Preliminary Geotechnical Engineering Investigation

Highlands Apartment Tract 3
Pooler, Georgia

January 17, 2017
Terracon Project No. ES165408

Prepared for:
TCA, LLC
Augusta, Georgia

Prepared by:
Terracon Consultants, Inc.
Savannah, Georgia

January 17, 2017

TCA, LLC
ATC Development
200 Boy Scout Road
Augusta, Georgia 30909

Attn: Shelly Martin
C: (706) 736 4748
E: shellym@atcdevelopment.com

Re: Preliminary Geotechnical Engineering Investigation
Highlands Apartment Tract 3
Pooler, Georgia
Terracon Project No. ES165408

Dear Ms. Martin:

Terracon Consultants, Inc. (Terracon) has completed the Preliminary Geotechnical Engineering Investigation for the above-referenced project. The services were performed in general accordance with our proposal No. PES165408 dated December 19, 2016. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the design and construction of the project.

We appreciate the opportunity to be of service to you. Should you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

GEORGIA Registered PROFESSIONAL Engineer GUOMING LIN

Yanbo Huang, Ph.D., E.I.T.
Staff Geotechnical Engineer

Guoming Lin, Ph.D., P.E.
Senior Principal

cc: 1 – Client (PDF)
1 – File

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

This report presents the findings of our Preliminary Geotechnical Engineering Investigation for the proposed Highlands Apartment Tract 3 located off Highlands Boulevard in Pooler, Georgia. The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations. Based on the results of the subsurface exploration and analyses, the following geotechnical considerations were identified:

- The subsurface conditions of the site are considered variable and marginally suitable to support lightly loaded structures using shallow foundations. In general, the soils in the upper 1 to 3 feet are loose silty sands to sands with clay, underlain by soft to stiff silty/sandy clays interbedded with clayey/silty sands with approximate thickness of 24 to 42 feet. The groundwater was encountered at approximate depths of 2 to 10 feet below the existing ground surface (BGS) based on CPT soundings and hand auger borings.

- The information regarding structural loads is not available at the time of this report. The assumed loads for our settlement analyses are presented in **Section 2.1**. We performed settlement analyses for shallow foundations using the assumed loads. Using the assumed light loads, the total settlement were estimated to be less than or close to 1.0 inch.

- The proposed buildings can be supported on a shallow foundation system provided the loads are less than the assumed values. If heavier loads are anticipated, ground improvement such as preloading with surcharge will be required.

- A net allowable bearing capacity of 1,500 pounds per square foot (psf) is recommended for shallow foundation design. The allowable bearing capacity is allowed to increase by 1/3 for transient wind load and seismic load conditions. Terracon should be retained to confirm and test the subgrade during construction to provide more specific recommendations on subgrade repair based on the conditions of the subgrade at the time of construction.

- For seismic design purposes, the subject site shall be classified as **Site Class D** in accordance with the International Building Code (IBC) 2012 and ASCE 7-10 Section 11.4.2.

- This is a preliminary investigation. A detailed geotechnical investigation is necessary for the design and construction of any specific development.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details are not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the findings and recommendations contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report's limitations.

PRELIMINARY GEOTECHNICAL ENGINEERING INVESTIGATION

Highlands Apartment Tract 3
Pooler, Georgia

Terracon Project No. ES165408
January 17, 2017

1.0 INTRODUCTION

Terracon has completed the Geotechnical Engineering Investigation for the proposed Highlands Apartment Tract 3 apartments located off Highlands Boulevard in Pooler, Georgia. The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations.

The field exploration program consisted of five (5) cone penetration test (CPT) soundings to a maximum depth of 44.2 feet below the existing ground surface (BGS) and five (5) hand auger borings to a maximum depth of about 5 feet BGS. The CPT sounding logs and hand auger boring logs along with a site location map and exploration location plan are included in **Appendix A** of this report.

The purpose of this study is to provide subsurface information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- site preparation
- groundwater conditions
- foundation design and construction
- pavement recommendation
- seismic considerations

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Proposed improvements	The construction of new multi-family apartments. The investigation is for Tract 3 which is about 23.5 acres.
Finished floor elevation	Not provide but assumed to be close to the existing ground surface.

Item	Description
Maximum loads	Not provided but following values are assumed for our settlement analysis. **Column load** = 50 kips. **Wall load** = 3.5 kips per linear foot. **Slab load** = 300 psf.
Maximum allowable settlement	Total settlement: 1 inch (assumed). Differential settlement: ½ inches over 40 feet or between columns (assumed).
Grading	We assume no fill will be placed over the site.

2.2 Site Location and Description

Item	Description
Location	The site is located off Highlands Boulevard in Pooler, Georgia. Latitude: 32.1718°, Longitude: -81.2270°
Existing improvements	None.
Current ground cover and access conditions	The site is a wooded area with an isolated wetland area.
Existing topography	Relatively level except a drainage ditch and mounts of soils.

Should any of the above information or assumptions be inconsistent with the planned construction, Terracon should be informed so that modifications to this report can be made as necessary.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the field exploration, the subsurface conditions at the project site are considered variable and contain soft clayey soils at different depths, and can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet, BGS)	Material Encountered	Equivalent SPT - N_{60}
Topsoil	0.5*	Silty sands with grass roots.	--
Stratum 1	1 to 3	Loose silty sands to sands with clay.	4 to 9

Description	Approximate Depth to **Bottom of Stratum** (feet, BGS)	Material Encountered	Equivalent SPT - N_{60}
Stratum 2	27 to 44	Soft to stiff silty/sandy clays interbedded with silty/clayey sands	3 to 10
Stratum 3	44.2, termination of soundings	Medium dense to dense silty sands interbedded with silty/sandy clays.	15 to 40

*The thickness of topsoil may be variable during earthwork as describe in **Section 4.2**.

Details of the subsurface conditions encountered at each sounding/boring location are presented on the individual CPT sounding and hand auger boring logs in **Appendix A** of this report. Stratification boundaries shown on the logs represent the approximate depth of changes in soil types; the transition between materials may be gradual.

3.2 Groundwater

The groundwater table was measured using a water level meter in hand auger borings and CPT soundings at depths of 2 to 10 feet BGS during the field exploration. Mottling of the soils was noted at depths of 1.5 to 2 feet BGS during our hand auger borings, which is interpreted as an indication of seasonal high groundwater level. It should be noted that groundwater levels tend to fluctuate with seasonal and climatic variations, as well as with construction activities. As such, the possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. The groundwater table should be checked prior to construction to assess its effect on site work and other construction activities.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The subsurface conditions of this site are considered variable and marginally suitable to support lightly loaded structures on shallow foundations. The generalized soil profile is presented in **Section 3.1**.

We understand this is a preliminary investigation, no information regarding structural loads is available. The assumed loads for our settlement analysis are presented in **Section 2.1** of this report. Shallow foundation settlement analyses were performed at each sounding location using the soil parameters derived from the CPT soundings and the assumed loads. Based on the settlement analyses, total settlements were estimated to be less than or close to than one inch at all sounding locations.

Therefore, the proposed buildings can be supported on a shallow foundation system provided the loads are less than the assumed values. If the heavier loads are expected, ground improvement such as preloading with surcharge will be required.

During our field operation, we found standing water was ponding at low laying areas on the access road and a ditch of about 5 feet wide by 2 to 3 feet deep. Mounts of soils were found along north side of St. Augustine Road Creek Road, which is about 5 feet height.

During the site preparation, after the removal of topsoil, the soft clayey soils found at 1 to 3 feet below the existing ground surface will be exposed and will likely cause an unstable subgrade for footing/slab support. To achieve stable subgrade, the contractor should expect undercutting and backfilling of these soft areas. It is anticipated that subgrade undercutting and backfilling will be required in those soft area for footing/slab support.

We recommend hand auger borings and dynamic cone penetration (DCP) testing be performed during construction to evaluate and confirm the subgrade conditions under the footings. It is anticipated that subgrade soil undercutting will be required during subgrade preparation for foundation.

During site preparation, topsoil, organic matter, stumps, existing fill, or other unsuitable materials should not be left in subgrade under buildings or pavements. All footings/slab should bear on suitable natural soil, or on properly compacted structural fills. Compacted fill should be placed directly on suitable natural soil. We recommend Terracon be retained to test the footing subgrade during construction so that Terracon can provide additional recommendations to prepare the subgrade based on the conditions uncovered during the footing preparation.

