GEOTECHNICAL INVESTIGATION
FOUNDATION RECOMMENDATIONS

6707 East Riverside Drive
Austin, Texas

Report For:

6707 Riverside Land, LLC
2309 Christopher Knoll
Vestavia, Alabama 35243

March 2022

Engineer's Job # 22104100.045

MLA Geotechnical TBPE FIRM # F-2684
Geotechnical Engineering and Construction Materials Testing
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LICENSED
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Foundation Recommendations

6707 East Riverside Drive
Austin, Texas

BACKGROUND

This report presents the results of a soil exploration and analysis for the proposed residence located at *6707 East Riverside Drive* in Austin, Texas. Authorization to perform this exploration and analysis was by Agreement for Engineering Services signed by Mr. Thomas Wilkins of 6707 Riverside Land, LLC on February 14, 2022.

The purposes of this investigation were to determine the soil profile, the engineering characteristics of the foundation soil and to provide criteria for use by the design engineers in preparing foundation designs for the proposed project. The scope included a review of geologic literature, a reconnaissance of the immediate site, the subsurface exploration, field and laboratory testing, and an engineering analysis and evaluation of the foundation materials.

The exploration and analysis of the subsurface conditions reported herein is considered sufficient in detail and scope to form a reasonable basis for foundation design. The recommendations submitted are based on the available soil information and the assumed preliminary design for the proposed structure. Any revision in the plans for the proposed structures from those stated in this report should be brought to the attention of the Geotechnical Engineer so that he may determine if changes in the foundation recommendations are required. Site work and foundation construction should be monitored by MLA Geotechnical to verify that these recommendations are implemented, and so that deviations from expected conditions can be properly evaluated.

This report has been prepared for the exclusive use of the client and their design professionals for specific application to the proposed project in accordance with generally accepted soils and foundation engineering practice. This report is not intended for use as a specification or construction contract document, but as a guide and information source to those qualified professionals who prepare such documents.

ARCHITECTURAL AND STRUCTURAL ASSUMPTIONS

The proposed residence is a one- to three-story residential building with wood framing and a masonry or fiber cement board exterior. **The shape factor‡ of this slab should be considered by the structural engineer.** If these assumptions are not correct, please contact the geotechnical engineer so they may review the recommendations contained herein for accuracy, completeness, and appropriateness. As finalized plans become available they should be shared with the Geotechnical Engineer so they may ascertain whether any modifications to the recommendations presented herein are necessary.

FIELD AND LABORATORY INVESTIGATION

One boring was drilled to the depth placed at the location as shown on the enclosed Log of Boring and Plan of Boring using a truck-mounted drilling rig. Water was not introduced into the boring. The field investigation included completing the soil boring, performing field tests, and recovering samples. Pocket penetrometer tests were performed on specimens during sampling. Representative soil samples were selected for laboratory index tests including Atterberg Limits and moisture content tests. The results of these tests and stratigraphy are presented on the Log of Boring found in ***Appendix A***. A key to the Soil Classification and symbols is located behind the last Log of Boring. See ***Appendix B*** for details of field and laboratory procedures, as applicable.

‡ The shape factor is defined as the perimeter of the slab squared divided by the slab area.

SITE TOPOGRAPHY, DRAINAGE AND VEGETATION

The site is situated on gently sloping topography with existing slopes ranging up to approximately 1 percent. Regionally, this site drains to the northeast. The vegetation at this site included grasses and mature trees.

SUBSURFACE CONDITIONS AND LOCAL GEOLOGY

Soil Profiles

The native soil profile identified in the boring consists of an upper layer of dark brown to tan moderate to high plasticity clay (CL-CH to CH). This soil profile has the potential for volume change with respect to varying moisture contents. This potential is taken into consideration for the foundation recommendations.

Geology

Local geologic maps indicate terrace deposits known as the Lower Colorado River Terrace Deposits, *Qlcr,* underlying this site [1,2]. These terrace deposits generally consist of high and low plasticity clay and sand with gravel layers. The proportion of sand and clay in these deposits was dependent on the depositional energies of these sediments. During periods of flooding, gravel layers were deposited and, as the floods receded, sands and clays were deposited. Generally, the older or lower portions of this formation are comprised of large materials such as sand and gravel. The more recent or upper portions of this terrace deposit consist primarily of clay with fine sand and occasionally fine gravel layers. This formation was also subject to periods of drought. These droughts lowered the water table in the sediments, which resulted in the deposition of calcareous material called evaporite. More recent alluvial material consisting of high plasticity clay overlies this formation, but is often not mapped separately.

Groundwater

Groundwater was not encountered in the boring during this investigation. Groundwater is a transient problem and may be encountered at other locations and in varying quantities depending on antecedent rainfall conditions and changes in land use.

CONCLUSIONS

1. Excavation and site work:

    a. Excavation for the construction of a slab-on-ground foundation may be performed using ordinary power equipment.

    b. All excavations should be braced and shored according to applicable law and building code. Consultation on excavations can be provided by the geotechnical engineer upon request. If shoring is required on this project, specific design recommendations can be developed upon analysis of the application.

    c. Groundwater is possible in shallow and deep excavations depending on antecedent rainfall. During periods of high rainfall, perched groundwater may cause the soils to become soft and difficult to compact.

2. Settlement potential:

    a. The potential for settlement greater than 1 inch of the natural soils on this site for light, one- to three-story structures may be categorized as low.

    b. Settlement potential of any uncontrolled (non-approved) fill is unpredictable.

    c. Heavy structures or structures more than three stories in height will require analysis beyond the scope of this report.

3. Expansive soil potential:

    The soils at this project site exhibited plasticity indices ranging from 31 to 49. A point estimate of the potential vertical rise, PVR, of the in-situ soil profile was found to be 4 ½ inches [3]. Thus, the potential for disruptive foundation movements due to swelling soils may be categorized as very high. Other magnitudes of PVR may be estimated by other methods and at other locations with varying results. However, the TxDOT Method is widely used and should be considered an index property of the site. PVR is considered in the final foundation recommendations.

4. Foundation Type:

The foundation type recommended for this project is a soil-supported, stiffened concrete slab. If recommendations for other foundation types are desired, please contact the Geotechnical Engineer. The shape factor of the slab should be considered by the structural engineer. The shape factor is defined as the perimeter of the slab squared divided by the slab area.

5. Faults:

Published geology maps do not indicate the presence of a fault on the project site and faulted conditions were not noted in the boring.

