REPORT OF PRELIMINARY GEOTECHNICAL EXPLORATION
FORT JACKSON ROAD PIPE CROSSING - SAVANNAH, GEORGIA
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INTRODUCTION

General

This report presents the results of a geotechnical exploration for the Fort Jackson Road Pipe Crossing project in Savannah, Georgia. The work was completed in general accordance with ECS Proposal No. 23:3407 per the Agreement between ECS and Client dated February 27, 2017.

Project Information

The information presented in this report is based on our site reconnaissance, project team emails, and our current understanding of the proposed project. We understand the following:

- The site is located on Fort Jackson Road, approximately one quarter mile northeast of the intersection with Woodcock Drive in Savannah, Chatham County, Georgia (see Photograph 1). A Site Location Diagram is included in the Appendix as Figure 1.
- The proposed project consists of the installation of a new storm water drainage pipe or small bridge to replace the existing failing pipe.
- The pipe or bridge will generally be installed perpendicular to the existing road.
- At the time of this study, no design or installation plans were available.

The attached Boring Location Plan (Figure 2) presents the existing site conditions at the time of this report. If any of the information presented in this report is incorrect or has changed, please advise ECS so that we may reevaluate our recommendations in the light of changes in the present project concept.

Site Conditions

During fieldwork for this geotechnical study, representatives of ECS visited the project site. Based on *Google earth street view* photos and observations during our site visit, the following observations were made:

- The site is bound on the east by wooded, undeveloped land and to the west by a water channel leading to the Savannah River. Across the channel are several large storage tanks.
- The Savannah River is located approximately ¼ mile north of the site.
- At the time of fieldwork, pavement distress was visible at the edges of Fort Jackson Road directly over the existing drainage pipe.
- The northwestern shoulder of the road has been undercut by erosion from the failing pipe crossing (Photograph 2).

Photograph 1: *View of Fort Jackson Road at pipeline crossing (Source: Google Street View).*

Photograph 2: View of northwestern shoulder that has been undercut by erosion from the failing pipe crossing *(Source: Google Street View).*

Purposes of Exploration

The purposes of this study were to explore the soil and groundwater conditions at the site and to develop preliminary engineering recommendations to help guide design and construction of the geotechnical aspects of the proposed project.

We accomplished the purposes of the study by:

1. Reviewing the available publications concerning local geology of the site and performing a general site reconnaissance;
2. Drilling one boring to explore the subsurface soil and groundwater conditions;
3. Performing laboratory tests on selected representative soil samples from the boring to evaluate pertinent engineering properties;
4. Evaluating the field, laboratory, and background data to develop appropriate geotechnical engineering recommendations.

FIELD EXPLORATION AND LABORATORY TESTING

Subsurface Exploration

To explore the subsurface conditions at this site, a Standard Penetration Test (SPT) boring was performed on the western shoulder of Fort Jackson Road. Boring B-1 was performed in the vicinity of the existing drainage pipe to a depth of approximately 40 feet below existing ground surface.

The boring location was determined in the field by our representative utilizing existing site features. The boring location shown on the attached Boring Location Plan (Figure 2) should be considered approximate.

The SPT boring was performed with a truck-mounted drill rig. The drill crew utilized a combination of continuous sampling and mud rotary techniques in the upper 10 feet. Mud rotary techniques were used past 10 feet to advance the borehole to termination depth. Quick Gel drilling fluid was used in the mud rotary phase of drilling to stabilize the walls of the boring.

Representative soil samples were obtained continuously in the upper 10 feet and at 5 foot intervals thereafter by means of the split-barrel sampling procedure in general accordance with ASTM D-1586. In this procedure, a 2-inch O.D., split-barrel sampler is driven into the soil a distance of 18 to 24 inches by a 140-pound hammer falling 30 inches.

The number of blows required to drive the sampler through a 12-inch interval is termed the Standard Penetration Test (SPT) N-value and is indicated for each sample on the boring log.