The following sections present our recommendations for the site work and subgrade preparations for the shallow foundations.

4.2 Earthwork

The site work conditions will be largely dependent on the weather and the contractor's means and methods in controlling surface drainage and protecting the subgrade. Site preparation should include the installation of a site drainage system, topsoil stripping and grubbing, subgrade preparation, densification and proofrolling. Due to the uneven ground surface of the site, the volume of topsoil and organics may be significantly greater than the area times the topsoil/organics thickness indicated in the boring logs. Rutting of the subgrade can also cause mixing of topsoil/organics with underlying soils, which will result in additional required topsoil/organics stripping. Subgrade undercut may be needed in some localized areas to remove tree stumps or other unsuitable materials.

4.2.1 Site Drainage

An effective drainage system should be installed prior to the initiation of site preparation and grading activities to intercept surface water and to improve overall shallow drainage. The drainage system may consist of perimeter ditches supplemented with parallel ditches and swales. Pumping equipment should be used if the above ditch system cannot effectively drain water away from the site, especially during the rainy season. The site should be graded to shed water and avoid ponding over the subgrade.

4.2.2 Densification and Proofrolling

Prior to fill placement, the entire building and pavement areas should be densified with a heavy-duty vibratory roller to achieve a uniform subgrade. The subgrade should be thoroughly proofrolled after the completion of densification. Proofrolling will help detect any isolated soft or loose areas that "pump", deflect or rut excessively, and also densify the near-surface soils for floor slab support.

A loaded tandem axle dump truck, capable of transferring a load in excess of 20 tons, should be utilized for this operation. Proofrolling should be performed under Terracon's observation. Areas where pumping, excessive deflection or rutting is observed after successive passes of the proofrolling equipment should be undercut, backfilled and then properly compacted.

4.2.3 Fill Material Consideration

Structural fill should be placed over a stable or stabilized subgrade. The soils to be used as structural fill should be free of organics, roots, or other deleterious materials. It should be non-plastic granular material containing less than 25 percent fines passing the No. 200 sieve. If necessary, non-plastic granular materials with 25 to 35 percent fines may be used as fill in less critical areas under close control of moisture and compaction. In general, after the removal of topsoil, the onsite soils which consist of silty/sandy clays (ML-CL/CL) are considered unsuitable for structural fill.

All structural fills should be placed in thin (8 to 10 inches loose) lifts and compacted to a minimum of 95% of the soil's Modified Proctor maximum dry density (ASTM D-1557). Fill brought to the site should be within 3 percent (wet or dry) of the optimum moisture content.

Some manipulation of the moisture content (such as wetting, drying) will be required during the filling operation to achieve the specified degree of compaction. The manipulation of the moisture content is highly dependent on both the weather and site drainage conditions. Therefore, the contractor should prepare both dry and wet fill materials to obtain the specified compaction during grading. A sufficient number of density tests should be performed to confirm the required compaction of the fill material.

4.3 Spread Footing Foundations

The proposed buildings can be supported on a shallow foundation system provided the loads are less than the assumed values. The following sections present design recommendations and construction considerations for the shallow foundations for the proposed building and related structural elements.

4.3.1 Spread Footing Design Recommendations

Description	Column	Wall
Net allowable bearing pressure [1]	1,500 psf	1,500 psf
Minimum dimensions	12 inches	12 inches
Minimum embedment below finished grade	18 inches	12 inches
Approximate total settlement [2]	<1 inch	<1 inch
Estimated differential settlement	<1 inch between columns	<1/2 inch over 40 feet
Ultimate Coefficient of sliding friction [3]	0.32	

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. It assumes any unsuitable fill or soft soils, if encountered, will be replaced with compacted structural fill.
2. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations. Footings should be proportioned to reduce differential settlements. Proportioning on the basis of equal total settlement is recommended; however, proportioning to relative constant dead-load pressure will also reduce differential settlement between adjacent footings.
3. Sliding friction along the base of the footing will not develop where net uplift conditions exist.

The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. The weight of the foundation concrete below grade may be neglected in dead load computations.

Foundation excavations should be observed by Terracon. If the soil conditions encountered differ significantly from those presented in this report, Terracon should be contacted to provide additional evaluation and supplemental recommendations.

4.3.2 Spread Footing Construction Considerations

The bottom of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavation to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Extremely wet or dry material, or any loose or disturbed material in the bottom of the footing excavations should be removed before concrete is placed. If the soils at bearing level become excessively dry, disturbed or saturated, the affected soils should be removed prior to placing concrete. A lean concrete mud-mat should be placed over the bearing soils if the excavations must remain open overnight or for an extended period of time.

Regarding construction of footings, we generally anticipate suitable material will be present at the bottom of the footings. However, there is a possibility that isolated zones of soft or loose native soils could be encountered below footing bearing level, even though field density tests are expected to be performed during fill placement. Therefore, it is important that Terracon be retained to observe, test, and evaluate the bearing soil prior to placing reinforcing steel and concrete to determine if additional footing excavation or other subgrade repair is needed for the design loads.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on those soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted structural backfill extending down to the suitable soils. Over-excavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation.

The over-excavation should then be backfilled up to the footing base elevation with well-graded granular material placed in lifts of 6 inches or less in loose thickness and compacted to at least 95 percent of the material's maximum dry density as determined by the Modified Proctor test (ASTM D-1557). No. 57 stone is recommended in lieu of structural fill when the volume of excavation is relatively small, recompaction of the fill is difficult, or the weather or construction schedule becomes a controlling factor.

4.4 Floor Slabs

4.4.1 Floor Slab Design Recommendations

Item	Description
Floor slab support	Compacted structural fill/inspected and tested natural ground.[1]
Modulus of subgrade reaction	100 pounds per square inch per in (psi/in) for point loading conditions.
Base course/capillary break [2]	4 inches of free draining granular material.
Vapor barrier	Project Specific.[3]
Structural considerations	Floor slabs should be structurally separated from columns and walls to allow relative movements.[4]

1. Because the existing ground may have been filled or disturbed previously, we recommend the subgrade be inspected and tested with proofrolling after the topsoil is stripped as outlined in the **Section 4.2** of this report.
2. The floor slab design should include a base course comprised of free-draining, compacted, granular material, at least 4 inches thick. The granular subbase may be graded aggregate base (GAB) or sands containing less

than 5 percent fines (material passing the #200 sieve). GAB subbase can also help improve workability of the subgrade especially during rain periods.

3. 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, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, 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. Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation. Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates that any differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks that occur beyond the length of the structural dowels. The structural engineer should account for this potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

4.4.2 Floor Slab Construction Considerations

Prior to construction of grade supported slabs, varying levels of remediation may be required to reestablish stable subgrades within slab areas due to construction traffic, rainfall, disturbance, desiccation, etc. As a minimum, the following measures are recommended.

- Interior trench backfill placed beneath slabs should be compacted in accordance with recommendations outlined in **Section 4.2** of this report.
- All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the stone base and concrete.

4.5 Pavement Considerations

We understand that the proposed development will include paved roads and parking lots. This section presents thickness recommendations for asphalt and concrete pavements and general considerations for pavement design and construction. The required pavement thickness will depend on:

- The traffic loads including traffic pattern and the service life of the pavement;
- Subgrade conditions including soil strength and drainage characteristics;
- Paving material characteristics;
- Climatic conditions of the region.

Information on traffic loads and patterns was not available at the time of this report. The subgrade conditions will depend on the in-situ soils at the subgrade level, characteristics of fill material for the subgrade as well as site preparation procedures.

Assuming the finished subgrade will be near the existing ground surface, after the removal of topsoil, the near surface soils are mostly silty/sandy clays which should have poor drainage characteristics and are deemed unsuitable for subgrade support. We recommend the upper two feet of the subgrade be relatively clean sands with percent fines less than 15 percent. Based on the findings of existing soils, we anticipate structural fill will be used for the pavement construction. Additional evaluation will be needed in the detailed geotechnical investigation based on the loads, grading plans and subsurface conditions to be obtained from the additional exploration.

