MC Squared, Inc.

Geotechnical Engineering Report

Watermain Replacement
DeKalb County Scott Boulevard Phase II
Decatur, DeKalb County, Georgia

Prepared for: ***Atkins***
1600 RiverEdge Parkway, Suite 700
Atlanta, GA 30328

Prepared by: ***MC Squared, Inc.***
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MC² Project No. A071801.060
August 2018

GEOTECHNICAL • ENVIRONMENTAL
MATERIALS TESTING

August 30, 2018

Mr. Michael K. Wooten, P.E.
Project Director
Atkins
1600 RiverEdge Parkway, Suite 700
Atlanta, GA 30328

Subject: Geotechnical Engineering Report
Watermain Replacement
DeKalb County Scott Boulevard Phase II
Decatur, DeKalb County, Georgia
MC² Proposal No. A071801.060

Dear Mr. Wooten:

MC Squared, Inc. (**MC²**) has completed geotechnical engineering services for a portion of the proposed watermain replacement located in the vicinity of East Ponce de Leon Avenue and Hillyer Avenue, in Decatur, DeKalb County, Georgia. This report outlines our geotechnical engineering recommendations for the proposed watermain replacement.

We trust that this report will assist you in the design and construction of the proposed project and we appreciate the opportunity to be of service to you. Should you have any questions, please do not hesitate to contact us.

Respectfully submitted,
MC²

Amir Moussly
Staff Engineer

Jodonna J. Jimenez, P.E.
Project Engineer

Prashanth Vaddu, P.E.
Project Manager
Georgia P.E. No. 039820

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1 PROJECT INFORMATION

1.1 Project Authorization

Authorization to proceed with this project was issued by **Mr. Michael Wooten, P.E.** of **Atkins** through the signed contract on August 17, 2018 and in general accordance with our proposal dated July 27, 2018 and revised August 2, 2018.

1.2 Project Description

The proposed project site is located just east of the MARTA Avondale transit station, near Scott Boulevard in Decatur, DeKalb County, Georgia (refer to **Sheet 1 – Project Location Map**). Project information was provided by **Mr. Michael Wooten, P.E.** of **Atkins** through e-mail and verbal communications. Based on our understanding, geotechnical engineering services are required to support the design of a watermain replacement. The objective of this project is to provide geotechnical subsurface information to assist with the design and construction of deep excavations for a watermain replacement, using a jack-and-bore installation methodology.

Mr. Wooten provided a one-page PDF entitled "MARTA Xing Boring Map" (refer to **Sheet 2 – Boring Location Plan**) specifying two (2) boring locations that he requested us to explore.

Structure specific loads, pipe material and final invert elevations at boring locations B-1 and B-2 were not available as of this report writing. However, it is our understanding that the approximate excavation depths for B-1 and B-2 are 15.5 feet and 23 feet below ground surface (bgs), respectively. If any of the project description information is incorrect or changes, please inform **MC^2** so that we may amend, the recommendations presented in this report, as appropriate.

2 SCOPE OF WORK AND SERVICES

The purpose of this report is to describe, in general terms, soil and groundwater conditions encountered at the site and to provide evaluations and recommendations to aid in the design and construction of the watermain replacement. To achieve the aforementioned objective, our scope of services included the following:

1. Visual reconnaissance of the project site, marking test boring locations and coordinating underground utility clearance through the state 811 service.

2. Coordinating marking of high pressure gas line with locator in addition to locating utilities (not marked by GA 811) utilizing ground penetrating radar (GPR). Reviewing client-provided utility maps prior to commencing our geotechnical field exploration program.

3. Coordinating area closures to set up a safe field exploration perimeter by boring B-2. Closely coordinating with active construction site superintendent to avoid conflicts with planned paving operations. Managing construction traffic utilizing flagmen and barricades.

4. Coordinating and mobilizing drilling equipment and tools required to perform rock coring. Mobilization included water truck and rock core barrels, in addition to coordination and rental of hydrant meter from DeKalb County Department of Watershed Management.

5. Advancing two (2) Standard Penetration Test (SPT) borings, to depths as indicated below:

Boring ID	**Depth (ft.)**		**Comment**
	Soil	Rock	
B-1	25.4	-	Auger Refusal at 25.4'.
B-2	33.5	-	Boring terminated at 33.5'.

6. Visually examining all recovered soil samples in the laboratory. Performing laboratory tests on selected representative samples to develop the soil legend for the project using the Unified Soil Classification Systems. Laboratory testing included Atterberg Limit tests, moisture content tests and gradation tests.

7. Engineering evaluation and analysis as it pertains to the planned jack-and-bore operations.

We present the following data and recommendations in this report:

1. A general assessment of area geology based on our past experience, study of readily available geological literature and boring information.

2. Subsurface soil profiles including laboratory test data and groundwater conditions.

3. General construction recommendations for the proposed watermain.

3 SITE CONDITIONS

3.1 Site Features

The project site is located in an urban area just east of the MARTA Avondale transit station in Decatur, DeKalb County, Georgia (refer to **Sheet 1 – Project Location Map** in **Figures**). The proposed watermain is anticipated to be installed below ground perpendicular to the existing railroad tracks (refer to **Sheet 2 – Boring Location Map** in **Figures**). Jack-and-bore pits are planned on both sides (north and south) of the existing railroad.

The northern jack-and-bore pit (near boring B-1) is planned to be installed within the existing paved parking lot of a private business. This area is bound by a single-story office building to the north, East Ponce de Leon Avenue to the east and south and Grove Place to the west. Several utility lines including overhead power are present very close to the planned jack-and-bore pit location. Based upon our review of the site plans provided by **Atkins** and our site reconnaissance, there are existing watermains that traverse east-west along the inside westbound lane adjacent to boring B-1 within the proposed watermain replacement footprint at an unknown depth.

The southern jack-and-bore pit (near boring B-2) is located within an active construction site at the northern terminus of Hillyer Avenue. B-2 is bound by MARTA railroad tracks to the north, active constructing staging area to the east, Hillyer Avenue to the south and a multi-story building to the west. During the period of our field activities (August 2018), we observed that a new pavement and related appurtenances were in the process of being constructed along Hillyer Avenue in the immediate vicinity of the project site.

Following our site reconnaissance, we reviewed readily available geological and geotechnical information as detailed in the following sections.

3.2 USDA Soil Survey

Our review of the U.S. Department of Agriculture (USDA) - Soil Conservation Service (SCS) maps for the project site indicates the improvements are located within the Ud mapping unit – Urban land. No published soils information is available for areas within the Urban land mapping unit.

This information was published in a report titled *Custom Soil Resource Report for DeKalb County, Georgia* using Version 9, dated October 2, 2017. The aerial images were photographed from May 4, 2014 to June 18, 2014. A portion of the **USDA Soil Survey Map** of the project area is included in the **Figures** (**Sheet 2 - USDA Soil Survey and USGS Topographic Map**).

The USDA Soil Survey is not an exact representation of the soils and conditions on the site. The mapping by USGS is based on interpretation of aerial maps with scattered shallow borings for confirmation. Accordingly, borders between mapping units are approximate and the change may be transitional. Differences may also occur from the typical stratigraphy, and small areas of other similar and dissimilar soils may occur within the soil mapping unit. As such, there may be differences in the mapped description and the boring descriptions obtained for this report. Development/urbanization can also cause differences in the typical stratigraphy. The survey is, however, a good basis for evaluating the shallow soil conditions of the area.

3.3 Topographic Map and Site History

Based on our review of the USGS topographic quadrangles titled “Northeast Atlanta Quadrangle”, the existing site is at an approximate elevation range of 1040 to 1060 feet (NAVD 1988 datum) (refer to the **USDA Soil Survey and USGS Topographic Map** in the **Figures – Sheet 2**). The elevation at the site does not appear to have changed drastically since 1954, date of the oldest readily available historical topographic map.

4 FIELD EXPLORATION PROGRAM

Our field exploration program consisted of two (2) SPT borings. The SPT borings were performed on August 7 and August 8, 2018. The field exploration services were performed by **MC^2**’s subcontractor under the direct supervision of **MC^2**’s qualified staff engineer and overseen by a Georgia licensed qualified professional engineer.

4.1 Standard Penetration Test (SPT) Borings

A total of two (2) SPT borings were completed at the site in general accordance with ASTM D1586 (Standard Test Method for Penetration Test and Split Barrel Sampling of Soils) using a truck-mounted, Foremost Mobile B-59, drill rig. The hollow-stem auger drilling method was used at this site. Representative soil samples were obtained using the split-barrel sampling procedure discussed below. In this procedure, a 2-in. outer-diameter, split-barrel sampler is driven into the soil by a 140-lb automatic hammer with a free-fall of 30-in. The number of blows required to drive the sampler through a 12-in. interval, after the initial 6-in. seating interval, is termed the Standard Penetration Resistance, or "N" value, and is indicated for each sample on the boring log. The "N" value may be taken as an indication of the relative density of in-situ soils. The N-value represented on our boring logs is an uncorrected field N-value. Based on the energy efficiency report for the drill rig that was used to perform our borings (Foremost Mobile B-59 truck-mounted drill rig), the average “energy transfer ratio” (ETR) is reported as 79%. The ETR is defined as the ratio of maximum transferred energy (Energy-Force-Velocity method, or EFV) divided by the theoretical hammer potential energy of 350 ft-lbs (computed from the 140-lb SPT hammer and the standard 30-in. drop as specified by ASTM D1586-99).

