Foundation Report
Bridge on Old SR 20 over NS Railroad
Huntsville, Alabama
S&ME Project No. 3282-19-054

PREPARED FOR:

Garver
5125 Research Drive, NW
Huntsville, Alabama 35805

PREPARED BY:

S&ME, Inc.
360D Quality Circle NW, Suite 450
Huntsville, AL 35806

May 6, 2020

May 6, 2020

Garver
5125 Research Drive, NW
Huntsville, Alabama 35805

Attention: Mr. Scott Leach, PE

Reference: **Foundation Report**
Bridge on Old SR 20 over NS Railroad
Huntsville, Alabama
S&ME Project No. 3282-19-054

Dear Scott:

S&ME, Inc. is pleased to provide this Foundation Report for the above reference project. Our work was performed in general accordance with S&ME Proposal No. 32-1900351, dated June 25, 2019 and authorized via Work Order No. 18057020. This report describes our understanding of the project, presents the results of the geotechnical field exploration and laboratory testing, and discusses our conclusions and recommendations.

S&ME appreciates the opportunity to be of service to you. Please call if you have questions concerning this report or any of our services.

Sincerely,

S&ME, Inc.

Jeffrey C. Pepper, PE
Principal Engineer
Alabama License No. 30081

James P. McGirl, PE
Principal Engineer

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1.0 Introduction

S&ME has completed the field and laboratory evaluation for the above referenced project. Our work was performed in general accordance with ALDOT BMPTP-398 procedures and S&ME Proposal No. 32-1900351, dated June 25, 2019.

The proposed project consists of rerouting Old Highway 20 in Huntsville, Alabama at its crossing with Beaverdam Creek and the Norfolk Southern (NS) railroad. The rerouting will include construction of two bridges, one at Beaverdam Creek and one at the NS railroad, and associated approach embankment fill slopes. The roadway is also being widened to five lanes.

S&ME was contracted to perform the geotechnical exploration and engineering evaluation of the bridge foundation and abutment retaining walls at the NS railroad. It is our understanding that another engineering firm is providing geotechnical services for the Beaverdam Creek bridge foundation, the embankment slope study(s), and the materials report for the roadway.

The bridge over the NS Railroad will be a three-span structure. The overpass will span over the existing NS Railroad mainline alignment and right-of-way for future rail spurs. The bridge begins at Station (Sta.) 95+95.20 and ends at Sta. 100+15.20. The three spans will be 140 feet, 145 feet, and 135 feet in length, respectively. The overpass structure will utilize mechanically stabilized earth (MSE) walls in order to limit encroachment on NS Railroad right-of-way. Based on the plan and elevation drawing, fill depths will be on the order of up to about 31 feet.

2.0 Exploration Methods

Field sampling and testing by S&ME were conducted in general accordance with ALDOT and AASHTO procedures and established geotechnical engineering practices. The Boring Logs are provided in Appendix II.

The geotechnical exploration consisted of drilling 12 borings. Fieldwork was conducted in general accordance with ALDOT BMTP-398 procedures. Boring locations and depths were likewise determined using ALDOT BMTP-398 procedures and modified in accordance to S&ME Proposal No. 32-1800425.

The borings were performed by a subcontracted drilling crew and logged by S&ME. The boring locations were surveyed in the field before and after drilling by Garver. The Northing, Easting, Station, Offset, and Elevation are included on the boring logs. The boring locations are shown on Figure II-1, Test Boring Location Plan, in Appendix II.

The borings were drilled with a Diedrich D-50 track mounted drilling rig. The drill rig was equipped with a rotary head drive. Hollow-stem augers were used to advance the holes to the termination depth. The drill rig was equipped with an automatic hammer system for the Standard Penetration Test (SPT). Soil samples were obtained in the borings using a split-barrel sampler in accordance with the procedures of AASHTO T-206. Relatively undisturbed Shelby tube samples were obtained in accordance with the procedures of AASHTO T-207. Rock

coring was completed using NQ rock coring techniques. A minimum of 20 feet of rock was cored from each boring.

3.0 Site Geology

The Geologic Map of Alabama indicates the subject site is underlain by the Fort Payne Chert. The Fort Payne Chert is typically described as very light to light-olive-gray, thin to thick-bedded fine to coarse-grained bioclastic (abundant pelmatozoans) limestone containing abundant nodules, lenses and beds of light to dark-grey chert. Upper part of formation locally consists of light-bluish-gray laminated siltstone containing vugs lined or filled with quartz and scattered throughout the formation are interbeds of medium to greenish-gray shale, shaly limestone and siltstone. Regolith derived from this unit consists of moderate-red to moderate reddish-orange clay with interbeds of dense chert or rectangular blocks of porous, fossiliferous chert. Our experience with these soils indicates they are typically moderately to highly plastic and moisture sensitive. Commonly present below the Fort Payne is a light-olive-gray claystone or shale (Maury Formation) which is mapped with the Fort Payne. The apparent thickness of the Fort Payne in this province varies due to differential dissolution of carbonate in the formation.

4.0 Subsurface Conditions

With the exception of NS-10 through NS-12, the majority of the borings encountered a 2 to 3-inch layer of topsoil. Borings NS-10 through NS-12 encountered about 12 inches of cultivated soils. Beneath the topsoil or cultivated soils, residual soils were encountered until auger refusal. Residual soils are derived from the weathering of the parent bedrock. The residual soils typically consisted of red, yellow, yellowish red lean and/or fat clay (CL/CH) or clayey gravel (GC) with varying amounts of chert, sand, and silt. SPT N-Values ranged between 2 blows per foot (bpf) to 38 bpf. Based on the SPT N-Values, the predominately clayey soils were typically stiff in consistency, and the predominately gravely soils were typically firm in density.

Groundwater was encountered at the time of drilling at depths ranging from about 23 feet to about 31 feet. Delayed groundwater level readings taken from a temporary piezometer installed in boring NS-06 indicated a stabilized groundwater depth of about 27 feet.

The preceding are generalized descriptions of the subsurface conditions. For specific records of the conditions encountered at each boring, refer to the Boring Logs in Appendix II. The stratification of the soil formations, as shown on the Boring Logs and profiles represents the subsurface conditions at the actual boring locations. Lines of demarcation represent the approximate boundary between subsurface units, but the transition may be gradual or not clearly defined.

5.0 Laboratory Results

Geotechnical laboratory testing performed included soil classification and natural moisture content. These test results are summarized in Table IV-1 in Appendix IV. Corrosivity testing consisting of sulfates, pH, minimum resistivity, and chlorides were also performed. The corrosivity test results are summarized in Table IV-2 in Appendix IV.

Unconfined compression tests on select rock core samples were performed to evaluate the rock strength and are summarized in Table IV-3 in Appendix IV. In addition, consolidation testing and triaxial shear strength testing were performed on select Shelby tube samples taken during the field exploration. These test results are also provided in Appendix IV.

6.0 Recommendations

6.1 Foundations

Based on the conditions encountered in our borings and foundation loadings, we recommend that the new bridge be supported on rock bearing foundations. Table 6-1 summarizes the factored and service foundation loadings provided by Garver for each abutment and bent.

Table 6-1: Foundation Loads (Rounded)

Location	Service Loads (kips)/(tons)	Factored Loads (kips)/(tons)
Abutment No's. 1 & 4	2,680/1,340	3,540/1,770
Bent No's. 2 & 3	6,510 /3,260	8,630/4,320
Individual Abutment Pile	90/45	120/60
Individual Bent Shaft	1170/585	1,600/800

Based on the condition of the rock encountered in the borings and rock core compression test results, the abutments and bents can be supported on either drilled shaft foundations socketed into rock or driven H-piles. H-Pile and drilled shaft capacities are summarized in Tables III-1 and III-2 in Appendix III.

6.1.1 H-Piles

H-piles should be driven to refusal in bedrock. We recommend that heavy rock driving tips be placed on the steel H-piles. We recommend that the piles be designed considering end-bearing capacity only. Lateral foundation loads should be accounted for by the use of battered piles. H-Pile maximum factored design loads are summarized in Table III-1 and are in accordance with the ALDOT Bridge Bureau's Structural Design Manual. The loadings provided are for foundation piles only.

6.1.2 Drilled Shafts

Drilled shafts can be designed using a factored shaft tip resistance of 150 kips per square foot (ksf) and a factored shaft side resistance of 10 ksf for skin friction in rock sockets. A resistance factor of φ=0.5 has been applied to both the tip resistance and the shaft side resistance. We recommend the drilled shaft tip be extended a minimum of one shaft diameter or five feet, whichever is greater, into the bedrock.

The drilled shafts are to be extended through residual soils and be socketed into rock. Dewatering will be required during construction, and the contractor should be prepared for groundwater seepage and expect the use of temporary casing.

During drilled shaft excavation, the contractor should be prepared for varying excavation conditions including soil, slightly weathered rock, and unweathered rock. The soil can be removed by conventional excavation equipment. If slightly weathered to unweathered rock is encountered, the contractor should be prepared to use coring for removal. Hand excavations may be required to adequately clean the bearing surface.

The geotechnical engineer should be allowed to observe the excavation to verify rock conditions in the rock socket. We recommend a single test probe hole be drilled in each drilled shaft to verify rock quality. Test probe or core holes should be a minimum of two shaft diameters. In addition, due to the likelihood each drilled shaft will be placed using the "Wet Method", Crosshole Sonic Logging (CSL) should be performed at each drilled shaft.

6.1.3 Spread Footings

Given the depth to bedrock, spread foundations are not a feasible alternative at the bent locations.

6.2 Abutment Retaining Walls

The provided information indicates the west abutment retaining wall will be located at Station 95+95.11, will be about 413 feet long, and will have a maximum above grade height of 31 feet. The east abutment retaining wall will be located at Station 100+02.11, will be about 396 feet long, and will have a maximum above grade height of 28 feet. Based on the provided hand sketched wall and abutment cross sections, we understand the distance from the face of the wall to the back of the pile cap will be 12 feet and the pile cap will be 4 ½ feet wide for both walls. The distance from the top of the pile cap to the top of the abutment will be about 8 ½ feet for both walls. Both vertical and battered piles will be used to support the bridge abutment. We understand an MSE wall will be used for both abutments. One-foot thick concrete will be used for wall facing. The following engineering analyses are based on the provided wall information and the test boring results.

6.2.1 Bearing Capacity

We performed an evaluation of the bearing capacity of the soils supporting the planned walls. The analyses were performed using LRFD criteria based on MSE walls as the selected wall system at both locations. Our initial analyses indicated inadequate bearing capacity and sliding resistance for both the west and east abutment walls. To improve bearing capacity and sliding stability, we analyzed the resisting forces assuming the wall facing and reinforced wall zone will bear on a minimum 4-foot-thick interval of ALDOT Underwater Embankment stone as described in Section 210 of ALDOT Standard Specifications for Highway Construction. We recommend the Underwater Embankment material have no more than 10 percent less than 2 inches in diameter sized particles and choked off with 6-inches of No. 57 surfacing material. The analyses results indicate adequate bearing capacity should be available for wall/reinforced zones bearing on this material. The results of the analysis are summarized in Table 6-2. A CDR of one or greater represents the factored driving forces are less than the factored resisting forces for the wall/reinforced zone bearing on a minimum of 4 feet of ALDOT Underwater Embankment stone as described above.

6.2.2 Sliding

We performed a sliding stability analysis for the walls using LRFD criteria based on an MSE wall for the selected wall system. As stated above, our initial analyses indicated inadequate sliding resistance for both the west and east abutment walls. To improve sliding stability, we analyzed the resisting forces assuming the wall facing and reinforced zones will bear on a minimum 4-foot-thick interval of ALDOT Underwater Embankment stone as described above. The analyses results indicate adequate resistance to sliding will be available for wall facing and reinforced zones bearing on this material. A geotextile should not be placed between the wall/reinforced zone base and Underwater Embankment stone, as the geotextile will reduce resistance to sliding.

The results of the analysis, provided in Table 6-2, indicate CDR values greater than one, or the factored driving forces are less than the factored resisting forces for walls and reinforced zones bearing on a minimum of 4 feet of ALDOT Underwater Embankment stone as previously described.

Table 6-2: Retaining Wall CDR Values for Stability

MSE Wall and Height	Height Behind Abutment (ft)	Total Wall Height (ft)	Reinforcement Length (ft)	Sliding	Bearing	
				Drained	Drained	Undrained
West – 33 ft.	8.5	41.5	30	1.53	2.22	3.90
East – 30 ft.	8.5	38.5	27	1.29	2.47	4.36

6.2.3 Global Stability

Retaining Wall cross sections were prepared based on the provided hand sketch of the wall and abutment cross sections for global stability analysis. The cross-sections were evaluated based on the proposed embankment geometry, the geometry of the existing ground surface, the subsurface data, and the planned maximum wall height shown on the hand sketch. The test boring data and the available laboratory test data from the specified area of the project were reviewed and the subsurface boundary conditions developed for the selected "critical" cross-sections. Table 6-3 presents the material properties used in our analyses. Based on the bearing capacity and sliding resistance analyses, the cross sections included 4 feet of ALDOT Underwater Embankment stone as previously described below the wall facing and reinforced zone. In accordance with AASHTO specifications, a surcharge of 250 pounds per square foot (psf) was applied over the full width of the proposed roadway cross-section to represent traffic loading for drained stability. A similar surcharge was used for the undrained stability analysis to represent the embankment being used as a haul road during construction.

Table 6-3: Material Strength Parameters

Material Type	Unit Weight γ (pcf)	Total Cohesion C (psf)	Total Friction Angle Φ (degrees)	Effective Cohesion C′ (psf)	Effective Friction Angle Φ′ (degrees)
Concrete	150	216,000	50	216,000	50
Retained Embankment Soil Fill	120	100	30	100	30
No. 57 Stone Reinforced Zone Fill	100	0	34	0	34
Fat Clay Residuum	120	300	20	0	33
Soft Fat Clay Residuum	120	200	10	0	25
Bedrock	150	50,000	50	50,000	50

Based on the test boring results, bedrock was modeled at an elevation of about 551 feet for both walls. Groundwater was modelled at an elevation of 571.5 feet for the west wall and 556.7 feet for the east wall, based on the boring results.

In accordance with AASHTO guidelines, the global stability of selected cross sections were analyzed for undrained (total stress) and drained (effective stress) conditions. Stability of a selected cross-section was assessed using a two-dimensional limit equilibrium modeling technique which simplifies the failure or "slip" surfaces by dividing the slope into vertical "slices" and fitting line segments or arcs of various radii and centers, or plane slip surfaces, to the slope. Various surfaces are then checked to determine the slip surface with the smallest ratio of resisting forces (soil strength) to driving forces (mass of the soil and water, traffic loading, and horizontal seismic force). The ratio of the resisting forces divided by the summation of the driving forces acting on the slices is the factor of safety for the slope section analyzed. The computer program SLIDE 2018 was used to perform the analyses. We used the Bishop Simplified and Spencer methods to evaluate the stability of the analyzed cross-sections. The resulting safety factors are provided in Table 6-4.

Table 6-4: Global Stability Analyses Results

Abutment Location	Approximate Depth of Retained Soil at Back Face of Wall (feet)	Top of Foundation Embedment Depth (feet)	Estimated Factor of Safety	
			Total Stress	Effective Stress
West Abutment	31	2	1.3	1.3
East Abutment	28	2	1.4	1.3

A safety factor of 1.3 or greater is required by AASHTO and FHWA. Our analyses included a 4-foot interval of ALDOT Underwater Embankment stone as previously described below the wall facing and reinforced wall zone. The results of our global wall slope stability analyses are included in Appendix IV.

6.2.4 Retaining Wall External Stability

The external stability of the wall in sliding, overturning, and bearing capacity was also evaluated in general accordance with the Eighth Edition of the AASHTO LRFD Bridge Design Manual. The analyses for external stability analyses are provided in Appendix III.

The analyses for external stability were performed assuming undercut and replacement of the bearing soils in the retaining wall footprint as recommended in Section 6.2.4 of this report. Our analyses assumed a strap density of 7 percent and strap lengths of 70 percent of the total wall height, including embedment. The capacity demand ratios (CDR) for the external stability of the wall are provided in Table 6-2. The CDR values represent the ratio of the factored resistance to the factored loads in the stability analyses. A CDR value greater than 1 indicates that the LRFD stability evaluation has been satisfied.

Table 6-5: Retaining Wall CDR Values for Stability

MSE Wall Height (ft)	Height Behind Abutment (ft)	Total Wall Height (ft)	Reinforcement Length (ft)	CDR Sliding	CDR Eccentricity	CDR Bearing
10	10	20	17	1.03	1.57	12.01
15	10	25	18	1.03	1.20	6.50
20	10	30	22	1.21	1.44	4.21

6.2.5 Settlement

Consolidation testing was performed on undisturbed samples collected in residual soils from borings drilled for each abutment. The test data was used to estimate settlement of residual soils below a four-foot interval of ALDOT Underwater Embankment. Our analyses indicate about 3 inches of total settlement should be expected in the center of the wall. The analyses results also indicate about one inch of differential settlement should be expected from the center of the wall to the ends of the wall. It is anticipated that approximately 90 percent of the settlement should occur about 45 days after construction. Based on time rate and amount of settlement, the effects of downdrag are within the acceptable range.

In order to limit the effects of downdrag on the abutment foundations, we recommend undercutting 4 feet beneath the MSE wall backfill. The removed material should be replaced with compacted crushed aggregate. If undercut and replacement is performed at the abutment, settlement of the retaining wall backfill will be on the order of 0.4 inches or less.

6.2.6 Other Design Requirements

A minimum top of foundation embedment depth of 2 feet below the ground surface at the front face of the wall will be required to satisfy FHWA minimum wall embedment depth requirements and for global stability. The foundation embedment depth should be increased as needed to maintain a minimum embedment of 2 feet below the point where a 4-foot-wide horizontal bench, as measured from the wall face, is provided in front of the wall. The bench may be graded, or the slope continued above the bench level.

Drainage of the retaining wall backfill should be provided with a drainage pipe along the inside corner of the wall and foundation at the base of the free draining backfill material. The backfill materials for use in the reinforced zone should consist of ASTM D448 No. 57 stone. The No. 57 stone should extend from the retaining wall facing to at least one foot beyond the length of the reinforcement strips or grid.

6.2.7 Alternate Retaining Wall Systems

Because the retaining wall will be used for the retention of soil fill, a gravity retaining wall system, such as an MSE wall or concrete cantilever wall, is typically used. Due to the height requirement and geometry requirements of the abutment foundations, we do not anticipate a concrete cantilever wall will be a feasible alternative.

6.3 Corrosion

Soil samples were collected at the project site and returned to our laboratory for resistivity, pH, sulfate, and chloride testing. Based on the results of these tests, the subsurface environment is considered to be non-aggressive. Class A concrete is recommended for the substructure foundations, and DS-1 concrete can be used for drilled shaft foundations.

6.4 Scour

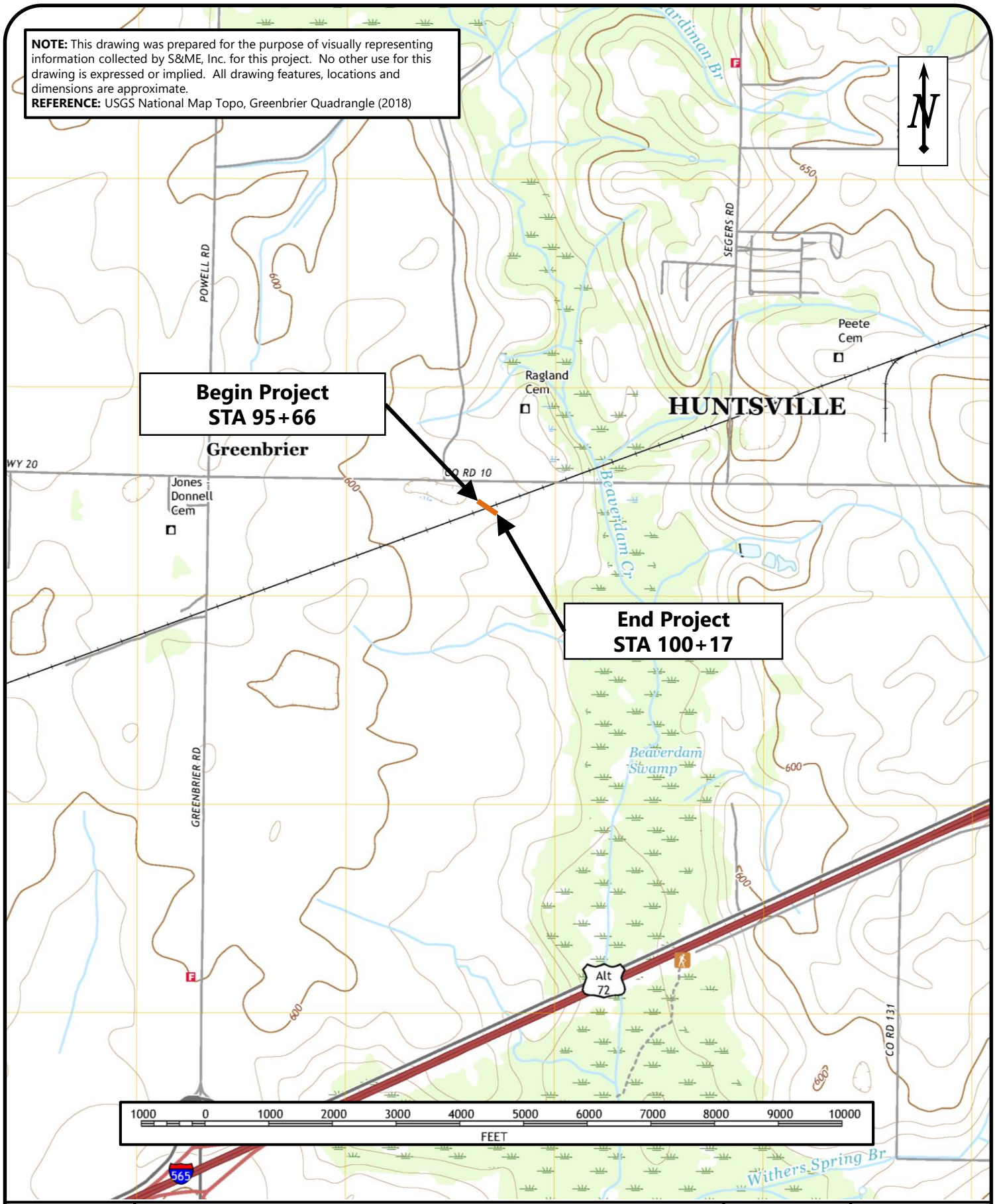
A formal scour analysis was not conducted for this project.

