Geotechnical Exploration Report
Butterfly Branch Pedestrian Bridge
Spartanburg, South Carolina
S&ME Project No. 1426-16-114

S&ME

Prepared for:
City of Spartanburg
PO Box 1749
Spartanburg, South Carolina 29302

Prepared by:
S&ME, Inc.
301 Zima Park Drive
Spartanburg, South Carolina 28704

December 5, 2016

December 5, 2016

City of Spartanburg
PO Box 1749
Spartanburg, South Carolina 29302

Attention: Mr. John (Jay) Squires
Streets & Storm Water Manager

Reference: **Geotechnical Exploration Report**
Butterfly Branch Pedestrian Bridge
Spartanburg, South Carolina
S&ME Project No. 1426-16-114

Dear Mr. Squires:

S&ME, Inc. is pleased to submit this Geotechnical Exploration Report for the referenced project. The exploration was performed in general accordance with our Proposal No. 14-1600794, dated November 10, 2016 and authorized by you on November 14, 2016. The purpose of the exploration was to evaluate general subsurface conditions near each end bent area with respect to foundation support and grading. This report presents a brief description of our understanding of the project, the exploration results, and our geotechnical conclusions and recommendations.

We appreciate the opportunity to provide our continued service to the City of Spartanburg. If you have any questions regarding the information in this report or we may be of further service, please contact us.

Sincerely,

S&ME, Inc.

Michael Revis
Dec 5 2016 2:45 PM

SOUTH CAROLINA
REGISTERED PROFESSIONAL ENGINEER
NO. 19495
MICHAEL G. REVIS

Michael Revis, P.E.
Senior Engineer

David Swoap, P.E.
Senior Engineer

SOUTH CAROLINA
S&ME, INC.
NO. C00473
CERTIFICATE OF AUTHORIZATION

MR/DS *T:\Projects\2016\GEO\1426-16-114 Butterfly Branch Bridge City of Sptbg\Deliverables\report\Butterfly Branch Pedestrian Bridge Geotechnical Report.docx*

Table of Contents

Appendix

1.0 Project Information

Our understanding of the project is based on the following:

- An e-mail transmittal from Mr. Squires to Mr. Richard Bonds, PE with S&ME on October 21, 2016 requesting geotechnical services;
- Review of *Bridge Layout Plan and Pedestrian Bridge Details* plan sheets (Pages 4.0 through 4.5, dated 11/7/16) prepared by Bridge Brothers and provided as an attachment to the above referenced e-mail;
- Review of *Existing Conditions Plan* (Page 2.0 dated 10/13/16) prepared by Blackwood Associates, Inc. and Landart and provided as an attachment to the above referenced e-mail; and
- A site visit by Mr. Revis conducted on November 16, 2016.

Based on the provided information, we understand a new pedestrian bridge will be constructed as part of the Butterfly Branch Greenway project in Spartanburg, South Carolina. Butterfly branch is currently piped at the proposed bridge location; however, the Greenway project will restore the Butterfly Branch channel and floodplain. Based on the provided information, the bridge is expected to be a 120 ft. long steel frame structure, with a structural height of about 8.5 ft., 10 ft. clear width and 4 in. concrete deck over metal decking. The bridge will be subjected to pedestrian and lawn maintenance equipment (10,000 lb. maximum vehicle weight). Foundation information was not provided; however, the bridge is expected to be supported by a deep foundation system with pile cap/abutment. The maximum vertical load (dead + live load) at each end bent bearing plate is expected to be 46.6 kips. There will be two (2) bearing plates per bent. The maximum total horizontal load at each bend bent will be approximately 4.8 kips.

The location of the bridge will be near the current alignment of Farley Street, near its intersection with Millpond Road. Site grading for the project will require excavation to depths of 8 to 10 ft. At the proposed branch crossing, the channel will be about 12 ft. wide, with the bottom of the bridge approximately 6 ft. above the water surface.

2.0 Exploration and Testing

The field exploration included a visual site reconnaissance by the Geotechnical Engineer and the performance of two (2) soil test borings (labeled B-1 and B-2) drilled to a depth of 40 ft. below the surface. The borings were generally performed near the requested locations provided by the City of Spartanburg and adjusted for underground utilities based on locate information provided by the SC811 service and a private contractor (USI, Inc.) hired by S&ME. Farley Street was temporarily closed for drill crew safety. The approximate boring locations are shown on the attached Figure 1 – Boring Location Plan in the Appendix. Ground surface elevations at the boring locations were interpreted from the provided topographic plan and are shown on the Boring Logs in the Appendix. Ground surface elevations should be considered approximate.

The borings were performed with a truck mounted drill rig (CME 45) with an automatic hammer, using hollow-stem auger techniques to advance each hole. Split-spoon samples and Standard Penetration Resistance (N) values were obtained at 2.5-ft. intervals in the upper 10 ft., and then at 5-ft. intervals thereafter. Prior to backfilling the boreholes with the auger cuttings and installing mechanical hole plugs, the depth to subsurface water was measured in each borehole. The asphalt was then patched using cold asphalt patch.

The samples obtained during the exploration were transported to our laboratory where they were visually and manually classified by the Geotechnical Engineer. The visual and manual classification was estimated based on the Unified Soil Classification System (USCS) and our experience with similar soil conditions.

