Geotechnical Engineering Report

Lee's Summit Medical Office Building
2100 Southeast Blue Parkway
Lee's Summit, Missouri

June 9, 2017
Terracon Project No. 02175168

Prepared for:
Hereford Dooley Architects
Nashville, Tennessee

Prepared by:
Terracon Consultants, Inc.
Lenexa, Kansas

June 9, 2017

Hereford Dooley Architects
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Attn: Mr. Trip Hereford, AIA
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Re: Geotechnical Engineering Report
Lee's Summit Medical Office Building
2100 Southeast Blue Parkway
Lee's Summit, Missouri
Terracon Project No. 02175168

Dear Mr. Hereford:

Terracon Consultants, Inc. (Terracon) has completed a geotechnical exploration for the proposed Medical Office Building at the Lee's Summit Medical Center in Lee's Summit, Missouri. These services were performed in general accordance with the Terracon proposal and agreement for services number P02175168 dated May 15, 2017. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, below grade walls, and pavements for the project.

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

Sincerely,
Terracon Consultants, Inc.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Sixteen (16) borings were performed for the proposed Medical Office Building (MOB) at Lee's Summit Medical Center in Lee's Summit, Missouri. Samples recovered from the borings were tested and logs of borings with test data are appended to this geotechnical engineering report. Professional opinions and recommendations presented in this report are summarized below.

- In general, the borings encountered medium stiff to very stiff fat clays over interbedded shale and limestone bedrock. Bedrock was encountered about depths of about 3 to 10 feet below the existing ground surface, corresponding to approximate elevations ranging from 991 to 998½ feet.

- Based on the subsurface conditions and the anticipated foundation loads, it appears feasible to support the building on drilled shaft foundations that derive their capacity from side friction and end bearing in moderately to slightly weathered limestone/shale bedrock.

- The fat clay soils encountered at this site have the potential to shrink and swell with seasonal fluctuations in the soil moisture content. To help reduce the potential for subgrade volume change, we recommend floor slabs be supported on a 24-inch layer of low volume change (LVC) material. On-site soils may need to be undercut to accommodate placement of the LVC material.

- Existing fill materials (consisting of fat clay with limestone fragments) were encountered at four of the borings to depths ranging from 2 to 5 feet. It appears that some compactive effort was applied to the fill material within the proposed building footprint. However, these materials should be evaluated and tested during construction and either approved by a representative from Terracon or removed and replaced with engineered fill.

The professional opinions and recommendations presented in this report are based on evaluation of data developed by testing discrete samples obtained from widely spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. We recommend Terracon be retained to observe excavations and perform tests during the site preparation, earthwork, and foundation construction phases of the project.

This executive summary should not be separated from or used apart from this report. This report presents recommendations and opinions based on our understanding of the project at the time the report was prepared. The report limitations are described in **Section 5.0**.

GEOTECHNICAL ENGINEERING REPORT
LEE'S SUMMIT MEDICAL OFFICE BUILDING
2100 SOUTHEAST BLUE PARKWAY
LEE'S SUMMIT, MISSOURI

Terracon Project No. 02175168
June 9, 2017

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) has completed a geotechnical exploration for the planned Medical Office Building at Lee's Summit Medical Center in Lee's Summit, Missouri. Sixteen borings were performed at the site to depths ranging from approximately 7 to 17 feet below the existing ground surface. Boring logs and an Exploration Plan are included in Appendix A. This report describes the subsurface conditions encountered at the boring locations, presents the test data, and provides geotechnical engineering recommendations regarding the following items:

- earthwork
- drilled shaft foundations
- seismic site class
- floor slabs
- below grade walls
- pavements

2.0 PROJECT INFORMATION

This section of the report reflects our understanding of the project based on information provided by the client. If our understanding of the project information is incorrect, please contact us so we can review the recommendations presented herein.

2.1 Site Location and Description

Item	Description
Location	Lee's Summit Medical Center 2100 Southeast Blue Parkway Lee's Summit, Missouri
Existing improvements	The site is currently occupied by an asphalt-paved parking lot with lawn and landscaping surrounding the parking lot.
Existing topography	The site is relatively flat.