Soil samples, recovered during the field exploration program, were placed into air-tight containers, labeled with the project number, boring number and corresponding depth bgs, and returned to our office to confirm field classification and perform laboratory testing, as required.

All soil samples collected will be retained in-house for 60 days from the date of release of this report and will be subsequently discarded without further notice unless requested otherwise by the client, in writing.

5 GEOTECHNICAL LABORATORY TESTING

A representative set of soil samples was tested in the laboratory to assist in the classification and determination of engineering characteristics of the soil based on their mechanical and physical behavior. Laboratory testing was accomplished in general accordance with applicable ASTM standards. Laboratory tests completed on soil samples retrieved for this project include:

- six (6) natural moisture content determinations;
- six (6) grain size analysis, including hydrometer testing;
- four (4) Atterberg limit determination tests; and
- visual classification.

Results for each of these laboratory tests are summarized in the following table and are also presented on the **Individual Boring Profiles** provided in the **Appendix** and the **Subsurface Boring Profiles** in **Figures** (refer to **Sheets 4 and 5**).

Table 1: Summary of Laboratory Testing of Soils

Boring No. (Depth) (ft.)	Moisture Content (%)	Percent Passing No. 200 Sieve (%)	Liquid Limit (%)	Plasticity Index (%)	Silt Content (%)	Clay Content (%)	USCS Classification
B-1 (2-4)	25.5	50.8	26	5	18.9	31.9	CL-ML
B-1 (8-10)	13.5	26.2	NP	NP	21.3	4.8	SM
B-1 (18.5-20)	33.6	41.8	-	-	33.6	8.3	SM
B-2 (4-6)	18.7	51.5	-	-	28.1	23.4	ML
B-2 (18.5-20)	23.3	32.5	23	2	21.9	10.7	SM
B-2 (23.5-25)	21.3	20.7	NP	NP	19.9	0.8	SM

6 SUBSURFACE CONDITIONS

6.1 Subsurface Soil Conditions

The subsurface conditions at the project site were explored using two (2) SPT borings, as detailed in **Section 4** of this report. The approximate boring locations are presented on **Sheet 2** in **Figures**.

Boring B-1 (Northern Jack-and-Bore Pit)

The boring performed encountered a layer of loose silty SAND (SM) to approximately 2 feet, below the top of the existing pavement section. The SM layer was underlain by stiff, sandy silty CLAY (CL-ML) to approximately 6 feet bgs and medium dense silty SAND (SM), micaceous, with rock fragments to 13.5 feet bgs. Below 13.5 feet, we encountered alternating layers of micaceous medium dense to very dense SAND with silt (SP-SM) and medium dense SM to boring termination depth of 25.4 feet. Boring B-1 was terminated in very dense auger refusal material at a depth of 25.4 feet bgs.

Boring B-2 (Southern Jack-and-Bore Pit)

Subsurface soils encountered at boring B-2 were relatively similar to the subsurface conditions observed in B-1. They consisted of dense poorly-graded SAND with rock fragments (SP) to 2 feet bgs underlain by medium dense SM to 4 feet bgs. This SM layer is underlain by firm sandy SILT (ML) to 6 feet bgs, followed by a layer of stiff CL to 8 feet bgs. Between 8 and 33.5 feet bgs, loose to dense SM was encountered. The boring was terminated at a depth of 33.5 feet bgs.

The subsurface description discussed above is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The **Subsurface Boring Profiles** (refer to **Sheet 4** in **Figures**) and **Individual Boring Profiles** (refer to the **Appendix**), should be reviewed for specific information at individual boring locations. These profiles include soil description, stratification and laboratory test results. The stratification shown on the boring profiles represents the conditions only at the location of the boring performed. Variations may exist between borings and project area.

6.2 Groundwater Conditions

Groundwater table was recorded at B-1 immediately after completion of drilling and before backfilling the hole. At boring B-2, a 12-hr. groundwater table reading was recorded. No groundwater was encountered in B-1 prior to the boring termination depth of 25.4 feet. The 12-hr. stabilized groundwater depth at B-2 was recorded at 31 feet bgs.

In general, groundwater levels tend to fluctuate during periods of prolonged drought and extended rainfall or storm events. If the groundwater level is critical to design or construction, multiple temporary observation wells should be installed at the site to monitor groundwater fluctuations over a period of time. This will permit more accurate determination of wet and dry water levels. Fluctuation of the groundwater levels should be anticipated. We recommend that the Contractor determine the actual groundwater levels at the time of the construction to determine groundwater impact on the construction procedure.

7 EVALUATIONS AND CONCLUSIONS

The following evaluations and conclusions have been developed by us on the basis of the previously described project characteristics, our review of published data, information provided by the project team members, our site exploration and subsurface conditions encountered.

Once final design plans and specifications are available, a general review by **MC^2** is strongly recommended as a means to check that the evaluations made in preparation of this report are relevant and that earthwork and foundation recommendations are properly interpreted and implemented.

1. The project site is located in an urban setting. Soil conditions can change drastically from one location to the next, depending on past developmental activities. Subsurface soil conditions appear fairly consistent between borings B-1 and B-2. However, variations should be expected between borings along the proposed watermain alignment. Additionally, several underground utilities, including a high-pressure gas line, appear to be present in the immediate vicinity of the project site at an unknown depth.

2. Our review of the USGS Topographic Map did not indicate any unusual features at the project site. As noted in **Section 3.3** of this report, the elevation at the site does not appear to have changed drastically since the oldest readily available USGS topographic map (dated 1954). The site is generally level with minor variation of elevation between boring locations B-1 and B-2, within the proposed watermain footprint. MARTA railroad tracks traversing east-west exist between borings B-1 and B-2.

3. Surface water control may be necessary to avoid water seepage into the excavation during construction to establish a stable foundation during installation of the watermain and appurtenances. Dewatering at this project may range from simple sump pumps to well points to cutoff walls, depending on the time of the year, depth of excavations and groundwater table at the time of construction. A qualified dewatering contractor should design the dewatering system.

4. Auger refusal material (top of rock) was encountered at a depth of 25.4 feet below pavement surface in boring B-1. Determination of rock quality was not a part of our scope.

As such, there is currently no available information regarding the quality of the encountered rock in boring B-1. Boring B-2 was terminated at a depth of 33.5 feet bgs in a medium dense silty SAND. Specific pipe invert elevation information was not available at the time of preparation of this report. However, it is our understanding that the pipe inverts and/or jack-and-bore pit bottoms are not anticipated to be deeper than 23-feet bgs at B-2 and 15.5 feet at B-1. We did not encounter rock at these anticipated pipe/jack-and-bore pit bottom elevations; however, DeKalb County is generally known for variable rock depths over short distances and the risk associated with the same should be taken into account during construction.

5. During **MC^2'**s field exploration program, it was observed that an active construction site was situated near boring B-2 on Hillyer Avenue. According to the construction manager from McShane Construction, a vein of solid granite was encountered by them at approximately 20 feet below ground surface (bgs). While the granite vein was not encountered in our boring (B-2), the risk associated with encountering rock during boring and excavation efforts for the proposed watermain replacement should be accounted for. Depending on the excavation locations, planned pipe invert elevations and the quality of rock, the contractor may need to be prepared for rock coring and/or rock blasting.

6. Subsurface utilities near boring B-1, such as existing sewer, water and gas lines, were apparent during our field exploration program. Subsurface utilities such as power and water were also apparent within the vicinity of B-2. Caution should be taken to maintain safe working distances away from existing subsurface utilities during deep excavations for the jack-and-bore pit.

7. While the groundwater table was not encountered above or near the proposed excavation depths, groundwater levels should be monitored. The direction of surface water drainage should be in consideration before selecting excavation locations. An appropriate surficial drainage mechanism, such as perimeter drains or another appropriate means, should be installed to impede stormwater from entering excavation pits.

8. It is likely that heavy equipment will be required to achieve deep excavations for the watermain replacement. Based on existing site conditions, there appears to be limited working space, in addition to potential utility conflicts. Accordingly, due precautions must be taken to avoid damage to existing underground and overhead utilities during construction.