6. Slab Moisture:

The recommendations in this report are not intended to address the effects of moisture migration through slabs. The Project Architect, Builder and/or Contractor should consider and address the means and methods and the requirements of the specific project for vapor emission reduction of slabs and drainage / waterproofing of below grade walls.

7. Past Use of Site:

There was no evidence in the samples obtained for this study that indicated the past use of this site as a municipal landfill. See the section ***Limitations of Report***.

RECOMMENDATIONS - FOUNDATION

A stiffened, slab-on-ground foundation system is recommended for this project. The following recommendations are for such a foundation system. This type of foundation system is designed to dampen soil movements beneath the foundation. These soil movements arise from varying soil moisture. Many of the recommendations in this report are intended to reduce this soil moisture variation. Some foundation movements may occur even in properly designed slab-on-ground foundations. Please contact the Geotechnical Engineer if alternate designs are desired.

1. This type of foundation includes reinforced perimeter and interior stiffening beams, monolithically cast with a reinforced slab. The following design parameters are recommended for use in sizing the foundation elements for the soil-supported stiffened concrete slab foundation. The structural engineer should also take into account the loads and the geometrics of the planned structures. **See note 1f on following page.**

   a. Post-tensioned slab – Post-Tension Design Parameters [4]
   Edge moisture variation distance (feet).
   $e_{m\ (center)}$ = 7.5
   $e_{m\ (edge)}$ = 3.8

   Differential Swell (inches)
   $y_{m\ (center\ lift)}$ = 2.16
   $y_{m\ (edge\ lift)}$ = 3.17

   Where e_m = edge moisture variation distance in feet.
   y_m = differential swell in inches.

   b. Conventional reinforcing Historically Equivalent BRAB #33 [5] Parameters
   Equivalent PI = 60 (*see note "f" on the following page*)

   c. Notes:

   Engineering judgment has been applied to the BRAB PI calculations. The Equivalent BRAB PI is included for historical purposes and for contractor's use in cost estimating. The primary design values are the Post-Tension Design parameters and may be used in the P.T.I. design method for slabs-on-ground.

d. Allowable Bearing Capacity:

Footings on this site established a minimum of 12 inches into the natively deposited surface clay should be sized for allowable bearing pressures of at most 2,000 psf. Any non-approved fill encountered should not be relied upon to provide adequate bearing capacity.

e. If the WRI [6] design method is to be used for foundation design on this site, the following parameters may be used:

Equivalent PI = See Recommendations on Previous Page

Climatic Rating, C_w = 18

f. All existing slab on ground foundation elements should be entirely removed prior to new foundation construction. If below grade foundation elements such as footings or piers remain, they should be removed to a minimum depth of 36 inches below the current ground surface, such that no new foundation elements are constructed in contact with any remaining foundation elements.

2. Strip and remove from the construction area any topsoil, organics, and vegetation to a minimum depth of 6 inches below the existing natural ground surface. Any fill of unknown consistency should be removed and replaced in accordance with the enclosed ***Residential Underslab Fill Recommendations*** if it is to be relied upon for slab support. Fill sections may be composed of on-site material excluding topsoil, vegetation, and organics.

3. The Architect, Builder and/or contractor should address vapor emission reducing schemes and the requirements of the specific project, especially when moisture-sensitive flooring materials are to be placed on the concrete slab. ACI 302.2R-06 can be used as a guideline [7].

4. Floor slabs may be formed on grade, if desired for economy.
5. Trees must not be planted or remain closer to the foundation than the mature drip line of the tree without consideration by the structural engineer. Please contact the structural engineer.
6. Air conditioner condensation overflow drains should be piped into the sanitary sewer, where the building code allows. Otherwise, the air conditioner condensation overflow drain should discharge clear and away from the foundation.
7. Drainage should be maintained away from the foundation, both during and after construction. Water should not be allowed to pond near the foundation. The following items should provide for positive drainage of water away from the foundation: sidewalks and other concrete flatwork, parking areas, driveways and other surface drainage features, and landscaping.
8. French drains are recommended around any slabs where seeping groundwater is encountered during construction.
9. Sidewalks and other flatwork should be doweled to the foundation elements, with adequate consideration of the differential forces that may develop.
10. Prior to construction, the Geotechnical Engineer should be given the opportunity to review the plans in order to ensure that all recommendations have been properly implemented. Also, the Geotechnical Engineer should be retained to complete necessary inspections to ensure that the foundation is installed in accordance with these recommendations.

RESIDENTIAL UNDERSLAB FILL RECOMMENDATIONS

A. Selection of fill material should be guided by the following criteria:

1. Maximum plasticity index: 20
   Minimum plasticity index: 3
2. Minimum and maximum passing #200 sieve: 10% to 70%
3. No stones larger than 1-1/2"

B. Compaction should be 95 percent of maximum laboratory density determined in accordance with American Society of Testing Materials, method ASTM D 698, using a compactive effort of 7.16 foot-lbs./in^3.

C. Placement should be in lifts not exceeding eight inches before compaction. The top of finished fill shall be within ten inches of underslab grade (but not above) and be bladed flat. Material excavated from beam trenches may be used for fine grading. Each compacted lift should be inspected and tested for density compliance by the Geotechnical Engineer prior to placing the next lift. Fill should extend at least 36 inches (72 inches on fills over six feet) beyond neat slab lines before sloping downward at not more than one on three slope to natural soil, unless grade changes are accomplished by properly designed deep foundation beams. Fill shall be within 2 percent of optimum moisture content during compaction. Backslopes shall be well compacted.

D. Testing and qualification of raw fill material, placement, and compaction may be performed by the Geotechnical Engineer. A 110 lb. sample of proposed fill material should be submitted to Geotechnical Engineer for approval and for determination of Moisture-Density Relationship, in advance of filling and compaction operations to permit inspection and testing as fill is placed. Not less than one field density test per 2000 square feet or minimum of 3 per lift is required.

E. Beam trenches shall be cut directly into compacted fill to plan dimensions and sacking of trenches will be permitted for inside of perimeter beams. In case sacking is used, density testing will not be performed closer than 4 feet from inside of perimeter beam face. The Geotechnical Engineer may require deepened exterior beams in lieu of excessively high fills.

F. Deviations from the above criteria may be permitted upon approval of the Geotechnical Engineer on an individual basis.