This value can be used as a qualitative indication of the in-place relative density of cohesionless soils. In a less reliable way, it also indicates the consistency of cohesive soils.

The drill crew prepared a field log of the soils encountered in the borings. After recovery, each sample was removed from the sampler and visually classified by the drill crew. Representative portions of each sample were then sealed and brought to our laboratory in Savannah, Georgia for further visual examination and testing.

Laboratory Testing Program

Representative split-barrel soil samples obtained during our field exploration were selected and tested in our laboratory to check field classifications and to help determine pertinent index and engineering properties of the site soils. The geotechnical laboratory testing included:

- Visual classification of soil samples in general conformance with ASTM D 2487,
- Index property testing of select soil samples including:
    - Natural moisture content determinations (ASTM D 2216), and
    - Percent passing the No. 200 sieve (ASTM D 1140)
    - Atterberg limits testing (ASTM D 4318)
    - Organic content testing (ASTM D 2974)

The laboratory test results are included on the Laboratory Testing Summary in the Appendix of this report. Atterberg limits and moisture content test results are also presented on the Boring Log.

A geotechnical engineer/geologist classified each soil sample from the SPT boring on the basis of texture and plasticity in accordance with the Unified Soil Classification System. The group symbols for each soil type are indicated in parentheses following the soil descriptions on the boring log. The geotechnical engineer/geologist grouped the various soil types into the major zones noted on the boring log. The stratification lines designating the interfaces between earth materials on the boring log are approximate; in-situ, the transitions may be gradual. The soil samples will be retained in our laboratory for a period of 60 days, after which, they will be discarded unless otherwise instructed.

SUBSURFACE CONDITIONS

Regional Geology

The site is located within Georgia's Coastal Plain Geologic Province. The soils of the Southern Coastal Plain Physiographic Province of Georgia are primarily composed of Pleistocene to Holocene age deposits. The soil in the Coastal Plain is the result of sediment deposition in a former marine environment, during a time when sea levels were much higher than they are at

present. The Pleistocene-Holocene deposits are generally composed of alternating sands, silts, and clays, which correspond to eustatic fluctuations in sea-level over several million years.

For the project site area, a Custom Soil Resource Report was created and downloaded from the NRCS website. The Custom Soil Resource Report has been included in the Appendix. A summary of the predominant near surface soil types at the site and their characteristics is included in the following table:

Soil Type	Constituents	Parent Material	Internal Drainage	Water Table (inches)
Made land (Mae)	No information	No information	No information	No information
Fresh Tidal Marsh (Tmh)	Silty Clay	Marine deposits	Poorly drained	0
Salty Tidal Marsh (Tml)	Silty Clay	Marine deposits	Poorly drained	0

The shallow groundwater table in the Coastal Plain region can fluctuate several feet with seasonal rainfall. Seasonal high groundwater levels are typically found at shallow depths in the flood plains with a reasonable probability of flooding in winter and spring. Seasonal high groundwater levels are typically found at depths greater than 2 feet below the ground surface in the gently rolling areas depending on rainfall. Seasonal high groundwater can also be found at the surface in poorly draining areas. It is important to note that the groundwater table can exhibit some distortions due to differences in vertical and lateral permeability.

Soil Conditions

Data from the soil test boring is included in the Appendix. The subsurface conditions discussed in the following paragraphs and those shown on the boring log represent an estimate of the subsurface conditions based on interpretation of the subsurface data using normally accepted geotechnical engineering judgments. We note that the transition between different soil strata is usually less distinct than those shown on the boring log.

The subsurface conditions indicated on the boring log are for the specific location explored. It is a well-known fact that the subsurface conditions will vary beyond the actual boring location. Consequently, conditions different than those indicated in this report should be expected in some areas of the pipe crossing.