3.0 Site and Subsurface Conditions

3.1 Site Conditions

The project site is located along Farley Street at its intersection with Millpond Road in Spartanburg, South Carolina. Butterfly Branch and its floodplain are visible about 150 ft. southeast of Farley Street; however, it is currently piped beneath Farley Street (and points to the northwest). Ground cover consist of asphalt along the public streets, and grass, crushed stone and/or bare earth beyond the street limits. The branch and floodplain area just southeast of Farley Street is overgrown. Multiple underground utilities are present along Farley Street and Millpond Road. Existing topography varies from highs of about 770 ft. to 772 ft. at the southwest and northeast abutment areas, respectively.

Pedestrian bridge area (looking from northeast to southwest)

3.2 Area Geology

The project site is in the Piedmont Physiographic Province of South Carolina. The Piedmont Physiographic Province is a relatively broad strip extending from central Alabama across Georgia and the Carolinas into Virginia. The rock types are primarily metamorphic gneiss and schist with some granite intrusions.

The major portion of the bedrock in the Piedmont is covered with a varying thickness of residual soil, which has been derived by chemical decomposition and physical weathering of the underlying rock. The residual soils developed during the weathering of this bedrock consist predominately of micaceous silty sands and sandy silts which grade to micaceous clayey silts and silty clays with nearness to the ground surface. The thickness residual soils can vary from only a few feet to in excess of 100 feet.

The boundary between the residual soil and the underlying bedrock is not sharply defined. Generally, a transition zone consisting of very hard soil and soft rock appropriately classified as “partially weathered rock” is found. Within the transition zone, large boulders or lenses of relatively fresh rock often exist, which are generally much harder than the surrounding material. The irregular bedrock surface is basically a consequence of differential weathering of the various minerals and joint patterns of the rock mass

Fill soils are placed by man in conjunction with activities such as construction grading, farming, or other past development. Fill can be comprised of a variety of soil types and can also contain debris from building demolition, organics, topsoil, trash, etc. The engineering properties of fill depend primarily on its composition, density, and moisture content. We do not expect that any documentation (i.e., in-place density tests, engineering monitoring reports, etc.) of the fill placement at this site was performed.

Typically, the upper soils along rivers, creeks, drainage features, and in flood plain areas are water-deposited materials (termed alluvium) that have been eroded and washed down from higher ground. These alluvial soils are usually wet, soft and compressible, having never been consolidated by pressures in excess of their present overburden.

3.3 Subsurface Conditions

3.3.1 Surface Material

Boring B-1 initially penetrated a 5 in. thick layer of asphalt, while boring B-2 encountered 8 in. of asphalt underlain by 2 in. of crushed stone. Surface material type and thickness will vary.

3.3.2 Existing Fill

Beneath the surface materials, each boring encountered a layer of existing fill to depths of about 5.5 ft. (B-1) and 3 ft. below the surface (B-2). The fill consisted of sandy lean clay (USCS symbol of “CL”), elastic silt with sand (MH) or clayey sand (SC). The fill contained trace concrete and coal fragments and an unburnt coal seam. The fill exhibited standard penetration resistance values (N-value) of 4 to 8 blows per foot (bpf), indicating a poor degree of compaction.

3.3.3 Alluvium

Below the fill, alluvial deposits were encountered to depths of about 12 ft. (B-1) and 8 ft. (B-2) below the existing ground surface.. An additional 5 ft. layer below the identified alluvium in boring B-1 was denoted as possible alluvium (to a depth of 16 ft. below the ground surface). Possible alluvium was used because it was difficult to conclusively determine if the materials were naturally occuring residual soil or alluvial. (However, based on the blow counts the possible alluvium has a much higher consistency than that typically classified as alluvium.) As previously mentioned, alluvium is material deposited by flowing water. The alluvial materials consist of sandy fat clay (CH), sandy lean clay (CL), silt with sand (ML) and silty sand (SM). The N-values in the alluvium varied from 2 to 6 bpf, indicating a very loose relative density for silty sand and a soft to firm consistency with the silt and clay. All of the sampled alluvium was wet.

3.3.4 Residuum

Below the alluvium/possible alluvium, residual soils consistent with the Piedmont Physiographic Province of South Carolina were encountered to a termination depth of 40 ft. below the ground surface of each boring. The residual soils were generally comprised of sandy silt (ML) and silty sand (SM) with a varying mica content. The residual soils are generally denoted as moist or wet on the Boring Logs.

Standard penetration resistance values (N-values) in the residual soils ranged from 4 to 21 bpf. These values indicate a very loose to medium dense relative density in the sandy soils and a stiff consistency in the silts. However, it should be noted that some of the N-values may have been influenced by sampling below the subsurface water table.

3.3.5 Subsurface Water

Subsurface water was encountered in borings B-1 and B-2 at the time of drilling at depths of 9.5 and 11 ft. (elevation 762.5 ft. and 759 ft.) below the surface, respectively. The holes were backfilled before leaving the site because of safety concerns and the asphalt was patched. Based on the observed water level in Butterfly Branch at the time of drilling and the provided topography, the static subsurface water level is expected to be between elevations 762 to 758 ft. Flood levels would be higher. It should be noted that groundwater levels will fluctuate during the year and from year to year due to seasonal and climatic changes, construction activity, branch levels, and other factors, and will be at different depths in the future.

