GEOServices, LLC, Geotechnical and Materials Engineers

March 17, 2020

Partners Development
520 West Summit Hill Drive, Suite 603
Knoxville, TN 37902

Attention: Mr. Thomas Rowe, Executive Director
Murfreesboro Housing Authority
trowe@mha-tn.org

Subject: **REPORT OF GEOTECHNICAL EXPLORATION**
Proposed Oakland Court Residential
East Hembree Street
Murfreesboro, Tennessee
GEOServices Project No. 31-201111

Dear Mr. Faison:

We are submitting the results of the geotechnical exploration performed for the proposed Oakland Court Residential development to be located in Murfreesboro, Tennessee. The geotechnical exploration was performed in accordance with our proposal 13-200109 dated February 14, 2020 and authorized by you on February 17, 2020.

The following report presents our findings and recommendations for the proposed construction of the new residential development. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Sincerely,

GEOServices, LLC

Samuel J. Hohl
Sam Hohl, E.I.
Staff Professional

DAVID J. PERRY
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 117490
STATE OF TENNESSEE

3/17/2020

David J. Perry, P.E.
Nashville Geotechnical Manager
TN 117490

REPORT OF

GEOTECHNICAL EXPLORATION

Oakland Court Residential
Murfreesboro, TN

GEOServices Project No. 31-201111

Submitted to:

Partners Development
520 West Summit Hill Drive, Suite 603
Knoxville, TN 37902

Submitted by:

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GEOServices, LLC, Geotechnical and Materials Engineers

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this geotechnical exploration was to characterize the subsurface conditions for the design and construction of the proposed Oakland Court residential development in Murfreesboro, Tennessee. This report provides recommendations for general site preparation including excavation and fill requirements, foundation design, and slab-on-grade construction.

1.2 PROJECT INFORMATION AND SITE DESCRIPTION

Initial project information was provided in a February 12, 2020 email transmission from Mr. Faison (Partners Development/Owners representative to the Murfreesboro Housing Authority) to Mr. David Perry (GEOS). Attached to the email was a dropbox link to a plan set titled “Oakland Court Redevelopment”, dated January 20, 2020, as developed by MHM Architecture. We understand 1-story residential duplex structures are planned to be constructed on the approximate 20-acre site south of E. Hembree Street and east of N. Academy Street in Murfreesboro, Tennessee. We understand from the proposed grading plan that maximum fill thicknesses and cut depths will be about 5 feet and 10 feet, respectively. We assume the structures will be wood-framed with brick veneer, and structural loadings will not exceed 50 kips and 1 kip per linear foot (klf). The site currently exists as a relatively level existing neighborhood with several single-family residential structures.

1.3 SCOPE OF STUDY

This geotechnical exploration involved a site reconnaissance, field exploration, laboratory testing, and engineering analysis. The following sections of this report present discussions of the field exploration, laboratory testing programs, site conditions, and conclusions and recommendations. Following the text of this report, figures, an observation trench summary, and laboratory test results are provided in the appendices. Appendix A provides figures and an observation trench summary. Appendix B provides laboratory tests performed and the results of these tests.

2.0 EXPLORATION

2.1 FIELD EXPLORATION

The site subsurface conditions were explored with eighteen (18) observation trenches (OT-1 through OT-3, OT-5 through OT-15, and OT-17 through OT-20) on March 6, 2020. OT-4 and OT-16 were not performed due to numerous underlying utilities at the test areas. Approximate observation trench locations are shown in Figure 3 in Appendix A. The observation trench locations were located by GEOServices personnel in the field by measuring off known site reference points on the provided site plan and utilizing GPS coordinates extrapolated from Google Earth. The depths reference the ground surface elevations at the site that existed at the time of the exploration. Testing of overburden soils was accomplished using a dynamic cone penetrometer (DCP). In dynamic cone penetrometer (DCP) testing, a 1.5-inch diameter cone (45^{o} vertex angle) is driven into the subgrade soil with a 15-pound steel mass falling 20 inches. The blows required to drive the embedded cone a depth of 1-3/4 inch have been correlated to N-values derived from the Standard Penetration Test (SPT). These DCP-values are indicated on the summary of observation trench logs at the testing depth, and provide an indication of the relative density of granular materials and strength of cohesive materials.

Upon completion, the observation trenches were monitored for the presence of groundwater and backfilled with the excavated material. Minor settlement should be expected at the test locations over time. Select soil samples were obtained and returned to our laboratory for testing. Detailed observation trench records are presented in Appendix A.

2.2 LABORATORY TEST PROGRAM

Soil samples collected during excavation activities were transported to our laboratory for visual classification and laboratory testing. The following laboratory testing was performed on select samples to determine various properties of the soil:

> Natural Moisture Content (ASTM D 2216): Moisture content determinations were performed. The natural moisture content is defined as the ratio of the weight of water present in the soil to the dry weight of soil.
>
> Atterberg Limits (ASTM D 4318): Atterberg Limit tests were performed. Atterberg Limits tests help us to confirm our visual classifications according to the AASHTO Classification System and the Unified Soil Classification System (USCS). The plastic limit and liquid limit represent the moisture content at which a cohesive soil changes from a semi-solid to a plastic state and from a plastic state to liquid state, respectively.

The test results are presented in the Soil Data Summary enclosed in Appendix B.

3.0 SUBSURFACE CONDITIONS

3.1 GEOLOGIC CONDITIONS

The subject site is located within the Central Basin Physiographic Province of Middle Tennessee. The Central Basin is an elliptical basin surrounded by the Highland Rim. The Basin is subdivided into inner and outer sections. The inner section is generally smooth and gently rolling in contrast to the higher and more deeply dissected outer Basin. Bedrock is primarily Ordovician limestone, shale and dolomite in the outer Basin. The inner basin is generally covered with limestone with patches of bare platy rock and thin topsoil with glade areas supporting red cedar trees. The region is moderate in karst development with many sinkholes and some large caves present, notably in the glade areas.