Pavement and Subgrade Drainage

Poor subgrade drainage is the most common cause of pavement failure. Pavement should be sloped to provide rapid drainage of surface water. Water should not be allowed to pond on or adjacent to the pavement which would saturate the subgrade soils and weaken the subgrade support. We recommend the site drainage be designed to maintain the groundwater at least two feet below the top of the subgrade.

Pavement subgrade drainage should surround the areas anticipated to have frequent wetting or having poor natural drainage, such as landscaped islands, along curbs, and gutters and around drainage structures. All landscaped areas in or adjacent to pavements should be sealed to reduce moisture migration to subgrade soils. Subgrade drains should be installed at the bottom of the Graded Aggregate Base (GAB) level. The civil engineer should decide the placement of the subgrade drains to avoid the saturation of pavement subgrade.

4.6 Seismic Considerations

Based on the findings in the field exploration and our knowledge of the local geological formation in the project area, the site can be classified as Site Class D in accordance with IBC 2012 and ASCE 7-10. The seismic design parameters obtained based on IBC 2012 and ASCE 7-10 are summarized in table below. The design response spectrum curve, as presented in the appendix, was developed based on the S_{DS} and S_{D1} values.

Summary of Seismic Design Parameters

Site Location (Lat. – Long.)	Site Classification	S_S	S_1	F_a	F_v	S_{DS}	S_{D1}
32.1718° -81.2270°	D	0.306g	0.119g	1.555	2.325	0.317g	0.184g

- In general accordance with the 2012 International Building Code and ASCE 7-10.
- The 2012 IBC and ASCE 7-10 require a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope does not include 100 foot soil profile determination. Explorations for this project extended to a maximum depth of 44.2 feet and this seismic site class definition was provided in consideration of the overall soil conditions as well as the general geology of the area.

5.0 GENERAL COMMENTS

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

The analyses and recommendations presented in this report are based upon the data obtained from the explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between exploration locations, across the site, or may be caused due to the modifying effects of construction or weather. Bear in mind that the nature and extent of such variations may not become evident until construction has started or until construction activities have ceased.

If variations do appear, Terracon should be notified immediately 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, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or hazardous conditions. If the owner is concerned about the potential for such contamination or pollution, please advise so that additional studies may be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project and site discussed, and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed 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 then either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

Image Courtesy of
Google Earth™

Project Manager:	YH
Drawn by:	YH
Checked by:	GL
Approved by:	GL

Project No.	ES165408
Scale:	N.T.S.
File Name:	
Date:	12-23-16

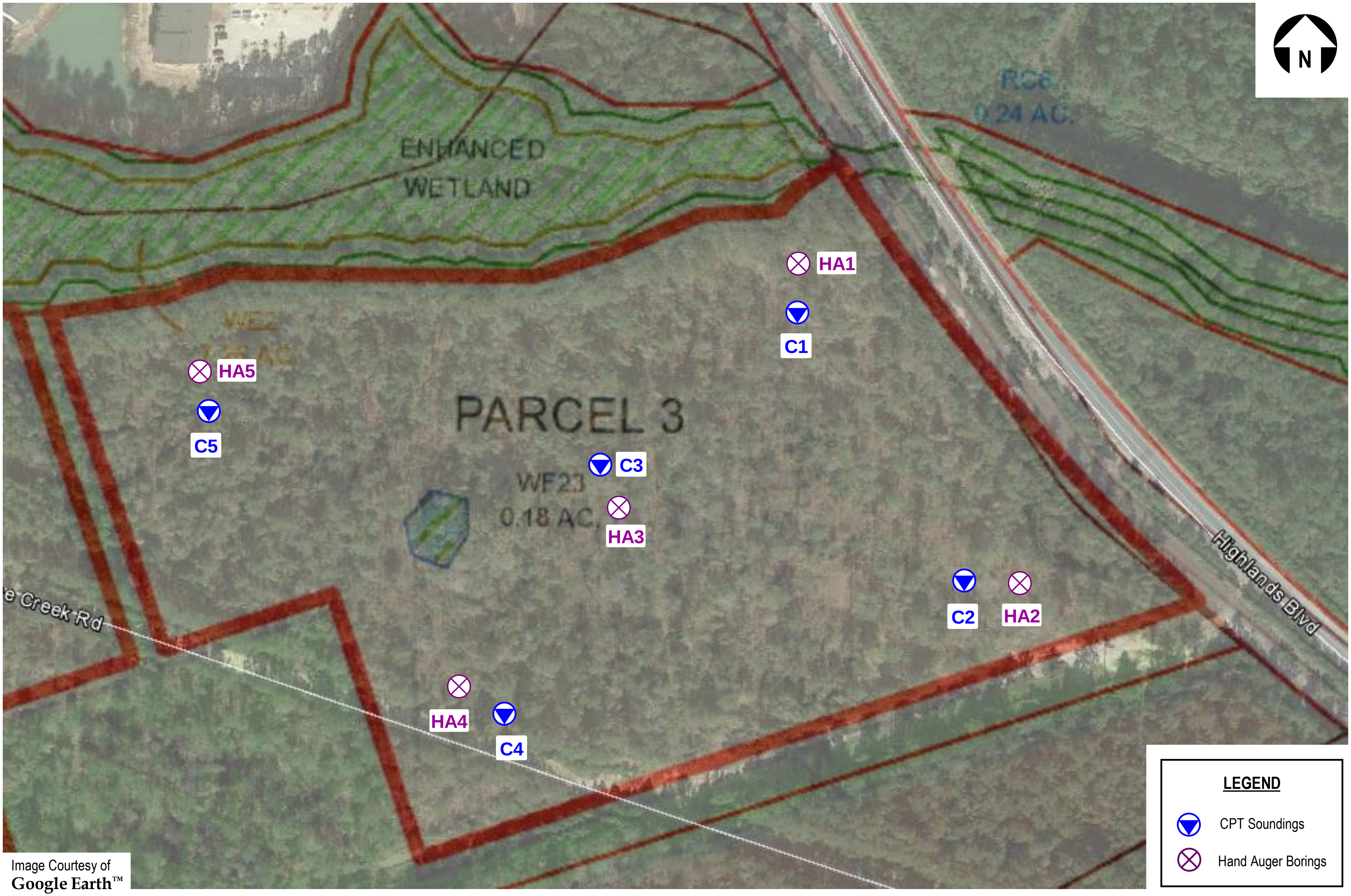
Terracon
Consulting Engineers & Scientists

2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

SITE LOCATION MAP

Highlands Apartment Tract 3
Pooler
Chatham County, Georgia

Exhibit:
A-1



NOTES:

CONCEPTUAL PLAN PROVIDED TO TERRACON BY SVN | KD LANCLOS & ASSOCIATES, LLC VIA EMAIL ON 12-16-16.

ALL EXPLORATION LOCATIONS WERE LOCATED IN THE FIELD USING A GPS UNIT AND / OR SITE LANDMARKS. EXPLORATION LOCATIONS SHOULD BE CONSIDERED APPROXIMATE. DIAGRAM IS FOR GENERAL LOCATION ONLY; NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Manager:	YH	Project No.	ES165408
Drawn by:	YH	Scale:	N.T.S.
Checked by:	GL	File Name:	
Approved by:	GL	Date:	12-23-16

Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

EXPLORATION LOCATION PLAN

Highlands Apartment Tract 3
Pooler
Chatham County, Georgia

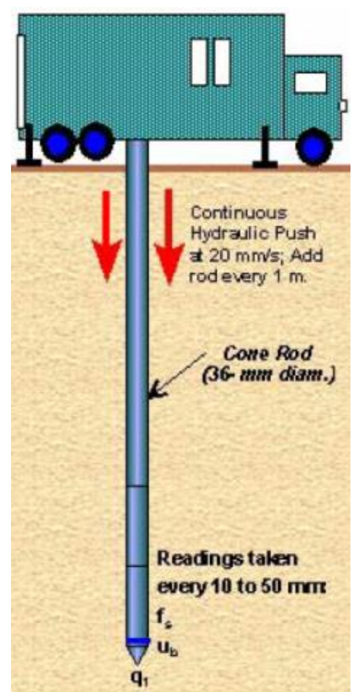
Exhibit:
A-2

Field Exploration Description

The locations of Cone Penetration Test (CPT) soundings and Hand Auger borings are determined by Terracon based on the proposed development and were located in the field using hand-held GPS units and in reference to existing features. These locations are shown in the Exploration Location Plan and should be considered approximate.