7.0 Plan Notes

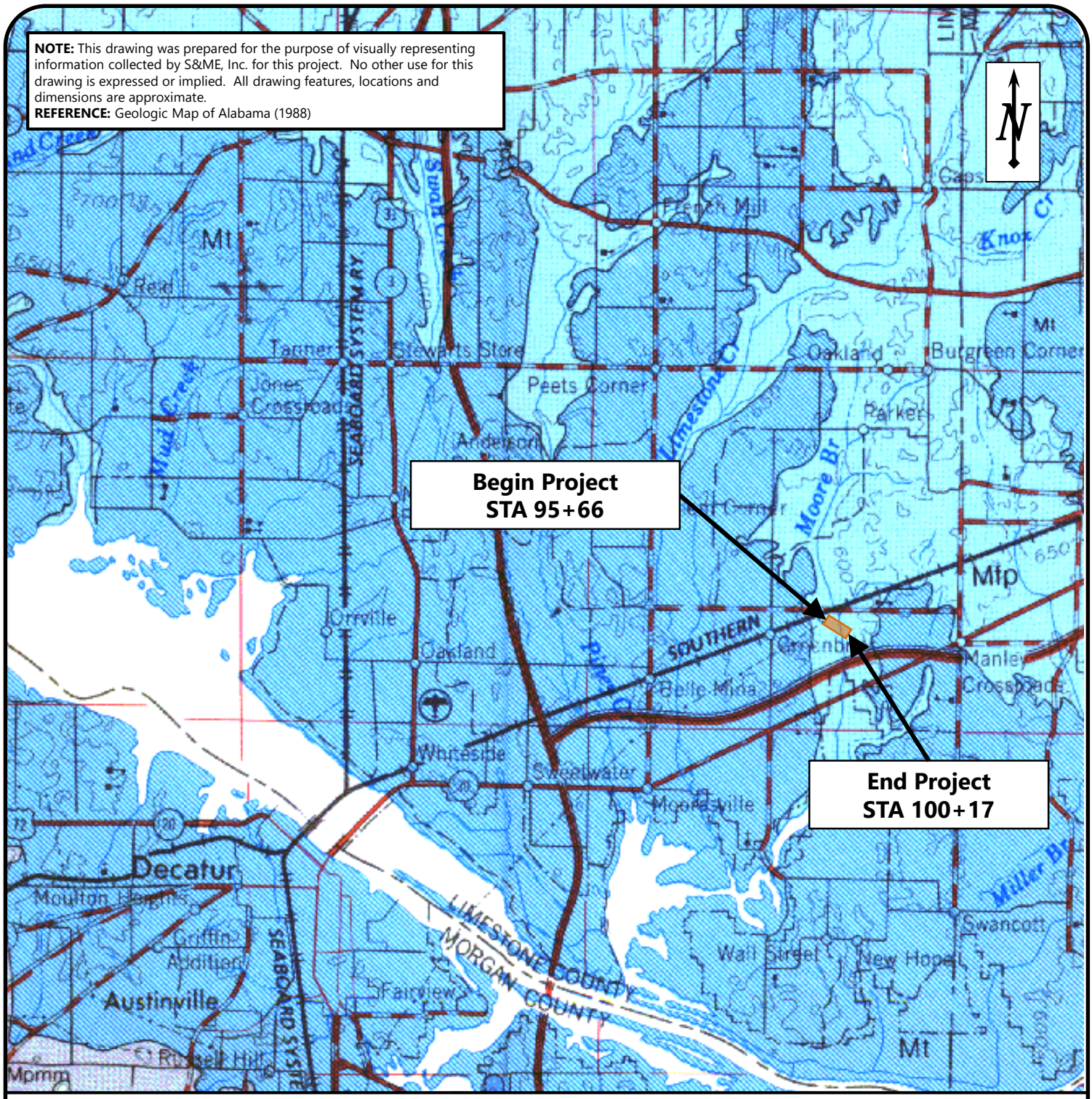
S&ME, Inc. recommends that the design include a note advising potential contractors of the existence of a Foundation Report and soil borings pertaining to this project. Access to the report and soil borings can be arranged by contacting Garver.

Appendices

Appendix I – Figures



	TOPOGRAPHIC MAP **Foundation Report** Bridge on Old SR 20 over NS Railroad Garver Huntsville, Limestone County, Alabama	SCALE: As Shown DATE: 7/2/2019 PROJECT NUMBER 3282-19-054	FIGURE NO. **I-1**



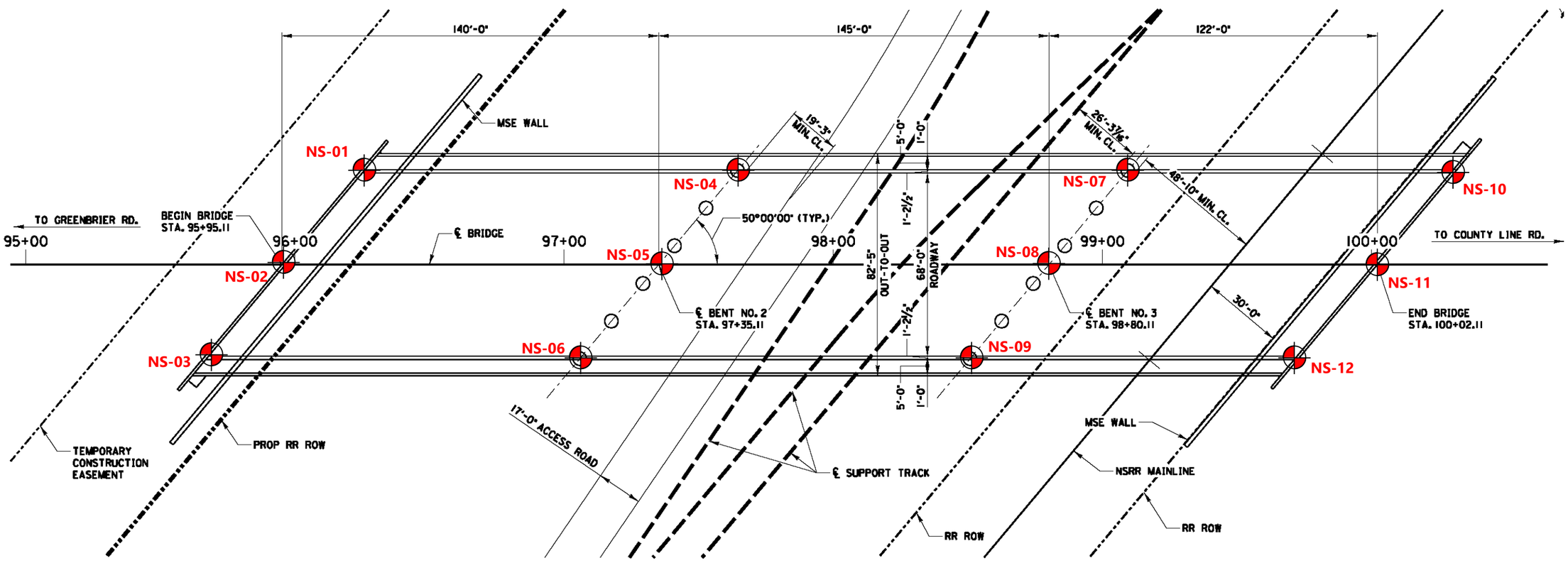
LEGEND

Mt – Tuscumbia Limestone

Mfp – Fort Payne Chert

	GEOLOGIC MAP **Foundation Report** Bridge on Old SR 20 over NS Railroad Garver Huntsville, Limestone County, Alabama	SCALE: Not to scale DATE: 7/2/2019 PROJECT NUMBER 3282-19-054	FIGURE NO. **I-2**

Appendix II – Field Exploration

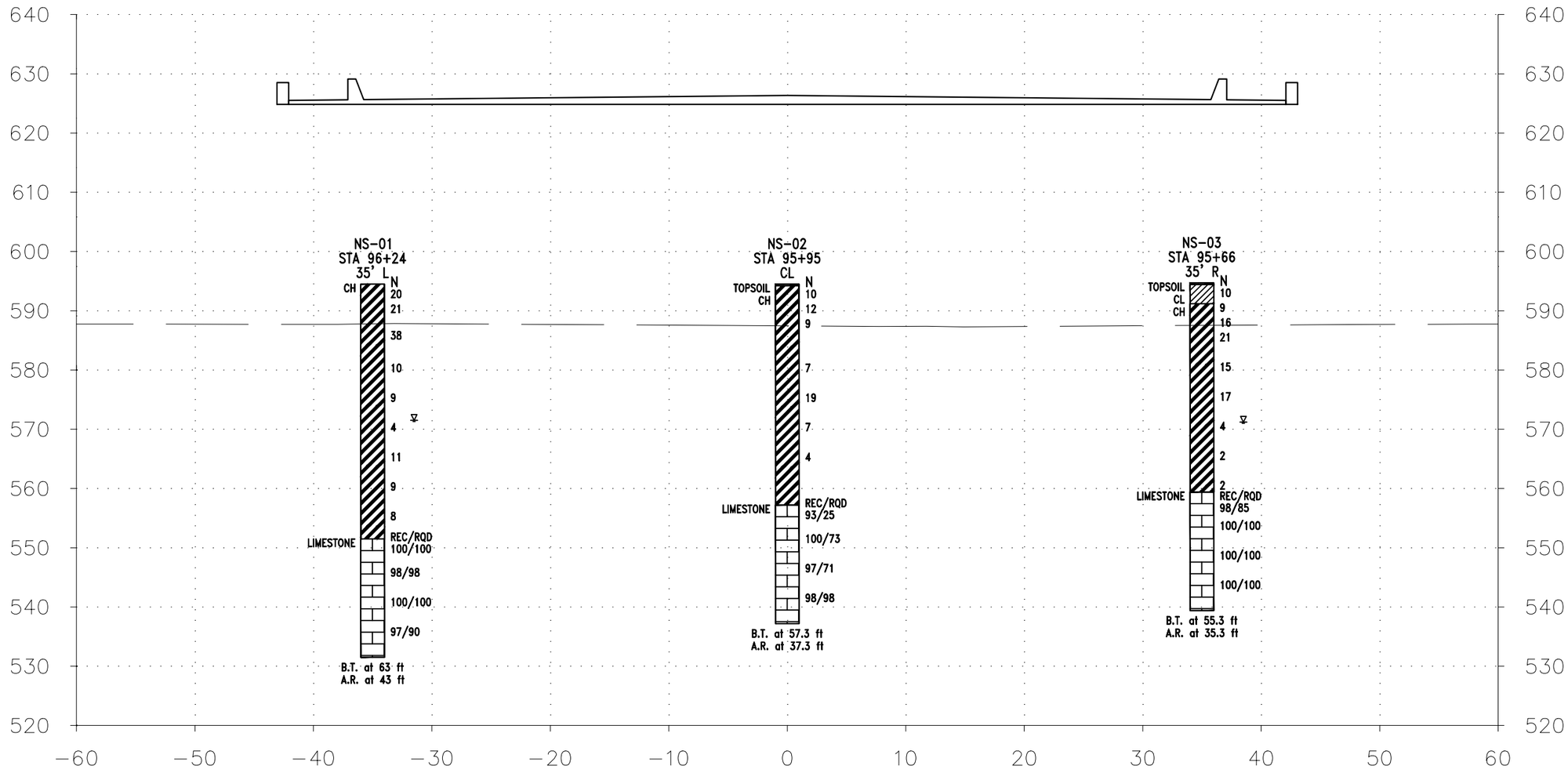


REFERENCE:
"General Plan and Elevation", Bridge on Old SR 20
Over NS Railroad, by Garver, 05/18.

TEST BORING LOCATION PLAN

Bridge on Old SR 20 over NS Railroad
Garver
Huntsville, Limestone County, Alabama

SCALE:	As Shown
DATE:	6/18/2019
PROJECT NUMBER	3282-19-054
FIGURE NO.	II-1



LEGEND

N - is penetration in blows per foot (ASTM D-1586)

REC - Core recovery in percent
RQD - Rock quality designation

S - Symbols described below

Split Spoon Sampling
Rock Core Sample (ASTM D-2113)
Water Table, time of boring
Water Table, delayed reading
Loss of drilling fluid

B.T.: Boring Terminated
A.R.: Auger Refusal

Existing Grade

Topsoil
Lean Clay
Fat Clay
Clayey Gravel
Limestone

0 2.5 5 7.5 10 15 20
HORIZONTAL: 1 inch = 10 feet

0 5 10 15 20 30 40
VERTICAL: 1 inch = 20eet

CROSS SECTION (West Abutment)
Foundation Report

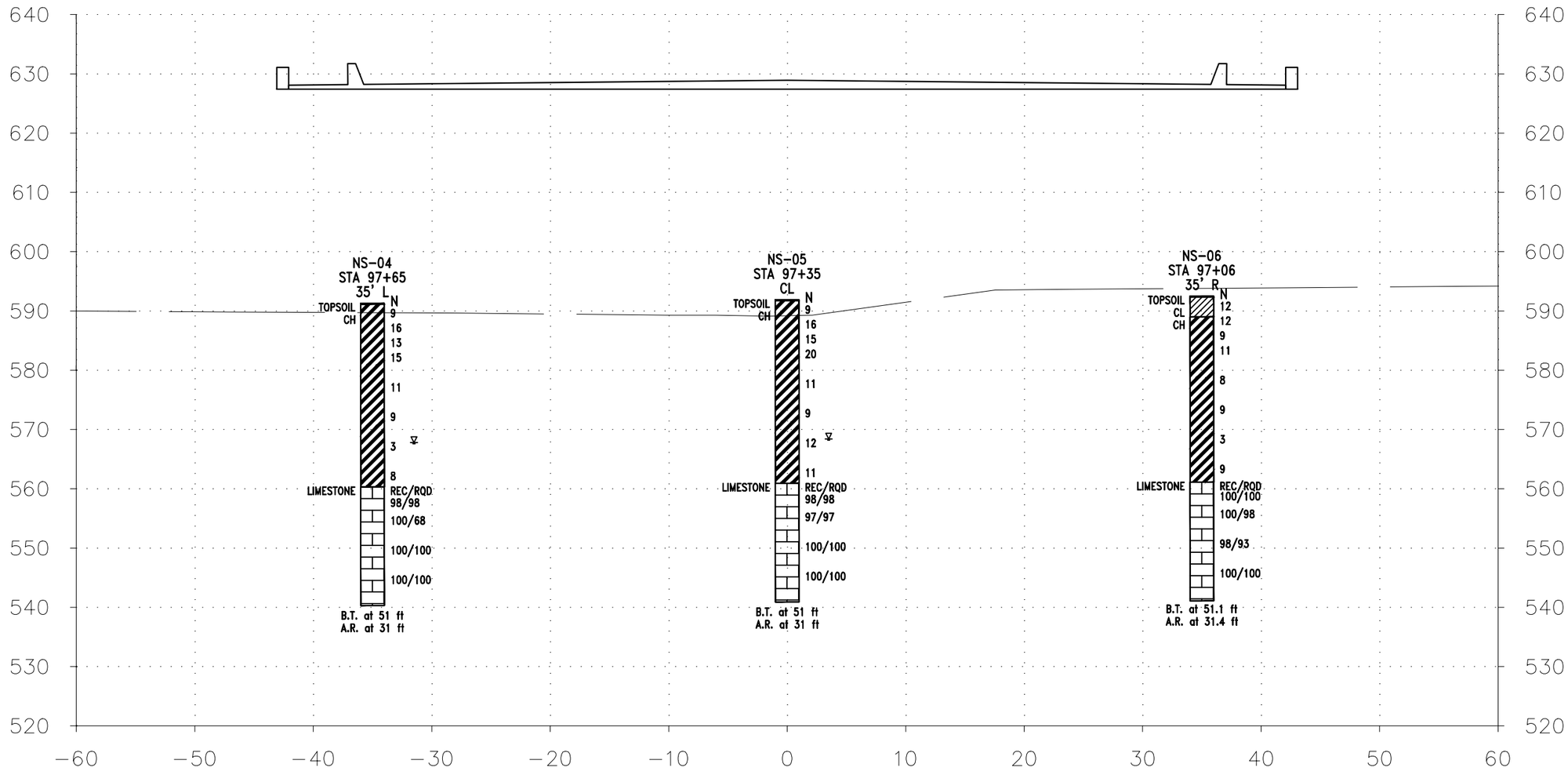
Old Highway 20 Bridge Over NS Railroad
Garver
Huntsville, Limestone County, Alabama

SCALE:
As shown

DATE:
2/24/2020

PROJECT NUMBER
3282-19-054

FIGURE NO.
II-2



LEGEND

N - is penetration in blows per foot (ASTM D-1586)

REC - Core recovery in percent
RQD - Rock quality designation

S - Symbols described below

Split Spoon Sampling

Rock Core Sample (ASTM D-2113)

Water Table, time of boring

Water Table, delayed reading

Loss of drilling fluid

B.T.: Boring Terminated
A.R.: Auger Refusal

Existing Grade

Topsoil

Lean Clay

Fat Clay

Clayey Gravel

Limestone

0 2.5 5 7.5 10 15 20
HORIZONTAL: 1 inch = 10 feet

40 30 20 15 10 5 0
VERTICAL: 1 inch = 20feet

CROSS SECTION (Bent No. 2)
Foundation Report

Old Highway 20 Bridge Over NS Railroad
Garver
Huntsville, Limestone County, Alabama

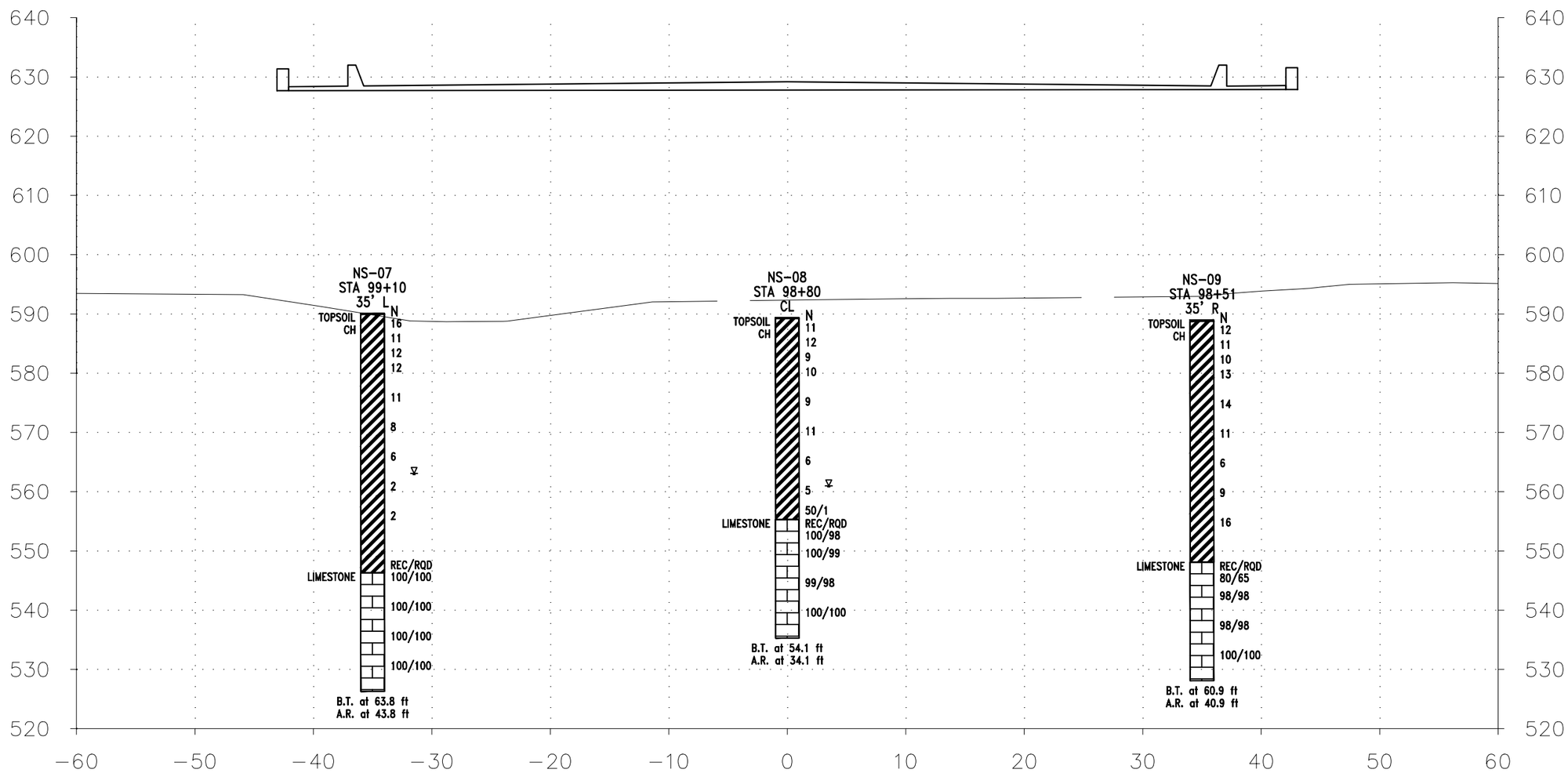
SCALE:
As shown

DATE:
2/24/2020

PROJECT NUMBER
3282-19-054

FIGURE NO.

II-3



LEGEND

N - is penetration in blows per foot (ASTM D-1586)

REC - Core recovery in percent
RQD - Rock quality designation

S - Symbols described below

Split Spoon Sampling
Rock Core Sample (ASTM D-2113)
Water Table, time of boring
Water Table, delayed reading
Loss of drilling fluid

B.T.: Boring Terminated
A.R.: Auger Refusal

Existing Grade

Topsoil
Lean Clay
Fat Clay
Clayey Gravel
Limestone

HORIZONTAL: 1 inch = 10 feet

VERTICAL: 1 inch = 20eet

CROSS SECTION (Bent No. 3)
Foundation Report

Old Highway 20 Bridge Over NS Railroad
Garver
Huntsville, Limestone County, Alabama

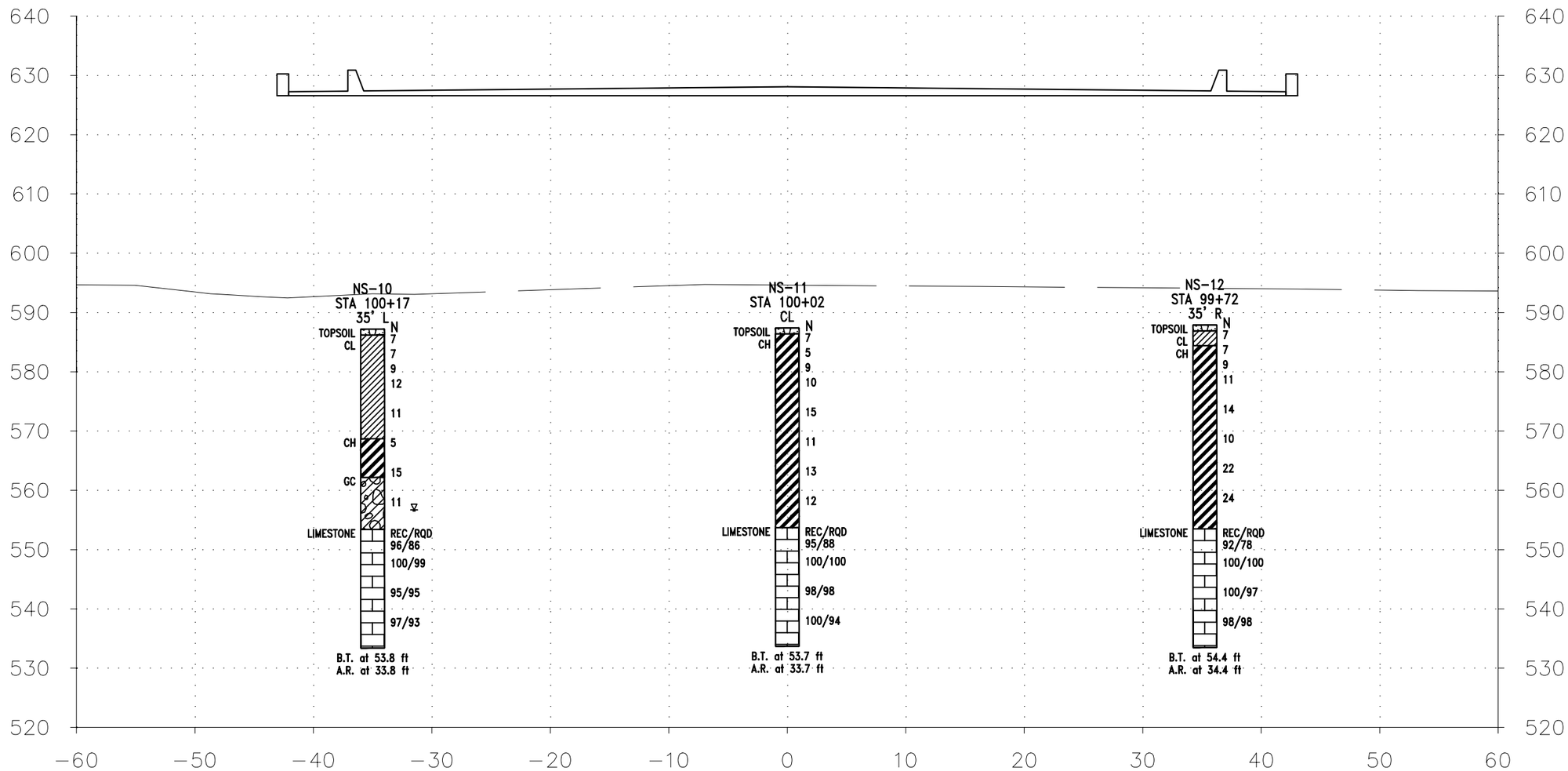
SCALE:
As shown

DATE:
2/24/2020

PROJECT NUMBER
3282-19-054

FIGURE NO.