G. Compliance with these recommendations as stated above or as modified by the Geotechnical Engineer for specific conditions can be the basis for certification of compliance with FHA Data Sheet 79G and VA requirements.

H. Structural support of slab foundations may be carried through underslab fill to natural soil at the designer's option. In this case, paragraphs "B" through "G" of this recommendation are void and the underslab fill will be considered "forming fill" only.

QUALITY ASSURANCE CONSIDERATIONS

Type of Work	Item	Sample Frequency	Sample Size	Minimum Testing
General Earthwork and Fill Material	Soil	1 per Soil Type	110 lbs.	♦ Sieve ♦ P.I. ♦ Moisture Density Relationship
	Compaction	1 per 5000 ft^2 per lift (min. of 3 per lift)		♦ Field Density Test
Select Under-slab Fill	Select Fill Material	1 per type per 1000 cu. yds. Min. one per job	110 lbs.	♦ Sieve ♦ P.I. ♦ Moisture Density Relationship
	Compaction	1 per 2000 ft^2 per lift (min. of 3 per lift)		♦ Field Density Test
Concrete	Mix Design	1 per concrete class		♦ Review & approval with confirmatory cylinders ♦ Plant & materials approval, testing, if questionable
	Aggregates (coarse & fine)	1 per 500 cu. yd. Min. 1 per job	30 lbs.	♦ Sieve, organic impurities, specific gravity
	Cement	1 per 1000 cu. yds. Min. 1 per job	10 lbs.	♦ Fineness ♦ Chemical compound ♦ See mill reports
	Concrete Placement	1 per 50 cu. yds. Or each days pour (if less)		♦ Slump ♦ Air Test ♦ 5 compressive cylinder tests, test 2 at 7 days, 2 at 28 days, 1 hold
Pier or Footing Inspection	Inspection and verification of bearing	Each Pier or Slab Footing		Qualified Inspector with Engineer's Review
	Concrete & Steel Placement	Each Pier or Slab Footing		Qualified Inspector
	Inspection of Reinforcing	Slab Pre-pour and Cable Stressing		Qualified Inspector

REFERENCES

1. Local geologic maps published by The Bureau of Economic Geology. Austin, Texas including:
   "Geologic Atlas of Texas" 15-minute quadrangles. March 9, 2004 geospatial data.
   "Geologic Map of the Austin Area, Texas 1992" Geology of Austin Area Plate VII.
   "Geologic Map of the West Half of Taylor Texas, 30 x 60 min quad. 2005. misc. map 43
   "Geologic Map of the New Braunfels, Texas 30 x 60 min quad" 2000. misc. map 39

2. "The Geology of Texas, Volume I, Stratigraphy", The University of Texas Bulletin No. 3232: August 22, 1932, The University of Texas, Austin, Texas, 1981.

3. "Method for Determining Potential Vertical Rise, PVR, Test Method Tex-124-E", Manual of Testing Procedures, Texas Department of Transportation Materials and Tests Division, September 1995.

4. "Design of Post-Tensioned Slabs-on-Ground", Third Edition. Post-Tensioning Institute, Farmington Hills, MI, 2008.

5. "Criteria for Selection and Design of Residential Slabs-on-Ground", Building Research Advisory Board, National Research Council of the National Academy of Sciences, Report #33, 1968.

6. "Design of Slabs-on-Ground Foundations – A Design, Construction & Inspection Aid For Consulting Engineers", Wire Reinforcement Institute, Hartford, Connecticut, Latest adopted version.

7. "Guide For Concrete Slabs that Receive Moisture-Sensitive Flooring" ACI 302.2R-06, American Concrete Institute, 2006.

LIMITATIONS OF REPORT

The conditions of the site at locations other than the boring location are not expressed or implied and conditions may be different at different times from the time of borings. Contractors or others desiring more information are advised to secure their own supplemental boring. This investigation and report, do not, and are not intended to determine the environmental conditions or evaluate possible hazardous or toxic waste conditions on this site or adjacent sites. Interested persons requiring this information are advised to contact MLA Geotechnical.

The recommendations in this report are not intended to address the interior environmental effects of moisture migration through slabs. The Client is responsible for addressing the requirements of this project with respect to moisture migration through slab on ground foundations.

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. The geotechnical engineer in charge of this project is not a mold prevention consultant and none of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report may not of itself be sufficient to prevent mold from growing in or on the structure(s) involved.

The analysis and recommendations contained herein are based on the available data as shown in this report and the writer's professional expertise, experience and training, and no other warranty is expressed or implied concerning the satisfactory use of these recommendations or data.

APPENDIX A

GEOTECHNICAL DATA

Approximate location of site in yellow
CAPCOG contours (2008) in orange
Travis County parcels (2019) in black

