# Geotechnical Engineering Report

**Proposed Greenville Fire Station #7 – Parcel 79548**

**Bayswater Road**

**Greenville, North Carolina**

December 14, 2018

Project No. 72185079

**Prepared for:**

Town of Greenville
North Carolina

**Prepared by:**

Terracon Consultants, Inc.
Winterville, North Carolina

December 14, 2018

Town of Greenville
Public Works
1500 Beatty Street
Greenville, North Carolina 27834

Attn: Mr. Devin Thompson
Building & Grounds Supervisor

Re: Geotechnical Engineering Report
Proposed Greenville Fire Station #7 – Parcel 79548
Bayswater Road
Greenville, North Carolina
Terracon Project No. 72185079

Dear Mr. Thompson:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal P72185079 dated July 16, 2018.

This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed fire station.

We appreciate the opportunity to be of service to you on this project. Materials testing services are provided by Terracon. We would be pleased to discuss these services with you. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

**Terracon Consultants, Inc.**

NORTH CAROLINA PROFESSIONAL SEAL 042183 ENGINEER ANDREW J. GLINIAK

12/14/18

Andrew J. Gliniak, P.E.
Geotechnical Project Engineer
Registered NC 042183

Kevin Sohrabnia, P.E.
Senior Principal

Enclosures

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# EXECUTIVE SUMMARY

The following items represent a brief summary of the findings of our subsurface exploration and recommendations for the proposed fire station to be located on Bayswater Road in Greenville, North Carolina. A total of nine CPT soundings were advanced to depths of 5, 20, and 50 feet below the existing ground surface.

- The borings encountered relatively dense undocumented fill to depths of 2 ½ to 5 ½ feet underlain by soft to stiff clay and loose to dense sands. Groundwater is estimated at a depth of 7 to 10 feet below existing grades.

- The fill appears to have been placed in a controlled manner, but we have no records to indicate the degree of control. Based on CPT data, the structure and pavements could be supported by the fill. However, even with the recommended construction procedures, there is inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. This is further discussed within the report text.

- After site stripping, the subgrade should be densified in place using a medium weight vibratory roller. Isolated repairs could be required in areas too wet for vibratory rolling.

- After completing the recommended earthwork, the structure can be supported on shallow foundations bearing on approved existing soils (if the owner is willing to accept some risks) or new engineered fill compacted as recommended and sized for a maximum net allowable soil bearing pressure of 2,000 psf.

- An IBC seismic site classification of "D" is appropriate for this site based on the results of the borings and our experience with the geology of the area.

- We recommend Terracon be retained to observe and test the foundation bearing materials as well as other construction materials at the site.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of report limitations.

# GEOTECHNICAL ENGINEERING REPORT
# PROPOSED GREENVILLE FIRE STATION #7 – PARCEL 79548
# BAYSWATER ROAD
# GREENVILLE, NORTH CAROLINA

**Terracon Project No. 72185079**
**December 14, 2018**

## 1.0 INTRODUCTION

We have completed the geotechnical engineering report for the proposed fire station to be located on Bayswater Road in Greenville, North Carolina. A total of nine CPT soundings were advanced to depths of 5, 20, and 50 feet below the existing ground surface. Hand augered borings were offset as required from the CPT locations for collection of soil samples. Logs of the borings along with site location and boring location plans are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface Soil Conditions
- Groundwater Conditions
- Earthwork
- Pavements
- Floor slab design and construction
- Foundation recommendations
- Seismic considerations

## 2.0 PROJECT INFORMATION

### 2.1 Project Description

| ITEM | DESCRIPTION |
|---|---|
| **Site Location** | See Appendix A, Exhibit A-1, Site Location Plan |
| **Site layout** | See Appendix A, Exhibit A-2, Boring Location Plan |
| **Structure** | A two-story, high bay, fire station building with a footprint of approximately 10,000 square feet. The project includes an asphalt parking lot and driveways. |
| **Building Construction** | The structure will be steel framed supported on a reinforced concrete foundation system, concrete slab-on-grade floors. |

| ITEM | DESCRIPTION |
|---|---|
| **Maximum loads** | Columns: 70 kips (assumed)<br>Walls: 2 kips/linear foot (assumed)<br>Floor Slab with no vehicles: 100 psf (assumed) |
| **Finished Floor Elevation** | Unknown, no grading plan was provided. |
| **Grading** | Up to 2 to 3 feet of fill (assumed) for general earthwork. We understand additional fill is not proposed at the site. |

### 2.2 Site Location and Description

| ITEM | DESCRIPTION |
|---|---|
| **Location** | On Bayswater Road in Greenville, NC. Parcel 79548 is located near the intersection of Bayswater Road, E Fire Tower Road and Ashcroft Drive. |
| **Site Coordinates** | Latitude: 35.5559° Longitude: -77.3682° |
| **Existing improvements** | Currently undeveloped. The site was formerly developed as a mobile home park. |
| **Current ground cover** | Grass. Some ponded surface water was noted near Bayswater Rd in the proposed pavement area. |
| **Existing topography** | Relatively level with shallow (less than 6 inches) depressions based on visual observations. |

## 3.0 SUBSURFACE CONDITIONS

### 3.1 Site Geology

The subject site is located in the Coastal Plain Physiographic Province. The Coastal Plain soils consist mainly of marine sediments that were deposited during successive periods of fluctuating sea level and moving shoreline. The soils include sands, silts, and clays with irregular deposits of shells, which are typical of those lain down in a shallow sloping sea bottom. Recent alluvial sands, silts, and clays are typically present near rivers and creeks.

According to USGS Mineral Resources On-Line Spatial Data based on the 1998 digital equivalent of the 1985 Geologic Map of North Carolina updated in 1998, the site is mapped within the Yorktown Formation and Duplin Formation, Undivided (Tertiary).

## 3.2 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as shown on the following table:

| Description | Approximate Depth to Bottom of Stratum (feet) | Material Encountered | Consistency/Density |
|---|---|---|---|
| Stratum 1 | 0.25 (3 inches) | Vegetation and Topsoil | NA |
| Stratum 2 | 2.5 to 5.5 | Fill: Clayey Sand, Silty Clayey Sand, Silty Sand, and Poorly Graded Sand | Loose to Dense |
| Stratum 3 | 22 | Lean Clay (CL), Clayey Sand (SC), Poorly Graded Sand (SP), Silty Sand (SM) | Soft to Stiff/ Loose to Dense |
| Stratum 4 | Boring Terminated – 50 | Clay, Silt and Sand Mixtures, and Sand like Material | Stiff / Medium Dense to Dense |

Laboratory tests for moisture content, Atterberg limits, and grain size were conducted on selected soil samples. The test results are presented in the Appendix B of this report and in the boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. For a comprehensive description of the conditions encountered in the borings, refer to the boring logs in Appendix A of this report.

## 3.3 Groundwater

Based on the CPT data and measured water levels in the borings, groundwater is anticipated at a depth of 7 to 10 feet below the existing ground surface at the time of field exploration.

The groundwater level can change due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

# 4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

## 4.1 Geotechnical Considerations

The borings encountered relatively dense undocumented sand fill to depths of 2 ½ to 5 ½ feet underlain by soft to stiff clay and loose to dense sands. Support of floor slabs and pavements on or above existing fill materials is discussed in this report. However, even with the recommended construction procedures, there is inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. If the owner's risk tolerance is low, the fill should be completely removed and replaced with new structural fill. Presuming that the owner can tolerate some risk, the building floor slab and pavements can be supported on the existing fill. This method of preparing the slab-on-grade and pavement subgrades is discussed in this report.

Based on the assumed grading, the existing fill will not be removed by the grading activities. To help manage the Owner's risk of allowing the fill to remain in-place for the slabs and pavements, Terracon recommends the existing fill be further evaluated at the time of construction. This should include performing hand auger borings to check the composition of the existing fill and field density testing or Dynamic Cone Penetrometer (DCP) tests to check its consistency and proofrolling of the existing subgrades. Depending on the findings, test pit excavation may also be necessary. It should be expected that undercutting and replacement of unsuitable fill soils may be required in isolated areas of the site to improve the subgrade support characteristics.

After site stripping, the subgrade should be densified in place using a medium weight vibratory roller. The purpose of the vibratory rolling is to densify the loose, near surface soils and potentially improve pavement, floor slab and foundation support. The site appears poorly drained and areas too wet for vibratory rolling could remain after site stripping. Isolated repairs could be required in these areas too wet for vibratory rolling.

Following the recommended earthwork, the structures can be supported on shallow foundations bearing on approved existing soils or new engineered fill compacted as recommended sized for a maximum net allowable soil bearing pressure of 2,000 psf.

A more complete discussion of these points and additional information is included in the following sections.

## 4.2 Earthwork

Site preparation should begin with the complete removal of surface vegetation and topsoil in the proposed building footprint and pavement areas. A Terracon representative should field verify the stripping depth during construction. Topsoil may be reused in areas of the site to be landscaped but should not be used as engineered fill or backfill.

The existing fill should be further evaluated by performing hand auger borings to check the composition of the existing fill and field density testing or Dynamic Cone Penetrometer (DCP) tests to check its consistency and proofrolling of the existing subgrades. Depending on the findings, test pit excavation may also be necessary which should be observed by the geotechnical engineer. Unsuitable fill soils should be removed and backfilled with engineered fill.

Since the site was previously developed, there is a potential for vaults or buried septic tanks, associated with the former mobile home park at this site. The best method for addressing underground structures, if encountered, would be to evaluate them during construction with the geotechnical engineer.

After stripping and prior to placing fill, the exposed subgrade soils in the building and pavement footprints should be densified in place using a medium weight vibratory roller. The purpose of the vibratory rolling is to densify the exposed subgrade soils for floor slab and pavement support and to potentially improve the foundation bearing soils. The roller should make at least 6 passes across the site, with the second set of 3 passes perpendicular to the first set of 3 passes. If water is brought to the surface by the vibratory rolling, the operation should be discontinued until the water subsides. Vibratory rolling should be completed during dry weather. After the vibratory rolling, pore pressures should be allowed to dissipate for a minimum of 16 hours. Isolated repairs should be anticipated in areas too wet for vibratory rolling.

After the waiting period, proofrolling should be performed on the exposed subgrade soils in areas to receive fill or at the design grade with a fully loaded, tandem-axle dump truck (20 ton minimum) or similar rubber-tired construction equipment. Proofrolling is recommended as a means of detecting areas of soft or unstable subgrade soils. The proofrolling should be performed during a period of dry weather to avoid degrading an otherwise suitable subgrade. The proofrolling operations should be observed by a representative of the geotechnical engineer. Subgrade soils that exhibit excessive rutting or deflection during proofrolling should be repaired as directed by the field representative. Typical repairs include overexcavation followed by replacement with either properly compacted engineered fill or by a subgrade stabilization fabric in conjunction with a clean sand fill or crushed stone.

### 4.2.1 Fill Material Types

Engineered fill should meet the following material property requirements:

| Fill Type [1] | USCS Classification | Acceptable Location for Placement |
|---|---|---|
| Imported Soil | Sand: SC, SM, SC-SM, SP | All locations and elevations. |
| On-site Soils [2] | Sand: SC, SC-SM, SM, SP | All locations and elevations. |

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. On site soils that meet the above soil classifications are generally suitable for fill if properly moisture conditioned.

### 4.2.2 Compaction Requirements

We recommend that the engineered fill be placed as recommended in the following table:

| ITEM | DESCRIPTION |
|---|---|
| **Fill Lift Thickness** | 9-inches or less in loose thickness (4” to 6” lifts when hand-operated equipment is used). |
| **Compaction Requirements [1]** | Compact to a minimum of 95% of the material’s standard Proctor maximum dry density (ASTM D 698). [2] |
| **Moisture Content – Structural Fill** | Within the range of -2% to +2% of optimum moisture content as determined by the standard Proctor test at the time of placement and compaction. |

1. Engineered fill should be tested for moisture content and compaction during placement. If in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the tests should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. It is not necessary to achieve 95% compaction on the existing ground prior to placing fill or beginning construction. However, the subgrade should be evaluated by a representative of the geotechnical engineer prior to placing fill or beginning construction.

It is important to note that the use of rubber-tired traffic, such as lulls, may impact the prepared subgrade soils leading to required re-grading. We recommend that the use of rubber-tired traffic be limited to the prepared subgrades or that the stabilized area be prepared for such traffic.

### 4.2.3 Grading and Drainage

During construction, grades should be sloped to promote runoff away from the construction area. Final surrounding grades should be sloped away from the structure on all sides to prevent ponding of water. If gutters / downspouts for the proposed building do not discharge directly onto pavement, they should not discharge directly adjacent to the building. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is day-lighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

### 4.2.4 Construction Considerations

Performing earthwork operations during warmer periods of the year (May through October) will reduce the potential for problems associated with wet unstable subgrades. Site drying conditions are typically enhanced when it is warm. The moisture sensitivity of the on-site soils does not preclude performing earthwork at other times of the year but does lead to an increased potential for having to perform some other form of remedial work.

The site should be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted.

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. Temporary excavations will most likely be required during grading operations. The grading contractor, by his contract, is usually 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. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; vibratory rolling, proofrolling; placement and compaction of controlled compacted fills; and backfilling of excavations.