II-4



LEGEND

N - is penetration in blows per foot (ASTM D-1586)

5 REC - Core recovery in percent
RQD - Rock quality designation

S - Symbols described below

18 70 NX Split Spoon Sampling
Rock Core Sample (ASTM D-2113)
100 BX Water Table, time of boring
23 Water Table, delayed reading
Loss of drilling fluid

B.T.: Boring Terminated
A.R.: Auger Refusal

Existing Grade

Topsoil
Lean Clay
Fat Clay
Clayey Gravel
Limestone

0 2.5 5 7.5 10 15 20
HORIZONTAL: 1 inch = 10 feet

40 30 20 15 10 5 0
VERTICAL: 1 inch = 20eet

CROSS SECTION (East Abutment)F
oundation Report

Old Highway 20 Bridge Over NS Railroad
Garver
Huntsville, Limestone County, Alabama

SCALE:
As shown

DATE:
2/24/2020

PROJECT NUMBER
3282-19-054

FIGURE NO.

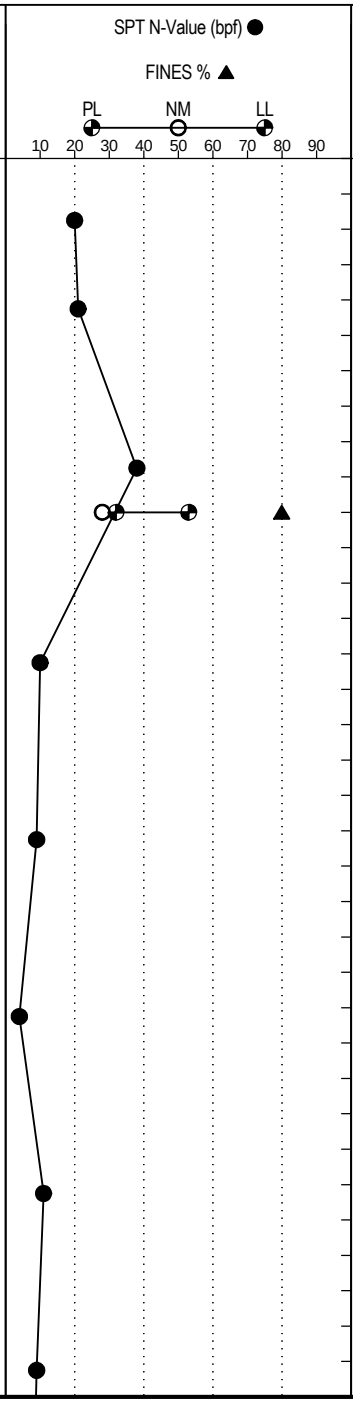
II-5

PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-01**

CLIENT: **Garver**	ELEVATION: **594.5 ft**	NOTES:	
DATE DRILLED: **7/16/19 - 7/16/19**	BORING DEPTH: **63.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518451.778**	EASTING: **356822.4**
SAMPLING METHOD: **Fixed Head Sample, Rock Core, Split spoon**		STATION: **96+24**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 3 INCHES							
	FAT CLAY (CH) with black oxides, red brown, very stiff to hard, moist RESIDUUM		SS-1		6	10	10	20
5		589.5	SS-2		6	9	12	21
			SS-3		3	3	35	38
10		584.5	UD-1			100%		
15	- - - With abundant black oxides, yellow-red with yellow mottling, stiff	579.5	SS-4		4	4	6	10
20		574.5	SS-5		4	5	4	9
25	- - - With abundant chert, yellow-red, soft, very moist	569.5	SS-6		6	2	2	4
30	- - - With black oxides and yellow mottling, stiff to firm	564.5	SS-7		5	6	5	11
			SS-8		4	5	4	9



WATER LEVEL

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

NOTES:

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3. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-01**

CLIENT: **Garver**	ELEVATION: **594.5 ft**	NOTES:	
DATE DRILLED: **7/16/19 - 7/16/19**	BORING DEPTH: **63.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518451.778**	EASTING: **356822.4**
SAMPLING METHOD: **Fixed Head Sample, Rock Core, Split spoon**		STATION: **96+24**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ (PL NM LL; 10 20 30 40 50 60 70 80 90)	N VALUE
		FAT CLAY (CH) with black oxides and yellow mottling RESIDUUM *(continued)*									
40				554.5	SS-9		5	3	5		8
		LIMESTONE, light gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality									
45				549.5	RC-1			100%	100%		
50				544.5	RC-2			98%	98%		
55				539.5	RC-3			100%	100%		
60		- - - With chert inclusions		534.5	RC-4			97%	90%		
		Refusal at 43 feet Boring terminated at 63 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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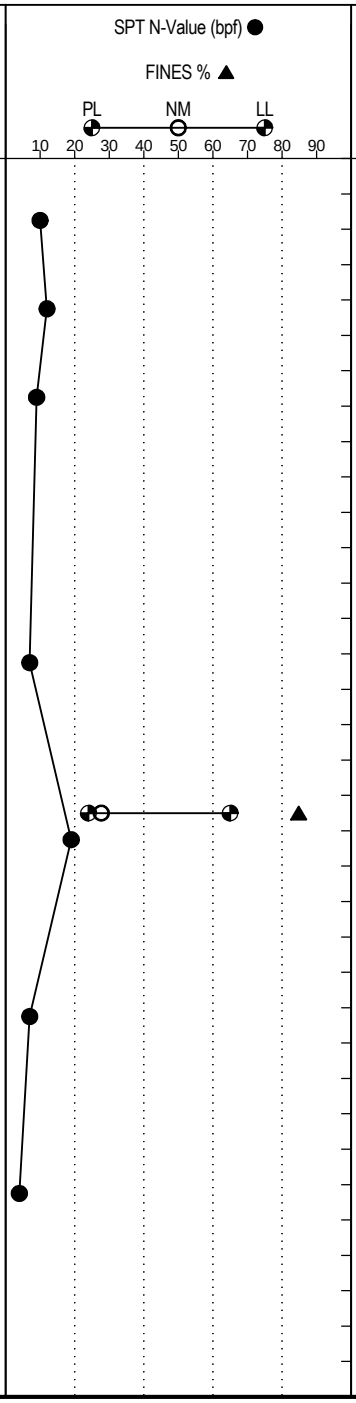
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-02**

CLIENT: **Garver**	ELEVATION: **594.5 ft**	NOTES:	
DATE DRILLED: **7/17/19 - 7/17/19**	BORING DEPTH: **57.3 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518435.941**	EASTING: **356781.091**
SAMPLING METHOD: **Fixed Head Sample, Rock Core, Split spoon**		STATION: **95+95**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 3 INCHES							
	FAT CLAY (CH), brown and red, stiff, moist RESIDUUM		SS-1		4	4	6	10
	- - - With black oxides		SS-2		4	4	8	12
5		589.5						
	- - - With chert and yellow mottling		SS-3		3	4	5	9
10		584.5	UD-1			100%		
	- - - Yellow, red, firm		SS-4		3	3	4	7
15		579.5						
	- - - With chert, very stiff		SS-5		5	7	12	19
20		574.5						
	- - - With abundant chert, firm, very moist		SS-6		4	3	4	7
25		569.5						
	- - - Brown, soft		SS-7		2	1	3	4
30		564.5						



S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-02

CLIENT: **Garver**	ELEVATION: **594.5 ft**	NOTES:	
DATE DRILLED: **7/17/19 - 7/17/19**	BORING DEPTH: **57.3 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518435.941**	EASTING: **356781.091**
SAMPLING METHOD: **Fixed Head Sample, Rock Core, Split spoon**		STATION: **95+95**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		FAT CLAY (CH), brown, soft , moist RESIDUUM *(continued)*									
		LIMESTONE, fractured, light gray, fine grained, thickly bedded, weathered, hard, excellent recovery, poor quality									
40				554.5	RC-1			93%	25%		
		- - - Fair quality									
45				549.5	RC-2			100%	73%		
50				544.5	RC-3			97%	71%		
		- - - With chert inclusions, unweathered, excellent quality									
55				539.5	RC-4			98%	98%		
		Refusal at 37.3 feet Boring terminated at 57.3 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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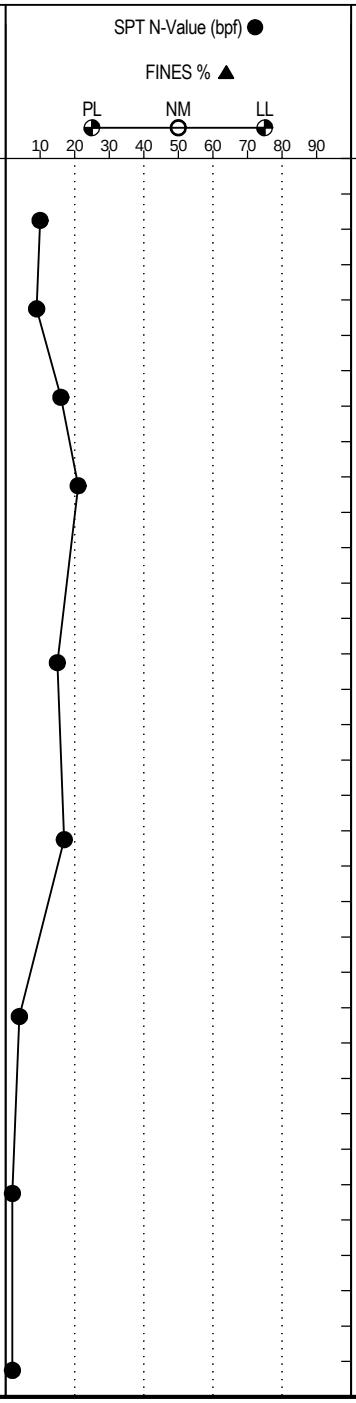
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-03**

CLIENT: **Garver**	ELEVATION: **594.7 ft**	NOTES:	
DATE DRILLED: **7/18/19 - 7/18/19**	BORING DEPTH: **55.3 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518421.279**	EASTING: **356737.255**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **95+66**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 3 INCHES							
	LEAN CLAY (CL) brown, stiff, very moist RESIDUUM		SS-1		2	4	6	10
5	FAT CLAY (CH) with black oxides, red, stiff to very stiff, moist	589.7	SS-2		3	4	5	9
	- - - With yellow mottling		SS-3		4	6	10	16
10		584.7	SS-4		4	9	12	21
15	- - - With chert, abundant yellow mottling, stiff	579.7	SS-5		4	7	8	15
20	- - - With abundant chert, very stiff	574.7	SS-6		5	9	8	17
25	- - - Soft, wet	569.7	SS-7		3	2	2	4
30	- - - With chert, brown, very moist	564.7	SS-8		1	1	1	2
	- - - With abundant chert and yellow mottling		SS-9		0	0	2	2



WATER LEVEL

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-03**

CLIENT: **Garver**	ELEVATION: **594.7 ft**	NOTES:	
DATE DRILLED: **7/18/19 - 7/18/19**	BORING DEPTH: **55.3 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518421.279**	EASTING: **356737.255**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **95+66**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		LIMESTONE, slightly weathered, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, weathered, hard, excellent recovery, good quality			RC-1			98%	85%		
40				554.7							
		- - - Unweathered, excellent quality			RC-2			100%	100%		
45				549.7							
					RC-3			100%	100%		
50				544.7							
					RC-4			100%	100%		
55				539.7							
		Refusal at 35.3 feet Boring terminated at 55.3 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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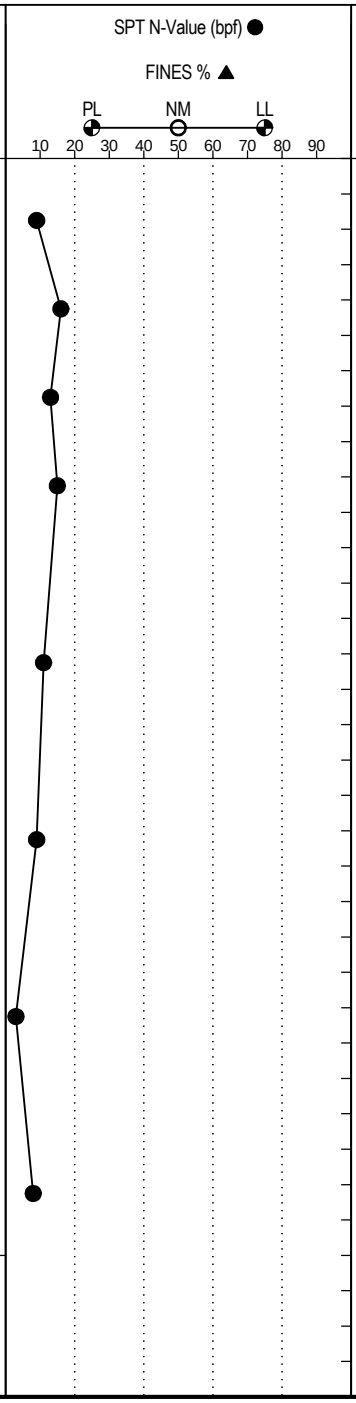
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-04**

CLIENT: **Garver**	ELEVATION: **591.3 ft**	NOTES:	
DATE DRILLED: **7/19/19 - 7/19/19**	BORING DEPTH: **51.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518482.129**	EASTING: **356634.021**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+65**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 2 INCHES							
	FAT CLAY (CH), red and brown, stiff to very stiff, moist RESIDUUM		SS-1		3	4	5	9
	- - - With black oxides, brown	586.3	SS-2		4	7	9	16
5	- - - Stiff		SS-3		4	6	7	13
	- - - With chert and yellow mottling	581.3	SS-4		4	7	8	15
10								
	- - - With sandy chert, yellow-red	576.3	SS-5		2	5	6	11
15								
	- - - Red with yellow mottling	571.3	SS-6		2	4	5	9
20								
	- - - With chert, red, brown and yellow, soft, wet	566.3	SS-7		2	1	2	3
25								
	- - - With abundant chert, brown, firm	561.3	SS-8		2	3	5	8
30								
	LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, slightly weathered, hard, excellent recovery, excellent to fair quality		RC-1			98%	98%	

WATER LEVEL ▽



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S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-04**

CLIENT: **Garver**	ELEVATION: **591.3 ft**	NOTES:	
DATE DRILLED: **7/19/19 - 7/19/19**	BORING DEPTH: **51.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518482.129**	EASTING: **356634.021**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+65**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, slightly weathered, hard, excellent recovery, excellent to fair quality *(continued)*									
		- - - Weathered, fair quality			RC-2			100%	68%		
40				551.3							
		- - - Unweathered, excellent quality									
					RC-3			100%	100%		
45				546.3							
					RC-4			100%	100%		
50				541.3							
		Refusal at 31 feet Boring terminated at 51 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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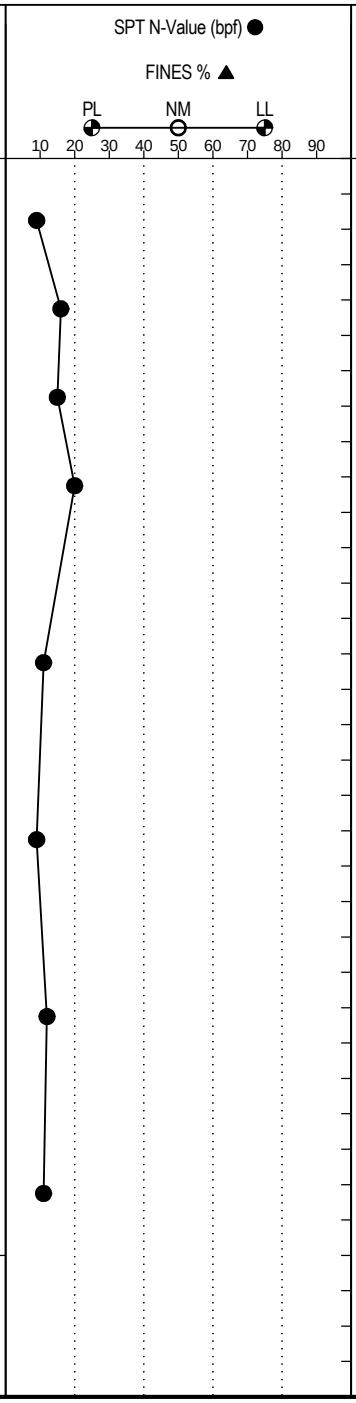
PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-05

CLIENT: **Garver**	ELEVATION: **591.9 ft**	NOTES:	
DATE DRILLED: **7/22/19 - 7/22/19**	BORING DEPTH: **51.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518498.293**	EASTING: **356676.164**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+35**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 2 INCHES							
	FAT CLAY (CH) with black oxides, red, stiff to very stiff, moist RESIDUUM		SS-1		2	4	5	9
	- - - With yellow mottling		SS-2		3	6	10	16
5		586.9						
	- - - With black oxides and sandy chert, red		SS-3		4	6	9	15
			SS-4		5	8	12	20
10		581.9						
	- - - With sandy chert, yellow-red, stiff		SS-5		4	4	7	11
15		576.9						
			SS-6		4	4	5	9
20		571.9						
	- - - With abundant chert, wet		SS-7		3	4	8	12
25		566.9						
	- - - With abundant chert, brown		SS-8		5	5	6	11
30		561.9						
	LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality		RC-1			98%	98%	



WATER LEVEL

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-05**

CLIENT: **Garver**	ELEVATION: **591.9 ft**	NOTES:	
DATE DRILLED: **7/22/19 - 7/22/19**	BORING DEPTH: **51.0 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **23.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518498.293**	EASTING: **356676.164**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+35**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality *(continued)*									
					RC-2			97%	97%		
40				551.9							
					RC-3			100%	100%		
45				546.9							
					RC-4			100%	100%		
50				541.9							
		Refusal at 31 feet Boring terminated at 51 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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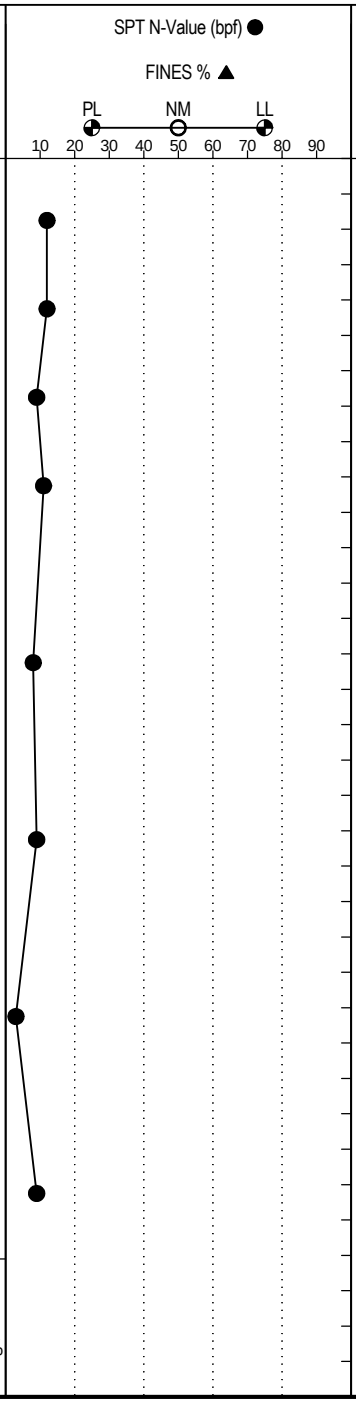
PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-06

CLIENT: **Garver**	ELEVATION: **592.5 ft**	NOTES:	
DATE DRILLED: **7/23/19 - 7/23/19**	BORING DEPTH: **51.1 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518513.75**	EASTING: **356718.653**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+06**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 2 INCHES							
	LEAN CLAY (CL) red and brown, stiff, moist RESIDUUM		SS-1		4	4	8	12
5	FAT CLAY (CH) with black oxides, dark red, yellow mottling, stiff, moist	587.5	SS-2		4	5	7	12
			SS-3		4	4	5	9
10		582.5	SS-4		4	6	5	11
15	- - - With sandy chert, red, firm	577.5	SS-5		3	3	5	8
20	- - - With yellow mottling, stiff	572.5	SS-6		3	4	5	9
25	- - - With chert, brown, soft, very moist	567.5	SS-7		2	1	2	3
30	- - - Stiff	562.5	SS-8		4	4	5	9
	LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality		RC-1			100%	100%	



WATER LEVEL

GRAPHIC LOG

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

NOTES:

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3. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-06