The Geologic Map of the Murfreesboro Quadrangle, Tennessee (Tennessee Division of Geology, 1965) shows that the site is underlain by the Ridley Limestone Formation. The Ridley formation is typically a brownish-gray to yellowish-brown, cryptocrystalline to very fine-grained with some beds ranging up to coarse-grained, medium to thick-bedded limestone with minor amounts of magnesium limestone as small irregular mottlings and thin bands, and thin lenses of chert locally. The limestone weathers to produce a layer of native soil (residuum) which is typically a brown or reddish-brown silty clay with chert. Vertical soil seams are common.

The limestone bedrock of the Ridley Limestone formation is susceptible to solution weathering and the creation of karst features, such as sinkholes. In general, because of the variable depth of overburden soils, karst features can be relatively small or very large in horizontal extent, and can extend into the bedrock several feet. Review of the USGS Murfreesboro Quadrangle, Tennessee, Topographic Quadrangle Map (1965) and site observations indicated no closed depressions on-site. However, it did indicate the presence of several closed depressions within

1 mile south-southwest of the site. We note the scale of the map often precludes mapping of smaller depressions.

Since the bedrock underlying the site mainly consists of carbonate rock, the site is susceptible to the typical carbonate hazards of irregular weathering, cave and cavern conditions, and overburden sinkholes. Carbonate rock, while appearing very hard and resistant, is soluble in slightly acidic water. This characteristic, plus differential weathering of the bedrock mass, is responsible for the hazards. Of these hazards, the occurrence of sinkholes is potentially the most damaging to overlying soil-supported structures. In Middle Tennessee, sinkholes occur primarily due to differential weathering of the bedrock and "flushing" or "raveling" of overburden soils into the cavities in the bedrock. The loss of solids creates a cavity or "dome" in the overburden. Growth of the dome over time or excavation over the dome can create a condition in which rapid, local subsidence or collapse of the roof of the dome occurs.

3.2 SUBSURFACE CONDITIONS

A surface layer of topsoil was encountered in each of the performed observation trenches to depths ranging from approximately 3 to 10 inches below the existing ground surface elevation. Beneath the surficial layers, fill and/or residual soils were encountered to termination depths of 8 feet below the existing ground surface elevation.

3.2.1 Existing Fill

Beneath the surficial layers, in 9 observation trenches (OT-1, OT-3, OT-5, OT-6, OT-10, OT-11, OT-14, OT-15, and OT-18), existing fill was encountered to depths ranging from about 1 to 2.5 feet below the existing ground surface elevation. Fill is generally classified as material which has been transported and placed by man. The fill generally consisted of brown and dark brown clays with varying amounts of rock fragments and organics. Dynamic Cone Penetrometer (DCP) testing of the fill soils ranged from 3 blows per increment (bpi) to 6 bpi, indicating a consistency of soft to firm. The natural moisture content of the fill soil retrieved from the observation trenches ranged from 20.4 to 23.9 percent. This soil is visually classified as lean clay (CL) in accordance with the Unified Soil Classification System (USCS).

3.2.2 Residual Soils

Beneath the surficial layers and/or the existing fill, residual soils were encountered within each of the observation trenches to termination depths of 8 feet below the existing ground surface elevation. Residual soils are generally defined as soils which have weathered in place from the underlying bedrock. The residual soils generally consisted of light brown, brown, and red clays with varying amounts of chert, organics and rock fragments. Dynamic Cone Penetrometer (DCP) testing of the residual soils ranged from 2 bpi to 9 bpi, indicating a consistency of very soft to stiff. The natural moisture content of the residual soil retrieved from the observation trenches ranged from 23.6 to 39 percent. Atterberg limits testing on three selected samples of the residual soils retrieved from observation trenches OT-5, OT-11, and OT-20 yielded liquid limits (LL) ranging from 40 to 55 percent and plasticity indices (PI) ranging from 22 to 34 percent. This soil is classified as lean clay (CL) and fat clay (CH) in accordance with the Unified Soil Classification System (USCS).

3.2.3 Subsurface Water

Subsurface water was not observed in any of the observation trenches during or at the completion of field activities. However, discontinuous zones of perched water may exist within the overburden and/or at the contact with bedrock. Subsurface water levels may fluctuate due to seasonal change in precipitation amounts or due to construction activities in the area. The groundwater presented in this report is the information that was collected at the time of our field activities. We recommend that the contractor determine the actual groundwater level at the site at the time of the construction activities.

3.2.4 General

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The observation trench summary included in Appendix A should be reviewed for specific information at individual observation trench locations. The depth and thickness of the subsurface strata indicated on the observation trench records were generalized from and interpolated between test locations. The transition between materials will be more or less gradual than indicated and may be abrupt. Information on actual subsurface conditions exists only at the specific observation trench locations and is relevant to the time the exploration was performed. Variations may occur and should be expected between observation trench locations. The stratification lines were used for our analytical purposes and, unless specifically stated otherwise, should not be used as the basis for design or construction cost estimates.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 SITE ASSESSMENT

Based on the results of our subsurface exploration this site is generally adaptable for the proposed development. However, as with most sites, some inherent geotechnical issues should be considered during the construction phases. These issues include the presence of potentially unmonitored existing fill, soft soils, moisture sensitive soils, and the underlying karst geology.

4.1.1 Existing Fill Soils

Existing fill materials were encountered within 9 observation trenches to depths ranging from about 1 to 2.5 feet below existing ground surface elevation. We are not aware nor have we been provided with testing or observation records for the fill. Accordingly, there are certain risks associated with construction on these types of fill. The primary risk consists of excessive and/or non-uniform settlement caused by extensive zones or pockets of soft, loose, or uncompacted material. Recommendations for dealing with the in-place fill material is included in later sections of this report.