## 4.3 Foundation Recommendations

### 4.3.1 Shallow Foundations

In our opinion, the proposed structure can be supported by shallow foundations after the recommended earthwork is completed. The shallow foundations can consist of either isolated wall footings or thickened portions of a monolithic slab. Design recommendations are presented in the following table and paragraphs.

| DESCRIPTION | VALUE |
|---|---|
| **Maximum Net allowable bearing pressure [1]** | 2,000 psf |
| **The required embedment below lowest adjacent finished grade for frost protection and protective embedment [2]** | 12 inches |
| **Minimum width for continuous wall footings** | 12 inches for thickened slab<br>16 inches for strip footings |
| **Minimum width for isolated column footings** | 24 inches |
| **Approximate total settlement [3]** | Up to 1 inch |
| **Estimated differential settlement [3]** | Up to 1/2 inch between columns and along 40 feet of wall |
| **Ultimate coefficient of sliding friction [4]** | 0.35 |

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. The maximum net allowable bearing pressure may be increased by 1/3 for temporary wind loads.
2. For frost protection and to reduce effects of seasonal moisture variations in subgrade soils. For perimeter footings and footings beneath unheated areas.
3. The actual magnitude of settlement that will occur beneath the foundations will depend upon the variations within the subsurface soil profile, the structural loading conditions and the quality of the foundation excavation. The estimated total and differential settlements listed assume that the foundation-related earthwork and the foundation design are completed in accordance with our recommendations.
4. For uplift resistance, use the weight of the foundation concrete plus the weight of the soil over the plan area of the footings. 110 pounds per cubic foot should be used for the density of the soil.

### 4.3.2 Construction Considerations

The foundation bearing materials should be evaluated at the time of the foundation excavation. This is an essential part of the construction process. A representative of the geotechnical engineer should use a combination of hand auger borings and dynamic cone penetrometer (DCP) testing to determine the suitability of the bearing materials for the design bearing pressure. DCP testing should be performed to a depth of 3 to 5 feet below the bottom of footing excavation. Unsuitable fill; excessively soft, loose, or wet bearing soils should be over excavated to a depth recommended by the geotechnical engineer. The excavated soils should be replaced with engineered fill or washed, crushed stone (NCDOT No. 57) wrapped in a geotextile fabric (Mirafi 140

N or equivalent). However, footings could bear directly on the soils after over excavation if approved by the geotechnical engineer. Isolated undercut of the existing fill should be anticipated.

The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at bearing level become excessively disturbed or saturated, the affected soil should be removed prior to placing concrete.

## 4.4 Seismic Considerations

| Code Used | Seismic Parameters |
|---|---|
| 2009 International Building Code (IBC) referenced in the 2012 North Carolina State Building Code | Seismic Site Class D |

Based on our experience with the geology of the area, it is our opinion that the subsurface characteristics reflect those of Site Class D as described in the 2012 North Carolina State Building Code. Based on the results of the borings, liquefaction is not expected based on the relatively low level of ground motions associated with the design earthquake.

## 4.5 Floor Slabs

| ITEM | DESCRIPTION |
|---|---|
| **Floor slab support** | Approved existing soils or new engineered fill. |
| **Modulus of subgrade reaction** | 100 pounds per square inch per inch (psi/in) for point loading conditions. |
| **Base Course** | 4 inches crushed stone (NCDOT No. 57) or CABC. |

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings. The slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

## 4.6 Pavements

The pavement subgrade should be thoroughly compacted and proofrolled as outlined in section **4.2 Earthwork** of this report. Loose/soft soils delineated by the proofrolling operations should be undercut and backfilled as recommended by the geotechnical engineer. The use of a geosynthetic fabric or geogrid and additional crushed stone is also a potential option for subgrade improvement.

Upon completion of any necessary remediation, the subgrade should be adequate for support of the pavement sections recommended below.

Pavement thickness design is dependent upon the following:

- Anticipated traffic conditions during the life of the pavement.
- Subgrade and paving material characteristics.
- Climatic conditions of the region.

Information relating to traffic loading and frequencies has not been provided to us. Two pavement section alternatives have been provided. The light-duty pavement sections are for car parking areas only. Heavy-duty pavement sections should be used for fire truck areas, concentrated car traffic (drive lanes / entrance drives) and garbage/delivery truck traffic areas. A subgrade CBR of 3 was selected for design of the recommended pavement sections based upon our experience with similar near surface subgrade soils and subgrade preparation in accordance with the earthwork portion of this report. We have assumed a 20-year design period and the following traffic volume:

Heavy-duty Areas

- Light-duty traffic
- Up to 10 firetrucks or heavy trucks per day

Light-duty Areas

- 100 cars and pickups per day

For areas subject to concentrated and repetitive loading conditions, i.e. dumpster pads and ingress/egress aprons, or in areas where vehicles will turn at low speeds, we recommend using a Portland cement concrete pavement with a thickness of at least 7 inches underlain by at least 4 inches of crushed stone. For dumpster pads, the concrete pavement area should be large enough to support the container and tipping axle of the refuse truck.

| Recommended Pavement Sections | | | |
|---|---|---|---|
| **Pavement Type** | **Material** | **Layer Thickness (inches)** | |
| | | **Light Duty** | **Heavy Duty** |
| Rigid | Portland Cement Concrete (4,000 psi) | 5 | 7 |
| | Crushed Aggregate Base Course (NCDOT CABC Type 1 or Type 2) | 4 [1] | 4 [1] |
| Flexible (Superpave) | Asphalt Surface (NCDOT S9.5B) | 3 [2] | 1.5 |
| | Asphalt Binder (NCDOT I19.0C) | -- | 2.5 |
| | Crushed Aggregate Base Course (NCDOT CABC Type 1 or Type 2) | 6 | 8 |

1. Crushed Aggregate Base Course is recommended for construction purposes. Concrete could be placed directly on an approved subgrade. However, stormwater can quickly degrade exposed subgrades without the crushed aggregate base course leading to additional subgrade repairs.
2. Placed in two 1.5 inch lifts

The placement of a partial pavement thickness for use during construction is not suggested without a detailed pavement analysis incorporating construction traffic. In addition, we should be contacted to confirm the traffic assumptions outlined above. If the actual traffic varies from the assumptions outlined above, modification of the pavement section thickness will be required.

Recommendations for pavement construction presented depend upon compliance with recommended material specifications. To assess compliance, observation and testing should be performed under the direction of the geotechnical engineer.

Asphalt concrete and aggregate base course materials should conform to the North Carolina Department of Transportation (NCDOT) “Standard Specifications for Roads and Structures”. Concrete pavement materials should conform to ACI 330.1 “Specifications for Unreinforced Parking Lots”. Concrete pavement should be air-entrained and have a minimum compressive strength of 4,000 psi after 28 days of laboratory curing per ASTM C-31. ACI 330R-01 recommendations should be followed concerning control and expansion joints, as well as other concrete pavement practices.

The performance of all pavements can be enhanced by minimizing excess moisture which can reach the subgrade soils. The following recommendations should be considered a minimum:

- Site grading at a minimum 2 percent grade away from the pavements.
- Subgrade and pavement surface with a minimum 1/4 inch per foot slope to promote proper surface drainage.
- Installation of joint sealant to seal cracks immediately.

Preventative maintenance should be planned and provided for through an ongoing pavement management program to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Preventative maintenance, which consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing), is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements.

# 5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications, so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

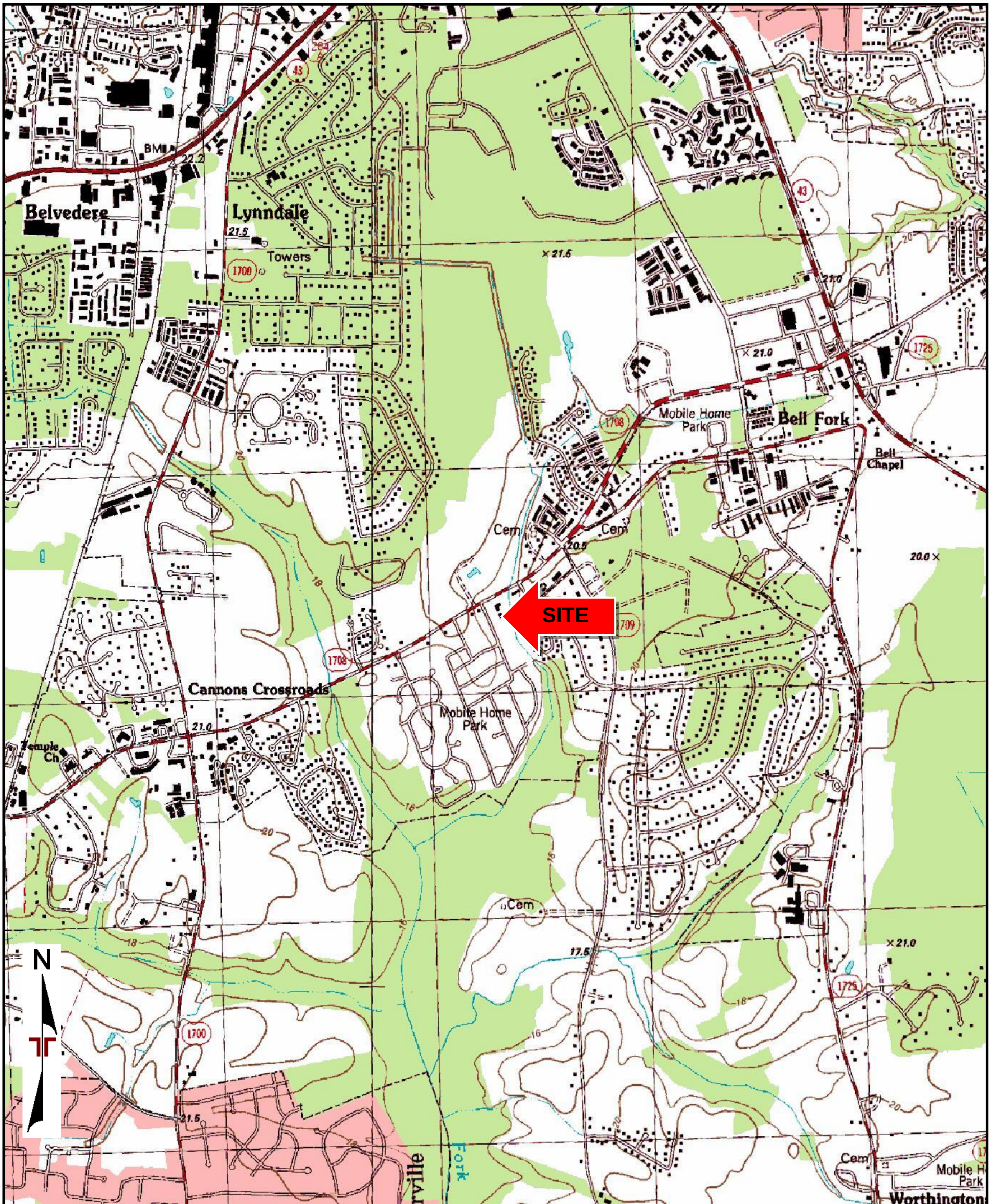
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

# APPENDIX A

# FIELD EXPLORATION




TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: GREENVILLE SW, NC (1/1/1998) and GREENVILLE SE, NC (1/1/1998).

| | | | | |
|---|---|---|---|---|
| Project Manager: AJG | Project No. 72185079 | Terracon | SITE LOCATION PLAN | Exhibit |
| Drawn by: AJG | Scale: 1"=2,000' | | Proposed Greenville Fire Station #7 - Parcel 79548 | A-1 |
| Checked by: KS | File Name: 72185079 EXA | 314 Beacon Dr | **Bayswater Road** | |
| Approved by: KS | Date: 12/13/18 | Winterville, NC 28590-7956 | **Greenville, NC** | |