3.3.6 General

The above description of subsurface conditions is relatively brief and general. Please refer to the generalized subsurface profile depicted on Figure 2 and the Boring Logs in the Appendix for more detailed information at individual boring locations.

4.0 Conclusions and Recommendations

4.1 General Discussion

Based on subsurface conditions, it is our opinion a shallow foundation system would be problematic because of the erratically compacted fill (which contains concrete and coal) and very low consistency alluvial soils, and the potentially large settlements that could occur in these soils due to the structural loads. Because of these conditions, we recommend a deep foundation system be used to support each end of the pedestrian bridge. There are several deep foundation types that could be installed to support the bridge including driven timber piles, helical piers and possibly micropiles; however, relatively small diameter drilled piers bearing in residuum (below the alluvium and preferably between 30 and 40 ft. below the existing ground surface) would provide an effective compromise for installation, performance and economics. If a shallow, conventional support is still considered, ground improvement and possibly construction dewatering would be required. The following recommendations pertain to drilled piers. If other foundation alternatives are considered, we can provide additional information.

4.2 Foundation Recommendations – Drilled Piers

4.2.1 Axial Loading

Based on the provided information, the end bent load will be on the order of 46.6 kips per bearing plate (or approximately 93.2 kips per bent). Given the anticipated bridge width and length, we would anticipate that each end bent can be supported by two (2) drilled piers bearing in residual soil. The drilled piers will provide support by a combination of end bearing on residual soil and skin friction in the residual soils.

Any existing fill and alluvial soils will not provide significant support and should be ignored in pier design for compression and uplift. For pier design, an allowable end bearing of 4 ksf can be used for piers bearing at least 30 ft. below the ground surface, with skin friction determined cumulatively (in residual soil only) using an allowable skin friction value of 0.3 ksf. These design values include a factor of safety of at least 2. In general, an allowable axial capacity of up to 50 kips (25 tons) is available for a 2-ft. diameter drilled pier bearing 30 ft. below the ground surface in residual soils and 70 kips (35 tons) bearing at 40 ft.

The uplift capacity for piers can be determined using the weight of the concrete and the skin friction in residual soils along the side of the pier. The buoyant unit weight of concrete should be used below the subsurface water levels. We suggest using a stabilized water elevation of 762 ft. for design purposes. Again, flood elevations would be higher.

4.2.2 *Lateral Loading*

Pier head conditions were modeled using the loads provided in the Bridge Reactions table on Page 4.1 of the Pedestrian Bridge Details (1) sheet and presented previously in Section 1.0. The 24 in. diameter piers were modeled for a "free" head condition. The overall structural capacity of the pier was not considered in our analysis and should be checked.

Based on the boring data, we estimate the piers have a minimum embedment length of 30 ft. below the design grade. The results of the lateral analyses are summarized in Table 4-1.

Table 4-1: LPile Results

Loading Case	Top Deflection (in.)	Maximum Shear, V (kips)	Maximum Moment, M (ft-kips)
V=4.8 kips	<0.1	4.8	30
δ=0.25 in.	0.25	26.7	170

Notes: δ- Deflection
V- Maximum Shear
M - Maximum Moment

Lateral capacity will be greatly reduced if the surrounding soils are eroded. Thus, we recommend protecting the piers by installing rip rap or other erosion control devices on the branch banks beneath and beyond the bridge limits to help reduce the potential of erosion.

4.2.3 *Drilled Pier Installation and Evaluation*

The following are general procedures recommended in constructing the drilled piers using the "dry" method. Because of the high subsurface water level, construction casing will be required to facilitate pier installation. The casing will need to be removed for the pier to develop the proper axial resistance.

1. Drilling equipment should have cutting teeth to result in a hole with little or no soil smeared or caked on the sides; a spiral like corrugated side should be produced. The pier diameters should be at least equal to the design diameter for the full depth.

2. The drilled piers should be drilled to satisfy a plumbness tolerance of 1.5 to 2 percent of the length and an eccentricity tolerance of 2 to 3 inches from plan location.

3. Subsurface water will be encountered to install the piers. Subsurface water should be removed by pumping, leaving no more than 2 inches in the bottom of each pier excavation.

4. A removable steel casing should be installed in the pier for the entire depth to prevent caving of the excavation sides due to soil relaxation. Loose or soft soils in the bottom of the piers should be removed.

5. The drilled pier excavations should be evaluated by a representative of the Geotechnical Engineer to confirm suitable end bearing conditions and to verify the proper diameter and bottom cleanliness. The piers should be evaluated immediately prior to and during concreting operations.

6. The drilled piers should be concreted as soon as practical after excavation to reduce the deterioration of the supporting soils due to soil caving and any subsurface water intrusion.

7. The slump of the concrete is very important for the development of side shear resistance. We recommend a concrete mix having a slump of 6 to 8 inches be used with the minimum compressive strength specified by the structural engineer. A mix design incorporating super plasticizer may be needed to obtain this slump.

8. The concrete may be allowed to fall freely through the open area in the reinforcing steel cage provided it is not allowed to strike the rebar or the casing prior to reaching the bottom of the pier excavation.