2.2 Project Description

Item	Description
Structure	The project consists of a new three-story, 13,280 square foot medical office building with a canopy and new parking and drive areas.
Building construction	The building will be steel framed with exterior LMV walls and a grade-supported concrete floor slab.
Maximum loads	In preparing this report, we have considered the following maximum loads: Columns: 600 kips (provided) Walls: 10 kips per lineal foot (klf) (assumed) Slabs: 125 pounds per square foot (psf) (assumed)
Grading	A site grading plan was not provided. We considered cuts and fills of up to 5 feet will be required to develop final design grades.
Below grade areas	Elevator pits are anticipated. No basements or retaining walls are planned.
Pavements	Both concrete and asphalt pavements will be utilized in the new parking and drive areas.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Conditions encountered at each boring location are indicated on the boring logs in Appendix A and are summarized in the following table. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in situ, the transition between materials may be gradual.

Stratum	Approximate Depth of Bottom of Stratum	Material Description	Comments
1a	10 to 12 inches [1]	Asphalt over Aggregate Base	5 to 6 inches of asphalt over 5 to 6 inches of aggregate base
1b	6 to 12 inches [2]	Root Zone	--
2	2 to 5 feet [3]	Fill	Fat clay with limestone fragments
3	3 to 10 feet Undetermined [4]	Fat Clay (CH)	Dark brown to red brown, stiff to very stiff
4	Undetermined [5]	Limestone/Shale Bedrock	Light brown to gray, completely to slightly weathered

1. Borings B-1, B-2, B-3, B-4, B-5, B-7 and B-8 encountered Stratum 1a at the surface.
2. Borings B-6, B-9, B-10, B-11, B-12, B-13, B-14, B-15 and B-16 encountered Stratum 1b at the surface.
3. Borings B-1, B-3, B-4 and B-12 encountered Stratum 2.
4. Borings B-9 and B-10 were terminated at a planned depth of 10 feet in Stratum 3.
5. All borings except B-9 and B-10 were terminated within Stratum 4 at a planned depth of 10 feet or auger refusal.

3.2 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was observed at boreholes B-10, B-11 and B-12 at the time of our subsurface exploration at depths ranging from 8½ to 10 feet. Long-term observations in piezometers or observation wells, sealed from the influence of surface water, would be needed to develop groundwater information. Groundwater level fluctuations occur due to variations in rainfall, runoff and other factors not evident at the time we performed the borings. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. Based on the conditions encountered the boring locations, groundwater should be expected near the soil/bedrock interface. The shale/limestone bedrock may be water-bearing, and water inflow will likely be encountered in drilled shaft excavations that penetrate into bedrock.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on anticipated foundation loads and subsurface conditions at the site, drilled shaft foundations bearing in the limestone/shale bedrock are recommended to support the new medical office building.

Existing fill materials (consisting of fat clay with limestone fragments) were encountered at four of the borings to depths ranging from 2 to 5 feet. It appears that some compactive effort was applied to the fill material within the proposed building footprint. However, these materials should be evaluated and tested during construction and either approved by a representative from Terracon or removed and replaced with engineered fill as outlined in Section **4.2**.

The fat clay soils encountered at this site have has the potential to shrink and swell with seasonal fluctuations in the soil moisture content. We recommend floor slabs be supported on at least 24 inches of low volume change (LVC) material, such as well-graded crushed stone aggregate or low plasticity clay. In areas where grades (following stripping of organic soils) will be less than 2 feet below the planned bottom of floor slab level, native fat clay soils should be undercut to accommodate placement of LVC material. In areas where the exposed grade (following stripping of organic soils) will be more than 2 feet below the bottom-of-floor-slab level, at least the upper 24 inches of new engineered fill should consist of LVC material. Placement of a layer of LVC material below the floor slab, as recommended in this report, will not eliminate all future subgrade volume change and resultant floor slab movements. However, use of an LVC zone should reduce the potential for subgrade volume change. Details regarding the LVC zone are provided in sections **4.2.2** and **4.5**.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and at least minor cracking in the structure could still occur. The severity of cracking and other cosmetic damage caused by movement of the floor slab, pavements, and sidewalks will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

4.2 Earthwork

Earthwork on this project should be observed and evaluated by Terracon. The following sections provide recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fill for the project.