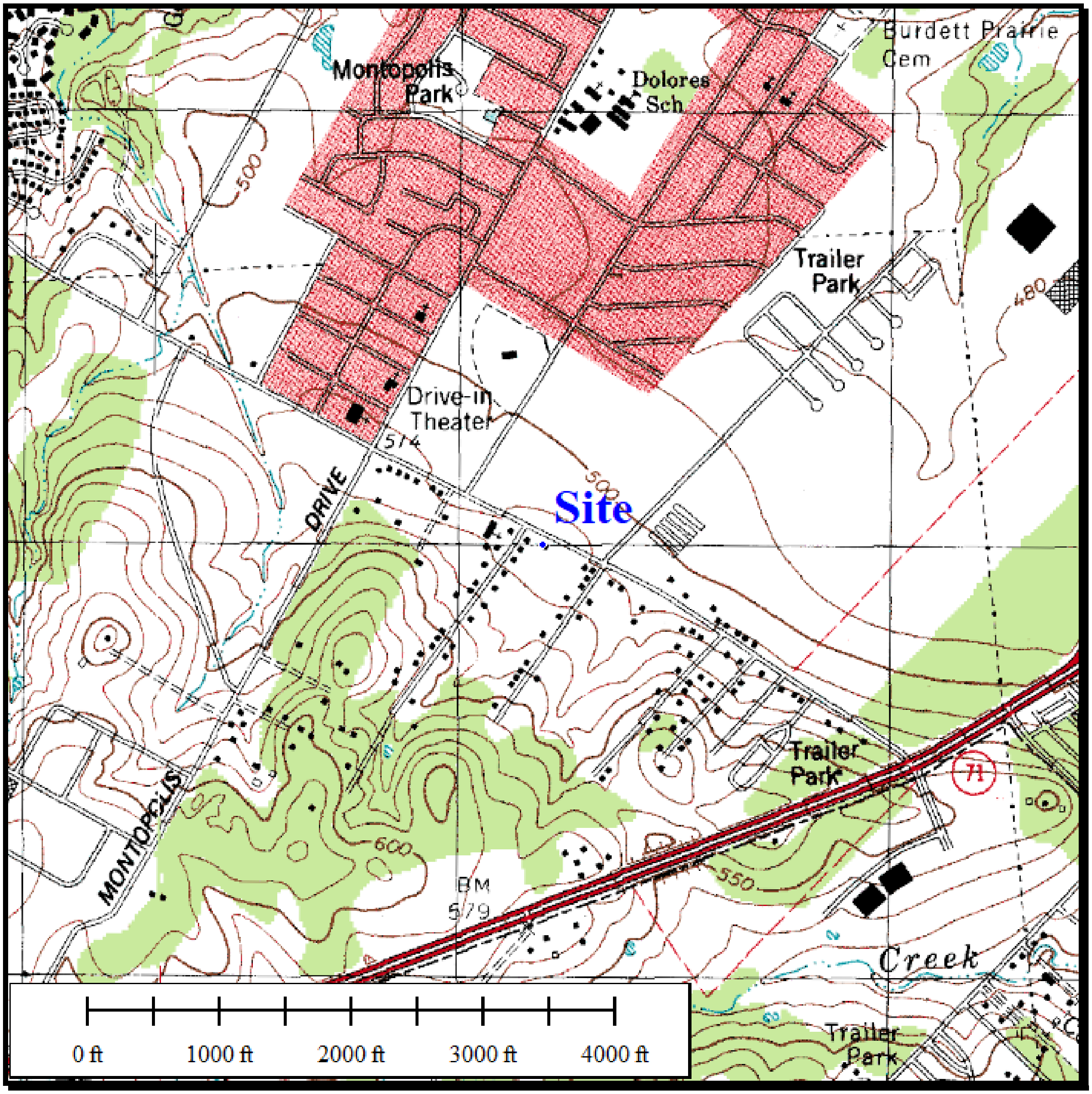
NAPP Aerial Photograph of Site – 1995

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
3.75-minute DOQQ. 1-meter ground resolution. apx. date 1995-6
(http://www.tnris.state.tx.us/digital.htm)

Approximate location of site in yellow
CAPCOG contours (2008) in orange
Travis County parcels (2019) in black

Aerial Photograph of Site – 2020

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
Apx. Date - 2020
(https://tnris.org/)