4.1.2 Soft Soil Conditions

Soft soil conditions were encountered in 5 observation trenches (OT-11, OT-14, and OT-17 through OT-19) within the fill and/or residuum strata at depths ranging from 2 to 4.5 feet below the existing ground surface elevation. These soft zones encountered can potentially impact the performance of the building, or pavement, depending on final grades. However, we do note this could be due to saturated near surface soils from recent rain events and we expect these soils to firm in the dryer months. We recommend that these soft soils be re-evaluated upon completion of the mass grading design.

4.1.3 Moisture Sensitive Soils

The subgrade soils at this site, as with most sites in middle Tennessee, consist of clayey soils. These materials will be sensitive to changes in moisture contents. As such, it will be advantageous to perform grading activities during periods of warm and/or dry weather. Areas that are wet or become unstable can possibly be repaired by scarification and recompaction if grading occurs during warm, dry weather. If grading occurs during wet, cool weather, we expect that additional soft soil at or near the surface soils across the site will have to be undercut and replaced. A budget contingency should be established for subgrade stabilization consistent with the time of year that grading will take place.

4.1.4 Karst Geology

A certain degree of risk with respect to sinkhole formation and subsidence should be considered with any site located within geologic areas underlain by potentially soluble rock units. While a detailed effort to assess the potential for sinkhole formation on this site was beyond the scope of this evaluation, our site reconnaissance and observation trenches did not encounter obvious indications of sinkhole development on the site. Furthermore, review of the USGS Murfreesboro Quadrangle, Tennessee, Topographic Quadrangle Map (1965) indicated no closed depressions on-site. However, it did indicate the presence of several closed depressions within 1 mile south-southwest of the site. Based on these findings and our experience with this formation at other sites, we consider that this site has no greater risk for sinkhole activity than other sites in the immediate vicinity of this site.

4.2 SITE PREPARATION

4.2.1 Subgrade

Vegetation, topsoil, existing utilities, existing foundations/slabs, organic soils, loose rock fragments greater than 6 inches and other debris should be removed from the proposed construction area. We anticipate that some of the fill materials may be removed during grading activities to establish planned subgrade elevations. However, the possibility exists that some previously placed fill materials may not be removed during mass grading activities. Therefore, we recommend the existing fill within the building footprints plus 5 feet beyond the most outer foundation limits should be undercut to stiff or better residual materials and/or bedrock and replaced with properly compacted structural fill materials. If the owner is willing to accept the risk of poor pavement performance with leaving the existing fill soils in place within the parking and drive areas, we would recommend these fill materials be thoroughly evaluated during mass grading activities to determine if any fill materials should be remediated. If unsuitable soil conditions are encountered, these unsuitable materials should be remediated at the geotechnical engineer's recommendations. We recommend the owner carry a contingency budget in the event that unsuitable soil materials are encountered. It is recommended that a contingency budget be reserved for undercutting and replacement for the development of this project. The actual depth of removal should be determined by a representative of the geotechnical engineer at the time of construction.

After completion of stripping operations and any required excavations to reach planned subgrade elevation, we recommend that the subgrade be proofrolled with a fully-loaded, tandem-axle dump truck or other pneumatic-tired construction equipment of similar weight. The geotechnical engineer or his representative should observe proofrolling. Weak or unstable areas should be remediated at the geotechnical engineer's recommendation. Areas to receive structural soil fill should also be proofrolled prior to the placement of any structural fill.

4.2.2 Shotrock / Processed Rock Fill

Shotrock fill, with acceptable gradation, can be used as structural fill. Shotrock utilized as structural fill should be well graded with a maximum rock size of 12-inches and be placed in lifts not to exceed 18 inches thick. Shotrock of this size should be placed at depths deeper than 3 feet below planned subgrade level and compacted as described below. Within the upper three feet of proposed subgrade, the rock or stone fill should have a maximum particle size of 6-inches in largest dimension when mixed with satisfactory material and placed in lifts not to exceed 12 inches thick. Rock fill should meet the criteria and be compacted as described in the following paragraphs.

Shotrock fill should have adequate fines to effectively "choke" the larger rock pieces, adequately filling voids or open spaces. The larger rock pieces should lie flat and not overlap each other. The percentage of soil in the fill should be limited to a maximum of 10 percent. Shotrock fill should be compacted using complete passes of a D-8 class crawler tractor, or equivalent. A pass is defined as a complete coverage of the surface with the D-8 track overlapping 50 percent. Half of the passes should be in each perpendicular direction. Shotrock fill placement should be accomplished under the full-time observation of a geotechnical representative. We recommend the use of a layer of compacted crusher run aggregate or the use of a geosynthetic between shotrock fill and structural soil fill when soil fill is placed over shotrock to prevent the migration of fines.

4.2.3 Structural Soil Fill

Material considered suitable for use as structural fill should be clean soil free of organics, trash, and other deleterious material, containing no rock fragments greater than 6 inches in any one dimension. Preferably, structural soil fill material should have a standard Proctor (ASTM D698) maximum dry density of 90 pcf or greater and a plasticity index (PI) of 35 percent or less. Materials with a PI greater that 35 percent are susceptible to volume changes with changes in moisture content. Volume changes in the foundation subgrade can cause structural distress in buildings, floor slabs, and pavements. Material to be used as structural fill should be tested by the geotechnical engineer to confirm that it meets the project requirements before being placed. This testing typically requires at least 3 to 4 days to complete. To avoid delays during grading, samples of proposed fill materials (both on-site and off-site) should be collected during site preparation activities.

Structural fill should be placed in loose, horizontal lifts not exceeding 8 inches in thickness. Each lift should be compacted to at least 95 percent of the soil's maximum dry density per the standard Proctor method (ASTM D698) and within the range of minus (-) 2 percent to plus (+) 2 percent of the optimum moisture content. Each lift should be tested by geotechnical personnel to confirm that the contractors' method is capable of achieving the project requirements before placing any subsequent lifts. Any areas, which have become soft or frozen, should be removed before additional structural fill is placed.