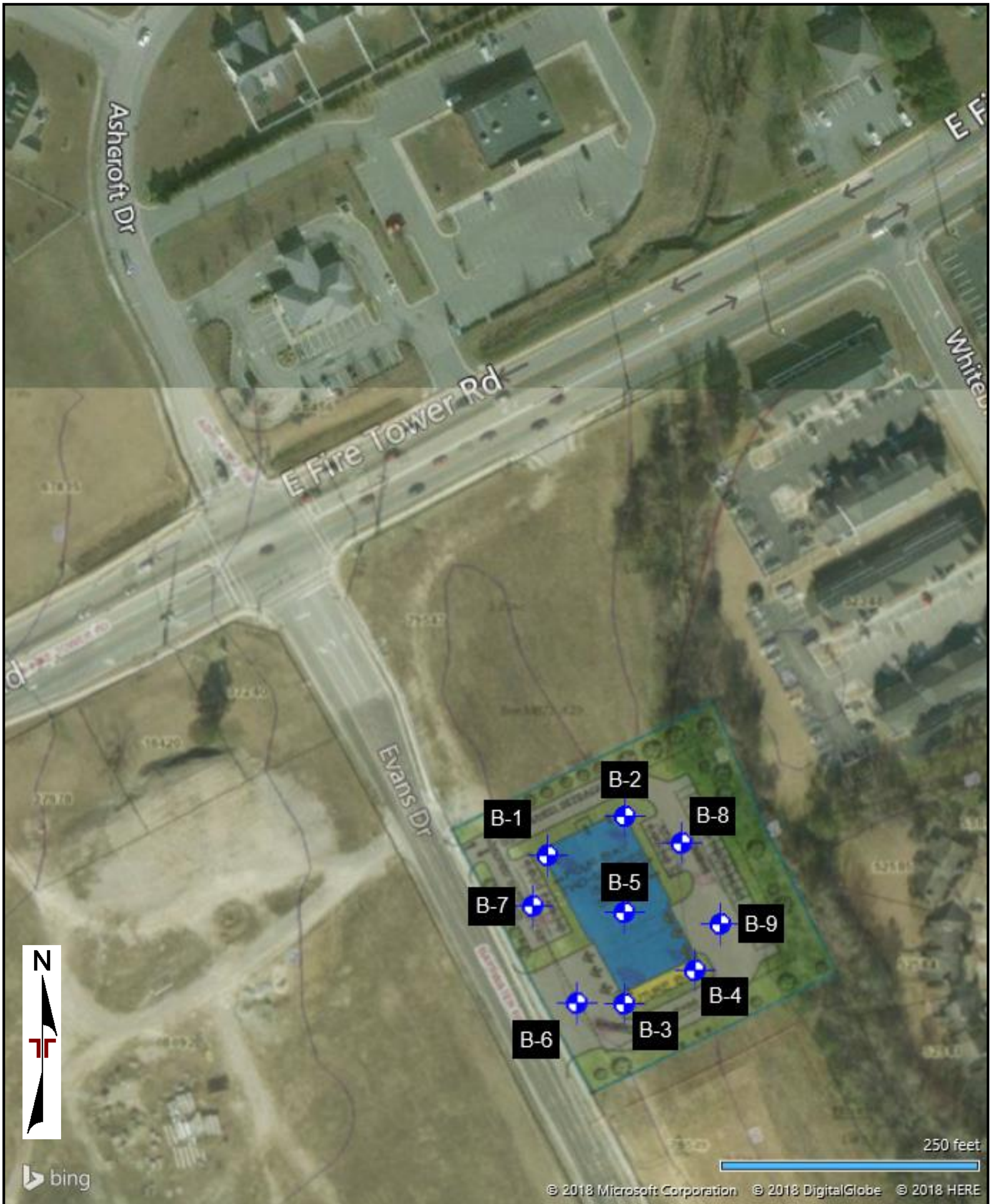



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS, SITE PLAN PROVIDED BY OTHERS

| | | | | |
|---|---|---|---|---|
| Project Manager: AJG | Project No. 72185079 | Terracon | BORING LOCATION PLAN | Exhibit |
| Drawn by: AJG | Scale: AS SHOWN | 314 Beacon Dr | Proposed Greenville Fire Station #7 - Parcel 79548 | A-2 |
| Checked by: KS | File Name: 72185079 EXA | Winterville, NC 28590-7956 | Bayswater Road | |
| Approved by: KS | Date: 12/13/18 | | Greenville, NC | |

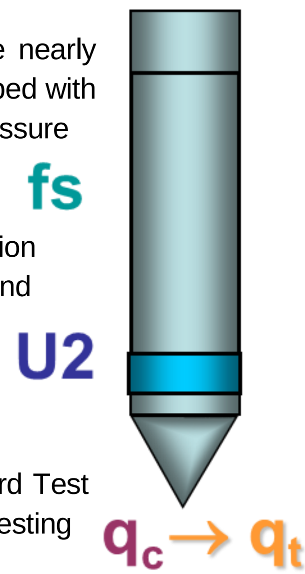
## Field Exploration Description

Coordinates of the borings were determined by overlaying the plans provided on aerial photography by referencing common features. The boring locations were marked in the field by Terracon by referencing existing site features and a handheld GPS. The location of the borings should be considered accurate only to the degree implied by the means and methods used to define it.

The soil test borings were performed by a track mounted power drilling rig utilizing cone penetration testing (CPT) to advance the borings. A hand auger was also used to collect soil samples at each boring location. Samples taken during the drilling process were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification.

## Cone Penetration Testing (CPT)

The CPT hydraulically pushes an instrumented cone through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 10 cm$^2$. Digital data representing the tip resistance, friction resistance, pore water pressure, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1½ and 2½ centimeters per second. These measurements are correlated to various soil properties used for geotechnical design. No soil samples are gathered through this subsurface investigation technique.




CPT testing is conducted in general accordance with ASTM D5778 "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils."

Upon completion, the data collected was downloaded and processed by the project engineer.

# CPT LOG NO. B-1



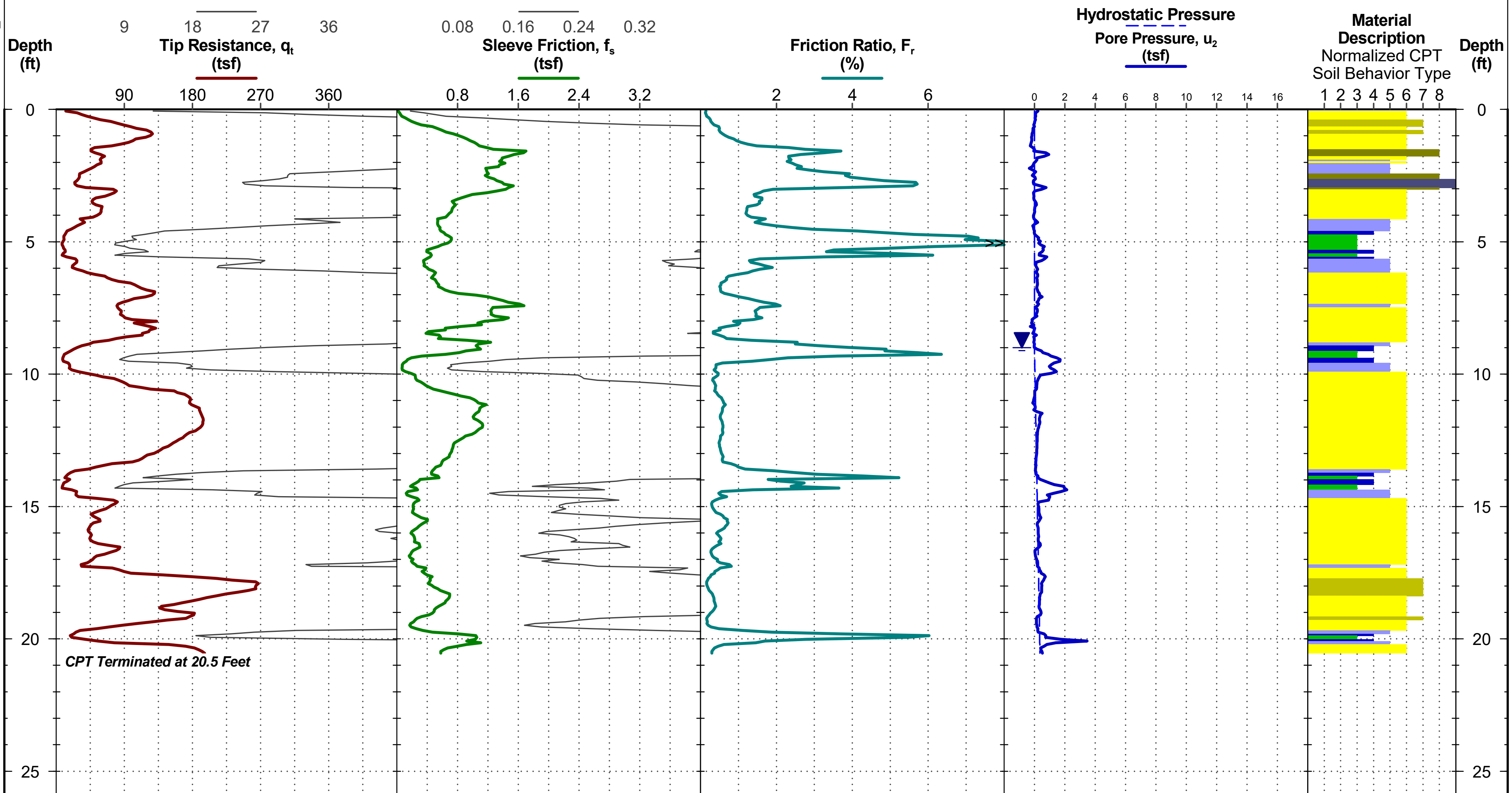
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road
Greenville, NC

Latitude: 35.556148°
Longitude: -77.36854°




**Cave in at 9.6 ft**
See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

**WATER LEVEL OBSERVATION**
▼ 9 ft measured water depth
(used in normalizations and correlations; see Appendix C)

Probe no. 5237 with net area ratio of 0.846
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 7/16/2018
Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$
Ring friction reducer with O.D. of 1.875 in

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| Rig: Geoprobe | Operator: BR |
| Project No.: 72185079 | Exhibit: A-4 |

# BORING LOG NO. B-1H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**SITE: Bayswater Road Greenville, NC**

**CLIENT: City of Greenville NC Greenville, NC**

| GRAPHIC LOG | LOCATION See Exhibit A-2<br>Latitude: 35.5561° Longitude: -77.3685°<br>DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - CLAYEY SAND (SC)**, trace organics, light brown to dark brown<br>2.8 | | | | | | |
| | ***Obstruction at 2.75 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-5 |

# CPT LOG NO. B-2



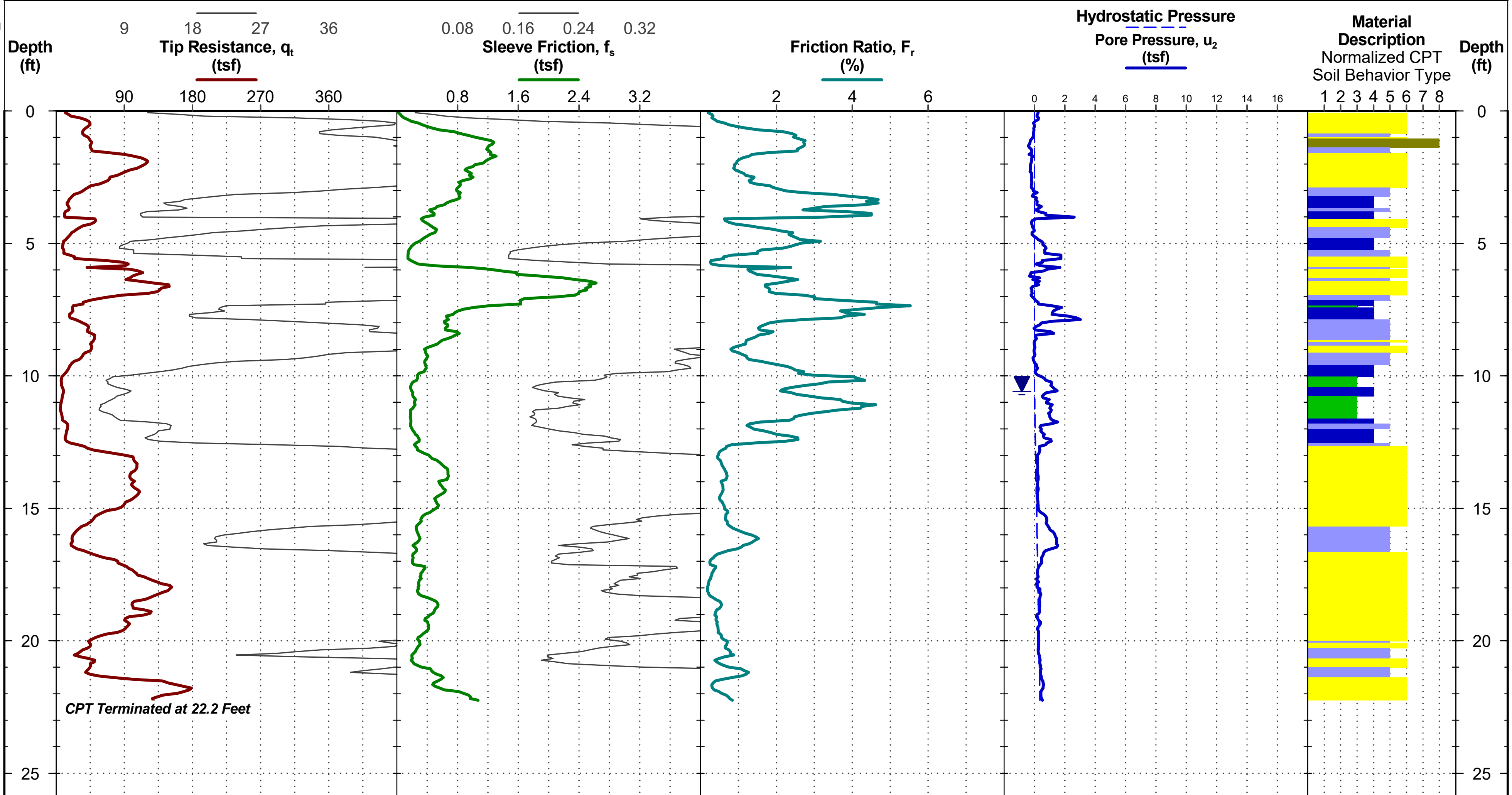
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road
Greenville, NC

