

Preliminary Geotechnical Data Report

Emergency Bridge Package 3 – S-101 (River Road) Martin Bridge Replacement Fairfield County, South Carolina

November 10, 2015 (Rev. 1)
Terracon Project No. 73155050F

Prepared for:

South Carolina Department of Transportation
Columbia, South Carolina

Prepared by:

Terracon Consultants, Inc.
Columbia, South Carolina

Offices Nationwide
Employee-Owned

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Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

November 10, 2015 (Rev. 1)



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

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

Re: Preliminary Geotechnical Data Report
Emergency Bridge Package 3 –
S-101 (River Road) Martin Bridge Replacement
Fairfield County, South Carolina
Terracon Project Number: 73155050F

Dear Mr. Harris:

Terracon Consultants Inc. (Terracon) has completed the geotechnical exploration and testing services for the above referenced project. These services were conducted in general accordance with the SCDOT Request for Subsurface Exploration and Laboratory Testing dated October 23, 2015. This geotechnical data report presents the findings of the subsurface exploration and laboratory testing along with an overview of testing activities.

1.0 INTRODUCTION

The South Carolina Department of Transportation (SCDOT) has contracted Terracon to perform subsurface exploration and laboratory testing for the Emergency Bridge Package 3 - S-101 (River Road) Martin Bridge Replacement in Fairfield County, South Carolina. The purpose of this work is to develop information relative to subsurface soil and groundwater conditions at the bridge location. This report presents the results of that work. No geotechnical recommendations are associated with the requested scope of study.

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



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Geotechnical



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2.0 PROJECT DESCRIPTION

The Martin Bridge project site is located on S-20-101 (River Road) in Fairfield County, SC. Site location and boring locations plans are presented in Appendix A of this report. It is our understanding that the project will include the demolition/removal of the existing bridge structure and the replacement with new bridge on the existing or similar horizontal alignment. The existing bridge is a 3-span structure apparently supported by wooden piles. It crosses an unnamed stream. The surface of the stream flow was about 16 feet below the existing bridge deck.

3.0 GEOTECHNICAL TESTING

Between October 27 and October 28 2015, two (2) soil test borings (designated STB-1 and STB-2) were performed at the bridge location. Borings STB-1 and STB-2 were performed approximately 10 feet to the east and west of the ends of the existing bridge, respectively, as shown on Exhibit A-2 in Appendix A.

3.1 Field Exploration

Our field exploration at the site consisted of two (2) Standard Penetration Test (SPT) Borings (STB-1, STB-2) at the general test locations provided to Terracon by the SCDOT. A description of our testing methods and graphical logs outlining the soil conditions at each test location are presented in Appendix A. The test locations were established in the field by Terracon and surveyed by Construction Support Services, LLC, after completion. At the time of our field exploration, the roadway in the area of the bridge was closed due to a washout on the east side of the bridge. The set up at each boring is provided in the photographs below.



Photo 1. Drill rig at STB-1 (S-20-101)



Photo 2. Drill rig at STB-2 (S-20-101)

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3.2 Laboratory Testing

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

- Eighteen (18) Natural Moisture Content Tests (ASTM D2216)
- Two (2) Atterberg Limits Tests (ASTM D4318)
- Thirteen (13) Wash #200 Tests

The laboratory procedures and results of the laboratory tests are presented in Appendix B.

4.0 CLOSURE

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

Sincerely,

Terracon Consultants, Inc.

Joseph D.M. Fredendall, E.I.T.
Field Engineer

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

Attachments

Copies: Addressee (1 via email)
File (1)

APPENDIX A - FIELD EXPLORATION

Exhibit A-1 – Site Location Map

Exhibit A-2 – Exploration Plan

Exhibit A-3 – Summary of Boring Data

Exhibit A-4 – Field Testing Description

Exhibit A-5 – Soil Description Terms

Exhibit A-6 – Rock Description Terms

Exhibits A-7 and A-8 - Boring Logs

Exhibit A-9 - Rock Core Photographs



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
 QUADRANGLES INCLUDE: FLINT HILL, SC (1/1/1971) and LIBERTY HILL, SC (1/1/1971).

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

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

Project No. 73155050F
 Scale: 1"=24,000 SF
 File Name: A-1 & A-2
 Date: Nov. 2015

Terracon

521 Clemson Road
 Columbia, SC 29229

SITE LOCATION MAP


S-101 (River Road) Martin Bridge Replacement
 Fairfield County, South Carolina

Exhibit

A-1



LEGEND

 SOIL TEST BORING LOCATION

100 feet



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<p>AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS</p> <p>DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES</p>	<p>Project Manager: PAM</p> <p>Drawn by: PTK</p> <p>Checked by: PAM</p> <p>Approved by: PAM</p>	<p>Project No. 73155050F</p> <p>Scale: AS SHOWN</p> <p>File Name: A-1 & A-2</p> <p>Date: Nov. 2015</p>	 <p>521 Clemson Road Columbia, SC 29229</p>	<p>EXPLORATION PLAN</p>	<p>Exhibit</p>
				<p>S-101 (River Road) Martin Bridge Replacement Fairfield County, South Carolina</p>	<p>A-2</p>

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November 10, 2015 (Rev. 1) ■ Terracon Project No. 73155050F



Summary of Boring Data

Boring No.	Ground Elevation (ft.)	Test Depth (ft.)	Northing	Easting	Latitude	Longitude
STB-1	238.3	68.7	932045.058	2047932.041	34.394932	-80.841101
STB-2	238.8	70.9	932019.532	2048003.949	34.394861	-80.840863

FIELD EXPLORATION DESCRIPTION

Overview

The testing locations were provided by the SCDOT and located in the field by Terracon by taking measurements from the existing bridge. The borings were surveyed by Construction Support Services, LLC after drilling was complete. The locations are shown on the Exploration Plan (Exhibit A-2).