Boring B-1 initially encountered approximately 3 inches of topsoil. Topsoil is a dark-colored surficial material with a high organic content and is generally unsuitable for structural support and some variation in thicknesses should be expected across the site. Undocumented fill was generally encountered below the topsoil and extended approximately 4 feet below the existing ground surface. The undocumented fill generally consisted of well to poorly graded sand. Traces of root fragments were observed in this stratum.

Beneath the undocumented fill materials, the borings generally encountered Sand with silt (SW-SM), silty Peat (PT), and organic sandy Silt (OL) to a depth of 10 feet below existing ground surface. Fat Clay (CH) was encountered from approximately 10 to 32 feet below existing ground surface and a stratum of Sand with clay (SW-SC) was encountered from approximately 32 to 40 feet below existing ground surface.

The generalized subsurface conditions are summarized in the following table:

Depth (feet)	Soil Description	Average N Value	Relative Density/Consistency	USCS Classification
0-4	Undocumented Fill	8	Loose	SP/SW FILL
4-6	Sand with Silt	6	Loose	SW-SM
6-8	Silty Peat	3	Soft	PT
8-10	Organic Sandy Silt	3	Soft	OL
10-32	Fat Clay	0	Very Soft	CH
32-40	Sand with Clay	11	Medium Dense	SW-SC

Groundwater Conditions

A groundwater level in the SPT boring was measured before casing was removed. Groundwater level in the SPT boring was approximately 5.6 feet below the existing ground surface. Groundwater level measurement for the boring can be found on the boring log in the Appendix.

Please note that groundwater levels in coastal geology fluctuate with tidal, seasonal, and climatic variations, and may be significantly different at other times. Depending on rainfall events, we expect groundwater levels to fluctuate significantly and generally correspond to levels in the adjacent drainage ditch. Groundwater levels should be checked prior to construction to assess possible effects on grading operations and other activities.

PRELIMINARY EVALUATIONS AND RECOMMENDATIONS

General

At the time this report was prepared the project was in the initial planning stages. As such, the type of structure (i.e. pipe, box culvert, bridge) that will be used to replace the existing stormwater pipe was unknown. The following analysis and recommendations are preliminary in nature intended for initial planning and design. They are not intended for final design and construction. Once the project concept and plans are further developed, the information should be provided to ECS for review. At that time, ECS can provide additional recommendations for supplemental exploration and laboratory testing to provide final recommendations for final design and construction.

The following preliminary engineering recommendations are based on our understanding of the proposed construction, the data obtained in the soil test boring performed, our site reconnaissance, and our experience with soils and subsurface conditions similar to those encountered at this site. Detailed evaluations and recommendations in the following sections should be read in full.

Design Implications of Fill, Soft Soils and Organics

Data obtained from the boring indicates that the subsurface conditions in the vicinity of the pipe consists of loose existing fill, underlain by layers of loose Sand with silt (SW-SM), soft silty Peat (PT), soft organic sandy Silt (OL) and very soft fat Clay (CH) continuing to a depth of 32 feet below existing ground surface. The loose sands, soft peat, soft organic silt and very soft fat clay layers are compressible. Over time these layers will continue to settle resulting from an on-going process of volume change (consolidation). The organic peat will continue to decay and consolidate over time. As such, any new structure placed on these soils would likely experience settlement.

Preliminary Recommendations

Based on the subsurface conditions encountered within the boring and our experience with similar site conditions, the soils in the vicinity of the pipe crossing appear generally unsuitable for replacement of the existing pipe with a new pipe without pile support. We understand the existing CMP storm pipe is failing, likely due to settlement related to the underlying compressible peat and soil layers noted in the boring.

Repair of the existing pipe using a pipe, culvert or bridge structure will need to be pile supported. Piles should extend through the loose sands, soft peat, soft organic silt and very soft fat clay layers and develop pile bearing resistance in the underlying medium dense sand. We anticipate that the piles will likely be friction piles. Types of piles that could be considered include auger cast in place (ACIP) piles or pre-stressed concrete (PSC) piles. Battered piles may be required for lateral stability.