CLIENT: **Garver**	ELEVATION: **592.5 ft**	NOTES:	
DATE DRILLED: **7/23/19 - 7/23/19**	BORING DEPTH: **51.1 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518513.75**	EASTING: **356718.653**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **97+06**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality *(continued)*									
					RC-2			100%	98%		
40				552.5							
					RC-3			98%	93%		
45				547.5							
					RC-4			100%	100%		
50				542.5							
		Refusal at 31.4 feet Boring terminated at 51.1 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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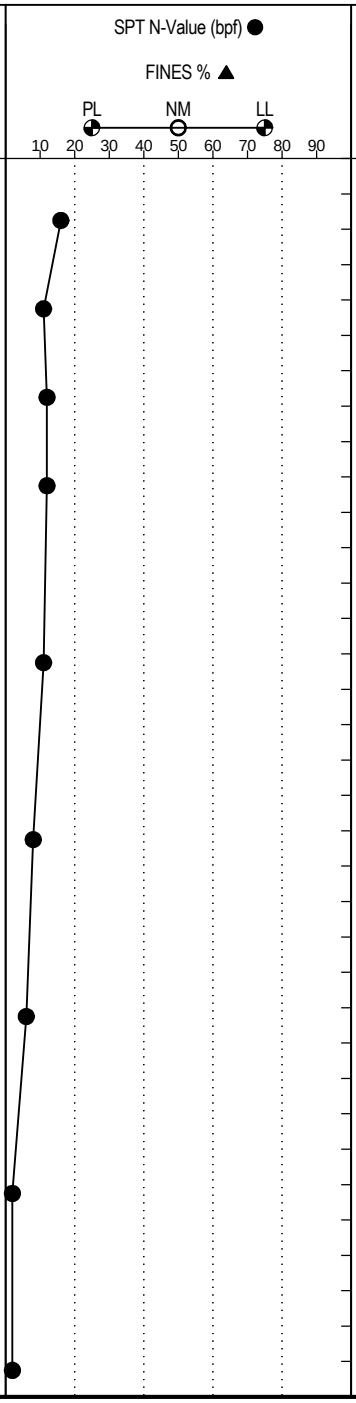
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-07**

CLIENT: **Garver**	ELEVATION: **590.1 ft**	NOTES:	
DATE DRILLED: **7/12/19 - 7/12/19**	BORING DEPTH: **63.8 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **27 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518586.993**	EASTING: **356594.084**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **99+10**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 2 INCHES							
	FAT CLAY (CH) with black oxides, red, very stiff, moist RESIDUUM		SS-1		6	8	8	16
	- - - Stiff	585.1	SS-2		4	5	6	11
5			SS-3		3	5	7	12
10		580.1	SS-4		5	7	5	12
15	- - - With yellow mottling	575.1	SS-5		3	5	6	11
20	- - - Firm	570.1	SS-6		3	3	5	8
25	- - - Sandy with chert, yellow-red	565.1	SS-7		4	3	3	6
30	- - - With chert, brown, soft	560.1	SS-8		0	0	2	2
	- - - Red and brown		SS-9		2	1	1	2



WATER LEVEL

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S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-07**

CLIENT: **Garver**	ELEVATION: **590.1 ft**	NOTES:	
DATE DRILLED: **7/12/19 - 7/12/19**	BORING DEPTH: **63.8 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **27 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518586.993**	EASTING: **356594.084**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **99+10**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL 10 20 30 40 50 60 70 80 90	N VALUE
		FAT CLAY (CH) red and brown RESIDUUM *(continued)*									
40				550.1							
45		LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality		545.1	RC-1			100%	100%		
50				540.1	RC-2			100%	100%		
55				535.1	RC-3			100%	100%		
60				530.1	RC-4			100%	100%		
		Refusal at 43.8 feet Boring terminated at 63.8 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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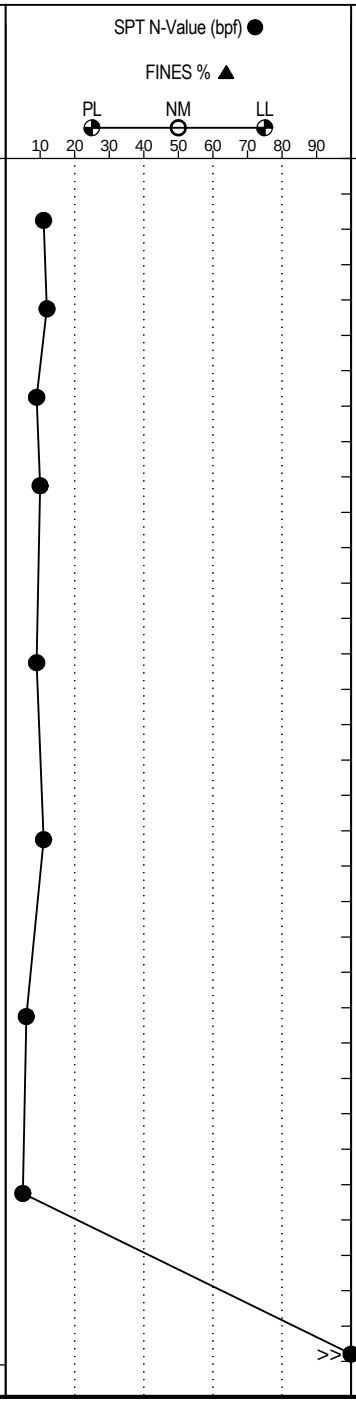
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-08**

CLIENT: **Garver**	ELEVATION: **589.4 ft**	NOTES:	
DATE DRILLED: **7/15/19 - 7/15/19**	BORING DEPTH: **54.1 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **28.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518570.746**	EASTING: **356552.272**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **98+80**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	TOPSOIL - 2 INCHES							
	FAT CLAY (CH) with black oxides, red, stiff, moist RESIDUUM		SS-1		6	6	5	11
5		584.4	SS-2		6	5	7	12
			SS-3		4	4	5	9
10		579.4	SS-4		4	5	5	10
15	- - - With weathered chert	574.4	SS-5		3	4	5	9
20	- - - With yellow mottling	569.4	SS-6		4	6	5	11
25	- - - With black oxides and chert, firm	564.4	SS-7		4	3	3	6
30	- - - With abundant chert, brown	559.4	SS-8		3	2	3	5
	- - - Hard		SS-9		36	50/1		>> 50/1



S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-08

CLIENT: **Garver**	ELEVATION: **589.4 ft**	NOTES:	
DATE DRILLED: **7/15/19 - 7/15/19**	BORING DEPTH: **54.1 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **28.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518570.746**	EASTING: **356552.272**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **98+80**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL 10 20 30 40 50 60 70 80 90	N VALUE
		LIMESTONE, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, excellent quality *(continued)*			RC-1			100%	98%		
40				549.4	RC-2			100%	99%		
45				544.4	RC-3			99%	98%		
50				539.4	RC-4			100%	100%		
		Refusal at 34.1 feet Boring terminated at 54.1 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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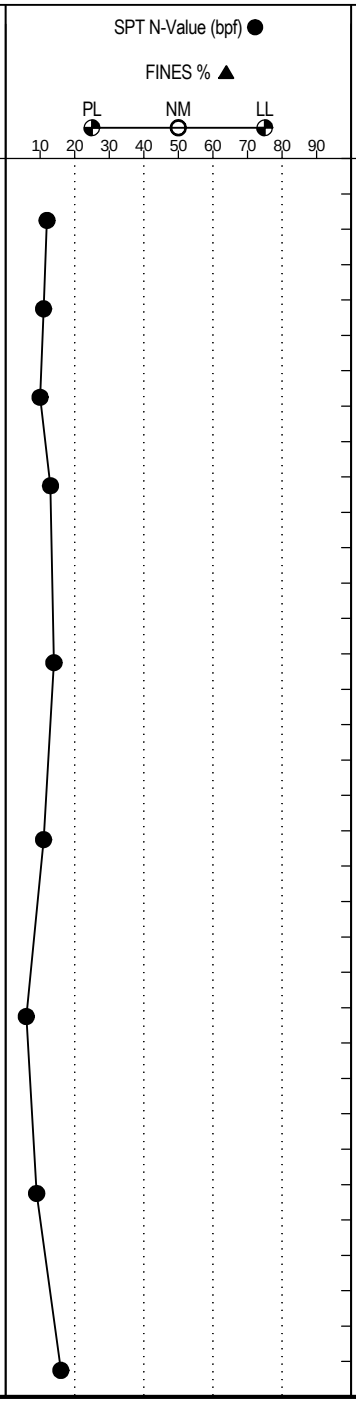
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-09**

CLIENT: **Garver**	ELEVATION: **589.0 ft**	NOTES:	
DATE DRILLED: **7/24/19 - 7/24/19**	BORING DEPTH: **60.9 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518555.638**	EASTING: **356508.952**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **98+51**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
		TOPSOIL - 3 INCHES								
		FAT CLAY (CH) with black oxides, red, stiff, moist RESIDUUM			SS-1		3	5	7	12
					SS-2		3	5	6	11
5				584.0	SS-3		4	4	6	10
					SS-5		4	5	8	13
10				579.0						
		- - - With abundant chert, yellow-red			SS-6		5	6	8	14
15				574.0						
		- - - With yellow mottling			SS-7		5	5	6	11
20				569.0						
		- - - Firm			SS-8		3	2	4	6
25				564.0						
		- - - With chert, brown and red, stiff			SS-9		1	4	5	9
30				559.0						
		- - - Very stiff			SS-10		1	2	14	16



S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-09

CLIENT: **Garver**	ELEVATION: **589.0 ft**	NOTES:	
DATE DRILLED: **7/24/19 - 7/24/19**	BORING DEPTH: **60.9 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518555.638**	EASTING: **356508.952**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **98+51**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL (10 20 30 40 50 60 70 80 90)	N VALUE
		FAT CLAY (CH) with chert, brown and red RESIDUUM *(continued)*									
40				549.0							
		LIMESTONE, light gray and dark gray, fine grained, thickly bedded, slightly weathered to unweathered, hard, good recovery, fair quality			RC-1			80%	65%		
45				544.0							
		- - - Excellent recovery, excellent quality			RC-2			98%	98%		
50				539.0							
					RC-3			98%	98%		
55				534.0							
					RC-4			100%	100%		
60				529.0							
		Refusal at 40.9 feet Boring terminated at 60.9 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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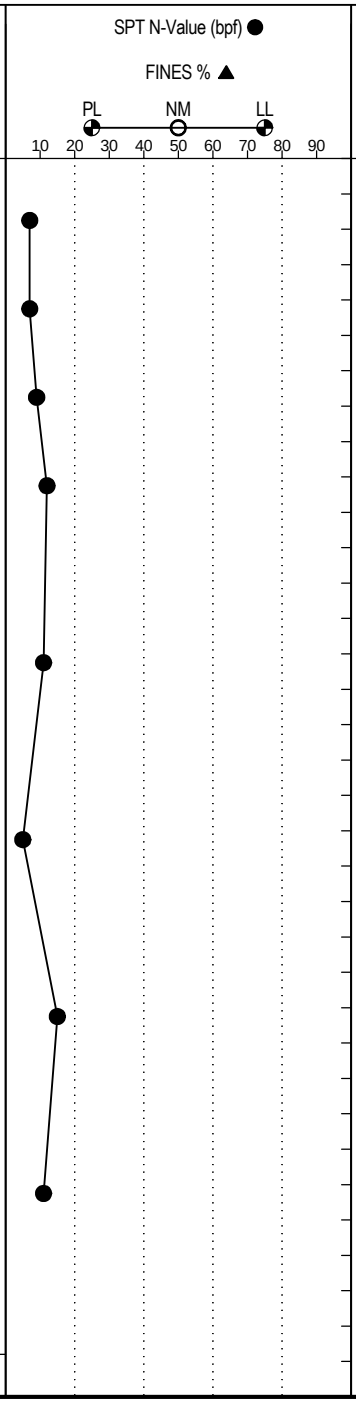
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-10**

CLIENT: **Garver**	ELEVATION: **587.2 ft**	NOTES:	
DATE DRILLED: **7/8/19 - 7/8/19**	BORING DEPTH: **53.8 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **30.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518626.108**	EASTING: **356391.47**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **100+17**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	CULTIVATED ZONE - 12 INCHES							
	LEAN CLAY (CL) with black oxides, dark red, firm to stiff, moist — RESIDUUM		SS-1		4	3	4	7
5		582.2	SS-2		2	3	4	7
			SS-3		4	4	5	9
10		577.2	SS-4		5	5	7	12
15	- - - With black oxides and weathered chert	572.2	SS-5		5	5	6	11
20	FAT CLAY (CH) with chert and silt, red and yellow, firm to stiff, moist - - - Chert seam	567.2	SS-6		3	2	3	5
	- - - With abundant chert		SS-7		7	8	7	15
25	CLAYEY GRAVEL (GC) with chert, white, firm, moist	562.2						
30	- - - Very moist	557.2	SS-8		4	4	7	11



S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-10

CLIENT: **Garver**	ELEVATION: **587.2 ft**	NOTES:	
DATE DRILLED: **7/8/19 - 7/8/19**	BORING DEPTH: **53.8 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **30.5 ft ATD**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518626.108**	EASTING: **356391.47**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **100+17**	OFFSET: **35' L**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL 10 20 30 40 50 60 70 80 90	N VALUE
		LIMESTONE, slightly fractured, light gray and dark gray, fine grained, thickly bedded, slightly weathered, hard, excellent recovery, good quality *(continued)*			RC-1			96%	86%		
		- - - Excellent quality									
40				547.2	RC-2			100%	99%		
45				542.2	RC-3			95%	95%		
50				537.2	RC-4			97%	93%		
		Refusal at 33.8 feet Boring terminated at 53.8 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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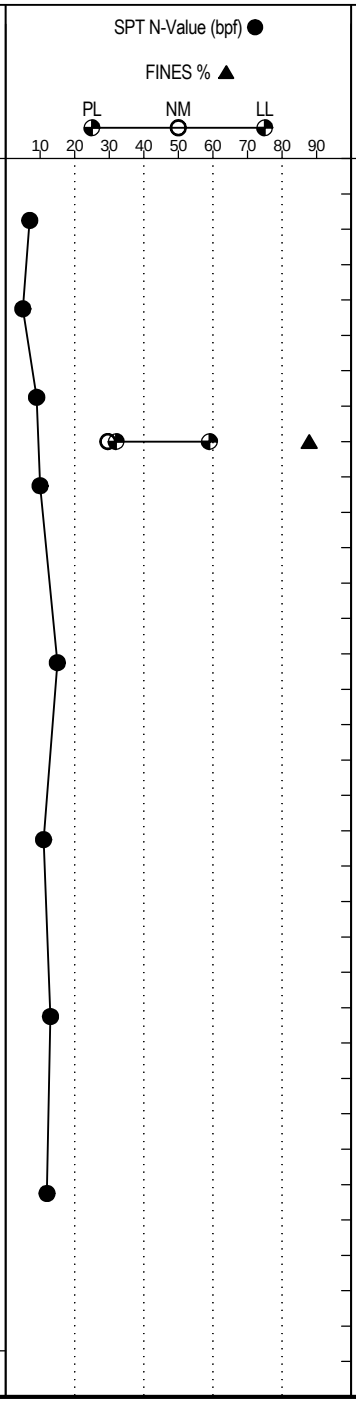
PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-11**

CLIENT: **Garver**	ELEVATION: **587.4 ft**	NOTES:	
DATE DRILLED: **7/10/19 - 7/10/19**	BORING DEPTH: **53.7 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518642.587**	EASTING: **356431.69**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **100+02**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	CULTIVATED ZONE - 12 INCHES							
	FAT CLAY (CH) with black oxides, red, firm, moist RESIDUUM		SS-1		3	4	3	7
5		582.4	SS-2		3	2	3	5
	- - - Stiff		SS-3		4	4	5	9
10		577.4	SS-4		4	5	5	10
15	- - - With chert and yellow mottling	572.4	SS-5		5	7	8	15
20		567.4	SS-6		3	7	4	11
25	- - - Abundant chert	562.4	SS-7		4	6	7	13
30		557.4	SS-8		3	5	7	12
	- - - Gravel, very moist							



WATER LEVEL

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

NOTES:

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2. *BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.*
3. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-11

CLIENT: **Garver**	ELEVATION: **587.4 ft**	NOTES:	
DATE DRILLED: **7/10/19 - 7/10/19**	BORING DEPTH: **53.7 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518642.587**	EASTING: **356431.69**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **100+02**	OFFSET: **CL**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL 10 20 30 40 50 60 70 80 90	N VALUE
		LIMESTONE, light gray and dark gray, fine grained, thickly bedded, very slightly weathered to unweathered, hard, excellent recovery, good quality *(continued)*			RC-1			95%	88%		
		- - - Excellent quality									
40				547.4	RC-2			100%	100%		
45				542.4	RC-3			98%	98%		
50				537.4	RC-4			100%	94%		
		Refusal at 33.7 feet Boring terminated at 53.7 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

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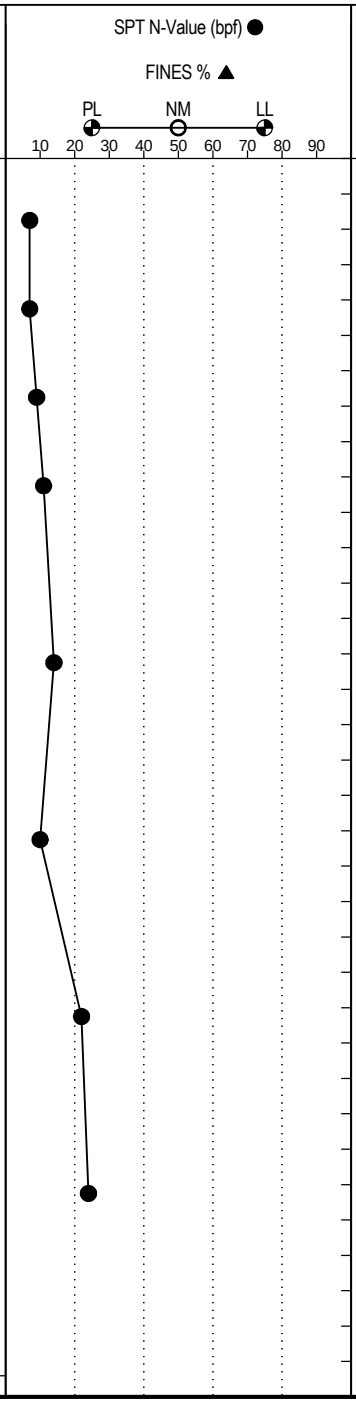
3. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT: **Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama** S&ME Project No. 3282-19-054	**BORING LOG NS-12**

CLIENT: **Garver**	ELEVATION: **587.9 ft**	NOTES:	
DATE DRILLED: **7/11/19 - 7/11/19**	BORING DEPTH: **54.4 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518657.279**	EASTING: **356474.578**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **99+72**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
	CULTIVATED ZONE - 12 INCHES							
	LEAN CLAY (CL) with black oxides, red, firm, moist		SS-1		4	4	3	7
	RESIDUUM							
5	FAT CLAY (CH) with black oxides, firm to very stiff, moist	582.9	SS-2		2	3	4	7
			SS-3		4	4	5	9
10		577.9	SS-4		4	5	6	11
15	- - - With yellow mottling	572.9	SS-5		4	4	10	14
20	- - - With abundant chert, yellow-red	567.9	SS-6		4	4	6	10
25		562.9	SS-7		5	10	12	22
30		557.9	SS-8		11	16	8	24



WATER LEVEL

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

NOTES:

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3. *STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.*
4. *WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.*

PROJECT:	Old Highway 20 Bridge Over NS Railroad Huntsville, Madison County, Alabama S&ME Project No. 3282-19-054	BORING LOG NS-12

CLIENT: **Garver**	ELEVATION: **587.9 ft**	NOTES:	
DATE DRILLED: **7/11/19 - 7/11/19**	BORING DEPTH: **54.4 ft**		
DRILL RIG: **ATV**	WATER LEVEL: **Not encountered**		
DRILLER: **Tri-State Drillers**	CAVE-IN DEPTH: **N/A**		
HAMMER TYPE: **Automatic**	LOGGED BY: **Elizabeth Bavis**	NORTHING: **1518657.279**	EASTING: **356474.578**
SAMPLING METHOD: **Rock Core, Split spoon**		STATION: **99+72**	OFFSET: **35' R**

DRILLING METHOD: **3¼" H.S.A.**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT / CORE DATA 1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	SPT N-Value (bpf) ● FINES % ▲ PL NM LL 10 20 30 40 50 60 70 80 90	N VALUE
		LIMESTONE, slightly fractured, with chert inclusions, light gray and dark gray, fine grained, thickly bedded, slightly weathered to unweathered, hard, excellent recovery, good quality *(continued)*			RC-1			92%	78%		
40		- - - Unfractured, excellent quality		547.9	RC-2			100%	100%		
45				542.9	RC-3			100%	97%		
50				537.9	RC-4			98%	98%		
		Refusal at 34.4 feet Boring terminated at 54.4 feet									

S&ME BORING LOG - VOGTLE 3282-19-054 BORINGS.GPJ S&ME 2011_03_09.GDT 3/5/20

NOTES:

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1	**Location / Orientation**	Boring NS-01 Rock Core
	Remarks	Run 1: 43 ft to 48 ft; Recovery = 100%, RQD = 100% Run 2: 48 ft to 53 ft; Recovery = 98%, RQD = 98%

2	**Location / Orientation**	Boring NS-01 Rock Core
	Remarks	Run 3: 53 ft to 58 ft; Recovery = 100%, RQD = 100% Run 4: 58 ft to 63 ft; Recovery = 97%, RQD = 90%

3	**Location / Orientation**	Boring NS-02 Rock Core
	Remarks	Run 1: 37.3 ft to 42.3 ft; Recovery = 93%, RQD = 25% Run 2: 42.3 ft to 47.3 ft; Recovery = 100%, RQD = 73%

4	**Location / Orientation**	Boring NS-02 Rock Core
	Remarks	Run 3: 47.3 ft to 52.3 ft; Recovery = 97%, RQD = 71% Run 4: 52.3 ft to 57.3 ft; Recovery = 98%, RQD = 98%

5	**Location / Orientation**	Boring NS-03 Rock Core
	Remarks	Run 1: 35.3 ft to 40.3 ft; Recovery = 98%, RQD = 85% Run 2: 40.3 ft to 45.3 ft; Recovery = 100%, RQD = 100%

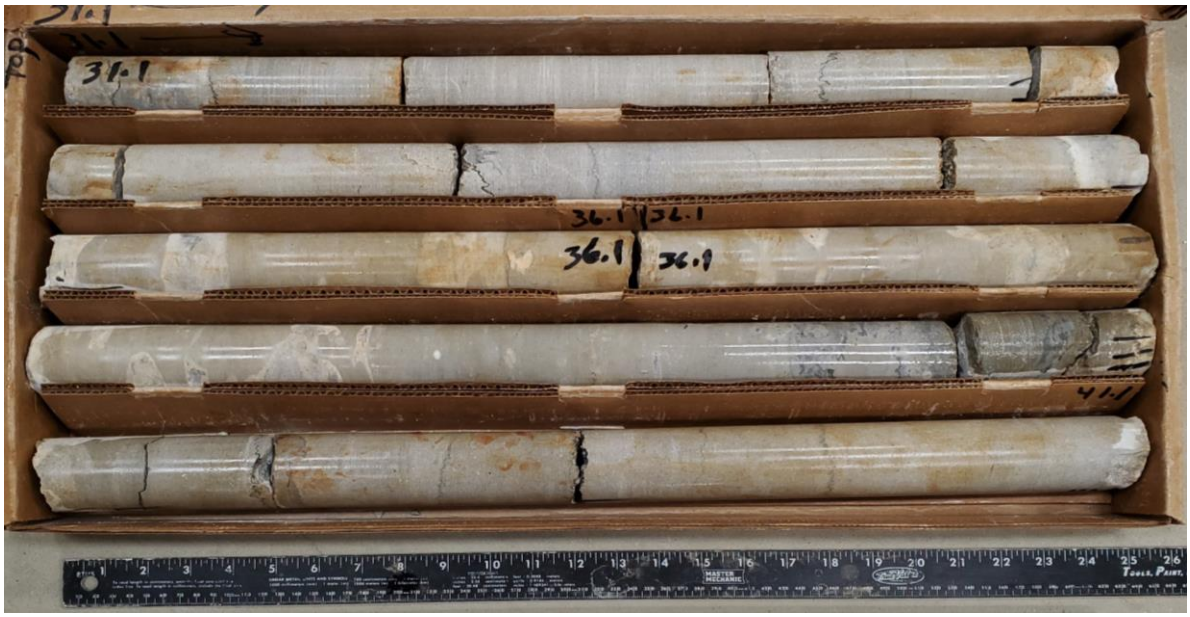
6	**Location / Orientation**	Boring NS-03 Rock Core
	Remarks	Run 3: 45.3 ft to 50.3 ft; Recovery = 100%, RQD = 100% Run 4: 50.3 ft to 55.3 ft; Recovery = 100%, RQD = 100%