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

Soil Test Borings (STB)

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

- SCDOT Geotechnical Design Manual 2010
- ASTM D5783, "Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geo-environmental Exploration"
- ASTM D1586 "Test Method for Penetration Test and Split-Barrel Sampling of Soils"
- ASTM D2113 "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration"
- ASTM D4220 "Standard Practices for Preserving and Transporting Soil"

Each boring was advanced using rotary wash drilling techniques. Five samples were collected in the upper 10 feet. Below that depth, samples were obtained at 5-foot intervals. Soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel sampler, also known as a standard split-spoon. The sampler is advanced into the soil a total of 18 inches (24-inches in the upper 10 feet) by striking the drill rod using a 140-pound automatic hammer falling 30 inches. The number of blows required to advance the sampler for each of the three, 6-inch increments is recorded. A fourth reading was recorded in the upper 10 feet. The sum of the number of blows for the second and third increments is called the "Standard Penetration Value", or N-value (N_{meas} , blows per foot). The N-value, when properly evaluated, is an index to the soil strength.

Soil Classification provides a general guide to the engineering properties of various soil types and enables the engineer to apply his experience to current situations. In our exploration, samples obtained during drilling operations are examined and visually classified by a geotechnical engineer using the procedures outlined in ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System). Laboratory testing was also performed on select split-spoon samples to evaluate index properties for further classification. The soils are described according to color, texture, and relative density or

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consistency (based on standard penetration resistance). An explanation of the soil descriptions shown on the logs is provided on Exhibit A-5.

The borings were advanced to refusal of the drilling equipment and continued below this depth using diamond bit rock coring techniques. NQ2 sized cores were recovered from the borehole. The rock recovery ratios (REC, percentage of the total core run), Rock Quality Designation (RQD, percentage of the total core run of pieces greater than 4 inches) were recorded along with a description of the rock. An explanation of the rock descriptions shown on the logs is provided on Exhibit A-6. Photos of the recovered rock core specimens are provided on Exhibit A-9 of the Appendix.

Due to the drilling method, time-of-drilling water levels could not be recorded as well as the rock coring introduces water into the borehole. The 24-hour groundwater readings were collected from the borings, where possible. These are indicated on the boring logs. Due to time limitations, 24-hour groundwater measurements could not be collected at Boring STB-1. At the conclusion of the work, the boreholes were backfilled and capped with cold-patch asphalt.

SOIL DESCRIPTION TERMS

Relative Density/Consistency Terms

<u>Relative Density</u> ¹			<u>Consistency</u> ²		
Descriptive Term	Relative Density	SPT Blow Count	Descriptive Term	Unconfined Compression Strength (q _u) (tsf)	SPT Blow Count
Very Loose	0 to 15%	4 and less	Very Soft	0.25 and less	2 and less
Loose	16 to 35%	5 to 10	Soft	0.26 to 0.50	3 to 4
Medium Dense	36 to 65%	11 to 30	Firm	0.51 to 1.00	5 to 8
Dense	66 to 85%	31 to 50	Stiff	1.01 to 2.00	9 to 15
Very Dense	86 to 100%	51 and more	Very Stiff	2.01 to 4.00	16 to 30
			Hard	4.01 and more	31 and more

Moisture Condition

<u>Descriptive Term</u>	<u>Criteria</u>
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually in coarse-grained soils below the water table

Color

Describe the sample color while sample is still moist.

Angularity¹

<u>Descriptive Term</u>	<u>Criteria</u>
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

HCl Reaction³

<u>Descriptive Term</u>	<u>Criteria</u>
None Reactive	No visible reaction
Weakly Reactive	Some reaction, with bubbles forming slowly
Strongly Reactive	Violent reaction, with bubbles forming immediately

Cementation³

<u>Descriptive Term</u>	<u>Criteria</u>
Weakly Cemented	Crumbles or breaks with handling or little finger pressure
Moderately Cemented	Crumbles or breaks with considerable finger pressure
Strongly Cemented	Will not crumble or break with finger pressure

Particle-Size Range¹

<u>Gravel</u>	Diameter, mm	Sieve Size	<u>Sand</u>	Diameter, mm	Sieve Size
Fine	4.76 to 19.1	#4 to ¾ inch	Fine	0.074 to 0.42	#200 to #40
Coarse	19.1 to 76.2	¾ inch to 3 inch	Medium	0.42 to 2.00	#40 to #10
			Coarse	4.00 to 4.76	#10 to #4

Primary Soil Type^{1,2}

The primary soil type will be shown in all capital letters.