4.2.4 Compacted Crushed Stone Fill

Compacted crushed stone fill should be Type A, Class A, and Grading D in accordance with Section 903.05 of the Tennessee Department of Transportation specifications. The crushed stone fill should be placed in loose, horizontal lifts not exceeding 10 inches in loose thickness. Each lift should be compacted to at least 95 percent of maximum dry density per the standard Proctor method (ASTM D698). Each lift should be compacted and tested by geotechnical personnel to confirm that the contractor's method is capable of achieving the project requirements before placing any subsequent lifts.

4.3 FOUNDATIONS

4.3.1 Shallow Foundations

Foundations for the proposed construction can be supported on stiff or better residual soil or properly compacted structural fill materials. The recommended allowable bearing capacity for design of the foundations is 2,000 pounds per square foot (psf) or less. If construction is performed during the wet months, we expect some isolated areas may need to be remediated to sufficiently support the recommended bearing capacity. However, as stated previously, we expect the on-site soils to firm in the dryer months. We recommend that continuous foundations be a minimum of 18 inches wide and isolated spread footings be a minimum of 24 inches wide to reduce the possibility of a localized punching shear failure. Exterior footings should be designed to bear at least 18 inches below finished exterior grade to protect against frost.

Foundation excavations should be opened, the subgrade evaluated, remedial work performed, and concrete placed in an expeditious manner. Exposure to weather often reduces foundation support capabilities, thus necessitating remedial measures prior to concrete placement. It is also important that proper surface drainage be maintained both during construction (especially in terms of maintaining dry footing trenches) and after construction.

4.3.2 Slab-on-Grade

For slab-on-grade construction, the site should be prepared as previously described. We recommend that the subgrade be topped with a minimum 4-inch layer of crushed stone to act as a capillary moisture block. The subgrade should be proofrolled and approved prior to the placement of the crushed stone. Based on the conditions encountered on this site, we recommend that the floor slabs be designed using a subgrade modulus of 100 pounds per cubic inch (pci). This modulus is appropriate for small diameter loads (i.e. a 1ft x 1ft plate) and should be adjusted for wider loads.

4.4 LATERAL EARTH PRESSURES

We are not aware of any below grade wall structures that are planned for this site. However, if retaining walls are added after the delivery of this report, we can provide recommendations once additional structural information has been provided.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 EXCAVATIONS

Excavations should be sloped or shored in accordance with local, state, and federal regulations, including OSHA (29 CFR Part 1926) excavation trench safety standards. The contractor is usually solely responsible for site safety. This information is provided only as a service and under no circumstances should GEOServices be assumed to be responsible for construction site safety.

5.2 FOUNDATION CONSTRUCTION

Foundation excavations should be opened, the subgrade evaluated, remedial work performed, and concrete placed in an expeditious manner. Exposure to weather often reduces foundation support capabilities, thus necessitating remedial measures prior to concrete placement. It is also important that proper surface drainage be maintained both during construction (especially in terms of maintaining dry footing trenches) and after construction. Soil backfill for footings should be placed in accordance with the recommendations for structural fill presented herein.

5.3 MOISTURE SENSITIVE SOILS

The fine-grained soils encountered at this site will be sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. Construction traffic patterns should be varied to prevent the degradation of previously stable subgrade. In addition, plastic soils which become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. We caution if site grading is performed during the wet weather season, methods such as discing and allowing the material to dry will be required to meet the required compaction recommendations. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

5.4 DRAINAGE AND SURFACE WATER CONCERNS

To reduce the potential for undercut and construction induced dropouts, water should not be allowed to collect in the foundation excavations, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped to facilitate removal of any collected rainwater, subsurface water, or surface runoff.

Positive site surface drainage should be provided to reduce infiltration of surface water around the perimeter of the building. The grades should be sloped away from the building and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill.

5.5 SINKHOLE CORRECTIVE ACTIONS AND CONSIDERATIONS

Based on our experience, corrective actions can also be performed to reduce the potential for sinkhole development at this site. These corrective actions, such as proper grade selection and positive site drainage, would decrease but not eliminate the potential for sinkhole development.

In general, the portions of a site that are excavated to achieve the desired grades will have a higher risk of sinkhole development than the areas that are filled, because of the exposure of relic fractures in the soil to rainfall and runoff. On the other hand, those portions of a site that receive a modest amount of fill (or that have been filled in the past) will have a decreased risk of sinkhole development caused by rainfall or runoff because the placement of a cohesive soil fill over these areas effectively caps the area with a relatively impervious “blanket” of remolded soil. Therefore, the recommendations that follow incorporate a modest remedial treatment program designed to make the surface of the soil in excavated areas less permeable.

Although it is our opinion that the risk of ground subsidence associated with sinkhole formation cannot be eliminated, we have found that several measures are useful in site design and development to reduce this potential risk. These measures include:

- Maintaining positive site drainage to route surface waters well away from structural areas both during construction and for the life of the structure.

- The scarification and re-compaction of the upper 6 to 10 inches of soil in earthwork cut areas.
- Verifying that subsurface piping beneath structures is carefully constructed and pressure tested prior to its placement in service.
- The use of pavement or lined ditches, particularly in cut areas, to collect and transport surface water to areas away from structures.

Considerations when building within a sinkhole prone area are to provide positive surface drainage away from any proposed building or parking area both during and after construction. Backfill in utility trenches of other excavations should consist of compacted, well-graded material such as dense graded aggregate or compacted on site soils. The use of an open graded stone such as No. 57 stone is not recommended unless the stone backfill is provided an exit path and not allowed to pond. If sinkhole conditions are observed, the type of corrective action is most appropriately determined by GEOServices on a case-by-case basis.

5.6 SLOPES

The project is still in the planning phase and detailed information regarding finished site grades and slope configurations is not yet available. Once finished site grades and slope configurations have been determined and if the slopes are taller than 5 feet, we should be contacted to provide recommendations for slope stability.