7	**Location / Orientation**	Boring NS-04 Rock Core
	Remarks	Run 1: 31 ft to 36 ft; Recovery = 98%, RQD = 98% Run 2: 36 ft to 41 ft; Recovery = 100%, RQD = 68%

8	**Location / Orientation**	Boring NS-04 Rock Core
	Remarks	Run 3: 41 ft to 46 ft; Recovery = 100%, RQD = 100% Run 4: 46 ft to 51 ft; Recovery = 100%, RQD = 100%

9	**Location / Orientation**	Boring NS-05 Rock Core
	Remarks	Run 1: 31 ft to 36 ft; Recovery = 98%, RQD = 98% Run 2: 36 ft to 41 ft; Recovery = 97%, RQD = 97%

10	**Location / Orientation**	Boring NS-05 Rock Core
	Remarks	Run 3: 41 ft to 46 ft; Recovery = 100%, RQD = 100% Run 4: 46 ft to 51 ft; Recovery = 100%, RQD = 100%



11	**Location / Orientation**	Boring NS-06 Rock Core
	Remarks	Run 1: 31.4 ft to 36.4 ft; Recovery = 100%, RQD = 100% Run 2: 36.4 ft to 41.1 ft; Recovery = 100%, RQD = 98%

12	**Location / Orientation**	Boring NS-06 Rock Core
	Remarks	Run 3: 41.4 ft to 46.4 ft; Recovery = 98%, RQD = 93% Run 4: 46.4 ft to 51.4 ft; Recovery = 100%, RQD = 100%

13	**Location / Orientation**	Boring NS-07 Rock Core
	Remarks	Run 1: 43.8 ft to 48.8 ft; Recovery = 100%, RQD = 100% Run 2: 48.8 ft to 53.8 ft; Recovery = 100%, RQD = 100%

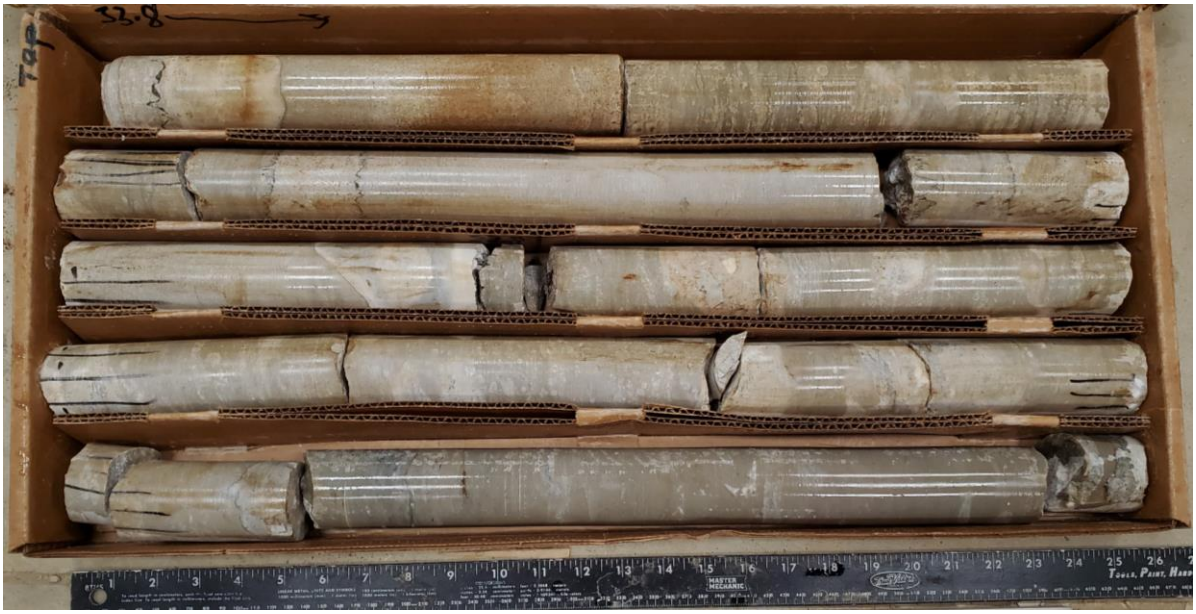
14	**Location / Orientation**	Boring NS-07 Rock Core
	Remarks	Run 3: 53.8 ft to 58.8 ft; Recovery = 100%, RQD = 100% Run 4: 58.8 ft to 63.8 ft; Recovery = 100%, RQD = 100%

15	**Location / Orientation**	Boring NS-08 Rock Core
	Remarks	Run 1: 34.1 ft to 39.1 ft; Recovery = 100%, RQD = 98% Run 2: 39.1 ft to 44.1 ft; Recovery = 100%, RQD = 99%

16	**Location / Orientation**	Boring NS-08 Rock Core
	Remarks	Run 3: 44.1 ft to 49.1 ft; Recovery = 99%, RQD = 98% Run 4: 49.1 ft to 54.1 ft; Recovery = 100%, RQD = 100%

17	**Location / Orientation**	Boring NS-09 Rock Core
	Remarks	Run 1: 40.9 ft to 45.9 ft; Recovery = 80%, RQD = 65% Run 2: 45.9 ft to 50.9 ft; Recovery = 98%, RQD = 98%

18	**Location / Orientation**	Boring NS-09 Rock Core
	Remarks	Run 3: 50.9 ft to 55.9 ft; Recovery = 98%, RQD = 98% Run 4: 55.9 ft to 60.9 ft; Recovery = 100%, RQD = 100%



19	**Location / Orientation**	Boring NS-10 Rock Core
	Remarks	Run 1: 33.8 ft to 38.8 ft; Recovery = 96%, RQD = 86% Run 2: 38.8 ft to 43.8 ft; Recovery = 100%, RQD = 99%

20	**Location / Orientation**	Boring NS-10 Rock Core
	Remarks	Run 3: 43.8 ft to 48.8 ft; Recovery = 95%, RQD = 95% Run 4: 48.8 ft to 53.8 ft; Recovery = 97%, RQD = 93%

21	**Location / Orientation**	Boring NS-11 Rock Core
	Remarks	Run 1: 33.7 ft to 38.7 ft; Recovery = 95%, RQD = 88% Run 2: 38.7 ft to 43.7 ft; Recovery = 100%, RQD = 100%

22	**Location / Orientation**	Boring NS-11 Rock Core
	Remarks	Run 3: 43.7 ft to 48.7 ft; Recovery = 98%, RQD = 98% Run 4: 48.7 ft to 53.7 ft; Recovery = 100%, RQD = 94%

23	**Location / Orientation**	Boring NS-12 Rock Core
	Remarks	Run 1: 34.4 ft to 39.4 ft; Recovery = 92%, RQD = 78% Run 2: 39.4 ft to 44.4 ft; Recovery = 100%, RQD = 100%

24	**Location / Orientation**	Boring NS-12 Rock Core
	Remarks	Run 3: 44.4 ft to 49.4 ft; Recovery = 100%, RQD = 97% Run 4: 49.4 ft to 54.4 ft; Recovery = 98%, RQD = 98%

Appendix III – Analyses and Recommendations

Table III-1: Summary of H-Pile Recommendations

Location	Pile Size	Maximum Factored Design Load (tons)	Approximate Ground Surface Elevation (ft MSL)	Estimated Tip Elevation (ft MSL)
Abutment No. 1 Sta. 95+95	HP 12x53	100	594 to 595	550 to 560
	HP 14x73	140		
	HP 14x89	170		
	HP 14x102	195		
Abutment No. 4 Sta. 100 + 02	HP 12x53	100	587 to 588	553 to 554
	HP 14x73	140		
	HP 14x89	170		
	HP 14x102	195		

Table III-2: Summary of Drilled Shaft Recommendations

Location	Drilled Shaft Diameter (in)	Factored Axial Compression Resistance (tons)	Approximate Ground Surface Elevation (ft MSL)	Approximate Refusal Elevation (ft MSL)	Estimated Shaft Tip Elevation (ft MSL)
Bent No. 2 Sta. 97+35	48	1250	592	561	556
	54	1540			556
	60	1860			556
Bent No. 3 Sta. 98+80	48	1250	590	551 to 556	541 to 550
	54	1540			541 to 550
	60	1860			541 to 550

Table III-3A: COM 624 Input Data Abutment 1

Depth	Soil Description (ASTM)	Soil/Rock Modulus, k (pci)	Unit Weight (pci)	Shear Strength (psi)	Internal Angle of Friction, Φ (degrees)	Strain, ε_{50} (in/in)
0-31	Crushed Agg (GC) FILL	1,000	0.058	--	35	--
31-55	Stiff CH	500	0.069	7.0	25	0.005
55-79	Firm CH	100	0.033	3.5	20	0.010
79-99	Limestone	2,000	0.084	350	40	0.0001

Table III-4A: COM 624 Input Data Bent 2

Depth (ft)	Soil Description (ASTM)	Soil/Rock Modulus, k (pci)	Unit Weight (pci)	Shear Strength (psi)	Internal Angle of Friction, Φ (degrees)	Strain, ε_{50} (in/in)
0-24	Stiff CH	500	0.069	7.0	25	0.005
24-31	Firm CH	100	0.033	3.5	20	0.010
31-51	Limestone	2,000	0.084	350	40	0.0001

Table III-5A: COM 624 Input Data Bent 3

Depth (ft)	Soil Description (ASTM)	Soil/Rock Modulus, k (pci)	Unit Weight (pci)	Shear Strength (psi)	Internal Angle of Friction, Φ (degrees)	Strain, ε_{50} (in/in)
0-27	Stiff CH	500	0.069	7.0	25	0.005
27-40	Soft CH	30	0.033	2.0	20	0.020
40-60	Limestone	2,000	0.084	350	40	0.0001

Table III-6A: COM 624 Input Data Abutment 4

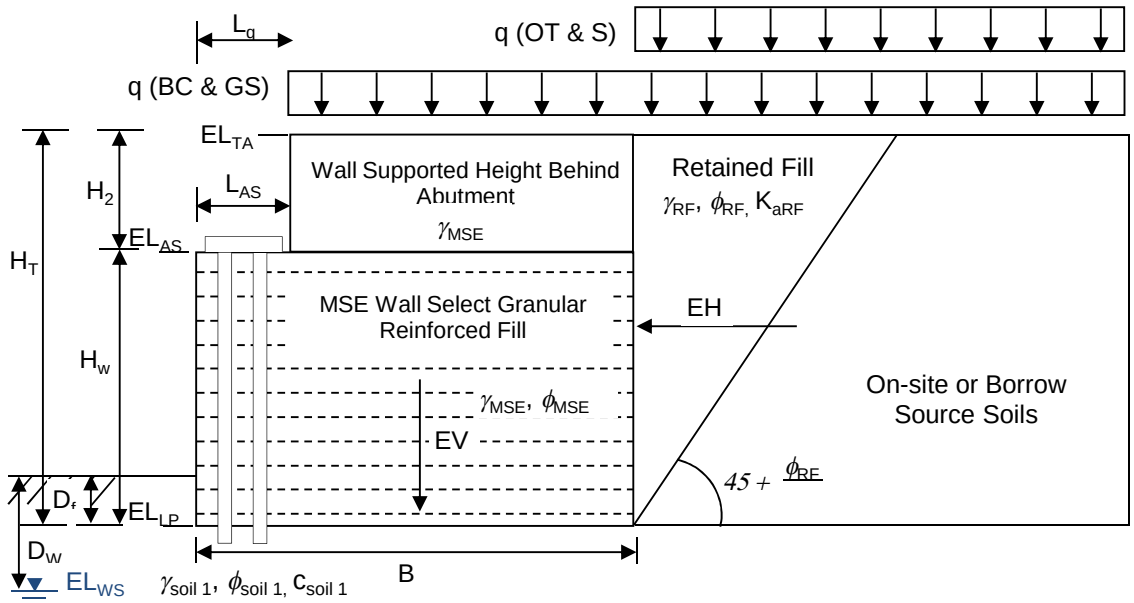
Depth	Soil Description (ASTM)	Soil/Rock Modulus, k (pci)	Unit Weight (pci)	Shear Strength (psi)	Internal Angle of Friction, Φ (degrees)	Strain, ε_{50} (in/in)
0-28	Crushed Agg (GC) FILL	1,000	0.058	--	35	--
28-62	Stiff CH	500	0.069	7.0	25	0.005
62-82	Limestone	2,000	0.084	350	40	0.0001

MSE WALL CALCULATION - ABUTMENT FACE (Sheet 1 of 5)

3282-19-054 Bridge on Old SR 20 ovr NS RR, West Abutment

Analysis description/Title

MSE Wall Stability Diagram and Design Parameters



$$K_{aRF} = \frac{1 - \sin\phi_{RF}}{1 + \sin\phi_{RF}}$$

Notes: $L_{T\ WALL}$ equals the length of the wall
EL_{WS} equals the elevation of the water table

γ_{MSE}	=	100	pcf	ϕ'_{MSE}	=	34	deg	$L_{T\ WALL}$ = 413 ft
H_W	=	33	ft	γ_{RF}	=	120	pcf	EL_{WS}* = 571 MSL
H_2	=	8.5	ft	ϕ'_{RF}	=	33	deg	D_w = 16 ft
EL_{LP}	=	585		K_{aRF}	=	0.295		D_f = 2 ft
EL_{AS}	=	618						
EL_{TA}	=	626.5		q	=	250	psf	
H_T	=	41.5	ft	L_q	=	10	ft	
B	=	30	ft	Representative Soil Profile:				
L_{AS}	=	10		NS-01 UNDERCUT				

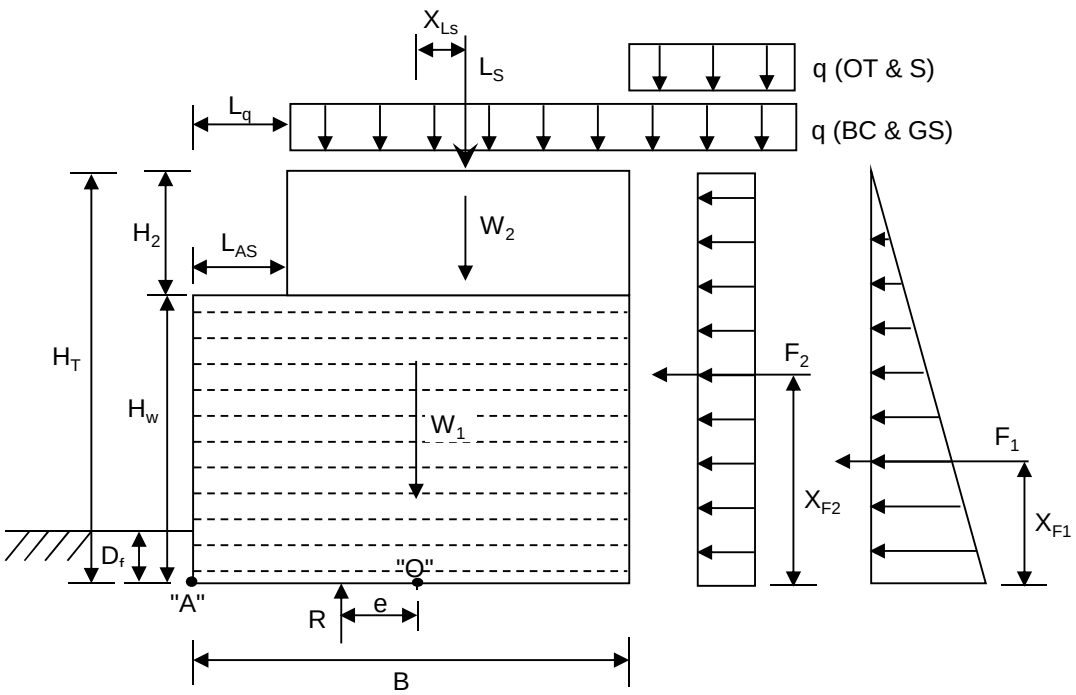
*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

Soil Layer 1				*Soil Layer 2*				*Soil Layer 3*			
Underwater Embankment				*CH*				*SOFT CH*			
Upper El.	=	585	MSL	Upper El.	=	581	MSL	Upper El.	=	569.5	MSL
Lower El.	=	581	MSL	Lower El.	=	569.5	MSL	Lower El.	=	551.5	MSL
$\gamma_{soil\ 1}$	=	120	pcf	$\gamma_{soil\ 2}$	=	120	pcf	$\gamma_{soil\ 3}$	=	120	pcf
$\gamma'_{soil\ 1}$	=	120	pcf	$\gamma'_{soil\ 2}$	=	57.6	pcf	$\gamma'_{soil\ 3}$	=	57.6	pcf
$\phi'_{soil\ 1}$	=	34	deg	$\phi'_{soil\ 2}$	=	33	deg	$\phi'_{soil\ 3}$	=	25	deg
$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 2}$	=	0	psf	$c'_{soil\ 3}$	=	0	psf
$\phi_{soil\ 1}$	=	34	deg	$\phi_{soil\ 2}$	=	20	deg	$\phi_{soil\ 3}$	=	10	deg
$c_{soil\ 1}$	=	0	psf	$c_{soil\ 2}$	=	300	psf	$c_{soil\ 3}$	=	200	psf

3282-19-054 Bridge on Old SR 20 ovr NS RR, West Abutment

Analysis description/Title

External Stability Diagram and Force Definitions



CDR Values (***Drained*** Undrained)

Sliding	***1.53*** / N/A
Eccen-tricity	1.76
Bearing Resis-tance	***2.22*** / 3.90

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

Sliding

φ_τ	=	1.0
γ_{EH}	=	1.5
γ_{EV}	=	1.0
γ_{LS}	=	1.75

Overturning

γ_{EH}	=	1.5
γ_{EV}	=	1.0
γ_{LS}	=	1.75

Bearing Resis-tance

φ_b	=	0.65
γ_{EH}	=	1.5
γ_{EV}	=	1.35
γ_{LS}	=	1.75

Interim Calculations

Force Calculations

W_1	=	99000.0	plf	$W_1 = H_W B \gamma_{MSE}$
W_2	=	17000.0	plf	$W_2 = H_2 \gamma_{MSE}(B - L_{AS})$
F_1	=	30483.8	plf	$F_1 = 0.5\gamma_{RF} H_T^2 K_{aRF}$
F_2	=	3060.6	plf	$F_2 = qH_T K_{aRF}$
L_S	=	5000.0	plf	$L_S = q(B - L_q)$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_W}{2})$)

Moment Arm Equations

$\bar{X}_{W1}$ = 0 (passes through "O")

$$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$$

$$\bar{X}_{F1} = \frac{H_T}{3}$$

$$\bar{X}_{F2} = \frac{H_T}{2}$$

$$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$$

MSE WALL CALCULATION - ABUTMENT FACE (Sheet 3 of 5)

3282-19-054 Bridge on Old SR 20 ovr NS RR, West Abutment

Analysis description/Title

X_{W1}	=	0.00	ft	M_{W1}	=	0.0	lb-ft/ft	M_{W1} = 0.0 lb-ft/ft
X_{W2}	=	-5.00	ft	M_{W2}	=	-85000.0	lb-ft/ft	M_{W2} = -114750.0 lb-ft/ft
X_{F1}	=	13.83	ft	M_{F1}	=	632386.4	lb-ft/ft	M_{F1} = 632386.4 lb-ft/ft
X_{F2}	=	20.75	ft	M_{F2}	=	111138.0	lb-ft/ft	M_{F2} = 111138.0 lb-ft/ft
X_{LS}	=	-5.00	ft	$M_x = \gamma_x F_x \bar{X}_x$				M_{LS} = -43750.0 lb-ft/ft

Drained Analysis

Sliding
(Articles 11.10.5.3 & 10.6.3.4)

δ	=	34	deg
Tan(δ)	=	0.675	
$R_R = \varphi_\tau R_\tau$	=	78243	plf
Q_S	=	51081.8	plf

Is $R_R > Q_S$? **Yes**

B/H_W	=	91%	
B/H_T	=	72%	

Is $B \geq 0.7H_T$ **Yes**

Eccentricity (Overturning)
(Articles 11.10.5.5 & 11.6.3.3)

R	=	116000.0	plf
e	=	5.68	ft
M_R	=	658524.4	lb-ft/ft

Is e < B/3? **Yes**

Effective Wall Width

B' = 18.64 ft

Eccentricity for BR
(Article 11.10.5.4)

R	=	165350.0	plf
e	=	3.54	ft
M_R	=	585024.4	lb-ft/ft

Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.

Effective Wall Width (BR)

B' = 22.92 ft

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

V = $\gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$\circlearrowleft + \sum M_{at}\, 0$

$= \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + \mathrm{Re} = 0$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

3282-19-054 Bridge on Old SR 20 ovr NS RR, West Abutment

Analysis description/Title

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 1}$	=	0	psf	$N_c = (N_q - 1)\cot\varphi'$ for $\phi_{soil\ i} > 0$
N_c	=	42.2	dim.	N_c	=	38.6	dim.	$N_c = 5.14$ for $\phi_{soil\ i} = 0$
s_c	=	1.039	dim.	s_c	=	1.038	dim.	$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_C}\right)$ for $\phi_{soil\ i} > 0$
i_c	=	1	dim.	i_c	=	1	dim.	$S_c = 1 + \left(\frac{B'}{5L}\right)$ for $\phi_{soil\ i} = 0$
N_{cm}	=	43.8	dim.	N_{cm}	=	40.1	dim.	