USCS Soil Designation

Indicate USCS soil designation as defined in ASTM D-2487 and D-2488

AASHTO Soil Designation

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

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

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

³ Use as required

DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock ^a

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) ^a

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

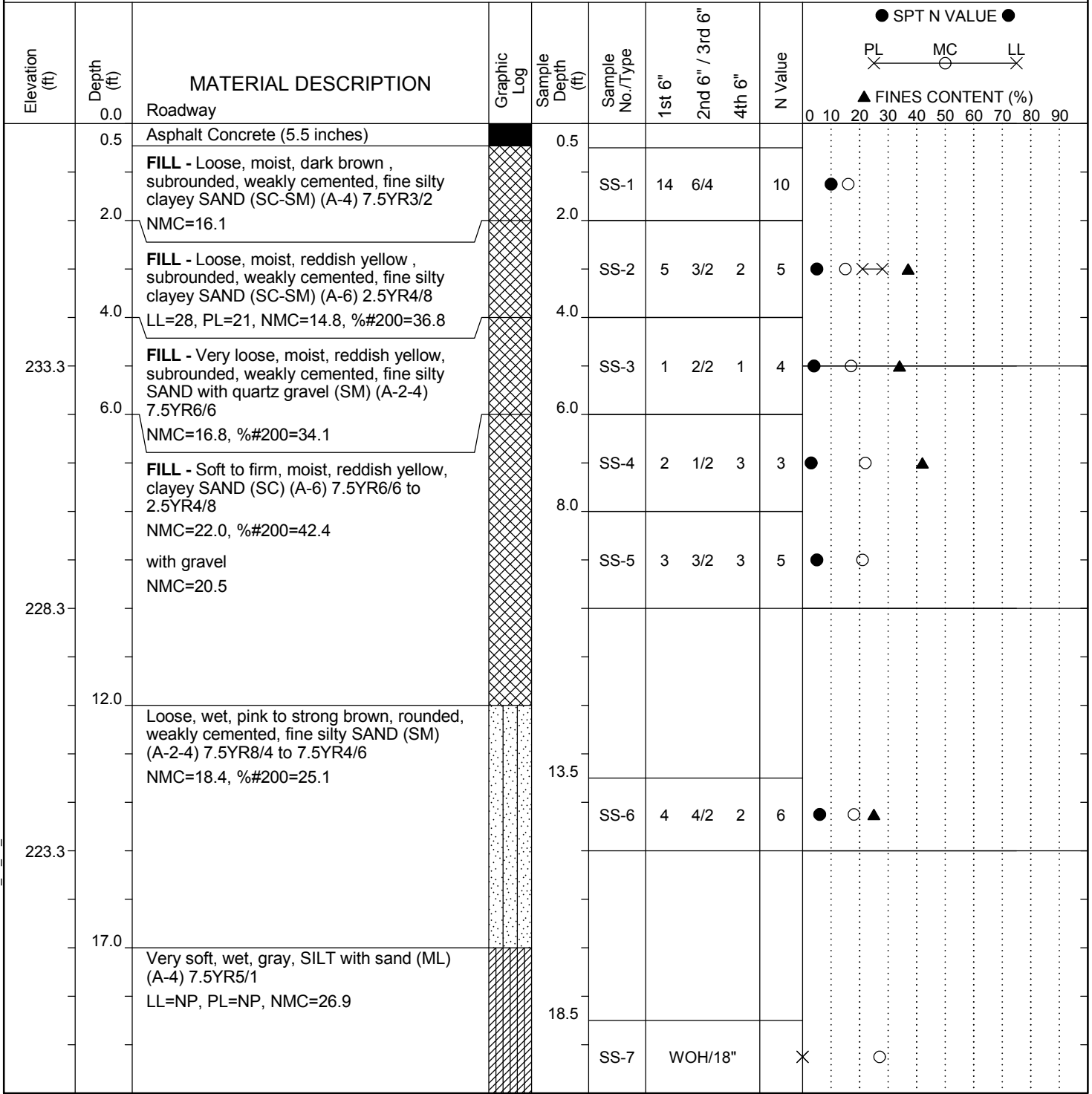
Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-1
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.3 ft	Latitude:	34.394932	Longitude:	-80.841101
Date Started:	10/28/2015				
Total Depth:	68.7 ft	Soil Depth:	38.7 ft	Core Depth:	68.7 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	2.94	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	N/R				



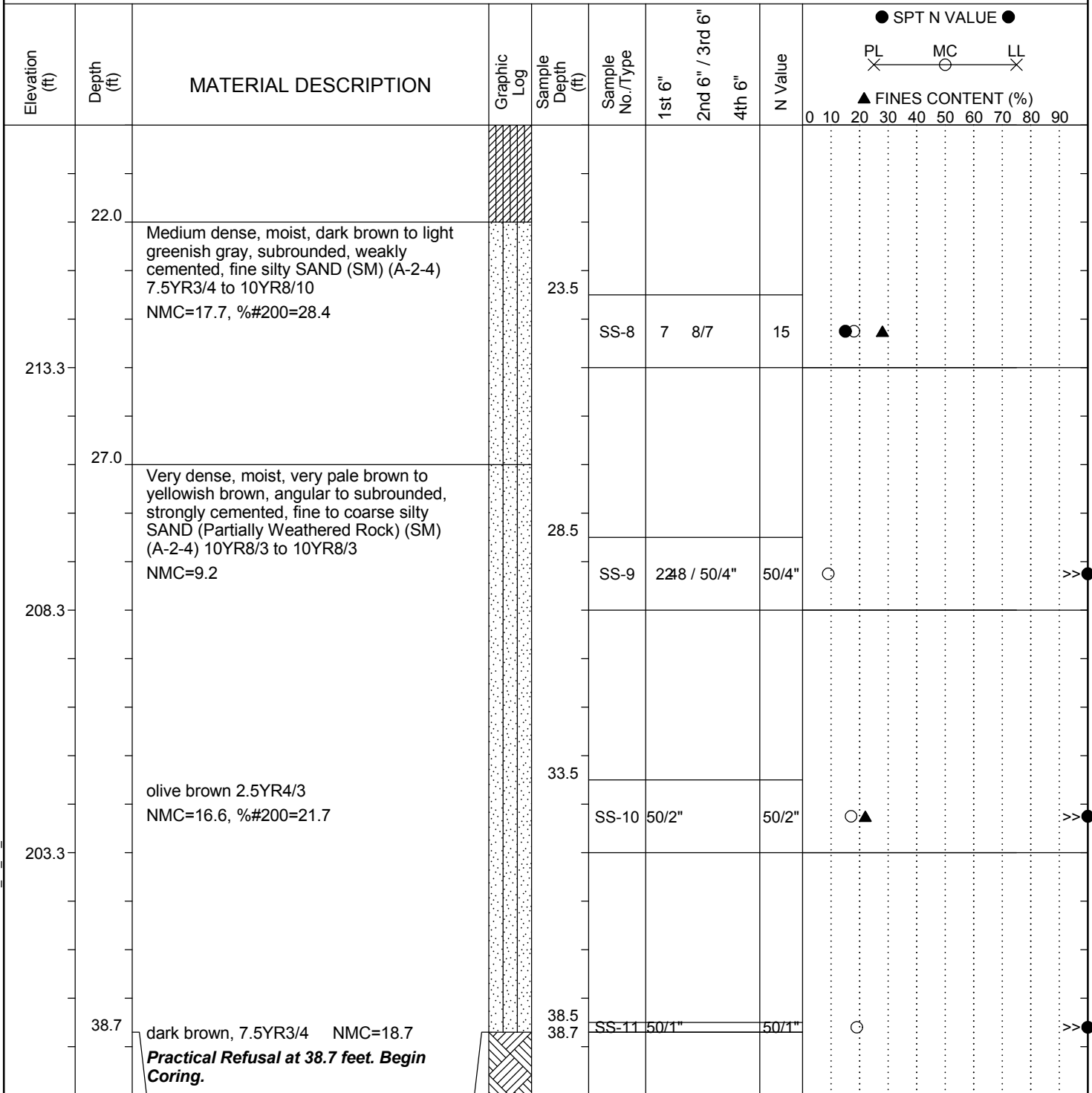
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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving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

SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-1
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.3 ft	Latitude:	34.394932	Longitude:	-80.841101
Date Started:	10/28/2015				
Total Depth:	68.7 ft	Soil Depth:	38.7 ft	Core Depth:	68.7 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	2.94	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	N/R				



LEGEND

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SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
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SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-1
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.3 ft	Latitude:	34.394932	Longitude:	-80.841101
Date Started:	10/28/2015				
Total Depth:	68.7 ft	Soil Depth:	38.7 ft	Core Depth:	68.7 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	2.94	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	N/R				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6" / 3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL — MC — LL X — O — X ▲ FINES CONTENT (%) 0 10 20 30 40 50 60 70 80 90
		Persimmon Fork Formation - Volcanic metatuff, brown, fine to medium grained, highly weathered, extremely weak, J, W, No, No, PI to St, VC, R, 7.5YR4/4 White9.5/N, RQD=0, %REC=15			NQ2-1					RQD=0, %REC=15, RMR=0
193.3	43.7	Volcanic metatuff, brown, fine to medium grained, highly weathered, extremely weak, J, W, No, No, PI to St, VC, R, 7.5YR4/4 White9.5/N, RQD=8, %REC=30		43.7	NQ2-2					RQD=8, %REC=30, RMR=0
188.3	48.7	Volcanic metatuff, brown, fine to medium grained, highly weathered, extremely weak, J, W, No, No, PI to St, VC, R, 7.5YR4/4 White9.5/N, RQD=0, %REC=40		48.7	NQ2-3					RQD=0, %REC=40, RMR=0
183.3	53.7	Volcanic metatuff, brown, fine to medium grained, highly weathered, extremely weak, J, W, No, No, PI to St, VC, R, 7.5YR4/4 White9.5/N, RQD=8, %REC=35		53.7	NQ2-4					RQD=8, %REC=35, RMR=0
	58.7	No Recovery, RQD=0, %REC=0		58.7						

LEGEND

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SAMPLER TYPE SS - Split Spoon UD - Undisturbed Sample AWG - Rock Core, 1-1/8" NQ - Rock Core, 1-7/8" CU - Cuttings CT - Continuous Tube		DRILLING METHOD HSA - Hollow Stem Auger CFA - Continuous Flight Augers DC - Driving Casing RW - Rotary Wash RC - Rock Core	
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SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

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Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.3 ft	Latitude:	34.394932	Longitude:	-80.841101
Date Started:	10/28/2015				
Total Depth:	68.7 ft	Soil Depth:	38.7 ft	Core Depth:	68.7 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	2.94	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	N/R				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6" / 3rd 6"	4th 6"	N Value	SPT N VALUE ●									
										PL	MC	LL							
										▲ FINES CONTENT (%)									
										0	10	20	30	40	50	60	70	80	90
173.3	63.7	Volcanic metatuff, brown, fine to medium grained, highly weathered, extremely weak, J, W, No, No, Pl to St, VC, R, 7.5YR4/4 White9.5/N, RQD=0, %REC=17		63.7	NQ2-5						RQD=0, %REC=0, RMR=0								
168.3	68.7	Coring Terminated at 68.7 feet			NQ2-6						RQD=0, %REC=17, RMR=0								
163.3																			