Latitude: 35.556252°
Longitude: -77.368287°




**Cave in at 15.6 ft**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

**WATER LEVEL OBSERVATION**

10.6 ft measured water depth
(used in normalizations and correlations; see Appendix C)

Probe no. 5237 with net area ratio of 0.846
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 7/16/2018
Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$
Ring friction reducer with O.D. of 1.875 in

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| Rig: Geoprobe | Operator: BR |
| Project No.: 72185079 | Exhibit: A-6 |

# BORING LOG NO. B-2H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC Greenville, NC**

**SITE: Bayswater Road Greenville, NC**

| GRAPHIC LOG | LOCATION See Exhibit A-2<br>Latitude: 35.5563° Longitude: -77.3683°<br>DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - SILTY CLAYEY SAND (SC-SM)**, trace organics, brown to dark brown | | | | | | |
| | 0.5 **FILL - CLAYEY SAND (SC)**, light gray to gray, and brown | | | | | | |
| | 4.0 | | | | | | |
| | ***Boring Terminated at 4 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-7 |

# CPT LOG NO. B-3



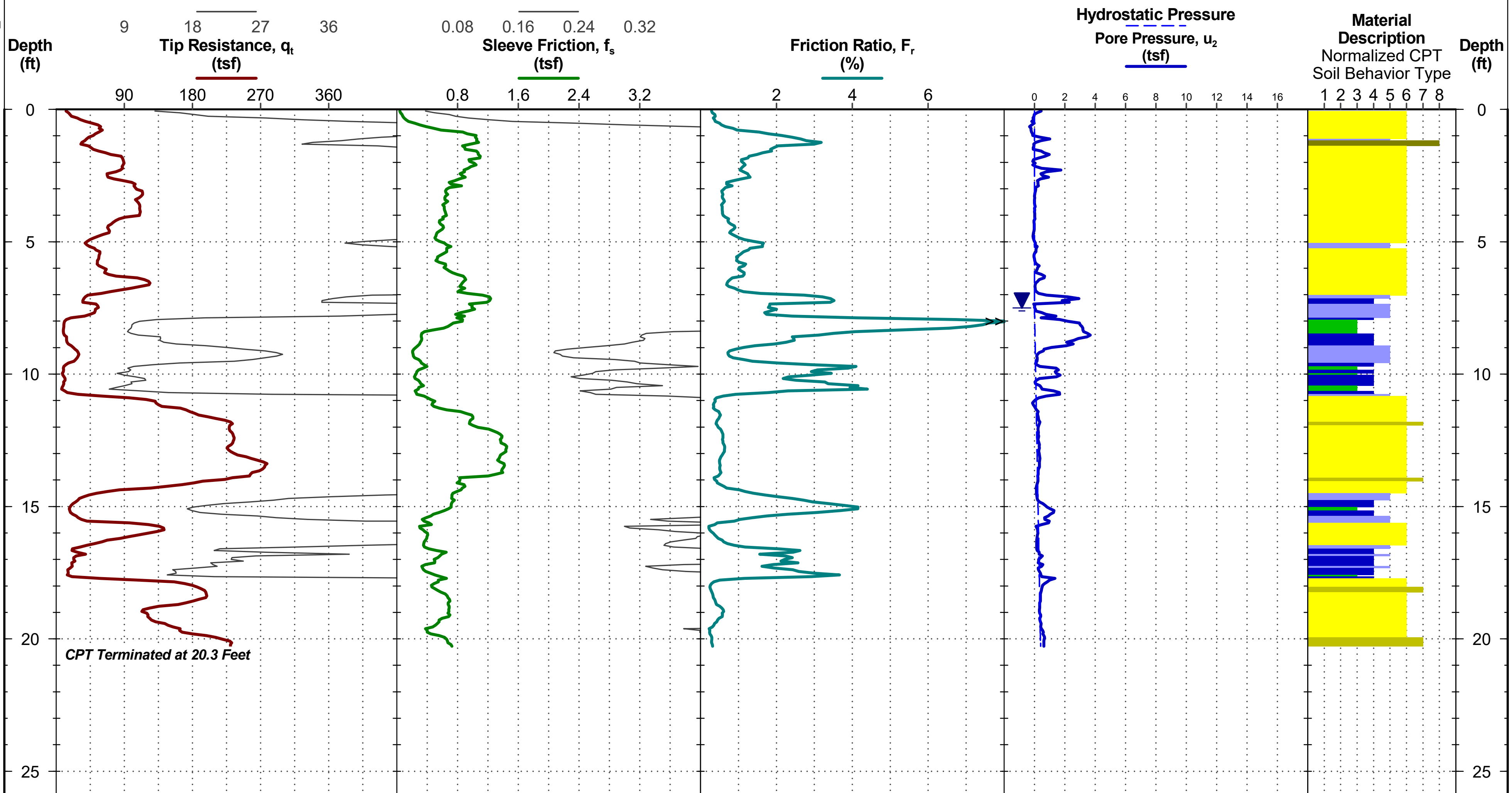
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road
Greenville, NC

Latitude: 35.555754°
Longitude: -77.368289°




**Cave in at 10.3 ft**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

**WATER LEVEL OBSERVATION**

7.5 ft measured water depth
(used in normalizations and correlations; see Appendix C)

Probe no. 5237 with net area ratio of 0.846
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 7/16/2018
Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$
Ring friction reducer with O.D. of 1.875 in

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| Rig: Geoprobe | Operator: BR |
| Project No.: 72185079 | Exhibit: A-8 |

# BORING LOG NO. B-3H

**PROJECT:** **Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT:** **City of Greenville NC Greenville, NC**

**SITE:** **Bayswater Road Greenville, NC**

| GRAPHIC LOG | LOCATION See Exhibit A-2<br>Latitude: 35.5558° Longitude: -77.3683°<br>DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - CLAYEY SAND (SC)**, trace organics, brown to dark brown, and light gray to gray | | | | | | |
| | 4.0 | | | | | | |
| | ***Boring Terminated at 4 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-9 |

# CPT LOG NO. B-4



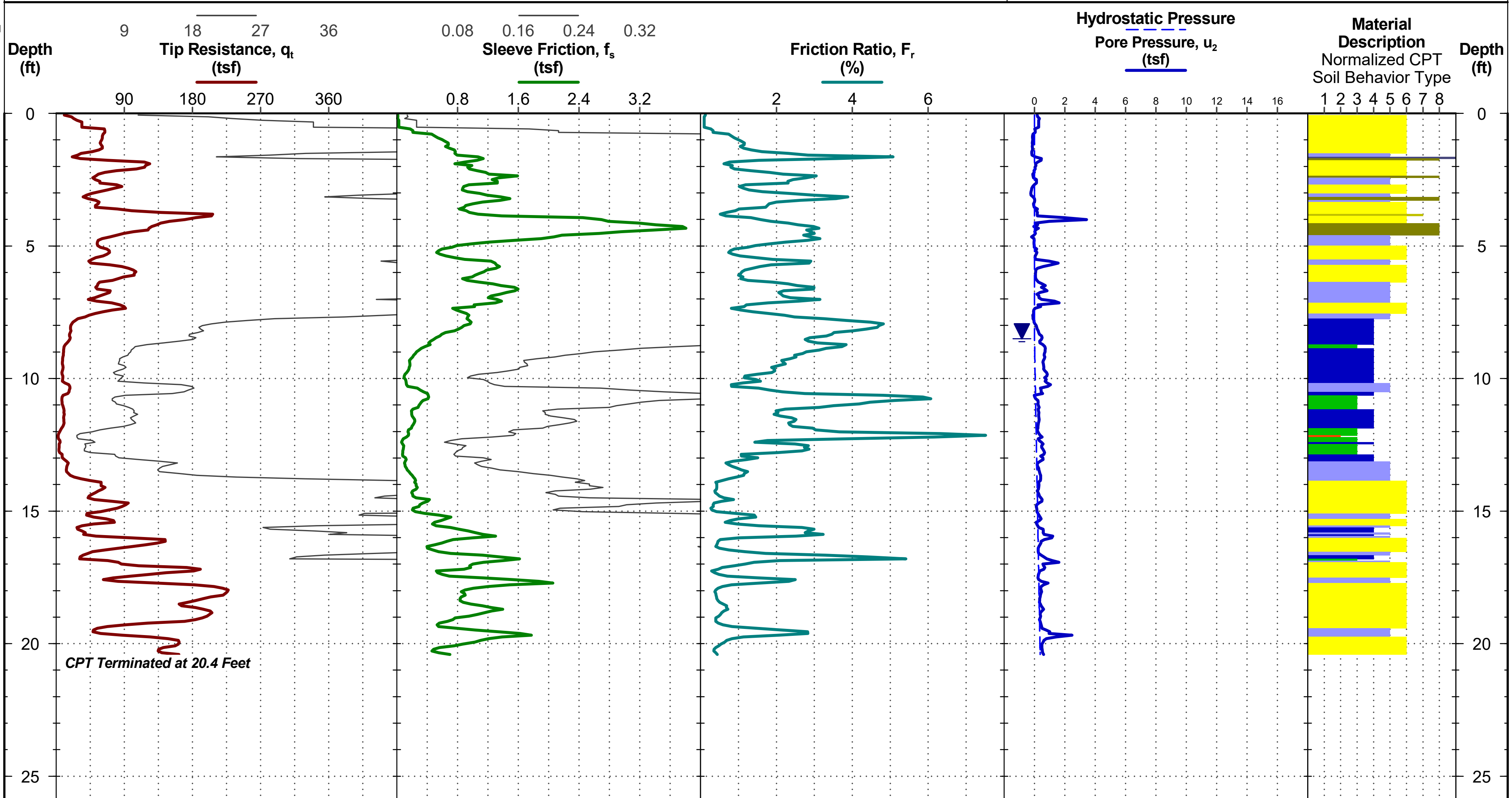
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road
Greenville, NC

Latitude: 35.555843°
Longitude: -77.368058°




**Cave in at 13.3 ft**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

**WATER LEVEL OBSERVATION**

8.5 ft measured water depth
(used in normalizations and correlations; see Appendix C)

Probe no. 5237 with net area ratio of 0.846
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 7/16/2018
Tip and sleeve areas of 10 cm$^2$ and 150 cm$^2$
Ring friction reducer with O.D. of 1.875 in

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| Rig: Geoprobe | Operator: BR |
| Project No.: 72185079 | Exhibit: A-10 |

# BORING LOG NO. B-4H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC Greenville, NC**

**SITE: Bayswater Road Greenville, NC**

| GRAPHIC LOG | LOCATION See Exhibit A-2<br>Latitude: 35.5558° Longitude: -77.3681°<br>DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - SILTY CLAYEY SAND (SC-SM)**, dark brown | | | | | | |
| | 0.5 **FILL - CLAYEY SAND (SC)**, brown to dark brown, gray, and tan | | | | | | |
| | 3.6 ***Obstruction at 3.6 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-11 |

# CPT LOG NO. B-5



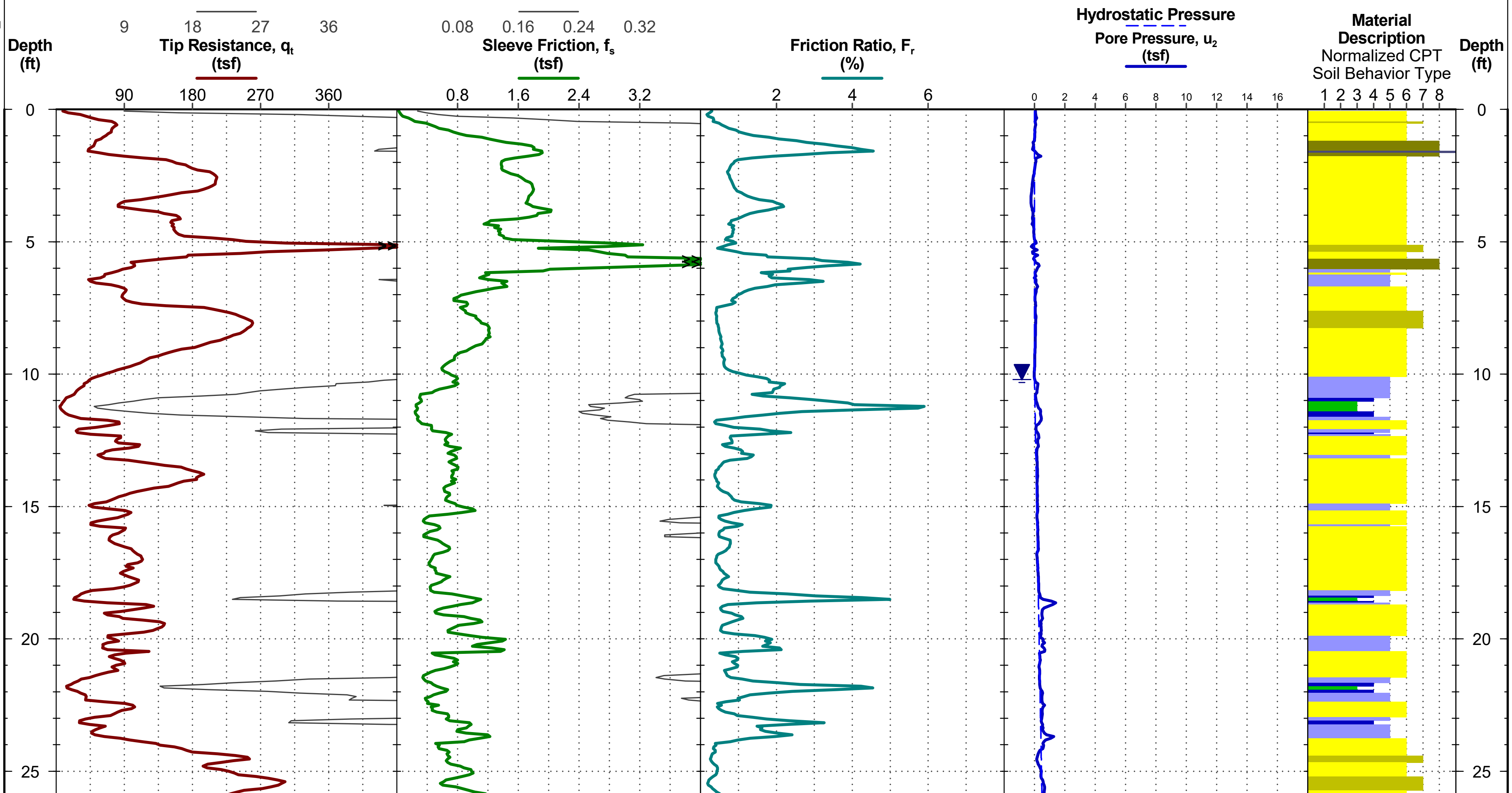
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road
Greenville, NC