γ_{MSE}	=	120	pcf	γ_{MSE}	=	120	pcf	$N_{CM} = N_C S_c i_c$
D_f	=	2	ft	D_f	=	2	ft	
N_q	=	29.4	dim.	N_q	=	26.1	dim.	$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$
s_q	=	1.037	dim.	s_q	=	1.036	dim.	
d_q	=	1.02	dim.	d_q	=	1.02	dim.	$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1)$ for $\phi_{soil\ i} > 0$
i_q	=	1	dim.	i_q	=	1	dim.	$S_q = 1$ for $\phi_{soil\ i} = 0$
N_{qm}	=	31.1	dim.	N_{qm}	=	27.6	dim.	
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.	$d_q = 1 + 2\tan(\phi_{soil\ i})(1 - \sin\phi_{soil\ i})^2 \tan^{-1}(D_f/B')$ (Hansen, 1968)

$\gamma'_{soil\ 1}$	=	120	pcf	$\gamma'_{soil\ 2}$	=	57.6	pcf	$N_{qm} = N_q S_q d_q i_q$
B'	=	22.92	ft	B'	=	22.92	ft	
N_γ	=	41.1	dim.	N_γ	=	35.2	dim.	$N_\gamma = 2(N_q + 1)\tan\varphi'$
s_γ	=	0.978	dim.	s_γ	=	0.978	dim.	$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right)$ for $\phi_{soil\ i} > 0$
i_γ	=	1	dim.	i_γ	=	1	dim.	$S_\gamma = 1$ for $\phi_{soil\ i} = 0$
$N_{\gamma m}$	=	40.2	dim.	$N_{\gamma m}$	=	34.4	dim.	$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.66	dim.	

Cohesion	0.0	psf	Cohesion	0.0	psf
Surcharge	7464.0	psf	Surcharge	6624.0	psf
Embedment	37039.6	psf	Embedment	14986.8	psf
q_{N1}	44503.6	psf	q_{N2}	21610.8	psf

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}} \qquad \sigma_V = \frac{\sum V}{B' - 2e}$$

2-Layer Approach - Article 10.6.3.1.2d

B'	=	22.92	ft
H_{CRIT}	=	23.53	ft
Use 2-layer solution?		**Yes**	

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	0.524	dim.
q_N	=	24616.209	psf
$q_R = \varphi_b q_N$	=	16000.536	psf
σ_V	=	7214.2	psf
Is $\sigma_V < q_R$?		**Yes**	

First Layer Only Solution

$q_N = q_{N1}$	=	44503.6	psf
$q_R = \varphi_b q_N$	=	28927.34	psf
σ_V	=	7214.2	psf
Is $\sigma_V < q_R$?		**Yes**	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - \sin^2(\varphi'_1)}{1 + \sin^2(\varphi'_1)}$

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)c'_1\cot(\phi'_1)\right]e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\phi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)c'_1\cot(\phi'_1)$$

3282-19-054 Bridge on Old SR 20 ovr NS RR, West Abutment

Analysis description/Title

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c_{soil\ 1}$	=	0	psf	$c_{soil\ 2}$	=	300	psf	
N_c	=	42.2	dim.	N_c	=	14.8	dim.	
s_c	=	1.039	dim.	s_c	=	1.024	dim.	
i_c	=	1	dim.	i_c	=	1	dim.	
N_{cm}	=	43.8	dim.	N_{cm}	=	15.2	dim.	
γ_{MSE}	=	100	pcf	γ_{MSE}	=	100	pcf	
D_f	=	2	ft	D_f	=	2	ft	
N_q	=	29.4	dim.	N_q	=	6.4	dim.	
s_q	=	1.037	dim.	s_q	=	1.02	dim.	
d_q	=	1.02	dim.	d_q	=	1.03	dim.	
i_q	=	1	dim.	i_q	=	1	dim.	
N_{qm}	=	31.1	dim.	N_{qm}	=	6.7	dim.	
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.	
$\gamma_{soil\ 1}$	=	120	pcf	$\gamma_{soil\ 2}$	=	120	pcf	
B'	=	22.92	ft	B'	=	22.92	ft	
N_γ	=	41.1	dim.	N_γ	=	5.4	dim.	
s_γ	=	0.978	dim.	s_γ	=	0.978	dim.	
i_γ	=	1	dim.	i_γ	=	1	dim.	
$N_{\gamma m}$	=	40.2	dim.	$N_{\gamma m}$	=	5.3	dim.	
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.67	dim.	
Cohesion		0.0	psf	Cohesion		4560.0	psf	
Surcharge		6220.0	psf	Surcharge		1340.0	psf	
Embedment		37039.6	psf	Embedment		4883.3	psf	
q_{N1}		43259.6	psf	q_{N2}		10783.3	psf	

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	22.92	ft
H_{CRIT}	=	45.25	ft
Use 2-layer solution?		**No**	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_*	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

2-Layer Solution - Undrained Case

q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		**N/A**	

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa + 1)N_*^2 + (1 + \kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa + 1)N_* + \kappa + \beta - 1][(N_* + \beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_* + 1)]}$$

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	N/A	psf
$0.5\sigma'_v$	=	N/A	psf
q_s	=	N/A	psf
B	=	N/A	ft
$R_R = \varphi_\tau R_\tau$	=	N/A	psf
Q_S	=	N/A	psf
Is $R_R > Q_S$?		**N/A**	

↑ For soft over stiff (EPRI, 1983)

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \leq s_c N_c$$

Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

$$R_\tau = Bq_s$$

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

$$\kappa = \frac{c_2}{c_1} \qquad N_* = s_c N_c$$

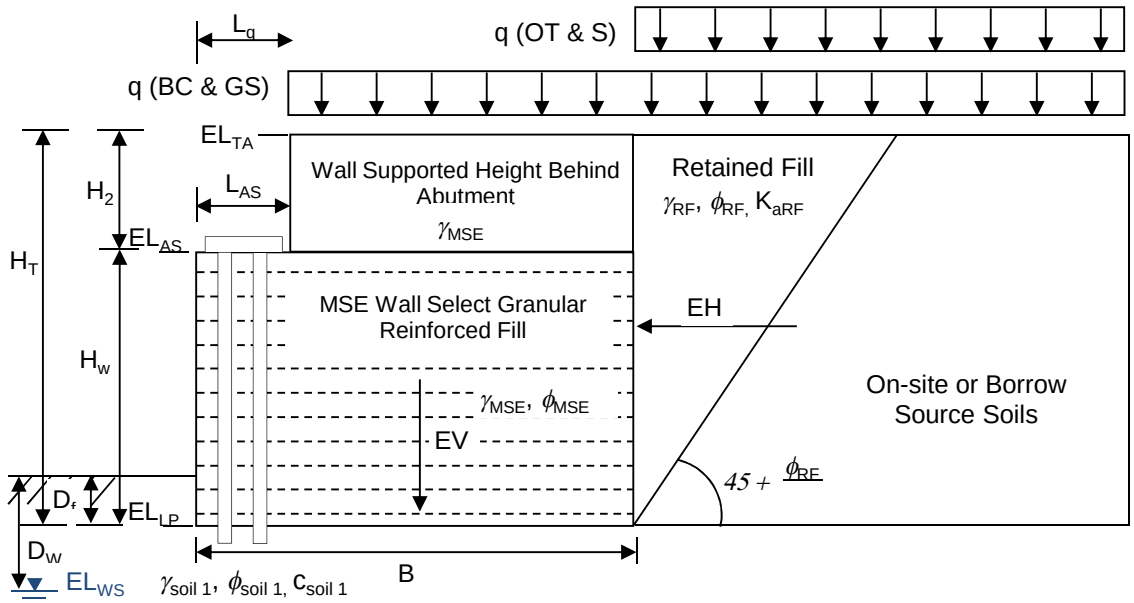
Single Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	43259.6	psf
$q_R = \varphi_b q_N$	=	28118.74	psf
σ_V	=	7214.2	psf
Is $\sigma_V < q_R$?		**Yes**	

3282-19-054 Bridge on Old SR 20 over NS RR, East Abutment

Analysis description/Title

MSE Wall Stability Diagram and Design Parameters



$$K_{aRF} = \frac{1 - \sin\phi_{RF}}{1 + \sin\phi_{RF}}$$

Notes: $L_{T\ WALL}$ equals the length of the wall
EL_{WS} equals the elevation of the water table

γ_{MSE}	=	100	pcf	ϕ'_{MSE}	=	34	deg	$L_{T\ WALL}$ = 396 ft
H_W	=	30	ft	γ_{RF}	=	120	pcf	EL_{WS}* = 557 MSL
H_2	=	8.5	ft	ϕ'_{RF}	=	30	deg	D_w = 35 ft
EL_{LP}	=	590		K_{aRF}	=	0.333		D_f = 2 ft
EL_{AS}	=	620						
EL_{TA}	=	628.5		q	=	250	psf	
H_T	=	38.5	ft	L_q	=	10	ft	
B	=	27	ft	Representative Soil Profile:				
L_{AS}	=	10		NS-10 UNDERCUT				

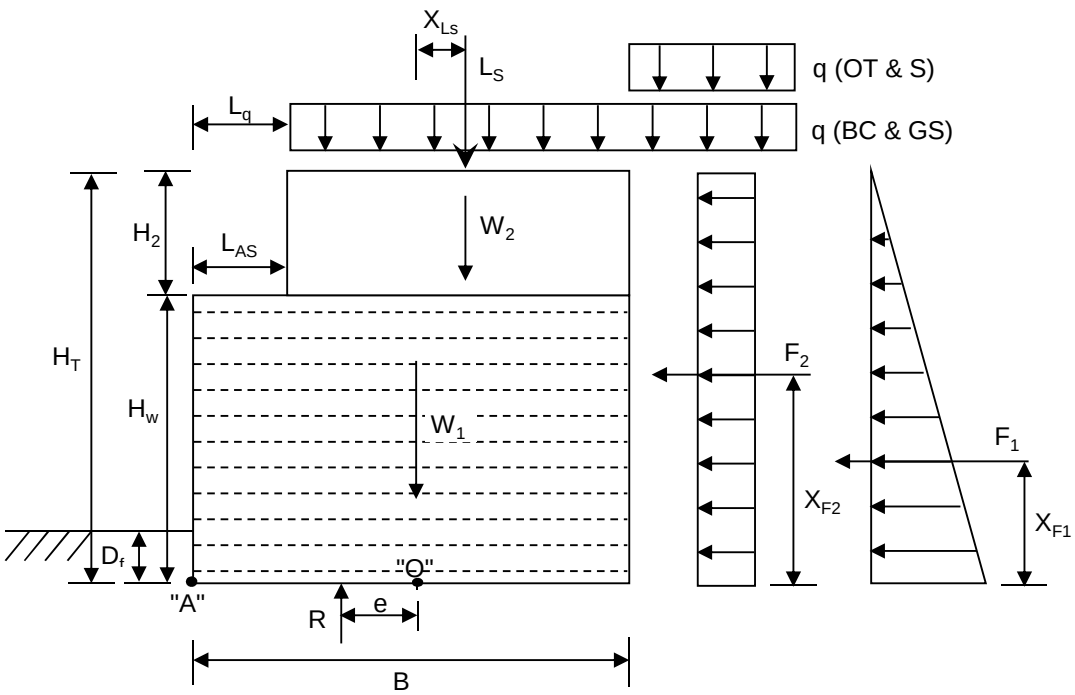
*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

Soil Layer 1				*Soil Layer 2*				*Soil Layer 3*			
Underwater Embankment				*CH*				*LIMESTONE*			
Upper El.	=	590	MSL	Upper El.	=	586	MSL	Upper El.	=	553	MSL
Lower El.	=	586	MSL	Lower El.	=	553	MSL	Lower El.	=	500	MSL
$\gamma_{soil\ 1}$	=	120	pcf	$\gamma_{soil\ 2}$	=	120	pcf	$\gamma_{soil\ 3}$	=	150	pcf
$\gamma'_{soil\ 1}$	=	120	pcf	$\gamma'_{soil\ 2}$	=	57.6	pcf	$\gamma'_{soil\ 3}$	=	87.6	pcf
$\phi'_{soil\ 1}$	=	34	deg	$\phi'_{soil\ 2}$	=	33	deg	$\phi'_{soil\ 3}$	=	50	deg
$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 2}$	=	0	psf	$c'_{soil\ 3}$	=	5000	psf
$\phi_{soil\ 1}$	=	34	deg	$\phi_{soil\ 2}$	=	20	deg	$\phi_{soil\ 3}$	=	50	deg
$c_{soil\ 1}$	=	0	psf	$c_{soil\ 2}$	=	300	psf	$c_{soil\ 3}$	=	5000	psf

3282-19-054 Bridge on Old SR 20 over NS RR, East Abutment

Analysis description/Title

External Stability Diagram and Force Definitions



CDR Values (***Drained*** Undrained)

Sliding	***1.29*** / N/A
Eccen-tricity	1.42
Bearing Resis-tance	***2.47*** / 4.36

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

φ_τ	=	1.0		γ_{EH}	=	1.5		φ_b	=	0.65	
γ_{EH}	=	1.5	Sliding	γ_{EV}	=	1.0	Overturning	γ_{EH}	=	1.5	Bearing Resis-tance
γ_{EV}	=	1.0		γ_{LS}	=	1.75		γ_{EV}	=	1.35	
γ_{LS}	=	1.75						γ_{LS}	=	1.75	

Interim Calculations

Force Calculations | *Moment Arm Equations*

W_1	= 81000.0	plf	$W_1 = H_W B \gamma_{MSE}$	$\bar{X}_{W1}$ = 0 (passes through "O")
W_2	= 14450.0	plf	$W_2 = H_2 \gamma_{MSE}(B - L_{AS})$	$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$
F_1	= 29615.4	plf	$F_1 = 0.5\gamma_{RF} H_T^2 K_{aRF}$	$\bar{X}_{F1} = \frac{H_T}{3}$
F_2	= 3205.1	plf	$F_2 = qH_T K_{aRF}$	$\bar{X}_{F2} = \frac{H_T}{2}$
L_S	= 4250.0	plf	$L_S = q(B - L_q)$	$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_W}{2})$)

MSE WALL CALCULATION - ABUTMENT FACE (Sheet 3 of 5)

3282-19-054 Bridge on Old SR 20 over NS RR, East Abutment

Analysis description/Title

X_{W1}	=	0.00	ft	M_{W1}	=	0.0	lb-ft/ft	M_{W1} = 0.0 lb-ft/ft
X_{W2}	=	-5.00	ft	M_{W2}	=	-72250.0	lb-ft/ft	M_{W2} = -97537.5 lb-ft/ft
X_{F1}	=	12.83	ft	M_{F1}	=	569948.4	lb-ft/ft	M_{F1} = 569948.4 lb-ft/ft
X_{F2}	=	19.25	ft	M_{F2}	=	107971.8	lb-ft/ft	M_{F2} = 107971.8 lb-ft/ft
X_{LS}	=	-5.00	ft	$M_x = \gamma_x F_x \bar{X}_x$				M_{LS} = -37187.5 lb-ft/ft

Drained Analysis

Sliding
(Articles 11.10.5.3 & 10.6.3.4)

δ	=	34	deg
Tan(δ)	=	0.675	
$R_R = \varphi_\tau R_\tau$	=	64381.8	plf
Q_S	=	50032	plf

Is $R_R > Q_S$? **Yes**

B/H_W	=	90%	
B/H_T	=	70%	

Is $B \geq 0.7H_T$ **Yes**

Eccentricity (Overturning)
(Articles 11.10.5.5 & 11.6.3.3)

R	=	95450.0	plf
e	=	6.35	ft
M_R	=	605670.2	lb-ft/ft

Is e < B/3? **Yes**

Effective Wall Width

B' = 14.30 ft

Eccentricity for BR
(Article 11.10.5.4)

R	=	136295.0	plf
e	=	3.99	ft
M_R	=	543195.2	lb-ft/ft

Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.

Effective Wall Width (BR)

B' = 19.02 ft

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

V = $\gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$$\circlearrowleft + \sum M_{at\,0}$$

$$= \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + \mathrm{Re} = 0$$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

3282-19-054 Bridge on Old SR 20 over NS RR, East Abutment

Analysis description/Title

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 1}$	=	0	psf
N_c	=	42.2	dim.	N_c	=	38.6	dim.
s_c	=	1.033	dim.	s_c	=	1.032	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	43.6	dim.	N_{cm}	=	39.8	dim.

$$N_c = (N_q - 1)\cot\varphi' \text{ for } \phi_{soil\ i} > 0$$

$$N_c = 5.14 \text{ for } \phi_{soil\ i} = 0$$

$$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_C}\right) \; for\ \phi_{soil\ i} > 0$$

$$S_c = 1 + \left(\frac{B'}{5L}\right) \; for\ \phi_{soil\ i} = 0$$

γ_{MSE}	=	120	pcf	γ_{MSE}	=	120	pcf
D_f	=	2	ft	D_f	=	2	ft
N_q	=	29.4	dim.	N_q	=	26.1	dim.
s_q	=	1.032	dim.	s_q	=	1.031	dim.
d_q	=	1.03	dim.	d_q	=	1.03	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	31.3	dim.	N_{qm}	=	27.7	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.

$$N_{CM} = N_C S_c i_c$$

$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$

$$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1) \; for\ \phi_{soil\ i} > 0$$

$$S_q = 1 \; for\ \phi_{soil\ i} = 0$$

$$d_q = 1 + 2\tan(\phi_{soil\ i})(1 - \sin\phi_{soil\ i})^2 \tan^{-1}(D_f/B')$$

(Hansen, 1968)

$\gamma'_{soil\ 1}$	=	120	pcf	$\gamma'_{soil\ 2}$	=	57.6	pcf
B'	=	19.02	ft	B'	=	19.02	ft
N_γ	=	41.1	dim.	N_γ	=	35.2	dim.
s_γ	=	0.981	dim.	s_γ	=	0.981	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	40.3	dim.	$N_{\gamma m}$	=	34.5	dim.
$C_{w\gamma}$	=	0.91	dim.	$C_{w\gamma}$	=	0.88	dim.

$$N_{qm} = N_q S_q d_q i_q$$

$$N_\gamma = 2(N_q + 1)\tan\varphi'$$

$$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right) \; for\ \phi_{soil\ i} > 0$$

$$S_\gamma = 1 \; for\ \phi_{soil\ i} = 0$$

$$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$$

Cohesion	0.0	psf	Cohesion	0.0	psf
Surcharge	7512.0	psf	Surcharge	6648.0	psf
Embedment	41851.2	psf	Embedment	16630.5	psf
q_{N1}	49363.2	psf	q_{N2}	23278.5	psf

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}}$$

$$\sigma_V = \frac{\sum V}{B' - 2e}$$

2-Layer Approach - Article 10.6.3.1.2d

B'	=	19.02	ft
H_{CRIT}	=	20.46	ft
Use 2-layer solution?		**Yes**	

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	0.524	dim.
q_N	=	27203.124	psf
$q_R = \varphi_b q_N$	=	17682.031	psf
σ_V	=	7165.9	psf
Is $\sigma_V < q_R$?		**Yes**	

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)c'_1\cot(\phi'_1)\right]e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\phi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)c'_1\cot(\phi'_1)$$

First Layer Only Solution

$q_N = q_{N1}$	=	49363.2	psf
$q_R = \varphi_b q_N$	=	32086.08	psf
σ_V	=	7165.9	psf
Is $\sigma_V < q_R$?		**Yes**	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - sin^2(\varphi'_1)}{1 + sin^2(\varphi'_1)}$

3282-19-054 Bridge on Old SR 20 over NS RR, East Abutment

Analysis description/Title

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c_{soil\ 1}$	=	0	psf	$c_{soil\ 2}$	=	300	psf	
N_c	=	42.2	dim.	N_c	=	14.8	dim.	
s_c	=	1.033	dim.	s_c	=	1.021	dim.	
i_c	=	1	dim.	i_c	=	1	dim.	
N_{cm}	=	43.6	dim.	N_{cm}	=	15.1	dim.	
γ_{MSE}	=	100	pcf	γ_{MSE}	=	100	pcf	
D_f	=	2	ft	D_f	=	2	ft	
N_q	=	29.4	dim.	N_q	=	6.4	dim.	
s_q	=	1.032	dim.	s_q	=	1.017	dim.	
d_q	=	1.03	dim.	d_q	=	1.03	dim.	
i_q	=	1	dim.	i_q	=	1	dim.	
N_{qm}	=	31.3	dim.	N_{qm}	=	6.7	dim.	
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.	
$\gamma_{soil\ 1}$	=	120	pcf	$\gamma_{soil\ 2}$	=	120	pcf	
B'	=	19.02	ft	B'	=	19.02	ft	
N_γ	=	41.1	dim.	N_γ	=	5.4	dim.	
s_γ	=	0.981	dim.	s_γ	=	0.981	dim.	
i_γ	=	1	dim.	i_γ	=	1	dim.	
$N_{\gamma m}$	=	40.3	dim.	$N_{\gamma m}$	=	5.3	dim.	
$C_{w\gamma}$	=	0.91	dim.	$C_{w\gamma}$	=	0.91	dim.	
Cohesion		0.0	psf	Cohesion		4530.0	psf	
Surcharge		6260.0	psf	Surcharge		1340.0	psf	
Embedment		41851.2	psf	Embedment		5504.0	psf	
q_{N1}		48111.2	psf	q_{N2}		11374.0	psf	

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	19.02	ft
H_{CRIT}	=	39.26	ft
Use 2-layer solution?		**No**	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_*	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

2-Layer Solution - Undrained Case

q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		**N/A**	

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa + 1)N_*^2 + (1 + \kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa + 1)N_* + \kappa + \beta - 1][(N_* + \beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_* + 1)]}$$

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	N/A	psf
$0.5\sigma'_v$	=	N/A	psf
q_s	=	N/A	psf
B	=	N/A	ft
$R_R = \varphi_\tau R_\tau$	=	N/A	psf
Q_S	=	N/A	psf
Is $R_R > Q_S$?		**N/A**	

↑ For soft over stiff (EPRI, 1983)