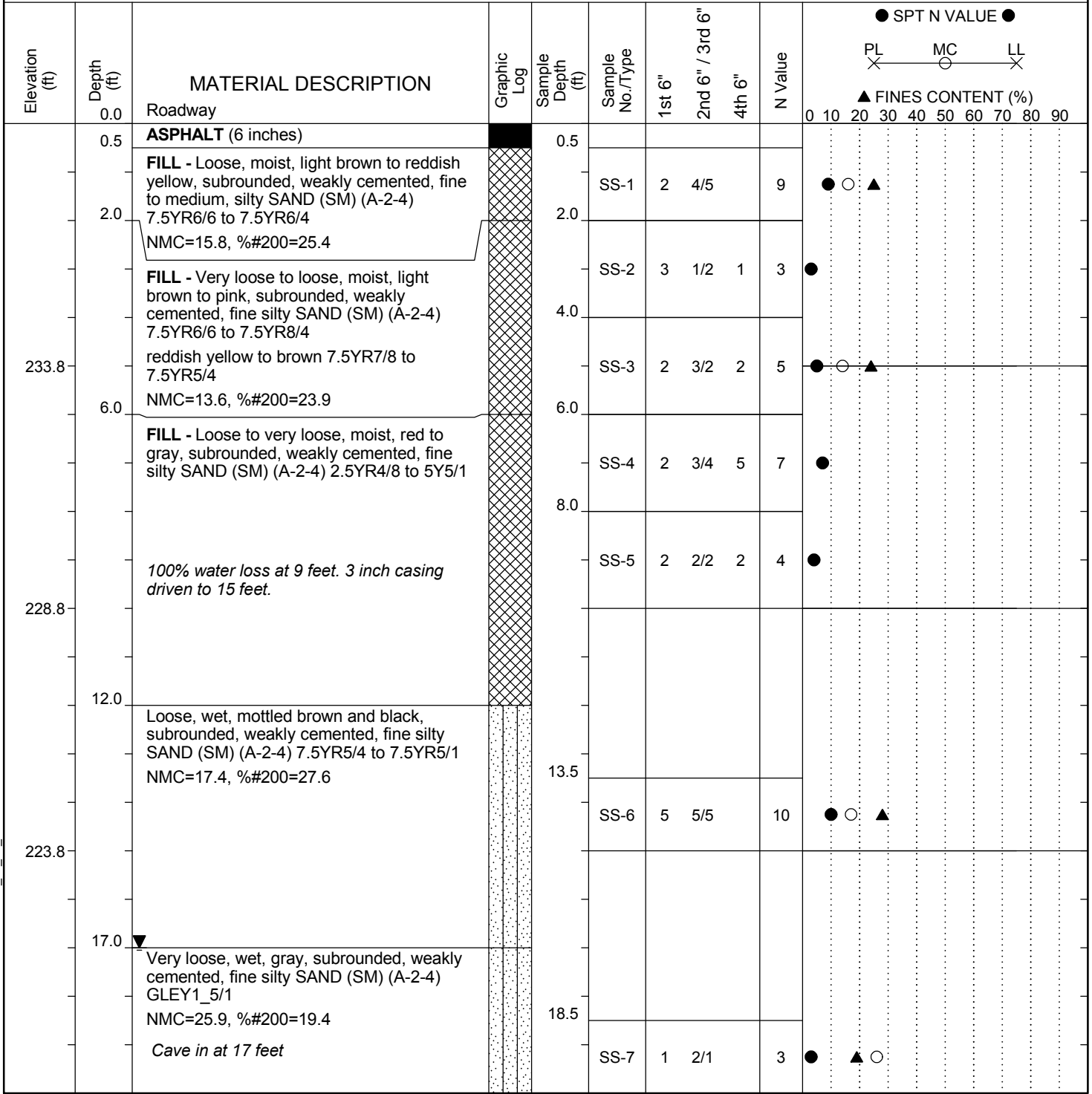
LEGEND

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

SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-2
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.8 ft	Latitude:	34.394861	Longitude:	-80.840863
Date Started:	10/27/2015				
Total Depth:	70.9 ft	Soil Depth:	40.9 ft	Core Depth:	70.9 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	3.88	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	17 feet				



LEGEND Continued Next Page

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

SC_DOT S-101 SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-2
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.8 ft	Latitude:	34.394861	Longitude:	-80.840863
Date Started:	10/27/2015				
Total Depth:	70.9 ft	Soil Depth:	40.9 ft	Core Depth:	70.9 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	3.88	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	17 feet				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6" / 3rd 6"	4th 6"	N Value	SPT N VALUE	PL	MC	LL	FINES CONTENT (%)
22.0		Loose, wet, light brownish gray, subrounded, weakly cemented, medium to coarse, poorly graded SAND with silt and gravel (SP-SM) (A-2-4) GLEY1_5/1 NMC=24.4, %#200=11.1		23.5	SS-8	2	3/5		8	●				
213.8														
27.0		Very dense, moist, strong brown, rounded to subangular, strongly cemented, fine to medium, poorly graded SAND with trace silt (SP) (A-3) 7.5YR4/6 NMC=31.8, %#200=2.8		28.5	SS-9	12	50/3"		50/3"	▲				
208.8														
32.0		Very dense, moist, reddish brown, rounded to subangular, strongly cemented, fine to medium, silty SAND (SM) (A-2-4) 5YR4/4 NMC=15.7, %#200=20.3		33.5	SS-10	38	50/3"		50/3"		○	▲		
203.8														
		Red to brown, 2.5YR4/8 to 7.5YR5/4		38.5	SS-11	50/2"			50/2"					

LEGEND

Continued Next Page

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

SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-2
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.8 ft	Latitude:	34.394861	Longitude:	-80.840863
Date Started:	10/27/2015				
Total Depth:	70.9 ft	Soil Depth:	40.9 ft	Core Depth:	70.9 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	3.88	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	17 feet				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6" / 3rd 6"	4th 6"	N Value	SPT N VALUE	PL	MC	LL	FINES CONTENT (%)
	40.9	Rotary Wash Refusal at 40.9 feet. Begin Coring.		40.9										
193.8		Persimmon Fork Formation - Volcanic metatuff, light brown and white, medium to coarse grained, subangular, highly weathered, extremely weak, J, W, No, No, PI, VC, R, 7.5YR6/4 and White9.5/N, RQD=0, %REC=8			NQ-1									RQD=0, %REG=8, RMR=0
	45.9	Volcanic metatuff, dark greenish black to very pale brown to greenish gray, medium to coarse grained, subangular, highly weathered, extremely weak to very weak rock, J, W, Su, Fe, PI, VC, 0 to 85, R, GLEY2.5/1 to 10YR8.5/1 to GLEY26/1, RQD=0, %REC=25		45.9	NQ-2									RQD=0, %REC=25, RMR=0
188.8		Volcanic metatuff, red to yellowish red, fine, subangular, moderately weathered, weak rock, J, W, Su, Fe, PI to St, VC, 75 to 0, R, 2.5YR7/6 to 5YR5/8, RQD=0, %REC=50		50.9	NQ-3									RQD=0, %REC=50, RMR=0
	55.9	Volcanic metatuff, light red to yellowish red, fine, subangular, moderately weathered, weak rock, J, W, Su to Pa, Fe Cl Sd, PI to St, VC, 75 to 80 to sub horizontal, R to SR, 2.5YR7/6 to 5YR5/8, RQD=0, %REC=65		55.9	NQ-4									RQD=0, %REC=65, RMR=0
183.8														