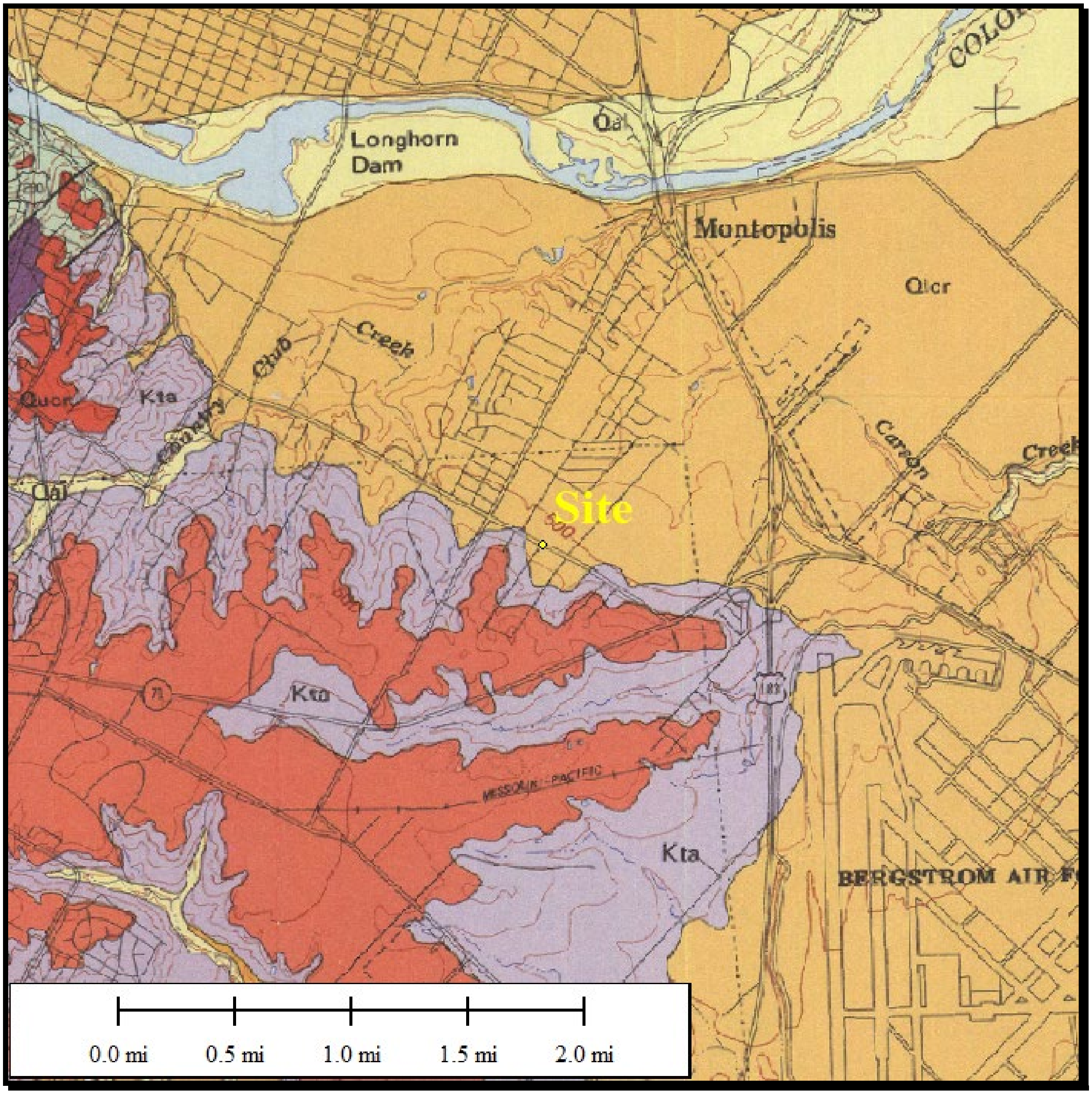


Approximate location of site in blue

U.S. 7.5 Minute Series Topographic Map
Montopolis Quadrangle, Texas

Contour Interval = 10 feet

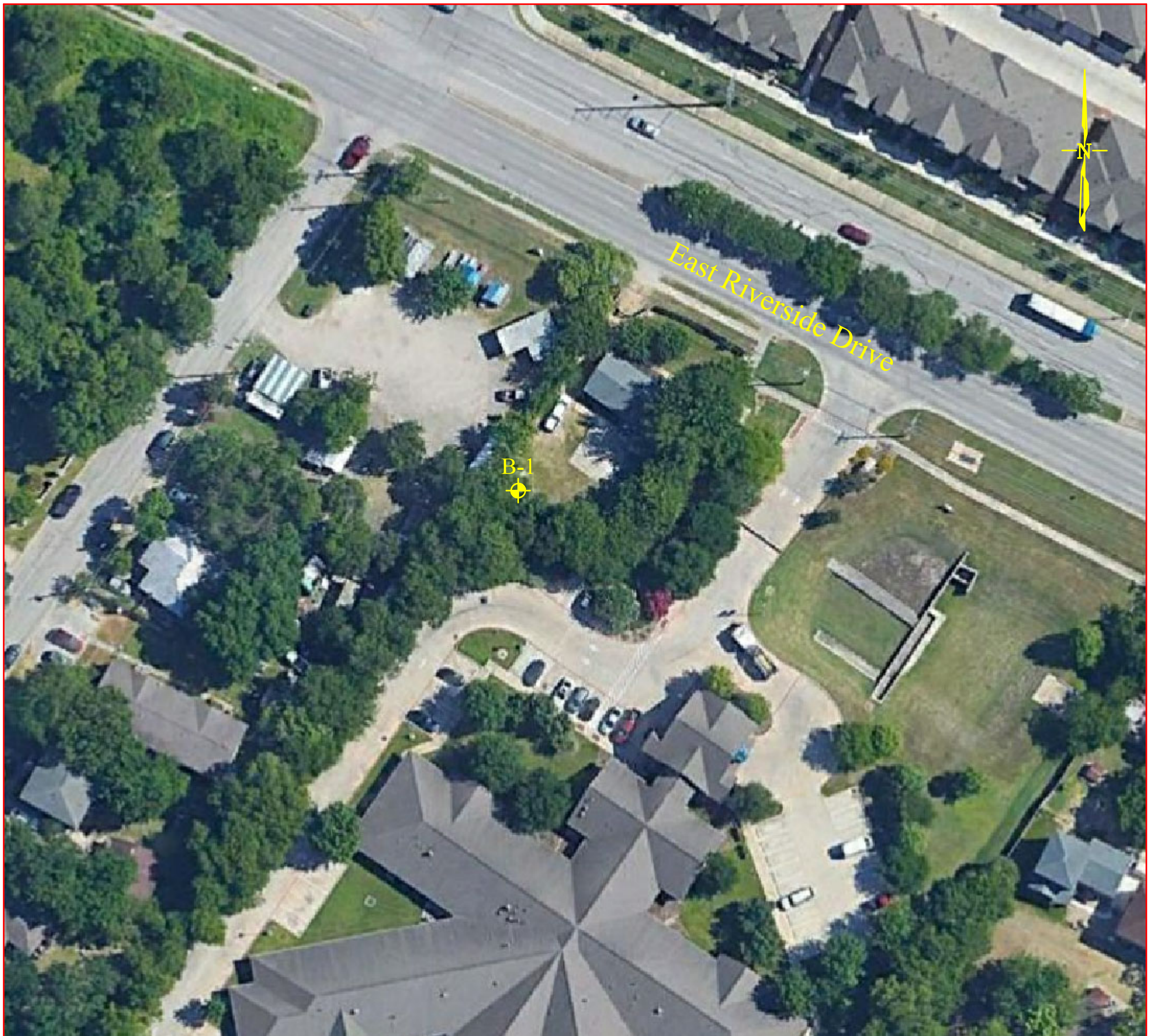
Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
(http://www.tnris.state.tx.us/digital.htm)



Approximate location of site in yellow

Geologic Setting of Site
Geologic Map of the Austin Area, Texas 1992
Contour Interval = 20 feet

Source: Bureau of Economic Geology, The University of Texas at Austin, Plate VII



SCALE = N.T.S.

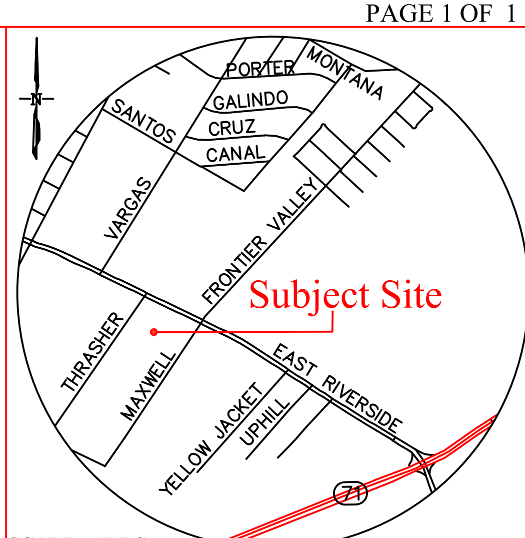
PLAN OF BORING

6707 East Riverside Drive
Austin, Texas
Job. No.: 22104100.045
Client: 6707 Riverside Land, LLC

LEGEND

B-#	Boring Number
⌖	Approx. Boring Location

VICINITY MAP



SCALE = N.T.S.