9. The protective steel casing should be extracted as concrete is placed. However, a head of concrete should be maintained above the bottom of the casing to prevent soil and water intrusion into the concrete below the casing.

Due to the inherent variability in the subsurface materials, a Geotechnical Engineer should verify the design parameters are valid during construction. Some modification to the design values presented above may be required in the field.

4.3 Seismic Information

We have reviewed the procedures outlined in 2015 International Building Code (IBC). Based on existing soil conditions in the borings and the expected foundation type and bearing depth, we recommend a Site Class of D be used in the design of each end bent.

4.4 Scour

Scour of the bridge foundations and branch banks near the end bent locations will be an important consideration, and should be evaluated as part of the bridge design. We understand this evaluation will be handled by others.

4.5 General Earthwork Recommendations

4.5.1 Fill Placement and Compaction

Fill placed around the bridge abutment should be raised to the design subgrade elevation with soil free of deleterious materials and rock fragments greater than 4 inches in diameter. The fill should be uniformly spread in 6- to 8- inch thick loose lifts and be compacted to at least 95 percent of the soil's maximum dry density, as determined by a laboratory standard Proctor compaction test (ASTM D-698). This percentage should be increased to 98 percent in the upper 1 foot of subgrade for the proposed pavement areas. The moisture content should be controlled at plus to minus 3 percent of optimum.

A qualified Materials Technician working under the direction of the Geotechnical Engineer should observe fill placement. The Technician should perform a sufficient number of in-place field density tests during mass grading and backfilling of utility trenches to assess whether the recommended compaction criteria have been achieved. Field check plugs should be performed to determine appropriate standard Proctor comparisons.

4.6 Excavation Considerations

Low to moderate consistency soils will most probably be encountered during installation of the bridge abutments. These type soils can normally be excavated by routine earthmoving equipment; however, because of their low consistency, we suggest using light wide-tracked equipment to help reduce the disturbance to the subgrade. Some heavier equipment could be needed to remove any large concrete pieces.

It is important to realize that in this geologic region it is always possible that rock, boulders, PWR and very dense soils can be encountered in areas intermediate of the borings or in unexplored areas and difficult excavation, including blasting, can be required. Please keep in mind that excavation of PWR, although not encountered at shallow depths by these borings, will require more diligent efforts by the contractor with the possibility of some light blasting or the use of a backhoe-mounted ram.

Excavations should be sloped or shored in accordance with local, state, and federal regulations, including OSHA (29 CFR Part 1926) excavation trench safety standards. The contractor is solely responsible for site safety. This information is provided only as a service and under no circumstances should we be assumed responsible for construction site safety.

4.7 Dewatering

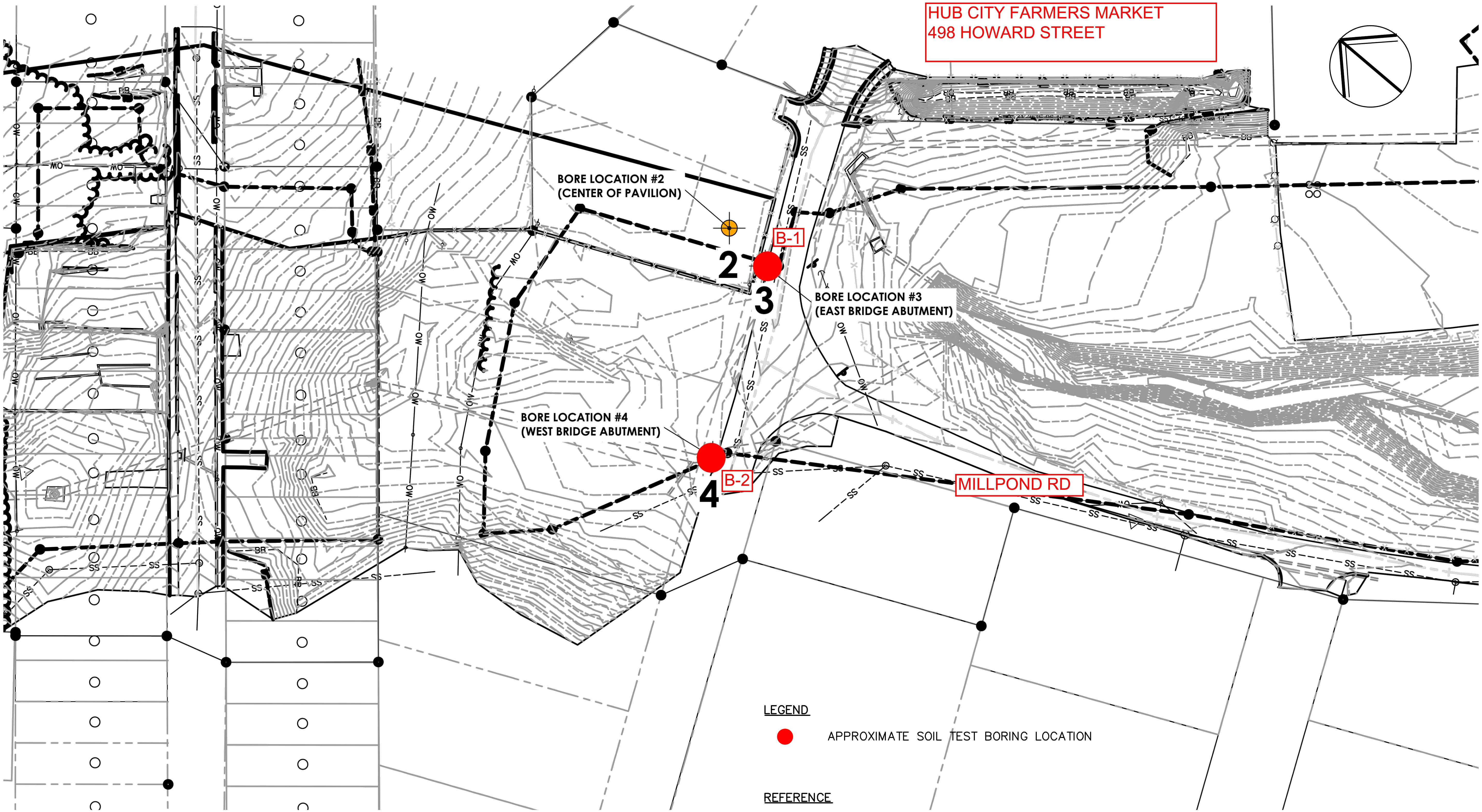
With using piers to support the bridge end bents, we do not anticipate dewatering (other than that required to dewater the cased pier excavations) to be required. However, if any excavations are made to facilitate abutment construction, then dewatering could be required. In general, if any excavation extends to near the branch water level, then an effective groundwater control system would most likely be needed during construction.