A deeper supplemental boring(s) and/or CPT sounding will be required to estimate the pile tip elevation(s) and recommend a pile type. We recommend the supplemental boring(s) and/or CPT sounding(s) be performed after it has been determined what type of structure will be used for the pipe replacement and the preliminary loads are known.

CLOSING

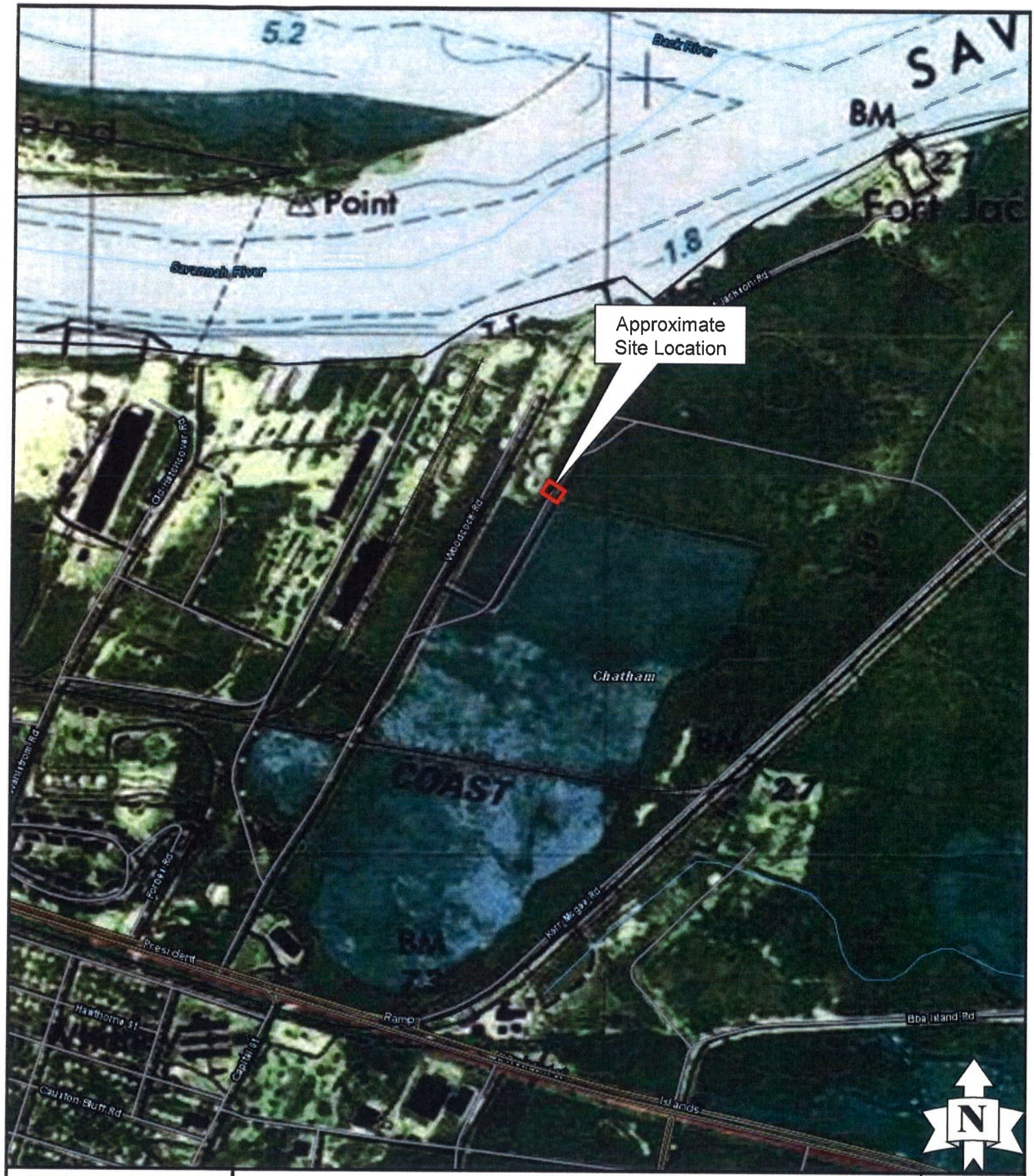
Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. ECS is not responsible for the conclusions, opinions or recommendations made by others based on these data. No third party is given the right to rely on this report without express written permission. The use of this report, in whole or in part, without the written permission of ECS, is done so at the user's sole risk.