Cone Penetration Testing

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.



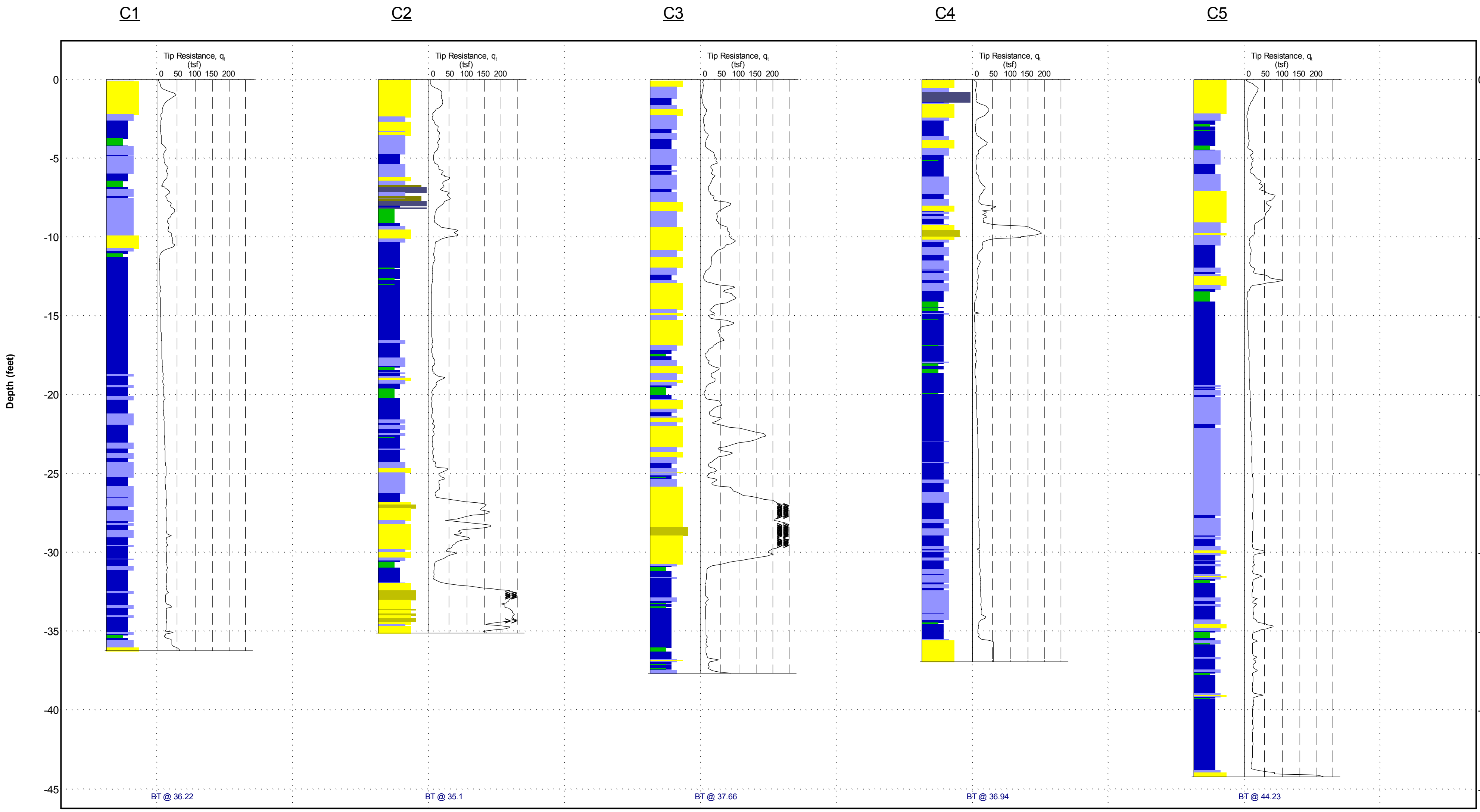
Source: FHWA NHI-06-088

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 were analyzed and processed by the project engineer.

Hand Auger Borings

Hand auger borings were conducted in general accordance with ASTM D 1452-80, Standard Practice for Soil Investigation and Sampling by Auger Borings. In this test, hand auger borings are drilled by rotating and advancing a bucket auger to the desired depths while periodically removing the auger from the hole to clear and examine the auger cuttings. The soils were classified in accordance with ASTM D2488.



Explanation

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

NOTES:
See Exhibit for orientation of soil profile.
See General Notes in Appendix C for symbols and soil classifications.
Soils profile provide dfor illustration purposes only.
Soils between borings may differ
AR - Auger Refusal
BT - Boring Termination

Project Manager:	Project No.: ES165408	Terracon 2201 Rowland Avenue Savannah, Georgia	SUBSURFACE PROFILE	EXHIBIT
Drawn by: YH	Scale: N.T.S.		HIGHLANDS APARTMENT TRACT 3 POOLER, GEORGIA	A-4
Approved by: GL	File Name:			
Date: 1/13/2017		PH. 912-629-4000 FAX. 912-629-4001		

SHEET 0 OF 1

CPT LOG NO. C1

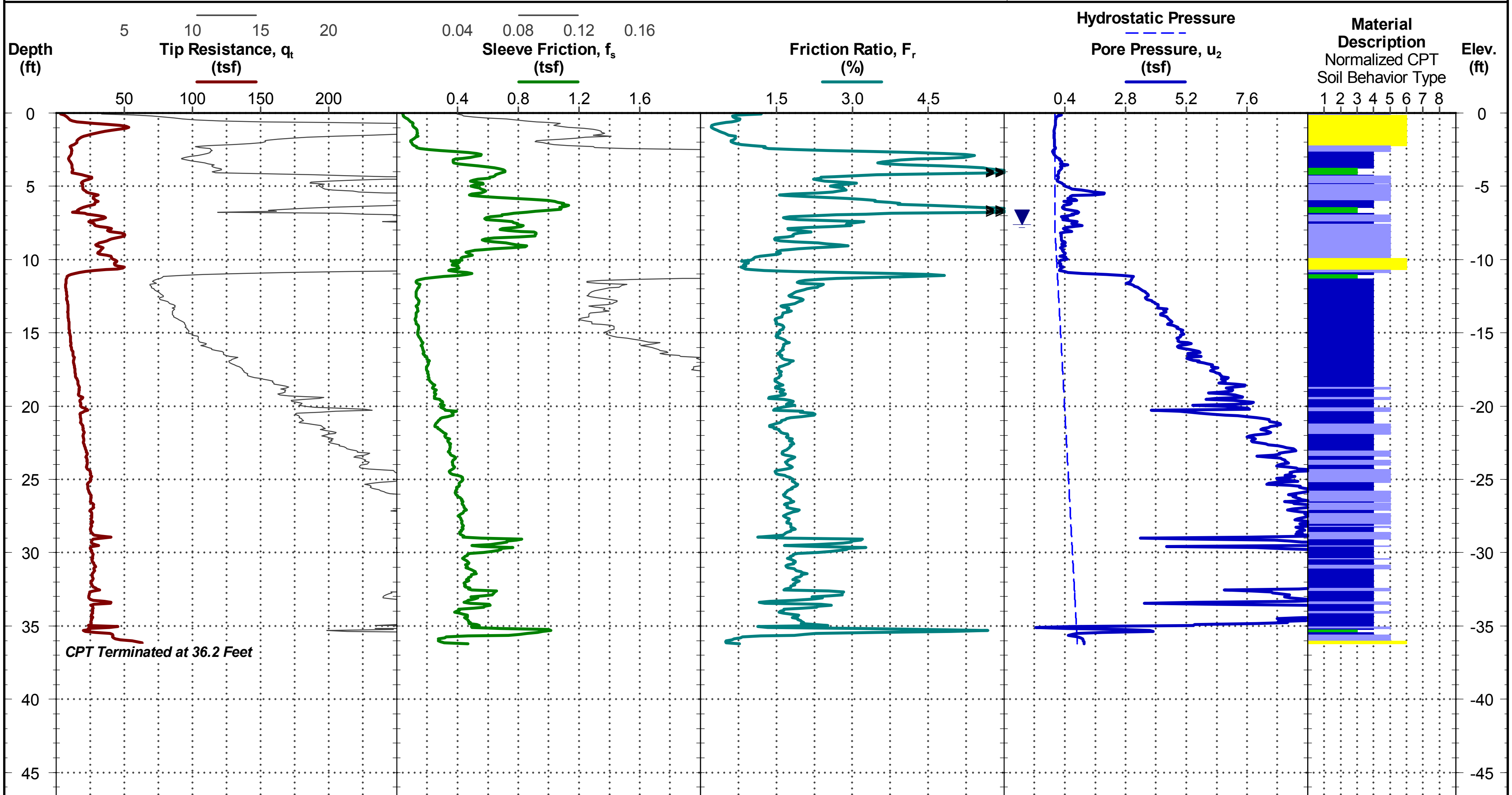
PROJECT: Highlands Apartment Tract 3

CLIENT: TCA, LLC
Augusta, Georgia

TEST LOCATION: See Exhibit A-2

SITE: Pooler, Georgia

Latitude: 32.17264°
Longitude: -81.22633°



See Exhibit A-3 for description of field procedures.
See Appendix B for explanation of symbols and abbreviations.