Latitude: 35.555997°
Longitude: -77.368289°




**Cave in at 14.6 ft**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

| WATER LEVEL OBSERVATION | | | CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
|---|---|---|---|---|
| 10.2 ft measured water depth (used in normalizations and correlations; see Appendix C) | Probe no. 5237 with net area ratio of 0.846<br>U2 pore pressure transducer location<br>Manufactured by Geotech A.B.; calibrated 7/16/2018<br>Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$<br>Ring friction reducer with O.D. of 1.875 in | Terracon<br>314 Beacon Dr<br>Winterville, NC | Rig: Geoprobe | Operator: BR |
| | | | Project No.: 72185079 | Exhibit: A-12 |

# CPT LOG NO. B-5



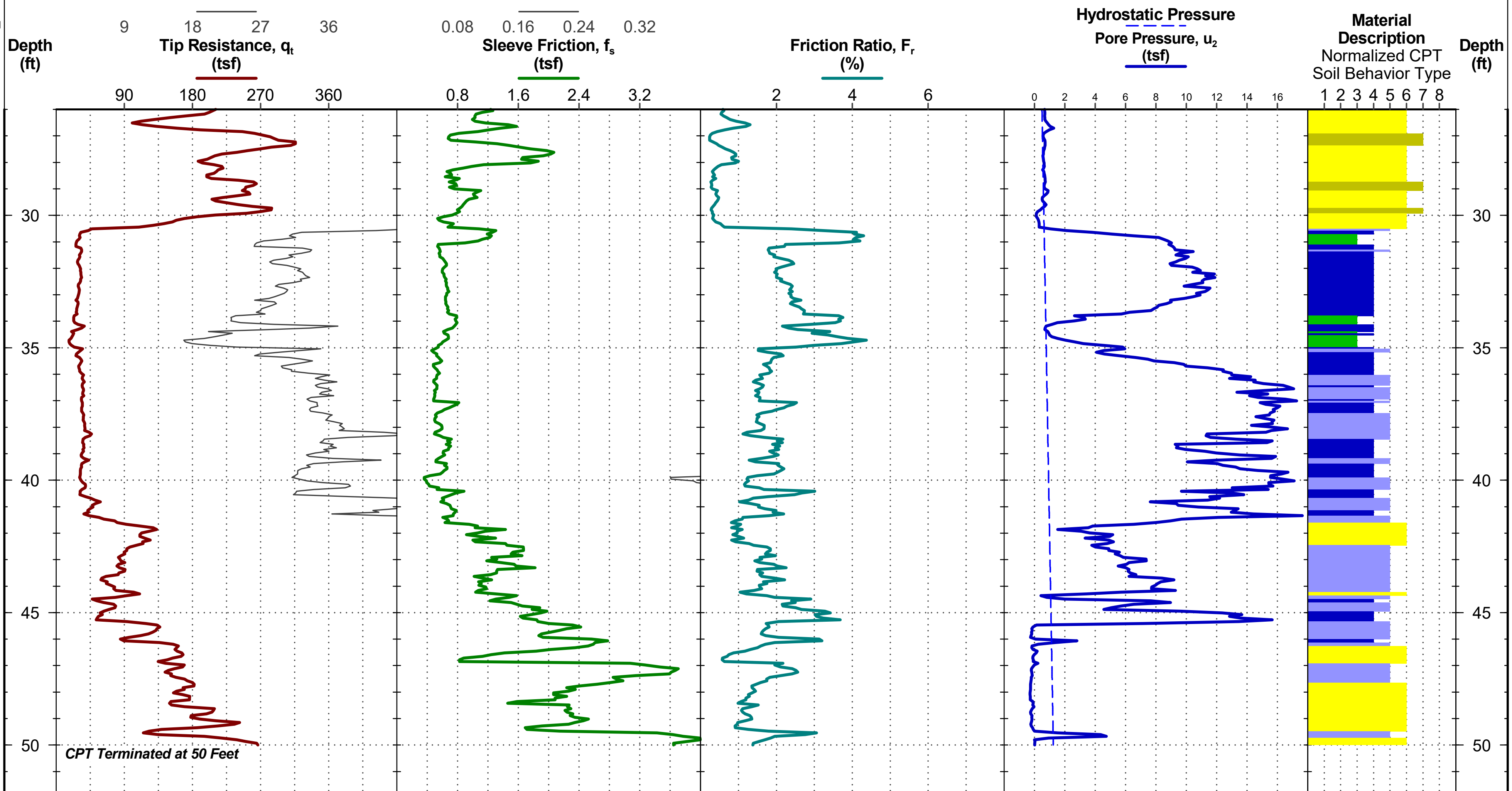
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC, Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road, Greenville, NC

Latitude: 35.555997°
Longitude: -77.368289°




**Cave in at 14.6 ft**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

**WATER LEVEL OBSERVATION**

10.2 ft measured water depth (used in normalizations and correlations; see Appendix C)

Probe no. 5237 with net area ratio of 0.846
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 7/16/2018
Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$
Ring friction reducer with O.D. of 1.875 in

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| Rig: Geoprobe | Operator: BR |
| Project No.: 72185079 | Exhibit: A-12 |

# BORING LOG NO. B-5H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC
Greenville, NC**

**SITE: Bayswater Road
Greenville, NC**

LOCATION See Exhibit A-2

Latitude: 35.556° Longitude: -77.3683°

| DEPTH | Material Description | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - CLAYEY SAND (SC)**, trace organics, dark brown, brown, and orange | | | | 18 | | |
| 3.0 | **FILL - POORLY GRADED SAND (SP)**, brown, orange and gray | | | | 13 | | |
| 3.5 | **FILL - CLAYEY SAND (SC)**, trace gravel, dark gray and dark brown | 5 | | | 14 | | |
| 5.4 | **POORLY GRADED SAND (SP)**, light gray to gray | | | | | | |
| 6.0 | **SANDY LEAN CLAY (CL)**, light gray to gray | | | | 29 | 32-14-18 | 59 |
| 6.4 | **SILTY SAND (SM)**, trace organics, brown to dark brown, and tan | | | | 12 | | |
| | | | | | 30 | | |
| 10.0 | ***Boring Terminated at 10 Feet*** | 10 | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

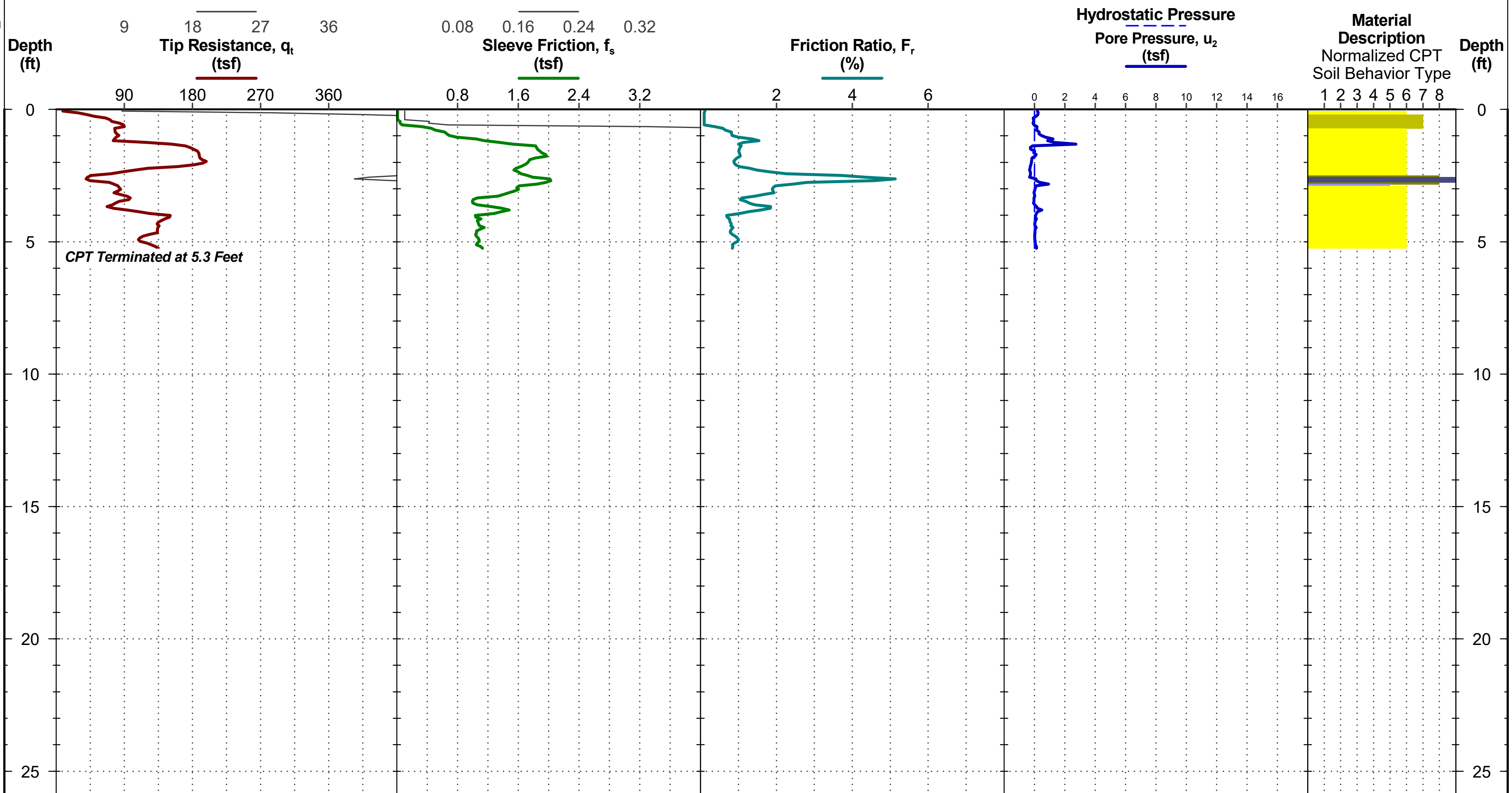
Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-13 |

# CPT LOG NO. B-6



| | | |
|---|---|---|
| **PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548 | **CLIENT:** City of Greenville NC<br>Greenville, NC | **TEST LOCATION:** See Exhibit A-2 |
| **SITE:** Bayswater Road<br>Greenville, NC | | Latitude: 35.555756°<br>Longitude: -77.368444° |




**Cave in at 5 ft**
**No free water observed**
See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

| **WATER LEVEL OBSERVATION** | Probe no. 5237 with net area ratio of 0.846<br>U2 pore pressure transducer location<br>Manufactured by Geotech A.B.; calibrated 7/16/2018<br>Tip and sleeve areas of 10 cm$^2$ and 150 cm$^2$<br>Ring friction reducer with O.D. of 1.875 in | Terracon<br>314 Beacon Dr<br>Winterville, NC | CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
|---|---|---|---|---|
| ▼ (used in normalizations and correlations; see Appendix C) | | | Rig: Geoprobe | Operator: BR |
| | | | Project No.: 72185079 | Exhibit: A-14 |

# BORING LOG NO. B-6H



**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC
Greenville, NC

**SITE:** Bayswater Road
Greenville, NC

LOCATION See Exhibit A-2

Latitude: 35.5558° Longitude: -77.3684°

| DEPTH | Description | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| 2.6 | **FILL - CLAYEY SAND (SC)**, trace gravel, dark brown | | | | | | |
| 3.2 | **SANDY LEAN CLAY (CL)**, trace organics, dark brown | | | | | | |
| 4.0 | **CLAYEY SAND (SC)**, dark brown | | | | | | |