ECS has full geotechnical design capabilities and experience with designing similar pile foundation systems. If requested, we can provide the county with a proposal to provide design drawings and specifications for the aforementioned bridge foundation system. These design documents could be provided to geotechnical contractors for soliciting formal bids for the construction, and implementing the repair.

ECS should be retained to provide testing services and observation during construction. If ECS is not retained for this extension of the field exploration, we cannot be responsible for the performance of the site improvements. We would be pleased to provide an estimated cost for these services at the appropriate time.

The scope of services for this study does not include environmental assessment or investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, groundwater, or groundwater within or beyond the site studied. Any statements in this report regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client.

Appendix I



ECS	**SITE LOCATION DIAGRAM**	Figure No.: 1
	REPORT OF PRELIMINARY GEOTECHNICAL EXPLORATION	Project No.: 23:2922
	Fort Jackson Road Pipe Crossing Savannah, Georgia	Not To Scale
	Reference: USGS Quadrangle	Date: 4/2017

LEGEND

Approximate Boring Location

B-# Boring Designation

Graphic Scale 1"=20'

20 10 0 5 10 15 20

ECS

PROJECT: Fort Jackson Road - Pipe Crossing
Savannah, GA

PREPARED FOR: Chatham County

FIGURE NAME: BORING LOCATION PLAN

REFERENCE: Google Maps 3/2017

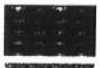
REVISIONS

JOB NO.	23:2922
SCALE	1"=20'
DRAWN	CLJ 3/2017
APPR.	KJH 3/2017

Figure No.: 2

Appendix II

REFERENCE NOTES FOR BORING LOGS

MATERIAL[1,2]		
		ASPHALT
		CONCRETE
		GRAVEL
		TOPSOIL
		VOID
		BRICK
		AGGREGATE BASE COURSE
	FILL[3]	MAN-PLACED SOILS
	GW	WELL-GRADED GRAVEL gravel-sand mixtures, little or no fines
	GP	POORLY-GRADED GRAVEL gravel-sand mixtures, little or no fines
	GM	SILTY GRAVEL gravel-sand-silt mixtures
	GC	CLAYEY GRAVEL gravel-sand-clay mixtures
	SW	WELL-GRADED SAND gravelly sand, little or no fines
	SP	POORLY-GRADED SAND gravelly sand, little or no fines
	SM	SILTY SAND sand-silt mixtures
	SC	CLAYEY SAND sand-clay mixtures
	ML	SILT non-plastic to medium plasticity
	MH	ELASTIC SILT high plasticity
	CL	LEAN CLAY low to medium plasticity
	CH	FAT CLAY high plasticity
	OL	ORGANIC SILT or CLAY non-plastic to low plasticity
	OH	ORGANIC SILT or CLAY high plasticity
	PT	PEAT highly organic soils

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS			
SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation %
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION		
DESIGNATION		PARTICLE SIZES
Boulders		12 inches (300 mm) or larger
Cobbles		3 inches to 12 inches (75 mm to 300 mm)
Gravel:	Coarse	¾ inch to 3 inches (19 mm to 75 mm)
	Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand:	Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
	Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
	Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS		
UNCONFINED COMPRESSIVE STRENGTH, Q_p[4]	SPT[5] (BPF)	CONSISTENCY[7] (COHESIVE)
<0.25	<3	Very Soft
0.25 - <0.50	3 - 4	Soft
0.50 - <1.00	5 - 8	Firm
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