LEGEND

Continued Next Page

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

SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

SCDOT Soil Test Log

Project ID:	Emergency Bridge Package 3	County:	Fairfield	Boring No.:	STB-2
Site Description:	S-101 (River Road) Martin Bridge Replacement			Route:	S-20-101
Eng./Geo.:	K. Zur	Boring Location:	Centerline	Offset:	None
Alignment:	MAINLINE				
Elev.:	238.8 ft	Latitude:	34.394861	Longitude:	-80.840863
Date Started:	10/27/2015				
Total Depth:	70.9 ft	Soil Depth:	40.9 ft	Core Depth:	70.9 ft
Date Completed:	10/28/2015				
Bore Hole Diameter (in):	3.88	Sampler Configuration		Liner Required:	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 55	Drill Method:	RW/RC	Hammer Type:	Automatic
Energy Ratio:	81.9%				
Core Size:	NQ2	Driller:	C. Fredrychowski	Groundwater:	TOB N/R
24HR:	17 feet				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6" / 3rd 6"	4th 6"	N Value	● SPT N VALUE ● PL — MC — LL X — O — X ▲ FINES CONTENT (%) 0 10 20 30 40 50 60 70 80 90										
173.8	60.9	Volcanic metatuff, light red to yellowish red, fine, subangular, moderately weathered, weak rock, J, MW, Su to Pa, Fe Cl Sd, Pl to St, VC, 85 to 90, R to SR, 2.5YR7/6 to 5YR5/8, RQD=0, %REC=43		60.9	NQ-5					RQD=0, %REC=43, RMR=0										
168.8	65.9	Volcanic metatuff, light brown, fine to medium grained, subangular, highly weathered, extremely weak rock, J, MW, No, No, Ir, M, VR, 7.5YR6/4, RQD=0, %REC=8		65.9	NQ-6					RQD=0, %REC=8, RMR=0										
163.8	70.9	Coring Terminated at 70.9 feet																		

LEGEND

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

SC_DOT S-101 SCDOT.GPJ SCDOT DATA TEMPLATE_12_30_2014.GDT 11/6/15

Preliminary Geotechnical Data Report

Emergency Bridge Package 3 – S-101 Martin Bridge ■ Fairfield County, SC
November 10, 2015 (Rev. 1) ■ Terracon Project No. 73155050F



Photo #1 STB-1 38.7'-58.7'

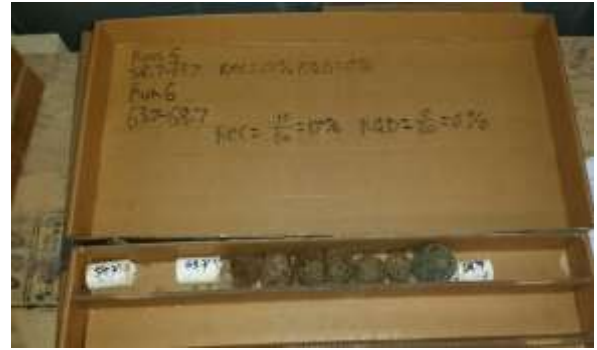


Photo #2 STB-1 58.7'-68.7'



Photo #3 STB-2 40.9'-60.9'



Photo #4 STB-2 60.9'-70.9'

APPENDIX B - LABORATORY TESTING

Exhibit B-1 – Laboratory Testing Description

Exhibit B-2 – Summary of Laboratory Data

Laboratory Data Sheets

Preliminary Geotechnical Data Report

Emergency Bridge Package 3 – S-101 Martin Bridge ■ Fairfield County, SC

November 10, 2015 (Rev. 1) ■ Terracon Project No. 73155050F



LABORATORY TESTING DESCRIPTION

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

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

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

- | | | |
|---|--------------------------------|----------------------------|
| ■ | Percent Fines | AASHTO T11 (ASTM D1140) |
| ■ | Atterberg Limits | AASHTO T89/T90(ASTM D4318) |
| ■ | Moisture Content Determination | AASHTO T265/(ASTM D2216) |

