27	1.00	1.00	1.00	4,192.9	1.00	51.0	5.5	64.9	64.9	46.0	10	ML
20	80	39.9	50.0	1.27	1.00	1.00	1.00	4,455.9	0.67	12.0	2.1	63.7	42.7	44.7	11	SM/SC/SC-SM
21	85	34.9	50.0	1.27	1.00	1.00	1.00	4,718.9	0.65	12.0	2.1	63.7	41.4	43.5	11	SM/SC/SC-SM
22	90	29.9	50.0	1.27	1.00	1.00	1.00	4,974.4	0.63	12.0	2.1	63.7	40.4	42.4	12	SM/SC/SC-SM
23	95	24.9	50.0	1.27	1.00	1.00	1.00	5,262.4	0.62	5.0	0.0	63.7	39.2	39.3	13	SW-SM/SW-SC/SP-SM/SP-SC
24	100	19.9	50.0	1.27	1.00	1.00	1.00	5,550.4	0.60	5.0	0.0	63.7	38.2	38.2	13	SW-SM/SW-SC/SP-SM/SP-SC
25	105	14.9	50.0	1.27	1.00	1.00	1.00	5,838.4	0.59	5.0	0.0	63.7	37.3	37.3	13	SW-SM/SW-SC/SP-SM/SP-SC
26	110	9.9	85.0	1.27	1.00	1.00	1.00	6,141.4	0.57	5.0	0.0	108.2	61.8	46.0	13	SW-SM/SW-SC/SP-SM/SP-SC
27	115	4.9	35.0	1.27	1.00	1.00	1.00	6,364.4	1.00	51.0	5.5	44.6	44.6	46.0	14	CL
28	120	-0.1	50.0	1.27	1.00	1.00	1.00	6,652.4	0.55	5.0	0.0	63.7	34.9	34.9	15	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-1A**
 Boring Station = **5949+31.75**
 Boring Offset = **8.75 ft RT**
 Ground Elevation at Boring (ft msl) = **119.9**
 Water Table Depth (Dw) (ft) = **6**
 Water Table Elevation (msl ft) = **113.9**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **15** each
 No. of Split Spoon Samples = **28** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	119.9																	
2	2.7	117.2	44.0	39.7	67.5	46.0	1	SM/SC/SC-SM		No Liquefaction		12.0				30		30	
3	4.7	115.2	29.0	28.0	47.6	46.0	2	SP/SW		No Liquefaction		0.0				32		32	
4	6.7	113.2	12.0	12.2	20.0	20.0	2	SP/SW		No Liquefaction		0.0				32		32	
5	8.7	111.2	4.0	4.3	6.5	6.5	2	SP/SW		No Liquefaction		0.0				30		30	
6	9.7	110.2	3.0	3.3	4.8	10.3	2	SP/SW		No Liquefaction		73.0				29		29	
7	10.7	109.2	3.0	3.3	3.3	8.8	3	CL		No Strength Loss		42.3					570		570
8	15	104.9	9.0	10.5	13.7	15.7	4	SM/SC/SC-SM		No Liquefaction		12.0				32		32	
9	20	99.9	25.0	30.2	35.2	40.7	5	SP/SW		No Liquefaction		57.7				36		36	
10	25	94.9	47.0	58.1	62.3	46.0	6	SM/SC/SC-SM		No Liquefaction		57.7				36		36	
11	30	89.9	50.0	62.6	62.6	46.0	6	SM/SC/SC-SM		No Liquefaction		57.7				36		36	
12	35	84.9	50.0	63.0	59.2	46.0	6	SM/SC/SC-SM		No Liquefaction		57.7				36		36	
13	40	79.9	22.0	27.9	27.9	33.4	7	ML		No Liquefaction		49.3				36		36	
14	45	74.9	50.0	63.5	53.9	46.0	8	SM/SC/SC-SM		No Liquefaction		56.0				36		36	
15	50	69.9	21.0	26.7	26.7	32.2	9	ML		No Liquefaction		66.3				30		30	
16	55	64.9	29.0	36.9	36.9	42.4	9	ML		No Liquefaction		73.7				30		30	
17	60	59.9	42.0	53.4	53.4	46.0	9	ML		No Liquefaction		73.7				30		30	
18	65	54.9	41.0	52.2	52.2	46.0	9	ML		No Liquefaction		73.7				30		30	
19	70	49.9	36.0	45.8	45.8	46.0	10	ML		No Liquefaction		51.0				30		30	
20	75	44.9	51.0	64.9	64.9	46.0	10	ML		No Liquefaction		51.0				30		30	
21	80	39.9	50.0	63.7	42.7	44.7	11	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
22	85	34.9	50.0	63.7	41.4	43.5	11	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
23	90	29.9	50.0	63.7	40.4	42.4	12	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
24	95	24.9	50.0	63.7	39.2	39.3	13	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
25	100	19.9	50.0	63.7	38.2	38.2	13	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
26	105	14.9	50.0	63.7	37.3	37.3	13	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
27	110	9.9	85.0	108.2	61.8	46.0	13	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
28	115	4.9	35.0	44.6	44.6	46.0	14	CL		No Strength Loss		51.0					4000		4000
	120	-0.1	50.0	63.7	34.9	34.9	15	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/29/2014
Project:	RBO Four Hole Swamp						
Location:	B-2	Station:	5949+65	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D	
Design Earthquake:	SEE	FEE
S_{D1} =	0.490	0.180
$k_{max} = PGA$ =	0.430	0.200
$\beta = S_{D1}/PGA$ =	1.140	0.900
α_w =	1.000	1.000
$k_h = k_{avg}$ =	0.430	0.200
M_w =	7.37	7.36
R =	63.5	64.2
\bar{V}_s =	1,005.40	1,005.40
Z_{HR} =	494.50	494.50
ϵ =	0.000	0.000
D_{a5-95}	30.15	30.09

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$0.50 \leq \beta \leq 1.5$

$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0$: for $h_{slope} \leq 20$ ft $\alpha_w = 1.0$

$k_h = k_{avg} = \alpha_w k_{max}$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

R < 20 km; $\epsilon = 0.015(R-20)$

R \geq 20 km; $\epsilon = 0$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	9/29/2014
Route:	US 301	County:	38 - Orangeburg	Location:	B-2	Station:	5949+65

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.4
R (km) =	63.5
D _{0.5-95} (sec) =	30.15

Boring Number =	B-2
Boring Station =	5949+65.00
Boring Offset =	9 ft RT
Ground Elevation at Boring (ft msl) =	108.8
Water Table Depth (D _w) (ft) =	0.0
Water Table Elevation (msl ft) =	108.8

Hammer Type =	Automatic
Energy Ratio =	79.0
Energy Correction (C _e) =	1.32
Borehole Diameter (in) =	4
Borehole Correction (CB) =	1.00

No. of Soil Layers =	13	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	111.5	feet
N-value Summary		

Sampler Configuration:	
Liner Required =	N
Liner Used =	N

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR* _{eq} /CRR* _{eq}	φ _{SL}	(D/C)SL ≤ φ _{SL}	R _u	Seismic Analysis Summary		Geotechnical Seismic Hazards Summary			
											φ' (degrees)	τ (psf)	ΔLDI _i (feet)	Σ ΔLDI _i (feet)	ΔS _i (inches)	
	0	108.8														
1	2.5	106.3	9.9	SM/SC/SC-SM	SSL	Sand-Like	2.93	0.90	Full Liquefaction	0.7 - 1.0	5.6		1.19	1.19	1.12	
2	5.5	103.3	22.6	SP/SW	NSL-S				No Liquefaction		32.0					
3	7.5	101.3	46.0	SP/SW	NSL-S				No Liquefaction		32.0					
4	9.5	99.3	33.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
5	11.5	97.3	46.0	ML	NSL-S				No Liquefaction		36.0					
6	16.5	92.3	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
7	20.4	88.4	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
8	26.5	82.3	33.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
9	31.5	77.3	29.6	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
10	36.5	72.3	33.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
11	41.5	67.3	21.8	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
12	46.5	62.3	30.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
13	51.5	57.3	41.6	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
14	56.5	52.3	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
15	61.5	47.3	35.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
16	66.5	42.3	44.2	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
17	71.5	37.3	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					
18	76.5	32.3	16.1	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		16.0					
19	81.5	27.3	26.8	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0					
20	86.5	22.3	43.3	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0					
21	91.5	17.3	42.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0					
22	106.5	2.3	37.9	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0					
23	111.5	-2.7	28.6	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0					

LDI Total (feet)	1.19	S Total (inches)	1.12
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^DDepth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	B-2

Designer:	R. Gardner - Midlands RPG
Date:	9/29/2014
Station:	5949+65

Boring Number =	B-2
Boring Station =	5949+65.00
Boring Offset =	9 ft RT
Ground Elevation at Boring (ft msl) =	108.8
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	108.8

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	13	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	112	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	108.8														
1	2.5	106.3	5.0	1.32	1.00	0.70	1.00	125.0	1.70	12.0	2.1	4.6	7.9	9.9	1	SM/SC/SC-SM
2	5.5	103.3	13.0	1.32	1.00	0.78	1.00	297.8	1.70	0.0	0.0	13.3	22.6	22.6	2	SP/SW
3	7.5	101.3	32.0	1.32	1.00	0.82	1.00	414.5	1.70	0.0	0.0	34.4	58.5	46.0	2	SP/SW
4	9.5	99.3	16.0	1.32	1.00	0.85	1.00	521.2	1.70	14.2	3.0	17.9	30.4	33.4	3	SM/SC/SC-SM
5	11.5	97.3	50.0	1.32	1.00	0.88	1.00	618.9	1.00	55.1	5.5	57.8	57.8	46.0	4	ML
6	16.5	92.3	50.0	1.32	1.00	0.93	1.00	881.9	1.51	46.7	5.5	61.1	91.9	46.0	5	SM/SC/SC-SM
7	20.4	88.4	50.0	1.32	1.00	0.95	1.00	1,087.0	1.36	39.2	5.5	62.7	85.0	46.0	6	SM/SC/SC-SM
8	26.5	82.3	18.0	1.32	1.00	0.98	1.00	1,407.9	1.19	39.2	5.5	23.1	27.5	33.0	6	SM/SC/SC-SM
9	31.5	77.3	17.0	1.32	1.00	0.99	1.00	1,670.9	1.09	39.2	5.5	22.1	24.1	29.6	6	SM/SC/SC-SM
10	36.5	72.3	21.0	1.32	1.00	0.99	1.00	1,933.9	1.02	43.8	5.5	27.4	27.9	33.4	7	SM/SC/SC-SM
11	41.5	67.3	13.0	1.32	1.00	1.00	1.00	2,196.9	0.95	47.1	5.5	17.0	16.3	21.8	8	SM/SC/SC-SM
12	46.5	62.3	21.0	1.32	1.00	1.00	1.00	2,459.9	0.90	47.1	5.5	27.6	24.9	30.4	8	SM/SC/SC-SM
13	51.5	57.3	32.0	1.32	1.00	1.00	1.00	2,722.9	0.86	47.1	5.5	42.1	36.1	41.6	8	SM/SC/SC-SM
14	56.5	52.3	41.0	1.32	1.00	1.00	1.00	2,985.9	0.82	47.1	5.5	53.9	44.1	46.0	8	SM/SC/SC-SM
15	61.5	47.3	29.0	1.32	1.00	1.00	1.00	3,248.9	0.78	48.7	5.5	38.2	29.9	35.4	9	SM/SC/SC-SM
16	66.5	42.3	39.0	1.32	1.00	1.00	1.00	3,511.9	0.75	48.7	5.5	51.3	38.7	44.2	9	SM/SC/SC-SM
17	71.5	37.3	50.0	1.32	1.00	1.00	1.00	3,767.4	0.73	23.0	4.9	65.8	48.0	46.0	10	SM/SC/SC-SM
18	76.5	32.3	17.0	1.32	1.00	1.00	1.00	4,055.4	0.70	7.9	0.3	22.4	15.7	16.1	11	SW-SM/SW-SC/SP-SM/SP-SC
19	81.5	27.3	30.0	1.32	1.00	1.00	1.00	4,343.4	0.68	5.0	0.0	39.5	26.8	26.8	12	SW-SM/SW-SC/SP-SM/SP-SC
20	86.5	22.3	50.0	1.32	1.00	1.00	1.00	4,631.4	0.66	5.0	0.0	65.8	43.3	43.3	12	SW-SM/SW-SC/SP-SM/SP-SC
21	91.5	17.3	50.0	1.32	1.00	1.00	1.00	4,919.4	0.64	5.0	0.0	65.8	42.0	42.0	12	SW-SM/SW-SC/SP-SM/SP-SC
22	106.5	2.3	49.0	1.32	1.00	1.00	1.00	5,790.9	0.59	5.0	0.0	64.5	37.9	37.9	12	SW-SM/SW-SC/SP-SM/SP-SC
23	111.5	-2.7	35.0	1.32	1.00	1.00	1.00	6,053.9	0.57	12.0	2.1	46.1	26.5	28.6	13	SM/SC/SC-SM

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-2**
 Boring Station = **5949+65.00**
 Boring Offset = **9 ft RT**
 Ground Elevation at Boring (ft msl) = **108.8**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.8**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **13** each
 No. of Split Spoon Samples = **23** each
 Total Profile Thickness = **112** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	108.8																	
2	2.5	106.3	5.0	4.6	7.9	9.9	1	SM/SC/SC-SM	Sand-Like	Full Liquefaction	31.7	12.0				31		6	
3	5.5	103.3	13.0	13.3	22.6	22.6	2	SP/SW		No Liquefaction		0.0				32		32	
4	7.5	101.3	32.0	34.4	58.5	46.0	2	SP/SW		No Liquefaction		0.0				32		32	
5	9.5	99.3	16.0	17.9	30.4	33.4	3	SM/SC/SC-SM		No Liquefaction		14.2				36		36	
6	11.5	97.3	50.0	57.8	57.8	46.0	4	ML		No Liquefaction		55.1				36		36	
7	16.5	92.3	50.0	61.1	91.9	46.0	5	SM/SC/SC-SM		No Liquefaction		46.7				36		36	
8	20.4	88.4	50.0	62.7	85.0	46.0	6	SM/SC/SC-SM		No Liquefaction		39.2				36		36	
9	26.5	82.3	18.0	23.1	27.5	33.0	6	SM/SC/SC-SM		No Liquefaction		39.2				36		36	
10	31.5	77.3	17.0	22.1	24.1	29.6	6	SM/SC/SC-SM		No Liquefaction		39.2				36		36	
11	36.5	72.3	21.0	27.4	27.9	33.4	7	SM/SC/SC-SM		No Liquefaction		43.8				36		36	
12	41.5	67.3	13.0	17.0	16.3	21.8	8	SM/SC/SC-SM		No Liquefaction		47.1				36		36	
13	46.5	62.3	21.0	27.6	24.9	30.4	8	SM/SC/SC-SM		No Liquefaction		47.1				36		36	
14	51.5	57.3	32.0	42.1	36.1	41.6	8	SM/SC/SC-SM		No Liquefaction		47.1				36		36	
15	56.5	52.3	41.0	53.9	44.1	46.0	8	SM/SC/SC-SM		No Liquefaction		47.1				36		36	
16	61.5	47.3	29.0	38.2	29.9	35.4	9	SM/SC/SC-SM		No Liquefaction		48.7				36		36	
17	66.5	42.3	39.0	51.3	38.7	44.2	9	SM/SC/SC-SM		No Liquefaction		48.7				36		36	
18	71.5	37.3	50.0	65.8	48.0	46.0	10	SM/SC/SC-SM		No Liquefaction		23.0				36		36	
19	76.5	32.3	17.0	22.4	15.7	16.1	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		7.9				36		16	
20	81.5	27.3	30.0	39.5	26.8	26.8	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
21	86.5	22.3	50.0	65.8	43.3	43.3	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
22	91.5	17.3	50.0	65.8	42.0	42.0	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
23	106.5	2.3	49.0	64.5	37.9	37.9	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
	111.5	-2.7	35.0	46.1	26.5	28.6	13	SM/SC/SC-SM		No Liquefaction		12.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/30/2014
Project:	RBO Four Hole Swamp						
Location:	B-3	Station:	5950+02	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp			Longitude:	80.6470
Route:	US 301	County:	38 - Orangeburg	Location:	B-3

Designer:	R. Gardner - Midlands RPG
Date:	9/30/2014
Station:	5950+02

Boring Number =	B-3
Boring Station =	5950+02.00
Boring Offset =	3 ft RT
Ground Elevation at Boring (ft msl) =	108.5
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	108.5

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	10	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	102	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	108.5														
1	2.5	106.0	5.0	1.32	1.00	0.70	1.00	144.0	1.70	0.5	0.0	4.6	7.9	7.9	1	SP/SW
2	5.5	103.0	12.0	1.32	1.00	0.78	1.00	316.8	1.70	0.5	0.0	12.3	20.9	20.9	1	SP/SW
3	7.5	101.0	18.0	1.32	1.00	0.82	1.00	432.0	1.70	0.5	0.0	19.3	32.9	32.9	1	SP/SW
4	9.5	99.0	12.0	1.32	1.00	0.85	1.00	546.2	1.70	0.5	0.0	13.4	22.8	22.8	1	SP/SW
5	11.5	97.0	42.0	1.32	1.00	0.88	1.00	641.4	1.00	51.9	5.5	48.5	48.5	46.0	2	ML
6	16.5	92.0	36.0	1.32	1.00	0.93	1.00	864.4	1.00	55.2	5.5	44.0	44.0	46.0	3	ML
7	20.3	88.2	50.0	1.32	1.00	0.95	1.00	1,064.3	1.37	43.6	5.5	62.6	85.9	46.0	4	SM/SC/SC-SM
8	26.5	82.0	11.0	1.32	1.00	0.98	1.00	1,390.4	1.20	43.6	5.5	14.1	16.9	22.4	4	SM/SC/SC-SM
9	31.5	77.0	17.0	1.32	1.00	0.99	1.00	1,653.4	1.10	43.6	5.5	22.1	24.3	29.8	4	SM/SC/SC-SM
10	36.5	72.0	13.0	1.32	1.00	0.99	1.00	1,916.4	1.02	47.3	5.5	17.0	17.3	22.8	5	SM/SC/SC-SM
11	41.5	67.0	18.0	1.32	1.00	1.00	1.00	2,179.4	0.96	47.3	5.5	23.6	28.1	5	SM/SC/SC-SM	
12	46.5	62.0	13.0	1.32	1.00	1.00	1.00	2,442.4	0.90	47.3	5.5	17.1	15.4	20.9	5	SM/SC/SC-SM
13	51.5	57.0	23.0	1.32	1.00	1.00	1.00	2,705.4	0.86	47.3	5.5	30.2	26.0	31.5	5	SM/SC/SC-SM
14	56.5	52.0	15.0	1.32	1.00	1.00	1.00	2,968.4	0.82	47.3	5.5	19.7	16.2	21.7	6	SM/SC/SC-SM
15	61.5	47.0	1.0	1.32	1.00	1.00	1.00	3,222.4	0.79	28.0	5.3	1.3	1.0	6.3	7	SM/SC/SC-SM
16	66.5	42.0	1.0	1.32	1.00	1.00	1.00	3,510.4	0.75	0.0	0.0	1.3	1.0	1.0	8	SP/SW
17	71.5	37.0	1.0	1.32	1.00	1.00	1.00	3,798.4	0.73	0.0	0.0	1.3	1.0	1.0	8	SP/SW
18	76.5	32.0	1.0	1.32	1.00	1.00	1.00	4,086.4	0.70	0.0	0.0	1.3	0.9	0.9	8	SP/SW
19	81.5	27.0	26.0	1.32	1.00	1.00	1.00	4,374.4	0.68	5.7	0.0	34.2	23.1	23.2	9	SW-SM/SW-SC/SP-SM/SP-SC
20	86.5	22.0	46.0	1.32	1.00	1.00	1.00	4,662.4	0.65	5.0	0.0	60.6	39.7	39.7	9	SW-SM/SW-SC/SP-SM/SP-SC
21	91.5	17.0	30.0	1.32	1.00	1.00	1.00	4,950.4	0.64	5.0	0.0	39.5	25.1	25.1	9	SW-SM/SW-SC/SP-SM/SP-SC
22	96.5	12.0	48.0	1.32	1.00	1.00	1.00	5,255.9	0.62	5.0	0.0	63.2	39.0	39.0	9	SW-SM/SW-SC/SP-SM/SP-SC
23	101.5	7.0	26.0	1.32	1.00	1.00	1.00	5,518.9	0.60	42.6	5.5	34.2	20.6	26.1	10	SM/SC/SC-SM

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-3**
 Boring Station = **5950+02.00**
 Boring Offset = **3 ft RT**
 Ground Elevation at Boring (ft msl) = **108.5**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.5**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **10** each
 No. of Split Spoon Samples = **23** each
 Total Profile Thickness = **102** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
	0	108.5																	
1	2.5	106.0	5.0	4.6	7.9	7.9	1	SP/SW	Sand-Like	Full Liquefaction	31.7	0.5				31		5	
2	5.5	103.0	12.0	12.3	20.9	20.9	1	SP/SW		No Liquefaction		0.5				32		32	
3	7.5	101.0	18.0	19.3	32.9	32.9	1	SP/SW		No Liquefaction		0.5				32		32	
4	9.5	99.0	12.0	13.4	22.8	22.8	1	SP/SW		No Liquefaction		0.5				32		32	
5	11.5	97.0	42.0	48.5	48.5	46.0	2	ML		No Liquefaction		51.9				36		36	
6	16.5	92.0	36.0	44.0	44.0	46.0	3	ML		No Liquefaction		55.2				36		36	
7	20.3	88.2	50.0	62.6	85.9	46.0	4	SM/SC/SC-SM		No Liquefaction		43.6				36		36	
8	26.5	82.0	11.0	14.1	16.9	22.4	4	SM/SC/SC-SM		No Liquefaction		43.6				36		36	
9	31.5	77.0	17.0	22.1	24.3	29.8	4	SM/SC/SC-SM		No Liquefaction		43.6				36		36	
10	36.5	72.0	13.0	17.0	17.3	22.8	5	SM/SC/SC-SM		No Liquefaction		47.3				36		36	
11	41.5	67.0	18.0	23.6	22.6	28.1	5	SM/SC/SC-SM		No Liquefaction		47.3				36		36	
12	46.5	62.0	13.0	17.1	15.4	20.9	5	SM/SC/SC-SM		No Liquefaction		47.3				36		36	
13	51.5	57.0	23.0	30.2	26.0	31.5	5	SM/SC/SC-SM		No Liquefaction		47.3				36		36	
14	56.5	52.0	15.0	19.7	16.2	21.7	6	SM/SC/SC-SM		No Liquefaction		47.3				36		36	
15	61.5	47.0	1.0	1.3	1.0	6.3	7	SM/SC/SC-SM		No Liquefaction		28.0				24		24	
16	66.5	42.0	1.0	1.3	1.0	1.0	8	SP/SW		No Liquefaction		0.0				24		24	
17	71.5	37.0	1.0	1.3	1.0	1.0	8	SP/SW		No Liquefaction		0.0				24		24	
18	76.5	32.0	1.0	1.3	0.9	0.9	8	SP/SW		No Liquefaction		0.0				24		24	
19	81.5	27.0	26.0	34.2	23.1	23.2	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.7				38		38	
20	86.5	22.0	46.0	60.6	39.7	39.7	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				38		38	
21	91.5	17.0	30.0	39.5	25.1	25.1	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				38		38	
22	96.5	12.0	48.0	63.2	39.0	39.0	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				38		38	
23	101.5	7.0	26.0	34.2	20.6	26.1	10	SM/SC/SC-SM		No Liquefaction		42.6				38		38	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	1/21/2015
Project:	RBO Four Hole Swamp						
Location:	B-3A	Station:	5950+10.72	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D	
Design Earthquake:	SEE	FEE
S_{D1} =	0.490	0.180
$k_{max} = PGA$ =	0.430	0.200
$\beta = S_{D1}/PGA$ =	1.140	0.900
α_w =	1.000	1.000
$k_h = k_{avg}$ =	0.430	0.200
M_w =	7.37	7.36
R =	63.5	64.2
\bar{V}_s =	1,005.40	1,005.40
Z_{HR} =	494.50	494.50
ϵ =	0.000	0.000
D_{a5-95}	30.15	30.09

β = Ground Motion Index: $0.50 \leq \beta \leq 1.5$
 α_w = Wave Scattering Scaling Factor: $1+0.01h_{slope}[(0.5\beta)-1] \leq 1.0$: for $h_{slope} \leq 20ft$ $\alpha_w = 1.0$
 k_h = Average seismic horizontal coefficient due to wave scattering: $k_h = k_{avg} = \alpha_w k_{max}$
 M_w = Moment Magnitude of Design Earthquake M_w & R = Deaggregation Analysis
R = Site-to-Source Distance
 \bar{V}_s = Average Shear Wave Velocity \bar{V}_s from Three-Point Method Excel Spreadsheet
 Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output
 ϵ = Near-fault directivity correction: $R < 20$ km; $\epsilon = 0.015(R-20)$
 D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48 $R \geq 20$ km; $\epsilon = 0$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	1/21/2015
Route:	US 301	County:	38 - Orangeburg	Location:	B-3A	Station:	5950+10.72

Boring Number =	B-3A
Boring Station =	5950+10.72
Boring Offset =	6.25 LT
Ground Elevation at Boring (ft msl) =	109.1
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	109.1

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	14	each
No. of Split Spoon Samples =	36	each
Total Profile Thickness =	120	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	109.1														
1	2	107.1	1.0	1.27	1.00	0.69	1.00	95.2	1.00	51.0	5.5	0.9	0.9	6.4	1	CL
2	4	105.1	3.0	1.27	1.00	0.74	1.00	195.4	1.00	51.0	5.5	2.8	2.8	8.3	1	CL
3	6	103.1	9.0	1.27	1.00	0.79	1.00	310.6	1.70	0.0	0.0	9.0	15.3	15.3	2	SP/SW
4	8	101.1	27.0	1.27	1.00	0.83	1.00	425.8	1.70	0.0	0.0	28.4	48.2	46.0	3	SP/SW
5	10	99.1	17.0	1.27	1.00	0.86	1.00	564.0	1.70	0.0	0.0	18.6	31.5	31.5	3	SP/SW
6	15	94.1	40.0	1.27	1.00	0.91	1.00	790.5	1.00	53.1	5.5	46.6	46.6	46.0	4	ML
7	20	89.1	50.0	1.27	1.00	0.95	1.00	1,065.0	1.37	42.8	5.5	60.5	82.9	46.0	5	SM/SC/SC-SM
8	25	84.1	27.0	1.27	1.00	0.97	1.00	1,303.0	1.00	51.0	5.5	33.4	33.4	38.9	6	ML
9	30	79.1	27.0	1.27	1.00	0.98	1.00	1,541.0	1.00	51.0	5.5	33.8	33.8	39.3	6	ML
10	35	74.1	36.0	1.27	1.00	0.99	1.00	1,779.0	1.00	51.0	5.5	45.4	45.4	46.0	6	ML
11	40	69.1	27.0	1.27	1.00	0.99	1.00	2,017.0	1.00	51.0	5.5	34.2	34.2	39.7	6	ML
12	45	64.1	16.0	1.27	1.00	1.00	1.00	2,255.0	1.00	63.3	5.5	20.3	20.3	25.8	6	ML
13	50	59.1	41.0	1.27	1.00	1.00	1.00	2,493.0	1.00	51.0	5.5	52.1	52.1	46.0	6	ML
14	52	57.1	47.0	1.27	1.00	1.00	1.00	2,588.2	1.00	68.3	5.5	59.8	59.8	46.0	6	ML
15	54	55.1	56.0	1.27	1.00	1.00	1.00	2,683.4	1.00	51.0	5.5	71.2	71.2	46.0	6	ML
16	56	53.1	50.0	1.27	1.00	1.00	1.00	2,778.6	1.00	51.0	5.5	63.6	63.6	46.0	6	ML
17	58	51.1	45.0	1.27	1.00	1.00	1.00	2,873.8	1.00	51.0	5.5	57.3	57.3	46.0	6	ML
18	60	49.1	2.0	1.27	1.00	1.00	1.00	2,969.0	1.00	60.1	5.5	2.5	2.5	8.0	7	MH
19	62	47.1	3.0	1.27	1.00	1.00	1.00	3,064.2	1.00	60.1	5.5	3.8	3.8	9.3	7	MH
20	64	45.1	1.0	1.27	1.00	1.00	1.00	3,159.4	1.00	64.0	5.5	1.3	1.3	6.8	7	MH
21	66	43.1	1.0	1.27	1.00	1.00	1.00	3,254.6	1.00	64.0	5.5	1.3	1.3	6.8	7	MH
22	68	41.1	1.0	1.27	1.00	1.00	1.00	3,349.8	1.00	62.8	5.5	1.3	1.3	6.8	7	MH
23	70	39.1	2.0	1.27	1.00	1.00	1.00	3,455.0	0.76	41.0	5.5	2.5	1.9	7.4	8	SM/SC/SC-SM
24	72	37.1	3.0	1.27	1.00	1.00	1.00	3,560.2	0.75	39.7	5.5	3.8	2.9	8.4	8	SM/SC/SC-SM
25	74	35.1	3.0	1.27	1.00	1.00	1.00	3,665.4	0.74	32.8	5.5	3.8	2.8	8.3	8	SM/SC/SC-SM
26	76	33.1	19.0	1.27	1.00	1.00	1.00	3,780.6	0.73	5.0	0.0	24.2	17.6	17.6	9	SW-SM/SW-SC/SP-SM/SP-SC
27	78	31.1	9.0	1.27	1.00	1.00	1.00	3,895.8	0.72	10.4	1.3	11.5	8.2	9.5	9	SW-SM/SW-SC/SP-SM/SP-SC
28	80	29.1	50.0	1.27	1.00	1.00	1.00	3,992.0	0.71	19.9	4.5	63.7	45.1	46.0	10	SM/SC/SC-SM
29	85	24.1	50.0	1.27	1.00	1.00	1.00	4,280.0	0.68	5.0	0.0	63.7	43.5	43.5	11	SW-SM/SW-SC/SP-SM/SP-SC
30	90	19.1	56.0	1.27	1.00	1.00	1.00	4,568.0	0.66	5.0	0.0	71.3	47.2	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC
31	95	14.1	69.0	1.27	1.00	1.00	1.00	4,856.0	0.64	5.0	0.0	87.9	56.4	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC
32	100	9.1	50.0	1.27	1.00	1.00	1.00	5,162.0	0.62	5.0	0.0	63.7	39.6	39.6	11	SW-SM/SW-SC/SP-SM/SP-SC
33	105	4.1	50.0	1.27	1.00	1.00	1.00	5,382.0	1.00	51.0	5.5	63.7	63.7	46.0	12	CL
34	110	-0.9	68.0	1.27	1.00	1.00	1.00	5,703.0	0.59	5.0	0.0	86.6	51.3	46.0	13	SW-SM/SW-SC/SP-SM/SP-SC
35	115	-5.9	50.0	1.27	1.00	1.00	1.00	5,941.0	1.00	80.0	5.5	63.7	63.7	46.0	14	MH
36	120	-10.9	50.0	1.27	1.00	1.00	1.00	6,179.0	1.00	80.0	5.5	63.7	63.7	46.0	14	MH

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-3A**
 Boring Station = **5950+10.72**
 Boring Offset = **6.25 LT**
 Ground Elevation at Boring (ft msl) = **109.1**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **109.1**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **14** each
 No. of Split Spoon Samples = **36** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths		
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)	
1	0	109.1																		
2	2	107.1	1.0	0.9	0.9	6.4	1	CL	HS Clay-Like	No Strength Loss		51.0					200		200	
3	4	105.1	3.0	2.8	2.8	8.3	1	CL	HS Clay-Like	No Strength Loss		51.0					600		600	
4	6	103.1	9.0	9.0	15.3	15.3	2	SP/SW	Sand-Like	Full Liquefaction	44.3	0.0						13		
5	8	101.1	27.0	28.4	48.2	46.0	3	SP/SW		No Liquefaction		0.0					32		32	
6	10	99.1	17.0	18.6	31.5	31.5	3	SP/SW		No Liquefaction		0.0					32		32	
7	15	94.1	40.0	46.6	46.6	46.0	4	ML	HS Clay-Like	No Strength Loss		53.1					1710		1710	
8	20	89.1	50.0	60.5	82.9	46.0	5	SM/SC/SC-SM	HS Clay-Like	No Strength Loss		42.8					1780		1780	
9	25	84.1	27.0	33.4	33.4	38.9	6	ML		No Liquefaction		51.0					36		36	
10	30	79.1	27.0	33.8	33.8	39.3	6	ML		No Liquefaction		51.0					36		36	
11	35	74.1	36.0	45.4	45.4	46.0	6	ML		No Liquefaction		51.0					36		36	
12	40	69.1	27.0	34.2	34.2	39.7	6	ML		No Liquefaction		51.0					36		36	
13	45	64.1	16.0	20.3	20.3	25.8	6	ML		No Liquefaction		63.3					36		36	
14	50	59.1	41.0	52.1	52.1	46.0	6	ML		No Strength Loss		51.0					2170		2170	
15	52	57.1	47.0	59.8	59.8	46.0	6	ML		No Strength Loss		68.3					2190		2190	
16	54	55.1	56.0	71.2	71.2	46.0	6	ML		No Strength Loss		51.0					2220		2220	
17	56	53.1	50.0	63.6	63.6	46.0	6	ML		No Strength Loss		51.0					2240		2240	
18	58	51.1	45.0	57.3	57.3	46.0	6	ML		No Strength Loss		51.0					2270		2270	
19	60	49.1	2.0	2.5	2.5	8.0	7	MH		No Liquefaction		60.1					26		5	
20	62	47.1	3.0	3.8	3.8	9.3	7	MH		No Liquefaction		60.1					28		5	
21	64	45.1	1.0	1.3	1.3	6.8	7	MH	HS Clay-Like	Strength Loss		64.0					300		150	
22	66	43.1	1.0	1.3	1.3	6.8	7	MH	HS Clay-Like	Strength Loss		64.0	0.004	83.4	1.8		300		240	
23	68	41.1	1.0	1.3	1.3	6.8	7	MH	HS Clay-Like	Strength Loss		62.8					300		240	
24	70	39.1	2.0	2.5	1.9	7.4	8	SM/SC/SC-SM	HS Clay-Like	Strength Loss		41.0	0.004	83.4	1.8		300		240	
25	72	37.1	3.0	3.8	2.9	8.4	8	SM/SC/SC-SM		No Liquefaction		39.7					27		5	
26	74	35.1	3.0	3.8	2.8	8.3	8	SM/SC/SC-SM	HS Clay-Like	Strength Loss		32.8					300		240	
27	76	33.1	19.0	24.2	17.6	17.6	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0					36		36	
28	78	31.1	9.0	11.5	8.2	9.5	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		10.4					31		5	
29	80	29.1	50.0	63.7	45.1	46.0	10	SM/SC/SC-SM		No Liquefaction		19.9					36		36	
30	85	24.1	50.0	63.7	43.5	43.5	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0					36		36	
31	90	19.1	56.0	71.3	47.2	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0					36		36	
32	95	14.1	69.0	87.9	56.4	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0					36		36	
33	100	9.1	50.0	63.7	39.6	39.6	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0					36		36	
34	105	4.1	50.0	63.7	63.7	46.0	12	CL		No Strength Loss		51.0						4000		4000
35	110	-0.9	68.0	86.6	51.3	46.0	13	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0	0.107	1.7	0.9		36		36	
36	115	-5.9	50.0	63.7	63.7	46.0	14	MH		No Strength Loss		80.0						3000		3000
	120	-10.9	50.0	63.7	63.7	46.0	14	MH		No Strength Loss		80.0						3000		3000

