June 5, 2018

Charlotte Water
5100 Brookshire Boulevard
Charlotte, North Carolina 28216

Attn: Mr. William M. Deal – Project Manager
P: 980-722-0786
E: wdeal@ci.charlotte.nc.us

Re: Geotechnical Engineering Report
I-77 Water Line Crossing at Gilead Road
Huntersville, North Carolina
Terracon Project No. 71185066

Dear Mr. Deal:

Terracon Consultants, Inc. (Terracon) appreciates the opportunity to provide geotechnical design services for the above referenced project. This report presents the finding of the subsurface exploration and provides geotechnical recommendations concerning project design and construction.

The proposed project consists of a utility tunnel crossing beneath Interstate I-77 north of Gilead Road in Huntersville, North Carolina. We understand that the tunnel will be installed approximately 8 to 11 feet below existing grades using bore and jack (underneath the interstate). Additionally, the project will include the construction of a receiving pit located west of the I-77 south bound lanes and a bore pit located east of the I-77 north bound lanes. At this time, we understand that the utility line will be continued from west of the bore pit and east of the receiving pit using cut and cover construction beneath the existing on ramps. Therefore, bore and jack settlement calculations are not included in this report for the on ramp crossings.

The approximate project location is indicated on the attached *Site Topographic Map* and *Site Location Map*, Exhibits A-1a and A-1b.

GENERAL SUBSURFACE STRATIGRAPHY

The proposed utility crossing was explored by drilling four soil test borings (B-01 through B-04) and sampling the soil at the approximate locations indicated on the attached *Boring Location Plan*, Exhibit A-2. Additionally, Sugar Creek Contractors has provided us with subsurface information they performed previously for the I-77 HOT Lanes project, which is included in Appendix D of this report. Individual boring logs are included as attachments, and the approximate subsurface conditions are indicated on the attached *Subsurface Profile*, Exhibit, A-3. The soil stratigraphy encountered and depths of each soil test boring are summarized below.

Boring No.	Approximate Existing Ground Elevation [1] (feet)	Boring Depth [2] (feet)	Residual Soil Depth [2] (feet)	PWR Depth [2] (feet)	Depth to Auger Refusal [2] (feet)
B-01	762	16	3 – 8 12 – 16	8 – 12	16
B-02	749	15	1 – 15	N/E [3]	N/E [3]
B-03	772	45	0 – 45	N/E	N/E
B-04	768	15	0 – 15	N/E	N/E
C-R-149	749	15	0 – 15	N/E	N/E
C-R-149 OFFSET	762	20	0 – 20	N/E	N/E

Notes: 1. Elevations estimated from available GIS information.
2. Depths referenced from the existing ground surface.
3. N/E – Not Encountered.
4. Borings performed by others and provided by Sugar Creek Contractors.
PWR: Partially Weathered Rock

GROUNDWATER

The boreholes were observed while drilling and after completion for the presence and level of groundwater. All groundwater depth measurements are included in the boring logs in Appendix A, and are summarized in the table below.

Boring No.	Approximate Existing Ground Elevation [1] (feet)	Depth of Groundwater Measurement [2] (feet)
B-01	762	N/E [3]
B-02	749	N/E
B-03	772	32.6
B-04	768	N/E

Notes: 1. Elevations estimated from available GIS information.
2. Depths referenced from the existing ground surface.
3. N/E – Not Encountered.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

LABORATORY TESTING RESULTS

The following laboratory tests were performed on select soil samples: natural moisture content, Atterberg limits and wash #200 grain size analyses. The results of these tests are summarized in the following table.

Boring No.	Depth [1] (ft)	Natural Moisture Content (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
B-01	6 – 7.5	16	- -	- -	- -	- -
B-02	3.5 – 5	31	56	41	36	5
B-02	13.5 – 15	38	- -	- -	- -	- -
B-03	8.5 – 10	24	56	46	40	6
B-03	28.5 – 30	30	48	37	33	4
B-03	38.5 – 40	28	- -	- -	- -	- -

1. Depths referenced from the existing ground surface.

CUT AND COVER CONSTRUCTION

Our understanding is that cut and cover construction operations may be performed for the utility line within the vicinity of the access ramps for I-77.

We anticipate that dewatering will not be required during this construction process. However, groundwater was encountered in boring B-03 near the proposed bore pit bottom elevation. If dewatering is required, sump pumps may be utilized if they are able to adequately remove the water and keep the site dry for construction operations. An alternative to sump pumps would be the installation of well points or deep wells. Terracon recommends that the contractor provide design documents from a North Carolina Registered Engineer with respect to the design of any proposed dewatering systems as well as means and methods of proposed construction.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Safety and Health Administration (OSHA) regulations to provide stability and safe working conditions. The grading contractor should be responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. If trench boxes are utilized, they should meet or exceed the appropriate OSHA requirements. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Based on final design of the pipe profiles, some PWR, especially in confined excavations, and rock may require blasting or impact hammering to efficiently excavate. PWR, intermittent rock lenses and boulders may be encountered during cut and cover operations, specifically in the area west of the I-77 south bound lanes. The depth and thickness of PWR, boulders, and rock lenses or seams can vary dramatically in short distances and between the testing locations.

TUNNEL AND RECEIVING/BORE PIT SHAFT CONSTRUCTION

Terracon anticipates that the tunnel beneath I-77 will be excavated in a combination of residual soils and PWR, based on the provided invert elevation and diameter of the pipe. The *Subsurface Profile*, Exhibit A-3, presents the approximate subsurface stratigraphy along the proposed tunnel and at the access pit locations.

The receiving and bore pit shafts will be constructed as part of the project. Terracon anticipates that these shafts will be constructed in residual soils, based on a maximum pit depth of 30 to 35 feet below existing grades; however, based on the results of boring B-01, PWR and / or auger refusal materials may be encountered near the bottom of the receiving pit. The shafts should be designed to resist the lateral forces exerted by the soils at each location, hydrostatic and uplift forces due to groundwater, if encountered, plus any surcharge loads from adjacent equipment and/or traffic.

The following table may be used to determine the lateral earth pressures for the soils of this site.

Type of Material	Unit Weight (pcf)	Internal Friction Angle (°)	Cohesion (psf)	Active Earth Pressure Coefficient, K_a	Passive Earth Pressure Coefficient, K_p	Coefficient of Earth Pressure at Rest, K_o
Residual Silts and Clays	110	28	100	0.36	2.77	0.53
Residual Sands	120	30	0	0.33	3.00	0.50
PWR	135	36	200	0.26	3.85	0.41

A modulus of soil reaction (E') value of 2,000 pounds per square inch (psi) may be used for the pipe deflection calculations. The recommended design lateral earth pressures and E' values do not include a factor of safety.

We anticipate water to be present within the lower portion of the bore pit's depths, and therefore the access shaft at that location should be designed for hydrostatic forces and uplift forces due to groundwater at an elevation of approximately 740 to 742 feet below existing grades within the vicinity of boring B-03. However, due to fluctuations of the water level during seasonal and climatic variations, these conditions may change during construction.

TUNNELING INDUCED SETTLEMENT

The potential for subsidence of the soils overlying the tunnel as a result of construction of the utility tunnel has been evaluated. This potential subsidence may be caused by groundwater depression and lost ground.