4.2.1 Site Preparation

Existing pavements and sidewalks should be demolished and removed from the construction area. Vegetation, topsoil, and any loose, soft, or otherwise unsuitable materials should also be stripped from planned construction areas. Based on information obtained at the boring locations, stripping depths on the order of 6 to 12 inches should be anticipated to remove the root zone materials. However, stripping depths may be different in areas not explored by the borings. Organic soils removed during site preparation should not be used as fill beneath the planned new buildings or pavement areas.

Following removal of pavements, stripping of organic soils, and removal of any other unsuitable materials, the soil within the proposed building areas should be further undercut (where necessary) to accommodate placement of the recommended 24-inch thick LVC layer below floor slabs. The undercut area should extend a minimum of 5 feet laterally outside of the building wall lines. Undercutting to facilitate placement of the LVC layer would not be necessary in areas where grades, following stripping of organic soils and removal of unsuitable materials, are more than 2 feet below the planned bottom of floor slab level.

After initial stripping and any necessary undercutting, the exposed soils should be proofrolled. A Terracon representative should observe the proofrolling. Proofrolling can be accomplished using a loaded tandem-axle dump truck with a gross weight of at least 20 tons, or similarly loaded equipment. Areas that rut, pump, or deflect during the proofrolling should be improved by scarification/compaction or by removal and replacement with engineered fill.

4.2.2 Fill Materials

All materials incorporated in engineered fill sections must be free of organic matter and debris. Fill materials should not be frozen and should not be placed on a frozen subgrade. A sample of each material type should be tested prior to being used on the site. Soil is commonly used as fill in this locale, but not all soils are suitable. Our professional opinions concerning suitability of fill materials are presented in the following table.

Suitability as Fill	Description	Unified Soil Classification	
		Group Symbol	**Group Name**
Suitable	Clean Gravel	GW	Well-graded gravel
		GP	Poorly graded gravel
	Gravel with fines	GM	Silty gravel
		GC	Clayey gravel
	Clean sand	SW	Well-graded sand
		SP	Poorly-graded sand
	Sand with fines	SM	Silty sand
		SC	Clayey sand
	Description	**Group Symbol**	**Group Name**
Marginally Suitable[1]	Silt	ML	Silt[2]
	Clay	CL	Lean clay[3]
	Clay	CH	Fat clay[4]
	Description	**Group Symbol**	**Group Name**
Unsuitable	Highly organic soils	MH	Elastic silt
		OL & OH	Organic clay & organic silt
		PT	Peat

1. Depends on location and intended use. Can be used if approved by geotechnical engineer.
2. Highly susceptible to frost action; unstable when wet. Should not be used directly below pavements and exterior slabs without prior approval of geotechnical engineer.
3. Can be expansive if dry or if liquid limit is 45 or greater. Requires approval of geotechnical engineer.
4. Expansive. Not recommended immediately below floors and other movement-sensitive features. Must be placed with strict moisture and density control to reduce swell potential.

Low volume change (LVC) material placed below the building floor slabs can consist of well-graded crushed stone aggregate (GM), such as Missouri Department of Transportation (MoDOT) Type 5 aggregate. Lean clay (CL) soils could also be used as LVC material provided they have a liquid limit less than 45 and a plasticity index less than 23. The on-site soils do not meet the LVC criteria, so LVC materials will need to be imported from off-site. If a granular leveling course (such as clean crushed stone aggregate) is used immediately below the floor slab, this material can be considered part of the 24-inch thick LVC zone.