6.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

The analyses and recommendations submitted herein are based, in part, upon the data obtained from the exploration. The nature and extent of variations between the observation trenches will not become evident until construction. We recommend that GEOServices be retained to observe the project construction in the field. GEOServices cannot accept responsibility for conditions which deviate from those described in this report if not retained to perform construction observation and testing. If variations appear evident, then we will re-evaluate the recommendations of this report. In the event that any changes in the nature, design, or location of the structures are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions modified or verified in writing. Also, if the scope of the project should change significantly from that described herein, these recommendations may have to be re-evaluated.

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDICES

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX A

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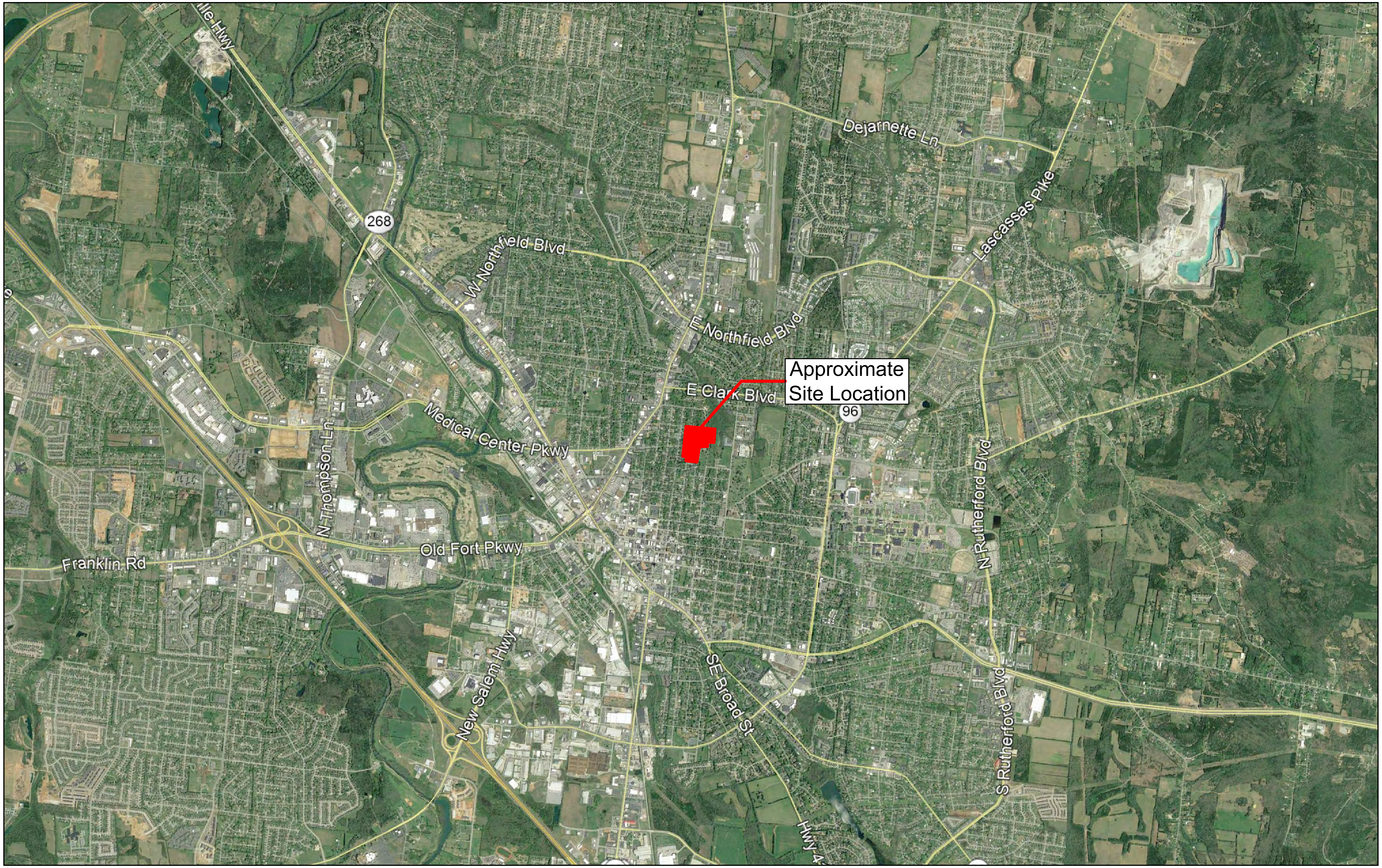


Notes:

1) Aerial Provided by: Google Earth Pro, (04/20/2018)