Groundwater depression (lowering of the water level) can be caused by intentional dewatering by the contractor during construction, or by the tunnel itself acting as a drain. The increase in effective stress, in turn, can cause the soils to settle. Based on our borings, it is anticipated that the groundwater level will not be lowered during construction of the utility tunnel but may be occur during the construction of the bore pit shaft, due to the ingress of groundwater both into the open shaft excavation. The extent of surface settlement as a consequence of the drawdown is a function of the amount and extent of groundwater table lowering, the subsurface sequence, and the nature of the soils affected. When the lowering of the groundwater occurs, the effective stress in the ground increases. In this case, the tunnel will be excavated in relatively loose granular soils and the increase in effective stress usually will be reflected as an elastic settlement. The elastic settlement typically represents the majority of the total settlement and its value is relatively small or insignificant in our ground settlement calculation.

The volume lost at the tunnel face can be related to the settlement expected at the ground surface and may potentially impact the settlement behavior of any overlying or adjacent pavements, or buried utilities transverse or parallel to the alignment of the proposed tunnel excavation. We calculated the ground surface settlement using an empirical method suggested by Peck (1969) and Schmidt (1974), whose equations are given in Chapter 7 of the *Technical Manual for Design and Construction of Road Tunnels – Civil Element* of the U.S Department of Transportation Federal Highway Administration. It is our understanding that the tunnel will be constructed with a bore and jack method; therefore, we assumed a volume loss of 1 to 1.5 percent in our calculations. We assumed a tunnel diameter of 4 feet and an invert elevation for the tunnel at 8 feet and 11 feet below existing grades in our calculations, for crossing underneath the south bound and north bound lanes of I-77 respectively. If these assumptions are incorrect, we should be notified so we may update our recommendations, if necessary. The results of these calculations are in the following table.

Existing Subsurface Material Type	Assumed Volume Loss [1] (%)	Maximum Settlement at the ground [2,3] (inches)	Estimated Effective Area of Settlement [4] (feet)
I-77 Southbound Crossing – 48 inch (B-02 and B-03)			
Granular	1%	0.26	12
	1.5%	0.40	
Cohesive	1%	0.14	22
	1.5%	0.21	
I-77 Northbound Crossing – 48 inch (B-02 and B-03)			
Granular	1%	0.19	16
	1.5%	0.29	
Cohesive	1%	0.11	29
	1.5%	0.16	

1. Based on the use of bore and jack method
2. Immediately above the centerline of the tunnel
3. Using shield machine tunneling (SMT)
4. Length of settlement area is estimated to be on both sides of the centerline from the road

Based on these results, the ground beneath interstate I-77 will have a maximum settlement of about 0.40 inches immediately above the centerline of the tunnel. This value indicates a relatively low level of settlement that the existing pavement on I-77 will experience. The length of the subsidence at the ground surface will be approximately 12 feet in both sides from the centerline of the tunnel beneath cohesionless soils, and approximately 22 feet beneath cohesive soils. It is noted that the assumed volume loss used to estimate settlements is heavily dependent on the tunneling contractor, their skill level with the methods performed, and means and methods for construction.

CONSTRUCTION CONSIDERATIONS

1. Excavations for the bore pit and access shaft is anticipated to encounter groundwater and will require dewatering. Typical dewatering methods include the use of sump pumps, or the installation of well points or deep wells. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

2. If the bore and jack method is used for this project, we recommend the annulus between the outer steel casing and the carrier pipe be backfilled with a grout mixed to produce a free flowing grout.

3. We recommend that backfill for the access shafts be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

   Backfill soils should meet the following compaction requirements:

ITEM	DESCRIPTION
Fill Lift Thickness	8- to 10-inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4- to 6- inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Compaction Requirements	95% of the materials maximum standard Proctor dry density (ASTM D 698)
Moisture Content Requirements	+/-3% of the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction

4. The geotechnical engineer should be retained during the construction phase of the project to observe backfill operations and to perform necessary tests.

CLOSURE

Terracon appreciates the opportunity to be of service to you on this project. This report is for the sole use of this project and should not be relied upon otherwise. If you have questions concerning the contents herein, please contact us.

Sincerely,
Terracon Consultants, Inc.

Sean M. Pardy, E.I.
Staff Professional

Christopher R. Briggs, P.E.
Geotechnical Department Manager

NORTH CAROLINA PROFESSIONAL SEAL 039271 ENGINEER CHRISTOPHER R. BRIGGS
6/5/18

Senior Review by: David J. Corley, P.E.

Attachment:

APPENDIX A – FIELD EXPLORATION

- Exhibit A-1a: Site Topographic Map
- Exhibit A-1b: Site Location Map
- Exhibit A-2: Boring Location Plan
- Exhibit A-3: Subsurface Profile
- Exhibit A-4: Field Exploration Description
- Exhibit A-5 to A-8: Boring Logs (5 pages)