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/30/2014
Project:	RBO Four Hole Swamp						
Location:	B-4	Station:	5950+42.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$0.50 \leq \beta \leq 1.5$

$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0$: for $h_{slope} \leq 20$ ft $\alpha_w = 1.0$

$k_h = k_{avg} = \alpha_w k_{max}$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

R < 20 km; $\epsilon = 0.015(R-20)$

R \geq 20 km; $\epsilon = 0$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp	Longitude:	80.6470	Date:	9/30/2014		
Route:	US 301	County:	38 - Orangeburg	Location:	B-4	Station:	5950+42.00

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.4
R (km) =	63.5
D _{0.5-95} (sec) =	30.15

Boring Number =	B-4
Boring Station =	5950+42.00
Boring Offset =	8 ft RT
Ground Elevation at Boring (ft msl) =	107.9
Water Table Depth (D _w) (ft) =	0.0
Water Table Elevation (msl ft) =	107.9

Hammer Type =	Automatic
Energy Ratio =	79.0
Energy Correction (C _e) =	1.32
Borehole Diameter (in) =	4
Borehole Correction (CB) =	1.00

No. of Soil Layers =	11	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	101.5	feet

Sampler Configuration:	
Liner Required =	N
Liner Used =	N

N-value Summary

SSL Screening Summary

SSL Triggering Summary

Seismic Analysis Summary

Geotechnical Seismic Hazards Summary

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR ^{*_{eq}} /CRR ^{*_{eq}}	φ _{SL}	(D/C)SL ≤ φSL	R _u	φ' (degrees)	τ (psf)	ΔLD _i (feet)	Σ ΔLD _i (feet)	ΔS _i (inches)
	0	107.9													
1	2.3	105.6	46.0	SP/SW	NSL-S				No Liquefaction		32.0				
2	3.3	104.6	46.0	SP/SW	NSL-S				No Liquefaction		32.0				
3	7.5	100.4	18.3	SP/SW	SSL	Sand-Like	1.69	0.90	Full Liquefaction	0.7 - 1.0	30.4		0.81	0.81	1.25
4	9.5	98.4	15.2	SP/SW	SSL	Sand-Like	1.98	0.90	Full Liquefaction	0.7 - 1.0	12.9		0.54	1.35	0.68
5	11.5	96.4	27.5	ML	NSL-S				No Liquefaction		36.0				
6	16.5	91.4	23.8	ML	NSL-S				No Liquefaction		36.0				
7	21.5	86.4	30.5	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
8	26.5	81.4	23.9	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
9	31.5	76.4	34.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
10	36.5	71.4	33.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
11	41.5	66.4	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
12	46.5	61.4	25.7	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
13	51.5	56.4	31.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
14	56.5	51.4	44.3	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
15	61.5	46.4	32.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
16	66.5	41.4	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
17	71.5	36.4	24.7	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
18	76.5	31.4	37.9	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
19	81.5	26.4	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
20	86.5	21.4	35.7	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
21	91.5	16.4	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
22	96.5	11.4	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
23	101.5	6.4	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				

LDI Total (feet)	1.35
S Total (inches)	1.93

^DDepth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	B-4

Designer:	R. Gardner - Midlands RPG
Date:	9/30/2014
Station:	5950+42.00

Boring Number =	B-4
Boring Station =	5950+42.00
Boring Offset =	8 ft RT
Ground Elevation at Boring (ft msl) =	107.9
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	107.9

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	11	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	102	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	107.9														
1	2.3	105.6	50.0	1.32	1.00	0.70	1.00	132.5	1.70	0.1	0.0	46.0	78.1	46.0	1	SP/SW
2	3.3	104.6	50.0	1.32	1.00	0.72	1.00	190.1	1.70	0.1	0.0	47.7	81.1	46.0	1	SP/SW
3	7.5	100.4	10.0	1.32	1.00	0.82	1.00	432.0	1.70	0.1	0.0	10.7	18.3	18.3	1	SP/SW
4	9.5	98.4	8.0	1.32	1.00	0.85	1.00	550.2	1.70	0.1	0.0	9.0	15.2	15.2	1	SP/SW
5	11.5	96.4	19.0	1.32	1.00	0.88	1.00	645.4	1.00	50.2	5.5	22.0	22.0	27.5	2	ML
6	16.5	91.4	15.0	1.32	1.00	0.93	1.00	874.4	1.00	52.4	5.5	18.3	18.3	23.8	3	ML
7	21.5	86.4	15.0	1.32	1.00	0.96	1.00	1,137.4	1.33	32.8	5.5	18.9	25.1	30.5	4	SM/SC/SC-SM
8	26.5	81.4	12.0	1.32	1.00	0.98	1.00	1,400.4	1.20	49.8	5.5	15.4	18.4	23.9	5	SM/SC/SC-SM
9	31.5	76.4	20.0	1.32	1.00	0.99	1.00	1,663.4	1.10	49.4	5.5	26.0	28.5	34.0	6	SM/SC/SC-SM
10	36.5	71.4	21.0	1.32	1.00	0.99	1.00	1,926.4	1.02	49.4	5.5	27.4	27.9	33.4	6	SM/SC/SC-SM
11	41.5	66.4	39.0	1.32	1.00	1.00	1.00	2,189.4	0.96	49.4	5.5	51.1	48.8	46.0	6	SM/SC/SC-SM
12	46.5	61.4	17.0	1.32	1.00	1.00	1.00	2,452.4	0.90	49.4	5.5	22.3	20.2	25.7	6	SM/SC/SC-SM
13	51.5	56.4	23.0	1.32	1.00	1.00	1.00	2,715.4	0.86	42.6	5.5	30.2	25.9	31.4	7	SM/SC/SC-SM
14	56.5	51.4	36.0	1.32	1.00	1.00	1.00	2,978.4	0.82	42.6	5.5	47.4	38.8	44.3	7	SM/SC/SC-SM
15	61.5	46.4	26.0	1.32	1.00	1.00	1.00	3,241.4	0.79	42.6	5.5	34.2	26.9	32.4	7	SM/SC/SC-SM
16	66.5	41.4	51.0	1.32	1.00	1.00	1.00	3,504.4	0.76	33.5	5.5	67.1	50.7	46.0	8	SM/SC/SC-SM
17	71.5	36.4	20.0	1.32	1.00	1.00	1.00	3,767.4	0.73	33.5	5.5	26.3	19.2	24.7	8	SM/SC/SC-SM
18	76.5	31.4	35.0	1.32	1.00	1.00	1.00	4,030.4	0.70	33.5	5.5	46.1	32.5	37.9	8	SM/SC/SC-SM
19	81.5	26.4	50.0	1.32	1.00	1.00	1.00	4,280.9	0.68	27.3	5.2	65.8	45.0	46.0	9	SM/SC/SC-SM
20	86.5	21.4	41.0	1.32	1.00	1.00	1.00	4,568.9	0.66	5.0	0.0	54.0	35.7	35.7	10	SW-SM/SW-SC/SP-SM/SP-SC
21	91.5	16.4	68.0	1.32	1.00	1.00	1.00	4,856.9	0.64	5.0	0.0	89.5	57.5	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC
22	96.5	11.4	72.0	1.32	1.00	1.00	1.00	5,144.9	0.62	5.0	0.0	94.8	59.1	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC
23	101.5	6.4	66.0	1.32	1.00	1.00	1.00	5,432.9	0.61	5.0	0.0	86.9	52.7	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-4**
 Boring Station = **5950+42.00**
 Boring Offset = **8 ft RT**
 Ground Elevation at Boring (ft msl) = **107.9**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **107.9**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **11** each
 No. of Split Spoon Samples = **23** each
 Total Profile Thickness = **102** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	107.9																	
1	2.3	105.6	50.0	46.0	78.1	46.0	1	SP/SW		No Liquefaction		0.1				32		32	
2	3.3	104.6	50.0	47.7	81.1	46.0	1	SP/SW		No Liquefaction		0.1				32		32	
3	7.5	100.4	10.0	10.7	18.3	18.3	1	SP/SW	Sand-Like	Full Liquefaction	48.3	0.1				32		30	
4	9.5	98.4	8.0	9.0	15.2	15.2	1	SP/SW	Sand-Like	Full Liquefaction	44.1	0.1				32		13	
5	11.5	96.4	19.0	22.0	22.0	27.5	2	ML		No Liquefaction		50.2				36		36	
6	16.5	91.4	15.0	18.3	18.3	23.8	3	ML		No Liquefaction		52.4				36		36	
7	21.5	86.4	15.0	18.9	25.1	30.5	4	SM/SC/SC-SM		No Liquefaction		32.8				36		36	
8	26.5	81.4	12.0	15.4	18.4	23.9	5	SM/SC/SC-SM		No Liquefaction		49.8				36		36	
9	31.5	76.4	20.0	26.0	28.5	34.0	6	SM/SC/SC-SM		No Liquefaction		49.4				36		36	
10	36.5	71.4	21.0	27.4	27.9	33.4	6	SM/SC/SC-SM		No Liquefaction		49.4				36		36	
11	41.5	66.4	39.0	51.1	48.8	46.0	6	SM/SC/SC-SM		No Liquefaction		49.4				36		36	
12	46.5	61.4	17.0	22.3	20.2	25.7	6	SM/SC/SC-SM		No Liquefaction		49.4				36		36	
13	51.5	56.4	23.0	30.2	25.9	31.4	7	SM/SC/SC-SM		No Liquefaction		42.6				36		36	
14	56.5	51.4	36.0	47.4	38.8	44.3	7	SM/SC/SC-SM		No Liquefaction		42.6				36		36	
15	61.5	46.4	26.0	34.2	26.9	32.4	7	SM/SC/SC-SM		No Liquefaction		42.6				36		36	
16	66.5	41.4	51.0	67.1	50.7	46.0	8	SM/SC/SC-SM		No Liquefaction		33.5				36		36	
17	71.5	36.4	20.0	26.3	19.2	24.7	8	SM/SC/SC-SM		No Liquefaction		33.5				36		36	
18	76.5	31.4	35.0	46.1	32.5	37.9	8	SM/SC/SC-SM		No Liquefaction		33.5				36		36	
19	81.5	26.4	50.0	65.8	45.0	46.0	9	SM/SC/SC-SM		No Liquefaction		27.3				36		36	
20	86.5	21.4	41.0	54.0	35.7	35.7	10	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
21	91.5	16.4	68.0	89.5	57.5	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
22	96.5	11.4	72.0	94.8	59.1	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
23	101.5	6.4	66.0	86.9	52.7	46.0	11	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	9/30/2014
Project:	RBO Four Hole Swamp						
Location:	B-5	Station:	5950+98.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$0.50 \leq \beta \leq 1.5$$

$$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	9/30/2014
Route:	US 301	County:	38 - Orangeburg	Location:	B-5	Station:	5950+98.00

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.4
R (km) =	63.5
D _{0.5-95} (sec) =	30.15

Boring Number =	B-5
Boring Station =	5950+98.00
Boring Offset =	8 ft LT
Ground Elevation at Boring (ft msl) =	105.5
Water Table Depth (D _w) (ft) =	0.0
Water Table Elevation (msl ft) =	105.5

Hammer Type =	Automatic
Energy Ratio =	79.0
Energy Correction (C _e) =	1.32
Borehole Diameter (in) =	4
Borehole Correction (CB) =	1.00

No. of Soil Layers =	12	each
No. of Split Spoon Samples =	25	each
Total Profile Thickness =	101.3	feet

Sampler Configuration:	
Liner Required =	N
Liner Used =	N

N-value Summary				SSL Screening Summary		SSL Triggering Summary				Soil Shear Strength for Seismic Analysis Summary		Geotechnical Seismic Hazards Summary			
SPT Sample Number	Depth ⁰ (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR ^{*_{eq}} /CRR ^{*_{eq}}	φ _{SL}	(D/C) _{SL} ≤ φ _{SL}	R _u	φ' (degrees)	τ (psf)	ΔLD _i (feet)	Σ ΔLD _i (feet)	ΔS _i (inches)
1	3.5	102.0	8.6	SM/SC/SC-SM	SSL	Sand-Like	3.08	0.90	Full Liquefaction	0.7 - 1.0	4.9		1.75	1.75	1.71
2	5.5	100.0	27.8	SP/SW	NSL-S				No Liquefaction		38.0				
3	7.5	98.0	13.0	ML	SSL	Sand-Like	1.79	0.90	Full Liquefaction	0.7 - 1.0	8.3		0.68	2.43	0.76
4	8.3	97.2	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
5	10	95.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
6	11	94.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
7	16	89.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
8	21	84.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
9	26	79.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
10	31	74.5	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
11	33.9	71.6	24.8	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
12	36.5	69.0	33.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
13	41.5	64.0	44.8	ML	PSL	NS Clay-Like	0.69	0.90	No Strength Loss			2090.00			
14	46.5	59.0	46.0	ML	PSL	NS Clay-Like	0.74	0.90	No Strength Loss			2160.00			
15	51.5	54.0	35.7	ML	NSL-S				No Liquefaction		30.0				
16	56.5	49.0	33.1	ML	NSL-S				No Liquefaction		30.0				
17	61.5	44.0	26.3	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
18	66.5	39.0	1.0	SP/SW	NSL-S				No Liquefaction		2.0				
19	71.5	34.0	1.9	SP/SW	NSL-S				No Liquefaction		2.0				
20	76.5	29.0	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
21	81.5	24.0	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
22	86.5	19.0	35.7	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
23	91.5	14.0	46.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
24	96.5	9.0	37.8	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
25	101.3	4.2	40.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				

2.43	2.47
LDI Total (feet)	S Total (inches)

⁰Depth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308		Latitude:	33.4570
Project:	RBO Four Hole Swamp				Longitude:	80.6470
Route:	US 301	County:	38 - Orangeburg	Location:	B-5	

Designer:	R. Gardner - Midlands RPG
Date:	9/30/2014
Station:	5950+98.00

Boring Number =	B-5
Boring Station =	5950+98.00
Boring Offset =	8 ft LT
Ground Elevation at Boring (ft msl) =	105.5
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	105.5

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	12	each
No. of Split Spoon Samples =	25	each
Total Profile Thickness =	101	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	105.5														
1	3.5	102.0	4.0	1.32	1.00	0.73	1.00	184.6	1.70	12.0	2.1	3.8	6.5	8.6	1	SM/SC/SC-SM
2	5.5	100.0	16.0	1.32	1.00	0.78	1.00	302.8	1.70	3.8	0.0	16.4	27.8	27.8	2	SP/SW
3	7.5	98.0	7.0	1.32	1.00	0.82	1.00	396.5	1.00	59.9	5.5	7.5	7.5	13.0	3	ML
4	8.3	97.2	50.0	1.32	1.00	0.83	1.00	438.6	1.70	47.8	5.5	54.7	92.9	46.0	4	SM/SC/SC-SM
5	10	95.5	50.0	1.32	1.00	0.86	1.00	528.0	1.70	12.0	2.1	56.4	95.9	46.0	5	SM/SC/SC-SM
6	11	94.5	50.0	1.32	1.00	0.87	1.00	580.6	1.70	12.0	2.1	57.3	97.5	46.0	5	SM/SC/SC-SM
7	16	89.5	50.0	1.32	1.00	0.92	1.00	843.6	1.54	12.0	2.1	60.8	93.6	46.0	5	SM/SC/SC-SM
8	21	84.5	50.0	1.32	1.00	0.96	1.00	1,106.6	1.34	12.0	2.1	62.9	84.5	46.0	5	SM/SC/SC-SM
9	26	79.5	50.0	1.32	1.00	0.97	1.00	1,369.6	1.21	12.0	2.1	64.1	77.5	46.0	6	SM/SC/SC-SM
10	31	74.5	50.0	1.32	1.00	0.98	1.00	1,632.6	1.11	12.0	2.1	64.8	71.8	46.0	6	SM/SC/SC-SM
11	33.9	71.6	14.0	1.32	1.00	0.99	1.00	1,785.1	1.06	41.2	5.5	18.2	19.3	24.8	7	SM/SC/SC-SM
12	36.5	69.0	21.0	1.32	1.00	0.99	1.00	1,930.9	1.02	41.2	5.5	27.4	27.9	33.4	7	SM/SC/SC-SM
13	41.5	64.0	30.0	1.32	1.00	1.00	1.00	2,168.9	1.00	52.3	5.5	39.3	39.3	44.8	8	ML
14	46.5	59.0	32.0	1.32	1.00	1.00	1.00	2,406.9	1.00	52.3	5.5	42.0	42.0	46.0	8	ML
15	51.5	54.0	23.0	1.32	1.00	1.00	1.00	2,644.9	1.00	50.1	5.5	30.2	30.2	35.7	8	ML
16	56.5	49.0	21.0	1.32	1.00	1.00	1.00	2,873.9	1.00	50.1	5.5	27.6	27.6	33.1	9	ML
17	61.5	44.0	23.0	1.32	1.00	1.00	1.00	3,127.9	0.80	12.0	2.1	30.3	24.2	26.3	10	SM/SC/SC-SM
18	66.5	39.0	1.0	1.32	1.00	1.00	1.00	3,415.9	0.77	2.6	0.0	1.3	1.0	1.0	11	SP/SW
19	71.5	34.0	2.0	1.32	1.00	1.00	1.00	3,703.9	0.73	2.6	0.0	2.6	1.9	1.9	11	SP/SW
20	76.5	29.0	59.0	1.32	1.00	1.00	1.00	3,991.9	0.71	5.0	0.0	77.7	55.0	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC
21	81.5	24.0	73.0	1.32	1.00	1.00	1.00	4,279.9	0.68	5.0	0.0	96.1	65.7	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC
22	86.5	19.0	41.0	1.32	1.00	1.00	1.00	4,567.9	0.66	5.0	0.0	54.0	35.7	35.7	12	SW-SM/SW-SC/SP-SM/SP-SC
23	91.5	14.0	81.0	1.32	1.00	1.00	1.00	4,855.9	0.64	5.0	0.0	106.6	68.4	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC
24	96.5	9.0	46.0	1.32	1.00	1.00	1.00	5,143.9	0.62	5.0	0.0	60.6	37.8	37.8	12	SW-SM/SW-SC/SP-SM/SP-SC
25	101.3	4.2	50.0	1.32	1.00	1.00	1.00	5,420.4	0.61	5.0	0.0	65.8	40.0	40.0	12	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-5**
 Boring Station = **5950+98.00**
 Boring Offset = **8 ft LT**
 Ground Elevation at Boring (ft msl) = **105.5**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **105.5**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **12** each
 No. of Split Spoon Samples = **25** each
 Total Profile Thickness = **101** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _r (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	105.5																	
2	3.5	102.0	4.0	3.8	6.5	8.6	1	SM/SC/SC-SM	Sand-Like	Full Liquefaction	28.9	12.0				30		5	
3	5.5	100.0	16.0	16.4	27.8	27.8	2	SP/SW		No Liquefaction		3.8				38		38	
4	7.5	98.0	7.0	7.5	7.5	13.0	3	ML	Sand-Like	Full Liquefaction	40.4	59.9				30		8	
5	8.3	97.2	50.0	54.7	92.9	46.0	4	SM/SC/SC-SM		No Liquefaction		47.8				36		36	
6	10	95.5	50.0	56.4	95.9	46.0	5	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
7	11	94.5	50.0	57.3	97.5	46.0	5	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
8	16	89.5	50.0	60.8	93.6	46.0	5	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
9	21	84.5	50.0	62.9	84.5	46.0	5	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
10	26	79.5	50.0	64.1	77.5	46.0	6	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
11	31	74.5	50.0	64.8	71.8	46.0	6	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
12	33.9	71.6	14.0	18.2	19.3	24.8	7	SM/SC/SC-SM		No Liquefaction		41.2				36		36	
13	36.5	69.0	21.0	27.4	27.9	33.4	7	SM/SC/SC-SM		No Liquefaction		41.2				36		36	
14	41.5	64.0	30.0	39.3	39.3	44.8	8	ML	NS Clay-Like	No Strength Loss		52.3					2090		2090
15	46.5	59.0	32.0	42.0	42.0	46.0	8	ML	NS Clay-Like	No Strength Loss		52.3					2160		2160
16	51.5	54.0	23.0	30.2	30.2	35.7	8	ML		No Liquefaction		50.1				30		30	
17	56.5	49.0	21.0	27.6	27.6	33.1	9	ML		No Liquefaction		50.1				30		30	
18	61.5	44.0	23.0	30.3	24.2	26.3	10	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
19	66.5	39.0	1.0	1.3	1.0	1.0	11	SP/SW		No Liquefaction		2.6				24		2	
20	71.5	34.0	2.0	2.6	1.9	1.9	11	SP/SW		No Liquefaction		2.6				25		2	
21	76.5	29.0	59.0	77.7	55.0	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
22	81.5	24.0	73.0	96.1	65.7	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
23	86.5	19.0	41.0	54.0	35.7	35.7	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
24	91.5	14.0	81.0	106.6	68.4	46.0	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
25	96.5	9.0	46.0	60.6	37.8	37.8	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
25	101.3	4.2	50.0	65.8	40.0	40.0	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	2/18/2015
Project:	RBO Four Hole Swamp						
Location:	B-5A	Station:	5950+99.11	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.: 40308		File No.: 38.040308			Latitude: 33.4570		Designer: R. Gardner - Midlands RPG	
Project: RBO Four Hole Swamp		County: 38 - Orangeburg			Longitude: 80.6470		Date: 2/18/2015	
Route: US 301		Location: B-5A					Station: 5950+99.11	

Boring Number = B-5A
 Boring Station = 5950+99.11
 Boring Offset = 8.13 ft RT
 Ground Elevation at Boring (ft msl) = 107.6
 Water Table Depth (Dw) (ft) = 0
 Water Table Elevation (msl ft) = 107.6

Design EQ = SEE
 Site Class = D
 PGA (g) = 0.43
 M_w = 7.37
 R (km) = 63.5
 D_{a5-95} (sec) = 30.15

No. of Soil Layers = 9 each
 No. of Split Spoon Samples = 33 each
 Total Profile Thickness = 120 feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ'_{vo} (psf)	C _N	Fines Content (FC)	$\Delta N'_{1.60}$	N'_{60}	$N'_{1.60}$	$N'_{1.60,CS}$	Soil Layer No.	Soil Type (USCS)
	0	107.6														
1	4	103.6	9.0	1.27	1.00	0.74	1.00	210.4	1.70	12.0	2.1	8.5	14.5	16.5	1	SM/SC/SC-SM
2	6	101.6	18.0	1.27	1.00	0.79	1.00	315.6	1.70	12.0	2.1	18.0	30.7	32.7	1	SM/SC/SC-SM
3	8	99.6	30.0	1.27	1.00	0.83	1.00	430.8	1.70	0.0	0.0	31.5	53.6	46.0	2	SP/SW
4	9	98.6	50.0	1.27	1.00	0.84	1.00	488.4	1.70	0.0	0.0	53.6	91.1	46.0	2	SP/SW
5	10	97.6	50.0	1.27	1.00	0.86	1.00	541.0	1.70	12.0	2.1	54.6	92.8	46.0	3	SM/SC/SC-SM
6	15	92.6	50.0	1.27	1.00	0.91	1.00	804.0	1.58	47.9	5.5	58.2	91.9	46.0	3	SM/SC/SC-SM
7	20	87.6	34.0	1.27	1.00	0.95	1.00	1,074.5	1.36	47.9	5.5	41.1	56.1	46.0	3	SM/SC/SC-SM
8	25	82.6	14.0	1.27	1.00	0.97	1.00	1,312.5	1.00	63.4	5.5	17.3	17.3	22.8	4	ML
9	30	77.6	15.0	1.27	1.00	0.98	1.00	1,550.5	1.00	63.4	5.5	18.8	18.8	24.3	4	ML
10	35	72.6	52.0	1.27	1.00	0.99	1.00	1,788.5	1.00	52.3	5.5	65.6	65.6	46.0	4	ML
11	40	67.6	20.0	1.27	1.00	0.99	1.00	2,026.5	1.00	52.3	5.5	25.3	25.3	30.8	4	ML
12	45	62.6	32.0	1.27	1.00	1.00	1.00	2,264.5	1.00	66.3	5.5	40.6	40.6	46.0	4	ML
13	50	57.6	41.0	1.27	1.00	1.00	1.00	2,502.5	1.00	66.3	5.5	52.1	52.1	46.0	4	ML
14	55	52.6	38.0	1.27	1.00	1.00	1.00	2,740.5	1.00	67.6	5.5	48.3	48.3	46.0	4	ML
15	60	47.6	46.0	1.27	1.00	1.00	1.00	2,978.5	1.00	67.6	5.5	58.5	58.5	46.0	4	ML
16	62	45.6	36.0	1.27	1.00	1.00	1.00	3,073.7	1.00	67.6	5.5	45.8	45.8	46.0	4	ML
17	64	43.6	50.0	1.27	1.00	1.00	1.00	3,168.9	1.00	67.6	5.5	63.6	63.6	46.0	4	ML
18	66	41.6	50.0	1.27	1.00	1.00	1.00	3,264.1	1.00	67.6	5.5	63.6	63.6	46.0	4	ML
19	68	39.6	49.0	1.27	1.00	1.00	1.00	3,359.3	1.00	67.6	5.5	62.4	62.4	46.0	4	ML
20	70	37.6	50.0	1.27	1.00	1.00	1.00	3,454.5	1.00	67.6	5.5	63.7	63.7	46.0	4	ML
21	72	35.6	46.0	1.27	1.00	1.00	1.00	3,549.7	1.00	67.6	5.5	58.6	58.6	46.0	4	ML
22	74	33.6	84.0	1.27	1.00	1.00	1.00	3,644.9	1.00	67.6	5.5	106.9	106.9	46.0	4	ML
23	76	31.6	50.0	1.27	1.00	1.00	1.00	3,740.1	1.00	67.6	5.5	63.7	63.7	46.0	4	ML
24	78	29.6	30.0	1.27	1.00	1.00	1.00	3,845.3	0.72	19.2	4.3	38.2	27.5	31.9	5	SM/SC/SC-SM
25	80	27.6	37.0	1.27	1.00	1.00	1.00	3,950.5	0.71	19.2	4.3	47.1	33.5	37.9	5	SM/SC/SC-SM
26	85	22.6	50.0	1.27	1.00	1.00	1.00	4,213.5	0.69	13.2	2.6	63.7	43.9	46.0	6	SM/SC/SC-SM
27	88.9	18.7	50.0	1.27	1.00	1.00	1.00	4,418.6	0.67	13.2	2.6	63.7	42.8	45.4	6	SM/SC/SC-SM
28	95	12.6	50.0	1.27	1.00	1.00	1.00	4,739.5	0.65	13.2	2.6	63.7	41.4	43.9	6	SM/SC/SC-SM
29	100	7.6	50.0	1.27	1.00	1.00	1.00	5,011.5	0.63	13.2	2.6	63.7	40.2	42.8	6	SM/SC/SC-SM
30	105	2.6	36.0	1.27	1.00	1.00	1.00	5,240.5	1.00	61.0	5.5	45.8	45.8	46.0	7	CH
31	110	-2.4	50.0	1.27	1.00	1.00	1.00	5,503.5	0.60	12.0	2.1	63.7	38.4	40.5	8	SM/SC/SC-SM
32	115	-7.4	50.0	1.27	1.00	1.00	1.00	5,775.5	0.59	12.0	2.1	63.7	37.5	39.5	8	SM/SC/SC-SM
33	120	-12.4	50.0	1.27	1.00	1.00	1.00	6,013.5	1.00	65.0	5.5	63.7	63.7	46.0	9	MH

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = B-5A
 Boring Station = 5950+99.11
 Boring Offset = 8.13 ft RT
 Ground Elevation at Boring (ft msl) = 107.6
 Water Table Depth (Dw) (ft) = 0
 Water Table Elevation (msl ft) = 107.6

Design EQ = SEE
 Site Class = D
 PGA (g) = 0.43
 M_w = 7.37
 R (km) = 63.5
 D_{as-95} (sec) = 30.15

No. of Soil Layers = 9 each
 No. of Split Spoon Samples = 33 each
 Total Profile Thickness = 120 feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths		
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)	
	0	107.6																		
1	4	103.6	9.0	8.5	14.5	16.5	1	SM/SC/SC-SM	Sand-Like	Full Liquefaction	43.0	12.0				35		18		
2	6	101.6	18.0	18.0	30.7	32.7	1	SM/SC/SC-SM		No Liquefaction		12.0				35		35		
3	8	99.6	30.0	31.5	53.6	46.0	2	SP/SW		No Liquefaction		0.0				36		36		
4	9	98.6	50.0	53.6	91.1	46.0	2	SP/SW		No Liquefaction		0.0				32		32		
5	10	97.6	50.0	54.6	92.8	46.0	3	SM/SC/SC-SM		No Liquefaction		12.0				32		32		
6	15	92.6	50.0	58.2	91.9	46.0	3	SM/SC/SC-SM		No Liquefaction		47.9				36		36		
7	20	87.6	34.0	41.1	56.1	46.0	3	SM/SC/SC-SM		No Liquefaction		47.9				36		36		
8	25	82.6	14.0	17.3	17.3	22.8	4	ML		No Liquefaction		63.4				30		30		
9	30	77.6	15.0	18.8	18.8	24.3	4	ML		No Liquefaction		63.4				30		30		
10	35	72.6	52.0	65.6	65.6	46.0	4	ML		No Liquefaction		52.3				30		30		
11	40	67.6	20.0	25.3	25.3	30.8	4	ML		No Liquefaction		52.3				30		30		
12	45	62.6	32.0	40.6	40.6	46.0	4	ML		No Liquefaction		66.3				30		30		
13	50	57.6	41.0	52.1	52.1	46.0	4	ML		No Liquefaction		66.3				30		30		
14	55	52.6	38.0	48.3	48.3	46.0	4	ML		No Liquefaction		67.6				30		30		
15	60	47.6	46.0	58.5	58.5	46.0	4	ML		No Liquefaction		67.6				30		30		
16	62	45.6	36.0	45.8	45.8	46.0	4	ML		No Liquefaction		67.6				30		30		
17	64	43.6	50.0	63.6	63.6	46.0	4	ML		No Liquefaction		67.6				30		30		
18	66	41.6	50.0	63.6	63.6	46.0	4	ML		No Liquefaction		67.6				30		30		
19	68	39.6	49.0	62.4	62.4	46.0	4	ML		No Liquefaction		67.6				30		30		
20	70	37.6	50.0	63.7	63.7	46.0	4	ML		No Liquefaction		67.6				30		30		
21	72	35.6	46.0	58.6	58.6	46.0	4	ML		No Liquefaction		67.6				30		30		
22	74	33.6	84.0	106.9	106.9	46.0	4	ML		No Liquefaction		67.6				30		30		
23	76	31.6	50.0	63.7	63.7	46.0	4	ML		No Liquefaction		67.6				30		30		
24	78	29.6	30.0	38.2	27.5	31.9	5	SM/SC/SC-SM		No Liquefaction		19.2				36		36		
25	80	27.6	37.0	47.1	33.5	37.9	5	SM/SC/SC-SM		No Liquefaction		19.2				36		36		
26	85	22.6	50.0	63.7	43.9	46.0	6	SM/SC/SC-SM		No Liquefaction		13.2				36		36		
27	88.9	18.7	50.0	63.7	42.8	45.4	6	SM/SC/SC-SM		No Liquefaction		13.2				36		36		
28	95	12.6	50.0	63.7	41.4	43.9	6	SM/SC/SC-SM		No Liquefaction		13.2				36		36		
29	100	7.6	50.0	63.7	40.2	42.8	6	SM/SC/SC-SM		No Liquefaction		13.2				36		36		
30	105	2.6	36.0	45.8	45.8	46.0	7	CH	HS Clay-Like	No Strength Loss		61.0	0.004	18.7	3.3	4000		4000		
31	110	-2.4	50.0	63.7	38.4	40.5	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36		
32	115	-7.4	50.0	63.7	37.5	39.5	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36		
33	120	-12.4	50.0	63.7	63.7	46.0	9	MH	NS Clay-Like	No Strength Loss		65.0					5000		5000	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/1/2014
Project:	RBO Four Hole Swamp						
Location:	B-6	Station:	5951+41.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	10/1/2014
Route:	US 301	County:	38 - Orangeburg	Location:	B-6	Station:	5951+41.00

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.4
R (km) =	63.5
D ₈₅₋₉₅ (sec) =	30.15

Boring Number =	B-6
Boring Station =	5951+41.00
Boring Offset =	8 ft RT
Ground Elevation at Boring (ft msl) =	107.8
Water Table Depth (D _w) (ft) =	0.0
Water Table Elevation (msl ft) =	107.8