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \leq s_c N_c$$

Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

$$R_\tau = Bq_s$$

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

$$\kappa = \frac{c_2}{c_1} \qquad N_* = s_c N_c$$

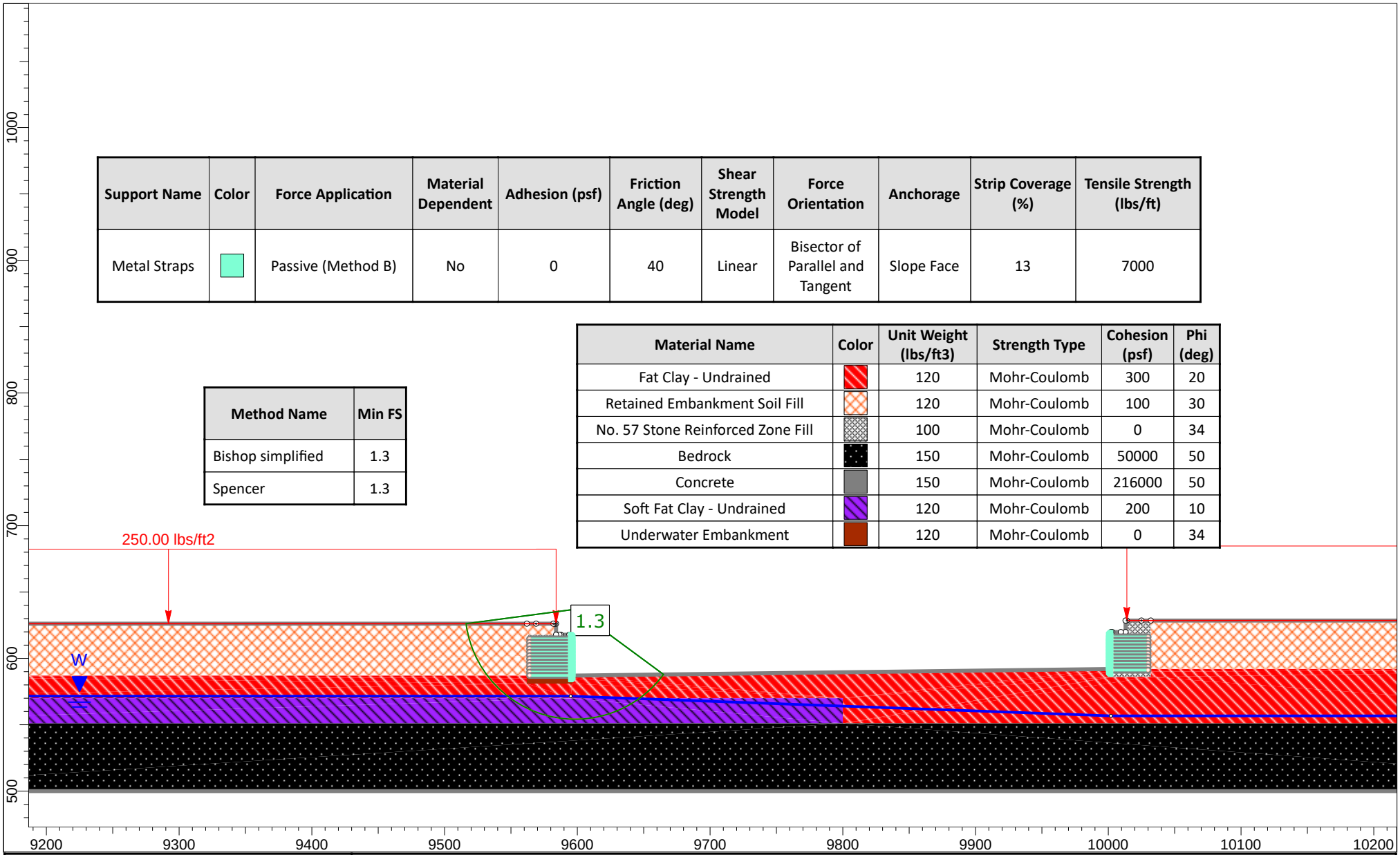
Single Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	48111.2	psf
$q_R = \varphi_b q_N$	=	31272.28	psf
σ_V	=	7165.9	psf
Is $\sigma_V < q_R$?		**Yes**	

Support Name	Color	Force Application	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Metal Straps		Passive (Method B)	No	0	40	Linear	Bisector of Parallel and Tangent	Slope Face	13	7000

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fat Clay - Undrained		120	Mohr-Coulomb	300	20
Retained Embankment Soil Fill		120	Mohr-Coulomb	100	30
No. 57 Stone Reinforced Zone Fill		100	Mohr-Coulomb	0	34
Bedrock		150	Mohr-Coulomb	50000	50
Concrete		150	Mohr-Coulomb	216000	50
Soft Fat Clay - Undrained		120	Mohr-Coulomb	200	10
Underwater Embankment		120	Mohr-Coulomb	0	34

Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3



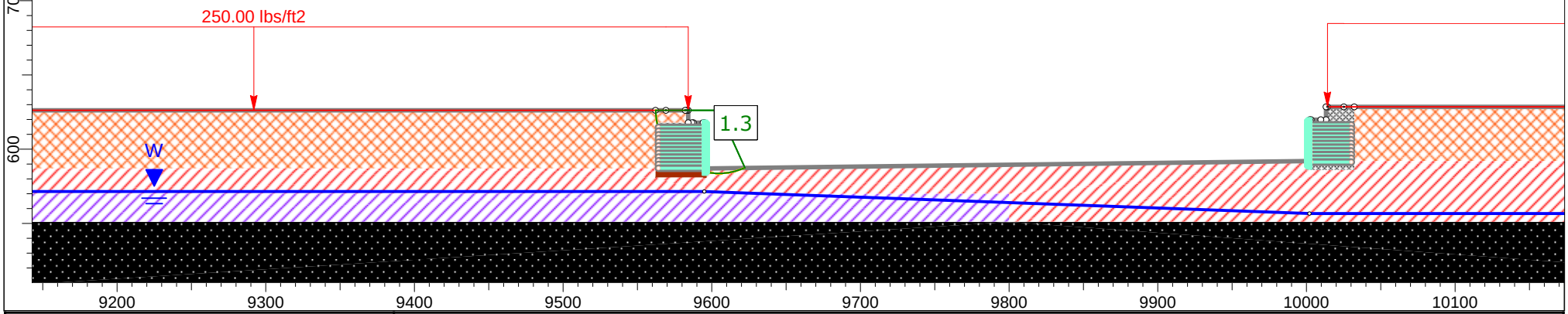
Project	Old Highway 20 West Abutment Wall		
Analysis Description	Total stress with 4 feet of undercut below wall and reinforced zone		
Drawn By	Jamie M. Hudson, PE	Scale 1:1200	Company S&ME, Inc.
Date	3/3/2020		File Name West Abutment Total Stress Undercut.slmd

SLIDEINTERPRET 8.009

Support Name	Color	Force Application	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Metal Straps		Passive (Method B)	No	0	40	Linear	Bisector of Parallel and Tangent	Slope Face	13	7000

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fat Clay - Drained		120	Mohr-Coulomb	0	33
Retained Embankment Soil Fill		120	Mohr-Coulomb	100	30
No. 57 Stone Reinforced Zone Fill		100	Mohr-Coulomb	0	34
Bedrock		150	Mohr-Coulomb	50000	50
Concrete		150	Mohr-Coulomb	216000	50
Soft Fat Clay - Drained		120	Mohr-Coulomb	0	25
Underwater Embankment		120	Mohr-Coulomb	0	34

Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3



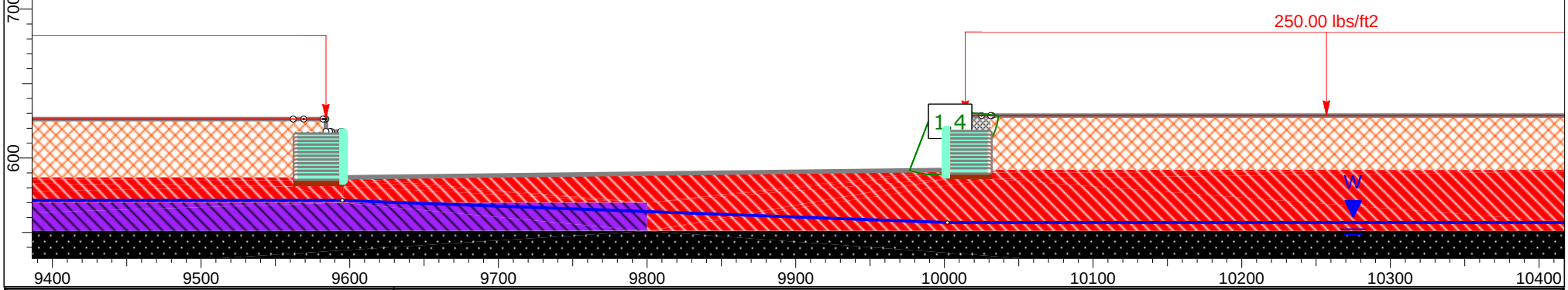
Project	Old Highway 20 West Bridge Abutment Wall		
Analysis Description	Effective stress with 4 feet of undercut below wall and reinforced zone		
Drawn By	Jamie M. Hudson, PE	Scale	1:1200
Company	S&ME, Inc.		
Date	3/2/2020	File Name	West Abutment Effective Stress Undercut.slmd

SLIDEINTERPRET 8.009

Support Name	Color	Force Application	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Metal Straps		Passive (Method B)	No	0	40	Linear	Bisector of Parallel and Tangent	Slope Face	13	7000

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fat Clay - Undrained		120	Mohr-Coulomb	300	20
Retained Embankment Soil Fill		120	Mohr-Coulomb	100	30
No. 57 Stone Reinforced Zone Fill		100	Mohr-Coulomb	0	34
Bedrock		150	Mohr-Coulomb	50000	50
Concrete		150	Mohr-Coulomb	216000	50
Soft Fat Clay - Undrained		120	Mohr-Coulomb	200	10
Underwater Embankment		120	Mohr-Coulomb	0	34

Method Name	Min FS
Bishop simplified	1.5
Spencer	1.4



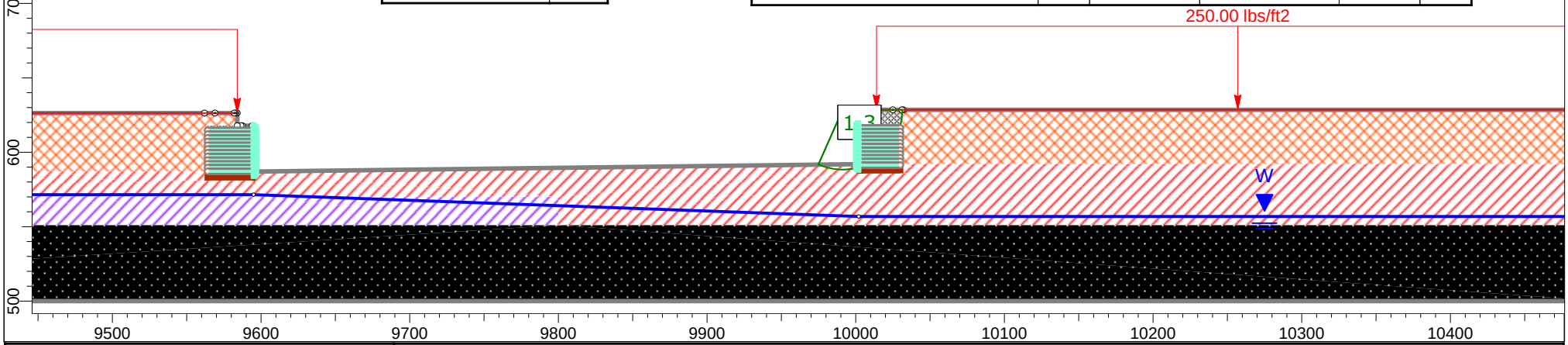
Project	Old Highway 20 East Bridge Abutment Wall		
Analysis Description	Total stress with 4 feet of undercut below wall and reinforced zone		
Drawn By	Jamie M. Hudson, PE	Scale	1:1200
Company	S&ME, Inc.		
Date	3/3/2020	File Name	East Abutment Total Stress Undercut.slmd

SLIDEINTERPRET 8.009

Support Name	Color	Force Application	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Metal Straps		Passive (Method B)	No	0	40	Linear	Bisector of Parallel and Tangent	Slope Face	13	7000

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fat Clay - Undrained		120	Mohr-Coulomb	300	20
Retained Embankment Soil Fill		120	Mohr-Coulomb	100	30
No. 57 Stone Reinforced Zone Fill		100	Mohr-Coulomb	0	34
Bedrock		150	Mohr-Coulomb	50000	50
Concrete		150	Mohr-Coulomb	216000	50
Soft Fat Clay - Undrained		120	Mohr-Coulomb	200	10
Underwater Embankment		120	Mohr-Coulomb	0	34

Method Name	Min FS
Bishop simplified	1.3
Spencer	1.3



Project	Old Highway 20 East Bridge Abutment Wall		
Analysis Description	Effective stress with 4 feet of undercut below wall and reinforced zone		
Drawn By	Jamie M. Hudson, PE	Scale	1:1200
Company	S&ME, Inc.		
Date	3/3/2020	File Name	East Abutment Effective Stress Undercut.slmd

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Appendix IV – Laboratory Testing

Station & Offset	Boring No.	Sample ID	Depth (ft)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Pass 200 % Silt % Clay	D50 (mm)	USCS	AASHTO Classification
STA 96+24 35' L	NS-01	UD-1	10.0	28.0	53	32	21	0.4	19.8	79.9		MH	A-7-5(19)
STA 95+95 CL	NS-02	SS-1	1.0	17.6									
STA 95+95 CL	NS-02	SS-2	3.5	22.6									
STA 95+95 CL	NS-02	SS-3	6.0	27.6									
STA 95+95 CL	NS-02	SS-4	13.5	38.6									
STA 95+95 CL	NS-02	SS-5	18.5	27.7	65	24	41	0.7	14.4	84.8		CH	A-7-6(38)
STA 95+95 CL	NS-02	SS-6	23.5	24.7									
STA 95+95 CL	NS-02	SS-7	28.5	35.4									
STA 97+06 35' R	NS-06	SS-1	1.0	21.3									
STA 97+06 35' R	NS-06	SS-2	3.5	23.3									
STA 97+06 35' R	NS-06	SS-3	6.0	27.0									
STA 97+06 35' R	NS-06	SS-4	8.5	29.4									
STA 97+06 35' R	NS-06	SS-5	13.5	33.9									
STA 97+06 35' R	NS-06	SS-6	18.5	32.4									
STA 97+06 35' R	NS-06	SS-7	23.5	22.2									

Soil Classification Summary

Garver
Project Number: 3282-19-054
Project Name: Bridge on Old SR 20 over NS Railroad
Location: Huntsville, Madison County, Alabama

Station & Offset	Boring No.	Sample ID	Depth (ft)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Pass 200		D50 (mm)	USCS	AASHTO Classification
										% Silt	% Clay			
STA 97+06 35' R	NS-06	SS-8	28.5	38.0										
STA 100+02 CL	NS-11	UD-1	8.0	29.6	59	32	27	0.3	11.8	87.9			MH	A-7-5(28)

Soil Classification Summary

Garver
Project Number: 3282-19-054
Project Name: Bridge on Old SR 20 over NS Railroad
Location: Huntsville, Madison County, Alabama

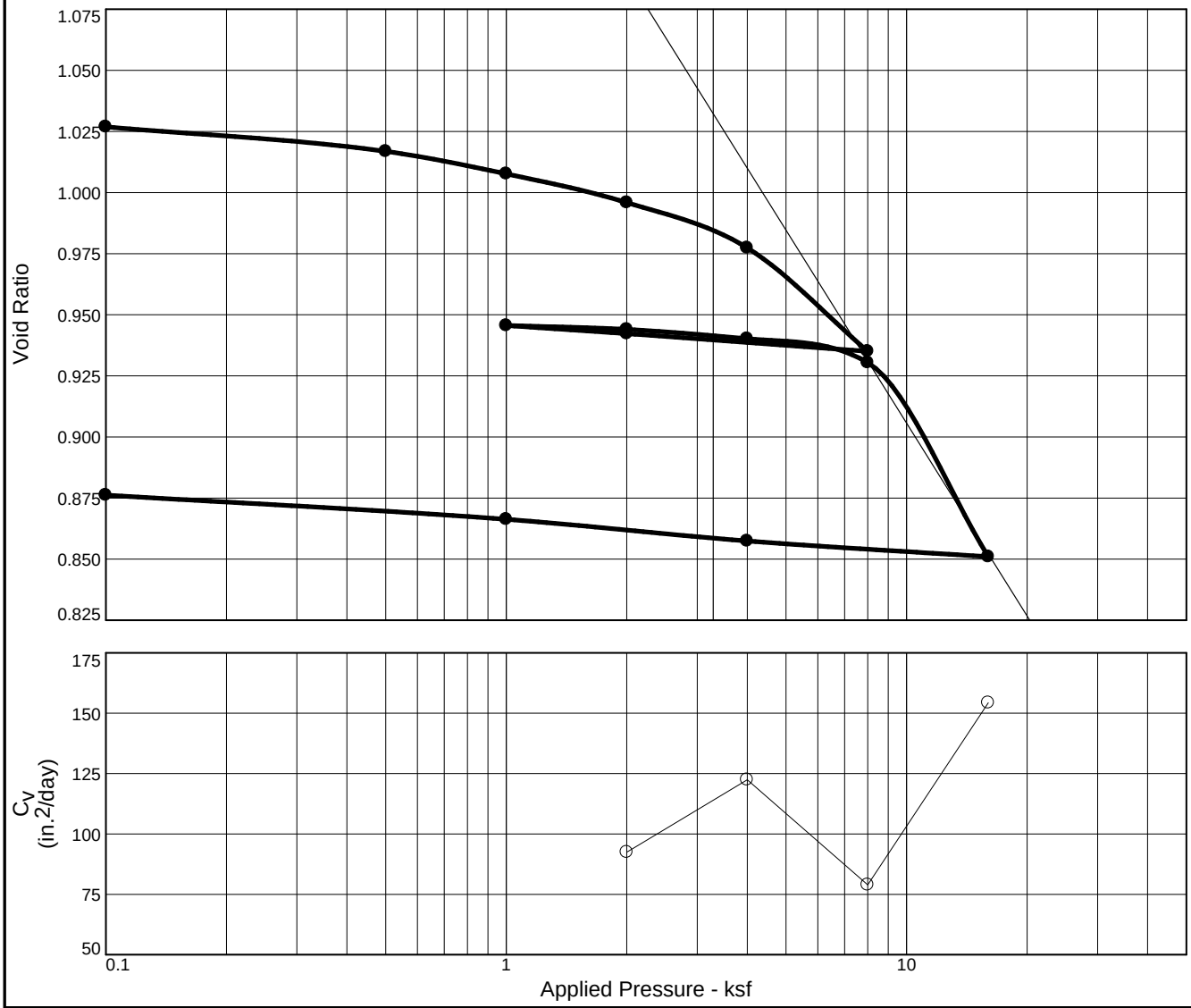
Table IV-2: Summary of Lab Results for Corrosivity

Location	Depth (ft)	pH	Total Chlorides (ppm)	Total Sulfates (ppm)	Minimum Resistivity (k-ohms-cm)
NS-01	10-12	--	--	--	19,000
NS-03	6-7.5	5.38	Not Detected	Not Detected	--
NS-03	8.5-10	5.23	Not Detected	Not Detected	--
NS-03	13.5-15	4.80	Not Detected	Not Detected	--

Table IV-3: Summary of Rock Core Compressive Strength Test

Location	Depth (ft)	Unconfined Compressive Strength (psi)
NS-02	43	13,660
NS-09	42.5	13,230

CONSOLIDATION TEST REPORT ASTM D2435



MATERIAL DESCRIPTION	USCS	AASHTO
Dark red slightly sandy silt		

LL	PI	Sp. Gr.	Overburden (ksf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P_c (ksf)	C_c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
53	21	2.768	8	85.2	91.3	28.0 %	30.2 %	75.3 %	95.3 %	1.028	0.876	5.4	0.26

	D2435 Method	C_r	Swell Press. (ksf)	%
Preparation Process: Trimmed intact specimen				
Condition of Test: Inundated	B			

Project No. 3282-19-054 **Client:** Garver, LLC

Project: Bridge on Old SR 20 over NS Railroad

Location: NS-01 **Depth:** 10'-12' **Sample Number:** UD-1

S&ME, Inc.

Duluth, Georgia

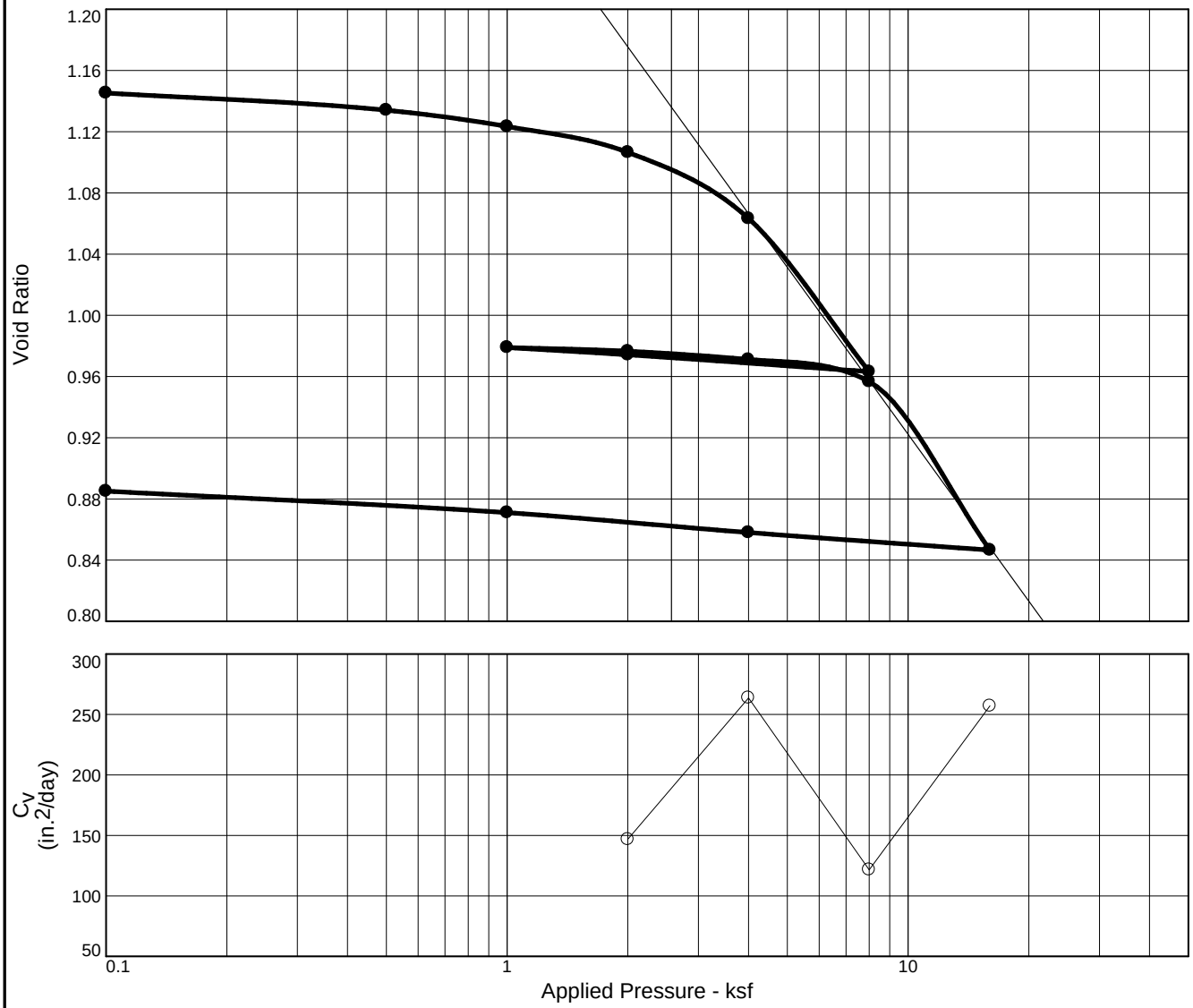
Remarks:

Checked By: Jimmy Hanson

Title: Geotechnical Lab Supervisor

Figure 1

CONSOLIDATION TEST REPORT ASTM D2435



MATERIAL DESCRIPTION	USCS	AASHTO
Dark red slightly sandy silt		

LL	PI	Sp. Gr.	Overburden (ksf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P_c (ksf)	C_c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
59	27	2.736	8	79.5	89.85	29.6 %	31.4 %	70.6 %	96.9 %	1.147	0.885	3.5	0.36

Preparation Process: Trimmed intact specimen

Condition of Test: Inundated

D2435 Method	C_r	Swell Press. (ksf)	%
B			

Project No. 3282-19-054 **Client:** Garver, LLC

Project: Bridge on Old SR 20 over NS Railroad

Location: NS-11 **Depth:** 8'-10' **Sample Number:** UD-1

S&ME, Inc.