APPENDIX B – LABORATORY TESTING

Exhibit B-1	Laboratory Testing Summary
Exhibit B-2	Laboratory Testing Results

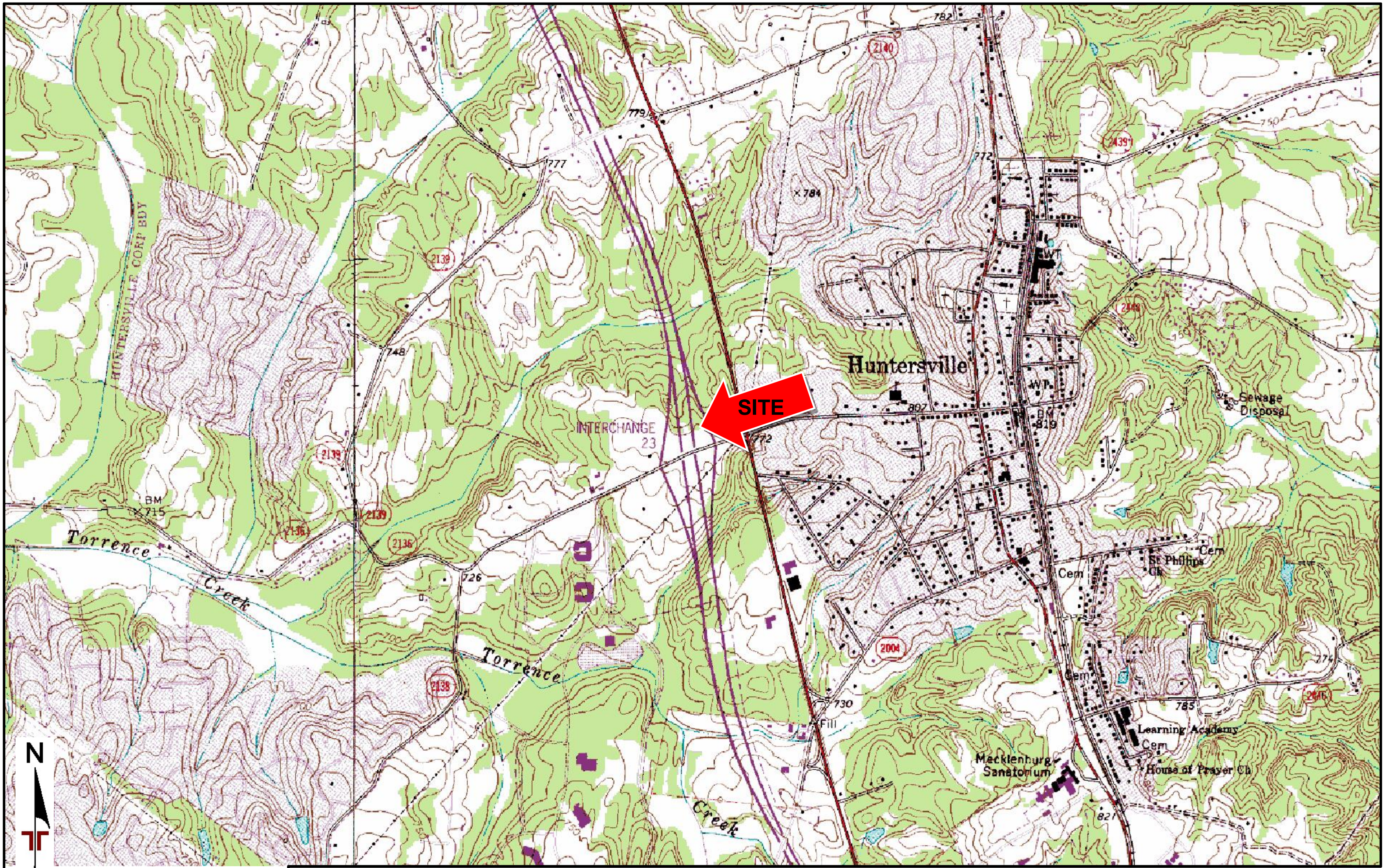
APPENDIX C – SUPPORTING DOCUMENTS

Exhibit C-1	General Notes
Exhibit C-2	Unified Soil Classification System

APPENDIX D – SUPPLEMENTAL INFORMATION

Exhibit D-1	NCDOT Site Plan
Exhibit D-2	NCDOT Cross Section
Exhibit D-3	NCDOT Boring Log C-R-149

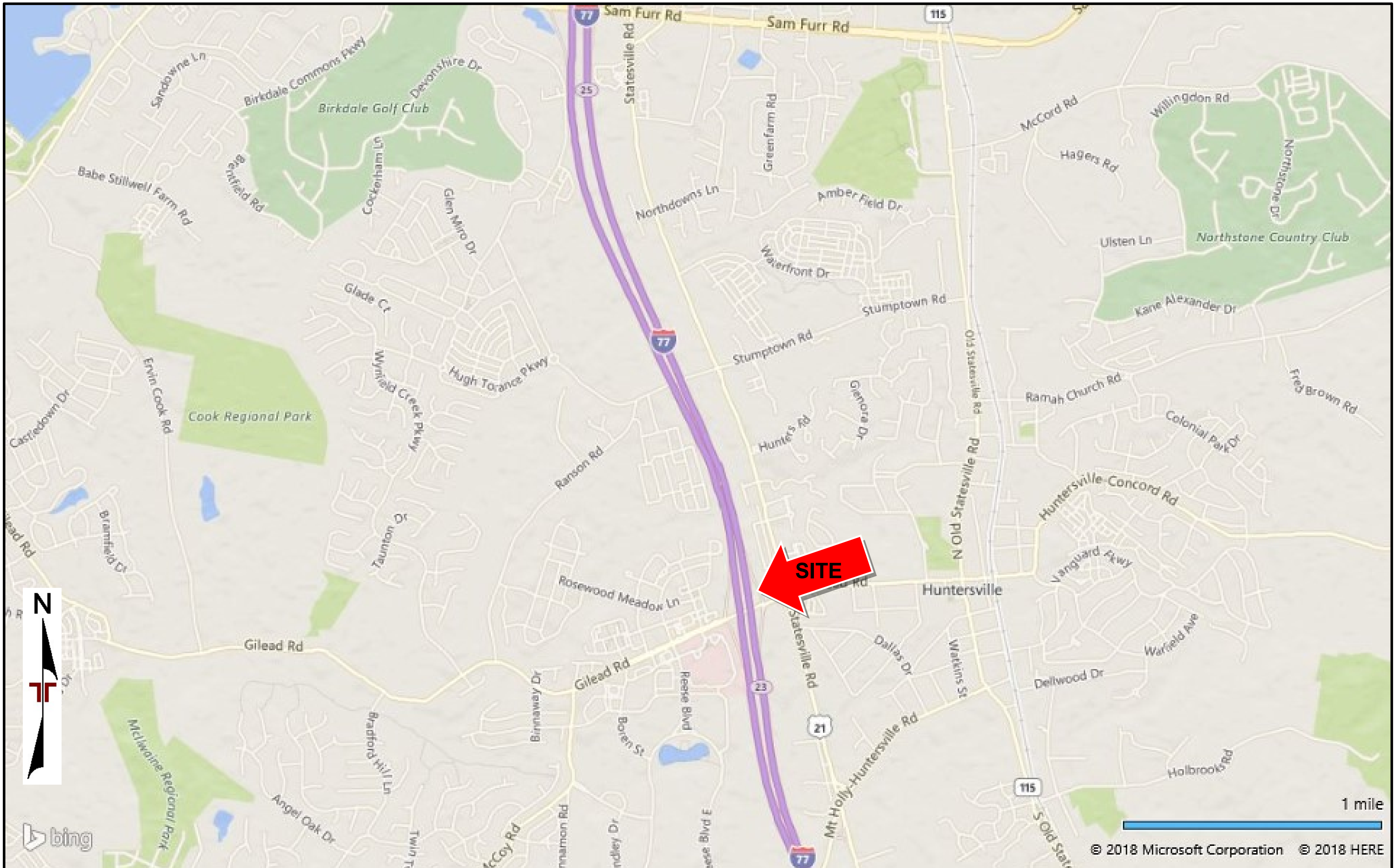
APPENDIX A
FIELD EXPLORATION



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: LAKE NORMAN SOUTH, NC (1/1/1993) and CORNELIUS, NC (1/1/1993).