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LOG OF BORING

Boring B-1
PAGE 1 OF 1

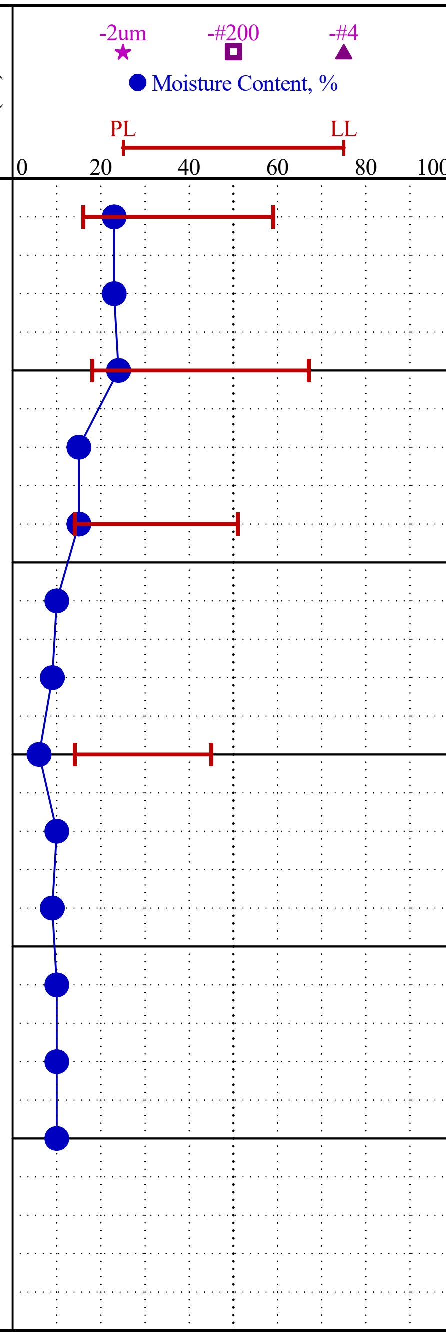
Job Name: 6707 East Riverside Drive
Job Location: Austin, Texas
Engineer's Job #: 22104100.045
Client: 6707 Riverside Land, LLC

Drill Date: March 7, 2022
Ground Elevation: n/a
Hole Size: 4.5 in.

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

Notes:

DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	CLAY, dark brown, with gravel, stiff, damp	CH	1.0	43
			1.0	
5			1.5	49
	... tan, with silt below 6.2'		-	
			-	37
10	CLAY, tan, with silt, with gravel, damp	CL-CH	-	
			-	
15			-	31
	... silty 16.0' to 26.0'		-	
			-	
20			-	
			-	
25			-	
			-	
		Qlcr	-	
30				



Termination Depth: 30.0 feet

22104100.045 - 6707 EAST RIVERSIDE DRIVE - LOGS.GPJ 4/4/22

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	CLAYS	LIQUID LIMIT GREATER THAN 50		CH	INORGANIC CLAYS OF HIGH PLASTICITY
SOILS OF MODERATE PLASTICITY				CL-CH	LOW PI CLAYS WITH APPRECIABLE HIGH PI MOTTLING, CLAY WITH BORDERLINE CLASSIFICATION
OTHER MATERIALS				FILL	MATERIAL NOT NATURALLY DEPOSITED
				LS	WEATHERED LIMESTONE INTACT LIMESTONE

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Key to Terms and Abbreviations

Descriptive Terms Characterizing Soils and Rock	Standard Description Abbreviations and Terms	Symbols and Abbreviations for Test Data
Argillaceous – having appreciable amounts of clay in the soil or rock mass. Used most often in describing limestones, occasionally sandstones. **Calcareous** – containing appreciable quantities of calcium carbonate. Can be either nodular or “powder.” **Crumbly** – cohesive soils which break into small blocks or crumbs on drying. **Evaporite** – deposits of salts and other soluble compounds. Most commonly calcium carbonate or gypsum. May be in either “powder” or visible crystal form. **Ferruginous** – having deposits of iron or nodules, typically oxidized and dark red in color. **Ferrous –** see Ferruginous **Fissured** – containing shrinkage cracks frequently filled with fine sand or silt, usually more or less vertical. **Fossiliferous –** containing appreciable quantities of fossils, fossil fragments, or traces of fossils **Laminated** – composed of thin layers of varying color or texture. Layers are typically distinct and varying in composition from sand to silt and clay. **Mottled** – characterized as having multiple colors organized in a marbled pattern. **Slickensided** – having inclined planes of weakness that are slick and glossy in appearance. **Varved** – see Laminated.	brn = brown dk = dark lt = light wx = weathered calc = calcareous sw = severely weathered cw = completely weathered n/a = not available b. = below **Engineering Units** pcf = pounds per cubic foot psf = pounds per square foot tsf = tons per square foot pF = picofarad psi = pounds per square inch kips = thousand pounds (force) ksf = kips per square foot	LL = Liquid Limit PL = Plastic Limit PI = Plasticity Index (LL-PL) NP = non-plastic γ_d = dry unit weight q_u = unconfined compressive strength q_c = confined compressive strength SPT = standard penetration test TCP = Texas cone penetration test (Texas Highway Department) N or N_{SPT} = blows per foot from SPT N_{TCP} = blows per foot from TCP SCR = standard core recovery RQD = rock quality designation RQI = see RQD

Terms Describing Consistency of Soil and Rock

COARSE GRAINED MATERIAL		SEDIMENTARY ROCK	
DESCRIPTIVE TERM	BLOWS/FT (SPT)	DESCRIPTIVE TERM	STRENGTH, TSF
very loose	0 – 4	soft	4 – 8
loose	4 – 10	medium	8 – 15
firm (medium)	10 – 30	hard	15 – 50
dense	30 – 50	very hard	over 50
very dense	over 50		

Describing Consistency of Fine Grained Soil

DESCRIPTIVE TERM	BLOWS/FT (SPT)	UNCONFINED COMPRESSION, TSF
very soft	< 2	< 0.25
soft	2 – 4	0.25 – 0.50
medium stiff	4 – 8	0.50 – 1.00
stiff	8 – 15	1.00 – 2.00
very stiff	15 – 30	2.00 – 4.00
hard	over 30	over 4.00

Sample Type Key

- Auger Cuttings
- Shelby Tube
- Split Spoon (SPT)
- Texas Cone (TCP)
- Rock Core
- No Sample

Revised: October 2018

APPENDIX B

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD PROCEDURES

Drilling and Sampling

Borings and test pits are typically staked in the field by the drillers, using simple taping or pacing procedures and locations are assumed to be accurate to within several feet. Unless noted otherwise, ground surface elevations (GSE) when shown on logs are estimated from topographic maps and are assumed to be accurate to within a foot. A Plan of Borings or Plan of Test Pits showing the boring locations and the proposed structures is provided in the Appendix.