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

▼ 7.6 ft measured water depth
(used in normalizations and correlations; see Appendix B)

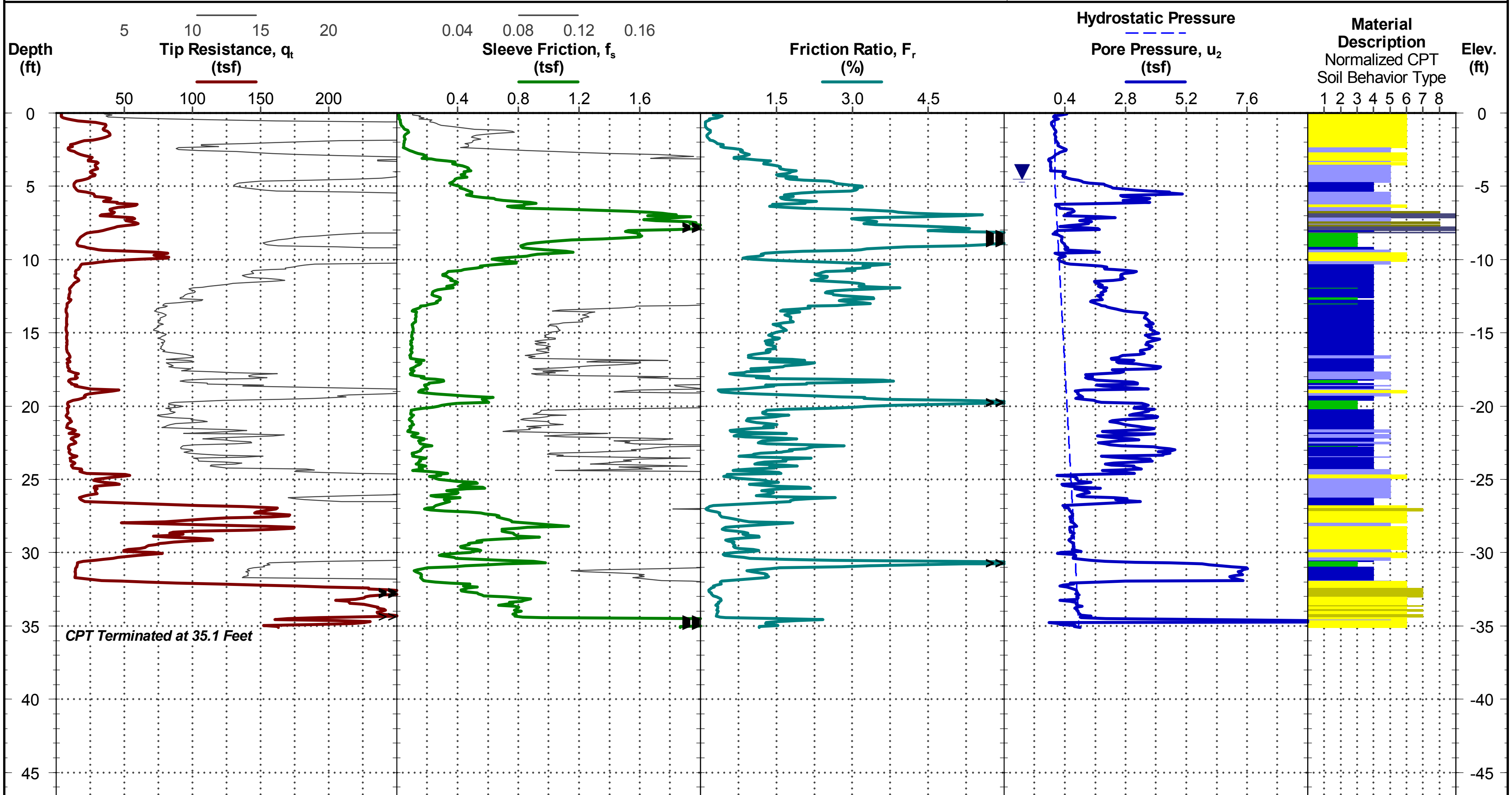
Probe no. 7522 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 1/5/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
2201 Rowland Ave
Savannah, GA

CPT Started: 1/12/2017	CPT Completed: 1/12/2017
Rig: Pagani TG73-200	Operator: JB
Project No.: ES165408	Exhibit: A-5-1

CPT LOG NO. C2

PROJECT: Highlands Apartment Tract 3	**CLIENT:** TCA, LLC Augusta, Georgia	**TEST LOCATION:** See Exhibit A-2
SITE: Pooler, Georgia		Latitude: 32.17161° Longitude: -81.22552°



See Exhibit A-3 for description of field procedures.
See Appendix B for explanation of symbols and abbreviations.

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 4.5 ft estimated water depth (used in normalizations and correlations; see Appendix B)	Probe no. 7522 with net area ratio of 0.84 U2 pore pressure transducer location Manufactured by Geotech A.B.; calibrated 1/5/2017 Tip and sleeve areas of 10 cm² and 150 cm² Ring friction reducer with O.D. of 1.875 in	Terracon 2201 Rowland Ave Savannah, GA	CPT Started: 1/12/2017 Rig: Pagani TG73-200 Project No.: ES165408	CPT Completed: 1/12/2017 Operator: JB Exhibit: A-5-2