Hammer Type =	Automatic
Energy Ratio =	79.0
Energy Correction (C _e) =	1.32
Borehole Diameter (in) =	4
Borehole Correction (CB) =	1.00

No. of Soil Layers =	8	each
No. of Split Spoon Samples =	10	each
Total Profile Thickness =	35.2	feet

Sampler Configuration:	
Liner Required =	N
Liner Used =	N

N-value Summary				SSL Screening Summary		SSL Triggering Summary				Seismic Analysis Summary		Geotechnical Seismic Hazards Summary			
SPT Sample Number	Depth ^o (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR _{eq} ⁺ /CRR _{eq} ⁺	φ _{SL}	(D/C) _{SL} ≤ φ _{SL}	R _u	φ' (degrees)	τ (psf)	ΔLDI _i (feet)	ΣΔLDI _i (feet)	ΔS _i (inches)
	0	107.8													
1	3.5	104.3	13.5	SM/SC/SC-SM	NSL-S				No Liquefaction		9.0				
2	5.5	102.3	19.1	SP/SW	NSL-S				No Liquefaction		32.0				
3	7.5	100.3	46.0	SP/SW	NSL-S				No Liquefaction		32.0				
4	9.5	98.3	13.3	SP/SW	NSL-S				No Liquefaction		9.0				
5	11.5	96.3	6.5	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		4.0				
6	15.2	92.6	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
7	20.2	87.6	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
8	25.2	82.6	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
9	30.2	77.6	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
10	35.2	72.6	46.0	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
													0.00	0.00	

LDI Total (feet) S Total (inches)

^oDepth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	B-6

Designer:	R. Gardner - Midlands RPG
Date:	10/1/2014
Station:	5951+41.00

Boring Number =	B-6	Design EQ =	SEE
Boring Station =	5951+41.00	Site Class =	D
Boring Offset =	8 ft RT	PGA (g) =	0.43
Ground Elevation at Boring (ft msl) =	107.8	M _w =	7.37
Water Table Depth (Dw) (ft) =	0	R (km) =	63.5
Water Table Elevation (msl ft) =	107.8	D _{a5-95} (sec) =	30.15

No. of Soil Layers =	8	each
No. of Split Spoon Samples =	10	each
Total Profile Thickness =	35	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	107.8														
1	3.5	104.3	7.0	1.32	1.00	0.73	1.00	184.6	1.70	12.0	2.1	6.7	11.4	13.5	1	SM/SC/SC-SM
2	5.5	102.3	11.0	1.32	1.00	0.78	1.00	299.8	1.70	1.6	0.0	11.2	19.1	19.1	2	SP/SW
3	7.5	100.3	28.0	1.32	1.00	0.82	1.00	415.0	1.70	43.7	5.5	30.1	51.2	46.0	3	SP/SW
4	9.5	98.3	7.0	1.32	1.00	0.85	1.00	530.2	1.70	2.1	0.0	7.8	13.3	13.3	4	SP/SW
5	11.5	96.3	3.0	1.32	1.00	0.88	1.00	654.4	1.70	8.8	0.6	3.5	5.9	6.5	5	SW-SM/SW-SC/SP-SM/SP-SC
6	15.2	92.6	50.0	1.32	1.00	0.92	1.00	849.0	1.53	12.0	2.1	60.3	92.6	46.0	6	SM/SC/SC-SM
7	20.2	87.6	50.0	1.32	1.00	0.95	1.00	1,112.0	1.34	34.6	5.5	62.6	84.0	46.0	7	SM/SC/SC-SM
8	25.2	82.6	50.0	1.32	1.00	0.97	1.00	1,375.0	1.21	34.6	5.5	64.0	77.1	46.0	7	SM/SC/SC-SM
9	30.2	77.6	50.0	1.32	1.00	0.98	1.00	1,638.0	1.10	59.9	5.5	64.7	71.5	46.0	8	SM/SC/SC-SM
10	35.2	72.6	50.0	1.32	1.00	0.99	1.00	1,901.0	1.03	68.2	5.5	65.2	66.9	46.0	8	SM/SC/SC-SM

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-6**
 Boring Station = **5951+41.00**
 Boring Offset = **8 ft RT**
 Ground Elevation at Boring (ft msl) = **107.8**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **107.8**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 M_w = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **8** each
 No. of Split Spoon Samples = **10** each
 Total Profile Thickness = **35** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ϕ_{SL}	D _r (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																ϕ' (degrees)	$\tau = c$ (psf)	ϕ' (degrees)	$\tau = c$ (psf)
	0	107.8																	
1	3.5	104.3	7.0	6.7	11.4	13.5	1	SM/SC/SC-SM		No Liquefaction		12.0				34		9	
2	5.5	102.3	11.0	11.2	19.1	19.1	2	SP/SW		No Liquefaction		1.6				32		32	
3	7.5	100.3	28.0	30.1	51.2	46.0	3	SP/SW		No Liquefaction		43.7				32		32	
4	9.5	98.3	7.0	7.8	13.3	13.3	4	SP/SW		No Liquefaction		2.1				32		9	
5	11.5	96.3	3.0	3.5	5.9	6.5	5	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		8.8				30		4	
6	15.2	92.6	50.0	60.3	92.6	46.0	6	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
7	20.2	87.6	50.0	62.6	84.0	46.0	7	SM/SC/SC-SM		No Liquefaction		34.6				36		36	
8	25.2	82.6	50.0	64.0	77.1	46.0	7	SM/SC/SC-SM		No Liquefaction		34.6				36		36	
9	30.2	77.6	50.0	64.7	71.5	46.0	8	SM/SC/SC-SM		No Liquefaction		59.9				36		36	
10	35.2	72.6	50.0	65.2	66.9	46.0	8	SM/SC/SC-SM		No Liquefaction		68.2				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	2/18/2015
Project:	RBO Four Hole Swamp						
Location:	B-6A	Station:	5951+42.68	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	2/18/2015
Route:	US 301	County:	38 - Orangeburg	Location:	B-6A	Station:	5951+42.68

Boring Number = **B-6A**
 Boring Station = **5951+42.68**
 Boring Offset = **7.28 ft LT**
 Ground Elevation at Boring (ft msl) = **108.6**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.6**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 M_w = **7.37**
 R (km) = **63.5**
 D_{a5-95} (sec) = **30.15**

No. of Soil Layers = **11** each
 No. of Split Spoon Samples = **33** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	108.6														
1	2	106.6	0.0	1.27	1.00	0.69	1.00	95.2	1.00	51.0	5.5	0.0	0.0	5.5	1	ML
2	4	104.6	7.0	1.27	1.00	0.74	1.00	210.4	1.70	0.0	0.0	6.6	11.2	11.2	2	SP/SW
3	6	102.6	10.0	1.27	1.00	0.79	1.00	325.6	1.70	0.0	0.0	10.0	17.0	17.0	2	SP/SW
4	8	100.6	26.0	1.27	1.00	0.83	1.00	440.8	1.70	0.0	0.0	27.3	46.4	46.0	2	SP/SW
5	10	98.6	12.0	1.27	1.00	0.86	1.00	565.0	1.70	5.0	0.0	13.1	22.3	22.3	3	SW-SM/SW-SC/SP-SM/SP-SC
6	15	93.6	50.0	1.27	1.00	0.91	1.00	828.0	1.55	34.6	5.5	58.2	90.5	46.0	4	SM/SC/SC-SM
7	20	88.6	50.0	1.27	1.00	0.95	1.00	1,091.0	1.35	34.6	5.5	60.5	81.9	46.0	4	SM/SC/SC-SM
8	25	83.6	50.0	1.27	1.00	0.97	1.00	1,365.5	1.21	34.6	5.5	61.8	74.8	46.0	4	SM/SC/SC-SM
9	30	78.6	29.0	1.27	1.00	0.98	1.00	1,603.5	1.00	59.9	5.5	36.3	36.3	41.8	5	ML
10	35	73.6	52.0	1.27	1.00	0.99	1.00	1,841.5	1.00	59.9	5.5	65.6	65.6	46.0	5	ML
11	40	68.6	27.0	1.27	1.00	0.99	1.00	2,079.5	1.00	59.9	5.5	34.2	34.2	39.7	5	ML
12	45	63.6	40.0	1.27	1.00	1.00	1.00	2,317.5	1.00	68.2	5.5	50.8	50.8	46.0	5	ML
13	50	58.6	45.0	1.27	1.00	1.00	1.00	2,555.5	1.00	68.2	5.5	57.2	57.2	46.0	5	ML
14	55	53.6	50.0	1.27	1.00	1.00	1.00	2,793.5	1.00	68.2	5.5	63.6	63.6	46.0	5	ML
15	60	48.6	50.0	1.27	1.00	1.00	1.00	3,031.5	1.00	72.2	5.5	63.6	63.6	46.0	6	ML
16	62	46.6	44.0	1.27	1.00	1.00	1.00	3,126.7	1.00	72.2	5.5	56.0	56.0	46.0	6	ML
17	64	44.6	50.0	1.27	1.00	1.00	1.00	3,221.9	1.00	72.2	5.5	63.6	63.6	46.0	6	ML
18	66	42.6	59.0	1.27	1.00	1.00	1.00	3,317.1	1.00	72.2	5.5	75.1	75.1	46.0	6	ML
19	68	40.6	50.0	1.27	1.00	1.00	1.00	3,412.3	1.00	70.9	5.5	63.7	63.7	46.0	6	ML
20	70	38.6	50.0	1.27	1.00	1.00	1.00	3,507.5	1.00	70.9	5.5	63.7	63.7	46.0	6	ML
21	72	36.6	50.0	1.27	1.00	1.00	1.00	3,602.7	1.00	70.9	5.5	63.7	63.7	46.0	6	ML
22	74	34.6	60.0	1.27	1.00	1.00	1.00	3,697.9	1.00	70.9	5.5	76.4	76.4	46.0	6	ML
23	76	32.6	50.0	1.27	1.00	1.00	1.00	3,793.1	1.00	70.9	5.5	63.7	63.7	46.0	6	ML
24	78	30.6	50.0	1.27	1.00	1.00	1.00	3,888.3	1.00	70.9	5.5	63.7	63.7	46.0	6	ML
25	80	28.6	28.0	1.27	1.00	1.00	1.00	3,984.5	0.71	21.2	4.7	35.7	25.3	29.9	7	SM/SC/SC-SM
26	85	23.6	50.0	1.27	1.00	1.00	1.00	4,272.5	0.68	11.5	1.8	63.7	43.6	45.4	8	SW-SM/SW-SC/SP-SM/SP-SC
27	90	18.6	50.0	1.27	1.00	1.00	1.00	4,560.5	0.66	11.5	1.8	63.7	42.2	44.0	8	SW-SM/SW-SC/SP-SM/SP-SC
28	95	13.6	50.0	1.27	1.00	1.00	1.00	4,848.5	0.64	11.5	1.8	63.7	40.9	42.7	8	SW-SM/SW-SC/SP-SM/SP-SC
29	100	8.6	50.0	1.27	1.00	1.00	1.00	5,154.5	0.62	11.5	1.8	63.7	39.7	41.5	8	SW-SM/SW-SC/SP-SM/SP-SC
30	105	3.6	30.0	1.27	1.00	1.00	1.00	5,383.5	1.00	56.0	5.5	38.2	38.2	43.7	9	CL
31	110	-1.4	50.0	1.27	1.00	1.00	1.00	5,646.5	0.60	17.8	4.0	63.7	37.9	41.9	10	SM/SC/SC-SM
32	115	-6.4	50.0	1.27	1.00	1.00	1.00	5,911.0	0.58	17.8	4.0	63.7	37.0	41.1	10	SM/SC/SC-SM
33	120	-11.4	50.0	1.27	1.00	1.00	1.00	6,149.0	1.00	80.0	5.5	63.7	63.7	46.0	11	MH

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-6A**
 Boring Station = **5951+42.68**
 Boring Offset = **7.28 ft LT**
 Ground Elevation at Boring (ft msl) = **108.6**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.6**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **11** each
 No. of Split Spoon Samples = **33** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	108.6																	
2	2	106.6	0.0	0.0	0.0	5.5	1	ML		No Liquefaction		51.0				20		4	
3	4	104.6	7.0	6.6	11.2	11.2	2	SP/SW		No Liquefaction		0.0				32		7	
4	6	102.6	10.0	10.0	17.0	17.0	2	SP/SW		No Liquefaction		0.0				32		21	
5	8	100.6	26.0	27.3	46.4	46.0	2	SP/SW		No Liquefaction		0.0				32		32	
6	10	98.6	12.0	13.1	22.3	22.3	3	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
7	15	93.6	50.0	58.2	90.5	46.0	4	SM/SC/SC-SM		No Liquefaction		34.6				36		36	
8	20	88.6	50.0	60.5	81.9	46.0	4	SM/SC/SC-SM		No Liquefaction		34.6				36		36	
9	25	83.6	50.0	61.8	74.8	46.0	4	SM/SC/SC-SM		No Liquefaction		34.6				36		36	
10	30	78.6	29.0	36.3	36.3	41.8	5	ML		No Liquefaction		59.9				30		30	
11	35	73.6	52.0	65.6	65.6	46.0	5	ML		No Liquefaction		59.9				30		30	
12	40	68.6	27.0	34.2	34.2	39.7	5	ML		No Liquefaction		59.9				30		30	
13	45	63.6	40.0	50.8	50.8	46.0	5	ML		No Liquefaction		68.2				30		30	
14	50	58.6	45.0	57.2	57.2	46.0	5	ML		No Liquefaction		68.2				30		30	
15	55	53.6	50.0	63.6	63.6	46.0	5	ML		No Liquefaction		68.2				30		30	
16	60	48.6	50.0	63.6	63.6	46.0	6	ML		No Strength Loss		72.2					2310		2310
17	62	46.6	44.0	56.0	56.0	46.0	6	ML		No Strength Loss		72.2					2340		2340
18	64	44.6	50.0	63.6	63.6	46.0	6	ML		No Strength Loss		72.2					2360		2360
19	66	42.6	59.0	75.1	75.1	46.0	6	ML		No Strength Loss		72.2					2390		2390
20	68	40.6	50.0	63.7	63.7	46.0	6	ML		No Strength Loss		70.9					2410		2410
21	70	38.6	50.0	63.7	63.7	46.0	6	ML		No Strength Loss		70.9					2440		2440
22	72	36.6	50.0	63.7	63.7	46.0	6	ML		No Strength Loss		70.9					2470		2470
23	74	34.6	60.0	76.4	76.4	46.0	6	ML		No Strength Loss		70.9					2490		2490
24	76	32.6	50.0	63.7	63.7	46.0	6	ML		No Strength Loss		70.9					2520		2520
25	78	30.6	50.0	63.7	63.7	46.0	6	ML		No Strength Loss		70.9					2540		2540
26	80	28.6	28.0	35.7	25.3	29.9	7	SM/SC/SC-SM		No Strength Loss		21.2					2570		2570
27	85	23.6	50.0	63.7	43.6	45.4	8	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.5				36		36	
28	90	18.6	50.0	63.7	42.2	44.0	8	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.5				36		36	
29	95	13.6	50.0	63.7	40.9	42.7	8	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.5				36		36	
30	100	8.6	50.0	63.7	39.7	41.5	8	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.5				36		36	
31	105	3.6	30.0	38.2	38.2	43.7	9	CL		No Strength Loss		56.0	0.006	15.2	3.1		4000		4000
32	110	-1.4	50.0	63.7	37.9	41.9	10	SM/SC/SC-SM		No Liquefaction		17.8				36		36	
33	115	-6.4	50.0	63.7	37.0	41.1	10	SM/SC/SC-SM		No Liquefaction		17.8				36		36	
	120	-11.4	50.0	63.7	63.7	46.0	11	MH		No Strength Loss		80.0					5000		5000

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/1/2014
Project:	RBO Four Hole Swamp						
Location:	B-7	Station:	5951+86.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

Soil Shear Strength Summary

Boring Number =	B-7
Boring Station =	5951+86.00
Boring Offset =	8 ft LT
Ground Elevation at Boring (ft msl) =	105
Water Table Depth (Dw) (ft) =	0
Water Table Elevation (msl ft) =	105

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{as-95} (sec) =	30.15

No. of Soil Layers =	7	each
No. of Split Spoon Samples =	12	each
Total Profile Thickness =	41	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	3.5	101.5	4.0	3.8	6.5	6.5	1	SP/SW	Sand-Like	Full Liquefaction	28.9	0.0				30	4		
2	5.5	99.5	5.0	5.1	8.7	8.7	1	SP/SW	Sand-Like	Full Liquefaction	33.3	0.0				32	5		
3	6.3	98.7	50.0	52.2	46.0	46.0	2	ML		No Liquefaction		56.5				36	36		
4	8.4	96.6	50.0	54.8	46.0	46.0	3	ML		No Liquefaction		50.7				36	36		
5	11.5	93.5	41.0	47.4	80.5	46.0	4	SM/SC/SC-SM		No Liquefaction		40.6				36	36		
6	16.5	88.5	26.0	31.7	48.0	46.0	5	SM/SC/SC-SM		No Liquefaction		64.2				36	36		
7	20.1	84.9	50.0	62.6	85.8	46.0	6	SM/SC/SC-SM		No Liquefaction		61.1				36	36		
8	21	84.0	50.0	62.9	84.4	46.0	6	SM/SC/SC-SM		No Liquefaction		61.1				36	36		
9	26	79.0	50.0	64.1	77.3	46.0	7	SM/SC/SC-SM		No Liquefaction		64.0				36	36		
10	31	74.0	50.0	64.8	71.7	46.0	7	SM/SC/SC-SM		No Liquefaction		64.0				36	36		
11	36	69.0	50.0	65.3	66.9	46.0	7	SM/SC/SC-SM		No Liquefaction		64.0				36	36		
12	41	64.0	50.0	65.5	63.0	46.0	7	SM/SC/SC-SM		No Liquefaction		64.0				36	36		

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	2/18/2015
Project:	RBO Four Hole Swamp						
Location:	B-7A	Station:	5951+87.63	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$0.50 \leq \beta \leq 1.5$$

$$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	RBO Four Hole Swamp			Longitude:	80.6470	Date:	2/18/2015
Route:	US 301	County:	38 - Orangeburg	Location:	B-7A	Station:	5951+87.63

Boring Number = **B-7A**
 Boring Station = **5951+87.63**
 Boring Offset = **8.39 ft RT**
 Ground Elevation at Boring (ft msl) = **108.3**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.3**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 M_w = **7.37**
 R (km) = **63.5**
 D_{a5-95} (sec) = **30.15**

No. of Soil Layers = **12** each
 No. of Split Spoon Samples = **33** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	108.3														
1	2	106.3	0.0	1.27	1.00	0.69	1.00	95.2	1.00	51.0	5.5	0.0	0.0	5.5	1	ML
2	4	104.3	0.0	1.27	1.00	0.74	1.00	190.4	1.00	51.0	5.5	0.0	0.0	5.5	1	ML
3	6	102.3	3.0	1.27	1.00	0.79	1.00	305.6	1.70	5.9	0.0	3.0	5.1	5.1	2	SW-SM/SW-SC/SP-SM/SP-SC
4	8	100.3	8.0	1.27	1.00	0.83	1.00	420.8	1.70	7.4	0.2	8.4	14.3	14.5	2	SW-SM/SW-SC/SP-SM/SP-SC
5	10	98.3	47.0	1.27	1.00	0.86	1.00	526.0	1.70	47.8	5.5	51.3	87.2	46.0	3	SM/SC/SC-SM
6	15	93.3	50.0	1.27	1.00	0.91	1.00	789.0	1.59	47.8	5.5	58.2	92.7	46.0	3	SM/SC/SC-SM
7	20	88.3	50.0	1.27	1.00	0.95	1.00	1,059.5	1.37	47.8	5.5	60.5	83.1	46.0	3	SM/SC/SC-SM
8	25	83.3	41.0	1.27	1.00	0.97	1.00	1,297.5	1.00	61.1	5.5	50.7	50.7	46.0	4	ML
9	30	78.3	52.0	1.27	1.00	0.98	1.00	1,535.5	1.00	61.1	5.5	65.1	65.1	46.0	4	ML
10	35	73.3	28.0	1.27	1.00	0.99	1.00	1,773.5	1.00	64.0	5.5	35.3	35.3	40.8	4	ML
11	40	68.3	36.0	1.27	1.00	0.99	1.00	2,011.5	1.00	64.0	5.5	45.6	45.6	46.0	4	ML
12	45	63.3	53.0	1.27	1.00	1.00	1.00	2,249.5	1.00	64.0	5.5	67.3	67.3	46.0	4	ML
13	50	58.3	50.0	1.27	1.00	1.00	1.00	2,487.5	1.00	76.0	5.5	63.5	63.5	46.0	5	ML
14	55	53.3	50.0	1.27	1.00	1.00	1.00	2,725.5	1.00	76.0	5.5	63.6	63.6	46.0	5	ML
15	60	48.3	50.0	1.27	1.00	1.00	1.00	2,963.5	1.00	76.0	5.5	63.6	63.6	46.0	5	ML
16	62	46.3	50.0	1.27	1.00	1.00	1.00	3,058.7	1.00	76.0	5.5	63.6	63.6	46.0	5	ML
17	64	44.3	43.0	1.27	1.00	1.00	1.00	3,153.9	1.00	68.0	5.5	54.7	54.7	46.0	6	ML
18	66	42.3	50.0	1.27	1.00	1.00	1.00	3,249.1	1.00	68.0	5.5	63.6	63.6	46.0	6	ML
19	68	40.3	50.0	1.27	1.00	1.00	1.00	3,344.3	1.00	68.0	5.5	63.7	63.7	46.0	6	ML
20	70	38.3	50.0	1.27	1.00	1.00	1.00	3,439.5	1.00	68.0	5.5	63.7	63.7	46.0	6	ML
21	72	36.3	6.0	1.27	1.00	1.00	1.00	3,544.7	0.75	16.1	3.6	7.6	5.7	9.3	7	SM/SC/SC-SM
22	74	34.3	7.0	1.27	1.00	1.00	1.00	3,649.9	0.74	16.1	3.6	8.9	6.6	10.2	7	SM/SC/SC-SM
23	76	32.3	7.0	1.27	1.00	1.00	1.00	3,755.1	0.73	16.1	3.6	8.9	6.5	10.1	7	SM/SC/SC-SM
24	78	30.3	50.0	1.27	1.00	1.00	1.00	3,860.3	0.72	16.4	3.7	63.7	45.8	46.0	8	SM/SC/SC-SM
25	80	28.3	50.0	1.27	1.00	1.00	1.00	3,965.5	0.71	16.4	3.7	63.7	45.2	46.0	8	SM/SC/SC-SM
26	85	23.3	50.0	1.27	1.00	1.00	1.00	4,228.5	0.69	16.4	3.7	63.7	43.8	46.0	8	SM/SC/SC-SM
27	90	18.3	50.0	1.27	1.00	1.00	1.00	4,491.5	0.67	16.4	3.7	63.7	42.5	46.0	8	SM/SC/SC-SM
28	95	13.3	50.0	1.27	1.00	1.00	1.00	4,774.5	0.65	8.5	0.5	63.7	41.2	41.7	9	SW-SM/SW-SC/SP-SM/SP-SC
29	100	8.3	50.0	1.27	1.00	1.00	1.00	5,005.0	1.00	51.0	5.5	63.7	63.7	46.0	10	CL
30	105	3.3	50.0	1.27	1.00	1.00	1.00	5,268.0	0.62	12.0	2.1	63.7	39.2	41.3	11	SM/SC/SC-SM
31	110	-1.7	50.0	1.27	1.00	1.00	1.00	5,543.5	0.60	12.0	2.1	63.7	38.2	40.3	11	SM/SC/SC-SM
32	115	-6.7	50.0	1.27	1.00	1.00	1.00	5,781.5	1.00	80.0	5.5	63.7	63.7	46.0	12	MH
33	120	-11.7	50.0	1.27	1.00	1.00	1.00	6,019.5	1.00	80.0	5.5	63.7	63.7	46.0	12	MH

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-7A**
 Boring Station = **5951+87.63**
 Boring Offset = **8.39 ft RT**
 Ground Elevation at Boring (ft msl) = **108.3**
 Water Table Depth (Dw) (ft) = **0**
 Water Table Elevation (msl ft) = **108.3**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D₀₅₋₉₅ (sec) = **30.15**

No. of Soil Layers = **12** each
 No. of Split Spoon Samples = **33** each
 Total Profile Thickness = **120** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	108.3																	
2	2	106.3	0.0	0.0	0.0	5.5	1	ML		No Liquefaction		51.0					24		24
3	4	104.3	0.0	0.0	0.0	5.5	1	ML		No Liquefaction		51.0					24		24
4	6	102.3	3.0	3.0	5.1	5.1	2	SW-SM/SW-SC/SP-SM/SP-SC	Sand-Like	Full Liquefaction	25.6	5.9	0.119	7.4	1.5		29		3
5	8	100.3	8.0	8.4	14.3	14.5	2	SW-SM/SW-SC/SP-SM/SP-SC	Sand-Like	Full Liquefaction	42.7	7.4	0.096	7.8	2.1		35		11
6	10	98.3	47.0	51.3	87.2	46.0	3	SM/SC/SC-SM		No Liquefaction		47.8					36		36
7	15	93.3	50.0	58.2	92.7	46.0	3	SM/SC/SC-SM		No Liquefaction		47.8					36		36
8	20	88.3	50.0	60.5	83.1	46.0	3	SM/SC/SC-SM		No Liquefaction		47.8					36		36
9	25	83.3	41.0	50.7	50.7	46.0	4	ML		No Liquefaction		61.1					30		30
10	30	78.3	52.0	65.1	65.1	46.0	4	ML		No Liquefaction		61.1					30		30
11	35	73.3	28.0	35.3	35.3	40.8	4	ML		No Liquefaction		64.0	0.003	21.3	1.9		30		30
12	40	68.3	36.0	45.6	45.6	46.0	4	ML		No Liquefaction		64.0					30		30
13	45	63.3	53.0	67.3	67.3	46.0	4	ML		No Liquefaction		64.0					30		30
14	50	58.3	50.0	63.5	63.5	46.0	5	ML	HS Clay-Like	No Strength Loss		76.0	0.003	14.7	0.5		2170		2170
15	55	53.3	50.0	63.6	63.6	46.0	5	ML	HS Clay-Like	No Strength Loss		76.0					2230		2230
16	60	48.3	50.0	63.6	63.6	46.0	5	ML	HS Clay-Like	No Strength Loss		76.0					2290		2290
17	62	46.3	50.0	63.6	63.6	46.0	5	ML	HS Clay-Like	No Strength Loss		76.0					2320		2320
18	64	44.3	43.0	54.7	54.7	46.0	6	ML	HS Clay-Like	Strength Loss		68.0	0.003	17.1	0.7		2350		1175
19	66	42.3	50.0	63.6	63.6	46.0	6	ML	HS Clay-Like	Strength Loss		68.0					2370		1185
20	68	40.3	50.0	63.7	63.7	46.0	6	ML	HS Clay-Like	Strength Loss		68.0					2400		1200
21	70	38.3	50.0	63.7	63.7	46.0	6	ML	HS Clay-Like	Strength Loss		68.0					2420		1210
22	72	36.3	6.0	7.6	5.7	9.3	7	SM/SC/SC-SM		No Liquefaction		16.1					29		5
23	74	34.3	7.0	8.9	6.6	10.2	7	SM/SC/SC-SM		No Liquefaction		16.1					30		6
24	76	32.3	7.0	8.9	6.5	10.1	7	SM/SC/SC-SM		No Liquefaction		16.1					30		6
25	78	30.3	50.0	63.7	45.8	46.0	8	SM/SC/SC-SM		No Liquefaction		16.4					36		36
26	80	28.3	50.0	63.7	45.2	46.0	8	SM/SC/SC-SM		No Liquefaction		16.4					36		36
27	85	23.3	50.0	63.7	43.8	46.0	8	SM/SC/SC-SM		No Liquefaction		16.4					36		36
28	90	18.3	50.0	63.7	42.5	46.0	8	SM/SC/SC-SM		No Liquefaction		16.4					36		36
29	95	13.3	50.0	63.7	41.2	41.7	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		8.5	0.093	5.3	1.6		36		36
30	100	8.3	50.0	63.7	63.7	46.0	10	CL	HS Clay-Like	No Strength Loss		51.0					4000		4000
31	105	3.3	50.0	63.7	39.2	41.3	11	SM/SC/SC-SM		No Liquefaction		12.0					36		36
32	110	-1.7	50.0	63.7	38.2	40.3	11	SM/SC/SC-SM		No Liquefaction		12.0					36		36
33	115	-6.7	50.0	63.7	63.7	46.0	12	MH	HS Clay-Like	No Strength Loss		80.0					5000		5000
	120	-11.7	50.0	63.7	63.7	46.0	12	MH	HS Clay-Like	No Strength Loss		80.0					5000		5000

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/1/2014
Project:	RBO Four Hole Swamp						
Location:	B-8	Station:	5952+17.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.5	64.2	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.15	30.09	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308			Latitude:	33.4570
Project:	RBO Four Hole Swamp		Longitude:	80.6470			
Route:	US 301	County:	38 - Orangeburg	Location:	B-8		

Designer:	R. Gardner - Midlands RPG
Date:	10/1/2014
Station:	5952+17.00

Boring Number =	B-8
Boring Station =	5952+17.00
Boring Offset =	8 ft RT
Ground Elevation at Boring (ft msl) =	120
Water Table Depth (Dw) (ft) =	10
Water Table Elevation (msl ft) =	110

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	10	each
No. of Split Spoon Samples =	24	each
Total Profile Thickness =	101	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ _{vo} (psf)	C _N	Fines Content (FC)	ΔN _{1,60}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	120.0														
1	3.5	116.5	13.0	1.32	1.00	0.73	1.00	420.0	1.70	11.9	2.0	12.5	21.2	23.3	1	SW-SM/SW-SC/SP-SM/SP-SC
2	5.5	114.5	11.0	1.32	1.00	0.78	1.00	660.0	1.70	0.0	0.0	11.2	19.1	19.1	2	SP/SW
3	7.5	112.5	4.0	1.32	1.00	0.82	1.00	900.0	1.49	0.0	0.0	4.3	6.4	6.4	2	SP/SW
4	9.5	110.5	5.0	1.32	1.00	0.85	1.00	1,141.5	1.32	0.0	0.0	5.6	7.4	7.4	2	SP/SW
5	11.5	108.5	5.0	1.32	1.00	0.88	1.00	1,268.9	1.26	20.1	4.5	5.8	7.3	11.7	3	SM/SC/SC-SM
6	15.1	104.9	2.0	1.32	1.00	0.92	1.00	1,476.3	1.16	0.0	0.0	2.4	2.8	2.8	4	SP/SW
7	21.5	98.5	2.0	1.32	1.00	0.96	1.00	1,852.4	1.04	1.8	0.0	2.5	2.6	2.6	4	SP/SW
8	26.5	93.5	34.0	1.32	1.00	0.98	1.00	2,115.4	0.97	12.0	2.1	43.7	42.4	44.5	5	SM/SC/SC-SM
9	30.3	89.7	50.0	1.32	1.00	0.98	1.00	2,315.3	0.93	59.4	5.5	64.8	60.2	46.0	5	SM/SC/SC-SM
10	30.4	89.6	50.0	1.32	1.00	0.98	1.00	2,320.5	0.93	59.4	5.5	64.8	60.1	46.0	6	SM/SC/SC-SM
11	31.3	88.7	50.0	1.32	1.00	0.99	1.00	2,367.9	0.92	59.4	5.5	64.9	59.6	46.0	6	SM/SC/SC-SM
12	36.3	83.7	50.0	1.32	1.00	0.99	1.00	2,630.9	0.87	59.4	5.5	65.3	56.9	46.0	6	SM/SC/SC-SM
13	41.3	78.7	50.0	1.32	1.00	1.00	1.00	2,893.9	0.83	59.4	5.5	65.5	54.5	46.0	6	SM/SC/SC-SM
14	46.3	73.7	50.0	1.32	1.00	1.00	1.00	3,156.9	0.80	59.4	5.5	65.6	52.3	46.0	7	SM/SC/SC-SM
15	51.3	68.7	50.0	1.32	1.00	1.00	1.00	3,419.9	0.76	59.4	5.5	65.7	50.3	46.0	7	SM/SC/SC-SM
16	56.5	63.5	22.0	1.32	1.00	1.00	1.00	3,693.4	0.74	12.0	2.1	28.9	21.3	23.4	8	SM/SC/SC-SM
17	61.5	58.5	36.0	1.32	1.00	1.00	1.00	3,956.4	0.71	12.0	2.1	47.4	33.7	35.8	8	SM/SC/SC-SM
18	66.5	53.5	44.0	1.32	1.00	1.00	1.00	4,219.4	0.69	12.0	2.1	57.9	39.9	41.9	8	SM/SC/SC-SM
19	71.5	48.5	40.0	1.32	1.00	1.00	1.00	4,482.4	0.67	12.0	2.1	52.7	35.2	37.2	8	SM/SC/SC-SM
20	76.5	43.5	39.0	1.32	1.00	1.00	1.00	4,745.4	0.65	12.0	2.1	51.3	33.3	35.4	8	SM/SC/SC-SM
21	81.5	38.5	44.0	1.32	1.00	1.00	1.00	5,008.4	0.63	12.0	2.1	57.9	36.6	38.7	8	SM/SC/SC-SM
22	86.5	33.5	42.0	1.32	1.00	1.00	1.00	5,263.9	0.62	12.0	2.1	55.3	34.1	36.2	8	SM/SC/SC-SM
23	91.5	28.5	39.0	1.32	1.00	1.00	1.00	5,551.9	0.60	5.0	0.0	51.3	30.8	30.8	9	SW-SM/SW-SC/SP-SM/SP-SC
24	96.5	23.5	50.0	1.32	1.00	1.00	1.00	5,839.9	0.59	5.0	0.0	65.8	38.5	38.5	10	SW-SM/SW-SC/SP-SM/SP-SC
															10	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-8**
 Boring Station = **5952+17.00**
 Boring Offset = **8 ft RT**
 Ground Elevation at Boring (ft msl) = **120**
 Water Table Depth (Dw) (ft) = **10**
 Water Table Elevation (msl ft) = **110**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **10** each
 No. of Split Spoon Samples = **24** each
 Total Profile Thickness = **101** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
	0	120.0																	
1	3.5	116.5	13.0	12.5	21.2	23.3	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.9				38		38	
2	5.5	114.5	11.0	11.2	19.1	19.1	2	SP/SW		No Liquefaction		0.0				32		32	
3	7.5	112.5	4.0	4.3	6.4	6.4	2	SP/SW		No Liquefaction		0.0				30		30	
4	9.5	110.5	5.0	5.6	7.4	7.4	2	SP/SW		No Liquefaction		0.0				31		31	
5	11.5	108.5	5.0	5.8	7.3	11.7	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	35.4	20.1				31		7	
6	15.1	104.9	2.0	2.4	2.8	2.8	4	SP/SW	Sand-Like	Full Liquefaction	22.9	0.0				26		3	
7	21.5	98.5	2.0	2.5	2.6	2.6	4	SP/SW	Sand-Like	Full Liquefaction	23.4	1.8				26		3	
8	26.5	93.5	34.0	43.7	42.4	44.5	5	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
9	30.3	89.7	50.0	64.8	60.2	46.0	5	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
10	30.4	89.6	50.0	64.8	60.1	46.0	6	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
11	31.3	88.7	50.0	64.9	59.6	46.0	6	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
12	36.3	83.7	50.0	65.3	56.9	46.0	6	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
13	41.3	78.7	50.0	65.5	54.5	46.0	6	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
14	46.3	73.7	50.0	65.6	52.3	46.0	7	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
15	51.3	68.7	50.0	65.7	50.3	46.0	7	SM/SC/SC-SM		No Liquefaction		59.4				36		36	
16	56.5	63.5	22.0	28.9	21.3	23.4	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
17	61.5	58.5	36.0	47.4	33.7	35.8	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
18	66.5	53.5	44.0	57.9	39.9	41.9	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
19	71.5	48.5	40.0	52.7	35.2	37.2	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
20	76.5	43.5	39.0	51.3	33.3	35.4	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
21	81.5	38.5	44.0	57.9	36.6	38.7	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
22	86.5	33.5	42.0	55.3	34.1	36.2	8	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
23	91.5	28.5	39.0	51.3	30.8	30.8	9	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
24	96.5	23.5	50.0	65.8	38.5	38.5	10	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	
							10	SW-SM/SW-SC/SP-SM/SP-SC											