8 RECOMMENDATIONS

8.1 Temporary Structure Excavations

Side slopes for temporary excavations may stand near one and a half (1.5) horizontal to one (1) vertical (1.5H:1V) for short dry periods of time and a maximum excavation depth of four (4) feet. Where restrictions do not permit slopes to be constructed as recommended above, the excavation should be shored in accordance with current OSHA requirements. In addition, any open cut excavations adjacent to existing structures should be evaluated by a geotechnical engineer on a case by case basis. During construction, excavated materials should not be stockpiled at the top of the slope within a horizontal distance equal to 1.5 times the excavation depth.

Excavation slopes should conform to OSHA, State of Georgia and any other local regulations. The dewatering system chosen for use on this project should consider the nature of the relatively permeable soils and fractured rocks encountered at the project site. The contractor should also assess equipment loads and vibrations when considering slopes or excavation bracing.

8.2 Federal Excavation Regulations

In Federal Register Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P". This document was issued to better insure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that all excavations, whether they be utility trenches, basement excavations, or footing excavations, be constructed in accordance with the revised OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's responsible person, as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

We are providing this information solely as a service to our client. **MC^2** is not assuming responsibility for construction site safety or the contractor’s activities; such responsibility is not being implied and should not be inferred.

8.3 Construction Recommendations

8.3.1 Site Preparation

Site preparation for the watermain should include stripping/removal of surface (topsoil) prior to replacing with properly compacted structural fill. The onsite soils classified as silty SANDS (SM) encountered in our borings generally appear suitable for use as structural fill. However, some of the micaceous silts may require very tight moisture control to achieve proper compaction. Organic and/or detrimental soils were not encountered in either of the borings completed by us.

We recommend that any proposed construction areas to receive fill be evaluated by proof-rolling prior to fill placement. Proof-rolling should be performed by traversing the construction areas with a loaded dump truck or similar compaction equipment weighing at least 20 tons. Proof-rolling operations should be observed by a representative of **MC^2**. Unstable soils which are revealed by proof-rolling and which cannot be adequately densified in place should be removed and replaced under the recommendations of the **MC^2** representative.

Structural fill should be free of organic material, have a plasticity index (PI) less than 20 and contain rock sizes no larger than 4 inches. The moisture content of fill soils at the time of placement and compaction should generally be within +/- 2% percentage points of their optimum moisture content. A representative of **MC^2** should observe fill placement operations and perform density tests concurrently to indicate if the specified compaction is being achieved. The upper foot of fill which will support pavements should be compacted to at least 98 percent of the soil's standard Proctor maximum dry density (ASTM D-698) within +/- 2% of the optimum moisture content for improved support. In areas which are at or above the finished grade, and which will support pavements or slabs, the upper 8 inches immediately below these systems should be scarified and recompacted to the 98 percent criteria of standard proctor within +/- 2% of the optimum moisture content. Structural fill should be free of organic material, have a plasticity index (PI) less than 20 and contain rock sizes no larger than 4 inches.

Density testing should be performed by a soils technician to determine the degree of compaction and verify compliance with the project specifications. For all structural fill and pavement, at least one field density test should be conducted for each 100 linear feet of fill area for each two-foot lift. Testing frequency should be increased in confined areas. Areas which do not meet the compaction specifications should be recompacted to the specified compaction. If fill has to be placed near existing structures, it should be placed in 6 to 8-inch loose lifts and compacted using a static roller. Within small excavations such as in utility trenches, around manholes, or within 5 feet of any of the structure walls, we recommend the use of smaller, hand or remote-guided equipment. Placement of loose lift thickness of 4 inches is recommended when using such equipment.

The contractor should exercise caution during construction, proof-rolling and compaction of soils so as not to cause settlement of the existing structures induced by vibrations. The Contractor must control and adjust the vibration so as to not disturb existing structures and/or subsurface utilities that may be in the vicinity of the project. The contractor is solely responsible for any settlement caused by his actions.

8.3.2 Excavation Considerations

As detailed in **Section 7.0** of this report, rock was not encountered above the anticipated excavation depths. However, rock depths are known to vary significantly over short distances. Accordingly, risk associated with the same should be accounted for.

8.3.2.1 Rock

If blasting of rock is required, the contractor should take appropriate precautionary measures prior to commencing blasting to ensure that the nearby facilities, structures, and utility lines are not adversely impacted. We recommend that a pre-blast survey be performed to record the condition of the existing structures prior to blasting and blast monitoring devices be installed at critical locations to monitor vibrations caused by blasting. The blasting and all associated tasks including precautionary measures related to blasting should be the sole responsibility of the contractor.

8.3.2.2 Definitions for Rock Payment

On many projects conflicts arise over the definition of rock. We suggest that the following definitions be incorporated into specifications to avoid such conflicts. These definitions have been used on other projects successfully and are included herein for your guidance.

Mass Excavation Rip Rock: Any material that cannot be removed by scrapers, loaders, pans, dozers, or graders; and requires loosening by using a single tooth ripper mounted on a crawler tractor having a minimum draw bar pull rated at not less than 56,000 pounds.

Mass Excavation Blast Rock: Any material which cannot be excavated after loosening with a single-tooth ripper mounted on a crawler tractor having a minimum draw bar pull rated at not less than 56,000 pounds (Caterpillar D 8K or equivalent) or by a Caterpillar 973 front end loader or equivalent; and occupying an original volume of at least one (1) cubic yard.

Trench Excavation Blast Rock: Any material which cannot be excavated with a backhoe having a bucket curling force rated at not less than 25,700 pounds (Caterpillar Model 225 or equivalent) and occupying an original volume of at least one half (1/2) cubic yard.

8.3.3 Lateral Earth Pressures

Below grade walls, where required, will be subject to lateral earth pressures. For walls which are restrained (braced) and adjacent to moderately compacted backfill, design is usually based on "at-rest" earth pressures. Active pressures are usually employed for unrestrained retaining wall design. Several earth pressure theories could be utilized. We used the equivalent fluid pressure or Rankine Theory.

Table 2: Earth Pressure Information

Earth Pressure Condition	Coefficient of Earth Pressure (K)	Unsubmerged Fluid Density (1) (pcf)	Submerged Fluid Density (2) (pcf)
At-Rest (K_o)	0.515	54	22
Active (K_a)	0.347	36	15
Passive (K_p)	2.882	303	123
(1) Fluid densities shown above are based on a clean sand backfill with an average internal friction angle of 29 degrees and a moist unit weight of 105 pcf. (2) Hydrostatic and seepage forces should be added to the submerged fluid densities when calculating total forces acting on retaining walls.			

It is our understanding that the existing pump station / wet well structure will remain operational until the new PS addressed in this report is completed. Accordingly, due consideration must be given towards the stability of the existing structures during construction of the proposed PS.

The above pressures do not include any surcharge effects for sloped backfill, point or area loads behind the walls and assume that adequate drainage provisions have been incorporated. The lateral earth pressures acting on below grade walls will be resisted by the sliding resistance forces along the base of the wall footing and the passive resistance resulting from footing embedment at the wall toe. Passive resistance could be neglected for a safer design (due to possible excavation or erosion in front of the wall at a future time). Should the backfill material have different densities and/or effective friction angle, the values shown in **Table 2** must be re-evaluated.

8.4 Drainage and Groundwater Considerations

Groundwater may be a concern during the installation of the watermain replacement, depending on final grades and the time of year construction is performed. We recommend that the Contractor determine the groundwater table prior to construction to determine the need for dewatering. For limited, relatively shallow excavations below the groundwater level, pumping from the excavation or sumps should be sufficient to control groundwater seepage. Deeper and larger excavations may require more extensive dewatering measures such as well points or cut-off walls. Depending on groundwater levels and the effectiveness of dewatering at the time of construction, seepage may enter the excavated areas from the bottom and sides. Such seepage will act to loosen soils and create difficult working conditions. Groundwater levels should be determined by the contractor immediately prior to construction. Recharge of groundwater a short distance from the dewatering location is recommended to avoid significant drawdowns which may trigger undue subsidence/settlement of existing structures in the vicinity.

All grades should be sloped away from the structures and surface drainage should be collected and discharged such that water is not permitted to flow into the excavation. Excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, groundwater or surface water runoff. Positive site drainage should be provided to reduce infiltration of surface water into excavations.

9 REPORT LIMITATIONS

The recommendations detailed herein are based on the available limited soil information obtained by **MC^2** and information provided by **Atkins** for the proposed project. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, **MC^2** should be notified immediately to determine if changes of recommendations are required. In the event that **MC^2** is not retained to perform these functions, **MC^2** cannot be responsible for the impact of those conditions on the performance of the project during construction and operation.

The scope of our services did not include an environmental assessment for determining the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors, colors, unusual or suspicious items or conditions are strictly for completeness of information.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the Geotechnical Engineer should be provided the opportunity to review the final design plans and specifications to assess that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of **Atkins and DeKalb County**. For additional reference describing the scope and limitations of this geotechnical report, please review the document enclosed in **Appendix** titled, “Important Information About this Geotechnical-Engineering Report.”