Summary of Laboratory Results

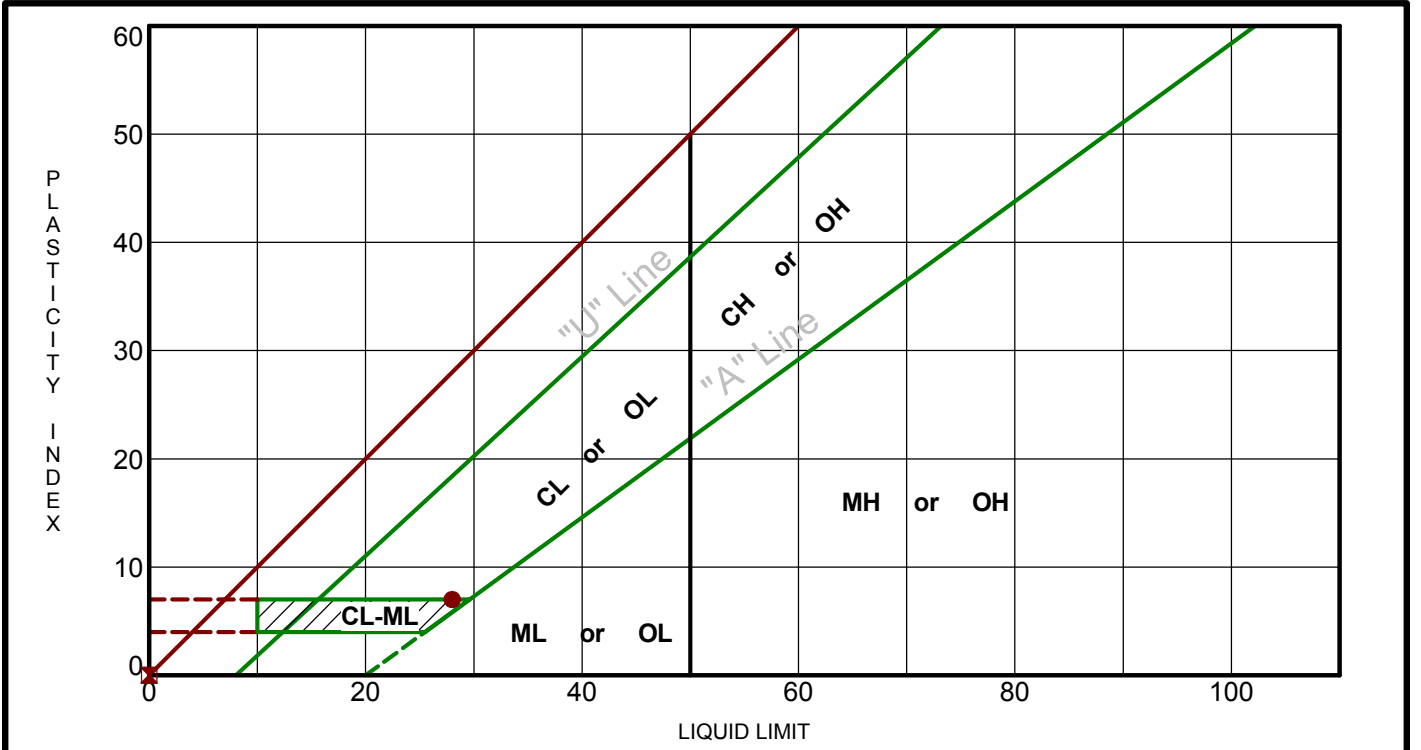
BORING ID	Depth	USCS Classification and Soil Description	Compressive Strength (psf)	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Dry Density (pcf)
STB-1	0.5 - 2	SILTY, CLAYEY SAND (SC-SM)										16.1	
STB-1	2 - 4	SILTY, CLAYEY SAND (SC-SM)		28	21	7	36.8	0.0	0.0			14.8	
STB-1	4 - 6	SILTY SAND (SM)					34.1	0.0	0.0			16.8	
STB-1	6 - 8	CLAYEY SAND (SC)					42.4	0.0	0.0			22.0	
STB-1	8 - 10	SILTY SAND (SM)										20.5	
STB-1	13.5 - 15	SILTY SAND (SM)					25.1	0.0	0.0			18.4	
STB-1	18.5 - 20	SILT with sand (ML)		NP	NP	NP						26.9	
STB-1	23.5 - 25	SILTY SAND (SM)					28.4	0.0	0.0			17.7	
STB-1	28.5 - 30	SILTY SAND (SM)										9.2	
STB-1	33.5 - 35	SILTY SAND (SM)					21.7	0.0	0.0			16.6	
STB-1	38.5 - 38.7	SILTY SAND (SM)										18.7	
STB-2	0.5 - 2	SILTY SAND (SM)					25.4	0.0	0.0			15.8	
STB-2	4 - 6	SILTY SAND (SM)					23.9	0.0	0.0			13.6	
STB-2	13.5 - 15	SILTY SAND (SM)					27.6	0.0	0.0			17.4	
STB-2	18.5 - 20	SILTY SAND (SM)					19.4	0.0	0.0			25.9	
STB-2	23.5 - 25	SAND with silt (SP-SM)					11.1	0.0	0.0			24.4	
STB-2	28.5 - 30	SAND (SP)					2.8	0.0	0.0			31.8	
STB-2	33.5 - 35	SILTY SAND (SM)					20.3	0.0	0.0			15.7	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. OLD-LAB SUMMARY: USCS S-101 LAB TESTING.GPJ TERRACON2012.GDT 1/11/15

PROJECT: Emergency Bridge Package 3	<p style="color: #8B0000; font-weight: bold; margin-top: 10px;">521 Clemson Road Columbia, South Carolina</p>	PROJECT NUMBER: 73155050F
SITE: S-101 (River Road) Martin Bridge Replacement Fairfield County, South Carolina		CLIENT: SCDOT
		EXHIBIT: B-2

ATTERBERG LIMITS RESULTS

ASTM D4318



LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS S-101 LAB TESTING.GPJ TERRACON2015.GDT 11/6/15

Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● STB-1	2 - 4	28	21	7	37	SC-SM	SILTY, CLAYEY SAND
✘ STB-1	18.5 - 20	NP	NP	NP			

PROJECT: Emergency Bridge Package 3	<p style="font-size: small;">521 Clemson Road Columbia, South Carolina</p>	PROJECT NUMBER: 73155050F
SITE: S-101 (River Road) Martin Bridge Replacement		CLIENT: SCDOT
		EXHIBIT: B-3












APPENDIX C - SUPPORTING DOCUMENTS

Exhibit C-1 – General Notes

Exhibit C-2 – Unified Soil Classification System

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING			WATER LEVEL		Water Initially Encountered	FIELD TESTS	(HP) Hand Penetrometer	
	Auger	Split Spoon			Water Level After a Specified Period of Time		(T) Torvane	
					Water Level After a Specified Period of Time		(b/f) Standard Penetration Test (blows per foot)	
	Shelby Tube	Macro Core		Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.			(PID) Photo-Ionization Detector	
							(OVA) Organic Vapor Analyzer	
Ring Sampler	Rock Core							
								