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/1/2014
Project:	RBO Four Hole Swamp						
Location:	B-9	Station:	5952+28.00	Finished Embankment Height (ft) ¹ =			

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D	
Design Earthquake:	SEE	FEE
S_{D1} =	0.490	0.180
$k_{max} = PGA$ =	0.430	0.200
$\beta = S_{D1}/PGA$ =	1.140	0.900
α_w =	1.000	1.000
$k_h = k_{avg}$ =	0.430	0.200
M_w =	7.37	7.36
R =	63.5	64.2
\bar{V}_s =	1,005.40	1,005.40
Z_{HR} =	494.50	494.50
ϵ =	0.000	0.000
D_{a5-95}	30.15	30.09

β = Ground Motion Index: $0.50 \leq \beta \leq 1.5$
 α_w = Wave Scattering Scaling Factor: $1+0.01h_{slope}[(0.5\beta)-1] \leq 1.0$: for $h_{slope} \leq 20ft$ $\alpha_w = 1.0$
 k_h = Average seismic horizontal coefficient due to wave scattering: $k_h = k_{avg} = \alpha_w k_{max}$
 M_w = Moment Magnitude of Design Earthquake M_w & R = Deaggregation Analysis
R = Site-to-Source Distance
 \bar{V}_s = Average Shear Wave Velocity \bar{V}_s from Three-Point Method Excel Spreadsheet
 Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output
 ϵ = Near-fault directivity correction: R < 20 km; $\epsilon = 0.015(R-20)$
 D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48 R \geq 20 km; $\epsilon = 0$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	RBO Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	B-9

Designer:	R. Gardner - Midlands RPG
Date:	10/1/2014
Station:	5952+28.00

Boring Number =	B-9
Boring Station =	5952+28.00
Boring Offset =	8 ft LT
Ground Elevation at Boring (ft msl) =	120
Water Table Depth (Dw) (ft) =	12.6
Water Table Elevation (msl ft) =	107.4

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.5
D _{a5-95} (sec) =	30.15

No. of Soil Layers =	12	each
No. of Split Spoon Samples =	23	each
Total Profile Thickness =	102	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	120.0														
1	3.5	116.5	7.0	1.32	1.00	0.73	1.00	400.0	1.70	18.9	4.3	6.7	11.4	15.7	1	SM/SC/SC-SM
2	5.5	114.5	5.0	1.32	1.00	0.78	1.00	640.0	1.70	0.0	0.0	5.1	8.7	8.7	2	SP/SW
3	7.5	112.5	4.0	1.32	1.00	0.82	1.00	880.0	1.51	5.6	0.0	4.3	6.5	6.5	3	SW-SM/SW-SC/SP-SM/SP-SC
4	9.5	110.5	3.0	1.32	1.00	0.85	1.00	1,121.5	1.34	0.0	0.0	3.4	4.5	4.5	4	SP/SW
5	11.5	108.5	2.0	1.32	1.00	0.88	1.00	1,342.5	1.22	12.0	2.1	2.3	2.8	4.9	5	SM/SC/SC-SM
6	16.5	103.5	27.0	1.32	1.00	0.93	1.00	1,709.1	1.08	4.6	0.0	33.0	35.7	35.7	6	SP/SW
7	21.5	98.5	54.0	1.32	1.00	0.96	1.00	1,972.1	1.01	48.4	5.5	68.1	68.6	46.0	7	SM/SC/SC-SM
8	26.5	93.5	36.0	1.32	1.00	0.98	1.00	2,235.1	0.95	35.7	5.5	46.2	43.7	46.0	8	SM/SC/SC-SM
9	31.5	88.5	35.0	1.32	1.00	0.99	1.00	2,507.1	0.89	35.7	5.5	45.4	40.6	46.0	8	SM/SC/SC-SM
10	36.5	83.5	21.0	1.32	1.00	0.99	1.00	2,745.1	1.00	59.4	5.5	27.4	27.4	32.9	9	ML
11	41.5	78.5	27.0	1.32	1.00	1.00	1.00	2,983.1	1.00	59.4	5.5	35.4	35.4	40.9	9	ML
12	46.5	73.5	24.0	1.32	1.00	1.00	1.00	3,221.1	1.00	59.4	5.5	31.5	31.5	37.0	9	ML
13	51.5	68.5	50.0	1.32	1.00	1.00	1.00	3,459.1	1.00	59.4	5.5	65.7	65.7	46.0	9	ML
14	56.5	63.5	20.0	1.32	1.00	1.00	1.00	3,697.1	1.00	59.4	5.5	26.3	26.3	31.8	9	ML
15	61.5	58.5	31.0	1.32	1.00	1.00	1.00	3,935.1	1.00	59.4	5.5	40.8	40.8	46.0	9	ML
16	66.5	53.5	43.0	1.32	1.00	1.00	1.00	4,173.1	1.00	59.4	5.5	56.6	56.6	46.0	9	ML
17	71.5	48.5	27.0	1.32	1.00	1.00	1.00	4,411.1	1.00	59.4	5.5	35.5	35.5	41.0	9	ML
18	76.5	43.5	34.0	1.32	1.00	1.00	1.00	4,649.1	1.00	59.4	5.5	44.8	44.8	46.0	9	ML
19	81.5	38.5	49.0	1.32	1.00	1.00	1.00	4,887.1	1.00	59.4	5.5	64.5	64.5	46.0	9	ML
20	86.5	33.5	43.0	1.32	1.00	1.00	1.00	5,110.1	1.00	59.4	5.5	56.6	56.6	46.0	9	ML
21	91.5	28.5	7.0	1.32	1.00	1.00	1.00	5,407.1	0.61	5.0	0.0	9.2	5.6	5.6	10	SW-SM/SW-SC/SP-SM/SP-SC
22	96.5	23.5	50.0	1.32	1.00	1.00	1.00	5,667.6	0.59	12.0	2.1	65.8	39.1	41.2	11	SM/SC/SC-SM
23	101.5	18.5	24.0	1.32	1.00	1.00	1.00	5,955.6	0.58	5.0	0.0	31.6	18.3	18.3	12	SW-SM/SW-SC/SP-SM/SP-SC

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **B-9**
 Boring Station = **5952+28.00**
 Boring Offset = **8 ft LT**
 Ground Elevation at Boring (ft msl) = **120**
 Water Table Depth (Dw) (ft) = **12.6**
 Water Table Elevation (msl ft) = **107.4**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.5**
 D_{as-95} (sec) = **30.15**

No. of Soil Layers = **12** each
 No. of Split Spoon Samples = **23** each
 Total Profile Thickness = **102** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
1	0	120.0																	
2	3.5	116.5	7.0	6.7	11.4	15.7	1	SM/SC/SC-SM		No Liquefaction		18.9				34		34	
3	5.5	114.5	5.0	5.1	8.7	8.7	2	SP/SW		No Liquefaction		0.0				32		32	
4	7.5	112.5	4.0	4.3	6.5	6.5	3	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.6				30		30	
5	9.5	110.5	3.0	3.4	4.5	4.5	4	SP/SW		No Liquefaction		0.0				28		28	
6	11.5	108.5	2.0	2.3	2.8	4.9	5	SM/SC/SC-SM		No Liquefaction		12.0				27		27	
7	16.5	103.5	27.0	33.0	35.7	35.7	6	SP/SW		No Liquefaction		4.6				36		36	
8	21.5	98.5	54.0	68.1	68.6	46.0	7	SM/SC/SC-SM		No Liquefaction		48.4				36		36	
9	26.5	93.5	36.0	46.2	43.7	46.0	8	SM/SC/SC-SM		No Liquefaction		35.7				36		36	
10	31.5	88.5	35.0	45.4	40.6	46.0	8	SM/SC/SC-SM		No Liquefaction		35.7				36		36	
11	36.5	83.5	21.0	27.4	27.4	32.9	9	ML		No Liquefaction		59.4				30		30	
12	41.5	78.5	27.0	35.4	35.4	40.9	9	ML		No Liquefaction		59.4				30		30	
13	46.5	73.5	24.0	31.5	31.5	37.0	9	ML		No Liquefaction		59.4				30		30	
14	51.5	68.5	50.0	65.7	65.7	46.0	9	ML		No Liquefaction		59.4				30		30	
15	56.5	63.5	20.0	26.3	26.3	31.8	9	ML		No Liquefaction		59.4				30		30	
16	61.5	58.5	31.0	40.8	40.8	46.0	9	ML		No Liquefaction		59.4				30		30	
17	66.5	53.5	43.0	56.6	56.6	46.0	9	ML		No Liquefaction		59.4				30		30	
18	71.5	48.5	27.0	35.5	35.5	41.0	9	ML		No Liquefaction		59.4				30		30	
19	76.5	43.5	34.0	44.8	44.8	46.0	9	ML		No Liquefaction		59.4				30		30	
20	81.5	38.5	49.0	64.5	64.5	46.0	9	ML		No Liquefaction		59.4				30		30	
21	86.5	33.5	43.0	56.6	56.6	46.0	9	ML		No Liquefaction		59.4				30		30	
22	91.5	28.5	7.0	9.2	5.6	5.6	10	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				29		29	
23	96.5	23.5	50.0	65.8	39.1	41.2	11	SM/SC/SC-SM		No Liquefaction		12.0				36		36	
	101.5	18.5	24.0	31.6	18.3	18.3	12	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/16/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-4	Station:	5952+50.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D	
Design Earthquake:	SEE	FEE
S_{D1} =	0.490	0.180
$k_{max} = PGA$ =	0.430	0.200
$\beta = S_{D1}/PGA$ =	1.140	0.900
α_w =	1.000	1.000
$k_h = k_{avg}$ =	0.430	0.200
M_w =	7.37	7.36
R =	63.3	64.1
\bar{V}_s =	1,005.40	1,005.40
Z_{HR} =	494.50	494.50
ϵ =	0.000	0.000
D_{a5-95}	30.12	30.07

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$0.50 \leq \beta \leq 1.5$

$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0$: for $h_{slope} \leq 20$ ft $\alpha_w = 1.0$

$k_h = k_{avg} = \alpha_w k_{max}$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

R < 20 km; $\epsilon = 0.015(R-20)$

R \geq 20 km; $\epsilon = 0$

SPT Correction Summary

PIN No.: 40308		File No.: 38.040308		Latitude: 33.4570	
Project: Bridge Replacement over Four Hole Swamp				Longitude: 80.6470	
Route: US 301		County: 38 - Orangeburg		Location: RW-4	

Designer:	R. Gardner - Midlands RPG
Date:	10/16/2014
Station:	5952+50.00

Boring Number =	RW-4	Design EQ =	SEE	No. of Soil Layers =	4	each
Boring Station =	5952+50.00	Site Class =	D	No. of Split Spoon Samples =	9	each
Boring Offset =	20' Rt	PGA (g) =	0.43	Total Profile Thickness =	25	feet
Ground Elevation at Boring (ft msl) =	119.5	M _w =	7.37			
Water Table Depth (Dw) (ft) =	6.5	R (km) =	63.3			
Water Table Elevation (msl ft) =	113	D _{a5-95} (sec) =	30.12			

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ'vo (psf)	C _N	Fines Content (FC)	ΔN'1,60	N'60	N'1,60	N'1,60,CS	Soil Layer No.	Soil Type (USCS)
	0	119.5														
1	3.5	116.0	4.0	1.32	1.00	0.73	1.00	401.0	1.70	20.2	4.5	3.8	6.5	11.0	1	SM/SC/SC-SM
2	5.5	114.0	3.0	1.32	1.00	0.78	1.00	641.0	1.70	4.1	0.0	3.1	5.2	5.2	2	SP/SW
3	7.5	112.0	5.0	1.32	1.00	0.82	1.00	818.6	1.56	4.1	0.0	5.4	8.4	8.4	2	SP/SW
4	9.5	110.0	4.0	1.32	1.00	0.85	1.00	935.3	1.46	4.1	0.0	4.5	6.5	6.5	2	SP/SW
5	11.4	108.1	8.0	1.32	1.00	0.88	1.00	1,035.2	1.39	21.3	4.7	9.2	12.8	17.5	3	SM/SC/SC-SM
6	16.4	103.1	12.0	1.32	1.00	0.93	1.00	1,298.2	1.24	21.3	4.7	14.6	18.2	22.8	3	SM/SC/SC-SM
7	21.4	98.1	50.0	1.32	1.00	0.96	1.00	1,561.2	1.13	49.3	5.5	63.0	71.3	46.0	4	SM/SC/SC-SM
8	24.7	94.8	50.0	1.32	1.00	0.97	1.00	1,734.8	1.07	49.3	5.5	63.8	68.6	46.0	4	SM/SC/SC-SM
9	25.1	94.4	50.0	1.32	1.00	0.97	1.00	1,755.9	1.07	49.3	5.5	63.9	68.2	46.0	4	SM/SC/SC-SM

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number = **RW-4**
 Boring Station = **5952+50.00**
 Boring Offset = **20' Rt**
 Ground Elevation at Boring (ft msl) = **119.5**
 Water Table Depth (Dw) (ft) = **6.5**
 Water Table Elevation (msl ft) = **113**

Design EQ = **SEE**
 Site Class = **D**
 PGA (g) = **0.43**
 Mw = **7.37**
 R (km) = **63.3**
 D_{as-95} (sec) = **30.12**

No. of Soil Layers = **4** each
 No. of Split Spoon Samples = **9** each
 Total Profile Thickness = **25** feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths	
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)
	0	119.5																	
1	3.5	116.0	4.0	3.8	6.5	11.0	1	SM/SC/SC-SM		No Liquefaction		20.2				30		30	
2	5.5	114.0	3.0	3.1	5.2	5.2	2	SP/SW		No Liquefaction		4.1				29		29	
3	7.5	112.0	5.0	5.4	8.4	8.4	2	SP/SW		No Liquefaction		4.1				31		31	
4	9.5	110.0	4.0	4.5	6.5	6.5	2	SP/SW		No Liquefaction		4.1				30		30	
5	11.4	108.1	8.0	9.2	12.8	17.5	3	SM/SC/SC-SM		No Liquefaction		21.3				34		34	
6	16.4	103.1	12.0	14.6	18.2	22.8	3	SM/SC/SC-SM		No Liquefaction		21.3				36		36	
7	21.4	98.1	50.0	63.0	71.3	46.0	4	SM/SC/SC-SM		No Liquefaction		49.3				36		36	
8	24.7	94.8	50.0	63.8	68.6	46.0	4	SM/SC/SC-SM		No Liquefaction		49.3				36		36	
9	25.1	94.4	50.0	63.9	68.2	46.0	4	SM/SC/SC-SM		No Liquefaction		49.3				36		36	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/16/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-5	Station:	5952+70.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

$0.50 \leq \beta \leq 1.5$

α_w = Wave Scattering Scaling Factor:

$1+0.01h_{slope}[(0.5\beta)-1] \leq 1.0$: for $h_{slope} \leq 20ft$ $\alpha_w = 1.0$

k_h = Average seismic horizontal coefficient due to wave scattering:

$k_h = k_{avg} = \alpha_w k_{max}$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

R < 20 km; $\epsilon = 0.015(R-20)$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

R \geq 20 km; $\epsilon = 0$

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	Bridge Replacement over Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	RW-5

Designer:	R. Gardner - Midlands RPG
Date:	10/16/2014
Station:	5952+70.00

Boring Number =	RW-5	Design EQ =	SEE
Boring Station =	5952+70.00	Site Class =	D
Boring Offset =	22' Lt	PGA (g) =	0.43
Ground Elevation at Boring (ft msl) =	119.4	M _w =	7.37
Water Table Depth (Dw) (ft) =	8.1	R (km) =	63.3
Water Table Elevation (msl ft) =	111.3	D _{a5-95} (sec) =	30.12

No. of Soil Layers =	4 each
No. of Split Spoon Samples =	11 each
Total Profile Thickness =	41 feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
0		119.4														
1	3.5	115.9	15.0	1.32	1.00	0.73	1.00	420.0	1.70	11.3	1.8	14.4	24.5	26.3	1	SW-SM/SW-SC/SP-SM/SP-SC
2	5.5	113.9	6.0	1.32	1.00	0.78	1.00	660.0	1.70	11.3	1.8	6.1	10.4	12.2	1	SW-SM/SW-SC/SP-SM/SP-SC
3	7.5	111.9	6.0	1.32	1.00	0.82	1.00	900.0	1.49	11.5	1.8	6.4	9.6	11.5	2	SW-SM/SW-SC/SP-SM/SP-SC
4	9.5	109.9	4.0	1.32	1.00	0.85	1.00	1,054.6	1.38	11.5	1.8	4.5	6.2	8.0	2	SW-SM/SW-SC/SP-SM/SP-SC
5	11.4	108.0	2.0	1.32	1.00	0.88	1.00	1,154.6	1.32	41.0	5.5	2.3	3.0	8.5	3	SM/SC/SC-SM
6	16.4	103.0	0.0	1.32	1.00	0.93	1.00	1,426.6	1.18	41.0	5.5	0.0	0.0	5.5	3	SM/SC/SC-SM
7	21.4	98.0	17.0	1.32	1.00	0.96	1.00	1,664.6	1.00	59.9	5.5	21.4	21.4	26.9	4	ML
8	26.4	93.0	23.0	1.32	1.00	0.97	1.00	1,902.6	1.00	59.9	5.5	29.5	29.5	35.0	4	ML
9	31.4	88.0	25.0	1.32	1.00	0.99	1.00	2,140.6	1.00	59.9	5.5	32.4	32.4	37.9	4	ML
10	35	84.4	50.0	1.32	1.00	0.99	1.00	2,311.9	1.00	59.9	5.5	65.2	65.2	46.0	4	ML
11	41.4	78.0	15.0	1.32	1.00	1.00	1.00	2,616.6	1.00	59.9	5.5	19.7	19.7	25.2	4	ML

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number =	RW-5
Boring Station =	5952+70.00
Boring Offset =	22' Lt
Ground Elevation at Boring (ft msl) =	119.4
Water Table Depth (Dw) (ft) =	8.1
Water Table Elevation (msl ft) =	111.3

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.3
D _{a5-95} (sec) =	30.12

No. of Soil Layers =	4	each
No. of Split Spoon Samples =	11	each
Total Profile Thickness =	41	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic S Strength ^t
																φ' (degrees)	τ = c (psf)	φ' (degrees)
	0	119.4																
1	3.5	115.9	15.0	14.4	24.5	26.3	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.3					36	36
2	5.5	113.9	6.0	6.1	10.4	12.2	1	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.3					33	33
3	7.5	111.9	6.0	6.4	9.6	11.5	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		11.5					32	32
4	9.5	109.9	4.0	4.5	6.2	8.0	2	SW-SM/SW-SC/SP-SM/SP-SC	Sand-Like	Full Liquefaction	31.2	11.5				30	5	
5	11.4	108.0	2.0	2.3	3.0	8.5	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	22.4	41.0				27	5	
6	16.4	103.0	0.0	0.0	0.0	5.5	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	0.0	41.0				25	4	
7	21.4	98.0	17.0	21.4	21.4	26.9	4	ML		No Strength Loss		59.9					1607	
8	26.4	93.0	23.0	29.5	29.5	35.0	4	ML		No Liquefaction		59.9					30	30
9	31.4	88.0	25.0	32.4	32.4	37.9	4	ML		No Liquefaction		59.9					30	30
10	35	84.4	50.0	65.2	65.2	46.0	4	ML		No Liquefaction		59.9					30	30
11	41.4	78.0	15.0	19.7	19.7	25.2	4	ML		No Strength Loss		59.9					1500	

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/16/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-6	Station:	5953+15.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering:

M_w = Moment Magnitude of Design Earthquake

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$0.50 \leq \beta \leq 1.5$$

$$1 + 0.01h_{slope}[(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w & R = Deaggregation Analysis

\bar{V}_s from Three-Point Method Excel Spreadsheet

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	Bridge Replacement over Four Hole Swamp			Longitude:	80.6470	Date:	10/16/2014
Route:	US 301	County:	38 - Orangeburg	Location:	RW-6	Station:	5953+15.00

Design EQ = **SEE**

Site Class = **D**

PGA (g) = **0.43**

M_w = **7.4**

R (km) = **63.3**

D₈₅₋₉₅ (sec) = **30.12**

Boring Number = **RW-6**

Boring Station = **5953+15.00**

Boring Offset = **22' Rt**

Ground Elevation at Boring (ft msl) = **119.2**

Water Table Depth (Dw) (ft) = **8.0**

Water Table Elevation (msl ft) = **111.2**

Hammer Type = **Automatic**

Energy Ratio = **79.0**

Energy Correction (C_e) = **1.32**

Borehole Diameter (in) = **4**

Borehole Correction (CB) = **1.00**

No. of Soil Layers = **5** each

No. of Split Spoon Samples = **8** each

Total Profile Thickness = **20.9** feet

Sampler Configuration:

Liner Required = **N**

Liner Used = **N**

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Screening Summary		SSL Triggering Summary			Seismic Analysis Summary			Geotechnical Seismic Hazards Summary					
					SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR* _{eq} /CRR* _{eq}	φ _{SL}	(D/C) _{SL} ≤ φ _{SL}	R _u	φ' (degrees)	τ (psf)	ΔLD _i (feet)	Σ ΔLD _i (feet)	ΔS _i (inches)			
	0	119.2																
1	3.5	115.7	8.5	SM/SC/SC-SM	NSL-S				No Liquefaction		28.7							
2	5.5	113.7	7.0	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		30.3							
3	7.5	111.7	1.6	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		25.0							
4	9.5	109.7	8.2	SM/SC/SC-SM	SSL	Sand-Like	1.63	0.90	Full Liquefaction	0.7 - 1.0	4.7			1.00	1.00		1.00	
5	11.5	107.7	17.5	SM/SC/SC-SM	SSL	Sand-Like	1.04	0.90	Full Liquefaction	0.7 - 1.0	23.7			0.08	1.08		0.32	
6	16.5	102.7	30.2	SP/SW	NSL-S				No Liquefaction		32.0							
7	20.3	98.9	46.0	ML	NSL-S				No Liquefaction		30.0							
8	20.9	98.3	46.0	ML	NSL-S				No Liquefaction		30.0							
													1.08		1.32			

LDI Total (feet) S Total (inches)

^DDepth at bottom of Split-Spoon Sampler.

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570
Project:	Bridge Replacement over Four Hole Swamp	Longitude:	80.6470		
Route:	US 301	County:	38 - Orangeburg	Location:	RW-6

Designer:	R. Gardner - Midlands RPG
Date:	10/16/2014

Station: 5953+15.00

Boring Number =	RW-6	Design EQ =	SEE
Boring Station =	5953+15.00	Site Class =	D
Boring Offset =	22' Rt	PGA (g) =	0.43
Ground Elevation at Boring (ft msl) =	119.2	M _w =	7.37
Water Table Depth (Dw) (ft) =	8	R (km) =	63.3
Water Table Elevation (msl ft) =	111.2	D _{a5-95} (sec) =	30.12

No. of Soil Layers =	5	each
No. of Split Spoon Samples =	8	each
Total Profile Thickness =	21	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ' _{vo} (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
	0	119.2														
1	3.5	115.7	3.0	1.32	1.00	0.73	1.00	401.0	1.70	16.0	3.6	2.9	4.9	8.5	1	SM/SC/SC-SM
2	5.5	113.7	4.0	1.32	1.00	0.78	1.00	641.0	1.70	5.0	0.0	4.1	7.0	7.0	2	SW-SM/SW-SC/SP-SM/SP-SC
3	7.5	111.7	1.0	1.32	1.00	0.82	1.00	882.5	1.51	5.0	0.0	1.1	1.6	1.6	2	SW-SM/SW-SC/SP-SM/SP-SC
4	9.5	109.7	2.0	1.32	1.00	0.85	1.00	1,018.9	1.40	25.1	5.1	2.2	3.1	8.2	3	SM/SC/SC-SM
5	11.5	107.7	8.0	1.32	1.00	0.88	1.00	1,115.1	1.34	25.1	5.1	9.2	12.4	17.5	3	SM/SC/SC-SM
6	16.5	102.7	21.0	1.32	1.00	0.93	1.00	1,438.1	1.18	0.0	0.0	25.6	30.2	30.2	4	SP/SW
7	20.3	98.9	50.0	1.32	1.00	0.95	1.00	1,619.0	1.00	51.0	5.5	62.6	62.6	46.0	5	ML
8	20.9	98.3	50.0	1.32	1.00	0.95	1.00	1,647.5	1.00	51.0	5.5	62.8	62.8	46.0	5	ML

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number =	RW-6
Boring Station =	5953+15.00
Boring Offset =	22' Rt
Ground Elevation at Boring (ft msl) =	119.2
Water Table Depth (Dw) (ft) =	8
Water Table Elevation (msl ft) =	111.2

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.3
D _{as-95} (sec) =	30.12

No. of Soil Layers =	5	each
No. of Split Spoon Samples =	8	each
Total Profile Thickness =	21	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N ₆₀	N _{1,60}	N _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ ψ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic Shear Strengths		
																φ' (degrees)	τ = c (psf)	φ' (degrees)	τ = c (psf)	
	0	119.2																		
1	3.5	115.7	3.0	2.9	4.9	8.5	1	SM/SC/SC-SM		No Liquefaction		16.0				29		29		
2	5.5	113.7	4.0	4.1	7.0	7.0	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				30		30		
3	7.5	111.7	1.0	1.1	1.6	1.6	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		5.0				25		25		
4	9.5	109.7	2.0	2.2	3.1	8.2	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	22.1	25.1				27		5		
5	11.5	107.7	8.0	9.2	12.4	17.5	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	44.8	25.1				34		24		
6	16.5	102.7	21.0	25.6	30.2	30.2	4	SP/SW		No Liquefaction		0.0				32		32		
7	20.3	98.9	50.0	62.6	62.6	46.0	5	ML		No Liquefaction		51.0				30		30		
8	20.9	98.3	50.0	62.8	62.8	46.0	5	ML		No Liquefaction		51.0				30		30		

^DDepth at bottom of Split-Spoon Sampler.

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Route:	US 301	County:	38 - Orangeburg	Longitude:	80.6470	Date:	10/16/2014
Project:	Bridge Replacement over Four Hole Swamp						
Location:	RW-7	Station:	5953+66.00	Finished Embankment Height (ft) ¹ =	0		

¹Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Seismic Data:

Site Class =	D		
Design Earthquake:	SEE	FEE	
S_{D1} =	0.490	0.180	g
$k_{max} = PGA$ =	0.430	0.200	g
$\beta = S_{D1}/PGA$ =	1.140	0.900	
α_w =	1.000	1.000	
$k_h = k_{avg}$ =	0.430	0.200	g
M_w =	7.37	7.36	
R =	63.3	64.1	km
\bar{V}_s =	1,005.40	1,005.40	ft/sec
Z_{HR} =	494.50	494.50	meters
ϵ =	0.000	0.000	
D_{a5-95}	30.12	30.07	sec

β = Ground Motion Index:

$$0.50 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01 h_{slope} [(0.5\beta) - 1] \leq 1.0: \text{ for } h_{slope} \leq 20\text{ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering:

$$k_h = k_{avg} = \alpha_w k_{max}$$

M_w = Moment Magnitude of Design Earthquake

M_w & R = Deaggregation Analysis

R = Site-to-Source Distance

\bar{V}_s = Average Shear Wave Velocity

\bar{V}_s from Three-Point Method Excel Spreadsheet

Z_{HR} = Depth from ground surface to hard rock $V_s > 5,000$ ft/sec; from SCENARIO_PC 2006 output

ϵ = Near-fault directivity correction:

$$R < 20 \text{ km}; \epsilon = 0.015(R-20)$$

D_{a5-95} = Duration of Earthquake as a function of acceleration: Use Eq. 12-48

$$R \geq 20 \text{ km}; \epsilon = 0$$

SPT-Based Soil Shear Strength Loss Evaluation

Idriss and Boulanger Procedure (2008) - SCDOT v1.2 - 07302012

PIN No.:	40308	File No.:	38.040308	Latitude:	33.4570	Designer:	R. Gardner - Midlands RPG
Project:	Bridge Replacement over Four Hole Swamp			Longitude:	80.6470	Date:	10/16/2014
Route:	US 301	County:	38 - Orangeburg	Location:	RW-7	Station:	5953+66.00

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.4
R (km) =	63.3
D _{a5-95} (sec) =	30.12

Boring Number =	RW-7
Boring Station =	5953+66.00
Boring Offset =	20' Lt
Ground Elevation at Boring (ft msl) =	119.7
Water Table Depth (D _w) (ft) =	7.9
Water Table Elevation (msl ft) =	111.8

Hammer Type =	Automatic
Energy Ratio =	79.0
Energy Correction (C _e) =	1.32
Borehole Diameter (in) =	4
Borehole Correction (CB) =	1.00

No. of Soil Layers =	5	each
No. of Split Spoon Samples =	8	each
Total Profile Thickness =	21.8	feet

Sampler Configuration:	
Liner Required =	N
Liner Used =	N

N-value Summary				SSL Screening Summary		SSL Triggering Summary				Seismic Analysis Summary		Geotechnical Seismic Hazards Summary			
SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{1,60,CS}	Soil Type (USCS)	SSL Potential	Sand-like or Clay-like	(D/C) _{SL} = CSR* _{eq} /CRR* _{eq}	φ _{SL}	(D/C) _{SL} ≤ φ _{SL}	R _u	φ' (degrees)	τ (psf)	ΔLDI (feet)	Σ ΔLDI (feet)	ΔS _i (inches)
	0	119.7													
1	3.5	116.2	22.4	SM/SC/SC-SM	NSL-S				No Liquefaction		36.0				
2	5.5	114.2	7.1	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		30.3				
3	7.5	112.2	3.4	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		27.1				
4	9.5	110.2	11.1	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		33.0				
5	11.5	108.2	8.3	SM/SC/SC-SM	SSL	Sand-Like	1.78	0.90	Full Liquefaction	0.7 - 1.0	4.7		1.00	1.00	1.00
6	16.5	103.2	22.3	SW-SM/SW-SC/SP-SM/SP-SC	NSL-S				No Liquefaction		36.0				
7	21.5	98.2	46.0	ML	NSL-S				No Liquefaction		30.0				
8	21.8	97.9	46.0	ML	NSL-S				No Liquefaction		30.0				
													1.00		1.00

^DDepth at bottom of Split-Spoon Sampler.

LDI Total (feet)	S Total (inches)
------------------	------------------

SPT Correction Summary

PIN No.:	40308	File No.:	38.040308		Latitude:	33.4570
Project:	Bridge Replacement over Four Hole Swamp				Longitude:	80.6470
Route:	US 301	County:	38 - Orangeburg	Location:	RW-7	

Designer:	R. Gardner - Midlands RPG
Date:	10/16/2014
Station:	5953+66.00

Boring Number =	RW-7	Design EQ =	SEE
Boring Station =	5953+66.00	Site Class =	D
Boring Offset =	20' Lt	PGA (g) =	0.43
Ground Elevation at Boring (ft msl) =	119.7	M _w =	7.37
Water Table Depth (Dw) (ft) =	7.9	R (km) =	63.3
Water Table Elevation (msl ft) =	111.8	D _{a5-95} (sec) =	30.12

No. of Soil Layers =	5	each
No. of Split Spoon Samples =	8	each
Total Profile Thickness =	22	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	C _E	C _B	C _R	C _S	σ'vo (psf)	C _N	Fines Content (FC)	ΔN' _{1,60}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)
0		119.7														
1	3.5	116.2	12.0	1.32	1.00	0.73	1.00	401.0	1.70	13.7	2.8	11.5	19.6	22.4	1	SM/SC/SC-SM
2	5.5	114.2	4.0	1.32	1.00	0.78	1.00	641.0	1.70	7.3	0.2	4.1	7.0	7.1	2	SW-SM/SW-SC/SP-SM/SP-SC
3	7.5	112.2	2.0	1.32	1.00	0.82	1.00	881.0	1.51	7.3	0.2	2.1	3.2	3.4	2	SW-SM/SW-SC/SP-SM/SP-SC
4	9.5	110.2	7.0	1.32	1.00	0.85	1.00	1,022.7	1.40	7.3	0.2	7.8	11.0	11.1	2	SW-SM/SW-SC/SP-SM/SP-SC
5	11.5	108.2	4.0	1.32	1.00	0.88	1.00	1,118.9	1.34	12.0	2.1	4.6	6.2	8.3	3	SM/SC/SC-SM
6	16.5	103.2	14.0	1.32	1.00	0.93	1.00	1,421.9	1.19	12.0	2.1	17.1	20.3	22.3	4	SW-SM/SW-SC/SP-SM/SP-SC
7	21.5	98.2	50.0	1.32	1.00	0.96	1.00	1,659.9	1.00	51.0	5.5	63.0	63.0	46.0	5	ML
8	21.8	97.9	50.0	1.32	1.00	0.96	1.00	1,674.1	1.00	51.0	5.5	63.1	63.1	46.0	5	ML

^DDepth at bottom of Split-Spoon Sampler.