***Boring Terminated at 4 Feet***

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

Terracon
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-15 |

# CPT LOG NO. B-7



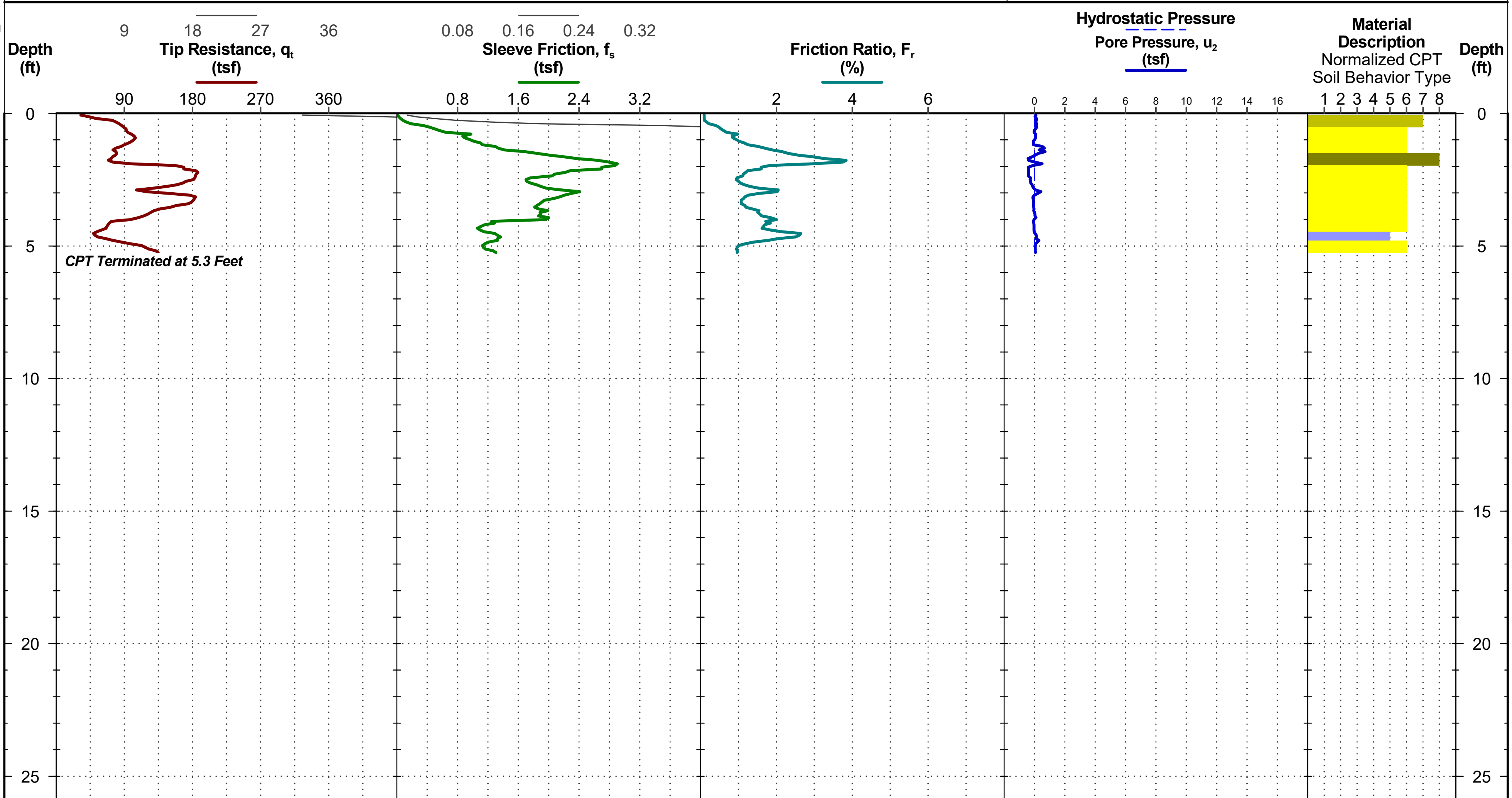
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC, Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road, Greenville, NC

Latitude: 35.556014°
Longitude: -77.368588°




**Cave in at 5 ft**

**No free water observed**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

| | | | | |
|---|---|---|---|---|
| **WATER LEVEL OBSERVATION** ▼ (used in normalizations and correlations; see Appendix C) | Probe no. 5237 with net area ratio of 0.846<br>U2 pore pressure transducer location<br>Manufactured by Geotech A.B.; calibrated 7/16/2018<br>Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$<br>Ring friction reducer with O.D. of 1.875 in | Terracon<br>314 Beacon Dr<br>Winterville, NC | CPT Started: 11/29/2018<br>Rig: Geoprobe<br>Project No.: 72185079 | CPT Completed: 11/29/2018<br>Operator: BR<br>Exhibit: A-16 |

# BORING LOG NO. B-7H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC Greenville, NC**

**SITE: Bayswater Road Greenville, NC**

LOCATION See Exhibit A-2

Latitude: 35.556° Longitude: -77.3686°

| GRAPHIC LOG | DEPTH | DESCRIPTION | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|---|
| | | **FILL - CLAYEY SAND (SC)**, trace gravel and organics, dark brown and brown | | | | | | |
| | 3.3 | **SANDY LEAN CLAY (CL)**, dark brown | | | | | | |
| | 4.0 | ***Boring Terminated at 4 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

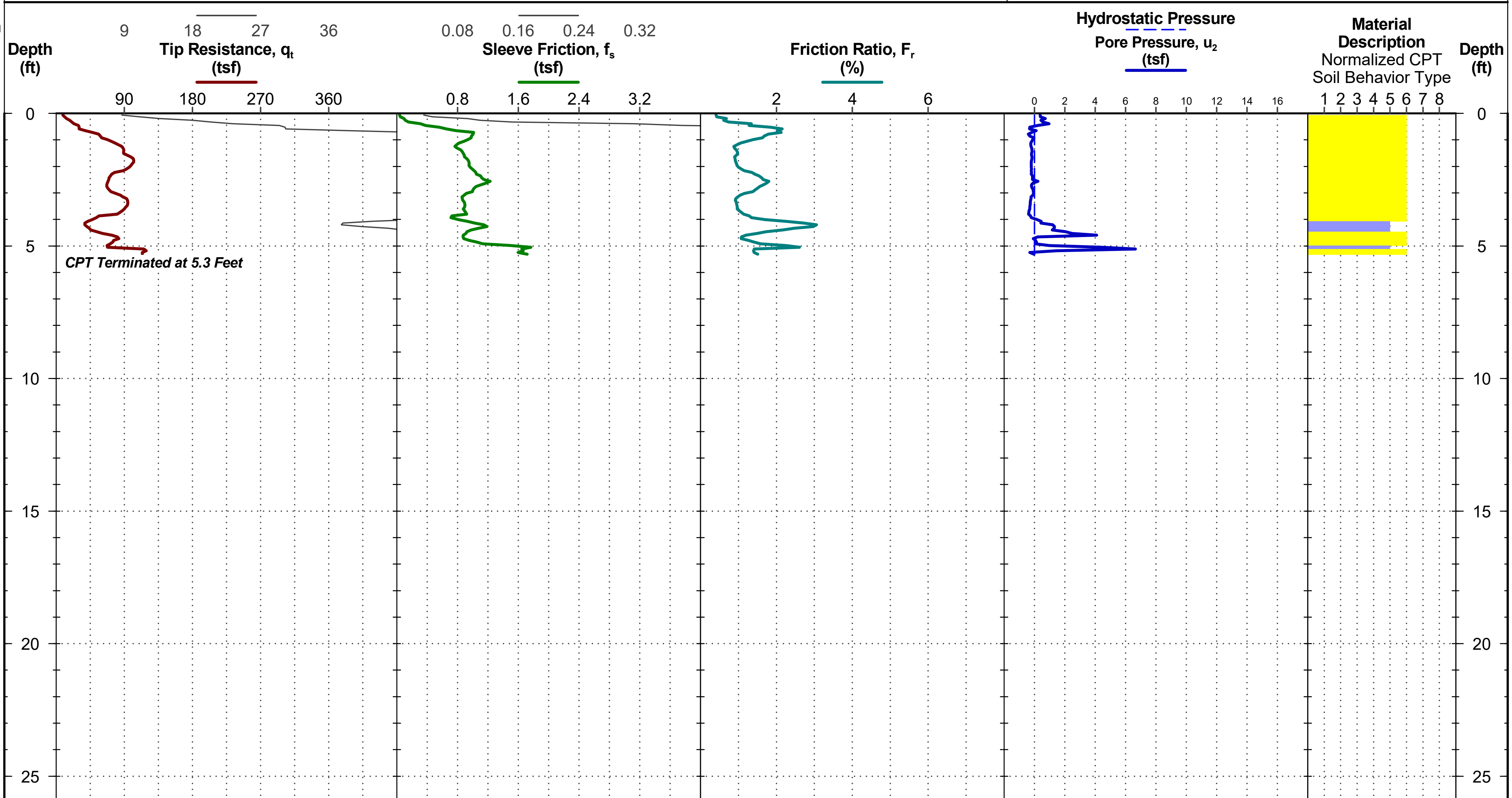
314 Beacon Dr
Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-17 |

# CPT LOG NO. B-8



| | | |
|---|---|---|
| **PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548 | **CLIENT:** City of Greenville NC Greenville, NC | **TEST LOCATION:** See Exhibit A-2 |
| **SITE:** Bayswater Road Greenville, NC | | Latitude: 35.556181° Longitude: -77.368102° |




**Cave in at 3.5 ft**

**No free water observed**

See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.

CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

| | | | | |
|---|---|---|---|---|
| **WATER LEVEL OBSERVATION** (used in normalizations and correlations; see Appendix C) | Probe no. 5237 with net area ratio of 0.846<br>U2 pore pressure transducer location<br>Manufactured by Geotech A.B.; calibrated 7/16/2018<br>Tip and sleeve areas of 10 cm$^2$ and 150 cm$^2$<br>Ring friction reducer with O.D. of 1.875 in | Terracon<br>314 Beacon Dr<br>Winterville, NC | CPT Started: 11/29/2018<br>Rig: Geoprobe<br>Project No.: 72185079 | CPT Completed: 11/29/2018<br>Operator: BR<br>Exhibit: A-18 |

# BORING LOG NO. B-8H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC Greenville, NC**

**SITE: Bayswater Road Greenville, NC**

| GRAPHIC LOG | LOCATION See Exhibit A-2<br>Latitude: 35.5562° Longitude: -77.3681°<br>DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - CLAYEY SAND (SC)**, light brown to dark brown, orange, and light gray | | | | | | |
| | 4.0 | | | | | | |
| | ***Boring Terminated at 4 Feet*** | | | | | | |

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

| | | |
|---|---|---|
| Advancement Method:<br>Hand Auger<br><br>Abandonment Method:<br>Boring backfilled with soil cuttings upon completion. | See Exhibit A-3 for description of field procedures.<br><br>See Appendix B for description of laboratory procedures and additional data (if any).<br><br>See Appendix C for explanation of symbols and abbreviations. | Notes: |

**WATER LEVEL OBSERVATIONS**

*Water level not determined*

*Dry cave*

Terracon
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Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-19 |