Grab Sample	No Recovery							

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS	RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
	Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 15
With	15 - 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

<u>Descriptive Term(s) of other constituents</u>	<u>Percent of Dry Weight</u>
Trace	< 5
With	5 - 12
Modifier	> 12

GRAIN SIZE TERMINOLOGY

<u>Major Component of Sample</u>	<u>Particle Size</u>
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 sieve (0.075mm)

PLASTICITY DESCRIPTION

<u>Term</u>	<u>Plasticity Index</u>
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A				Soil Classification		
				Group Symbol	Group Name ^B	
Coarse Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines ^C	$Cu \geq 4$ and $1 \leq Cc \leq 3$ ^E	GW	Well-graded gravel ^F	
		Gravels with Fines: More than 12% fines ^C	Fines classify as ML or MH	GP	Poorly graded gravel ^F	
			Fines classify as CL or CH	GM	Silty gravel ^{F,G,H}	
		Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines ^D	$Cu \geq 6$ and $1 \leq Cc \leq 3$ ^E	GC	Clayey gravel ^{F,G,H}
	Sands with Fines: More than 12% fines ^D		Fines classify as ML or MH	SW	Well-graded sand ^I	
			Fines classify as CL or CH	SP	Poorly graded sand ^I	
	Silts and Clays: Liquid limit less than 50		Inorganic:	$PI > 7$ and plots on or above "A" line ^J	SM	Silty sand ^{G,H,I}
		Organic:	Liquid limit - oven dried < 0.75	SC	Clayey sand ^{G,H,I}	
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit 50 or more	Inorganic:	$PI < 4$ or plots below "A" line ^J	CL	Lean clay ^{K,L,M}	
		Organic:	Liquid limit - not dried < 0.75	ML	Silt ^{K,L,M}	
			PI plots on or above "A" line	OL	Organic clay ^{K,L,M,N}	
		Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots below "A" line	OH	Organic silt ^{K,L,M,O}
	Organic:		Liquid limit - oven dried < 0.75	CH	Fat clay ^{K,L,M}	
			Liquid limit - not dried < 0.75	MH	Elastic Silt ^{K,L,M}	
	Highly organic soils:		Primarily organic matter, dark in color, and organic odor			OH
					PT	Organic silt ^{K,L,M,Q}
Highly organic soils:				PT	Peat	

^A Based on the material passing the 3-inch (75-mm) sieve

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

^D Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$$^E Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

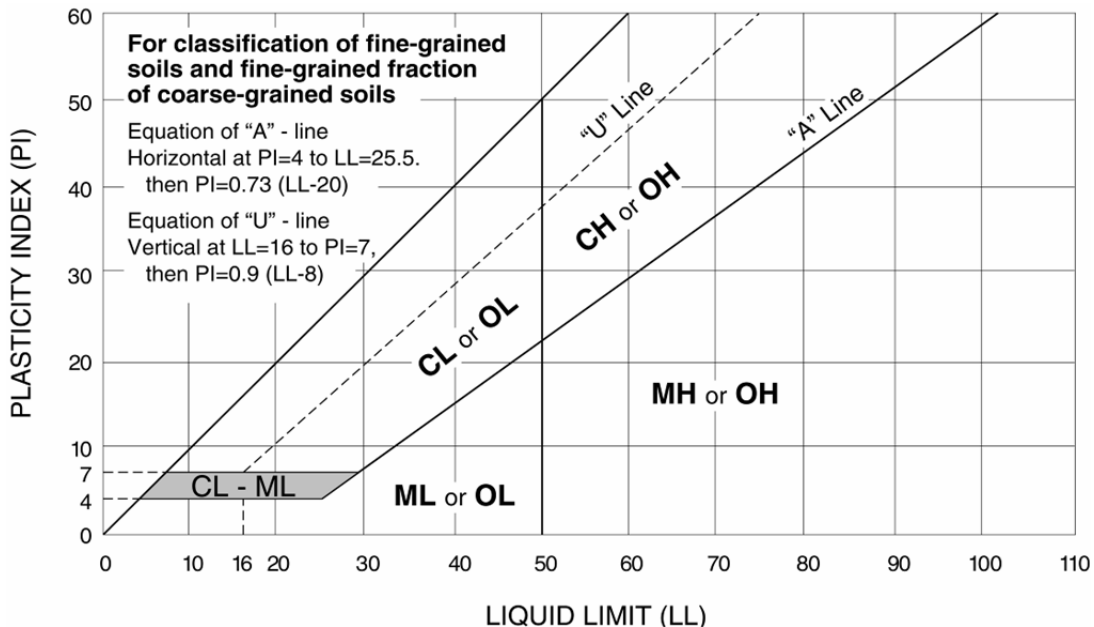
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Term	Description
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS

Description	Field Identification	Uniaxial Compressive Strength, PSI (MPa)
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION

Fracture Spacing (Joints, Faults, Other Fractures)		Bedding Spacing (May Include Foliation or Banding)	
Description	Spacing	Description	Spacing
Extremely close	< ¾ in (<19 mm)	Laminated	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	Very thin	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	Thin	2 in – 1 ft (50 – 300 mm)
Moderate	8 in – 2 ft (200 – 600 mm)	Medium	1 ft – 3 ft (300 – 900 mm)
Wide	2 ft – 6 ft (600 mm – 2.0 m)	Thick	3 ft – 10 ft (900 mm – 3 m)
Very Wide	6 ft – 20 ft (2.0 – 6 m)	Massive	> 10 ft (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0 degree angle.

ROCK QUALITY DESIGNATION (RQD*)

Description	RQD Value (%)
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

*The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009
Technical Manual for Design and Construction of Road Tunnels – Civil Elements