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

Project Manager: CRB	Project No. 71185066	Terracon 2701 Westport Rd Charlotte, NC 28208-3608	SITE TOPOGRAPHIC MAP I-77 Water Line Crossing at Gilead Road **I-77 North of Gilead Road Overpass** **Huntersville, NC**
Drawn by: SMP	Scale: 1"=2,000'		
Checked by: JMP	File Name: A-1a		Exhibit A-1a
Approved by: DJC	Date: 05/24/2018		



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager: CRB	Project No. 71185066
Drawn by: SMP	Scale: AS SHOWN
Checked by: JMP	File Name: A-1b
Approved by: DJC	Date: 05/24/2018

Terracon

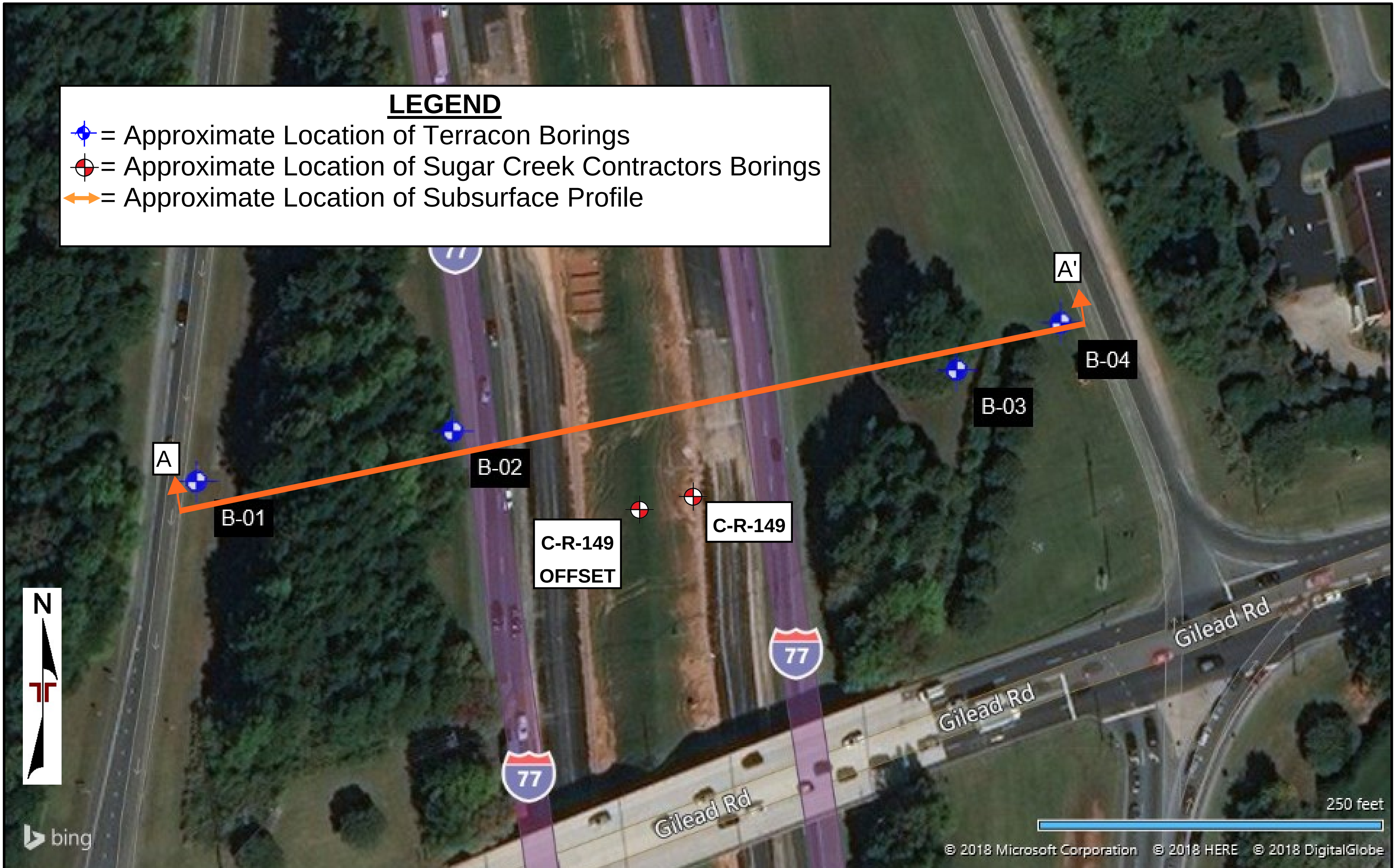
2701 Westport Rd
Charlotte, NC 28208-3608

SITE LOCATION MAP

I-77 Water Line Crossing at Gilead Road
I-77 North of Gilead Road Overpass
Huntersville, NC

Exhibit

A-1b



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

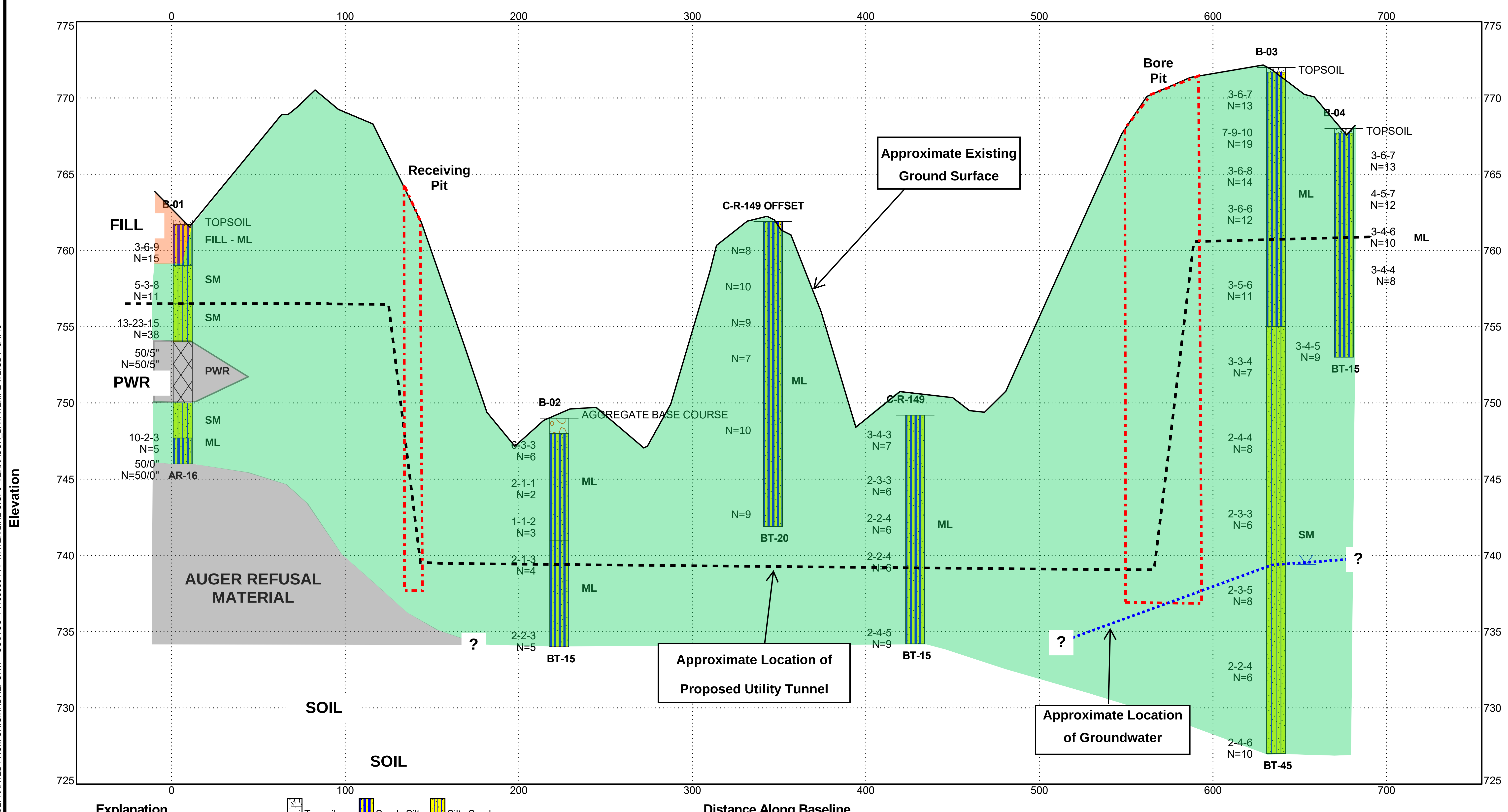
Project Manager: CRB	Project No. 71185066
Drawn by: SMP	Scale: AS SHOWN
Checked by: JMP	File Name: A-2
Approved by: DJC	Date: 05/24/2018