Soil Shear Strength Summary

Boring Number =	RW-7
Boring Station =	5953+66.00
Boring Offset =	20' Lt
Ground Elevation at Boring (ft msl) =	119.7
Water Table Depth (Dw) (ft) =	7.9
Water Table Elevation (msl ft) =	111.8

Design EQ =	SEE
Site Class =	D
PGA (g) =	0.43
M _w =	7.37
R (km) =	63.3
D _{as-95} (sec) =	30.12

No. of Soil Layers =	5	each
No. of Split Spoon Samples =	8	each
Total Profile Thickness =	22	feet

SPT Sample Number	Depth ^D (ft)	Elevation (ft msl)	N _{Meas}	N' ₆₀	N' _{1,60}	N' _{1,60,CS}	Soil Layer No.	Soil Type (USCS)	Screening Sand-Like or Clay-Like	Triggering (D/C) _{SL} ≤ φ _{SL}	D _R (%)	Fines Content (%)	D ₁₀ (%)	C _u	C _c	Static Shear Strengths		Seismic S Strength ^I
																φ' (degrees)	τ = c (psf)	φ' (degrees)
	0	119.7																
1	3.5	116.2	12.0	11.5	19.6	22.4	1	SM/SC/SC-SM		No Liquefaction		13.7				36		36
2	5.5	114.2	4.0	4.1	7.0	7.1	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		7.3				30		30
3	7.5	112.2	2.0	2.1	3.2	3.4	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		7.3				27		27
4	9.5	110.2	7.0	7.8	11.0	11.1	2	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		7.3				33		33
5	11.5	108.2	4.0	4.6	6.2	8.3	3	SM/SC/SC-SM	Sand-Like	Full Liquefaction	31.7	12.0				30		5
6	16.5	103.2	14.0	17.1	20.3	22.3	4	SW-SM/SW-SC/SP-SM/SP-SC		No Liquefaction		12.0				36		36
7	21.5	98.2	50.0	63.0	63.0	46.0	5	ML		No Liquefaction		51.0				30		30
8	21.8	97.9	50.0	63.1	63.1	46.0	5	ML		No Liquefaction		51.0				30		30

^DDepth at bottom of Split-Spoon Sampler.

Appendix VII

SLIDE 6.0 Results

PROJECT NAME: US 301 RBO Four Hole Swamp

CALCULATION: Global Stability Analysis

PROBLEM

Evaluate the global stability of the proposed roadway embankments using the computer program Slide 7.0.

PROJECT INFORMATION

Project Type: Bridge Replacement (Southbound)

Existing Alignment: 2-lane paved road of variable shoulder widths

Proposed Alignment: 2-lane paved road of variable shoulder widths

Proposed Bridge Dimensions: 47.25 x 294 feet

Stations: 5941+40 to 5960+00, (Bridge 5949+30.00 to 5952+24.00)

Grades: Proposed finished centerline grades will be raised approximately 2 feet

End Slopes: 2:1

Side Slopes: Right 4:1, Left 2:1

Added Fill: Not expected to exceed 2.5 feet at the shoulder breaks

Travel ways: 12 feet wide

Medians: NA

Project Features: The proposed bridge will be constructed on the existing alignment and southbound traffic shifted to share the northbound bridge during construction of the proposed bridge.

GIVEN/ASSUMPTIONS

- **ROC II** was used for the fill sections at the abutments and cross sections within the 150-foot limits from each bridge end.
- Seismic Design was used due to ROC II
- Short Term (during construction, total stress analysis) only considered a live load surcharge of 250psf (Load Factor, $\gamma = 1.0$)
- Long Term (effective stress analysis) considered a uniform surcharge of 400psf (Load Factor, $\gamma = 1.0$) to simulate the live load surcharge (LS) of 250 psf and a future dead load surcharge of 150 psf
- Soil strength parameters determined in the SSL spreadsheet. Soil Strength Parameters were limited if necessary by maximum values outlined in the SCDOT GDM.
- Others listed as used.

- **ROC IV** was used for the fill sections outside the 150-foot limits from each bridge end.
- Seismic Design was not used for ROC IV
- Short Term (during construction, total stress analysis) only considered a live load surcharge of 250psf (Load Factor, $\gamma = 1.0$)



PROJECT ID	0040308
DATE	05/24/2016
COMPUTED BY	RSG
CHECKED BY	SMS

- Long Term (effective stress analysis) considered a uniform surcharge of 400psf (Load Factor, $\gamma = 1.0$) to simulate the live load surcharge (LS) of 250 psf and a future dead load surcharge of 150 psf
- Soil strength parameters determined in the SSL spreadsheet. Soil Strength Parameters were limited if necessary by maximum values outlined in the SCDOT GDM.
- Others listed as used.

METHODOLOGY

SLIDE 7.0

Global slope stability analyses for the Service and Extreme Event I limit states were conducted using Rocscience, Inc. slope stability software SLIDE 7.0. The global slope stability analyses were conducted in the longitudinal and transverse directions. We analyzed the end slopes utilizing the bridge plan and profile provided by the HDS dated September 15, 2014. This profile extended from Station 5947+60 to Station 5954+00. Each end slope was plotted on 11x17 paper and coordinates drawn on them as they appear in Slide 7.0. Cross sections for the transverse analyses were selected based on critical areas along the proposed alignment from the road plans provided to us dated August 29, 2014. We also utilized a special cross section for Station 5952+24 as that was the deepest fill height. Each cross-section used was plotted on 11x17 paper and coordinates drawn on them as they appear in Slide 7.0. The maximum bridge approach fill height analyzed was 2 feet at Bents 1 and 8. Slope stability analyses assumed a groundwater table elevation of 110 feet-msl to account for seasonal variations.

The computer software SLIDE evaluates slope stability using Modified Bishop, Janbu, and Spencer methods as required by the GDM choosing the lowest Factor of Safety (FOS). All three methods for Circular Search Analysis were used to evaluate slope stability for the Service conditions, both Total and Effective Stress and in the Extreme Event I condition. Soil strength parameters were assigned to each of the identified soil layers for the slope stability analysis. These properties are based on the site characterization from the subsurface exploration conducted by ICA Engineering and Professional Services Industries, Inc., (PSI) and an engineer evaluation performed by GeoStellar Engineering. The engineering properties necessary for the slope stability analysis are:

- Moist unit weights
- Friction angle
- Cohesion

For additional information on the soil strength parameters used in this analysis, refer to the Soil Strength Parameters Calculations Package.

For all conditions, a 250-psf live load surcharge for traffic loading was considered in the analyses. The potential failure surface with the lowest Factor of Safety (FOS) is shown on each figure presented in the results. The cross-section geometries are also shown.

The lowest factor of safety determined in Slide 7.0 was converted into a resistance factor by computing the reciprocal of the FOS. The calculated resistance factor was compared to the maximum allowable resistance factor shown in Table 9-9 of the GDM. If the calculated resistance factor did not surpass the maximum shown in the GDM, the slope was considered acceptable. If the calculated resistance factor did surpass the maximum shown in the GDM, a Newmark Analysis was performed to determine the associated displacement.

RESULTS and DISCUSSION

Slope stability for the proposed roadway was not an issue due to slopes being at a 2:1 or flatter and minimal fill heights. The Slide 7.0 results are attached herein.

A table summarizing the results of this analysis is also provided as an attachment.

ATTACHMENTS

Summary of Resistance Factors for Embankments for Service and Extreme Event I conditions

SLIDE 7.0 Analysis for STA 5947+00 SS – TSA Service
SLIDE 7.0 Analysis for STA 5947+00 SS – ESA Service

SLIDE 7.0 Analysis for STA 5949+00 SS – TSA Service
SLIDE 7.0 Analysis for STA 5949+00 SS – TSA EEI FEE
SLIDE 7.0 Analysis for STA 5949+00 SS – TSA EEI SEE
SLIDE 7.0 Analysis for STA 5949+00 SS – ESA Service

SLIDE 7.0 Analysis for EB1 Abutment – TSA Service
SLIDE 7.0 Analysis for EB1 Abutment – TSA EEI FEE
SLIDE 7.0 Analysis for EB1 Abutment – TSA EEI SEE
SLIDE 7.0 Analysis for EB1 Abutment – ESA Service

SLIDE 7.0 Analysis for EB8 Abutment – TSA Service
SLIDE 7.0 Analysis for EB8 Abutment – TSA EEI FEE
SLIDE 7.0 Analysis for EB8 Abutment – TSA EEI SEE
SLIDE 7.0 Analysis for EB8 Abutment – ESA Service

SLIDE 7.0 Analysis for STA 5952+24 SS – TSA Service
SLIDE 7.0 Analysis for STA 5952+24 SS – TSA EEI FEE
SLIDE 7.0 Analysis for STA 5952+24 SS – TSA EEI SEE
SLIDE 7.0 Analysis for STA 5952+24 SS – ESA Service

SLIDE 7.0 Analysis for STA 5953+00 SS – TSA Service
SLIDE 7.0 Analysis for STA 5953+00 SS – TSA EEI FEE
SLIDE 7.0 Analysis for STA 5953+00 SS – TSA EEI SEE
SLIDE 7.0 Analysis for STA 5953+00 SS – ESA Service



Station (ROC) Cut/Fill	Analysis Method	Soil Shear Strength Parameters	Limit State	Slope	Design EQ	Required RF	Calculated RF	Calculated FOS
Roadway Station 5947+00 (ROC IV) Fill	Circular - Spencer	Total Stress	Service	Side	-	0.70	0.31	3.21
		Effective Stress	Service	Side	-	0.70	0.27	3.64
Roadway Station 5949+00 (ROC II) Fill	Circular - Spencer	Total Stress	Service	Side	-	0.65	0.30	3.31
			Extreme Event I	Side	FEE	0.90	0.58	1.73
				Side	SEE	0.90	0.92*	1.09
		Effective Stress	Service	Side	-	0.65	0.27	3.66
Bridge Abutment EB1 (ROC II) Fill	Circular - Spencer	Total Stress	Service	End	-	0.65	0.64	1.57
			Extreme Event I	End	FEE	0.90	0.95*	1.06
				End	SEE	0.90	1.32*	0.76
		Effective Stress	Service	End	-	0.65	0.62	1.62
Bridge Abutment EB8 (ROC II) Fill	Circular - Spencer	Total Stress	Service	End	-	0.65	0.63	1.58
			Extreme Event I	End	FEE	0.90	0.97*	1.04
				End	SEE	0.90	1.39*	0.72
		Effective Stress	Service	End	-	0.65	0.64	1.56
Roadway Station 5952+24 (ROC II) Fill	Circular - Spencer	Total Stress	Service	Side	-	0.65	0.33	3.03
			Extreme Event I	Side	FEE	0.90	0.80	1.25
				Side	SEE	0.90	1.27*	0.79
		Effective Stress	Service	Side	-	0.65	0.34	2.93

*Newmark Displacement Analysis performed.



South Carolina
Department of Transportation

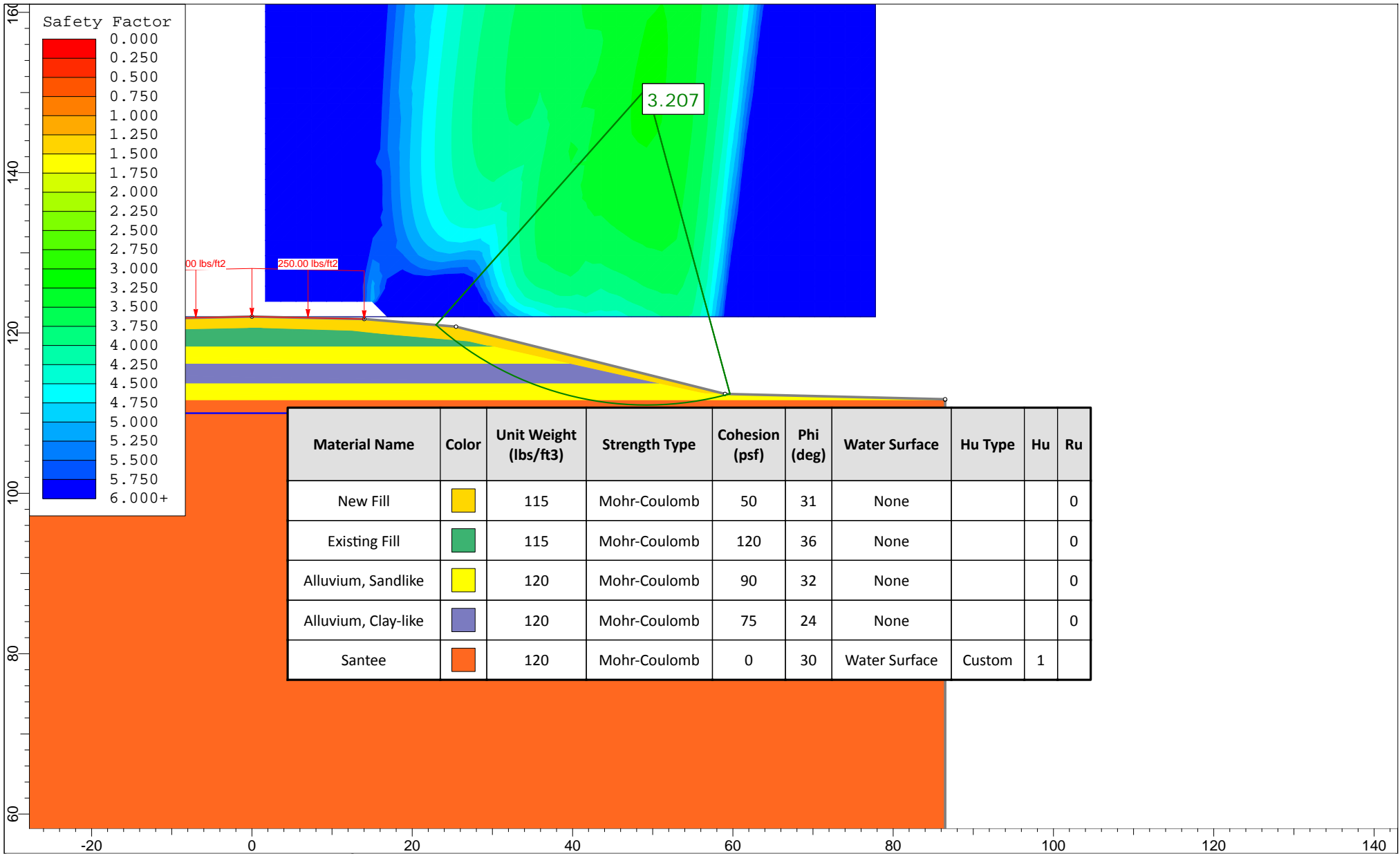
PROJECT ID 0040308
 DATE 05/24/2016
 COMPUTED BY RSG
 CHECKED BY SMS

Station (ROC) Cut/Fill	Analysis Method	Soil Shear Strength Parameters	Limit State	Slope	Design EQ	Required RF	Calculated RF	Calculated FOS
Roadway Station 5953+00 (ROC II) Fill	Circular - Spencer	Total Stress	Service	Side	-	0.65	0.32	3.13
			Extreme Event I	Side	FEE	0.90	0.68	1.50
				Side	SEE	0.90	1.12*	0.89
		Effective Stress	Service	Side	-	0.65	0.33	3.01

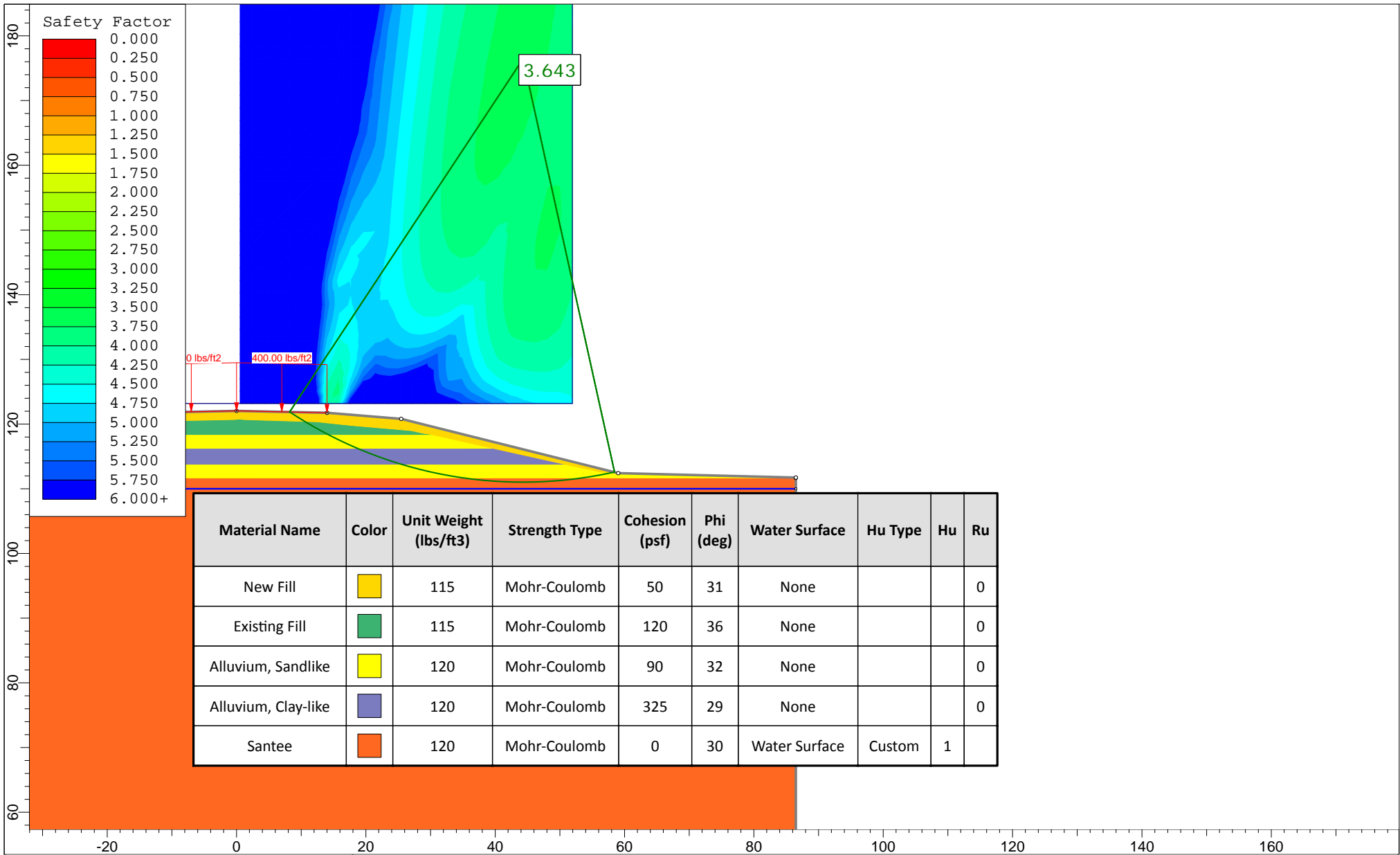
*Newmark Displacement Analysis performed.


Newmark Displacement Results

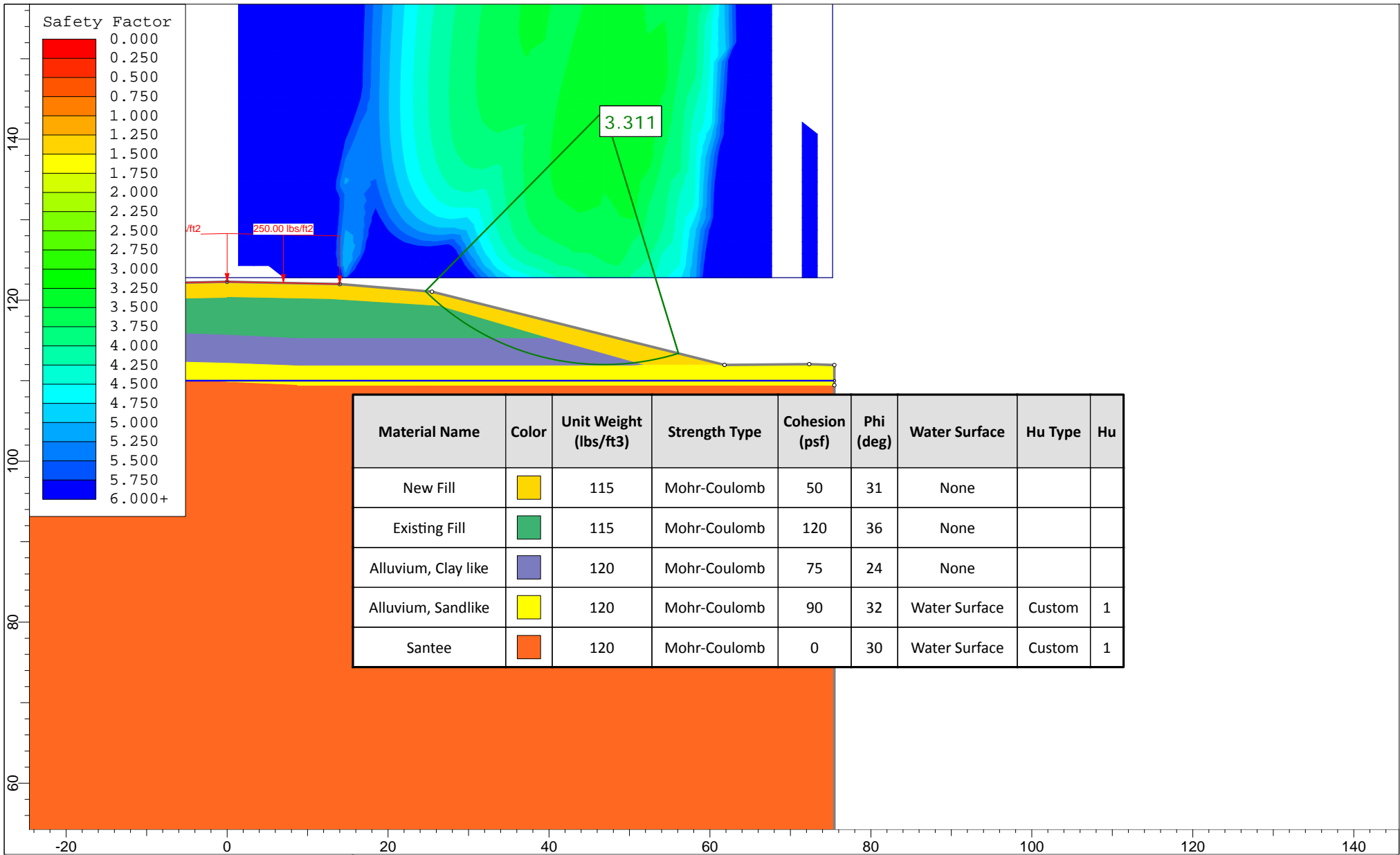
Station	Performance Limits (in)	Displacement (in)
Sta 5949+00 SEE	12	0.00
Abut 1 Stat 5949+30 SEE	12	2.48
Abut 1 Sta 5949+30 FEE	6	0.00
Abut 8 Sta 5952+24 SEE	12	3.54
Abut 8 Sta 5952+24 FEE	6	0.00
Sta 5952+24 SEE	12	0.52
Sta 5953+00 SEE	6	0.03




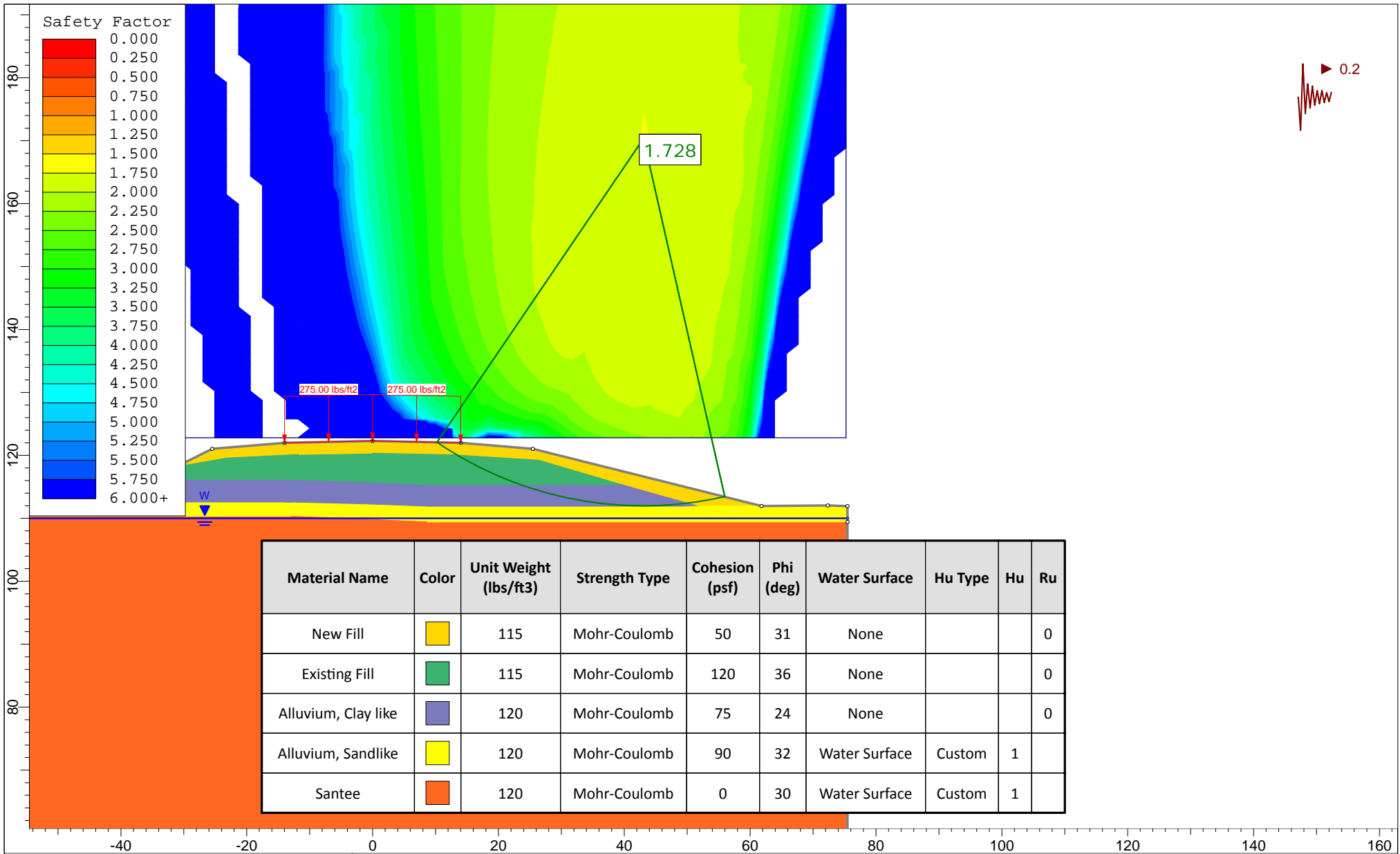
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	Analysis Description			Station 5947+00 Short Term (TSA)		
	Drawn By	RSG	Scale	1:199	Company	SCDOT
	Date	5/31/2016, 2:35:26 PM		File Name	Sta 5947+00 Short Term (TSA).slim	



	<i>Project</i> US 301 RBO Four Hole Swamp		
	<i>Analysis Description</i> Station 5947+00 LongTerm (ESA)		
	<i>Drawn By</i> RSG	<i>Scale</i> 1:247	<i>Company</i> SCDOT
	<i>Date</i> 5/31/2016, 2:35:26 PM		<i>File Name</i> Sta 5947+00 Long Term (ESA).slim



	Project			US 301 RBO Four Hole Swamp		
	Analysis Description			Sta 5949+00 Short Term (TSA)		
	Drawn By	RSG	Scale	1:198	Company	SCDOT
	Date	6/2/2016, 10:37:19 AM		File Name	Sta 5949+00 Short Term (TSA).slim	

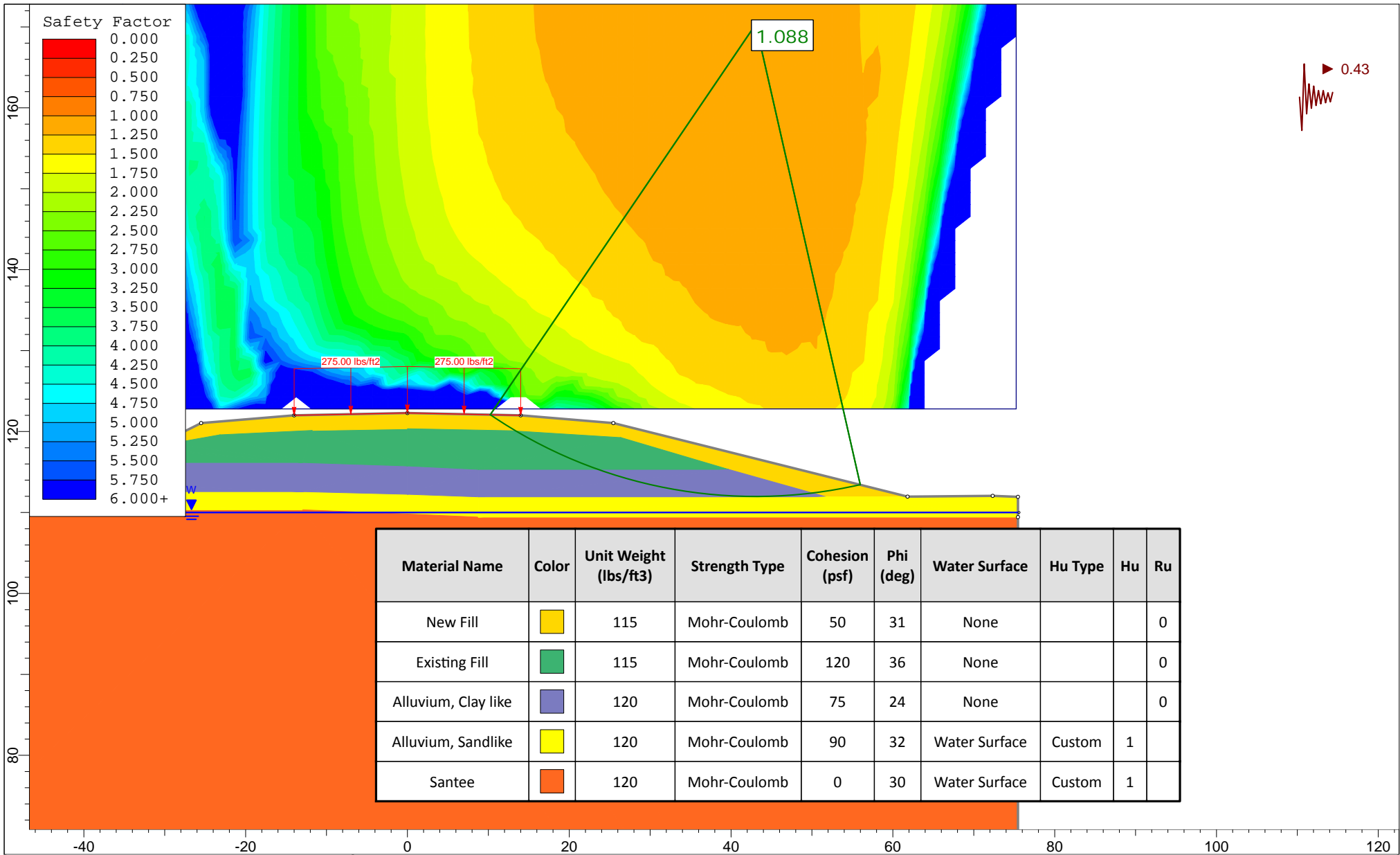


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	120	36	None			0
Alluvium, Clay like		120	Mohr-Coulomb	75	24	None			0
Alluvium, Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
Santee		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	