CPT LOG NO. C3

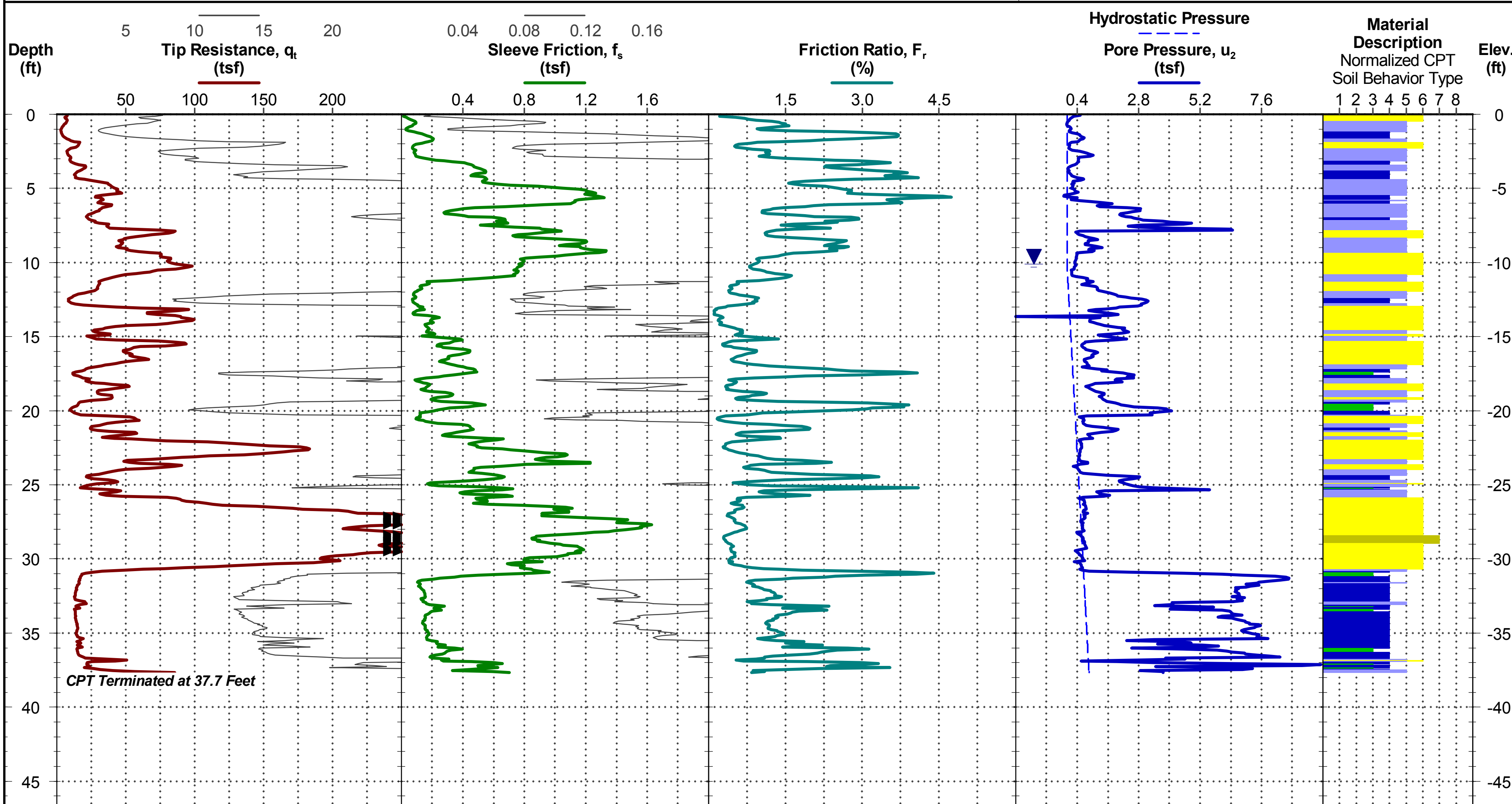
PROJECT: Highlands Apartment Tract 3

CLIENT: TCA, LLC
Augusta, Georgia

TEST LOCATION: See Exhibit A-2

SITE: Pooler, Georgia

Latitude: 32.17203°
Longitude: -81.22723°



See Exhibit A-3 for description of field procedures.
See Appendix B for explanation of symbols and abbreviations.

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

▼ 10.1 ft measured water depth
(used in normalizations and correlations; see Appendix B)

Probe no. 7522 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 1/5/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
2201 Rowland Ave
Savannah, GA

CPT Started: 1/12/2017	CPT Completed: 1/12/2017
Rig: Pagani TG73-200	Operator: JB
Project No.: ES165408	Exhibit: A-5-3

CPT LOG NO. C4

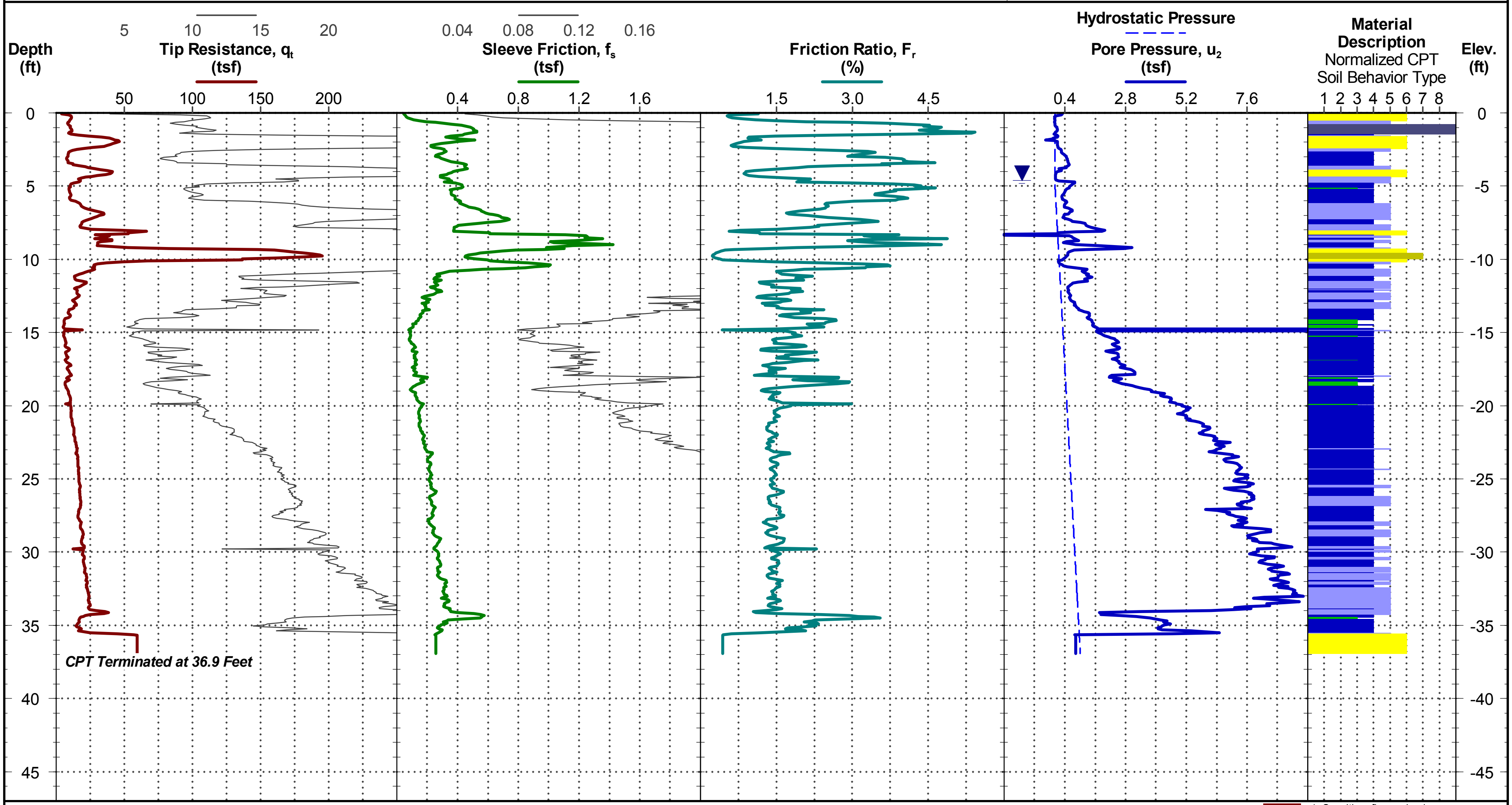
PROJECT: Highlands Apartment Tract 3

CLIENT: TCA, LLC
Augusta, Georgia

TEST LOCATION: See Exhibit A-2

SITE: Pooler, Georgia

Latitude: 32.17106°
Longitude: -81.22772°



See Exhibit A-3 for description of field procedures.
See Appendix B for explanation of symbols and abbreviations.

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

4.6 ft measured water depth
(used in normalizations and correlations; see Appendix B)

Probe no. 7522 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 1/5/2017
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
2201 Rowland Ave
Savannah, GA

CPT Started: 1/12/2017	CPT Completed: 1/12/2017
Rig: Pagani TG73-200	Operator: JB
Project No.: ES165408	Exhibit: A-5-4