FIGURES

LEGEND:

★ Project Location

Source: Google Earth
Image Date: 3/31/2017

0′ 500′ 1000′
Graphic Scale (feet)

DATE	NAME	REVISION	APPROVED BY:

MC SQUARED, INC.
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Ph:770-650-0873 Fax:770-650-7825

MC²
Geotechnical • Environmental
Materials Testing

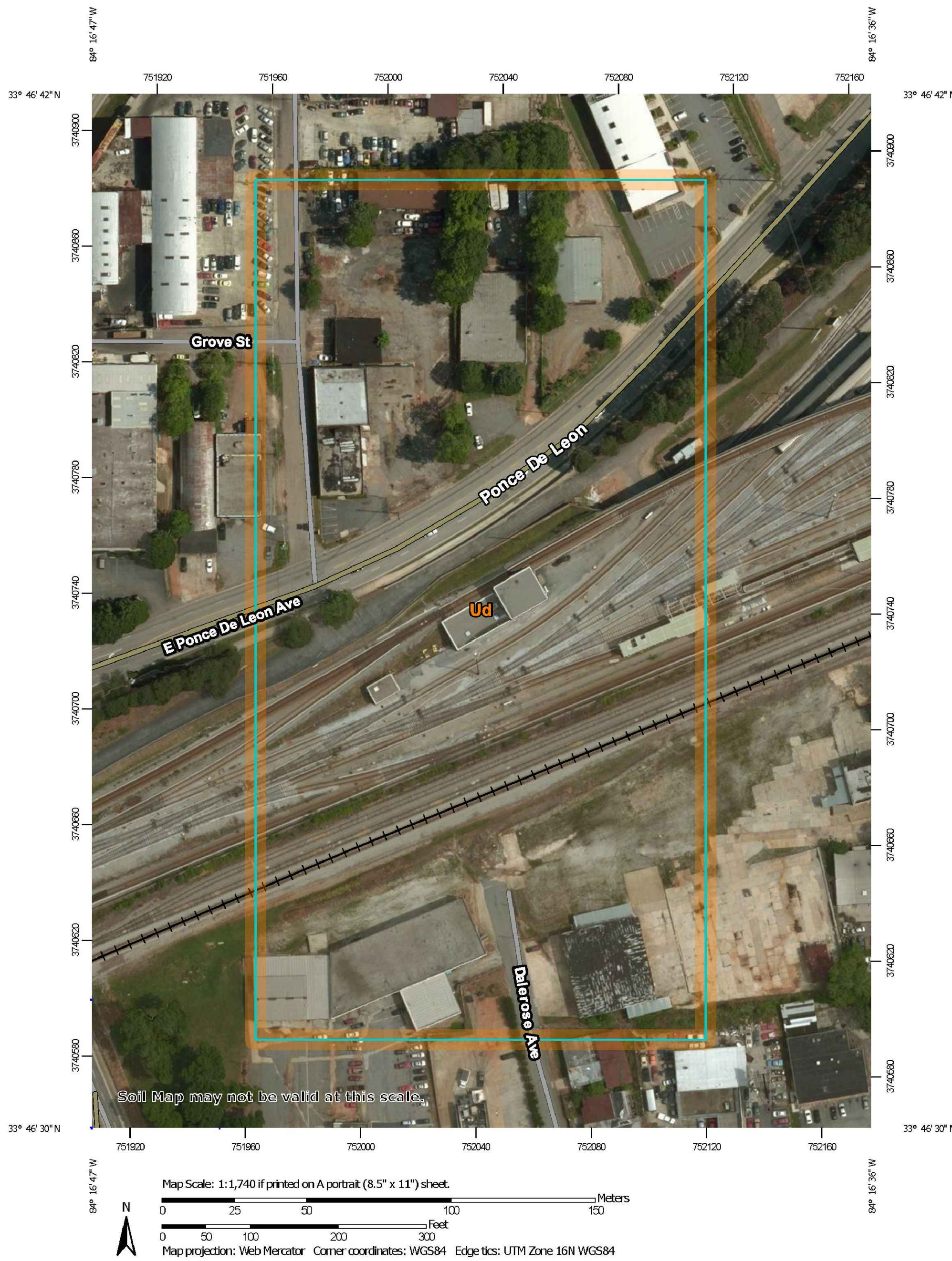
GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Prashanth Vaddu, P.E.
GEORGIA LICENSE No. PE039820

	NAME	DATE
DESIGNED BY:	KH	8/21/2018
DRAWN BY:	KH	8/21/2018
CHECKED BY:	AM	8/21/2018
SUPERVISED BY:	PV	

Project Location Map

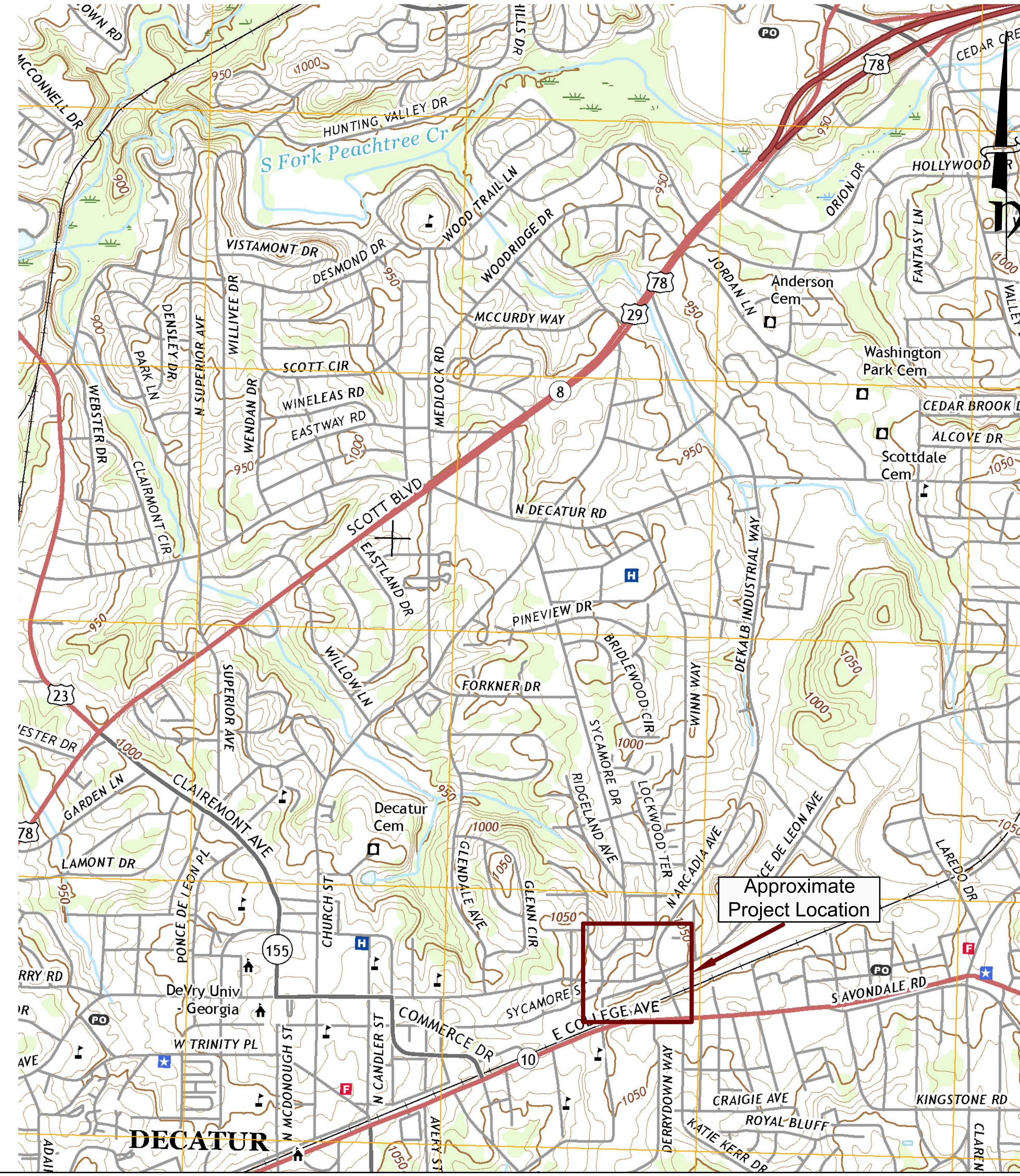
DeKalb County Scott Boulevard Phase II
Decatur, DeKalb County, Georgia

MC² PROJ. NO.	SHEET NO.
A071801.060	1



DeKalb County, GA

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ud	Urban land	11.5	100.0%
Totals for Area of Interest		11.5	100.0%



Source: United States Department of Agriculture
The survey data is Version 9 dated October 2, 2017,
with aerial images taken May 4, 2014 to June 18, 2014.