4.2.3 Fill Compaction Requirements

Item		Description
Lift Thickness (maximum)		9 inches in loose thickness when large, self-propelled compaction equipment is used. 4 inches when small, hand-guided equipment (plate or "jumping jack" compactor) is used.
Minimum Compaction Requirements [1]		At least 95 percent of the material's maximum dry density [1]
Moisture Content of Clay Soil	LL<45	-2 to +2 percent of optimum moisture content value [1]
	LL>45	0 to 4 percent above the optimum moisture content value [1]
Moisture Content of Granular Material		Sufficient to achieve compaction without pumping when proofrolled
1. As determined by the standard Proctor test (ASTM D698)		

We recommend that engineered fill be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

4.2.4 Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of clay fill to reduce the infiltration and conveyance of surface water through the trench backfill.

Utility trenches are common sources of water infiltration and migration. All utility trenches that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective "trench plug" that extends at least 5 feet out from the face of the building exterior. The plug material should consist of clay compacted at a water contact at or above the soil's optimum water content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this memorandum.

4.2.5 Grading and Drainage

Grades should be developed to direct surface water flow away from or around the site during construction. Exposed subgrades should be sloped to provide positive drainage so that saturation of subgrades is avoided. Surface water that accumulates on the site should be promptly removed. Final surrounding grades should promote rapid surface drainage away from structures and pavements. Accumulation of water adjacent to the building could contribute to significant moisture increases in the subgrade soils and subsequent softening/settlement or expansion/heave. Roof drains should discharge into a storm sewer or at least 10 feet away from the building.

4.2.6 Earthwork Construction Considerations

Care should be taken to avoid disturbance of prepared subgrades. Unstable subgrade conditions can develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. If unstable subgrade conditions develop, stabilization measures will need to be employed. Construction traffic over the completed subgrade should be avoided to the extent practical. If the subgrade becomes frozen, desiccated, saturated, or disturbed, the affected materials should be removed or these materials should be scarified, moisture conditioned, and compacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the owner, contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties. Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation, placement and compaction of controlled compacted fills, backfilling of excavations into completed subgrades, and just prior to construction of the building floor slab.

4.3 Drilled Shaft Foundations

Based on the anticipated foundation loads and the subsurface conditions encountered at the boring locations, we recommend the building be supported on drilled shaft foundations that derive their capacity from end bearing and side friction in moderately to slightly weathered limestone/shale bedrock. Design recommendations and construction considerations for drilled shaft foundations are presented in the following sections.

4.3.1 Drilled Shaft Design Recommendations

Parameter	Value
Allowable side friction in highly to slightly weathered shale/limestone bedrock	5 ksf [1]
Allowable end bearing in moderately to slightly weathered limestone bedrock	100 ksf [1]
Minimum shaft diameter	30 inches
Minimum penetration into moderately to slightly weathered bedrock ("rock socket" length)	2 shaft diameters [2]
Estimated total settlement	½ inch or less [3]
Estimated differential settlement	½ inch or less [3]

1. The top of the moderately to slightly weathered limestone bedrock ranged from approximately elevation 986 feet (at boring B-1) to 993 feet (at boring B-8). The structural engineer should refer to the appended boring logs and exploration plan to evaluate the required shaft tip elevations based on the structural loading, shaft diameter, and embedment depth.
2. The actual required penetration depth into the limestone bedrock will be dictated by the required axial capacity and/or the required lateral capacity.
3. Does not include elastic compression of drilled shaft under axial load.

Recommended soil parameters for analyzing lateral deflection of drilled shaft foundations under design loading conditions using the computer program LPILE are provided in the following table. LPILE analyzes pile deflection as a function of the design loads and subsurface soil conditions.