GRAVELS, SANDS & NON-COHESIVE SILTS	
SPT[5]	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

RELATIVE AMOUNT[7]	COARSE GRAINED (%)[8]	FINE GRAINED (%)[8]
Trace	≤5	≤5
Dual Symbol *(ex: SW-SM)*	10	10
With	15 - 20	15 - 25
Adjective *(ex: "Silty")*	≥25	≥30

WATER LEVELS[6]		
▽	WL	Water Level (WS)(WD) (WS) While Sampling (WD) While Drilling
▽	SHW	Seasonal High WT
▼	ACR	After Casing Removal
▽	SWT	Stabilized Water Table
	DCI	Dry Cave-In
	WCI	Wet Cave-In

[1] *Classifications and symbols per ASTM D 2488-09 (Visual-Manual Procedure) unless noted otherwise.*

[2] *To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.*

[3] *Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-**FILL**)].*

[4] *Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).*

[5] *Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf).*

[6] *The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.*

[7] *Minor deviation from ASTM D 2488-09 Note 16.*

[8] *Percentages are estimated to the nearest 5% per ASTM D 2488-09.*

CLIENT	JOB #	BORING #	SHEET
Chatham County	23:2922	B-1	1 OF 2

PROJECT NAME: Fort Jackson Road Pipe Crossing

ARCHITECT-ENGINEER:

SITE LOCATION: Fort Jackson Road, Savannah, Chatham County, GA

NORTHING | EASTING | STATION

CALIBRATED PENETROMETER TONS/FT²

ROCK QUALITY DESIGNATION & RECOVERY
RQD% - - - REC% ——

PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

STANDARD PENETRATION BLOWS/FT

ENGLISH UNITS

BOTTOM OF CASING | LOSS OF CIRCULATION | SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0	S-1	SS	24	24	Topsoil Depth [3"] (SP/SW POSSIBLE FILL) POORLY GRADED/ WELL-GRADED SAND, Tannish Brown to Orangish Brown, Moist, Loose			5 5 4 4 4 4 3 2 3 3 3 6 4 2 1 1 2 2 1 1
	S-2	SS	24	24	(SP/SW POSSIBLE FILL) POORLY GRADED/ WELL-GRADED SAND, Contains Roots, Light Tannish Brown, Moist, Loose			
5	S-3	SS	24	24	(SW-SM) WELL-GRADED SAND WITH SILT, Brown to Orangish Brown, Wet, Loose	▽		
	S-4	SS	24	24	(PT) PEAT, Dark Gray, Wet, Soft			
	S-5	SS	24	24	(ML) SANDY SILT, Contaning Organics, Dark Gray, Saturated, Soft			
10					(CH) FAT CLAY, Dark Gray, Wet, Very Soft			
	S-6	SS	18	18				WOH WOH
15								
	S-7	SS	18	18				WOH WOH
20								
	S-8	SS	18	18				WOH WOH
25								
	S-9	SS	18	18				1 1 1
30								

9 | 7 | 7.1 | 6 | 3 | 3 | 0 | 0 | 0 | 41 | 62 | 108.2 | 2

CONTINUED ON NEXT PAGE.