NORTHEAST ATLANTA QUADRANGLE
GEORGIA
7.5 MINUTE SERIES TOPOGRAPHIC
NGVD: 1988 - DATE: 2017
Source: United States Geological Survey

DATE	NAME	REVISION	APPROVED BY:

MC SQUARED, INC.
Geotechnical Consultants
1275 Shiloh Road NW
Suite 2620
Kennesaw, GA 30144
Ph:770-650-0873 Fax:770-650-7825

GEOTECHNICAL • ENVIRONMENTAL
MATERIALS TESTING

GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Prashanth Vaddu, P.E.
GEORGIA LICENSE No. PE039820

	NAME	DATE
DESIGNED BY:	KH	8/21/2018
DRAWN BY:	KH	8/21/2018
CHECKED BY:	AM	8/21/2018
SUPERVISED BY:	PV	

USDA Soil Survey and USGS Topographic Map

DeKalb County Scott Boulevard Phase II
Decatur, DeKalb County, Georgia

MC² PROJ. NO.	SHEET NO.
A071801.060	2

LEGEND:

Approximate SPT Boring Location

Proposed Water Main

Source: Google Earth
Image Date: 3/14/18

0′ 150′ 300′
Graphic Scale (feet)

DATE	NAME	REVISION	APPROVED BY:

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	NAME	DATE
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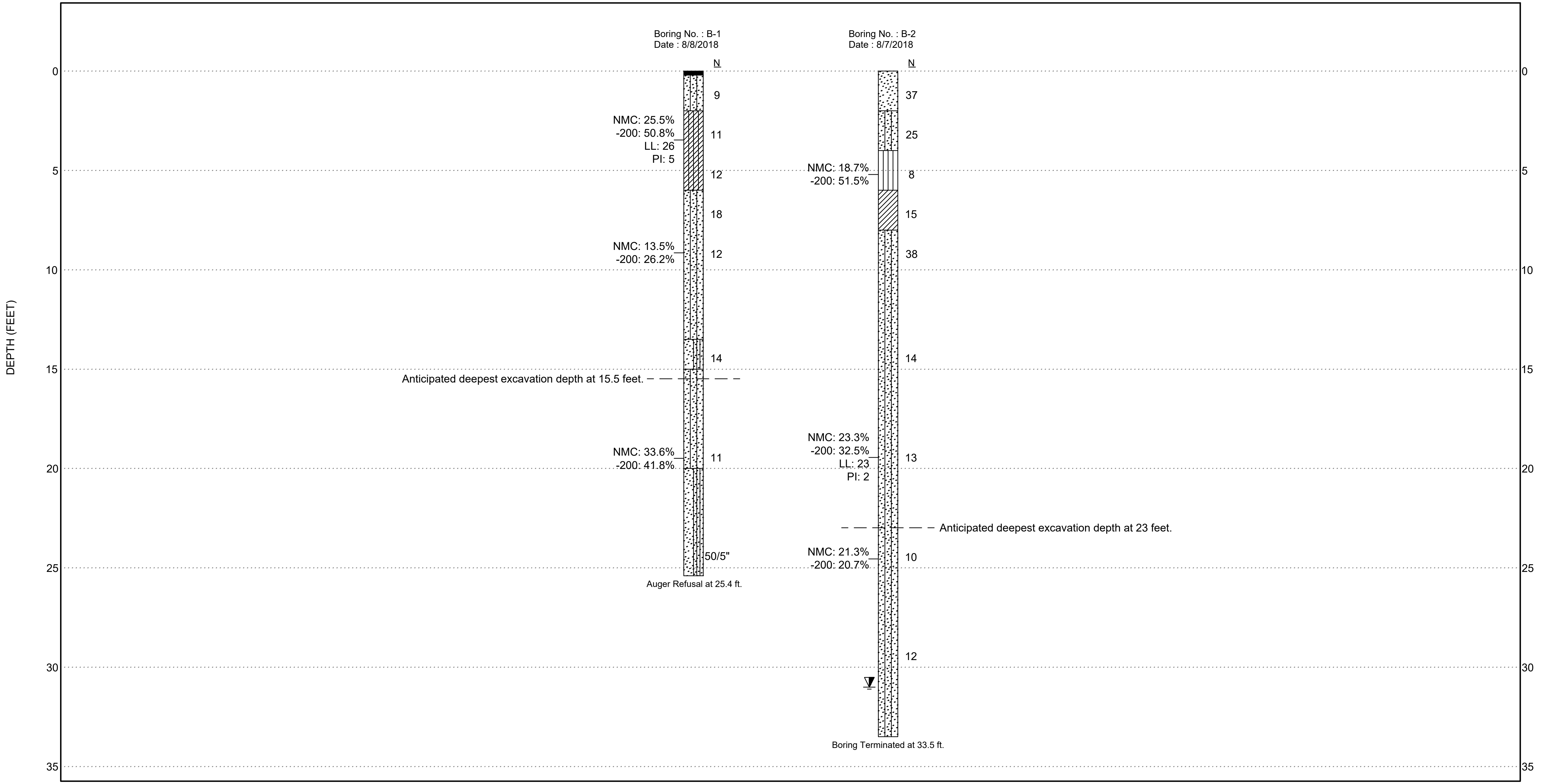
DRAWN BY:	KH	8/21/2018
CHECKED BY:	AM	8/21/2018
SUPERVISED BY:	PV	

Boring Location Map

DeKalb County Scott Boulevard Phase II
Decatur, DeKalb County, Georgia

MC² PROJ. NO.	SHEET NO.
A071801.060	3



DATE	NAME	REVISION	APPROVED BY

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GEORGIA ENGINEERING CERTIFICATE OF AUTHORIZATION No. PEF004822
Prashanth Vaddu PE
GEORGIA LICENSE No. 039820

	NAME	DATE
DESIGNED BY:	TC	8/21/2018
DRAWN BY:	KH	8/21/2018
CHECKED BY:	AM	8/21/2018
SUPERVISED BY:	PV	

SUBSURFACE BORING PROFILES	MC² PROJ. NO.	SHEET NO.
DeKalb County Scott Boulevard Phase II Decatur, DeKalb County, Georgia	A071801.060	4

LEGEND

- Top Soil
- Asphalt
- Concrete
- (GAB) Graded Aggregate Base
- Limerock Base
- No. 57 Stone
- Soil Cement
- (SP) Poorly Graded Sand
- (SP-SM) Poorly Graded Sand With Silt
- (SP-SC) Poorly Graded Sand With Clay
- (SM) Silty Sand
- (SC) Clayey Sand
- (MH) Elastic Silt
- (ML) Silt
- (CL-ML) Silty Clay
- (CH) Fat Clay
- (CL) Lean Clay
- (OH) Organic Clay
- (OL) Organic Silt
- Peat
- Fill
- Bedrock
- Limestone
- (WLS) Weathered Limestone
- (PWR) Partially Weathered Rock
- Granite
- Gneiss
- Schist

NOTES:

∇	Water Table At Time Of Drilling
∇	Water Table After 24 Hours
GNE	Groundwater Not Encountered
GNA	Groundwater Not Apparent
GNM	Groundwater Not Measured
CL	Center Line
RT	Right Of Center Line
LT	Left of Center Line
BGS	Below Ground Surface
HA	Hand Auger
PA	Power Auger
NMC	Natural Moisture Content (%)
-200	Fines Passing A No. 200 Sieve (%)
PI	Plasticity Index
NP	Non Plastic
LL	Liquid Limit
OC	Organic Content (%)
N	SPT N-Value
WOH	Weight-Of-Hammer
WOR	Weight-Of-Rod
CPT	Cone Penetrometer Test
SPT	Standard Penetration Test
DT	Dilatometer Test
LOC	Loss Of Circulation
ROC	Regain Of Circulation
REC	Rock Core Recovery(%)
RQD	Rock Quality Designation
ST	Shelby Tube Sample
q_u	Unconfined Compressive Strength From Pocket Penetrometer In tsf

GRANULAR MATERIALS- RELATIVE DENSITY	SPT (BLOWS/FT)
VERY LOOSE	≤ 4
LOOSE	5-10
MEDIUM	11-30
DENSE	31-50
VERY DENSE	GREATER THAN 50
SILTS AND CLAYS CONSISTENCY	**SPT (BLOWS/FT)**
VERY SOFT	≤ 2
SOFT	3-4
FIRM	5-8
STIFF	9-15
VERY STIFF	16-30
HARD	30-50
VERY HARD	GREATER THAN 50
SPT Spoon Inside Diameter 1 3/8" SPT Spoon Outside Diameter 2"	ASTM Standard Drop Safety Hammer Average Hammer Drop Height 30" Hammer Weight 140 lbs

DATE	NAME	REVISION	APPROVED BY:

MC²
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DESIGNED BY:	KH	8/21/2018
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SUPERVISED BY:	PV	

Legend	MC² PROJ. NO.	SHEET NO.
DeKalb County Scott Boulevard Phase II Decatur, DeKalb County, Georgia	A071801.060	5