Soil Description (elevation in feet)	LPILE p-y Curve Model	Effective Unit Weight γ (pcf)	Undrained Shear Strength, s_u - clay Uniaxial Compressive Strength, q_u - rock	Strain Factor ε_{50} – clay k_{rm} - rock
Fat Clay and completely to highly weathered limestone/shale bedrock (from 3 feet below top of shaft elevation to 986 to 993 feet [1 2])	3- Stiff clay w/o free water	120	1,000 psf	0.007
Moderately to slightly weathered limestone/shale bedrock (below 986 to 993 feet [1])	8- Weak rock (Reese)	140	2,000 psi [3]	0.0005

1. The top of the moderately to slightly weathered limestone bedrock ranged from approximately elevation 986 feet (at boring B-1) to 993 feet (at boring B-8). The structural engineer should refer to the appended boring logs and exploration plan to evaluate the required shaft tip elevations based on the structural loading, shaft diameter, and embedment depth.
2. Ignore the lateral capacity of the top 3 feet of the drilled shaft.
3. For the Weak Rock model in LPile, uniaxial compressive strength (provided here) is input instead of undrained shear strength.

If center to center spacing between drilled shafts will be less than 8 diameters in the direction of loading, appropriate reduction factors should be applied to these parameters. If closely-spaced shafts are planned, Terracon should be retained to review the proposed foundation configuration and provide appropriate reduction factors.

The structural capacity of the drilled shafts should be analyzed using the combined stresses induced by axial and lateral forces. The response of drilled shafts to lateral loads is dependent upon the soil/structure interaction as well as the actual cross section, length, stiffness, and "fixity" (fixed or free head condition) of the shafts.

4.3.2 Drilled Shaft Construction Considerations

A Terracon representative should observe each drilled shaft excavation to verify that conditions in the excavation are consistent with those encountered in the test borings. If unsuitable materials are encountered, it may be necessary to deepen the shaft excavation.

The contractor is responsible for determining the means and methods for effectively performing the shaft excavations. In our opinion, use of a rock auger will likely be required to penetrate into the limestone bedrock and develop the required rock socket for each drilled shaft. We recommend the contractor have at least two types of rock augers (e.g., a spade-tooth bit and bullet-tooth bit) available on-site for each planned shaft diameter.

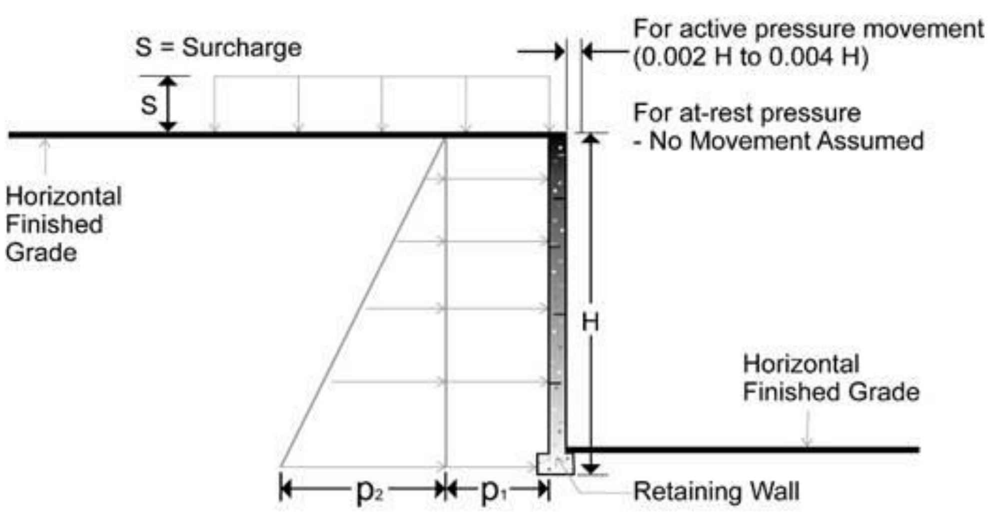
We do not expect that personnel will enter the excavation to clean or observe the bearing materials; however, temporary steel casing must be installed if personnel will enter the shaft excavation. While removing temporary casing from a shaft excavation during concrete placement, the concrete inside the casing should be maintained at a sufficient level to prevent soil intrusion into the shaft excavation and resist any earth pressures outside the casing during the entire casing removal procedure.