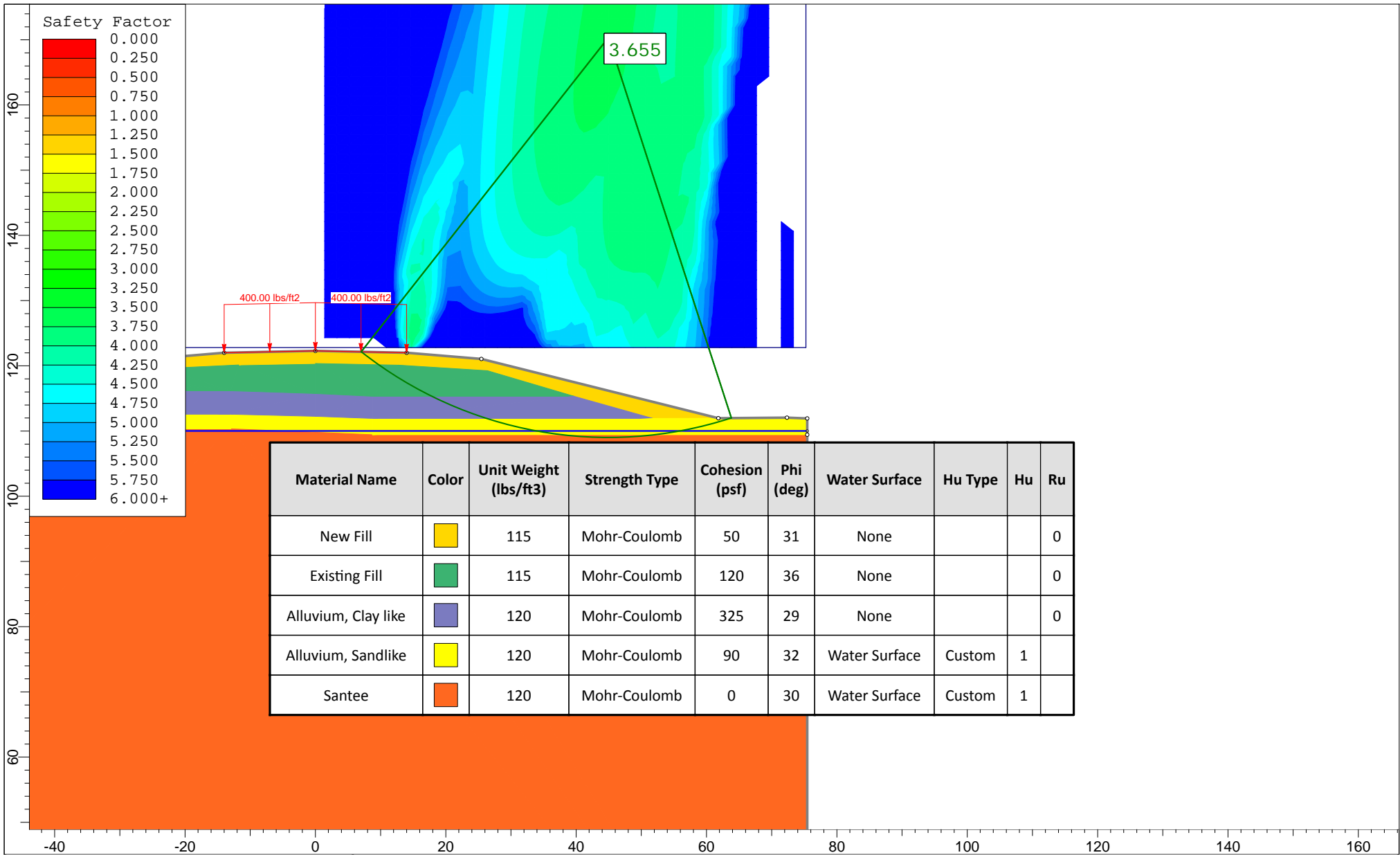
SLIDEINTERPRET 7.013


Project		US 301 RBO Four Hole Swamp	
Analysis Description		Sta 5949+00 EEI (TSA)	
Drawn By	RSG	Scale	1:253
		Company	SCDOT
Date	6/2/2016, 10:37:19 AM		File Name
		Sta 5949+00 Seismic.slmd	

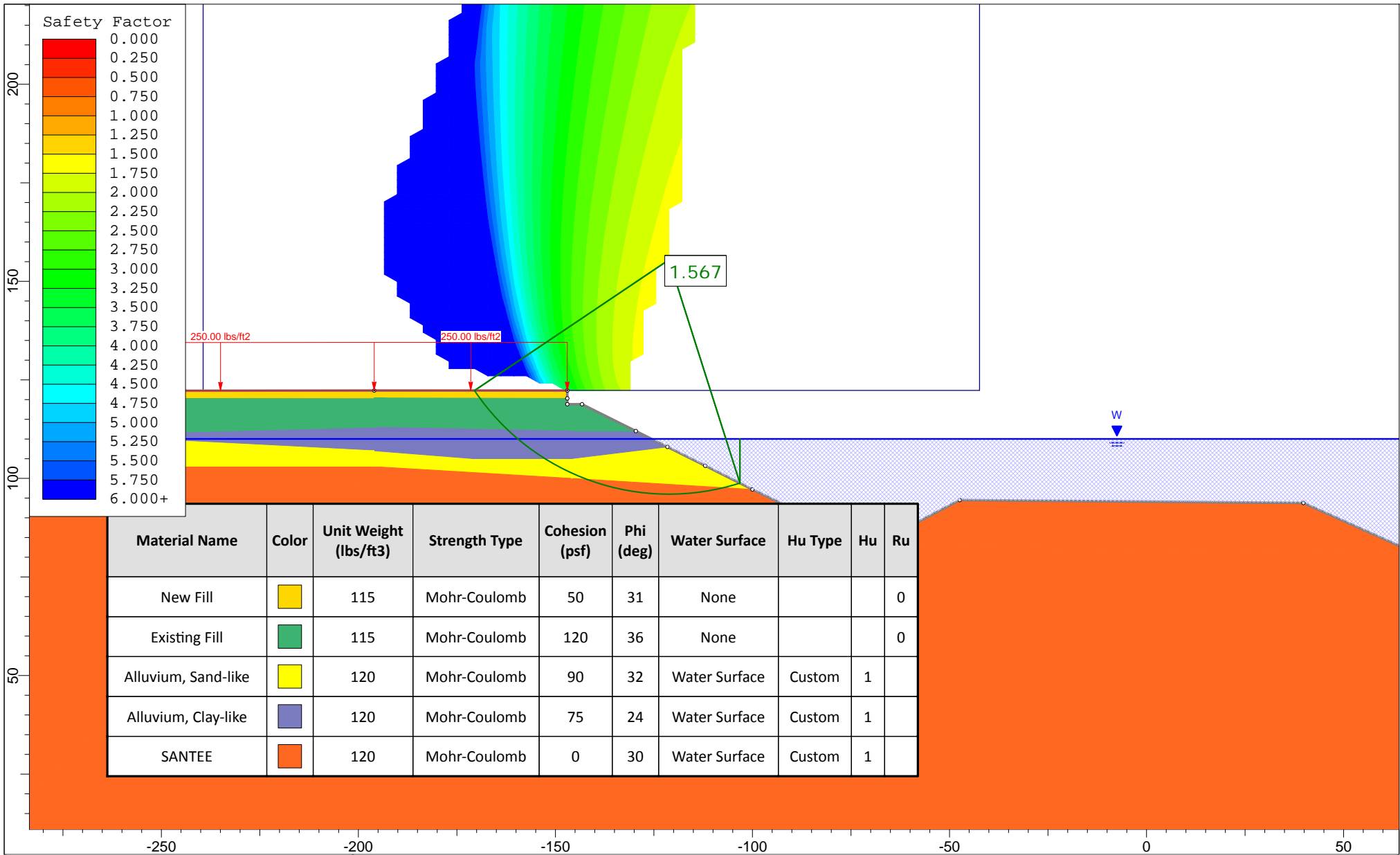







SLIDEINTERPRET 7.013

Project		US 301 RBO Four Hole Swamp	
Analysis Description		Sta 5949+00 EEI	
Drawn By	RSG	Scale	1:197
		Company	SCDOT
Date	6/2/2016, 10:37:19 AM		File Name
		Sta 5949+00 Seismic.slmd	



	Project			US 301 RBO Four Hole Swamp		
	Analysis Description			Sta 5949+00 Long Term (ESA) Static		
	Drawn By	RSG	Scale	1:245	Company	SCDOT
	Date	6/2/2016, 10:37:19 AM		File Name	Sta 5949+00 Long Term (ESA).slim	

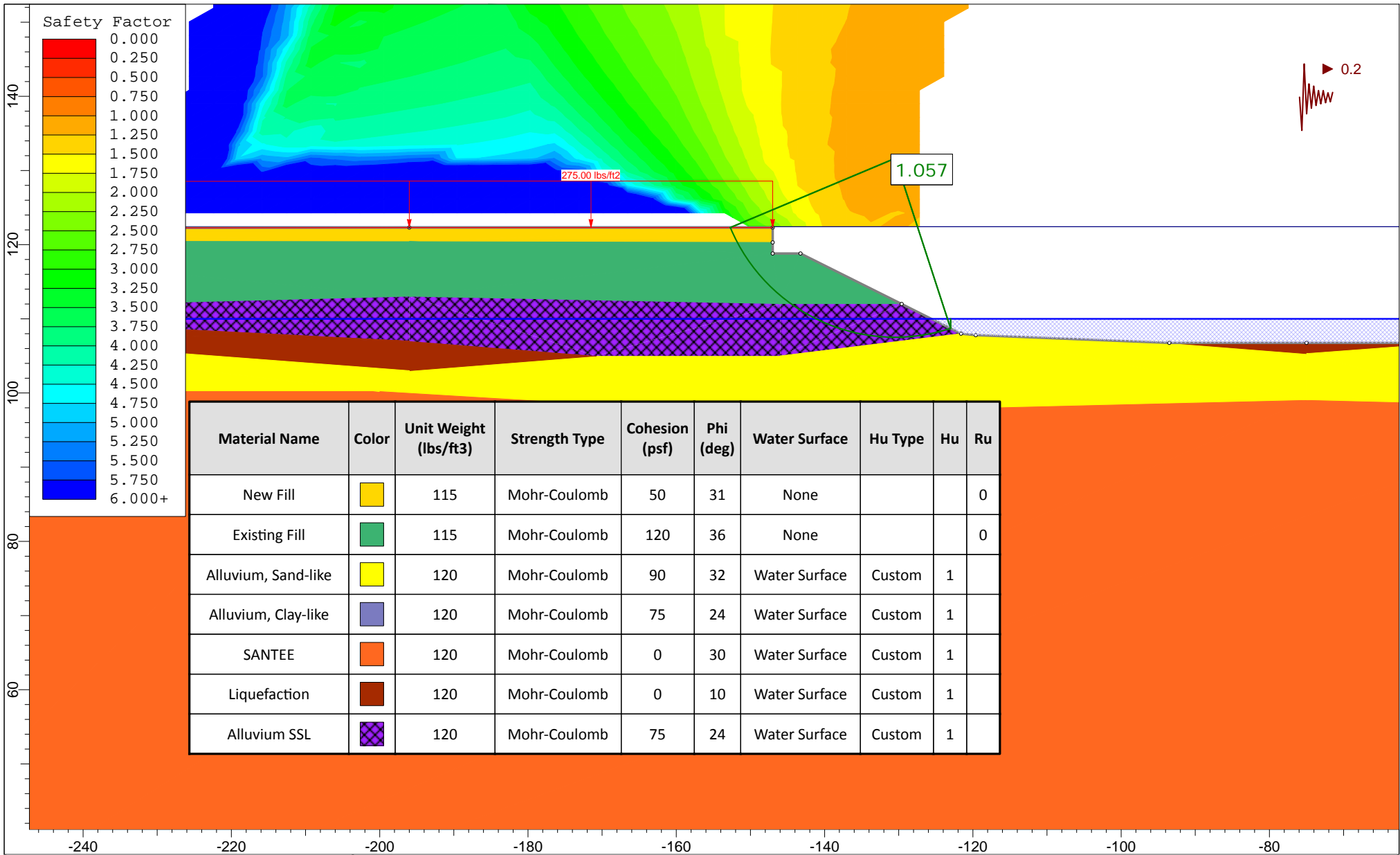


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	120	36	None			0
Alluvium, Sand-like		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
Alluvium, Clay-like		120	Mohr-Coulomb	75	24	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	

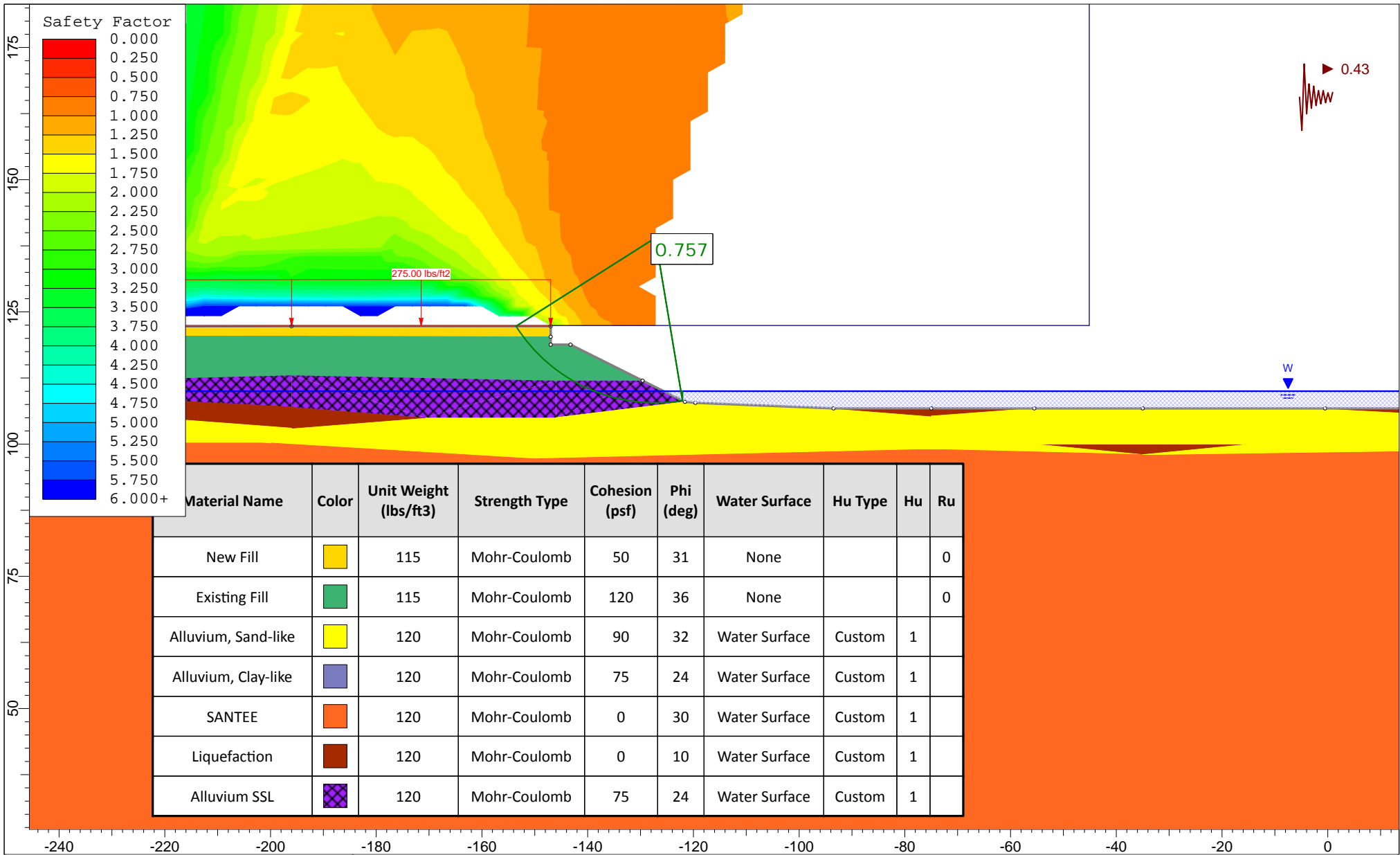


SLIDEINTERPRET 7.013


Project				US 301 over Four Hole Swamp, Orangeburg County							
Analysis Description				BOB Static Short Term (TSA)							
Drawn By		RSG		Scale		1:405		Company		SCDOT	
Date		4/22/2016, 2:17:16 PM				File Name		BOB Short Term TSA.slim			

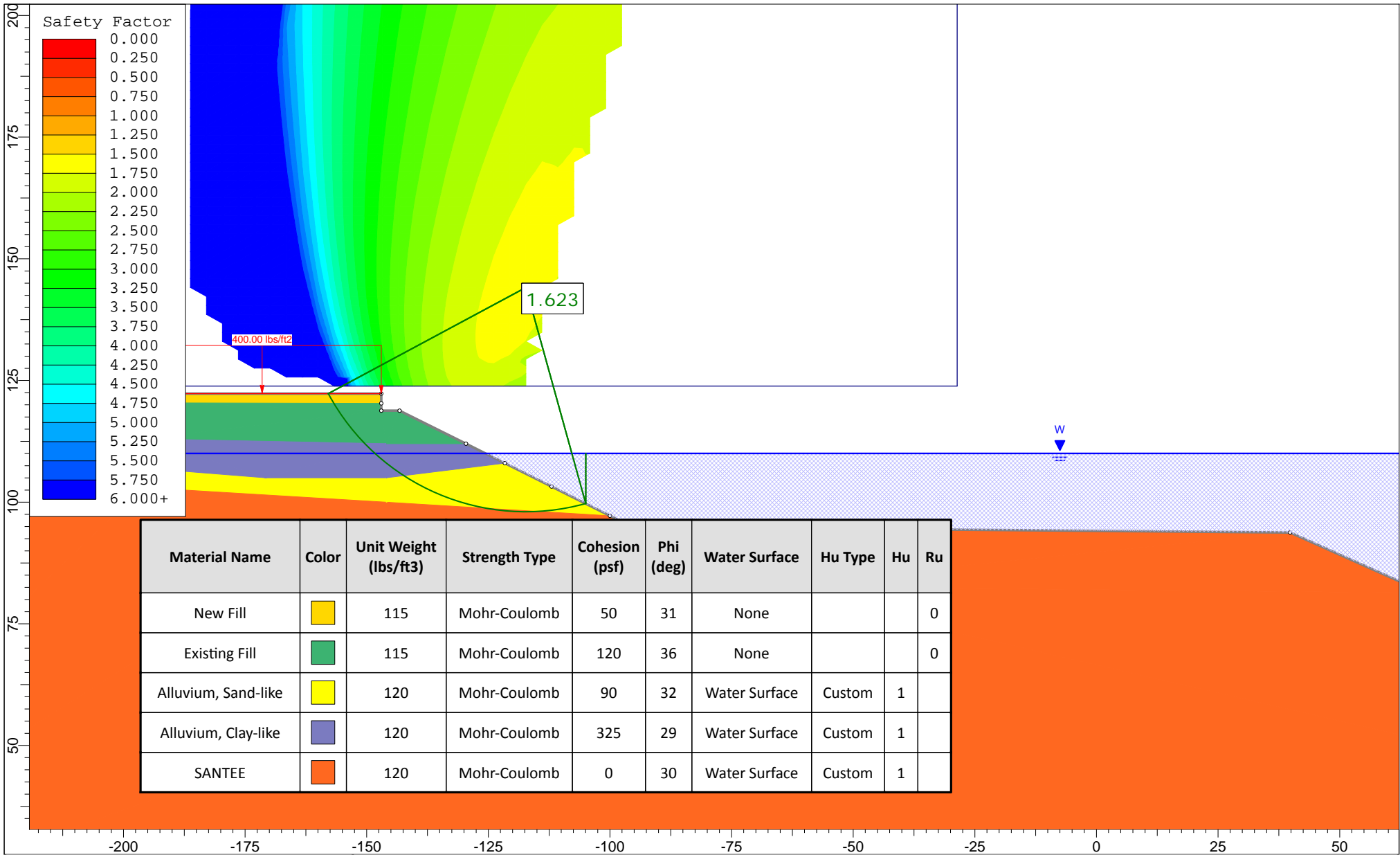







	<i>Project</i> US 301 over Four Hole Swamp, Orangeburg County			
	<i>Analysis Description</i> BOB EEI (TSA)			
	<i>Drawn By</i> RSG	<i>Scale</i> 1:215	<i>Company</i> SCDOT	
	<i>Date</i> 4/22/2016, 2:17:16 PM		<i>File Name</i> BOB Seismic.slm	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	120	36	None			0
Alluvium, Sand-like		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
Alluvium, Clay-like		120	Mohr-Coulomb	75	24	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquefaction		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	
Alluvium SSL		120	Mohr-Coulomb	75	24	Water Surface	Custom	1	

	Project			US 301 over Four Hole Swamp, Orangeburg County		
	Analysis Description			BOB EEI (TSA)		
	Drawn By	RSG	Scale	1:302	Company	SCDOT
	Date	4/22/2016, 2:17:16 PM		File Name	BOB Seismic.slmd	

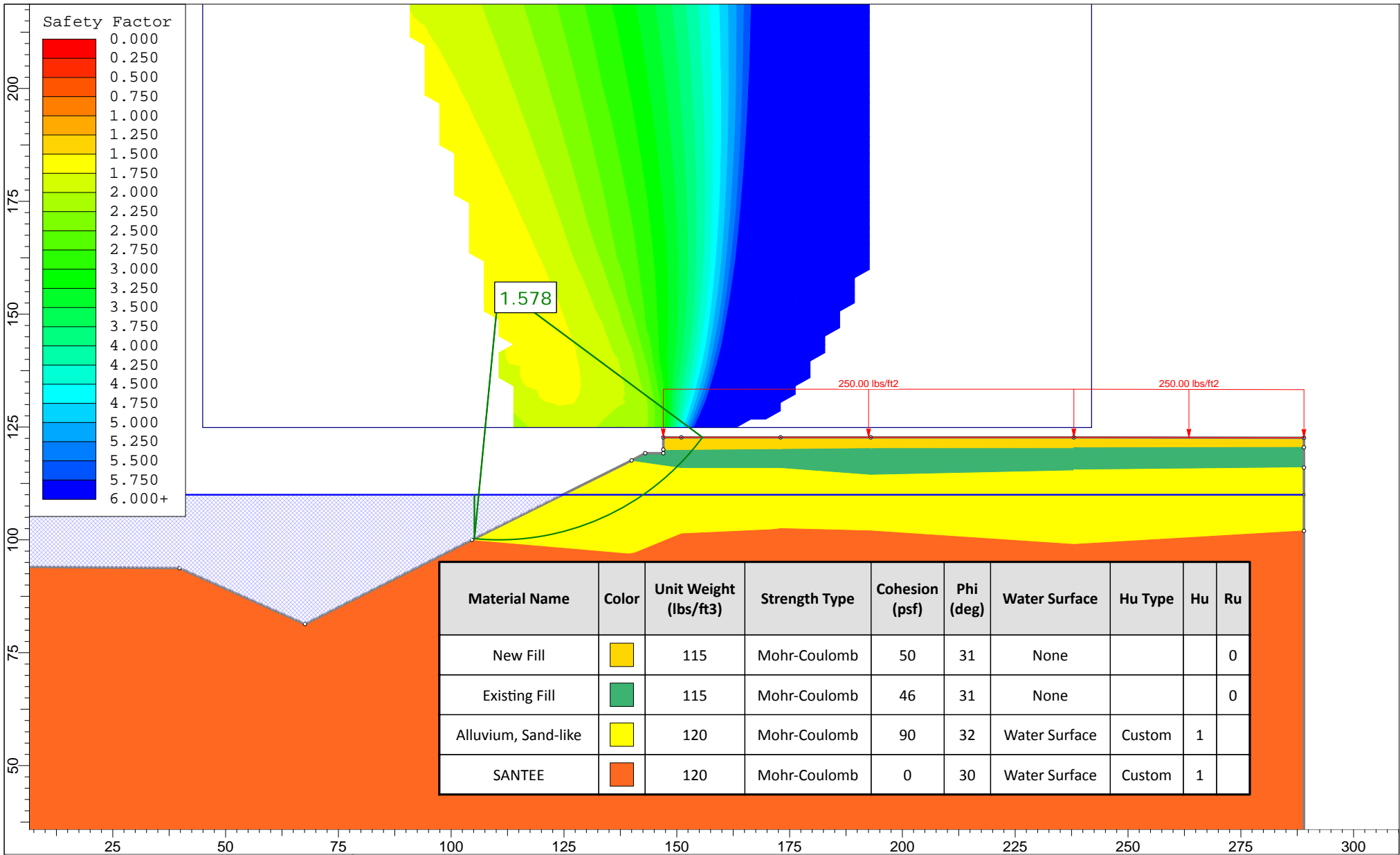






Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	120	36	None			0
Alluvium, Sand-like		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
Alluvium, Clay-like		120	Mohr-Coulomb	325	29	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	



SLIDEINTERPRET 7.013

<i>Project</i>				US 301 over Four Hole Swamp, Orangeburg County			
<i>Analysis Description</i>				Static LongTerm (ESA)			
<i>Drawn By</i>	RSG	<i>Scale</i>	1:328	<i>Company</i>	SCDOT		
<i>Date</i>	4/22/2016, 2:17:16 PM			<i>File Name</i>	BOB Long Term ESA.slim		

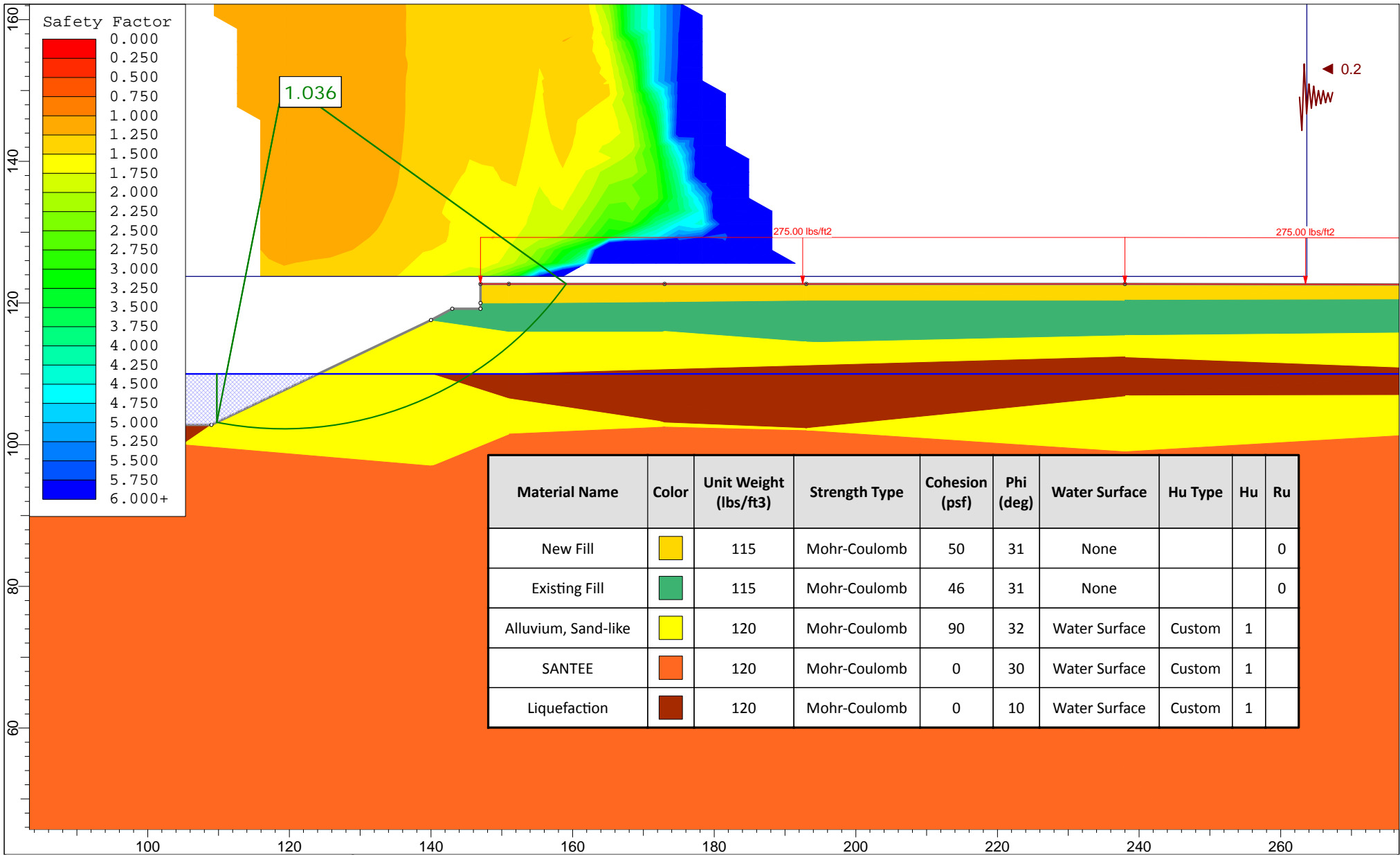


Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium, Sand-like		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	

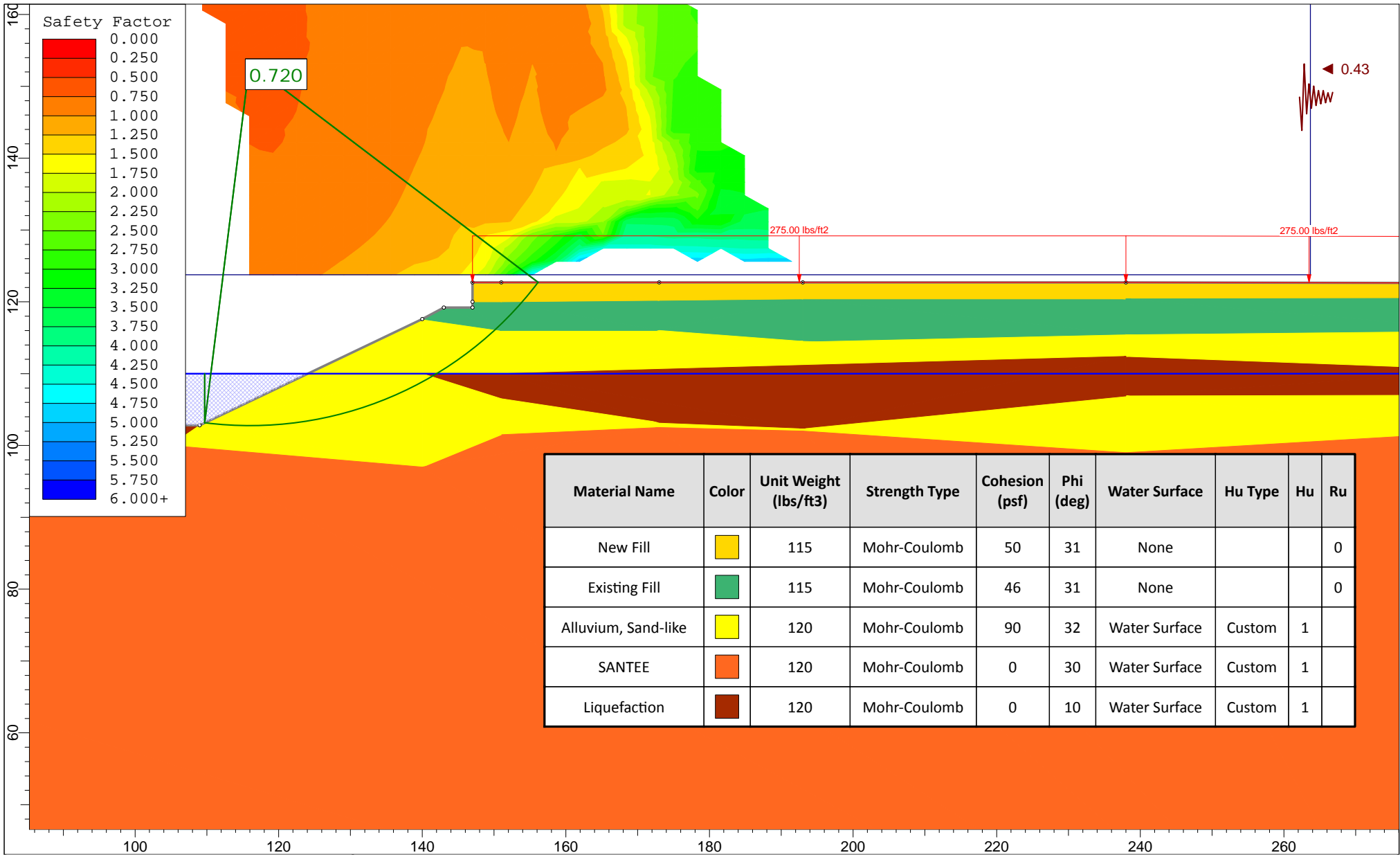







SLIDEINTERPRET 7.013

Project				US 301 over Four Hole Swamp, Orangeburg County			
Analysis Description				Static ShortTerm (TSA)			
Drawn By	RSG	Scale	1:353	Company	SCDOT		
Date	4/22/2016, 2:17:16 PM			File Name	EOB Short Term TSA.slim		



	Project			US 301 over Four Hole Swamp, Orangeburg County		
	Analysis Description			EOB EEI (TSA)		
	Drawn By	RSG	Scale	1:225	Company	SCDOT
	Date	4/22/2016, 2:17:16 PM		File Name	EOB Seismic.sldm	

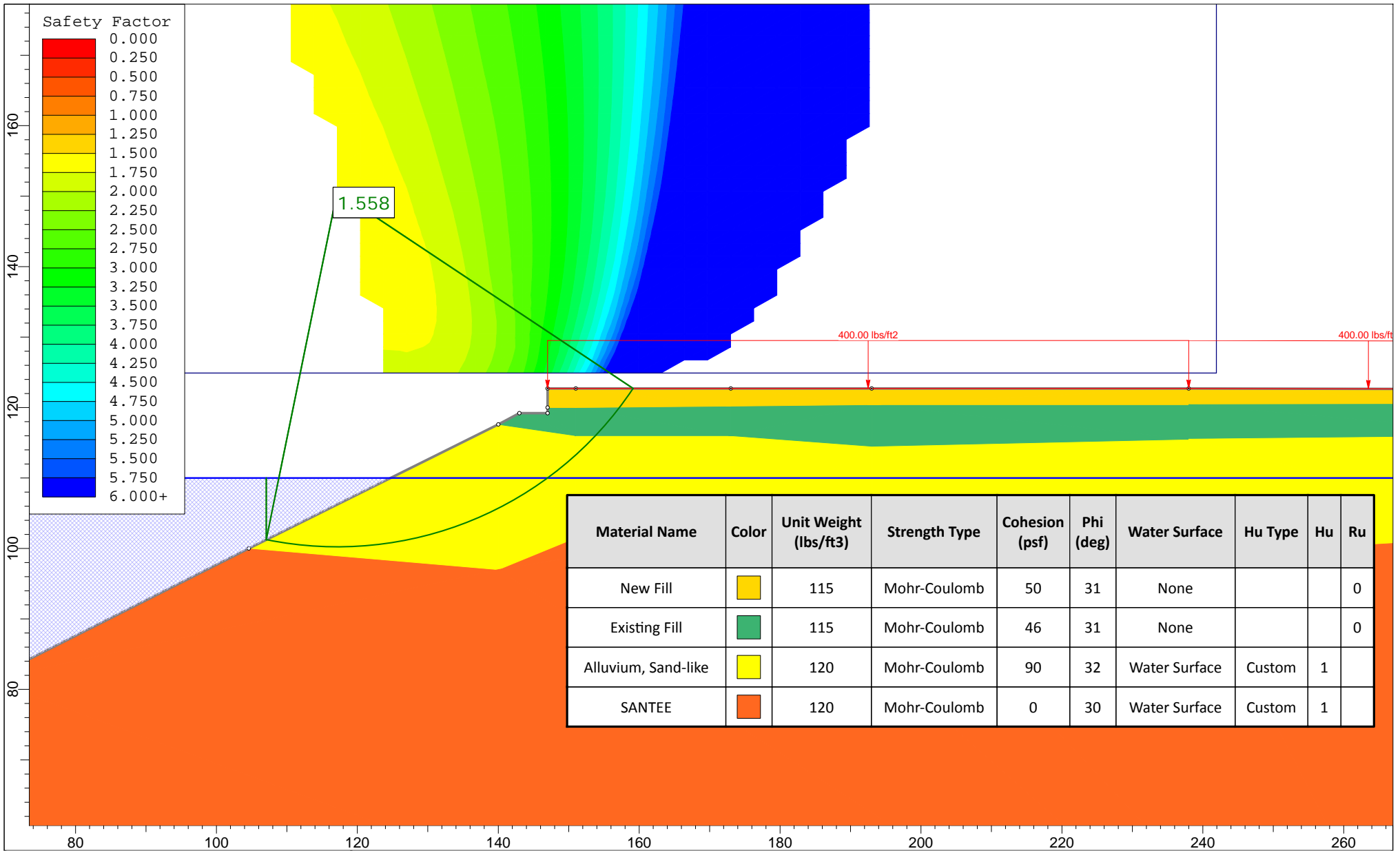


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium, Sand-like		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquefaction		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	