APPENDIX

Soil Profile

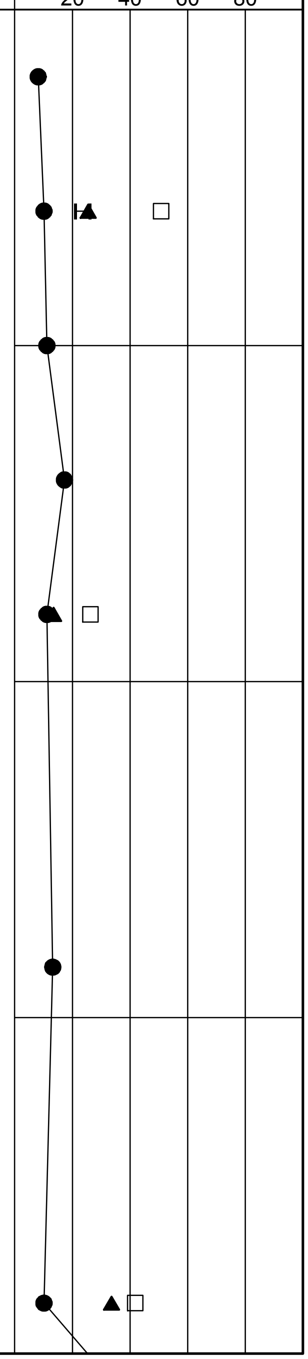
BORING ID: B-1

GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

CLIENT Atkins
PROJECT NAME DeKalb County Scott Boulevard Phase II
PROJECT NUMBER A071801.060
PROJECT LOCATION Decatur, DeKalb County, Georgia
DATE STARTED 8/8/18 **COMPLETED** 8/8/18
GROUND ELEVATION: -
HOLE SIZE 4 inches
DRILLING CONTRACTOR M&W Drilling, LLC
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING GNE
LOGGED BY A. Moussly **CHECKED BY** P. Vaddu
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
0		2 Inches of Asphalt			
	SM	Loose, brown to reddish brown, silty fine SAND with rock fragments	SS 1	5-4-5-7 (9)	
	CL-ML	Stiff, brown to reddish brown, orange brown, sandy silty CLAY with rock fragments	SS 2	4-5-6-8 (11)	
5			SS 3	3-5-7-9 (12)	
	SM	Medium dense, brown to reddish brown, silty fine SAND with rock fragments, micaceous	SS 4	6-9-9-10 (18)	
10			SS 5	5-6-6-10 (12)	
	SP-SM	Medium dense, brown to grayish brown, poorly-graded fine SAND with silt	SS 6	4-6-8 (14)	
15	SM	Medium dense, brown, black, silty fine SAND, micaceous			
		Anticipated deepest excavation depth.			
20			SS 7	4-4-7 (11)	

● SPT N VALUE ●
⊕ ORGANIC CONTENT % ⊕
PL MC LL
☐ FINES CONTENT (%) ☐
20 40 60 80



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Soil Profile

BORING ID: B-1

CLIENT Atkins
PROJECT NAME DeKalb County Scott Boulevard Phase II
PROJECT NUMBER A071801.060
PROJECT LOCATION Decatur, DeKalb County, Georgia

DEPTH (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)	● SPT N VALUE ● / ⊕ ORGANIC CONTENT % ⊕ / PL MC LL / ☐ FINES CONTENT (%) ☐ (20 40 60 80)
20		SP-SM	Very dense, grayish brown, poorly-graded SAND with silt				
25			Auger Refusal at 25.4 feet.	SS 8	5-10-50/5"		>>
			Bottom of hole at 25.4 feet.				

Soil Profile

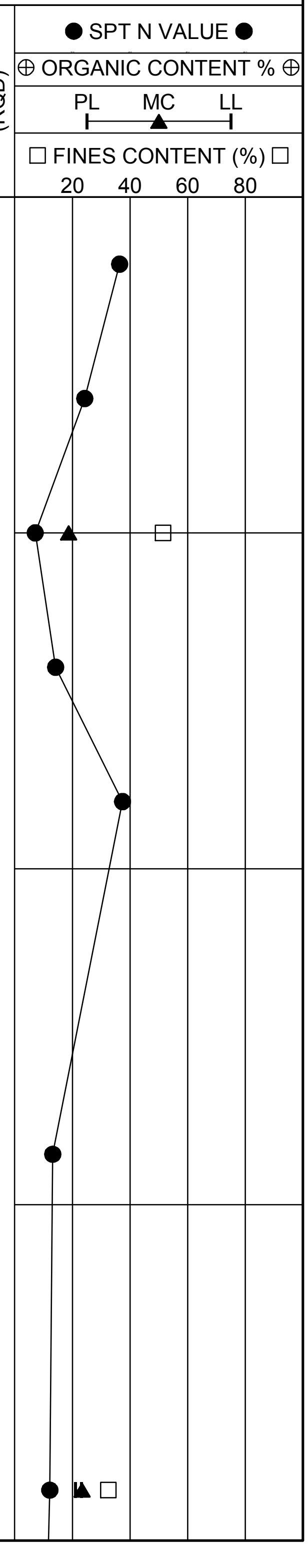
BORING ID: B-2

MC² GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

CLIENT Atkins
PROJECT NAME DeKalb County Scott Boulevard Phase II
PROJECT NUMBER A071801.060
PROJECT LOCATION Decatur, DeKalb County, Georgia
DATE STARTED 8/7/18 **COMPLETED** 8/7/18
GROUND ELEVATION: - **HOLE SIZE** 4 inches
DRILLING CONTRACTOR M&W Drilling, LLC
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING GNE
LOGGED BY A. Moussly **CHECKED BY** P. Vaddu
AT END OF DRILLING ---
NOTES
12hrs AFTER DRILLING 31.0 ft

DEPTH (ft): 0, 5, 10, 15, 20

USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)
SP	Dense, gray, poorly-graded fine SAND with rock fragments	SS 1	7-9-28-44 (37)	
SM	Medium dense, dark brown, silty fine SAND with rock fragments	SS 2	26-18-7-7 (25)	
ML	Firm, brown to reddish brown, sandy SILT	SS 3	9-4-4-4 (8)	
CL	Stiff, brown to orange brown, sandy CLAY	SS 4	4-6-9-17 (15)	
SM	Loose to dense, dark brown to orange brown, silty fine SAND, micaceous	SS 5	13-16-22-24 (38)	
		SS 6	8-7-7 (14)	
		SS 7	6-5-8 (13)	



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Soil Profile

BORING ID: B-2

MC² Geotechnical • Environmental Materials Testing

CLIENT Atkins

PROJECT NAME DeKalb County Scott Boulevard Phase II

PROJECT NUMBER A071801.060

PROJECT LOCATION Decatur, DeKalb County, Georgia

DEPTH (ft)	GRAPHIC LOG	USCS Group Symbol	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	RECOVERY % (RQD)	● SPT N VALUE ● / ⊕ ORGANIC CONTENT % ⊕ / PL MC LL / ☐ FINES CONTENT (%) ☐ (20 40 60 80)
20		SM	Loose to dense, dark brown to orange brown, silty fine SAND, micaceous				
			Anticipated deepest excavation depth.				
25				SS 8	3-4-6 (10)		
				SS 9	5-5-7 (12)		
30							
			Bottom of hole at 33.5 feet.				