5.0 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice. The conclusions and recommendations contained herein are based on the applicable standards of the profession at the time this report was prepared. No other warranty, express or implied, is made.

The evaluations and recommendations submitted in this report are based, in part, upon the data obtained from the subsurface exploration. The nature and extent of variations in subsurface conditions will not become evident until construction. If variations appear evident during installation of the bridge foundations, then the conclusions and recommendations contained in this report may need to be re-evaluated. In the event any changes in the nature, design, or location of the bridge are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions of the report modified or verified in writing by S&ME, Inc.

Appendix



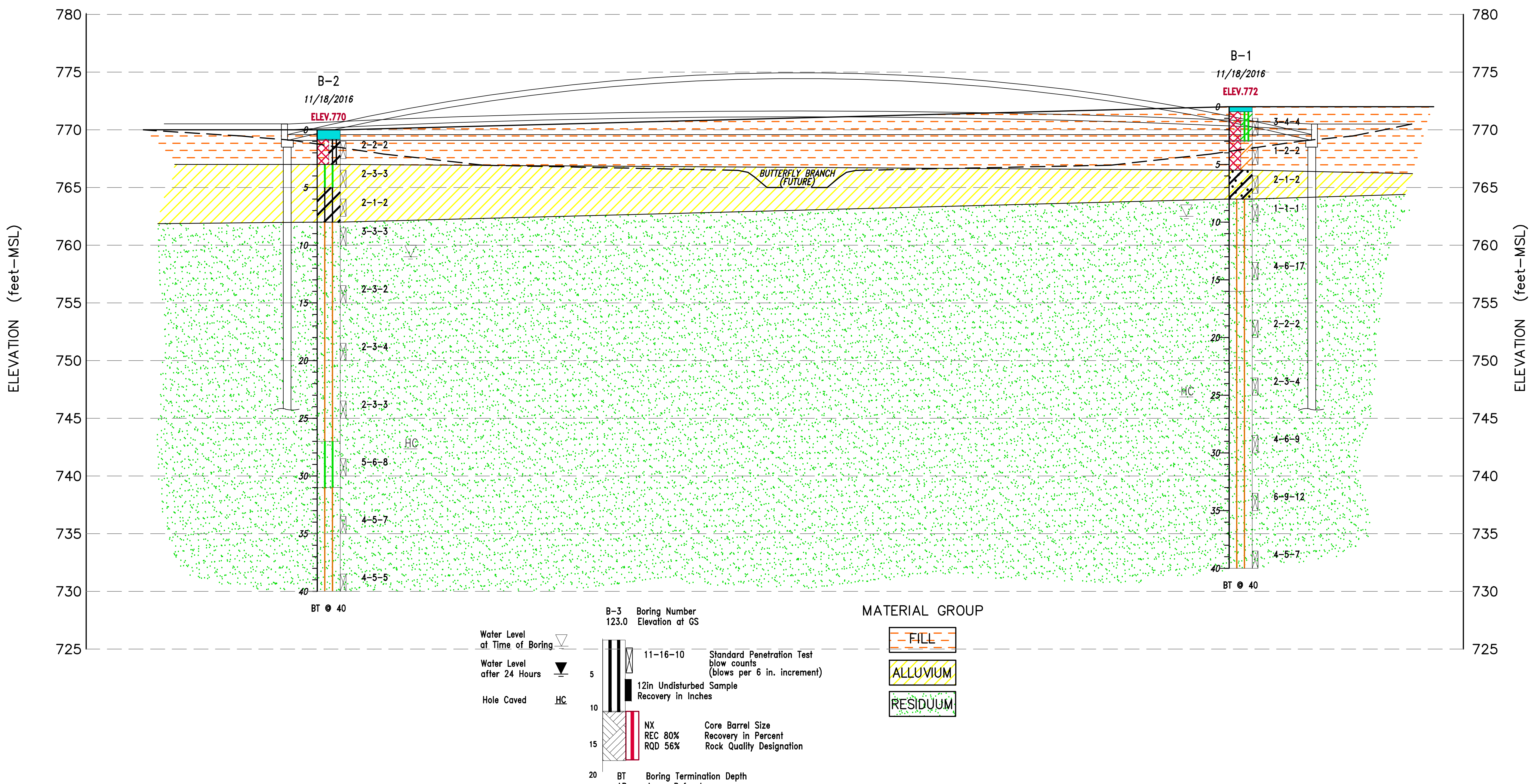
LEGEND

● APPROXIMATE SOIL TEST BORING LOCATION

REFERENCE

EXISTING CONDITIONS PLAN (SHEET 2.0 OF 7 DATED 10/13/16) PREPARED BY BLACKWOOD & ASSOCIATES, INC. AND LANDART.

DRAWN BY: MGR	CHK'D BY: DAS	SCALE: SCALE −60 0 60 FEET	S&ME, Inc. 301 ZIMA PARK DRIVE, SPARTANBURG, SC 29301 NC PE FIRM LICENSE NO. F-0176	BORING LOCATION PLAN	FIGURE NO.
PROJECT NO.: 1426-16-114	DATE: 12-5-16		864.232.8987 Greenville 864.574.2360 Spartanburg 864.576.8730 Fax www.smeinc.com	BUTTERFLY BRANCH PEDESTRIAN BRIDGE SPARTANBURG, SOUTH CAROLINA	1



NOTES

1. N = STANDARD PENETRATION TEST RESISTANCE VALUE (BLOWS PER FOOT)
2. THE DEPICTED STRATIGRAPHY IS SHOWN FOR ILLUSTRATIVE PURPOSES ONLY
3. THE ACTUAL SUBSURFACE CONDITIONS WILL VARY BETWEEN BORING LOCATIONS

DRAWN BY:	CHK'D BY:	SCALE:
MGR	DAS	1"= 10' (Vertical)
PROJECT NO.: 1426-16-114	DATE: 12-5-16	NTS (Horizontal)

S&ME

S&ME, Inc.
301 ZIMA PARK DRIVE, SPARTANBURG, SC 29301
NC PE FIRM LICENSE NO. F-0176

864.232.8987 Greenville
864.574.2360 Spartanburg
864.576.8730 Fax
www.smeinc.com

GENERALIZED SUBSURFACE PROFILE

BUTTERFLY BRANCH PEDESTRIAN BRIDGE

SPARTANBURG, SOUTH CAROLINA

FIGURE NO. 2

LEGEND TO SOIL CLASSIFICATION AND SYMBOLS

SOIL TYPES (USCS CLASSIFICATION)

(Shown in Graphic Log)

- Fill
- Asphalt
- Concrete
- Topsoil
- Gravel (GW, GM, GP)
- Sand (SW, SP)
- Silt (ML)
- Clay (CL, CH)
- Organic (OL, OH)
- Silty Sand (SM)
- Clayey Sand (SC)
- Sandy Silt (ML)
- Clayey Silt (MH)
- Sandy Clay (CL, CH)
- Silty Clay (CL, CH)
- Partially Weathered Rock
- Cored Rock

WATER LEVELS

(Shown in Water Level Column)

▽ = Water Level At Termination of Boring
▼ = Water Level Taken After 24 Hours
◄ = Loss of Drilling Water
HC = Hole Cave

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	STD. PENETRATION RESISTANCE BLOWS/FOOT
Very Soft	0 to 2
Soft	3 to 4
Firm	5 to 8
Stiff	9 to 15
Very Stiff	16 to 30
Hard	31 to 50
Very Hard	Over 50

RELATIVE DENSITY OF COHESIONLESS SOILS

RELATIVE DENSITY	STD. PENETRATION RESISTANCE BLOWS/FOOT
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	Over 50

SAMPLER TYPES

(Shown in Samples Column)

- Shelby Tube
- Split Spoon
- Rock Core
- No Recovery

TERMS

Standard Penetration Resistance - The Number of Blows of 140 lb. Hammer Falling 30 in. Required to Drive 1.4 in. I.D. Split Spoon Sampler 1 Foot. As Specified in ASTM D-1586.

REC - Total Length of Rock Recovered in the Core Barrel Divided by the Total Length of the Core Run Times 100%.