# CPT LOG NO. B-9



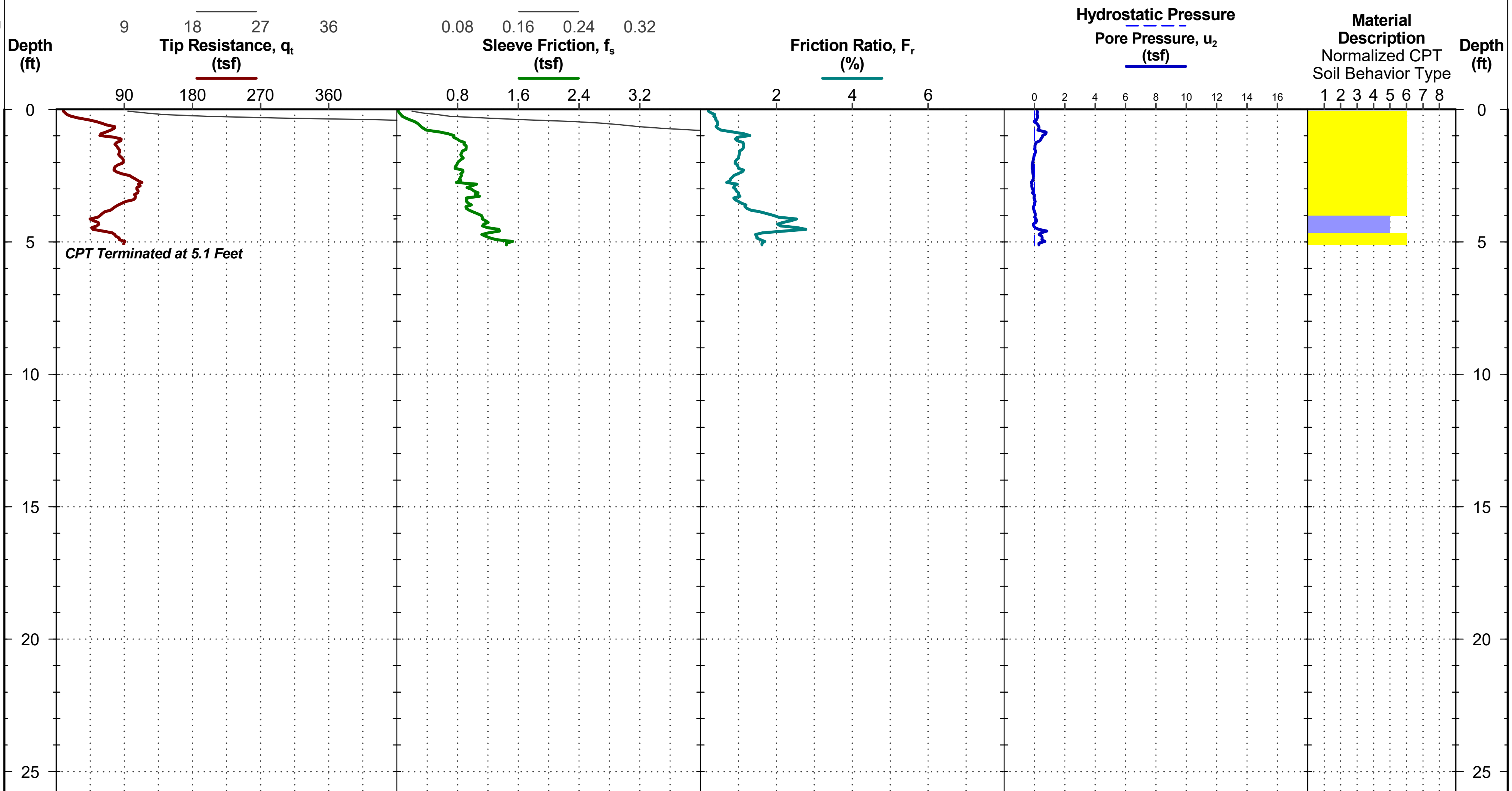
**PROJECT:** Proposed Greenville Fire Station #7 - Parcel 79548

**CLIENT:** City of Greenville NC, Greenville, NC

**TEST LOCATION:** See Exhibit A-2

**SITE:** Bayswater Road, Greenville, NC

Latitude: 35.555966°
Longitude: -77.367975°




**Cave in at 5 ft**
**No free water observed**
See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

Auger anchors used as reaction force.
CPT sensor calibration reports available upon request.

1 Sensitive, fine grained
2 Organic soils - clay
3 Clay - silty clay to clay
4 Silt mixtures - clayey silt to silty clay
5 Sand mixtures - silty sand to sandy silt
6 Sands - clean sand to silty sand
7 Gravelly sand to dense sand
8 Very stiff sand to clayey sand
9 Very stiff fine grained

| | | | | |
|---|---|---|---|---|
| **WATER LEVEL OBSERVATION** | Probe no. 5237 with net area ratio of 0.846<br>U2 pore pressure transducer location<br>Manufactured by Geotech A.B.; calibrated 7/16/2018<br>Tip and sleeve areas of 10 $cm^2$ and 150 $cm^2$<br>Ring friction reducer with O.D. of 1.875 in | Terracon<br>314 Beacon Dr<br>Winterville, NC | CPT Started: 11/29/2018 | CPT Completed: 11/29/2018 |
| (used in normalizations and correlations; see Appendix C) | | | Rig: Geoprobe | Operator: BR |
| | | | Project No.: 72185079 | Exhibit: A-20 |

# BORING LOG NO. B-9H



**PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548**

**CLIENT: City of Greenville NC Greenville, NC**

**SITE: Bayswater Road Greenville, NC**

LOCATION See Exhibit A-2

Latitude: 35.556° Longitude: -77.368°

| GRAPHIC LOG | DEPTH | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | WATER CONTENT (%) | ATTERBERG LIMITS LL-PL-PI | PERCENT FINES |
|---|---|---|---|---|---|---|---|
| | **FILL - CLAYEY SAND (SC)**, trace organics, brown to dark brown | | | | | | |
| | 0.5 **FILL - SILTY SAND (SM)**, light brown and light gray | | | | | | |
| | 1.5 **FILL - CLAYEY SAND (SC)**, light gray to gray | | | | | | |
| | 4.0 ***Boring Terminated at 4 Feet*** | | | | | | |

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with soil 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**

*No free water observed*

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Winterville, NC

| | |
|---|---|
| Boring Started: 11-29-2018 | Boring Completed: 11-29-2018 |
| Drill Rig: | Driller: BR |
| Project No.: 72185079 | Exhibit: A-21 |

# APPENDIX B

# LABORATORY TESTING

## Laboratory Test Description

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Soils laboratory testing was performed under the direction of a geotechnical engineer and included visual classification, moisture content, grain size analysis, and Atterberg limits testing as appropriate. The results of the laboratory testing are shown on the borings logs and in Appendix B.

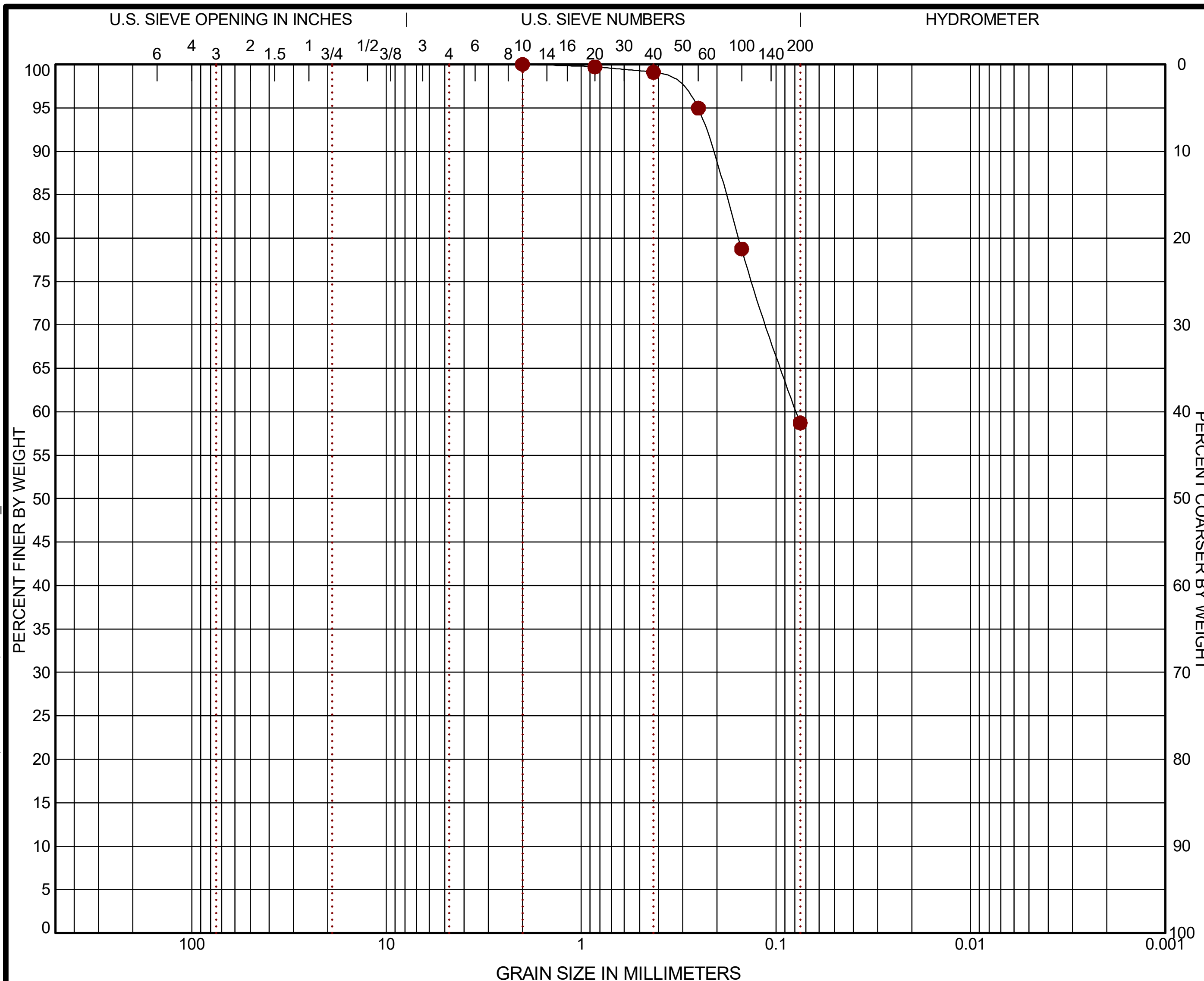
The laboratory test methods are described in the ASTM Standards listed below:

ASTM D2216 Standard Test Method of Determination of Water Content of Soil and Rock by Mass
ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488 Standard Practice of Description and Identification of Soils (Visual Manual Method)
ASTM D422 Standard Test Method for Particle Size Analysis of Soils
ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than No. 200 Sieve in Soils by Washing
ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

# GRAIN SIZE DISTRIBUTION

**ASTM D422 / ASTM C136**




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BORING ID | DEPTH | % COBBLES | % GRAVEL | % SAND | % SILT | % FINES | % CLAY | USCS |
|---|---|---|---|---|---|---|---|---|---|
| ● | **B-5H** | **6 - 6.4** | **0.0** | **0.0** | **41.3** | | **58.7** | | **CL** |
| | | | | | | | | | |
| | | | | | | | | | |

| | GRAIN SIZE | | |
|---|---|---|---|
| | ● | | |
| $D_{60}$ | **0.078** | | |
| $D_{30}$ | | | |
| $D_{10}$ | | | |
| | COEFFICIENTS | | |
| $C_C$ | | | |
| $C_U$ | | | |

| ● | | | | | |
|---|---|---|---|---|---|
| Sieve | % Finer | Sieve | % Finer | Sieve | % Finer |
| **#10** | **100.0** | | | | |
| **#20** | **99.7** | | | | |
| **#40** | **99.09** | | | | |
| **#60** | **94.96** | | | | |
| **#100** | **78.76** | | | | |
| **#200** | **58.72** | | | | |

SOIL DESCRIPTION
● SANDY LEAN CLAY (CL)

REMARKS
● 6 to 6.4 ft

PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548

SITE: Bayswater Road
Greenville, NC

Terracon
314 Beacon Dr
Winterville, NC

PROJECT NUMBER: 72185079

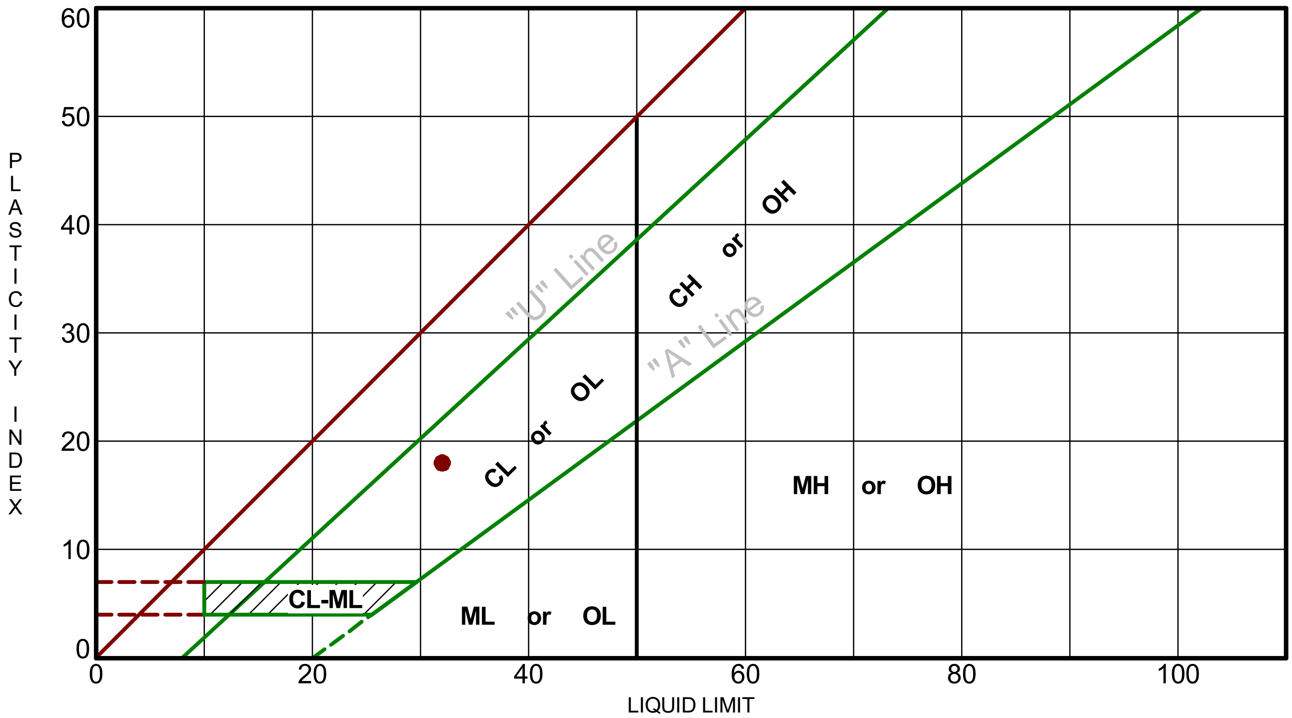
CLIENT: City of Greenville NC
Greenville, NC

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 72185079 FIRE STATION OPTION 1; GREENVILLE, NC.GPJ TERRACON_DATATEMPLATE.GDT 12/13/18

# ATTERBERG LIMITS RESULTS

ASTM D4318




| | Boring ID | Depth | LL | PL | PI | Fines | USCS | Description |
|---|---|---|---|---|---|---|---|---|
| ● | **B-5H** | **6 - 6.4** | **32** | **14** | **18** | **59** | **CL** | **SANDY LEAN CLAY** |

| | |
|---|---|
| PROJECT: Proposed Greenville Fire Station #7 - Parcel 79548 | PROJECT NUMBER: 72185079 |
| SITE: Bayswater Road<br>Greenville, NC | CLIENT: City of Greenville NC<br>Greenville, NC |
| | EXHIBIT: B-3 |

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# APPENDIX C

# SUPPORTING DOCUMENTS

# SPT GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

**SAMPLING**

| | |
|---|---|
| Auger | Split Spoon |
| Shelby Tube | Macro Core |
| Ring Sampler | Rock Core |
| Grab Sample | No Recovery |

**WATER LEVEL**

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

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.