SUMMARY OF LABORATORY RESULTS

MC Squared, Inc.
1275 Shiloh Road, Suite 2620
Kennesaw, GA 30144

GEOTECHNICAL • ENVIRONMENTAL MATERIALS TESTING

CLIENT Atkins

PROJECT NAME DeKalb County Scott Boulevard Phase II

PROJECT NUMBER A071801.060

PROJECT LOCATION Decatur, DeKalb County, GA

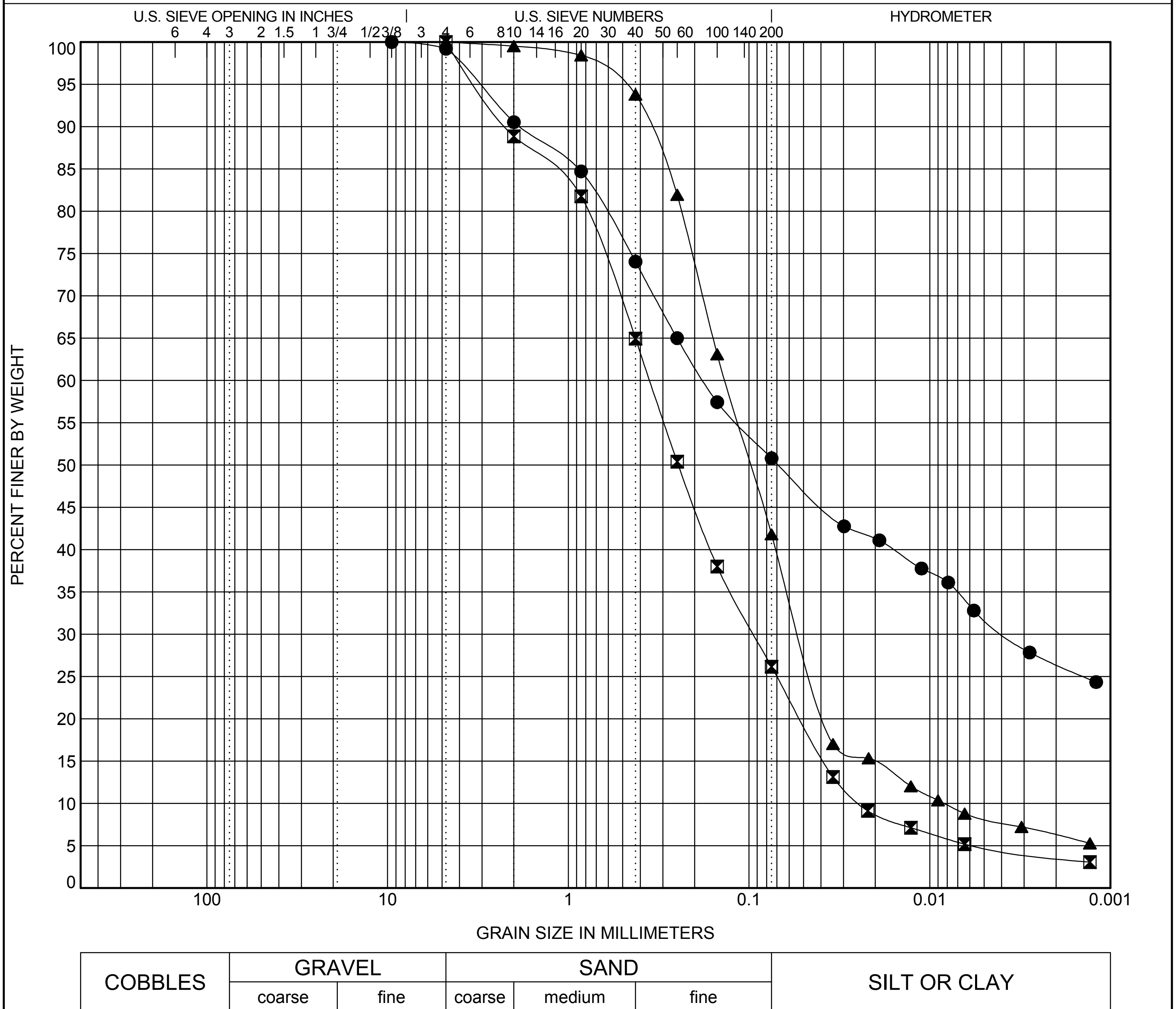
Sample No.	Soil Description	USCS Class	%< Finer Sieve 1.5"	3/4"	#10	#40	#60	#200	D75 (mm)	Clay Count %	NMC (%)	Total Volume Change %	Swell %	Shrinkage %	MDD pcf	OMC %	LL %	PL %	PI %	Erosion Index	Soil support Value
B-1 (2.0'-4.0')	Stiff, brown to reddish brown, sandy silty CLAY (CL-ML)	CL-ML	-	100	90.5	74.0	65.0	50.8	0.452	31.9	25.5	-	-	-	-	-	26	21	5	-	-
B-1 (8.0'-10.0')	Medium dense, brown to reddish brown, silty fine SAND (SM)	SM	-	100	88.8	65.0	50.4	26.2	0.643	4.8	13.5	-	-	-	-	-	NP	NP	NP	-	-
B-1 (18.5'-20.0')	Medium dense, brown, black silty fine SAND (SM)	SM	-	100	99.5	93.8	81.9	41.8	0.207	8.3	33.6	-	-	-	-	-	-	-	-	-	-
B-2 (4.0'-6.0')	Firm, brown to reddish brown, sandy SILT (ML)	ML	-	100	98.9	78.3	67.1	51.5	0.363	23.4	18.7	-	-	-	-	-	-	-	-	-	-
B-2 (18.5'-20.0')	Loose to dense, dark brown to brown, silty fine SAND (SM)	SM	-	100	92.4	66.9	54.6	32.5	0.62	10.7	23.3	-	-	-	-	-	23	21	2	-	-
B-2 (23.5'-25.0')	Loose to dense, dark brown to brown, silty fine SAND (SM)	SM	-	100	97.4	71.6	54.5	20.7	0.488	0.8	21.3	-	-	-	-	-	NP	NP	NP	-	-

GRAIN SIZE DISTRIBUTION

MC Squared, Inc.
1275 Shiloh Road,Suite 2620
Kennesaw, GA 30144

CLIENT Atkins **PROJECT NAME** DeKalb County Scott Boulevard Phase II

PROJECT NUMBER A071801.060 **PROJECT LOCATION** Decatur, DeKalb County, GA



	Specimen Identification	Classification	LL	PL	PI	Cc	Cu
●	**B-1 (2.0'-4.0')**	**Stiff, brown to reddish brown, sandy silty CLAY (CL-ML)**	**26**	**21**	**5**		
⊠	**B-1 (8.0'-10.0')**	**Medium dense, brown to reddish brown, silty fine SAND (SM)**	**NP**	**NP**	**NP**	**1.02**	**14.62**
▲	**B-1 (18.5'-20.0')**	**Medium dense, brown, black silty fine SAND (SM)**	**-**	**-**	**-**	**2.37**	**16.33**

	Specimen Identification	D100	D60	D30	D10	NMC	%Gravel	%Sand	%Silt	%Clay
●	**B-1 (2.0'-4.0')**	**9.5**	**0.178**	**0.004**		**25.5**	**0.8**	**48.4**	**18.9**	**31.9**
⊠	**B-1 (8.0'-10.0')**	**4.75**	**0.355**	**0.094**	**0.024**	**13.5**		**73.8**	**21.3**	**4.8**
▲	**B-1 (18.5'-20.0')**	**4.75**	**0.136**	**0.052**	**0.008**	**33.6**		**58.2**	**33.6**	**8.3**

Note-Sample soaked for 16 hrs (+/- 10 min)