Terracon
2701 Westport Rd
Charlotte, NC 28208-3608

BORING LOCATION PLAN

I-77 Water Line Crossing at Gilead Road
I-77 North of Gilead Road Overpass
Huntersville, NC

Exhibit
A-2



Explanation

B-01 — Borehole Number
Borehole Lithology
AR / BT — Borehole Termination Type
Water Level Reading at time of drilling.
Water Level Reading after drilling.

Topsoil | Sandy Silt | Silty Sand | Weathered Rock | ABC

NOTES:
See Exhibit A-3 for orientation of soil profile.
Soils profile provided for illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager: CRB	Project No.: 71185066	Terracon 2701 Westport Rd Charlotte, NC PH. 704-509-1777 FAX. 704-509-1888	**SUBSURFACE PROFILE** Section A-A' I-77 WATER LINE CROSSING AT GILEAD ROAD I-77 NORTH OF GILEAD ROAD OVERPASS HUNTERSVILLE, NC
Drawn by: SMP	Scale: Not To Scale		
Approved by: DJC	File Name: 71185066.A-3		EXHIBIT A-3
Date: 6/1/2018			

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COSTCO 71185066 I-77 WATER LINE C.GPJ TERRACON_DATATEMPLATE.GDT 6/1/18

Field Exploration Description

The boring locations were laid out on the site and measured from available site features by Terracon personnel. The locations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with an ATV-mounted rotary drill rig using hollow stem augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split-barrel sampling procedure.

In the split barrel sampling procedure, the number of blows required to advance a standard 2 inch O.D. split barrel sampler the last 12 inches of the typical total 18 inch penetration by means of a 140 pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The soil samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings and bentonite pellets prior to the drill crew leaving the site.

Field logs of the borings were prepared by the field professional. These logs included visual classifications of the materials encountered during drilling as well as the field professional's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

BORING LOG NO. B-01

PROJECT: I-77 Water Line Crossing at Gilead Road

CLIENT: Charlotte Water Charlotte, NC

SITE: I-77 North of Gilead Road Overpass Huntersville, NC

LOCATION See Exhibit A-2

Latitude: 35.4097° Longitude: -80.8589°

Approximate Surface Elev: 762 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**TOPSOIL**, 4-inches	761.5+/-							
3.0	**FILL - SANDY SILT (ML)**, reddish brown, stiff	759+/-			X	3-6-9 N=15			
5.5	**SILTY SAND (SM)**, fine to medium grained, black and brown, medium dense, residuum	756.5+/-	5		X	5-3-8 N=11			
8.0	**SILTY SAND (SM)**, trace fine gravel, fine to coarse grained, gray, black, and white, dense, residuum	754+/-			X	13-23-15 N=38	16		
12.0	**PARTIALLY WEATHERED ROCK (PWR)**, Sampled as black, gray, and tan, silty SAND	750+/-	10	Dry Cave-in	X	50/5"			
14.3	**SILTY SAND (SM)**, fine to coarse grained, black, gray, and tan, loose, residuum	747.5+/-			X	10-2-3 N=5			
16.0	**SANDY SILT (ML)**, brown, black, and tan, medium stiff, micaceous, residuum	746+/-	15			50/0"			

Auger Refusal at 16 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

Elevations were determined by Google Earth and STV Engineers, Inc. drawing Project Reference No. I-5714 Sheet No. UC-7

WATER LEVEL OBSERVATIONS

No free water observed

Dry Cave-in

Terracon

2701 Westport Rd
Charlotte, NC

Boring Started: 05-03-2018	Boring Completed: 05-03-2018
Drill Rig: CME 550X	Driller: J. Cain
Project No.: 71185066	Exhibit: A-5

BORING LOG NO. B-02

PROJECT: I-77 Water Line Crossing at Gilead Road

CLIENT: Charlotte Water
Charlotte, NC

SITE: I-77 North of Gilead Road Overpass
Huntersville, NC

LOCATION See Exhibit A-2

Latitude: 35.4098° Longitude: -80.8583°

Approximate Surface Elev: 749 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.0	**AGGREGATE BASE COURSE**, 12-inches	748+/-							
	SANDY SILT (ML), reddish brown, soft to medium stiff, traca mica, residuum				X	6-3-3 N=6			
					X	2-1-1 N=2	31	41-36-5	56
			5						
					X	1-1-2 N=3			
8.0	7 ft: 6 inch thick poorly-graded coarse SAND seam	741+/-							
	SANDY SILT (ML), black, tan, and brown, medium stiff, micaceous, residuum				X	2-1-3 N=4			
			10						
				Dry Cave-in					
15.0		734+/-	15		X	2-2-3 N=5	38		
	Boring Terminated at 15 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

Elevations were determined by Google Earth and STV Engineers, Inc. drawing Project Reference No. I-5714 Sheet No. UC-7

WATER LEVEL OBSERVATIONS

No free water observed

Dry Cave-in

Terracon
2701 Westport Rd
Charlotte, NC

Boring Started: 05-03-2018	Boring Completed: 05-03-2018
Drill Rig: CME 550X	Driller: J. Cain
Project No.: 71185066	Exhibit: A-6

BORING LOG NO. B-03

PROJECT: I-77 Water Line Crossing at Gilead Road

CLIENT: Charlotte Water, Charlotte, NC

SITE: I-77 North of Gilead Road Overpass, Huntersville, NC

LOCATION See Exhibit A-2

Latitude: 35.41° Longitude: -80.857°

Approximate Surface Elev: 772 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**TOPSOIL**, 4-inches	771.5+/-							
	SANDY SILT (ML), red to red with white, brown, and black, stiff to very stiff, trace mica, residuum				X	3-6-7 N=13			
			5		X	7-9-10 N=19			
					X	3-6-8 N=14			
			10		X	3-6-6 N=12	24	46-40-6	56
			15		X	3-5-6 N=11			
17.0	**SILTY SAND (SM)**, red with white, brown, and black to yellowish brown, black, and white, loose to medium dense, miceceous, residuum	755+/-							
			20		X	3-3-4 N=7			
			25		X	2-4-4 N=8			
			30		X	2-3-3 N=6	30	37-33-4	48
				▽					
			35		X	2-3-5 N=8			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

Elevations were determined by Google Earth and STV Engineers, Inc. drawing Project Reference No. I-5714 Sheet No. UC-7