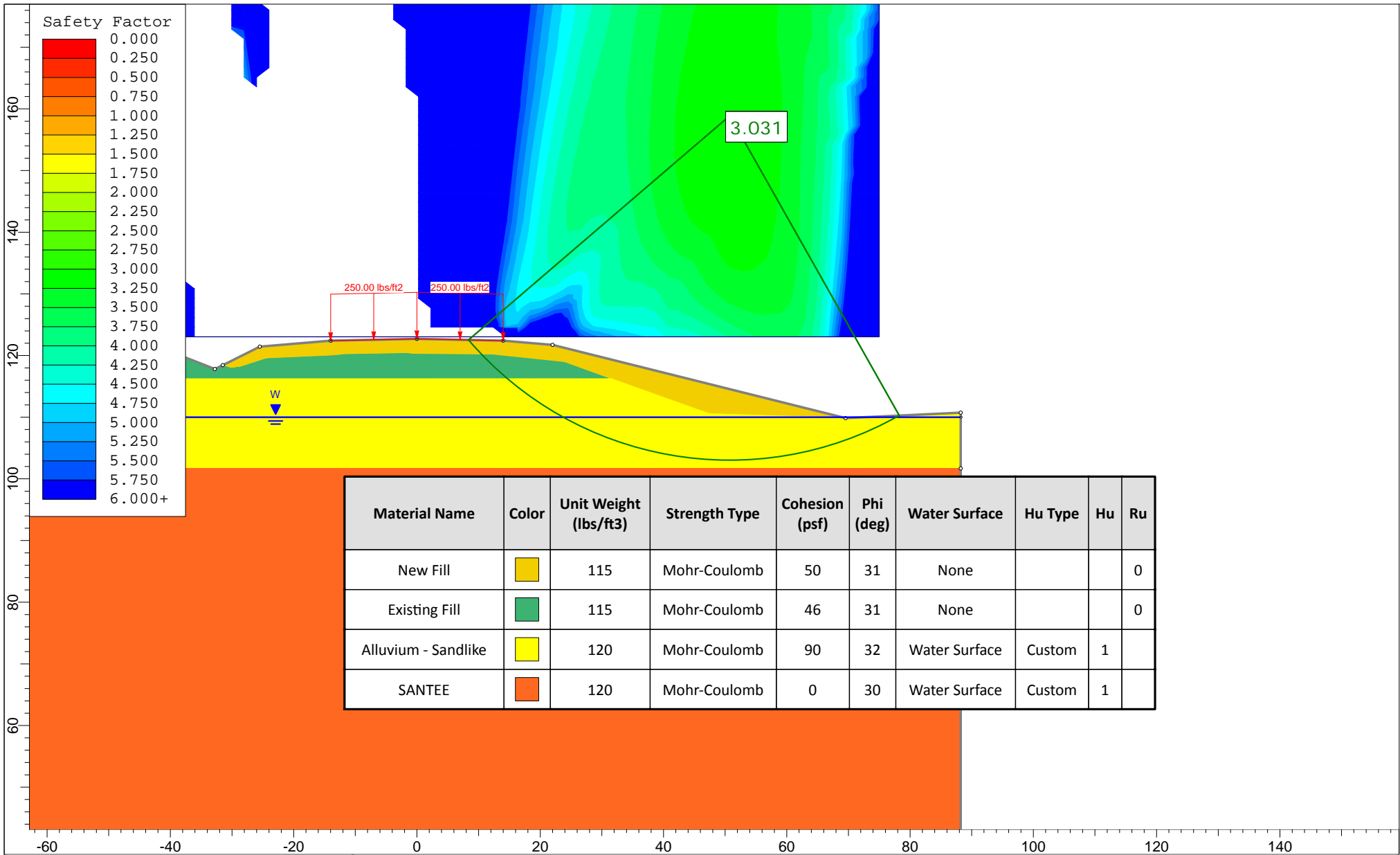
SLIDEINTERPRET 7.013





<i>Project</i>				US 301 over Four Hole Swamp, Orangeburg County			
<i>Analysis Description</i>				EOB EEI (TSA)			
<i>Drawn By</i>	RSG	<i>Scale</i>	1:222	<i>Company</i>	SCDOT		
<i>Date</i>	4/22/2016, 2:17:16 PM			<i>File Name</i>	EOB Seismic.sldm		



SLIDEINTERPRET 7.013

<i>Project</i>				US 301 over Four Hole Swamp, Orangeburg County			
<i>Analysis Description</i>				Static LongTerm (ESA)			
<i>Drawn By</i>	RSG	<i>Scale</i>	1:225	<i>Company</i>	SCDOT		
<i>Date</i>	4/22/2016, 2:17:16 PM			<i>File Name</i>	EOB Long Term ESA.slim		

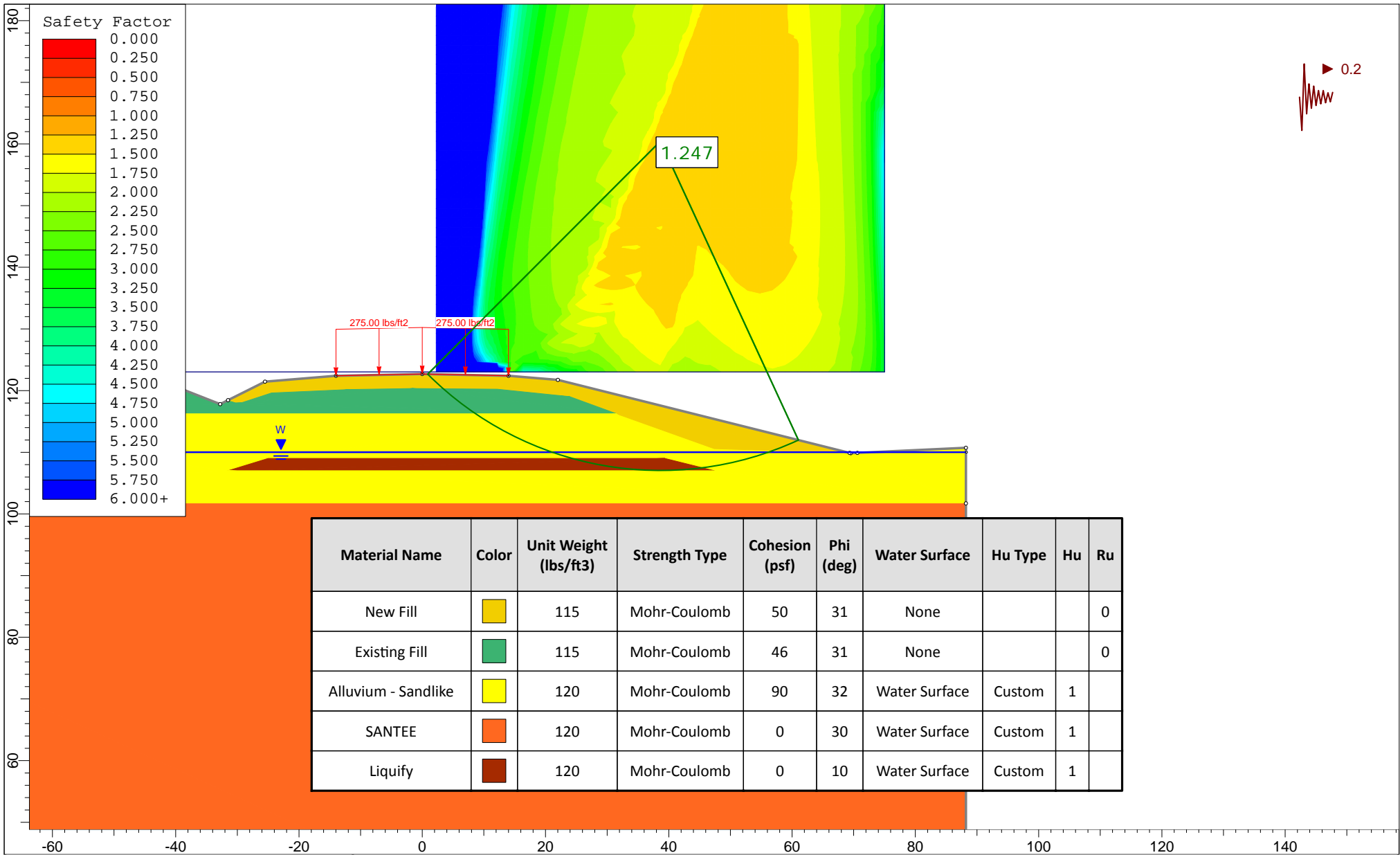







Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium - Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	



SLIDEINTERPRET 7.013

Project		US 301 RBO Four Hole Swamp, Orangeburg County	
Analysis Description		Station 5952+24 Short Term (TSA)	
Drawn By	RSG	Scale	1:259
		Company	SCDOT
Date	6/6/2016, 3:05:34 PM		File Name
		Sta 5952+24 Short Term TSA.slim	

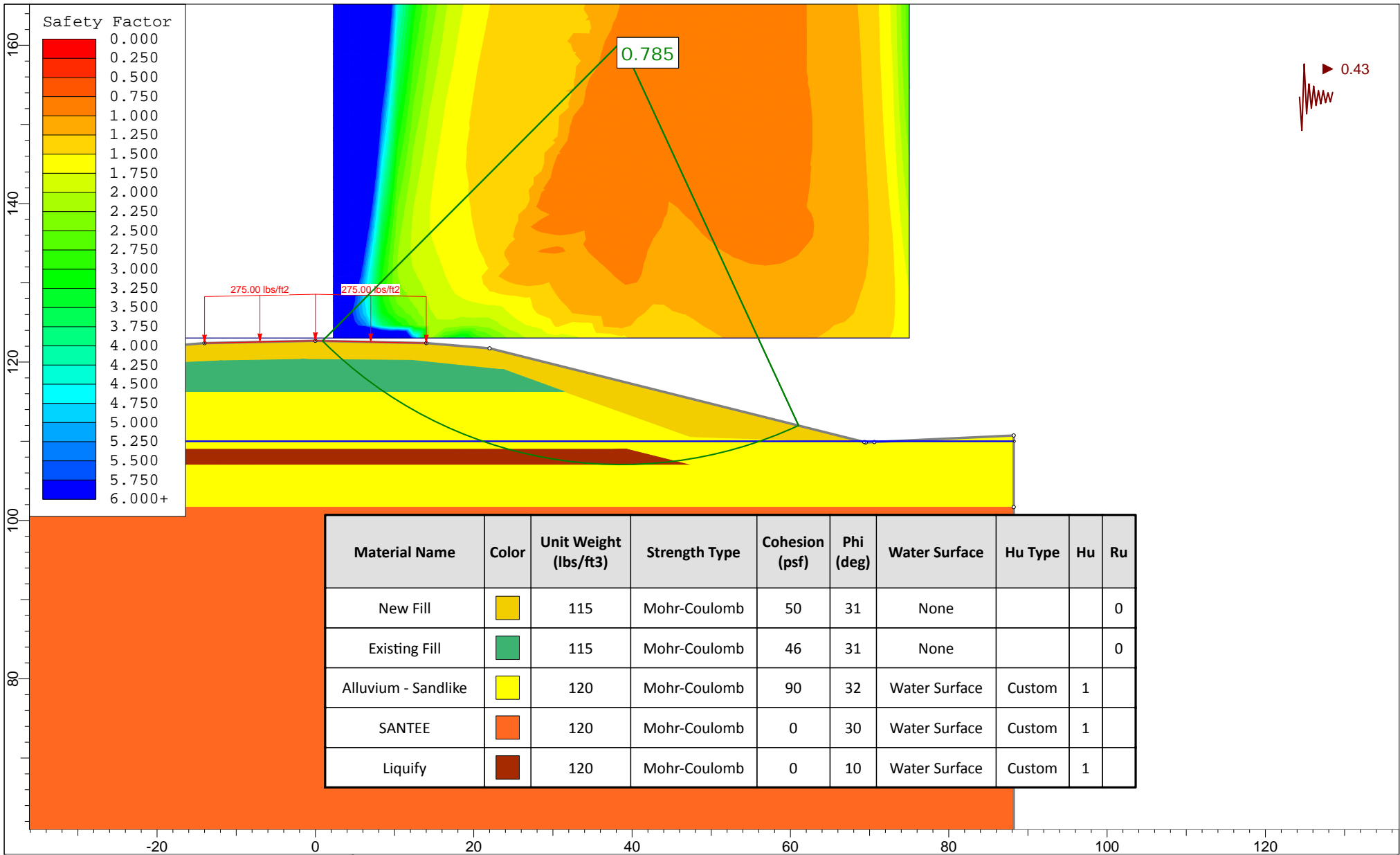







Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium - Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquify		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	



SLIDEINTERPRET 7.013

Project				US 301 RBO Four Hole Swamp, Orangeburg County			
Analysis Description				Station 5952+24 EEI (TSA)			
Drawn By	RSG	Scale	1:259	Company	SCDOT		
Date	6/6/2016, 3:05:34 PM			File Name	Sta 5952+24 Seismic.slmd		

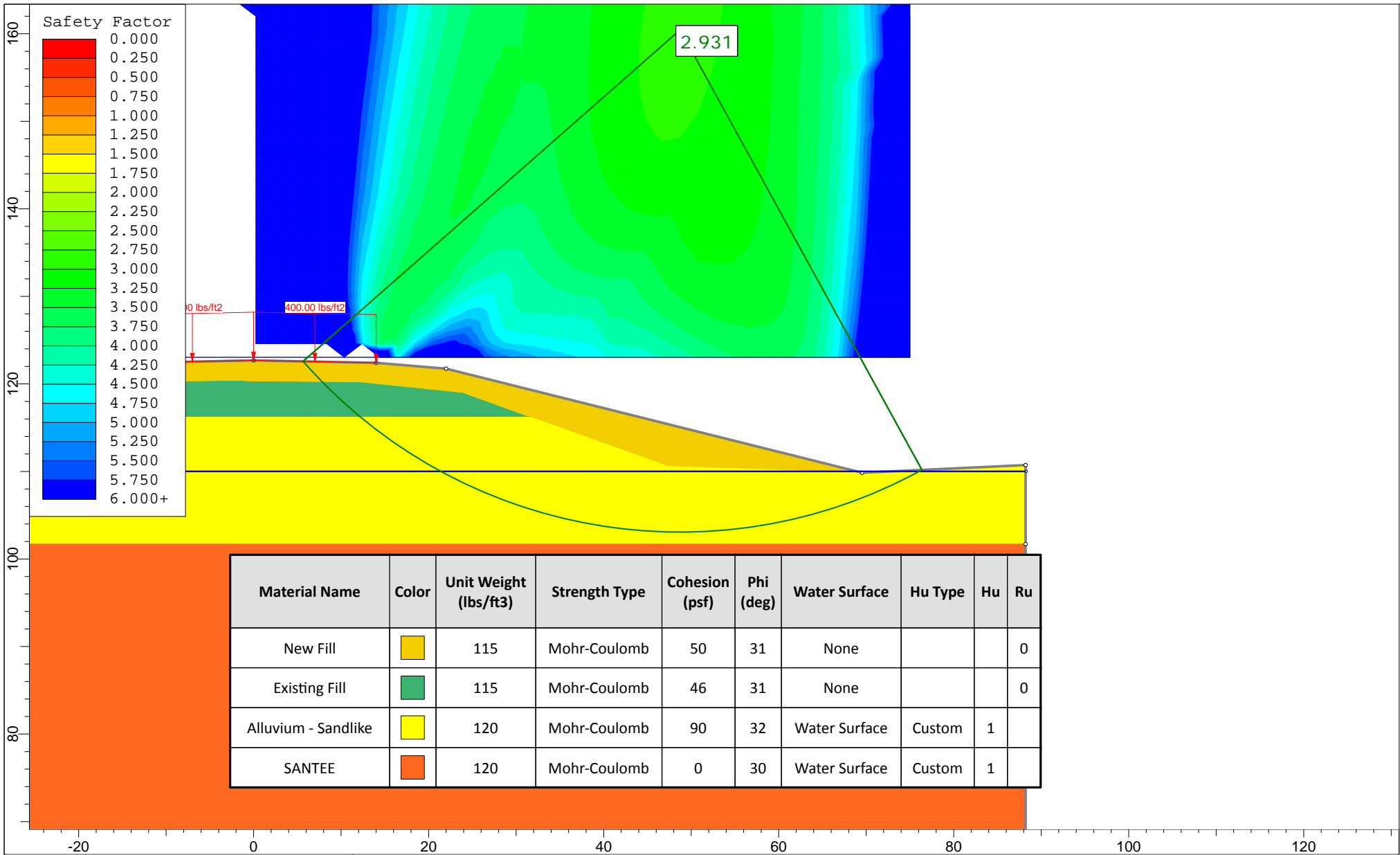


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium - Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquify		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	



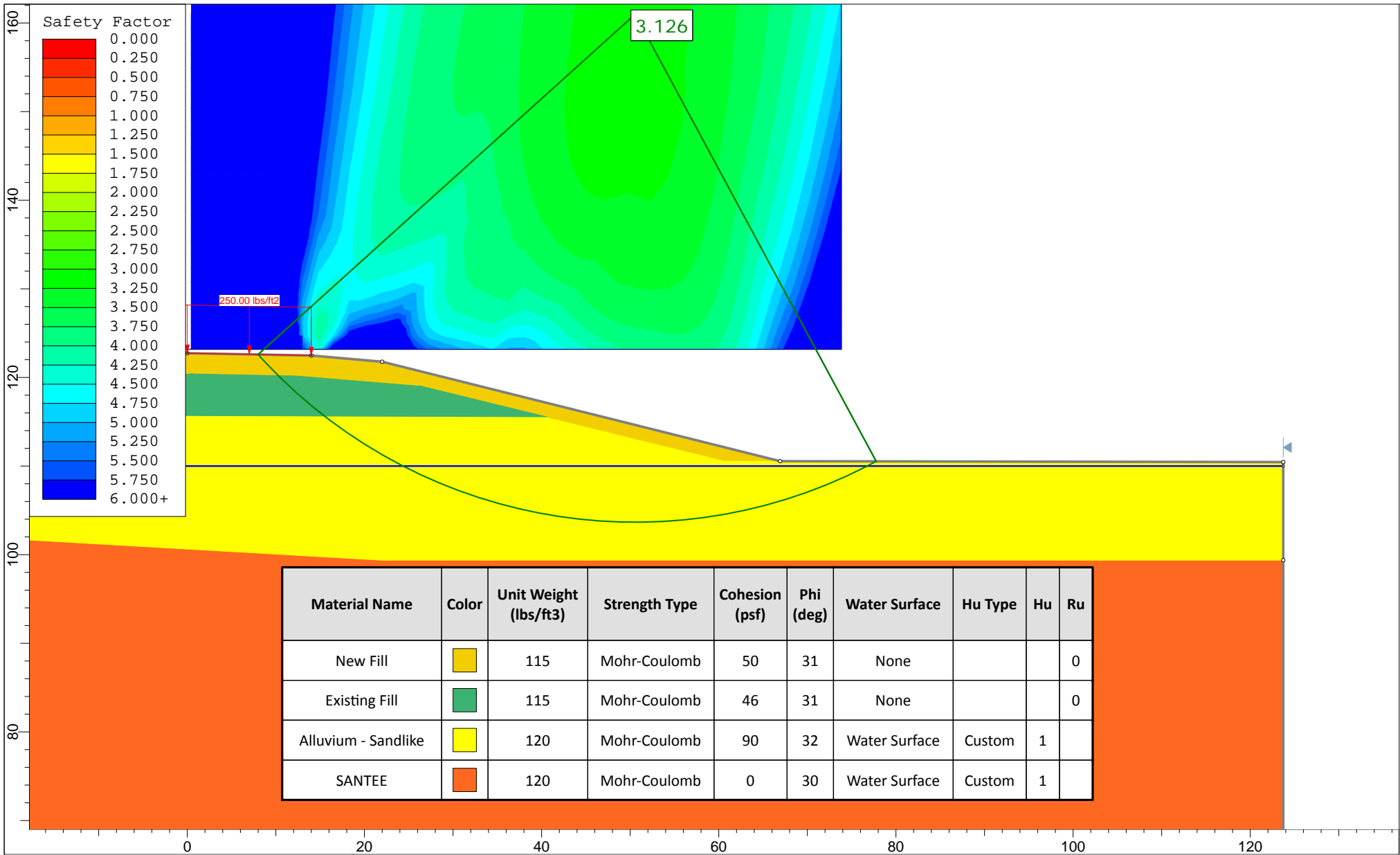
SLIDEINTERPRET 7.013

Project				US 301 RBO Four Hole Swamp, Orangeburg County			
Analysis Description				Station 5952+24 EEI (TSA)			
Drawn By	RSG	Scale	1:201	Company	SCDOT		
Date	6/6/2016, 3:05:34 PM			File Name	Sta 5952+24 Seismic.slmd		



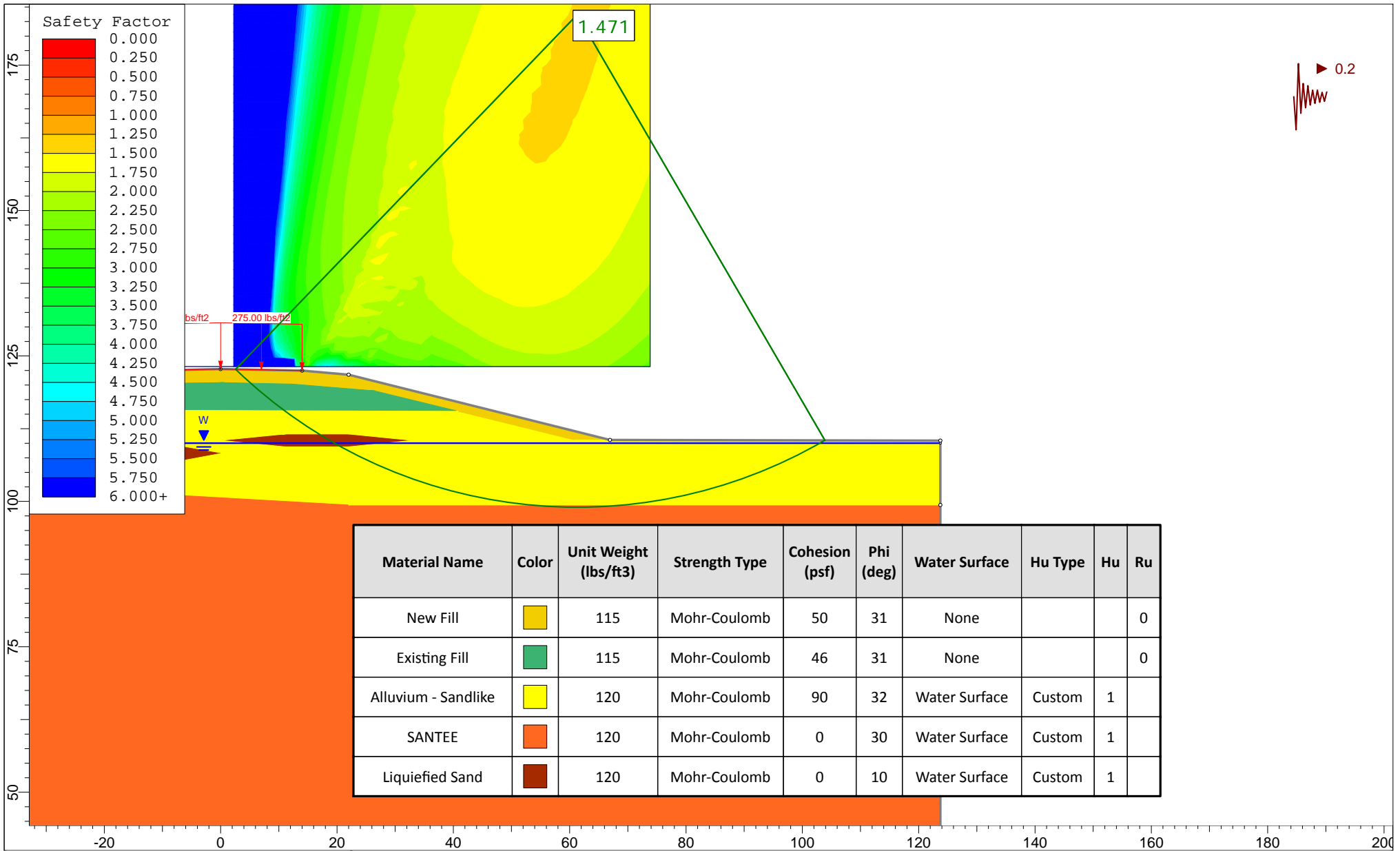
SLIDEINTERPRET 7.013






Project		US 301 RBO Four Hole Swamp, Orangeburg County	
Analysis Description		Station 5952+24 Long Term (ESA)	
Drawn By	RSG	Scale	1:182
		Company	SCDOT
Date	6/6/2016, 3:05:34 PM		File Name
		Sta 5952+24 Long Term ESA.slim	



SLIDEINTERPRET 7.013

<i>Project</i>				US 301 RBO Four Hole Swamp, Orangeburg County			
<i>Analysis Description</i>				Station 5953+00 Static (TSA)			
<i>Drawn By</i>	RSG	<i>Scale</i>	1:180	<i>Company</i>	SCDOT		
<i>Date</i>	6/13/2016, 10:17:27 AM			<i>File Name</i>	Sta 5953+00 Long Term (TSA).slim		

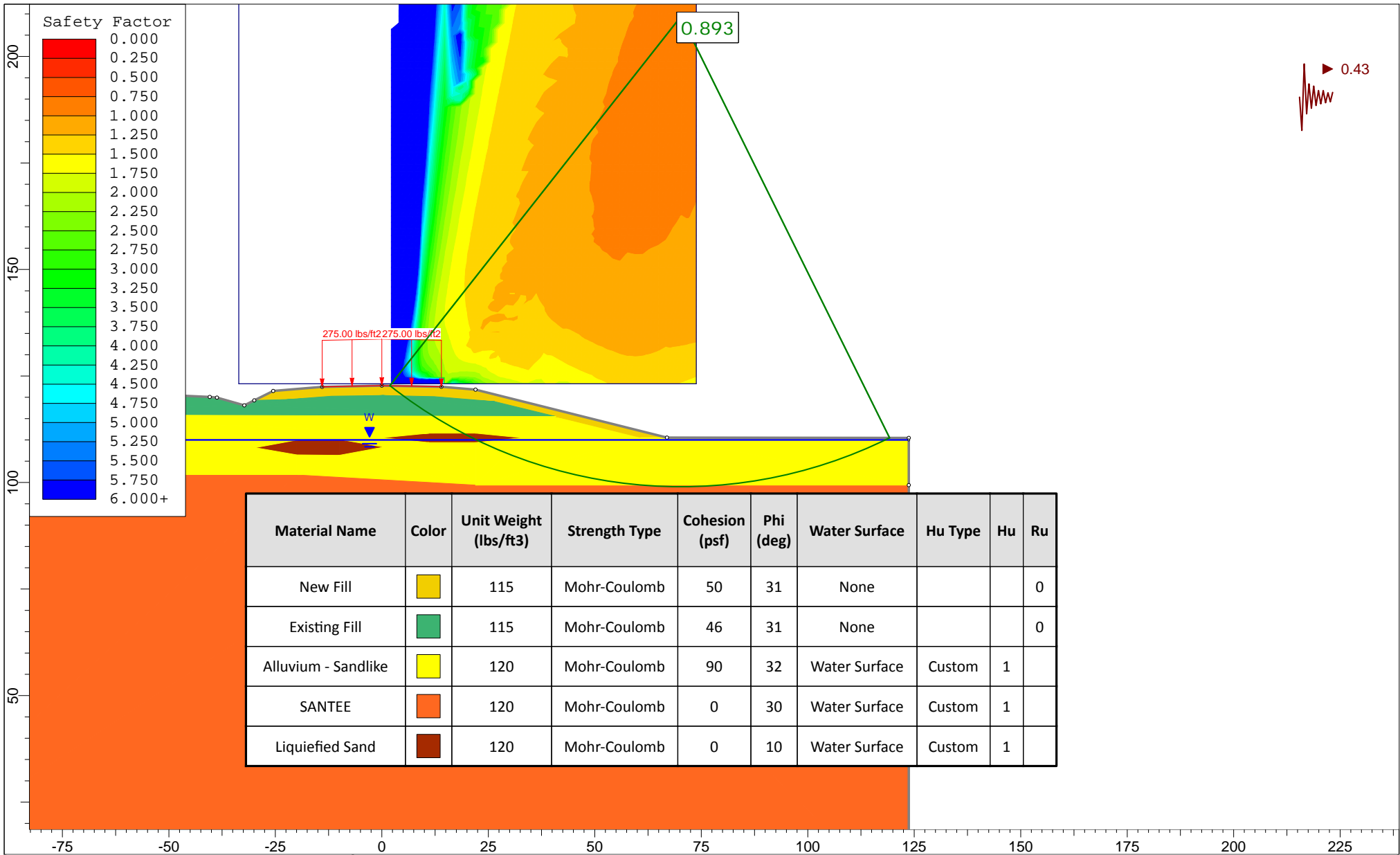







Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium - Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquefied Sand		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	



SLIDEINTERPRET 7.013

Project				US 301 RBO Four Hole Swamp, Orangeburg County			
Analysis Description				Station 5953+00 EEI (TSA)			
Drawn By	RSG	Scale	1:273	Company	SCDOT		
Date	6/13/2016, 10:17:27 AM			File Name	Sta 5953+00 Seismic.slmd		

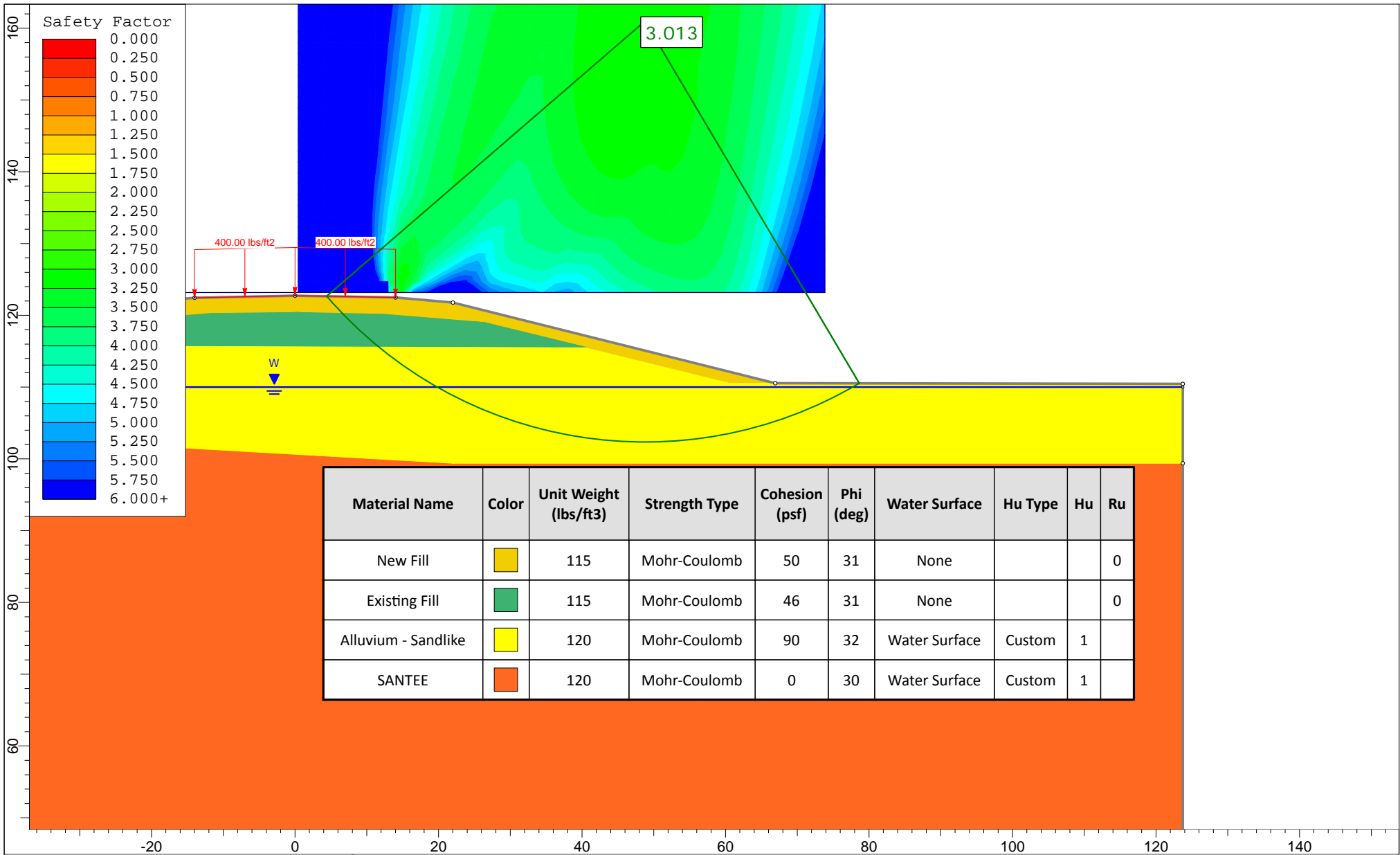


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
New Fill		115	Mohr-Coulomb	50	31	None			0
Existing Fill		115	Mohr-Coulomb	46	31	None			0
Alluvium - Sandlike		120	Mohr-Coulomb	90	32	Water Surface	Custom	1	
SANTEE		120	Mohr-Coulomb	0	30	Water Surface	Custom	1	
Liquefied Sand		120	Mohr-Coulomb	0	10	Water Surface	Custom	1	