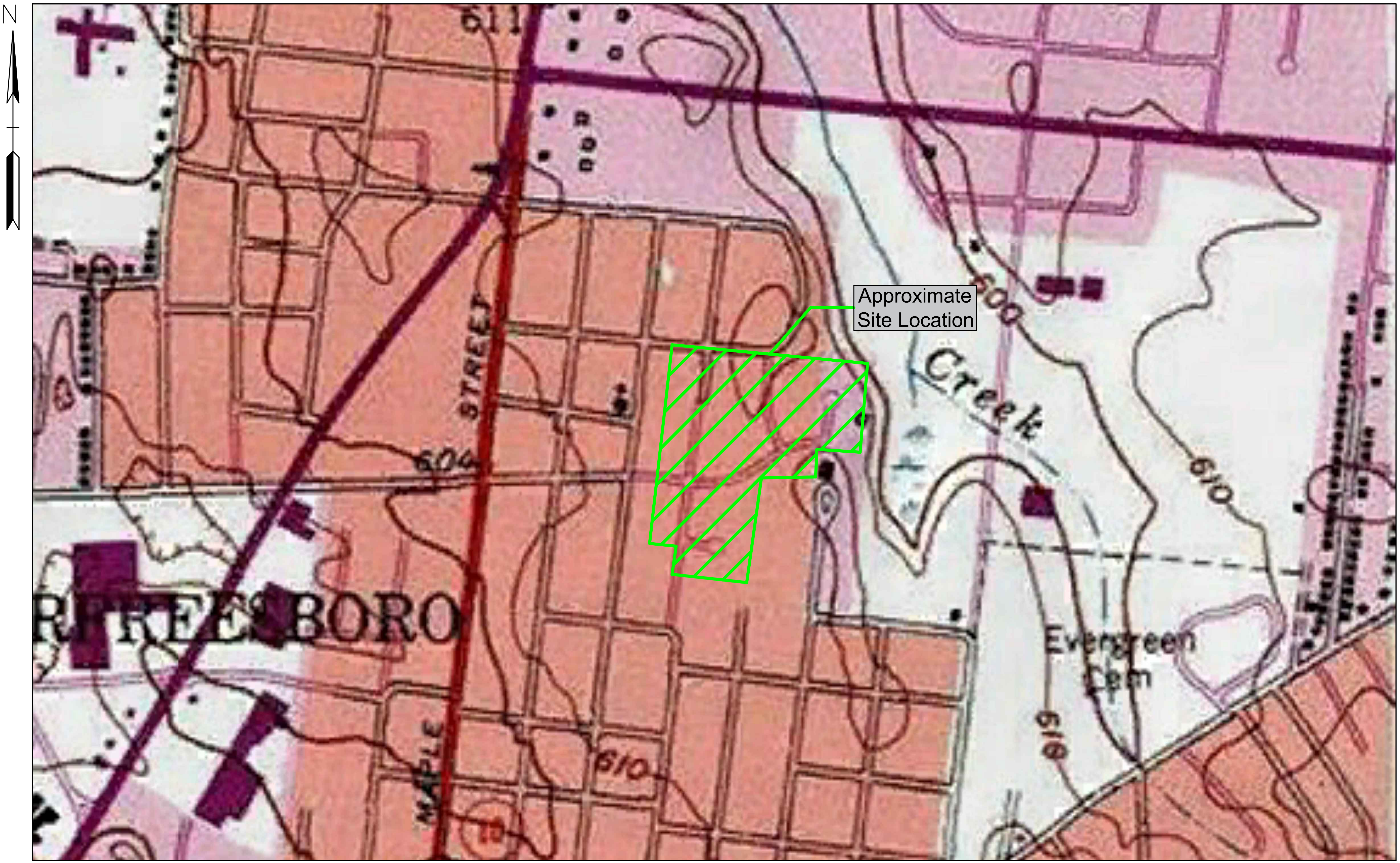
GEOServices, LLC, Geotechnical and Materials Engineers

Site Vicinity Plan
Proposed Oakland Court Residential
East Hembree Street
Murfreesboro, Tennessee

DATE:
03/16/2020

GEOS Project No.
31-201111

FIGURE:
1



Source Provided by: MYTOPO

GEOS
GEOServices, LLC, Geotechnical and Materials Engineers

USGS Topographic Map
Proposed Oakland Court Residential
East Hembree Street
Murfreesboro, Tennessee

DATE:
03/16/2020

GEOS Project No.
31-201111

FIGURE:
2

Notes:

1) Site Source Provided by: Client
2) Aerial Provided by: Google Earth Pro, (04/20/2018)
3) Observation Trench Locations are shown in general arrangement only
4) Do Not use Observation Trench Locations for determinations of Distance or Quantities

Observation Trench Location & Identifier

GEOServices, LLC, Geotechnical and Materials Engineers

Observation Trench Location Plan
Proposed Oakland Court Residential
East Hembree Street
Murfreesboro, Tennessee

DATE:
03/16/2020

GEOS Project No.
31-201111

FIGURE:
3

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2 mm to 4.74 mm
MEDIUM SAND:	0.425 mm to 2 mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

COARSE GRAINED SOILS (SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
OVER 50	VERY DENSE

FINE GRAINED SOILS (SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0 - 2	VERY SOFT	0 - 500
3 - 4	SOFT	500 - 1000
5 - 8	FIRM	1000 - 2000
9 - 15	STIFF	2000 - 4000
16 - 30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000 +

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATON. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATED THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING REPRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)	DESCRIPTION
25	25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10"	75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR	PENETRATION REFUSAL OF SAMPLER AFTER INITIAL 6" SEATING

SAMPLING SYMBOLS

ST:	UNDISTURBED SAMPLE
SS:	SPLIT SPOON SAMPLE
CORE:	ROCK CORE SAMPLE
AU:	AUGER OR BAG SAMPLE

SOIL PROPERTY SYMBOLS

N:	STANDARD PENETRATION, BPF
M:	MOISTURE CONTENT %
LL:	LIQUID LIMIT %
PI:	PLASTICITY INDEX %
Qp:	POCKET PENETROMETER VALUE, TSF
Qu:	UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW:	DRY UNIT WEIGHT, PCF

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

PERCENT	QUALITY
90 TO 100	EXCELLENT
75 TO 90	GOOD
50 TO 75	FAIR
25 TO 50	POOR
0 TO 25	VERY POOR

ROCK HARDNESS

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH: CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE: CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CAN NOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Oakland Court	TEST PIT OBSERVATION RECORD	GEOServices, LLC-Geotechnical and Materials Engineers
Murfreesboro, Tennessee	Test Pit No.: OT-1	
GEOServices Project No. 31-201111		
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (3 Inches)					
1.0	Lean CLAY (CL) with rock fragments and some organics - brown, firm, moist, (FILL)					
2.0		5-6-6 @ 2'				23.9
3.0	Fat CLAY (CH) with abundant chert and rock fragments - red, firm, moist, (RESIDUUM)					
4.0		6-8-8 @ 4'				24.9
5.0						
6.0		TNP @ 6'				39.0
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-2	GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (7 Inches)					
1.0	Lean CLAY (CL) with chert at depth - brown to reddish-brown, firm to stiff, moist, (RESIDUUM)					
2.0		5-6-6 @ 2'				24.7
3.0						
4.0		6-8-9 @ 4'				25.6
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ______________________________