WATER LEVEL OBSERVATIONS

▽ *At completion of drilling*

Dry Cave-in

Terracon
2701 Westport Rd
Charlotte, NC

Boring Started: 05-03-2018	Boring Completed: 05-03-2018
Drill Rig: CME 550X	Driller: J. Cain
Project No.: 71185066	Exhibit: A-7

BORING LOG NO. B-03

PROJECT: I-77 Water Line Crossing at Gilead Road

**CLIENT: Charlotte Water
Charlotte, NC**

**SITE: I-77 North of Gilead Road Overpass
Huntersville, NC**

LOCATION See Exhibit A-2

Latitude: 35.41° Longitude: -80.857°

Approximate Surface Elev: 772 (Ft.) +/-

GRAPHIC LOG	DEPTH / MATERIAL DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), red with white, brown, and black to yellowish brown, black, and white, loose to medium dense, miceceous, residuum *(continued)*							
					2-2-4 N=6	28		
		40	Dry Cave-in					
					2-4-6 N=10			
	45.0 … 727+/-	45						
	Boring Terminated at 45 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

At completion of drilling

Dry Cave-in

Terracon
2701 Westport Rd
Charlotte, NC

Boring Started: 05-03-2018	Boring Completed: 05-03-2018
Drill Rig: CME 550X	Driller: J. Cain
Project No.: 71185066	Exhibit: A-7

BORING LOG NO. B-04

PROJECT: I-77 Water Line Crossing at Gilead Road

CLIENT: Charlotte Water
Charlotte, NC

SITE: I-77 North of Gilead Road Overpass
Huntersville, NC

LOCATION See Exhibit A-2

Latitude: 35.41° Longitude: -80.8568°

Approximate Surface Elev: 768 (Ft.) +/-

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**TOPSOIL**, 4-inches	767.5+/-							
	SANDY SILT (ML), red and brown with black and white, stiff to very stiff, trace mica to micaceous, residuum				X	3-6-7 N=13			
			5		X	4-5-7 N=12			
					X	3-4-6 N=10			
			10		X	3-4-4 N=8			
				Dry Cave-in					
	Yellowish brown and black				X	3-4-5 N=9			
15.0	***Boring Terminated at 15 Feet***	753+/-	15						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

Elevations were determined by Google Earth and STV Engineers, Inc. drawing Project Reference No. I-5714 Sheet No. UC-7

WATER LEVEL OBSERVATIONS

No free water observed

Dry Cave-in

Terracon
2701 Westport Rd
Charlotte, NC

Boring Started: 05-03-2018	Boring Completed: 05-03-2018
Drill Rig: CME 550X	Driller: J. Cain
Project No.: 71185066	Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 71185066 I-77 WATER LINE C.GPJ TERRACON_DATATEMPLATE.GDT 6/5/18

APPENDIX B
LABORATORY TESTING

Laboratory Testing Summary

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the enclosed General Notes and the Unified Soil Classification System (USCS) included in Appendix C of this report. (All classification was by visual manual procedures.) At that time, the field descriptions were confirmed or modified as necessary. Additional laboratory tests were conducted in general accordance with the applicable ASTM standards on selected soil samples; the test results are presented on the boring logs in Appendix A. Also shown on the boring logs are estimated Unified Soil Classification Symbols. The laboratory test results were used for the geotechnical engineering analyses, and the development of tunneling and earthwork recommendations.

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

- In-situ Moisture Content
- Wash #200 Sieve Analysis
- Atterberg Limits

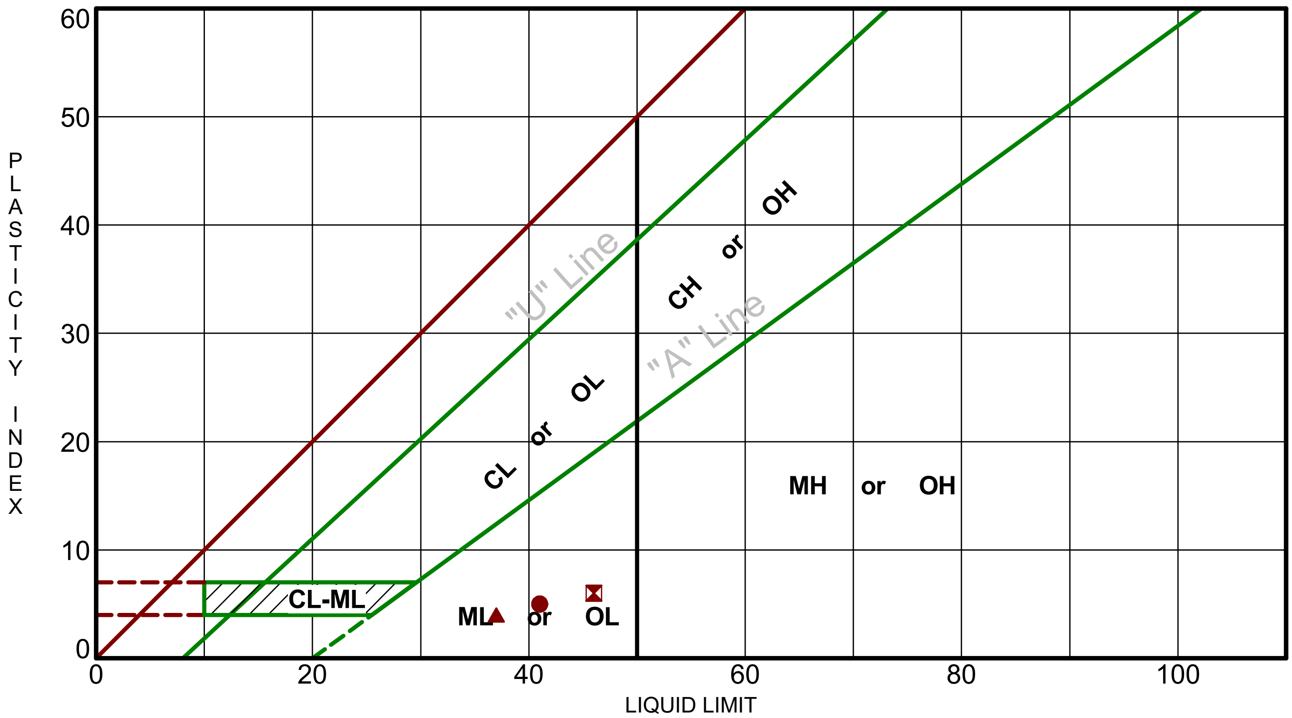
The following table summarizes the results of our laboratory testing services:

Boring No.	Depth [1] (ft)	Natural Moisture Content (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
B-01	6 – 7.5	16	- -	- -	- -	- -
B-02	3.5 – 5	31	56	41	36	5
B-02	13.5 – 15	38	- -	- -	- -	- -
B-03	8.5 – 10	24	56	46	40	6
B-03	28.5 – 30	30	48	37	33	4
B-03	38.5 – 40	28	- -	- -	- -	- -

1. Depths referenced from the existing ground surface.

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-02	3.5 - 5	41	36	5	56	ML	SANDY SILT
⊠	B-03	8.5 - 10	46	40	6	56	ML	SANDY SILT
▲	B-03	28.5 - 30	37	33	4	48	SM	SILTY SAND