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Kennesaw, GA 30144

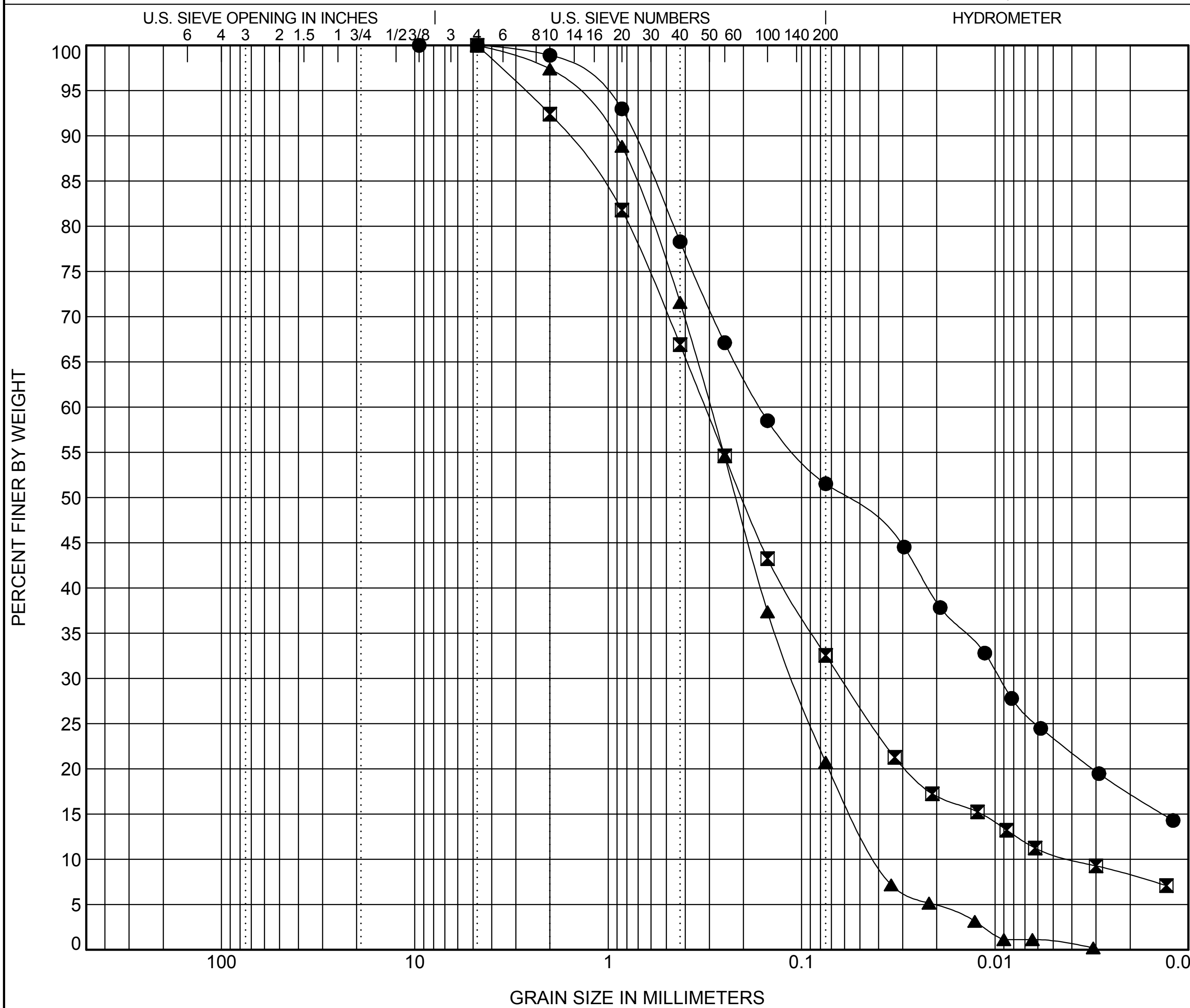
GRAIN SIZE DISTRIBUTION

CLIENT Atkins

PROJECT NAME DeKalb County Scott Boulevard Phase II

PROJECT NUMBER A071801.060

PROJECT LOCATION Decatur, DeKalb County, GA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	LL	PL	PI	Cc	Cu
●	**B-2 (4.0'-6.0')**	**Firm, brown to reddish brown, sandy SILT (ML)**	**-**	**-**	**-**		
⧗	**B-2 (18.5'-20.0')**	**Loose to dense, dark brown to brown, silty fine SAND (SM)**	**23**	**21**	**2**	**3.14**	**80.22**
▲	**B-2 (23.5'-25.0')**	**Loose to dense, dark brown to brown, silty fine SAND (SM)**	**NP**	**NP**	**NP**	**1.02**	**7.33**

	Specimen Identification	D100	D60	D30	D10	NMC	%Gravel	%Sand	%Silt	%Clay
●	**B-2 (4.0'-6.0')**	**9.5**	**0.164**	**0.009**		**18.7**	**0.0**	**48.5**	**28.1**	**23.4**
⧗	**B-2 (18.5'-20.0')**	**4.75**	**0.316**	**0.062**	**0.004**	**23.3**		**67.5**	**21.9**	**10.7**
▲	**B-2 (23.5'-25.0')**	**4.75**	**0.297**	**0.11**	**0.04**	**21.3**		**79.3**	**19.9**	**0.8**

Note-Sample soaked for 16 hrs (+/- 10 min)

TEST PROCEDURES

The general field procedures employed by **MC Squared, Inc.** (**MC^2**) are summarized in the American Society for Testing and Materials (ASTM) Standard D420 which is entitled "Investigating and Sampling Soil and Rock". This recommended practice lists recognized methods for determining soil and rock distribution and groundwater conditions. These methods include geophysical and in-situ methods as well as borings.

STANDARD DRILLING TECHNIQUES

To obtain subsurface samples, borings are drilled using one of several alternate techniques depending upon the subsurface conditions. Some of these techniques are:

In Soils:

a) Continuous hollow stem augers.
b) Rotary borings using roller cone bits or drag bits, and water or drilling mud to flush the hole.
c) "Hand" augers.

In Rock:

a) Core drilling with diamond-faced, double or triple tube core barrels.
b) Core boring with roller cone bits.

The drilling method used during this exploration is presented in the following paragraph.

<u>Hollow Stem Augering:</u> A hollow stem auger consists of a hollow steel tube with a continuous exterior spiral flange termed a flight. The auger is turned into the ground, returning the cuttings along the flights. The hollow center permits a variety of sampling and testing tools to be used without removing the auger.

<u>Core Drilling</u>: Soil drilling methods are not normally capable of penetrating through hard cemented soil, weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound, continuous rock. Material which cannot be penetrated by auger or rotary soil-drilling methods at a reasonable rate is designated as "refusal material". Core drilling procedures are required to penetrate and sample refusal materials.

Prior to coring, casing may be set in the drilled hole through the overburden soils, to keep the hole from caving and to prevent excessive water loss. The refusal materials are then cored according to ASTM D-2113 using a diamond-studded bit fastened to the end of a hollow, double or triple tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each drill run, the core barrel is brought to the surface, the core recovery is measured, and the core is placed, in sequence, in boxes for storage and transported to our laboratory.

SAMPLING AND TESTING IN BOREHOLES

Several techniques are used to obtain samples and data in soils in the field, however the most common methods in this area are:

a) Standard Penetration Testing
b) Undisturbed Sampling
c) Dynamic Cone Penetrometer Testing
d) Water Level Readings

The procedures utilized for this project are presented below.

Standard Penetration Testing: At regular intervals, the drilling tools are removed and soil samples obtained with a standard 2-inch diameter split tube sampler connected to an A or N-size rod. The sampler is first seated 6 inches to penetrate any loose cuttings, then driven an additional 12 inches with blows of a 140-pound safety hammer falling 30 inches. Generally, the number of hammer blows required to drive the sampler the final 12 inches is designated the "penetration resistance" or "N" value, in blows per foot (bpf). The split barrel sampler is designed to retain the soil penetrated, so that it may be returned to the surface for observation. Representative portions of the soil samples obtained from each split barrel sample are placed in jars, sealed and transported to our laboratory.

The standard penetration test, when properly evaluated, provides an indication of the soil strength and compressibility. The tests are conducted according to ASTM Standard D698 / D1586. The depths and N-values of standard penetration tests are shown on the Boring Logs. Split barrel samples are suitable for visual observation and classification tests but are not sufficiently intact for quantitative laboratory testing.

Water Level Readings: Water level readings are normally taken in the borings and are recorded on the Boring Records. In sandy soils, these readings indicate the approximate location of the hydrostatic water level at the time of our field exploration. In clayey soils, the rate of water seepage into the borings is low and it is generally not possible to establish the location of the hydrostatic water level through short-term water level readings. Also, fluctuation in the water level should be expected with variations in precipitation, surface run-off, evaporation, and other factors. For long-term monitoring of water levels, it is necessary to install piezometers.

The water levels reported on the Boring Logs are determined by field crews immediately after the drilling tools are removed, and several hours after the borings are completed, if possible. The time lag is intended to permit stabilization of the groundwater level that may have been disrupted by the drilling operation.

Occasionally the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the cave-in zone.

BORING LOGS

The subsurface conditions encountered during drilling are reported on a field boring log prepared by the Driller. The log contains information concerning the boring method, samples attempted and recovered, indications of the presence of coarse gravel, cobbles, etc., and observations of groundwater. It also contains the driller's interpretation of the soil conditions between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are kept on file in our office.

After the drilling is completed a geotechnical professional classifies the soil samples and prepares the final Boring Logs, which are the basis for our evaluations and recommendations.

SOIL CLASSIFICATION

Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply his past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our Boring Logs.

The classification system discussed above is primarily qualitative and for detailed soil classification two geotechnical laboratory tests are necessary; grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D-2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties are presented in this report.

The following table presents criteria that are typically utilized in the classification and description of soil and rock samples for preparation of the Boring Logs.

Relative Density of Cohesionless Soils From Standard Penetration Test		**Consistency of Cohesive Soils**	
Very Loose	≤ 4 bpf	Very Soft	≤ 2 bpf
Loose	5 - 10 bpf	Soft	3 - 4 bpf
Medium Dense	11 - 30 bpf	Firm	5 - 8 bpf
Dense	31 - 50 bpf	Stiff	9 - 15 bpf
Very Dense	> 50 bpf	Very Stiff	16 - 30 bpf
		Hard	31 – 50 bpf
(bpf = blows per foot, ASTM D 1586)		Very Hard	> 50 bpf

Relative Hardness of Rock		**Particle Size Identification**	
Very Soft	disintegrates or easily compresses to touch; can be hard to very hard soil.	Boulders	Larger than 12"
		Cobbles	3" - 12"
Soft	May be broken with fingers.	Gravel	
		Coarse	3/4" - 3"
Moderately Soft	May be scratched with a nail, corners and edges may be broken with fingers.	Fine	4.76mm - 3/4"
		Sand	
		Coarse	2.0 - 4.76 mm
Moderately Hard	Light blow of hammer required to break samples.	Medium	0.42 - 2.00 mm
		Fine	0.42 - 0.074 mm
Hard	Hard blow of hammer required to break sample.	Fines (Silt or Clay)	Smaller than 0.074 mm

Rock Continuity

$$\textbf{RECOVERY} = \frac{\text{Total Length of Core}}{\text{Length of Core Run}} \times 100\ \%$$

Description	Core Recovery %
Incompetent	Less than 40
Competent	40 - 70
Fairly Continuous	71 - 90
Continuous	91 - 100

Relative Quality of Rocks

$$\textbf{RQD} = \frac{\text{Cumulative length of all pieces} \geq 4"}{\text{Length of Core Run}} \times 100\ \%$$

Description	RQD %
Very Poor	0 - 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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