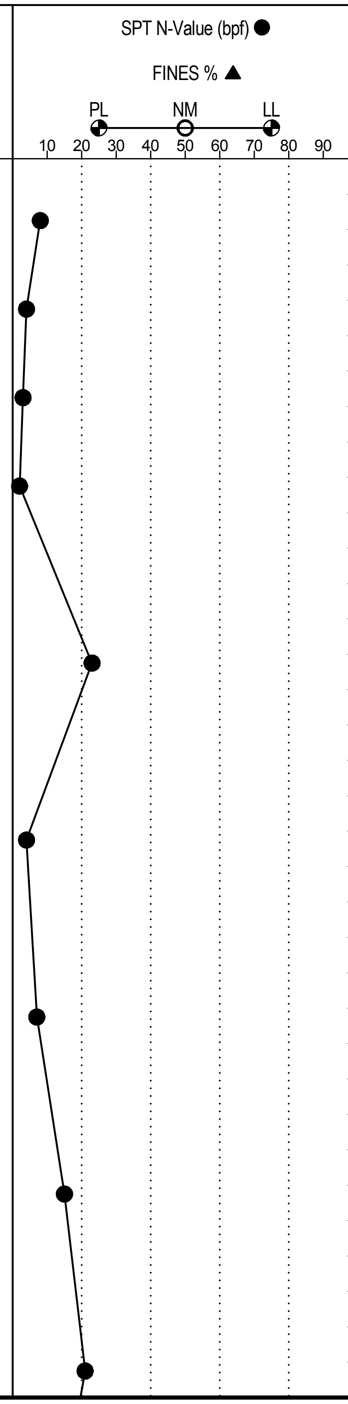
RQD - Total Length of Sound Rock Segments Recovered that are Longer Than or Equal to 4" (mechanical breaks excluded) Divided by the Total Length of the Core Run Times 100%.

S&ME

PROJECT: Butterfly Branch Pedestrian Bridge Spartanburg, South Carolina S&ME Project No. 1426-16-114		BORING LOG B-1	
CLIENT: **City of Spartanburg**	ELEVATION: **772.0 ft**	NOTES:	
DATE DRILLED: **11/18/16**	BORING DEPTH: **40.0 ft**		
DRILL RIG: **CME 45**	WATER LEVEL: **9.5 ft at TOB**		
DRILLER: **T. Whitehead, S. Bowman**	CAVE-IN DEPTH: **25'**		
HAMMER TYPE: **Automatic**	LOGGED BY: **M. Revis**	NORTHING: **1137548**	EASTING: **1717239**
SAMPLING METHOD: **Split spoon**			
DRILLING METHOD: **3¼" H.S.A.**			

MATERIAL DESCRIPTION
ASPHALT - 5 inches
FILL: ELASTIC SILT WITH SAND (MH) - firm, red orange, medium to fine, trace concrete fragments
FILL: CLAYEY SAND (SC) - very loose, tan black, fine, unburnt coal seams
ALLUVIUM: SANDY FAT CLAY (CH) - soft, dark gray, fine, wet
ALLUVIUM: SILTY SAND (SM) - very loose, light gray tan, trace clay, trace organics, very wet
POSSIBLE ALLUVIUM: SILTY SAND (SM) - medium dense, light gray, coarse to medium, trace mica, wet
RESIDUUM: SILTY SAND (SM) - very loose to medium dense, tan white brown, medium to fine, slightly micaceous, moist

DEPTH (feet)	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
			1	3	4	4	8
5		767.0	2	1	2	2	4
			3	2	1	2	3
10	∇	762.0	4	1	1	1	2
15		757.0	5	4	6	17	23
20		752.0	6	2	2	2	4
25	HC	747.0	7	2	3	4	7
30		742.0	8	4	6	9	15
			9	6	9	12	21



NOTES:

1. *THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.*
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.*

S&ME

PROJECT: **Butterfly Branch Pedestrian Bridge**
Spartanburg, South Carolina
S&ME Project No. 1426-16-114

BORING LOG B-1

CLIENT: **City of Spartanburg**	ELEVATION: **772.0 ft**
DATE DRILLED: **11/18/16**	BORING DEPTH: **40.0 ft**
DRILL RIG: **CME 45**	WATER LEVEL: **9.5 ft at TOB**
DRILLER: **T. Whitehead, S. Bowman**	CAVE-IN DEPTH: **25'**
HAMMER TYPE: **Automatic**	LOGGED BY: **M. Revis**
SAMPLING METHOD: **Split spoon**	
DRILLING METHOD: **3¼" H.S.A.**	

NOTES:

NORTHING: **1137548** EASTING: **1717239**

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	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
		RESIDUUM: SILTY SAND (SM) - very loose to medium dense, tan white brown, medium to fine, slightly micaceous, moist *(continued)*			10		4	5	7		12
40		Boring terminated at 40 feet		732.0							

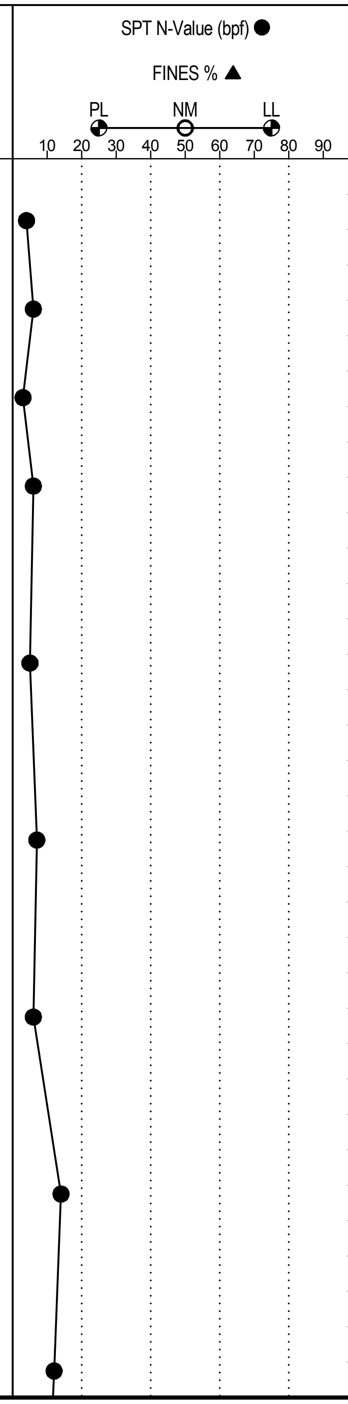
NOTES:

1. ***THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.***
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: **Butterfly Branch Pedestrian Bridge** **Spartanburg, South Carolina** **S&ME Project No. 1426-16-114**	**BORING LOG B-2**

CLIENT: **City of Spartanburg**	ELEVATION: **770.0 ft**	NOTES:
DATE DRILLED: **11/18/16**	BORING DEPTH: **40.0 ft**	
DRILL RIG: **CME 45**	WATER LEVEL: **11 ft at TOB**	
DRILLER: **T. Whitehead, S. Bowman**	CAVE-IN DEPTH: **27.5'**	
HAMMER TYPE: **Automatic**	LOGGED BY: **M. Revis**	NORTHING: **1137476** EASTING: **1717141**
SAMPLING METHOD: **Split spoon**		
DRILLING METHOD: **3¼" H.S.A.**		

DEPTH (feet)	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	1st 6in / RUN #	2nd 6in / REC	3rd 6in / RQD	N VALUE
0	**ASPHALT** - 8" Asphalt / 2" Crushed Stone								
	FILL: SANDY LEAN CLAY (CL) - soft, red, medium to fine, trace coal fragments, moist			1		2	2	2	4
	ALLUVIUM: SILT WITH SAND (ML) - firm, tan yellow, fine			2		2	3	3	6
5	**ALLUVIUM: SANDY LEAN CLAY (CL)** - soft, tan orange, medium to fine, very wet		765.0	3		2	1	2	3
	RESIDUUM: SILTY SAND (SM) - loose, light brown white orange, medium to fine, moist			4		3	3	3	6
10		∇	760.0						
15			755.0	5		2	3	2	5
20			750.0	6		2	3	4	7
25			745.0	7		2	3	3	6
	SANDY SILT (ML) - stiff, red brown, fine, slightly micaceous, dry	HC							
30			740.0	8		5	6	8	14
	SILTY SAND (SM) - medium dense to loose, brown white orange, medium to fine, moist to wet			9		4	5	7	12



NOTES:

1. *THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.*
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.*

S&ME

PROJECT: **Butterfly Branch Pedestrian Bridge Spartanburg, South Carolina** S&ME Project No. 1426-16-114	**BORING LOG B-2**

CLIENT: **City of Spartanburg**	ELEVATION: **770.0 ft**	NOTES:
DATE DRILLED: **11/18/16**	BORING DEPTH: **40.0 ft**	
DRILL RIG: **CME 45**	WATER LEVEL: **11 ft at TOB**	
DRILLER: **T. Whitehead, S. Bowman**	CAVE-IN DEPTH: **27.5'**	
HAMMER TYPE: **Automatic**	LOGGED BY: **M. Revis**	NORTHING: **1137476** EASTING: **1717141**
SAMPLING METHOD: **Split spoon**		
DRILLING METHOD: **3¼" H.S.A.**		

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO.	SAMPLE TYPE	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
		SILTY SAND (SM) - medium dense to loose, brown white orange, medium to fine, moist to wet *(continued)*			10		4	5	5	●	10
40		Boring terminated at 40 feet		730.0							

S&ME BORING LOG - VOGTLE 1426-16-114 - BUTTERFLY BRANCH BRIDGE.GPJ S&ME 2009_09_24.GDT 12/2/16

NOTES:

1. *THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.*
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.*

S&ME

❖ Field Testing Procedures

Soil Test Borings

All borings and sampling were conducted in accordance with ASTM D-1586 test method. Initially, the borings were advanced by either mechanically augering or wash boring through the overburden soils. When necessary, a heavy drilling fluid is used below the water table to stabilize the sides and bottom of the borehole. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel or split-spoon sampler. The sampler was first seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is designated as the "Standard Penetration Resistance" or N-value. The penetration resistance, when properly evaluated, can be correlated to consistency, relative density, strength and compressibility of the sampled soils.

Water Level Readings

Water level readings are normally taken in conjunction with borings and are recorded on the Boring Logs following termination of drilling (designated by ▽) and at a period of 24 hours following termination of drilling (designated by ▼). These readings indicate the approximate location of the hydrostatic water table at the time of our field exploration. The groundwater table may be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should also be expected with variations in surface run-off, evaporation, construction activity and other factors.

Occasionally the boreholes sides will cave, preventing the water level readings from being obtained or trapping drilling water above the cave-in zone. In these instances, the hole cave-in depth (designated by HC) is measured and recorded on the Boring Logs. Water level readings taken during the field operations do not provide information on the long-term fluctuations of the water table. When this information is required, piezometers are installed to prevent the boreholes from caving.

Important Information About Your
Geotechnical Engineering Report

Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.

Geotechnical Findings Are Professional Opinions
Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

Scope of Geotechnical Services
Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

Services Are Performed for Specific Projects
Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project. Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

Geo-Environmental Issues
The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

Geotechnical Recommendations Are Not Final
Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.