A log of each boring or pit is prepared as drilling and sampling progressed. In the laboratory, the driller's classification and description is reviewed by a Geotechnical Engineer. Individual logs of each boring or pit are provided in the Appendix. Descriptive terms and symbols used on the logs are in accordance with the Unified Soil Classification System (ASTM D-2487). A reference key is also provided. The stratification of the subsurface material represents the soil conditions at the actual boring locations, and variations may occur between borings. Lines of demarcation represent the approximate boundary between the different material types, but the transition may be gradual.

A truck-mounted rotary drill rig utilizing rotary wash drilling or continuous flight hollow or solid stem auger procedures is used to advance the borings, unless otherwise noted. A backhoe provided by others is used to place test pits. Test pits are advanced to the required depth, refusal (typically bedrock) or to the limits of the equipment. Samples of soil are obtained from the borings or test pit spoils for subsequent laboratory study. Samples are sealed in plastic bags and marked as to depth and boring/pit locations in the field. Cores are wrapped in a polyethylene wrap to preserve field moisture conditions, placed in core boxes and marked as to depth and core runs. Unless notified to the contrary, samples and cores will be stored for 90 days, then discarded.

Standard Penetration Test and Split-Barrel Sampling of Soils (ASTM D-1586) (SPT)

This sampling method consists of driving a 2 inch outside diameter split barrel sampler using a 140 pound hammer freely falling through a distance of 30 inches. The sampler is first seated 6 inches into the material to be sampled and then driven an additional 12 inches. The number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance. The results of the SPT is recorded on the boring logs as "N" values.

Thin-Walled Tube Sampling of Soils (ASTM D-1587) (Shelby Tube Sampling)

This method consists of pushing thin walled steel tubes, usually 3 inches in diameter, into the soils to be sampled using hydraulic pressure or other means. Cohesive soils are usually sampled in this manner and relatively undisturbed samples are recovered.

Soil Investigation and Sampling by Auger Borings (ASTM D-1452)

This method consists of auguring a hole and removing representative soil samples from the auger flight or bit at intervals or with each change in the substrata. Disturbed samples are obtained and this method is, therefore, limited to situations where it is satisfactory to determine the approximate subsurface profile and obtain samples suitable for Index Property testing.

Diamond Core Drilling for Site Investigation (ASTM D-2113)

This method consists of advancing a hole into hard strata by rotating a single or double tube core barrel equipped with a cutting bit. Diamond, tungsten carbide, or other cutting agents may be used for the bit. Wash water or air is used to remove the cuttings and to cool the bit. Normally, a 3 inch outside diameter by 2-1/8 inch inside diameter coring bit is used unless otherwise noted. The rock or hard material recovered within the core barrel is examined in the field and in the laboratory and the cores are stored in partitioned boxes. The intactness of all rock core specimens is evaluated in two ways. The first method is the Standard Core Recovery (SCR) expressed as the length of the total core recovered divided by the length of the core run, expressed as a percentage:

$$SCR = \frac{\text{total core length recovered}}{\text{length of core run}} \times 100\%$$

This value is exhibited on the boring logs as the Standard Core Recovery (SCR).

The second procedure for evaluating the intactness of the rock cores is by Rock Quality Designation (RQD). The RQD provides an additional qualitative measure of soundness of the rock. This index is determined by measuring the intact recovered core unit which exceed four inches in length divided by the total length of the core run:

$$RQD = \frac{\text{all core lengths greater than 4''}}{\text{length of core run}} \times 100\%$$

The RQD is also expressed as a percentage and is shown on the boring logs.

Vane Shear Tests

In-situ vane shear tests may be used to determine the shear strength of soft to medium cohesive soil. This test consists of placing a four-bladed vane in the undisturbed soil and determining the torsional force applied at the ground surface required to cause the cylindrical perimeter surface of the vane to be sheared. The torsional force sufficient to cause shearing is converted to a unit of shearing resistance or cohesion of the soil surrounding the cylindrical surface.

THD Cone Penetrometer Test

The THD Cone Penetrometer Test is a standard field test to determine the relative density or consistency and load carrying capacity of foundation soils. This test is performed in much the same manner as the Standard Penetration Test described above. In this test, a 3 inch diameter penetrometer cone is used in place of a split-spoon sampler. This test calls for a 170-pound weight falling 24 inches. The actual test in hard materials consists of driving the penetrometer cone and accurately recording the inches of penetration for the first and second 50 blows for a total of 100 blows. These results are then correlated using a table of load capacity vs. number of inches penetrated per 100 blows.

Pocket Penetrometer Test

A pocket penetrometer or hand penetrometer is a small device used to estimate the shear capacity or unconfined compressive strength of a soil sample. The device consists of a spring-loaded probe which measures the pressure required to penetrate the probe into a soil sample for specified depth. This test can only be performed on cohesive soil samples. This pressure is reported in tons per square foot (tsf) on the Logs of Boring. A hyphen (-) indicates that the soil sample was too loose or too soft to perform the test. This test is considered rudimentary and too inaccurate to be used for direct design parameters; however, this test is useful for correlations among soil strata and general stiffness descriptions.

Ground Water Observation

Ground moisture observations are made during the operations and are reported on the logs of boring or pit. Moisture condition of cuttings are noted, however, the use of water for circulation precludes direct observation of wet conditions. Water levels after completing the borings or pits are noted. Seasonal variations, temperatures and recent rainfall conditions may influence the levels of the ground water table and water may be present in excavations, even though not indicated on the logs.

STANDARD LABORATORY PROCEDURES

To adequately characterize the subsurface material at this site, some or all of the following laboratory tests are performed. The results of the actual tests performed are shown graphically on the Logs of Boring or Pit.

Moisture Content - ASTM D-2216

Natural moisture contents of the samples (based on dry weight of soil) are determined for selected samples at depths shown on the respective boring logs. These moisture contents are useful in delineating the depth of the zone of moisture change and as a gauge of correlation between the various index properties and the engineering properties of the soil. For example, the relationship between the plasticity index and moisture content is a source of information for the correlation of shear strength data.

Dry Density - ASTM D-7263

The dry density, γ_d, (bulk density or unit weight) of the samples is determined for selected samples at depths shown on the respective boring logs using Method B of the aforementioned ASTM standard. The in-situ density was determined from undisturbed SPT samples and the dry density was calculated using moisture content results. These dry density values are useful for calculating other characteristic values such as porosity, void ratio, and mass composition of soil. Additionally, these values can also be used to assess the degree of compaction or consolidation of fill materials.