PROJECT: I-77 Water Line Crossing at Gilead Road

SITE: I-77 North of Gilead Road Overpass
Huntersville, NC

Terracon
2701 Westport Rd
Charlotte, NC

PROJECT NUMBER: 71185066

CLIENT: Charlotte Water
Charlotte, NC

EXHIBIT: B-2

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING		WATER LEVEL		FIELD TESTS		
	Standard Penetration Test		▽ Water Initially Encountered		N	Standard Penetration Test Resistance (Blows/Ft.)
			▽ Water Level After a Specified Period of Time		(HP)	Hand Penetrometer
			▼ Water Level After a Specified Period of Time		(T)	Torvane
			Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.		(DCP)	Dynamic Cone Penetrometer
					(PID)	Photo-Ionization Detector
					(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

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

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

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

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

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

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

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

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

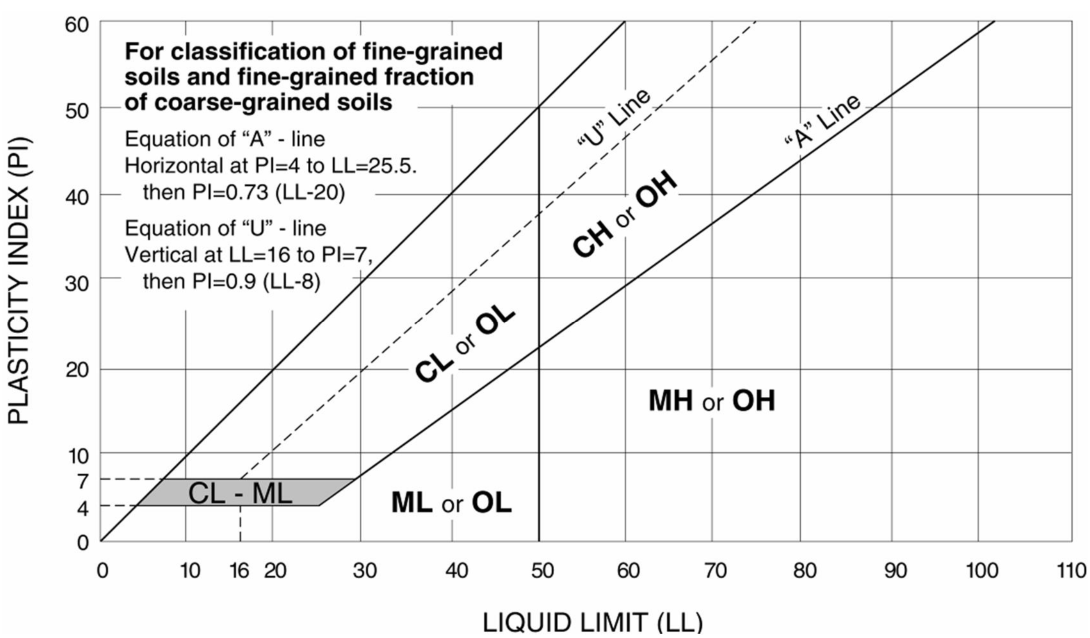
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

APPENDIX D
SUPPLEMENTAL INFORMATION

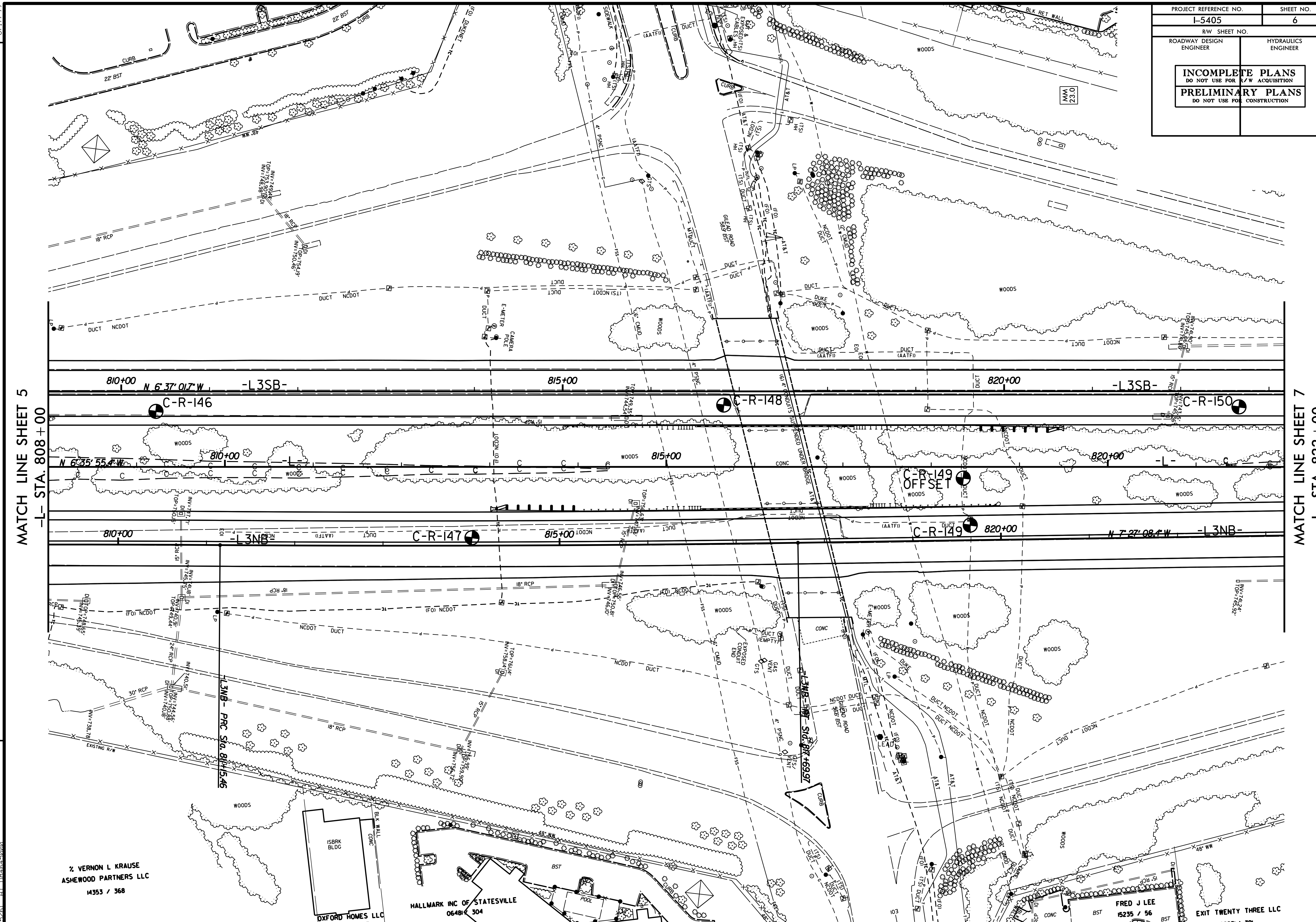
PROJECT REFERENCE NO.	SHEET NO.
I-5405	6
R/W SHEET NO.	
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