Duluth, Georgia

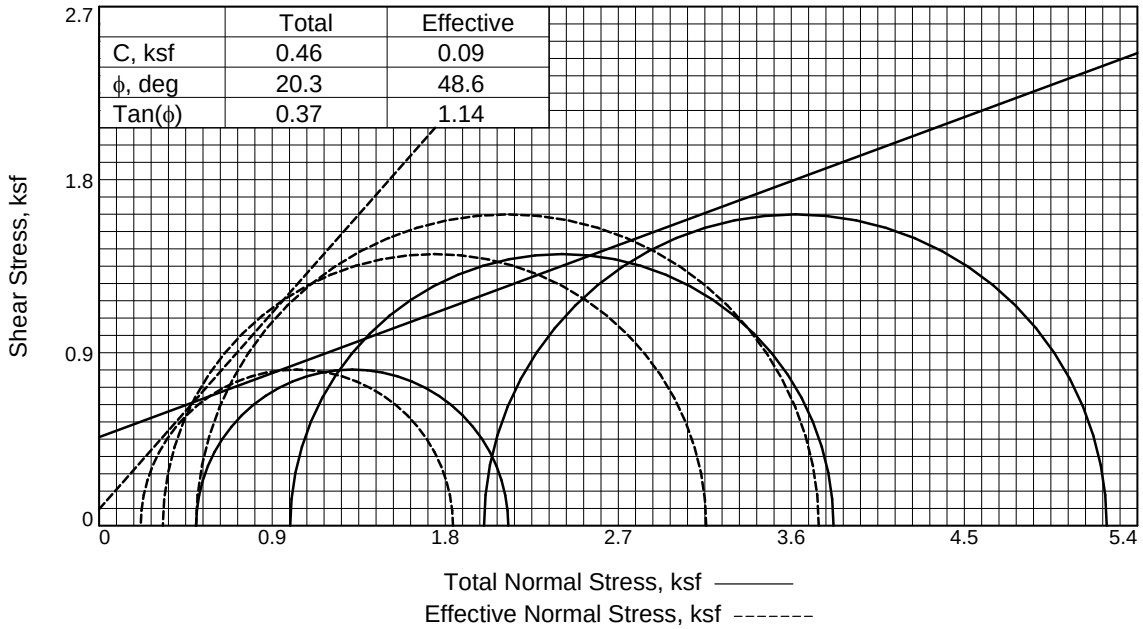
Remarks:

Checked By: Jimmy Hanson

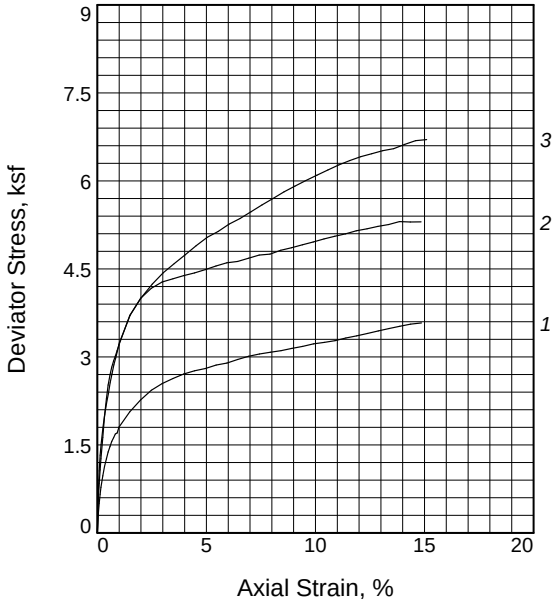
Title: Geotechnical Lab Supervisor

Figure 1

C & phi are not test results but an interpretation of the test results. The designer is responsible for interpreting test data as provided by S&ME.



	Total	Effective
C, ksf	0.46	0.09
ϕ, deg	20.3	48.6
Tan(ϕ)	0.37	1.14



Sample No.		1	2	3
Initial	Water Content, %	24.5	24.5	24.5
	Dry Density, pcf	92.9	95.7	96.2
	Saturation, %	78.8	84.2	85.2
	Void Ratio	0.8607	0.8055	0.7965
	Diameter, in.	2.855	2.850	2.860
	Height, in.	6.067	6.084	5.991
At Test	Water Content, %	30.8	28.5	27.8
	Dry Density, pcf	93.3	96.7	97.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8515	0.7878	0.7696
	Diameter, in.	2.850	2.841	2.846
	Height, in.	6.057	6.064	5.961
Strain rate, %/min.		0.10	0.10	0.10
Back Pressure, psi		70.00	70.00	70.00
Cell Pressure, psi		73.50	76.90	83.90
Fail. Stress, ksf		1.62	2.83	3.24
Excess Pore Pr., ksf		0.29	0.66	1.50
Ult. Stress, ksf		3.58	5.30	6.71
Excess Pore Pr., ksf		-0.43	-0.46	0.00
$\bar{\sigma}_1$ Failure, ksf		1.84	3.16	3.74
$\bar{\sigma}_3$ Failure, ksf		0.22	0.33	0.50

Type of Test:
CU with Pore Pressures

Sample Type: Intact

Description: Dark red slightly sandy silt

LL= 53 **PL=** 32 **PI=** 21

Specific Gravity= 2.768

Remarks: Trimmed intact specimens to length

Figure 1

Client: Garver, LLC

Project: Bridge on Old SR 20 over NS Railroad

Location: NS-01

Sample Number: UD-1 **Depth:** 10'-12'

Proj. No.: 3282-19-054 **Date Sampled:** 7/16/19

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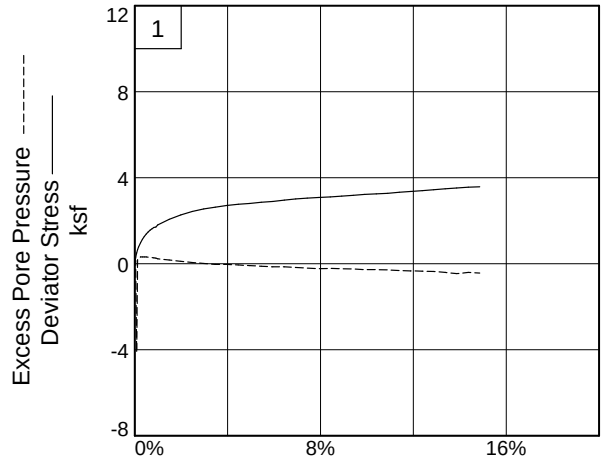
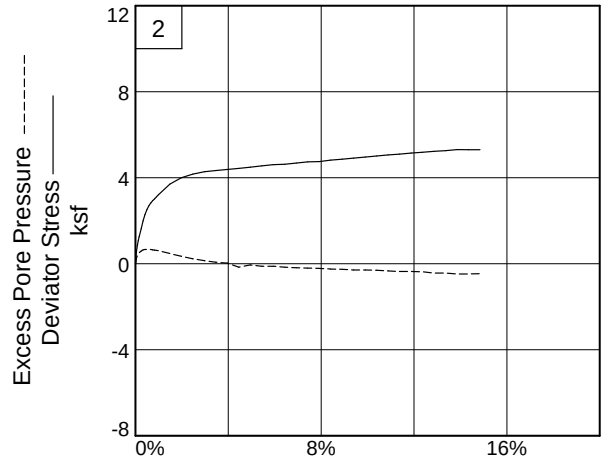
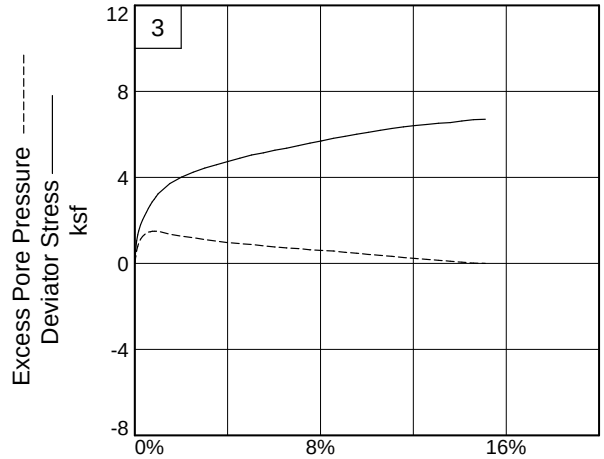
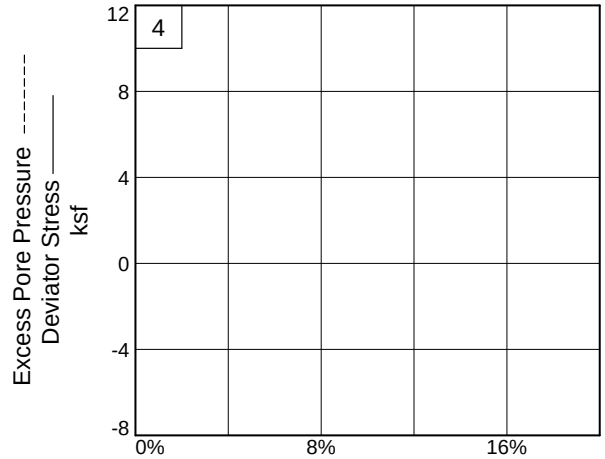
S&ME, Inc.
Duluth, Georgia

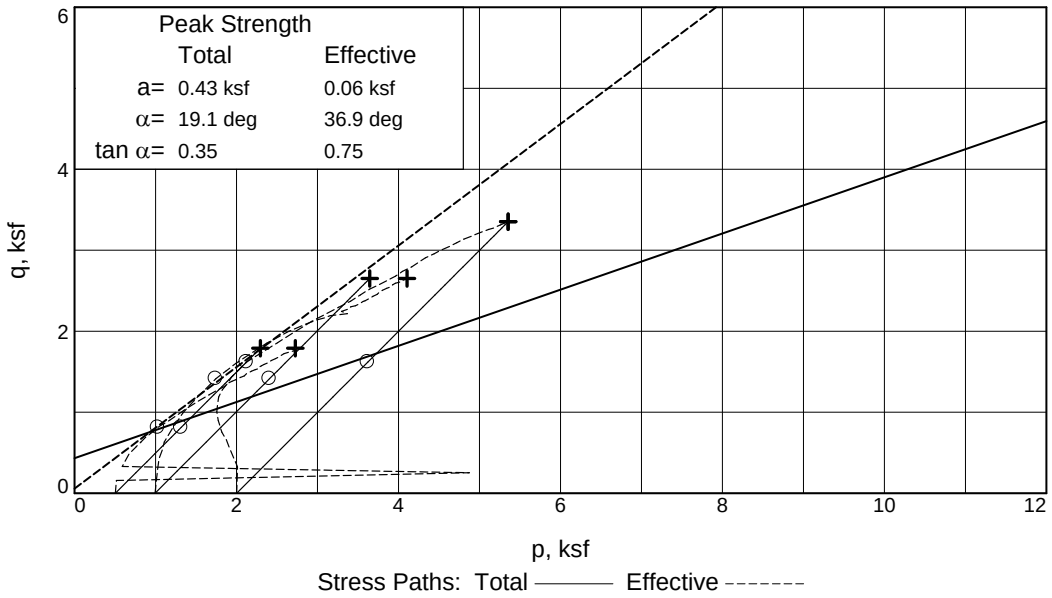
Checked By: Jimmy Hanson









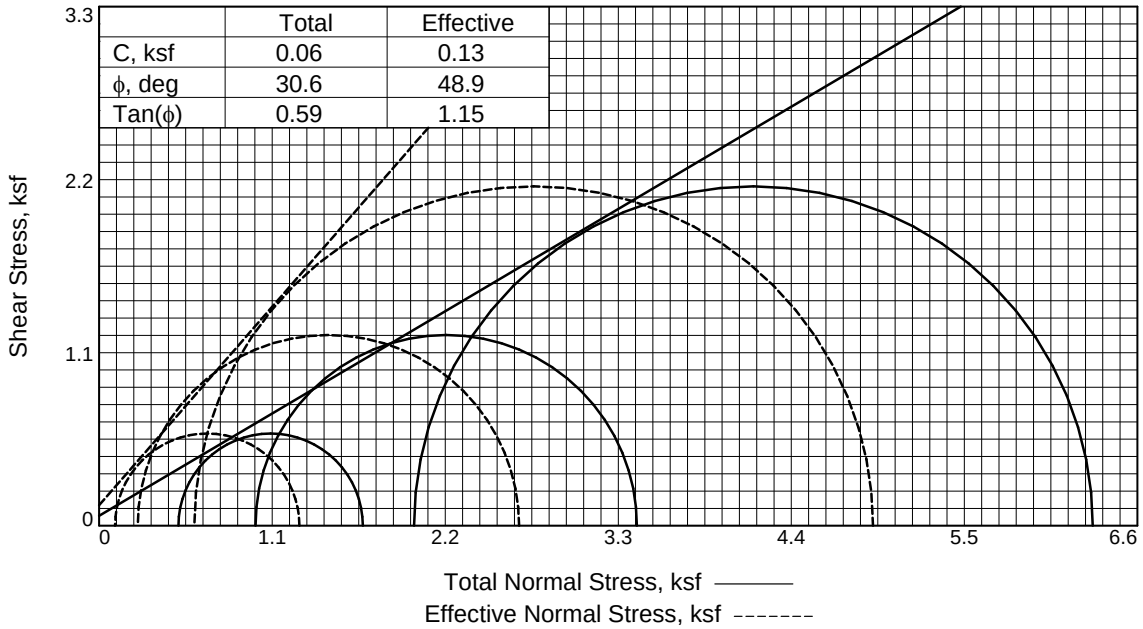


Client: Garver, LLC
Project: Bridge on Old SR 20 over NS Railroad
Location: NS-01 **Depth:** 10'-12' **Sample Number:** UD-1
Project No.: 3282-19-054 **Figure** 2

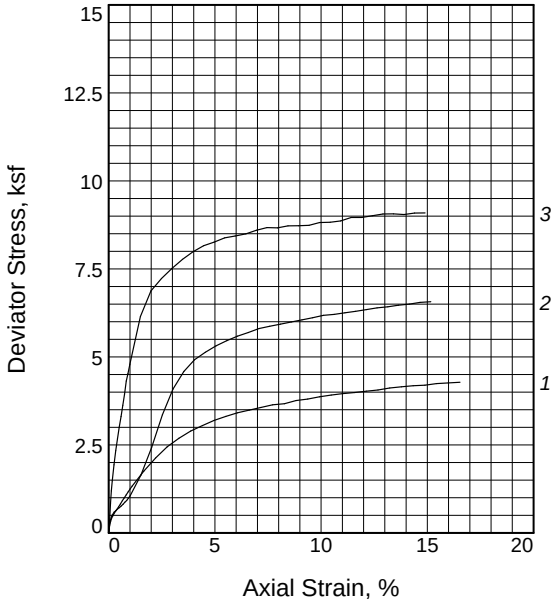
S&ME, Inc.

Checked By: Jimmy Hanson

C & phi are not test results but an interpretation of the test results. The designer is responsible for interpreting test data as provided by S&ME.



	Total	Effective
C, ksf	0.06	0.13
ϕ, deg	30.6	48.9
Tan(ϕ)	0.59	1.15



Sample No.		1	2	3
Initial	Water Content, %	21.9	21.9	21.9
	Dry Density, pcf	96.1	98.1	99.9
	Saturation, %	77.0	80.8	84.3
	Void Ratio	0.7768	0.7406	0.7102
	Diameter, in.	2.880	2.873	2.880
	Height, in.	5.458	5.979	6.074
At Test	Water Content, %	27.8	25.7	25.0
	Dry Density, pcf	97.0	100.3	101.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7612	0.7032	0.6841
	Diameter, in.	2.872	2.852	2.865
	Height, in.	5.442	5.936	6.043
Strain rate, %/min.		0.10	0.10	0.10
Back Pressure, psi		70.00	70.00	70.00
Cell Pressure, psi		73.50	76.90	83.90
Fail. Stress, ksf		1.17	2.42	4.31
Excess Pore Pr., ksf		0.40	0.75	1.40
Ult. Stress, ksf		4.28	6.57	9.09
Excess Pore Pr., ksf		-0.68	-0.94	-1.09
$\bar{\sigma}_1$ Failure, ksf		1.27	2.67	4.92
$\bar{\sigma}_3$ Failure, ksf		0.10	0.24	0.60

Type of Test:
CU with Pore Pressures

Sample Type: Intact

Description: Dark red slightly sandy silt

Assumed Specific Gravity= 2.736

Remarks: Trimmed intact specimens to length

Client: Garver, LLC

Project: Bridge on Old SR 20 over NS Railroad

Location: NS-12

Sample Number: UD-1 **Depth:** 10'-12'

Proj. No.: 3282-19-054 **Date Sampled:** 7/11/19

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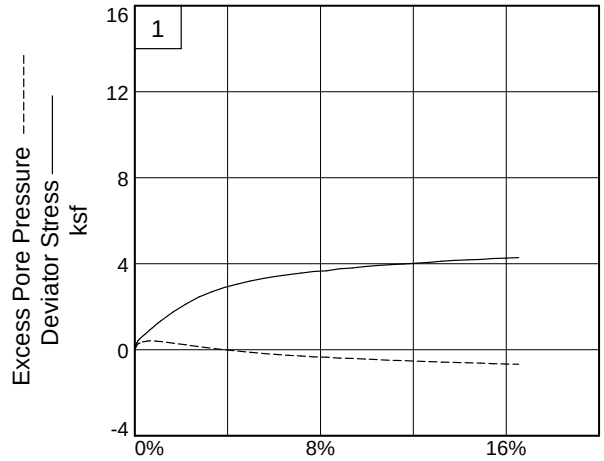
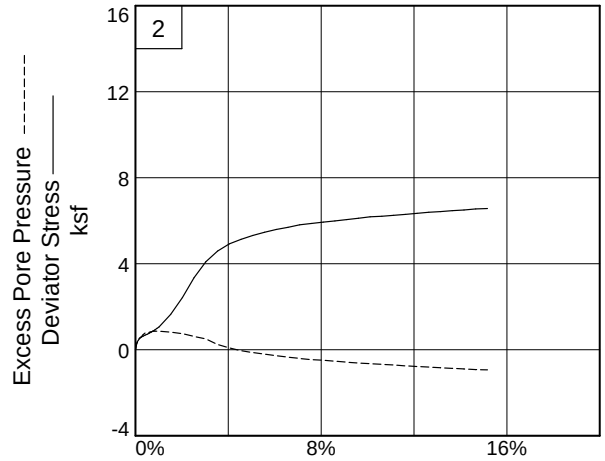
S&ME, Inc.
Duluth, Georgia

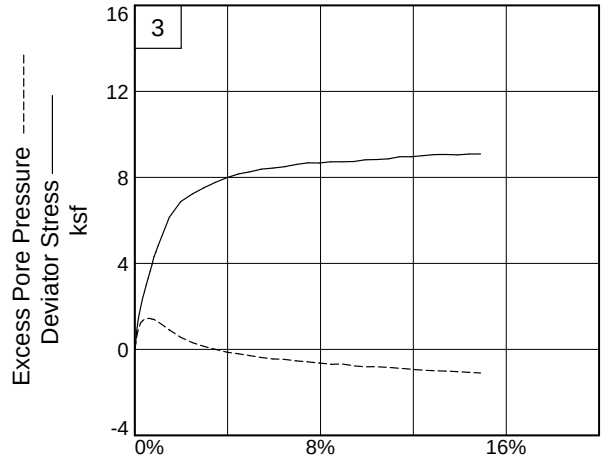
Figure 1

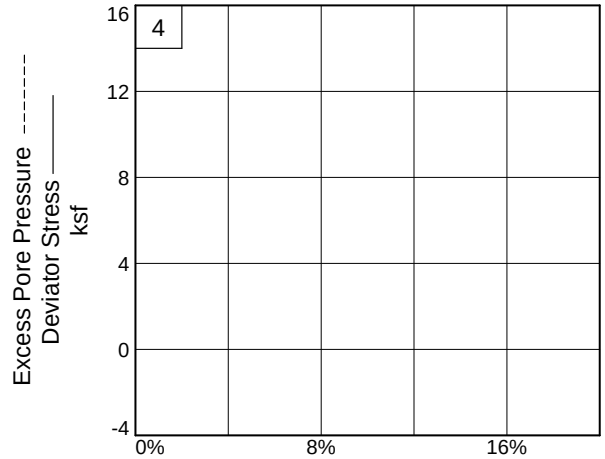
C & phi are not test results but an interpretation of the test results. The designer is responsible for interpreting test data as provided by S&ME.

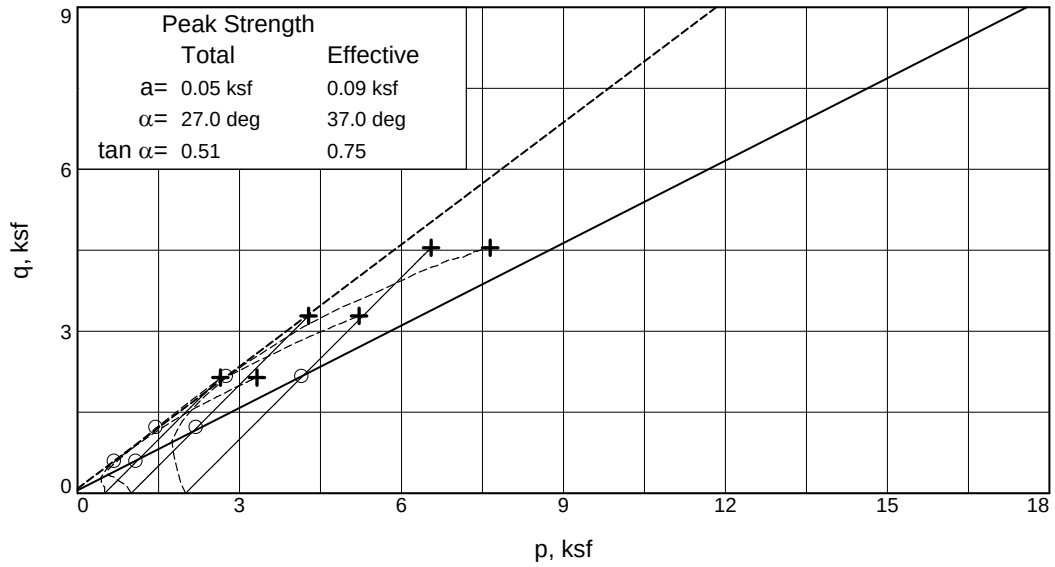
Checked By: Jimmy Hanson











Stress Paths: Total ——— Effective -------

Client: Garver, LLC
Project: Bridge on Old SR 20 over NS Railroad
Location: NS-12 **Depth:** 10'-12' **Sample Number:** UD-1
Project No.: 3282-19-054 **Figure** 2

S&ME, Inc.

Checked By: Jimmy Hanson

C & phi are not test results but an interpretation of the test results. The designer is responsible for interpreting test data as provided by S&ME.