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-3	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (4 Inches)					
1.0	Lean CLAY (CL) with trace organics - brown and dark brown, firm, moist, (FILL)					
2.0		5-5-5 @ 2'				20.4
3.0	Fat CLAY (CH) with chert - red to light brown, firm, moist, (RESIDUUM)					
4.0		6-7-8 @ 4'				25.0
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-5	GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (4 Inches)					
1.0	Lean CLAY (CL) with trace rock fragments - brown and dark brown, moist, (FILL)					
2.0	Lean CLAY (CL) with trace chert - brownish-red, moist, (RESIDUUM)	TNP @ 2'	45	18	27	24.9
3.0						
4.0	Fat CLAY (CH) with chert - brownish-red to light brown, moist, (RESIDUUM)	TNP @ 4'				27.2
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court

Murfreesboro, Tennessee

GEOServices Project No. 31-201111

TEST PIT OBSERVATION RECORD

Test Pit No.: **OT-6**

GEOServices, LLC-Geotechnical and Materials Engineers

Date Excavated: **March 6, 2020**

Observed By: Sam Hohl

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (3 Inches)					
1.0	Lean CLAY (CL) with trace rock fragments - brown and dark brown, moist, (FILL)					
2.0		4-5-5 @ 2'				24.8
3.0						
4.0		5-6-7 @ 4'				27.9
5.0	Fat CLAY (CH) with chert - brownish-red to light brown, firm, moist, (RESIDUUM)					
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-7	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (6 Inches)					
1.0	Lean CLAY (CL) with trace organics - brown, moist, (RESIDUUM)					
2.0		TNP @ 2'				25.6
3.0						
4.0	Fat CLAY (CH) with abundant chert - brownish-red, moist, (RESIDUUM)	TNP @ 4'				26.3
5.0						
6.0		TNP @ 6'				28.1
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ____________________

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-8	GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (5 Inches)					
1.0	Lean CLAY (CL) - brownish-red, firm, moist, (RESIDUUM)					
2.0		5-5-6 @ 2'				28.6
3.0						
4.0		6-6-8 @ 4'				27.3
5.0	Fat CLAY (CH) with trace chert - red and light brown, firm, moist, (RESIDUUM)					
6.0		TNP @ 6'				28.2
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court	TEST PIT OBSERVATION RECORD	GEOS
Murfreesboro, Tennessee	Test Pit No.: OT-9	GEOServices, LLC-Geotechnical and Materials Engineers
GEOServices Project No. 31-201111		
Date Excavated: March 6, 2020	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (6 Inches)					
1.0 – 4.0	Lean CLAY (CL) - brown to reddish-brown, firm, moist, (RESIDUUM)	5-5-7 @ 2'				29.1
		7-9-8 @ 4'				29.4
4.0 – 8.0	Fat CLAY (CH) with abundant chert - brownish-red to light brown, stiff, moist, (RESIDUUM)	TNP @ 6'				32.9
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ______________________

Oakland Court **Murfreesboro, Tennessee** GEOServices Project No. 31-201111	**TEST PIT OBSERVATION RECORD** **Test Pit No.:** **OT-10**	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: **March 6, 2020**	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (3 Inches)					
1.0	Lean CLAY (CL) with trace rock fragments - brown and dark brown, moist, (FILL)					
2.0	Lean CLAY (CL) with trace chert - reddish-brown, moist, (RESIDUUM)	TNP @ 2'				24.8
3.0						
4.0		TNP @ 4'				25.4
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court **Murfreesboro, Tennessee** GEOServices Project No. 31-201111	**TEST PIT OBSERVATION RECORD** **Test Pit No.:** **OT-11**	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: **March 6, 2020**	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (6 Inches)					
1.0	Lean CLAY (CL) with organics - brown, soft, moist, (FILL)					
2.0		5-3-3 @ 2'				22.4
3.0	Lean CLAY (CL) with chert at depth - brown to light brown, soft, moist, (RESIDUUM)					
4.0		2-3-4 @ 4'	40	18	22	32.1
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ____________________

Oakland Court **Murfreesboro, Tennessee** GEOServices Project No. 31-201111	**TEST PIT OBSERVATION RECORD** **Test Pit No.:** **OT-12**	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: **March 6, 2020**	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (8 Inches)					
1.0	Lean CLAY (CL) - brownish-red, moist, (RESIDUUM)					
2.0		TNP @ 2'				24.2
3.0						
4.0		TNP @ 4'				25.9
5.0	Fat CLAY (CH) with trace chert - red and light brown, moist, (RESIDUUM)					
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-13	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (10 Inches)					
1.0	Lean CLAY (CL) with trace organics near surface and some chert at depth - brown to reddish-brown, moist, (RESIDUUM)					
2.0		TNP @ 2'				24.0
3.0						
4.0		TNP @ 4'				26.9
5.0						
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-14	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	**Observed By:** Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (5 Inches)					
1.0	Lean CLAY (CL) with trace organics - brown, moist, (FILL)					
2.0	Lean CLAY (CL) - brownish-red, soft to firm, moist, (RESIDUUM)	4-4-4 @ 2'				25.8
3.0						
4.0		5-5-6 @ 4'				28.0
5.0						
6.0		TNP @ 6'				32.1
7.0	Fat CLAY (CH) with chert - light brown, moist, (RESIDUUM)					
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-15	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (3 Inches)					
1.0	Lean CLAY (CL) with trace organics - brown, moist, (FILL)					
2.0	Lean CLAY (CL) - brown, moist, (RESIDUUM)	TNP @ 2'				24.5
3.0						
4.0	Fat CLAY (CH) with abundant chert - reddish-brown, moist, (RESIDUUM)	TNP @ 4'				27.1
5.0						
6.0		TNP @ 6'				28.6
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court	TEST PIT OBSERVATION RECORD	GEOS
Murfreesboro, Tennessee	Test Pit No.: OT-17	GEOServices, LLC-Geotechnical and Materials Engineers
GEOServices Project No. 31-201111		
Date Excavated: **March 6, 2020**	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (7 Inches)					
1.0	Lean CLAY (CL) - brown, firm to soft, moist, (RESIDUUM)					
2.0		4-5-5 @ 2'				23.6
3.0						
4.0		4-4-4 @ 4'				27.2
5.0	Fat CLAY (CH) with abundant chert - brownish-red, moist, (RESIDUUM)					
6.0		TNP @ 6'				28.4
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ______________________