**FIELD TESTS**

| | |
|---|---|
| (HP) | Hand Penetrometer |
| (T) | Torvane |
| (b/f) | Standard Penetration Test (blows per foot) |
| (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 Includes gravels, sands and silts. | | | CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance | | | |
|---|---|---|---|---|---|---|
| **Descriptive Term (Density)** | **Standard Penetration or N-Value Blows/Ft.** | **Ring Sampler Blows/Ft.** | **Descriptive Term (Consistency)** | **Unconfined Compressive Strength, Qu, tsf** | **Standard Penetration or N-Value Blows/Ft.** | **Ring Sampler Blows/Ft.** |
| Very Loose | 0 - 3 | 0 - 6 | Very Soft | less than 0.25 | 0 - 1 | < 3 |
| Loose | 4 - 9 | 7 - 18 | Soft | 0.25 to 0.50 | 2 - 4 | 3 - 4 |
| Medium Dense | 10 - 29 | 19 - 58 | Medium-Stiff | 0.50 to 1.00 | 4 - 8 | 5 - 9 |
| Dense | 30 - 50 | 59 - 98 | Stiff | 1.00 to 2.00 | 8 - 15 | 10 - 18 |
| Very Dense | > 50 | $\geq$ 99 | Very Stiff | 2.00 to 4.00 | 15 - 30 | 19 - 42 |
| | | | Hard | > 4.00 | > 30 | > 42 |

## 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 |

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# 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 | < 0.75 | OL | Organic clay [K,L,M,N] |
| | | | Liquid limit - not dried | | | 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 | < 0.75 | OH | Organic clay [K,L,M,P] |
| | | | Liquid limit - not dried | | | 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.

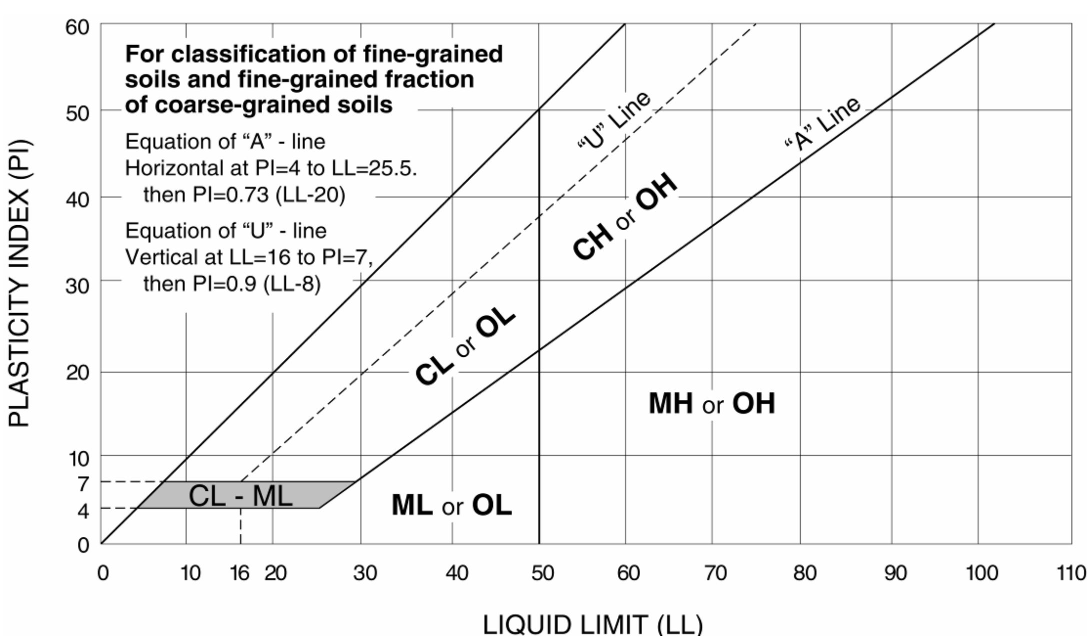


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Exhibit C-2

# CPT GENERAL NOTES

## DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

Uncorrected Tip Resistance, $q_c$
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance, $q_t$
Cone resistance corrected for porewater and net area ratio effects
$q_t = q_c + U2(1 - a)$
Where a is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

Pore Pressure, U1/U2
Pore pressure generated during penetration
U1 - sensor on the face of the cone
U2 - sensor on the shoulder (more common)

Sleeve Friction, fs
Frictional force acting on the sleeve divided by its surface area

Normalized Friction Ratio, FR
The ratio as a percentage of fs to $q_t$, accounting for overburden pressure

To be reported per ASTM D7400, if collected:

Shear Wave Velocity, Vs
Measured in a Seismic CPT and provides direct measure of soil stiffness

## DESCRIPTION OF GEOTECHNICAL CORRELATIONS

Normalized Tip Resistance, $Q_t$
$Q_t = (q_t - \sigma_{V0})/\sigma'_{V0}$

Over Consolidation Ratio, OCR
OCR (1) $= 0.25(Q_t)^{1.25}$
OCR (2) $= 0.33(Q_t)$

Undrained Shear Strength, Su
$Su = Q_t \times \sigma'_{V0}/N_{kt}$
$N_{kt}$ is a geographical factor (shown on Su plot)

Sensitivy, St
$St = (q_t - \sigma_{V0}/N_{kt}) \times (1/fs)$

Effective Friction Angle, $\phi'$
$\phi'$ (1) $= \tan^{-1}(0.373[\log(q_t/\sigma'_{V0}) + 0.29])$
$\phi'$ (2) $= 17.6 + 11[\log(Q_t)]$

Unit Weight
$UW = (0.27[\log(FR)]+0.36[\log(q_t/atm)]+1.236) \times UW_{water}$
$\sigma_{V0}$ is taken as the incremental sum of the unit weights

Small Strain Shear Modulus, $G_0$
$G_0$ (1) $= \rho Vs^2$
$G_0$ (2) $= 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$

Soil Behavior Type Index, Ic
$Ic = [(3.47 - \log(Q_t))^2 + (\log(FR) + 1.22)^2]^{0.5}$

SPT $N_{60}$
$N_{60} = (q_t/atm) / 10^{(1.1268 - 0.2817Ic)}$

Elastic Modulus, Es (assumes $q/q_{ultimate} \sim 0.3$, i.e. FS = 3)
Es (1) $= 2.6\Psi G_0$ where $\Psi = 0.56 - 0.33\log Q_{t,clean\ sand}$
Es (2) $= G_0$
Es (3) $= 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$
Es (4) $= 2.5q_t$

Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{V0})$
For Ic > 2.2 (fine-grained soils)
$\alpha_M = Q_t$ with maximum of 14
For Ic < 2.2 (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

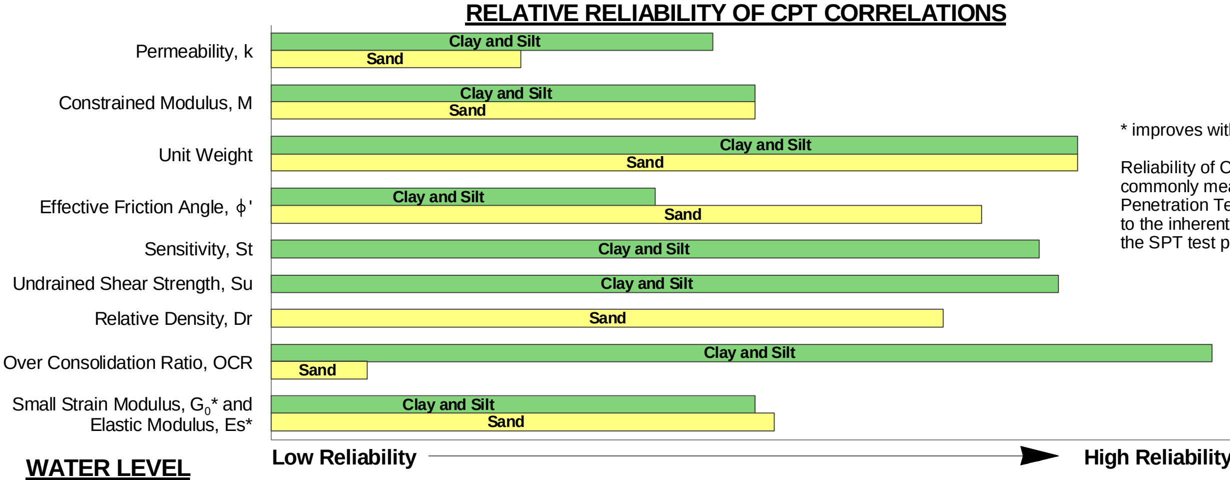
Hydraulic Conductivity, k
For 1.0 < Ic < 3.27  $k = 10^{(0.952 - 3.04Ic)}$
For 3.27 < Ic < 4.0  $k = 10^{(-4.52 - 1.37Ic)}$

Relative Density, Dr
$Dr = (Q_t / 350)^{0.5} \times 100$

## REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include tip resistance, sleeve resistance, and porewater pressure. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

## RELATIVE RELIABILITY OF CPT CORRELATIONS




* improves with seismic Vs measurements

Reliability of CPT-predicted $N_{60}$ values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

## WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

*Measured - Depth to water directly measured in the field*

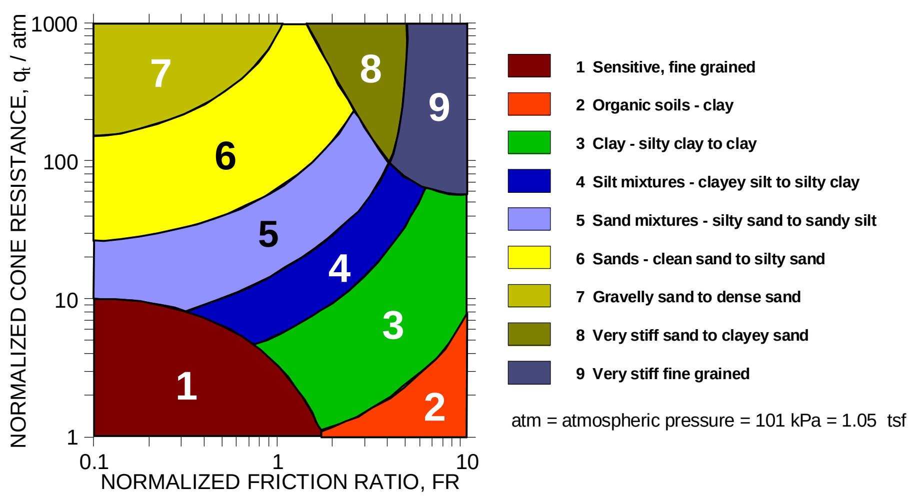
*Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions*

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

## CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance ($q_t$), friction resistance (fs), and porewater pressure (U2). The normalized friction ratio (FR) is used to classify the soil behavior type.

Typically, silts and clays have high FR values and generate large excess penetration porewater pressures; sands have lower FRs and do not generate excess penetration porewater pressures. Negative pore pressure measurements are indicative of fissured fine-grained material. The adjacent graph (Robertson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.




atm = atmospheric pressure = 101 kPa = 1.05 tsf

## REFERENCES


Kulhawy, F.H., Mayne, P.W., (1997). "Manual on Estimating Soil Properties for Foundation Design," Electric Power Research Institute, Palo Alto, CA.
Mayne, P.W., (2013). "Geotechnical Site Exploration in the Year 2013," Georgia Institue of Technology, Atlanta, GA.
Robertson, P.K., Cabal, K.L. (2012). "Guide to Cone Penetration Testing for Geotechnical Engineering," Signal Hill, CA.
Schmertmann, J.H., (1970). "Static Cone to Compute Static Settlement over Sand," *Journal of the Soil Mechanics and Foundations Division*, 96(SM3), 1011-1043.


Terracon