CPT LOG NO. C5

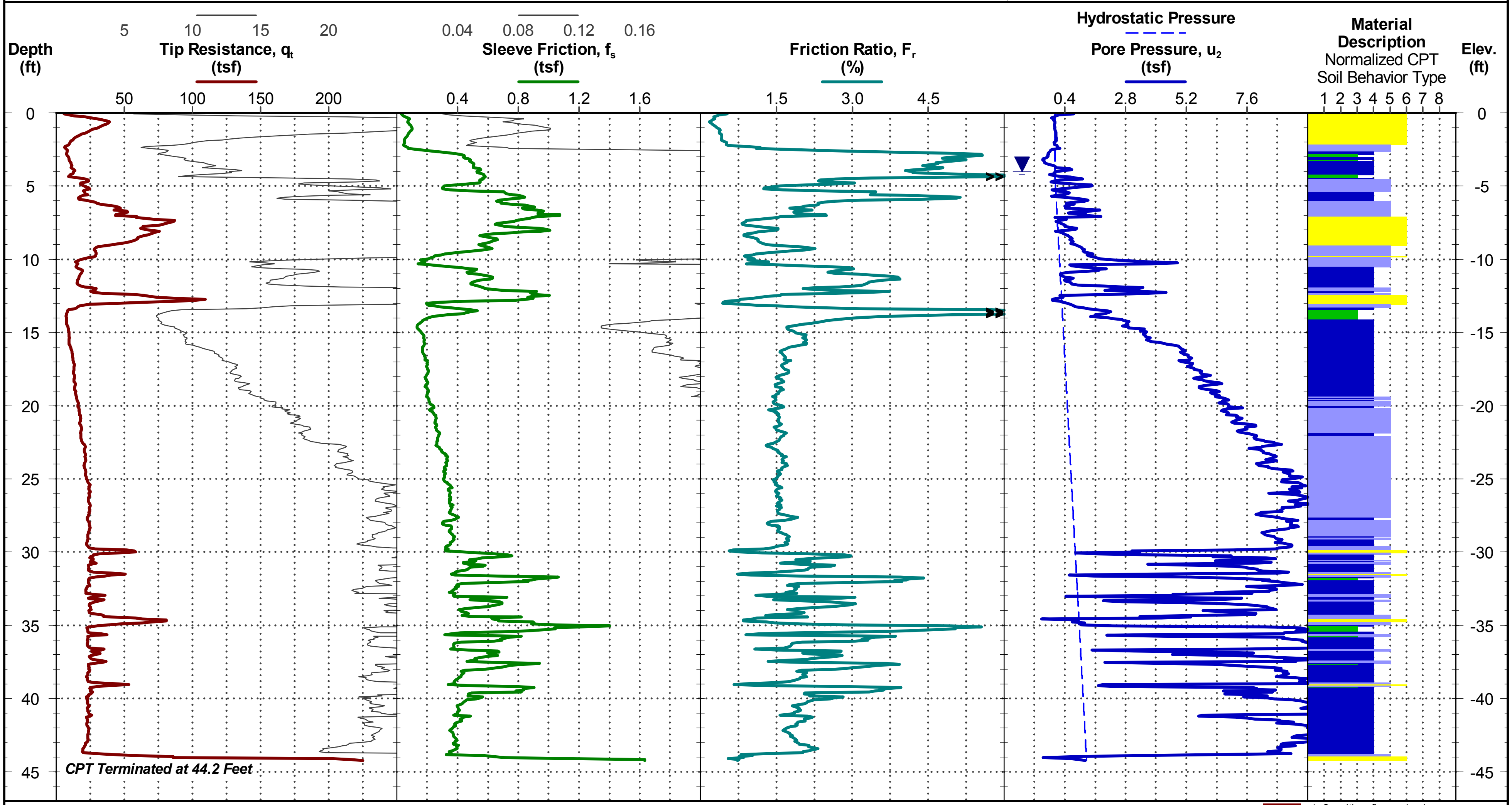
PROJECT: Highlands Apartment Tract 3

CLIENT: TCA, LLC
Augusta, Georgia

TEST LOCATION: See Exhibit A-2

SITE: Pooler, Georgia

Latitude: 32.1722°
Longitude: -81.22913°



See Exhibit A-3 for description of field procedures.
See Appendix B for explanation of symbols and abbreviations.

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

▼ 4 ft measured water depth
(used in normalizations and correlations; see Appendix B)

Probe no. 7522 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 1/5/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
2201 Rowland Ave
Savannah, GA

CPT Started: 1/12/2017	CPT Completed: 1/12/2017
Rig: Pagani TG73-200	Operator: JB
Project No.: ES165408	Exhibit: A-5-5

Hand Auger Boring Logs

Project Name: Highlands Apartment Tract 3
Project No.: ES165408
Project Location: Pooler, Georgia

Tested date: 12/27/2016 Performed by: GH

HA1		
Depth (inch, BGS)	**Material Description**	**USCS Classification**
0 to 6	Dark brown fine silty sands with small tree roots (topsoil)	--
6 to 18	Gray/orange fine sand with clay	SP-SC
18 to 60	Gray/orange sandy clays	CL
No groundwater encountered	**Mottling @ 18" BGS**	

HA2		
Depth (inch, BGS)	**Material Description**	**USCS Classification**
0 to 6	Dark brown fine silty sands with some grass roots (topsoil)	--
6 to 12	Dark brown fine silty sands	SM
12 to 24	Gray/orange fine sands with clay	SP-SC
24 to 60	Gray/orange sandy clays	CL
Groundwater @ 24" BGS	**Mottling @ 24" BGS**	

HA3		
Depth (inch, BGS)	**Material Description**	**USCS Classification**
0 to 6	Dark brown fine silty sands with small tree roots (topsoil)	--
6 to 18	Gray/orange fine sands with clay	SP-SC
18 to 24	Gray fine sands	SP
24 to 60	Gray/orange sandy clays	CL
No groundwater encountered	**Mottling @ 24" BGS**	

HA4		
Depth (inch, BGS)	**Material Description**	**USCS Classification**
0 to 6	Dark brown fine silty sands with grass roots (topsoil)	--
6 to 24	Gray/orange fine sands with clay	SP-SC
24 to 60	Gray/orange sandy clays	CL
Groundwater @ 36" BGS	**Mottling @ 24" BGS**	

HA5		
Depth (inch, BGS)	**Material Description**	**USCS Classification**
0 to 6	Dark gray fine silty sands with some tree roots (topsoil)	--
6 to 24	Brown fine silty sands	SM
24 to 60	Gray/orange fine sands with clay	SP-SC
No groundwater encountered	**Mottling @ 24" BGS**	

BGS = Below existing Ground Surface

APPENDIX B
SUPPORTING INFORMATION

Seismic Design Parameters Based on IBC2012 Code and ASCE 7-10 Standard
Terracon Project Name: Highlands Apartment Tract 3
Terracon Project Number: ES165408

Terracon

Site Location: Pooler, Georgia
Latitude : 32.17183
Longitude : -81.227

Site Class: D
Design Response Spectrum for the Site Class

S_s	0.306	S_1	0.119
F_a	1.555	F_v	2.325
S_{MS}	0.476	S_{M1}	0.276
S_{DS}	0.317	S_{D1}	0.184

	Period (sec)	Sa (g)
	0.000	0.127
T_0	0.116	0.317
	0.200	0.317
T_S	0.580	0.317
T	0.700	0.263
	0.800	0.230
	0.900	0.204
	1.000	0.184
	1.100	0.167
	1.200	0.153
	1.300	0.142
	1.400	0.131
	1.500	0.123
	1.600	0.115
	1.700	0.108
	1.800	0.102
	1.900	0.097
	2.000	0.092