SLIDEINTERPRET 7.013

Project		US 301 RBO Four Hole Swamp, Orangeburg County	
Analysis Description		Station 5953+00 EEI (TSA)	
Drawn By	RSG	Scale	1:374
		Company	SCDOT
Date	6/13/2016, 10:17:27 AM		File Name
		Sta 5953+00 Seismic.slmd	



	Project				US 301 RBO Four Hole Swamp, Orangeburg County				
	Analysis Description				Station 5953+00 Static (ESA)				
	Drawn By		RSG	Scale		1:222	Company		SCDOT
	Date		6/13/2016, 10:17:27 AM			File Name		Sta 5953+00 Long Term (ESA).slim	

Simplified Newmark Charts
SCDOT GDM 13.17.2 (NCHRP 12-70, 2007)

Project ID:	0040308	County:	38 - Orangeburg	Latitude:	33.457	Designer:	Renée S. Gardner
Route:	US 301	Location/Station:	Station 5949+00 Right side slope	Longitude:	80.647	Date:	6/2/2016
Description:	RBO Four Hole Swamp					Finished Embankment Height (ft)² =	2

²Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Slope Stability Yield Acceleration:

K _y =	0.43	0.18	g
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Seismic Data:

Site Class =		
Design Earthquake:	SEE	FEE
S _{D1} =	0.49	0.18
k _{max} = PGA =	0.43	0.20
β = S _{D1} /PGA =	1.14	0.90
α _w =	1.00	1.00
k _h = k _{avg} = α _w k _{max} =	0.43	0.20
V _{Peak} =	26.95	9.90
k _y /k _{max} =	1.000	0.900

β = Ground Motion Index: 0.5 ≤ β ≤ 1.5

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering

V_{peak} = Peak ground velocity

0.5 ≤ β ≤ 1.5

1 + 0.01h_{slope}[(0.5β)-1] ≤ 1.0; for h_{slope} ≤ 20 ft α_w = 1.0

k_h = k_{avg} = α_wk_{max}

Eq 12-46 of GDM = 55S_{D1}

Log (d) =	0.00	-2.87
Displacement (CEUS-Soil):	0.00	0.00

log(d) = -1.49 - 0.75log(k_y/k_{max}) + 3.62log[1 - (k_y/k_{max})] - 0.85log(k_{max}) + 1.61log(V_{peak})

GDM Eq 13-106

84% Confidence level	0.00	0.00	inches
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GDM 13.17.2 For embankments classified as ROC= I or II the displacements computed using the simplified charts should be multiplied by 2

Simplified Newmark Charts
SCDOT GDM 13.17.2 (NCHRP 12-70, 2007)

Project ID: 0040308	County: 38 - Orangeburg	Latitude: 33.457	Designer: Renée S. Gardner
Route: US 301	Location/Station: End Bent 1 STA 5949+30	Longitude: 80.647	Date: 6/1/2016
Description: RBO Four Hole Swamp			Finished Embankment Height (ft)² = 2

²Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Slope Stability Yield Acceleration:

K _y =	0.235	0.20	g
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Seismic Data:

Site Class =		
Design Earthquake:	SEE	FEE
S_{D1} =	0.49	0.18
k_{max} = PGA =	0.43	0.20
β = S_{D1}/PGA =	1.14	0.90
α_w =	1.00	1.00
k_h = k_{avg} = α_wk_{max} =	0.43	0.20
V_{Peak} =	26.95	9.90
k_y/k_{max} =	0.547	1.000

β = Ground Motion Index: 0.5 ≤ β ≤ 1.5

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering

V_{peak} = Peak ground velocity

0.5 ≤ β ≤ 1.5

1 + 0.01h_{slope}[(0.5β)-1] ≤ 1.0; for h_{slope} ≤ 20 ft α_w = 1.0

k_h = k_{avg} = α_wk_{max}

Eq 12-46 of GDM = 55S_{D1}

Log (d) =	0.09	0.00
Displacement (CEUS-Soil):	1.24	0.00

log(d) = -1.49 - 0.75log(k_y/k_{max}) + 3.62log[1 - (k_y/k_{max})] - 0.85log(k_{max}) + 1.61log(V_{peak})

GDM Eq 13-106

84% Confidence level	2.48	0.00	inches
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GDM 13.17.2 For embankments classified as ROC= I or II the displacements computed using the simplified charts should be multiplied by 2

Simplified Newmark Charts
SCDOT GDM 13.17.2 (NCHRP 12-70, 2007)

Project ID:	0040308	County:	38 - Orangeburg	Latitude:	33.457	Designer:	Renée S. Gardner
Route:	US 301	Location/Station:	End Bent 8 STA 5952+24	Longitude:	80.647	Date:	6/1/2016
Description:	RBO Four Hole Swamp					Finished Embankment Height (ft)² =	2

²Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Slope Stability Yield Acceleration:

K _y =	0.22	0.20	g
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Seismic Data:

Site Class =			
Design Earthquake:	SEE	FEE	
S_{D1} =	0.49	0.18	g
k_{max} = PGA =	0.43	0.20	g
β = S_{D1}/PGA =	1.14	0.90	
α_w =	1.00	1.00	
k_h = k_{avg} = α_wk_{max} =	0.43	0.20	g
V_{Peak} =	26.95	9.90	in/sec
k_y/k_{max} =	0.507	1.000	

β = Ground Motion Index: 0.5 ≤ β ≤ 1.5
 α_w = Wave Scattering Scaling Factor: 1 + 0.01h_{slope}[(0.5β)-1] ≤ 1.0; for h_{slope} ≤ 20 ft α_w = 1.0
 k_h = Average seismic horizontal coefficient due to wave scattering k_h = k_{avg} = α_wk_{max}
 V_{peak} = Peak ground velocity Eq 12-46 of GDM = 55S_{D1}

Log (d) =	0.25	0.00	
Displacement (CEUS-Soil):	1.77	0.00	inches

log(d) = -1.49 - 0.75log(k_y/k_{max}) + 3.62log[1 - (k_y/k_{max})] - 0.85log(k_{max}) + 1.61log(V_{peak}) GDM Eq 13-106

84% Confidence level

3.54	0.00
------	------

 inches GDM 13.17.2 For embankments classified as ROC= I or II the displacements computed using the simplified charts should be multiplied by 2

Simplified Newmark Charts
SCDOT GDM 13.17.2 (NCHRP 12-70, 2007)

Project ID: 0040308	County: 38 - Orangeburg	Latitude: 33.457	Designer: Renée S. Gardner
Route: US 301	Location/Station: Station 5952+24 Right side slope	Longitude: 80.647	Date: 6/2/2016
Description: RBO Four Hole Swamp			Finished Embankment Height (ft)² = 2

²Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Slope Stability Yield Acceleration:

K _y =	0.297	0.18	g
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Seismic Data:

Site Class =		
Design Earthquake:	SEE	FEE
S _{D1} =	0.49	0.18
k _{max} = PGA =	0.43	0.20
β = S _{D1} /PGA =	1.14	0.90
α _w =	1.00	1.00
k _h = k _{avg} = α _w k _{max} =	0.43	0.20
V _{Peak} =	26.95	9.90
k _y /k _{max} =	0.691	0.900

β = Ground Motion Index:

$$0.5 \leq \beta \leq 1.5$$

α_w = Wave Scattering Scaling Factor:

$$1 + 0.01h_{\text{slope}}[(0.5\beta)-1] \leq 1.0; \text{ for } h_{\text{slope}} \leq 20 \text{ ft } \alpha_w = 1.0$$

k_h = Average seismic horizontal coefficient due to wave scattering

$$k_h = k_{\text{avg}} = \alpha_w k_{\text{max}}$$

V_{Peak} = Peak ground velocity

$$\text{Eq 12-46 of GDM} = 55S_{D1}$$

Log (d) =	-0.59	-2.87
-----------	-------	-------

$$\log(d) = -1.49 - 0.75 \log(k_y/k_{\text{max}}) + 3.62 \log[1 - (k_y/k_{\text{max}})] - 0.85 \log(k_{\text{max}}) + 1.61 \log(V_{\text{Peak}})$$

GDM Eq 13-106

Displacement (CEUS-Soil):	0.26	0.00	inches
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84% Confidence level	0.52	0.00	inches
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GDM 13.17.2 For embankments classified as ROC= I or II the displacements computed using the simplified charts should be multiplied by 2

Simplified Newmark Charts
SCDOT GDM 13.17.2 (NCHRP 12-70, 2007)

Project ID:	0040308	County:	38 - Orangeburg	Latitude:	33.457	Designer:	Renée S. Gardner
Route:	US 301	Location/Station:	Station 5953+00 Right side slope	Longitude:	80.647	Date:	6/13/2016
Description:	RBO Four Hole Swamp					Finished Embankment Height (ft)² =	2

²Embankment height measured from natural ground surface

Bridge & Roadway Information:

OC =	II
ROC =	II

Slope Stability Yield Acceleration:

K _y =	0.365	0.18	g
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Seismic Data:

Site Class =		
Design Earthquake:	SEE	FEE
S_{DI} =	0.49	0.18
k_{max} = PGA =	0.43	0.20
β = S_{DI}/PGA =	1.14	0.90
α_w =	1.00	1.00
k_h = k_{avg} = α_wk_{max} =	0.43	0.20
V_{Peak} =	26.95	9.90
k_y/k_{max} =	0.849	0.900

β = Ground Motion Index: 0.5 ≤ β ≤ 1.5

α_w = Wave Scattering Scaling Factor:

k_h = Average seismic horizontal coefficient due to wave scattering

V_{peak} = Peak ground velocity

$$0.5 \leq \beta \leq 1.5$$

$$1 + 0.01h_{\text{slope}}[(0.5\beta)-1] \leq 1.0; \text{ for } h_{\text{slope}} \leq 20 \text{ ft } \alpha_w = 1.0$$

$$k_h = k_{\text{avg}} = \alpha_w k_{\text{max}}$$

$$\text{Eq 12-46 of GDM} = 55S_{DI}$$

Log (d) =	-1.78	-2.87
------------------	-------	-------

Displacement (CEUS-Soil): 0.02 0.00 inches

$$\log(d) = -1.49 - 0.75 \log(k_y/k_{\text{max}}) + 3.62 \log[1 - (k_y/k_{\text{max}})] - 0.85 \log(k_{\text{max}}) + 1.61 \log(V_{\text{peak}})$$

GDM Eq 13-106

84% Confidence level 0.03 0.00 inches

GDM 13.17.2 For embankments classified as ROC= I or II the displacements computed using the simplified charts should be multiplied by 2

Appendix VIII

FoSSA 2.0 Results

PROJECT ID	<u>0040308</u>
DATE	<u>05/25/16</u>
COMPUTED BY	<u>RSG</u>
CHECKED BY	<u>SMS</u>

PROJECT NAME: US-301 RBO Four Hole Swamp

SUBJECT: Settlement Analysis

PROBLEM

Determine the amount of static settlement, both elastic and consolidation, which will occur due to fill placement on virgin soils and liquefaction-induced settlement that will occur due to the liquefying of course grained soils during a seismic event to accommodate the proposed bridge replacement.

PROJECT INFORMATION

Project Type: Bridge Replacement (Southbound)

Existing Alignment: 2-lane paved road of variable shoulder widths

Proposed Alignment: 2-lane paved road of variable shoulder widths

Proposed Bridge Dimensions: 47.25 x 294 feet

Survey Begins: 5941+40

Survey Ends: 5960+00

Grades: Proposed finished centerline grades will be raised approximately 2 feet

End Slopes: 2:1

Side Slopes: Right 4:1, Left 2:1

Added Fill: Not expected to exceed 2.5 feet at the shoulder breaks

Travel ways: 12 feet wide

Medians: Grassed median left of the roadway alignment

Project Features: The proposed bridge will be constructed on the existing alignment and southbound traffic shifted to share the northbound bridge during construction of the proposed bridge.

GIVEN/ASSUMPTIONS

- Design guidelines and Performance Limits (PL) come from the SCDOT Geotechnical Design Manual (GDM), 2010 Version 1.1, Table 10-26.
- Field-tests conducted are STB, and DMT.
- Field sampling consisted of split spoon, bulk and an undisturbed sample.
- Lab testing consist of Atterberg limits, natural moisture content, grain size distribution with wash 200, corrosion series, organic loss contents, standard proctors, and direct shear tests.
- ROC II within the end-slope governing threshold, ROC IV outside of the threshold.
- Elastic Settlement of coarse-grained soil occurs immediately after proposed fill is placed.
- Consolidation settlement will be negligible due to lack of fine-grained soils at this site.
- Design ground water level is 110' MSL.
- Liquefaction settlement was calculated using SSL.

METHODOLOGY

FOSSA 2.0

Cross sections selected for analysis were based on soft fine-grained soils obtained by undisturbed samples and proposed fill heights. The computer program FoSSA (2.0) was used to evaluate settlement including the elastic compression of sand and the primary consolidation of clay following Hook's Law and Terzaghi's 1-D differential equation, respectively. Elastic and consolidation settlement are evaluated to determine if performance limits for embankment settlement are met as required by the GDM for ROC II and IV, depending on location of selected cross-sections.

RESULTS and DISCUSSION

Analysis results show that most of the settlement is immediate and will occur during construction. There are clay layers; however, the overconsolidated clay is expected to have minimal consolidation that will occur over the course of construction activities. Elastic settlement that will occur at this site will be immediate. A summary table of deformations for the embankments analyzed along with the comparison to the Performance Limits is included as an attachment.



South Carolina
Department of Transportation

PROJECT ID	<u>0040308</u>
DATE	<u>05/25/16</u>
COMPUTED BY	<u>RSG</u>
CHECKED BY	<u>SMS</u>

ATTACHMENTS

Summary Table of Calculated Deformations
Embankment Settlement Performance Tables
FOSSA 2.0 Reports for each Station



South Carolina
Department of Transportation

PROJECT ID	<u>0040308</u>
DATE	<u>05/25/16</u>
COMPUTED BY	<u>RSG</u>
CHECKED BY	<u>SMS</u>

**US-301 RBO Four Hole Swamp
Calculated Deformations**

Station	Deformation ID No.	Performance Limits	Calculated Deformations	Mitigated Deformations
RW-2 Sta. 5948+00	EV-01	8.00"	0.48"	-
	EV-02	0.10"/yr	0.0"/yr	-
	EV-03	1.50"	0.045"	-
B-1 Sta. 5949+30	EV-01	8.00"	0.36"	-
	EV-02	0.10"/yr	0.0"/yr	-
	EV-03	1.50"	0.045"	-
	EV-05	2.00"	0.0"	-
B-9 Sta. 5952+24	EV-01	8.00"	0.48"	-
	EV-02	0.10"/yr	0.0"/yr	-
	EV-03	1.50"	0.08"	-
	EV-05	2.00"	0.0"	-
RW-5 Sta. 5953+00	EV-01	8.00"	0.60"	-
	EV-02	0.10"/yr	0.0"/yr	-
	EV-03	1.50"	0.08"	-
RW-7 Sta. 5954+00	EV-01	8.00"	0.48"	-
	EV-02	0.10"/yr	0.0"/yr	-
	EV-03	1.50"	0.08"	-



EMBANKMENT SETTLEMENT PERFORMANCE TABLES

Table 10-24, Embankment Performance Limits at SLS

Deformation ID No.		Service Limit State Performance Limit Description	ROC		
			I	II	III
		Minimum Design Life (Years)	100	100	100
Settlement (Longitudinal)	EV-01	Maximum Vertical Settlement at the adjusted profile grade over the design life of the embankment. (Inches)	8.00"	8.00"	16.00"
	EV-02	Maximum Settlement Rate per year after the roadway has been paved. (Inches per year)	0.10	0.10	0.20
	EV-03	Maximum Vertical Differential Settlement occurring longitudinally along the adjusted profile grade after the roadway has been paved. Differential ratio is shown in parenthesis for informational purposes. (Inches per 50 Feet of Embankment Longitudinally)	1.00" (1/600)	1.50" (1/400)	2.00" (1/300)
Settlement (Transverse)	EV-04	Maximum Vertical Differential Settlement occurring transverse to the adjusted profile grade between the existing embankment and the new widened embankment after the roadway has been paved. (Inches per 5 feet of embankment width)	0.10" (1/600)	0.15" (1/400)	0.20" (1/300)

Table 10-25, Bridge/Embankment Transition Settlement Performance Limit at SLS

Deformation ID No.		Service Limit State Performance Limit Description	ROC		
			I	II	III
Settlement (Longitudinal)	EV-05	Maximum Vertical Differential Settlement Between End Bent and End of Approach Slab (Inches). The Approach Slab length (L_{Slab}) is measured in feet.	$0.075 \times L_{Slab}$	$0.100 \times L_{Slab}$	$0.125 \times L_{Slab}$

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section:		Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
	X [ft.]	Y [ft.]							
1	-14.00	0.00	1	104423	0.3000	0.0083	119.00	118.96	0.04
			2	104423	0.3000	0.0051			
			3	104423	0.3000	0.0044			
			4	104423	0.3000	0.0095			
			5	104423	0.3000	0.0100			
			6	104423	0.3000	0.0007			
2	0.00	0.00	1	104423	0.3000	0.0091	119.00	118.96	0.04
			2	104423	0.3000	0.0055			
			3	104423	0.3000	0.0048			
			4	104423	0.3000	0.0107			
			5	104423	0.3000	0.0117			
			6	104423	0.3000	0.0008			
3	14.00	0.00	1	104423	0.3000	0.0082	119.00	118.96	0.04
			2	104423	0.3000	0.0049			
			3	104423	0.3000	0.0042			
			4	104423	0.3000	0.0093			
			5	104423	0.3000	0.0101			
			6	104423	0.3000	0.0007			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-131.03	112.17	SM Existing Embankment
	2	-122.04	112.30	
	3	-117.58	113.10	
	4	-106.52	115.10	
	5	-81.15	119.71	
	6	-71.42	120.49	
	7	-59.12	120.69	
	8	-46.92	120.44	
	9	-35.55	119.77	
	10	-33.65	119.62	
	11	-31.49	118.25	
	12	-29.49	118.25	
	13	-27.86	119.00	
	14	27.76	119.00	
	15	43.15	115.10	
	16	51.13	113.10	
	17	56.21	111.85	
	18	68.84	111.62	
2	1	-131.03	112.17	SW-SM
	2	-122.04	112.30	
	3	-117.58	113.10	
	4	-106.52	115.10	
	5	43.15	115.10	
	6	51.13	113.10	
	7	56.21	111.85	
	8	68.84	111.62	
3	1	-131.03	112.17	SM
	2	-122.04	112.30	
	3	-117.58	113.10	
	4	51.13	113.10	
	5	56.21	111.85	
	6	68.84	111.62	
4	1	-131.03	111.30	Liquefiable SM
	2	68.84	111.30	
5	1	-131.03	107.10	SP
	2	68.84	107.10	
6	1	-131.03	102.60	SANTEE Formation ML
	2	68.84	102.60	

INPUT DATA -- FOUNDATION LAYERS -- 5 layers

Wet Unit Weight, γ [lb/ft ³]	Poisson's Ratio μ	Description of Soil
1 115.00	0.30	SM Existing Embankment
2 115.00	0.30	SC
3 115.00	0.30	SC-SM
4 120.00	0.30	SP
5 115.00	0.30	SANTEE Formation SM

INPUT DATA -- EMBANKMENT LAYERS -- 1 layers

Wet Unit Weight, γ [lb/ft ³]	Description of Soil
1 115.00	New Fill

INPUT DATA OF WATER

Point #	Coordinates (X, Z) :	
	(X) [ft.]	(Z) [ft.]
1	-130.63	112.20
2	61.82	112.20

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section:		Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
	X [ft.]	Y [ft.]							
1	-14.00	0.00	1	104423	0.3000	0.0113	119.90	119.87	0.03
			2	104423	0.3000	0.0038			
			3	104423	0.3000	0.0069			
			4	104423	0.3000	0.0062			
			5	104423	0.3000	0.0004			
2	0.00	0.00	1	104423	0.3000	0.0128	119.90	119.87	0.03
			2	104423	0.3000	0.0044			
			3	104423	0.3000	0.0084			
			4	104423	0.3000	0.0078			
			5	104423	0.3000	0.0006			
3	14.00	0.00	1	104423	0.3000	0.0109	119.90	119.87	0.03
			2	104423	0.3000	0.0038			
			3	104423	0.3000	0.0074			
			4	104423	0.3000	0.0071			
			5	104423	0.3000	0.0005			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-130.63	109.53	SM Existing Embankment
	2	-129.17	109.43	
	3	-128.10	109.60	
	4	-115.68	112.10	
	5	-85.34	119.63	
	6	-59.50	120.66	
	7	-40.40	120.09	
	8	-38.50	119.93	
	9	-34.68	117.95	
	10	-31.68	117.95	
	11	-27.70	119.90	
	12	15.92	119.90	
	13	26.39	119.25	
	14	51.53	112.10	
	15	51.97	111.87	
	16	61.82	111.96	
2	1	-130.63	109.53	SC
	2	-129.17	109.43	
	3	-128.10	109.60	
	4	-115.68	112.10	
	5	51.53	112.10	
	6	51.97	111.87	
	7	61.82	111.96	
3	1	-130.63	109.53	SC-SM
	2	-129.17	109.43	
	3	-128.10	109.60	
	4	61.82	109.60	
4	1	-130.63	104.90	SP
	2	61.82	104.90	
5	1	-130.63	100.40	SANTEE Formation SM
	2	61.82	100.40	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION		
		(X) [ft.]	(Z) [ft.]			
1				New Fill		
		X1 = -27.78 [ft]	1		-27.70	119.90
		X2 = 61.87 [ft]	2		-25.50	121.04
			3		-14.00	122.00
			4		0.00	122.29
			5		14.00	122.00
			6		25.50	121.04
		7	61.82	111.96		

US 301 RBO Fourhole Swamp

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PROJECT IDENTIFICATION

Title: US 301 RBO Fourhole Swamp
Project Number: 38.0040308 - Orangeburg Co.
Client: SCDOT
Designer: RSG
Station Number: 5953+00

Description:

Company's information:

Name:
Street:

Telephone #:
Fax #:
E-Mail:

Original file path and name: P:\Orangeb \5_Design\2_Final\8_Embankments\FoSSA\5952+24.2ST
Original date and time of creating this file: Wed Jan 07 14:37:03 2015

GEOMETRY: Analysis of a 2D geometry

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-129.90	113.41	SW-SM Existing Embankment
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	-86.11	119.74	
	6	-59.50	120.68	
	7	-40.60	120.09	
	8	-38.70	119.93	
	9	-32.26	118.10	
	10	-30.02	119.00	
	11	26.46	119.00	
	12	38.73	116.00	
	13	45.28	114.40	
	14	61.29	110.55	
	15	71.23	110.55	
2	1	-129.90	113.41	SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	38.73	116.00	
	6	45.28	114.40	
	7	61.29	110.55	
	8	71.23	110.55	
3	1	-129.90	113.41	Liq SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	45.28	114.40	
	5	61.29	110.55	
	6	71.23	110.55	
4	1	-129.90	109.50	Liq SM
	2	71.23	109.50	
5	1	-129.90	101.20	SANTEE Formation ML
	2	71.23	101.20	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION	
		(X) [ft.]	(Z) [ft.]		
1	X1 = -30.02 [ft]	1	-30.02	119.00	SW-SM
	X2 = 110.55 [ft]	2	-25.50	121.49	
		3	-14.00	122.45	
		4	0.00	122.74	
		5	14.00	122.45	
		6	22.00	121.78	
		7	71.23	110.55	

HISTORY OF SETTLEMENT ANALYSES

Case #	Location of 1D Section :		Ultimate Settlement, Sc	After... [days]	Actual Settlement, [ft.]	U-ave (min.for all consol.layers) [%]	USER'S DESCRIPTION
	(X) [ft.]	(Y) [ft.]	[ft.]				
1	---	---	---	---	---	---	
2	---	---	---	---	---	---	
3	---	---	---	---	---	---	
4	---	---	---	---	---	---	
5	---	---	---	---	---	---	
6	---	---	---	---	---	---	
7	---	---	---	---	---	---	
8	---	---	---	---	---	---	
9	---	---	---	---	---	---	
10	---	---	---	---	---	---	
11	---	---	---	---	---	---	
12	---	---	---	---	---	---	
13	---	---	---	---	---	---	
14	---	---	---	---	---	---	
15	---	---	---	---	---	---	

HISTORY OF STAGED CONSTRUCTION

Case #	Location of 1D Section :		Ultimate Settlement, Sc [ft.]	After... [days]	Actual Settlement, [ft.]	U-ave (min.for all consol.layers) [%]	USER'S DESCRIPTION
	(X) [ft.]	(Y) [ft.]					
1	---	---	---	---	---	---	
2	---	---	---	---	---	---	
3	---	---	---	---	---	---	
4	---	---	---	---	---	---	
5	---	---	---	---	---	---	
6	---	---	---	---	---	---	
7	---	---	---	---	---	---	
8	---	---	---	---	---	---	
9	---	---	---	---	---	---	
10	---	---	---	---	---	---	
11	---	---	---	---	---	---	
12	---	---	---	---	---	---	
13	---	---	---	---	---	---	
14	---	---	---	---	---	---	
15	---	---	---	---	---	---	

US 301 RBO Fourhole Swamp

Report created by FoSSA(2.0): Copyright (c) 2003-2012, ADAMA Engineering, Inc.

PROJECT IDENTIFICATION

Title: US 301 RBO Fourhole Swamp
Project Number: 38.0040308 - Orangeburg Co.
Client: SCDOT
Designer: RSG
Station Number: 5953+00

Description:

Company's information:

Name:
Street:

Telephone #:
Fax #:
E-Mail:

Original file path and name: P:\Orangeb l\5_Design\2_Final\8_Embankments\FoSSA\5952+24.2ST
Original date and time of creating this file: Wed Jan 07 14:37:03 2015

GEOMETRY: Analysis of a 2D geometry

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section:		Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
	X [ft.]	Y [ft.]							
1	-14.00	0.00	1	104423	0.3000	0.0078	119.00	118.95	0.05
			2	104423	0.3000	0.0040			
			3	104423	0.3000	0.0124			
			4	104423	0.3000	0.0214			
			5	104423	0.3000	0.0008			
2	0.00	0.00	1	104423	0.3000	0.0084	119.00	118.95	0.05
			2	104423	0.3000	0.0043			
			3	104423	0.3000	0.0135			
			4	104423	0.3000	0.0243			
			5	104423	0.3000	0.0009			
3	14.00	0.00	1	104423	0.3000	0.0078	119.00	118.95	0.05
			2	104423	0.3000	0.0039			
			3	104423	0.3000	0.0120			
			4	104423	0.3000	0.0213			
			5	104423	0.3000	0.0008			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-129.90	113.41	SW-SM Existing Embankment
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	-86.11	119.74	
	6	-59.50	120.68	
	7	-40.60	120.09	
	8	-38.70	119.93	
	9	-32.26	118.10	
	10	-30.02	119.00	
	11	26.46	119.00	
	12	38.73	116.00	
	13	45.28	114.40	
	14	61.29	110.55	
	15	71.23	110.55	
2	1	-129.90	113.41	SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	38.73	116.00	
	6	45.28	114.40	
	7	61.29	110.55	
	8	71.23	110.55	
3	1	-129.90	113.41	Liq SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	45.28	114.40	
	5	61.29	110.55	
	6	71.23	110.55	
4	1	-129.90	109.50	Liq SM
	2	71.23	109.50	
5	1	-129.90	101.20	SANTEE Formation ML
	2	71.23	101.20	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION	
1	X1 = -30.02 [ft]	1	-30.02	119.00	SW-SM
	X2 = 110.55 [ft]	2	-25.50	121.49	
		3	-14.00	122.45	
		4	0.00	122.74	
		5	14.00	122.45	
		6	22.00	121.78	
		7	71.23	110.55	

HISTORY OF SETTLEMENT ANALYSES

Case #	Location of 1D Section : (X) [ft.]	(Y) [ft.]	Ultimate Settlement, Sc [ft.]	After... [days]	Actual Settlement, [ft.]	U-ave (min.for all consol.layers) [%]	USER'S DESCRIPTION
1	---	---	---	---	---	---	
2	---	---	---	---	---	---	
3	---	---	---	---	---	---	
4	---	---	---	---	---	---	
5	---	---	---	---	---	---	
6	---	---	---	---	---	---	
7	---	---	---	---	---	---	
8	---	---	---	---	---	---	
9	---	---	---	---	---	---	
10	---	---	---	---	---	---	
11	---	---	---	---	---	---	
12	---	---	---	---	---	---	
13	---	---	---	---	---	---	
14	---	---	---	---	---	---	
15	---	---	---	---	---	---	

HISTORY OF STAGED CONSTRUCTION

Case #	Location of 1D Section :		Ultimate Settlement, Sc	After... [days]	Actual Settlement, [ft.]	U-ave (min.for all consol.layers) [%]	USER'S DESCRIPTION
	(X) [ft.]	(Y) [ft.]	[ft.]				
1	---	---	---	---	---	---	
2	---	---	---	---	---	---	
3	---	---	---	---	---	---	
4	---	---	---	---	---	---	
5	---	---	---	---	---	---	
6	---	---	---	---	---	---	
7	---	---	---	---	---	---	
8	---	---	---	---	---	---	
9	---	---	---	---	---	---	
10	---	---	---	---	---	---	
11	---	---	---	---	---	---	
12	---	---	---	---	---	---	
13	---	---	---	---	---	---	
14	---	---	---	---	---	---	
15	---	---	---	---	---	---	

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section:		Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
	X [ft.]	Y [ft.]							
1	-14.00	0.00	1	104423	0.3000	0.0078	119.00	118.95	0.05
			2	104423	0.3000	0.0040			
			3	104423	0.3000	0.0124			
			4	104423	0.3000	0.0214			
			5	104423	0.3000	0.0008			
2	0.00	0.00	1	104423	0.3000	0.0084	119.00	118.95	0.05
			2	104423	0.3000	0.0043			
			3	104423	0.3000	0.0135			
			4	104423	0.3000	0.0243			
			5	104423	0.3000	0.0009			
3	14.00	0.00	1	104423	0.3000	0.0078	119.00	118.95	0.05
			2	104423	0.3000	0.0039			
			3	104423	0.3000	0.0120			
			4	104423	0.3000	0.0213			
			5	104423	0.3000	0.0008			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z *
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-129.90	113.41	SW-SM Existing Embankment
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	-86.11	119.74	
	6	-59.50	120.68	
	7	-40.60	120.09	
	8	-38.70	119.93	
	9	-32.26	118.10	
	10	-30.02	119.00	
	11	26.46	119.00	
	12	38.73	116.00	
	13	45.28	114.40	
	14	61.29	110.55	
	15	71.23	110.55	
2	1	-129.90	113.41	SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	-102.02	116.00	
	5	38.73	116.00	
	6	45.28	114.40	
	7	61.29	110.55	
	8	71.23	110.55	
3	1	-129.90	113.41	Liq SW-SM
	2	-111.58	113.94	
	3	-109.32	114.40	
	4	45.28	114.40	
	5	61.29	110.55	
	6	71.23	110.55	
4	1	-129.90	109.50	Liq SM
	2	71.23	109.50	
5	1	-129.90	101.20	SANTEE Formation ML
	2	71.23	101.20	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION		
					(X) [ft.]	(Z) [ft.]
1		X1 = -30.02 [ft]	1	-30.02	119.00	SW-SM
		X2 = 110.55 [ft]	2	-25.50	121.49	
			3	-14.00	122.45	
			4	0.00	122.74	
			5	14.00	122.45	
			6	22.00	121.78	
			7	71.23	110.55	

INPUT DATA – FOUNDATION LAYERS – 5 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	115.00	0.30	SM Existing Embankment
2	120.00	0.30	SP-SM
3	115.00	0.30	SM
4	120.00	0.30	SW-SM
5	110.00	0.30	SANTEE Formation ML

INPUT DATA – EMBANKMENT LAYERS – 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	115.00	New Fill

INPUT DATA OF WATER

Point #	Coordinates (X, Z) :	
	(X) [ft.]	(Z) [ft.]
1	-129.81	110.00
2	64.84	110.00

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	-129.81	112.72	SM Existing Embankment
	2	-113.79	113.54	
	3	-102.79	115.90	
	4	-86.59	119.46	
	5	-59.39	120.64	
	6	-35.64	119.74	
	7	-33.76	119.59	
	8	-31.04	118.50	
	9	-28.64	119.70	
	10	-11.96	119.46	
	11	25.78	119.13	
	12	39.42	115.90	
	13	60.31	110.96	
	14	64.84	110.92	
2	1	-129.81	112.72	SP-SM
	2	-113.49	113.54	
	3	-102.79	115.90	
	4	39.42	115.90	
	5	60.31	110.96	
	6	64.84	110.92	
3	1	-129.81	109.90	SM
	2	64.84	109.90	
4	1	-129.81	106.40	SW-SM
	2	64.84	106.40	
5	1	-129.81	101.70	SANTEE Formation ML
	2	64.84	101.50	