REVISIONS

8/17/99



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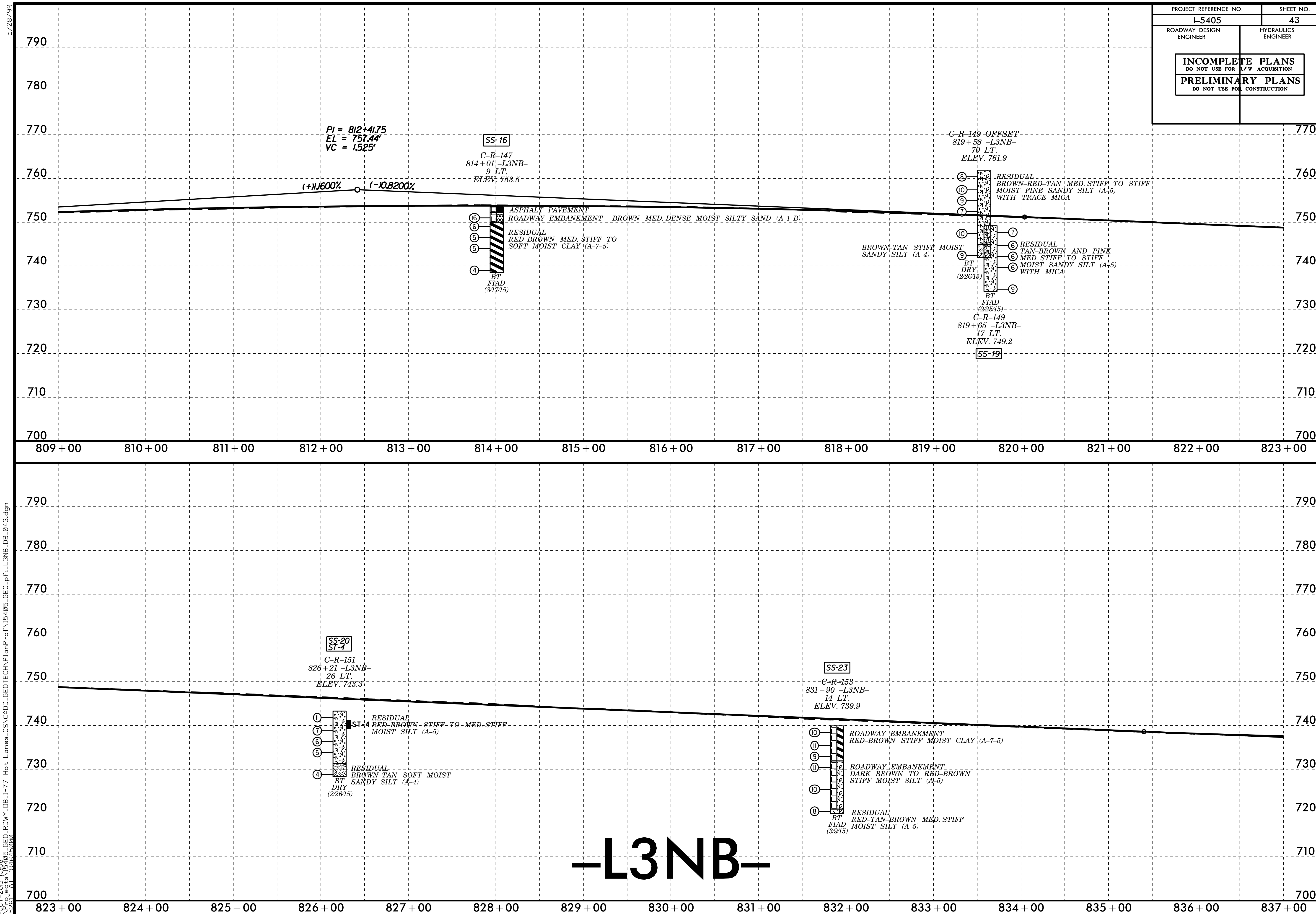
PROJECT REFERENCE NO.	SHEET NO.
I-5405	43
ROADWAY DESIGN ENGINEER	HYDRAULICS ENGINEER

INCOMPLETE PLANS
DO NOT USE FOR R/W ACQUISITION

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION



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SHEET

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45454.3.P3S1	TIP I-5405	COUNTY MECKLENBURG	GEOLOGIST Contract Geologist
SITE DESCRIPTION I-77 Hot Laness: Central Section Roadway			GROUND WTR (ft)
BORING NO. C-R-148	STATION 816+82	OFFSET 16 ft RT	ALIGNMENT L3SB	0 HR. Dry
COLLAR ELEV. 749.6 ft	TOTAL DEPTH 15.0 ft	NORTHING 608,905	EASTING 1,446,434	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE SDS7893 CME-550X 82% 03/13/2015	DRILL METHOD H.S. Augers	HAMMER TYPE Automatic	
DRILLER Contract Driller	START DATE 03/12/15	COMP. DATE 03/12/15	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI	SOIL AND ROCK DESCRIPTION
750									749.6 GROUND SURFACE 0.0
	749.1	0.5	2	4	4	8		M	**ROADWAY EMBANKMENT** Red/Brown to Tan/Brown, Medium Stiff to Soft, SILT (A5) - Moist
745	746.1	3.5	1	2	1	3	SS-17	45% M	744.1 5.5
	743.6	6.0	2	1	2	3	SS-18	46% M	**ROADWAY EMBANKMENT** Tan/Brown, Soft, CLAY (A-7-5) - Moist
740	741.1	8.5	1	2	2	4		M	737.6 12.0
735	736.1	13.5	1	2	3	5		M	**RESIDUAL** Tan/Brown, Medium Stiff, SILT (A5) - Moist 734.6 15.0
									Boring Terminated at Elevation 734.6 ft in Residual, Medium Stiff, SILT (A5).

WBS 45454.3.P3S1	TIP I-5405	COUNTY MECKLENBURG	GEOLOGIST Contract Geologist
SITE DESCRIPTION I-77 Hot Laness: Central Section Roadway			GROUND WTR (ft)
BORING NO. C-R-149	STATION 819+65	OFFSET 17 ft LT	ALIGNMENT L3NB	0 HR. Dry
COLLAR ELEV. 749.2 ft	TOTAL DEPTH 15.0 ft	NORTHING 609,198	EASTING 1,446,537	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE SDS7893 CME-550X 82% 03/13/2015	DRILL METHOD H.S. Augers	HAMMER TYPE Automatic	
DRILLER Contract Driller	START DATE 02/25/15	COMP. DATE 02/25/15	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI	SOIL AND ROCK DESCRIPTION
750									749.2 GROUND SURFACE 0.0
	748.7	0.5	3	4	3	7		M	**RESIDUAL** Tan/Brown and Pink, Medium Stiff to Stiff, Sandy SILT (A5), with Mica - Moist
745	745.7	3.5	2	3	3	6		M	
	743.2	6.0	2	2	4	6		M	
740	740.7	8.5	2	2	4	6		M	
735	735.7	13.5	2	4	5	9	SS-19	39% M	734.2 15.0
									Boring Terminated at Elevation 734.2 ft in Residual, Medium Stiff to Stiff, Sandy SILT (A5).