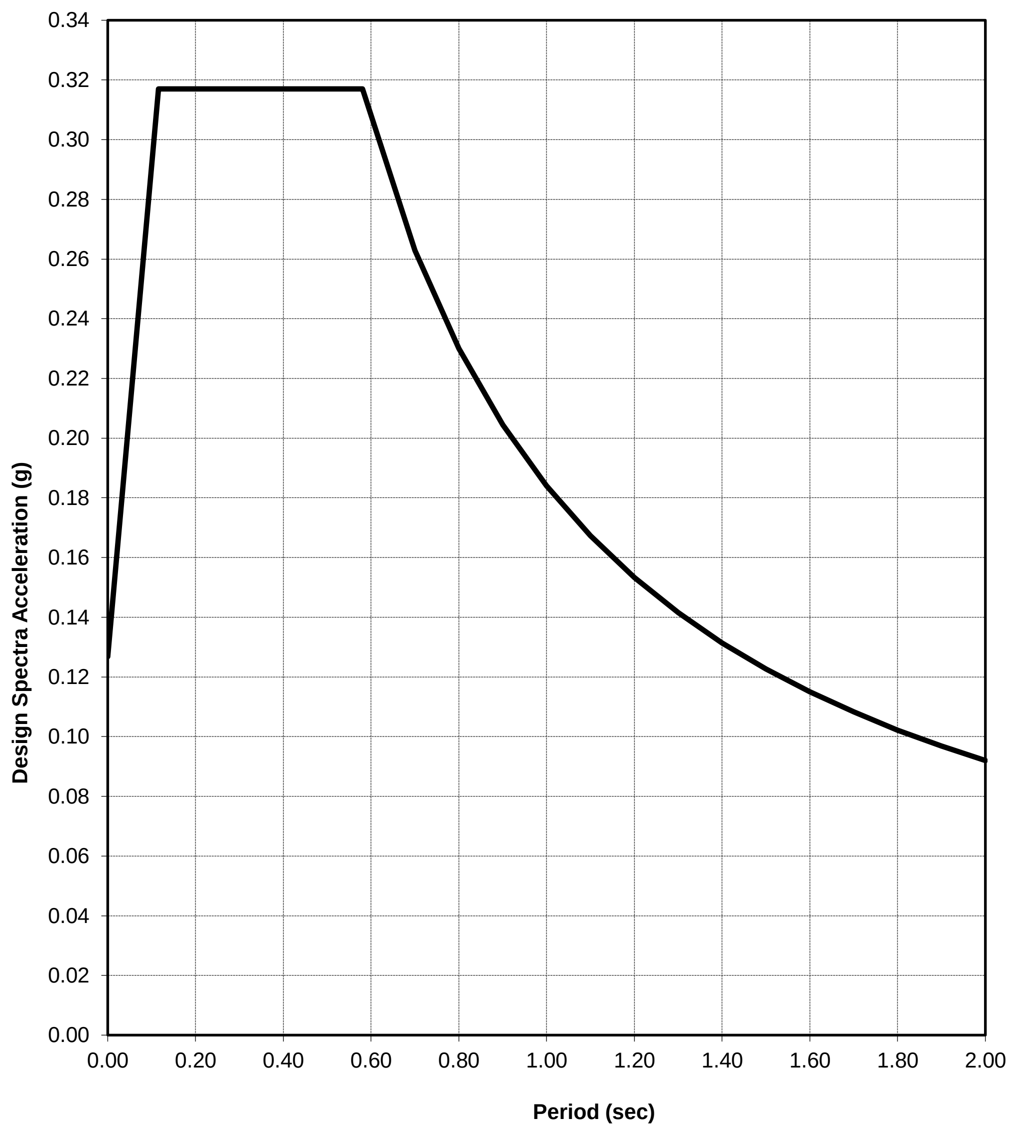


Exhibit B-1

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger
Split Spoon
Shelby Tube
Macro Core
No Recovery
Rock Core
Ring Sampler

GROUNDWATER

Groundwater Initially Encountered

Groundwater Level After a Specified Period of Time

Static Groundwater Level After a Specified Period of Time

No Groundwater Observed

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.

STENGTH 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)	**Std. Penetration Resistance (blows per foot)**	**Descriptive Term (Consistency)**	**Undrained Shear Strength (kips per square foot)**	**Std. Penetration Resistance (blows per foot)**
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	5 - 7
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 14
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	above 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

Descriptive Term(s) of other constituents	Percent of Dry Weight
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

Terracon

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-in. (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] $Cu = D_{60}/D_{10} \qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 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 $\geq$ 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 $\geq$ 30% plus No. 200 predominantly sand, add "sandy" to group name.

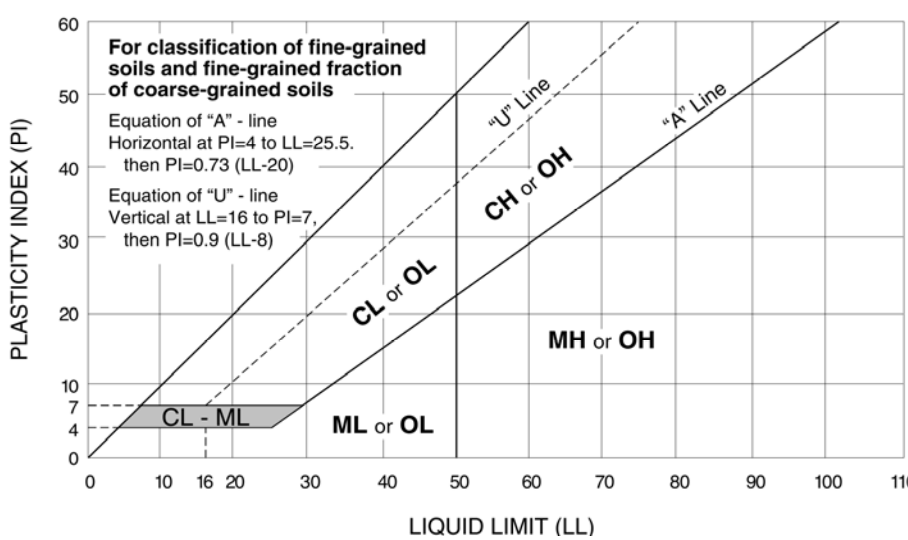
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ 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

Exhibit B-3

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
$Q_t = (q_t - \sigma_{vo})/\sigma'_{vo}$

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

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

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

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

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

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

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

Small Strain Modulus, G_0
$G_0 = \rho Vs^2$

Elastic Modulus, Es (assumes $q/q_{ultimate}$ ~ 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) $= 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{vo})$
Es (4) $= 2.5q_t$

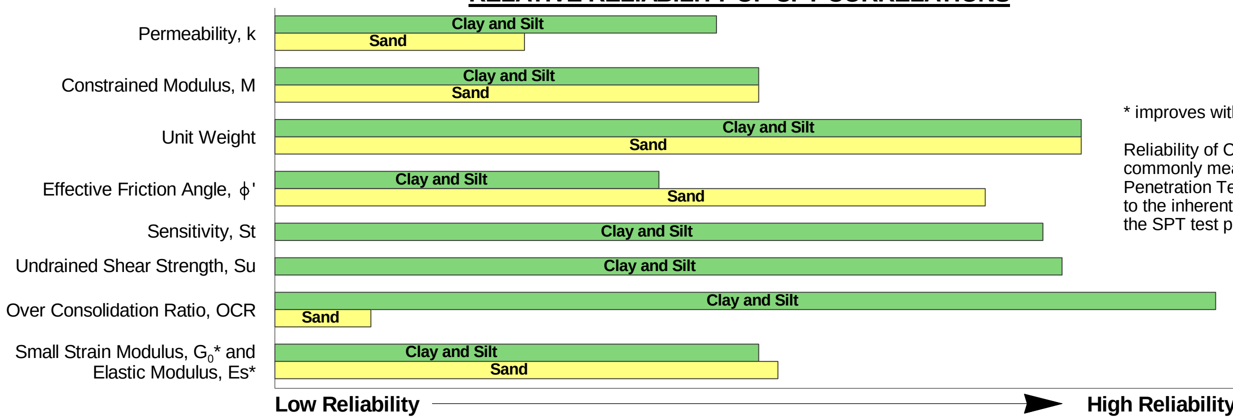
Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{vo})$
For Ic > 2.2 (fine-grained soils)
$\alpha_M = Q_t$ with maximum of 14
For Ic < 2.2 (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

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

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

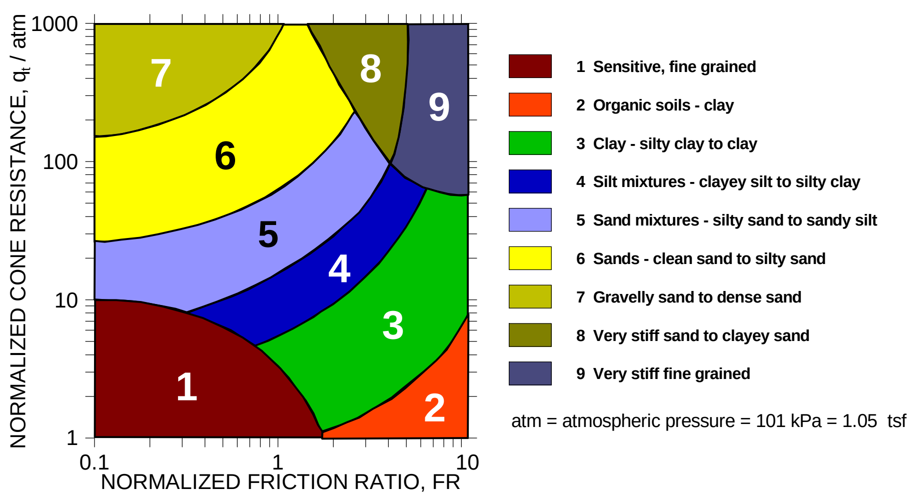
Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

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.



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 Institute 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.