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-18	GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (3 Inches)					
1.0	Lean CLAY (CL) with trace organics - brown and dark brown, moist, (FILL)					
2.0	Lean CLAY (CL) - brown, firm to soft, moist, (RESIDUUM)	4-5-5 @ 2'				
3.0						
4.0		3-4-4 @ 4'				
5.0	Fat CLAY (CH) with abundant chert - brownish-red, moist, (RESIDUUM)					
6.0		TNP @ 6'				
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments:

Oakland Court Murfreesboro, Tennessee GEOServices Project No. 31-201111	TEST PIT OBSERVATION RECORD Test Pit No.: OT-19	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Date Excavated: March 6, 2020	Observed By: Sam Hohl	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (8 Inches)					
1.0	Lean CLAY (CL) - brown, soft to firm, moist, (RESIDUUM)					
2.0		3-3-4 @ 2'				25.4
3.0						
4.0		4-5-5 @ 4'				25.1
5.0	Fat CLAY (CH) with abundant chert - light brown with black mottling, moist, (RESIDUUM)					
6.0		TNP @ 6'				23.9
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

Excavated test pit

Excavated material

Comments: ______________________________

Oakland Court	TEST PIT OBSERVATION RECORD	GEOS GEOServices, LLC-Geotechnical and Materials Engineers
Murfreesboro, Tennessee	**Test Pit No.:** **OT-20**	
GEOServices Project No. 31-201111		
Date Excavated: **March 6, 2020**	**Observed By: Sam Hohl**	

Depth (feet)	Material Description	DCP Values	LL	PL	PI	%M
	Topsoil (10 Inches)					
1.0	Fat CLAY (CH) with chert at depth - brownish-red to light brown to red, moist, (RESIDUUM)					
2.0		TNP @ 2'	55	21	34	27.9
3.0						
4.0		TNP @ 4'				30.9
5.0						
6.0		TNP @ 6'				27.7
7.0						
8.0	Observation Trench Termination at 8 feet					
9.0						

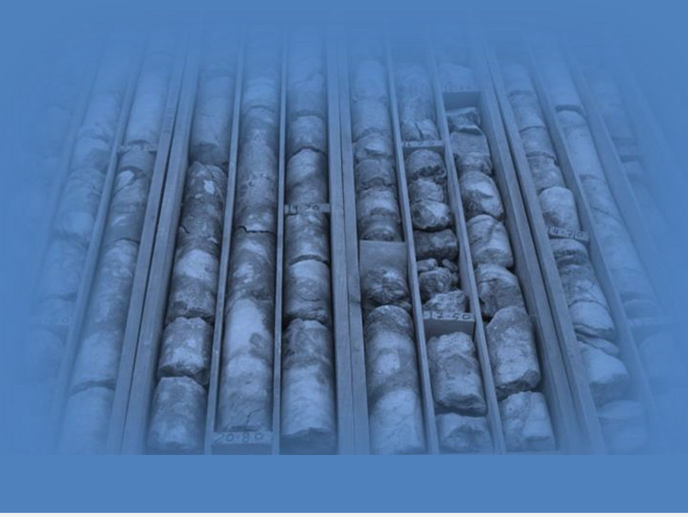
Excavated test pit

Excavated material

Comments:

GEOServices, LLC, Geotechnical and Materials Engineers

APPENDIX B



SOIL DATA SUMMARY Oakland Court Residential - Murfreesboro, Tennessee GEOServices Project No. 31-201111 March 16, 2020							
Observation Trench Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Soil Type
				LL	PL	PI	
1	1	2	23.9%				
	2	4	24.9%				
	3	6	39.0%				
2	1	2	24.7%				
	2	4	25.6%				
3	1	2	20.4%				
	2	4	25.0%				
5	1	2	24.9%	45	18	27	CL
	2	4	27.2%				
6	1	2	24.8%				
	2	4	27.9%				
7	1	2	25.6%				
	2	4	26.3%				
	3	6	28.1%				
8	1	2	28.6%				
	2	4	27.3%				
	3	6	28.2%				
9	1	2	29.1%				
	2	4	29.4%				
	3	6	32.9%				
10	1	2	24.8%				
	2	4	25.4%				
11	1	2	22.4%				
	2	4	32.1%	40	18	22	CL
12	1	2	24.2%				
	2	4	25.9%				
13	1	2	24.0%				
	2	4	26.9%				
14	1	2	25.8%				
	2	4	28.0%				
	3	6	32.1%				

GEOServices, LLC-Geotechnical and Materials Engineers

SOIL DATA SUMMARY Oakland Court Residential - Murfreesboro, Tennessee GEOServices Project No. 31-201111 March 16, 2020							
Observation Trench Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Soil Type
				LL	PL	PI	
15	1	2	24.5%				
	2	4	27.1%				
	3	6	28.6%				
17	1	2	23.6%				
	2	4	27.2%				
	3	6	28.4%				
19	1	2	25.4%				
	2	4	25.1%				
	3	6	23.9%				
20	1	2	27.9%	55	21	34	CH
	2	4	30.9%				
	3	6	27.7%				