Atterberg Limits - ASTM D-4318

The Atterberg Limits are the moisture contents at the time the soil meets certain arbitrarily defined tests. At the moisture content defined as the plastic limit, Pw, the soil is assumed to change from a semi-solid state to a plastic state. By the addition of more moisture, the soil may be brought up to the moisture content defined as the liquid limit, Lw, or that point where the soil changes from a plastic state to a liquid state. A soil existing at a moisture content between these two previously described states is said to be in a plastic state. The difference between the liquid limit, Lw, and the plastic limit, Pw, is termed the plasticity index, Iw. As the plasticity index increases, the ability of a soil to attract water and remain in a plastic state increases. The Atterberg Limits that were determined are plotted on the appropriate log.

The Atterberg Limits are quite useful in soil exploration as an indexing parameter. Using the Atterberg Limits and grain size analysis, A. Casagrande developed the Unified Soils Classification System (USCS) which is widely used in the geotechnical engineering field. This system related the liquid limit to the plasticity index by dividing a classification chart into various zones according to degrees of plasticity of clays and silts. Although the Atterberg Limits are an indexing parameter, K. Terzaghi has related these limits to various engineering properties of a soil. Some of these relationships are as follows:

1. As the grain size of the soil decreases, the Atterberg Limits increase.
2. As the percent clay in the soil increases, the Atterberg Limits increase.
3. As the shear strength increases, the Atterberg Limits decrease.
4. As the compressibility of a soil increases, the Atterberg Limits increase.

Free Swell Test - ASTM D-4546-96

The free swell test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method B of the aforementioned ASTM standard determines the amount of swell (vertical heave) of a sample. This is done by placing the sample in a consolidometer under a seating load equal to the overburden pressure and giving the sample free access to water. The height is measured and the swell is calculated as the vertical displacement divided by the original height of the specimen. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Swell Pressure Test - ASTM D-4546-96

The swell pressure test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method C of the aforementioned ASTM standard determines the pressure required to keep a soil sample at equilibrium under swelling conditions. This is done by placing the sample in a consolidometer under a seating load and giving the sample free access to water. A constant height of the sample is maintained and the vertical pressure on the sample is adjusted until equilibrium is reached. The vertical pressure on the sample at equilibrium is reported as the swell pressure. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Soil Suction Test - ASTM D-5298-94

Soil suction (potential) tests are performed to determine both the matric and total suction values for the samples tested. Soil suction measures the free energy of the pore water in a soil. In a practical sense, soil suction is an indication of the affinity of a given soil sample to retain water. Soil suction provides useful information on a variety of characteristics of the soil that are affected by the soil water including volume change, deformation, and strength.

Soil suction tests are performed using the filter paper method per ASTM D-5298. Results of these tests are shown graphically on the logs of boring and tabulated in summary sheet of laboratory data.

For matric suction values found using this method, it should be noted that when the soil is in a dry state adequate contact between the filter paper and the soil may not be possible. This lack of contact may result in the determination of total suction instead of matric suction.

Triaxial Shear Test - ASTM D-2850-70

Triaxial tests may be performed on samples that are approximately 2.83 inches in diameter, unless a smaller diameter sample was necessary to achieve a more favorable length:diameter (L:D) ratio. A minimum length to diameter ratio (L:D) of 2.0 is maintained to reduce end effects.

The triaxial tests are typically unconsolidated-undrained using nitrogen gas for chamber confining pressure. Confining pressures are selected to conform to in-situ hydrostatic pressure considering the earth to be a fluid of 120 pcf. In this test, undisturbed Shelby tube samples are trimmed so that their ends are square and then pressed in a triaxial compression machine. The load at which failure occurs is the compressive strength. The results of the triaxial tests and the correlated hand penetrometer strengths can be utilized to develop soil shear strength values. These test provide the confined compressive strength, q_c, which are presented on the Logs of Boring at the depth of the samples tested.

Unconfined Compressive Strength of Rock Cores - ASTM D-2938

The unconfined compressive strength, q_u, is a valuable parameter useful in the design of foundation footings. This value, qu, is related to the shearing resistance of the rock and thus to the capacity of the rock to support a load. In completing this test it is imperative that the length:diameter ratio of the core specimens are maintained at a minimum of 2:1. This ratio is set so that the shear plane will not extend through either of the end caps. If the ratio is less than 2.0 a correction is applied to the result.

Grain Size Analysis - ASTM D-421 and D-422

Grain size analysis tests are performed to determine the particle size and distribution of the samples tested. The grain size distribution of the soils coarser than the Standard Number 200 sieve is determined by passing the sample through a standard set of nested sieves, and the distribution of sizes smaller than the No. 200 sieve is determined by a sedimentation process, using a hydrometer. The results are given on the log of Boring/Pit or on Grain Size Distribution semi-log graphs within the report.

Slake Durability Test - ASTM D-4644

The slake durability test provides an index for the durability of a shale, or similar rock, considering the effects of wetting, drying, and abrasion. This index is used to quantify the strength of weak rock formations when exposed to natural wetting and drying cycles, especially in the context of underground tunneling and excavation. The index, $I_d(2)$, represents the percentage, by mass, of rock material retained after two wetting and drying cycles. These cycles are simulated by oven drying the sample followed by ten minutes of tumbling and soaking in water within a drum and trough apparatus. After tumbling and soaking, the sample is oven-dried and the mass of the sample is recorded. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Brazilian Tensile Strength - ASTM D-3967

The Brazilian (splitting) tensile strength, σ_t, is useful in rock mechanics design, especially in regard to tunneling. This value is an indirect representation of the true uniaxial tensile strength. The Brazilian test is typically used more commonly than direct tensile strength tests because it is less difficult, more cost effective, and more represented of in-situ conditions. The test is conducted by mechanically compressing a rock core sample along its vertical diameter, causing the sample to fail due to tension along the horizontal diameter caused by the Poisson effect.

CERCHAR Abrasivity Index (CAI) Test - ASTM D-7625

The CERCHAR Abrasivity Index (CAI) is used to determine the abrasivity of rocks. This is particularly useful in assessing the potential wearing on cutting tools during excavation. The CAI of a rock is determined by the CERCHAR test, which consists of scraping steel pins across a rock surface and measuring the wear of each pin. The rock specimen is held in a mechanical vice, while a conical steel pin fastened to a 15-pound head is drug across the face of the specimen using a lever being pulled 1 centimeter in 1 second. The CAI is calculated based on the resultant diameter on the end of the pin.