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

▽ WL 5.6 WS ☐ WD ☒	BORING STARTED 03/16/17	CAVE IN DEPTH
▽ WL(SHW) ▽ WL(ACR)	BORING COMPLETED 03/16/17	HAMMER TYPE Auto
▽ WL	RIG Truck FOREMAN Christian	DRILLING METHOD HSA

CLIENT	JOB #	BORING #	SHEET
Chatham County	23:2922	B-1	2 OF 2
PROJECT NAME	ARCHITECT-ENGINEER		
Fort Jackson Road Pipe Crossing			

SITE LOCATION: Fort Jackson Road, Savannah, Chatham County, GA

NORTHING | EASTING | STATION

CALIBRATED PENETROMETER TONS/FT²

ROCK QUALITY DESIGNATION & RECOVERY
RQD% - - - REC% ——

PLASTIC LIMIT% | WATER CONTENT% | LIQUID LIMIT%

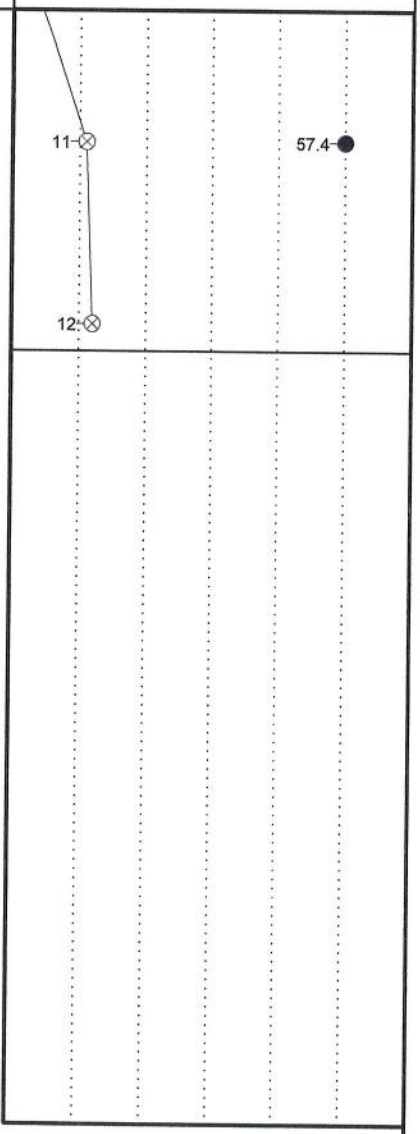
STANDARD PENETRATION BLOWS/FT

DESCRIPTION OF MATERIAL — ENGLISH UNITS

BOTTOM OF CASING | LOSS OF CIRCULATION

SURFACE ELEVATION

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					(CH) FAT CLAY, Dark Gray, Wet, Very Soft			
					(SW-SC) WELL-GRADED SAND WITH CLAY, Dark Gray, Wet, Medium Dense			
35	S-10	SS	18	18				3 5 6
40	S-11	SS	18	18				5 5 7
					END OF BORING @ 40'			
45								
50								
55								
60								



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL.

WL 5.6 WS ☐ WD ☒	BORING STARTED 03/16/17	CAVE IN DEPTH
WL(SHW) WL(ACR)	BORING COMPLETED 03/16/17	HAMMER TYPE Auto
WL	RIG Truck FOREMAN Christian	DRILLING METHOD HSA

Laboratory Testing Summary

Sample Source	Sample Number	Depth (feet)	MC[1] (%)	Soil Type[2]	Atterberg Limits[3]			Percent Passing No. 200 Sieve[4]	Moisture - Density (Corr.)[5]		CBR Value[6]	Other
					LL	PL	PI		Maximum Density (pcf)	Optimum Moisture (%)		
B-1												
	S-2	2.0 - 4.0	7.1	SP/SW				2.8				
	S-4	6.0 - 8.0		PT								OC=54.76%
	S-8	23.5 - 25.0	108.2	CH	62	41	21	89.8				
	S-10	33.5 - 35.0	57.4	SW/SC				26.0				

Notes: 1. ASTM D 2216, 2. ASTM D 2487, 3. ASTM D 4318, 4. ASTM D 1140, 5. See test reports for test method, 6. See test reports for test method

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content (ASTM D 2974)

Project No. 23:2922

Project Name: Fort Jackson Road Pipe Crossing

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