The limestone layer may be water-bearing, and water inflow should be expected when drilled shaft excavations penetrate into the limestone. It may not be practical to dewater the excavations; therefore, the contractor should be prepared to place concrete using a tremie or concrete pump. If more than 6 inches of water is present in the base of an excavation, free-fall placement of concrete should not be allowed. To facilitate construction, reinforcing steel should be ready and on site, and concrete should be available within a very short period of time for placement after the excavation is completed. If shaft excavations must remain open for an extended time, the shaft conditions should be re-evaluated immediately prior to placing concrete. The concrete mixture for drilled shafts be designed to have a slump in the range of 6 to 8 inches.

4.4 Below Grade Walls

4.4.1 Lateral Earth Pressures

Walls with unbalanced backfill levels on opposite sides (e.g., elevator pits) should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Lateral Earth Pressure Parameters

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Unit Weight (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a)	Granular - 0.3 Clay - 0.42	40 50	(0.3)S (0.42)S	(40)H (50)H
At-Rest (K_o)	Granular - 0.47 Clay - 0.59	60 70	(0.47)S (0.59)S	(60)H (70)H
Passive (K_p)	Granular - 3.25 Clay - 2.4	420 300	--- ---	--- ---

<u>Applicable conditions to the above include:</u>

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- Clay soil backfill: unit weight = 125 pcf (maximum), and ϕ = 24 degrees (minimum)
- Granular material backfill: unit weight = 130 pcf (maximum), and ϕ = 32 degrees (minimum)
- Horizontal backfill, compacted as recommended in the report
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No loading from nearby footing or slabs
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

To reduce the potential for hydrostatic loading on elevator pit walls and retaining walls, we recommend that drains be installed along the base of the walls. Drain lines should be surrounded by free-draining granular material encapsulated with an approved geotextile filter fabric. The granular material should extend from the drainage pipes to within 2 feet of final grade for retaining walls and be capped with a cohesive fill material placed and compacted as recommended in Section **4.2** of this report. The granular backfill around elevator pit walls should extend to the granular levelling course below the surrounding floor slab. As an alternative to filter graded gravel, free-draining 1-inch nominal size gravel could be used for the drains if the entire system, including the gravel, is encapsulated with an appropriate geotextile filter fabric.

The drainage pipes should be sloped to provide positive gravity drainage to a down gradient storm sewer or to another suitable frost-free outlet that will allow gravity drainage. Periodic maintenance of drainage systems is necessary so that they do not become plugged and inoperative.

A prefabricated drainage structure placed against retaining walls may also be used as an alternative to free-draining granular fill above the pipe. A prefabricated drainage structure consists of a plastic drainage core or mesh that is covered with filter fabric to prevent soil intrusion. The drainage structure is fastened to the wall after the wall has been waterproofed and prior to placing backfill.

4.5 Floor Slab

4.5.1 Floor Slab Design Recommendations

Item	Description
Floor slab support [1,]	24 inches (minimum) of low volume change (LVC) materials over native soils or engineered fill soils
Modulus of subgrade reaction	100 pounds per square inch per inch of deflection (psi/in or pci) for point loading conditions
Granular leveling course layer thickness [2, 3]	4 inches (minimum)
Capillary break layer thickness [3, 4]	6 inches (minimum)

1. LVC materials must meet the criteria discussed in Section **4.2.2**.
2. If the purpose of this layer is solely to create a level base for concrete placement to maintain a more uniform slab thickness, well graded sand, gravel or crushed stone can be used.
3. These granular materials may be considered part of the LVC zone.
4. If penetration of moisture vapor through the slab is a concern, the floor slab design should include a capillary break layer instead of the granular leveling course layer described above. Capillary break layers should be comprised of granular materials that have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant addition design considerations.

Joints should be constructed in slabs at regular intervals as recommended by the American Concrete Institute (ACI) to help control the location of cracks. It should be understood that differential settlement between the floor slab and foundations could occur.

Typically, some increase in the floor slab subgrade moisture content will occur because of gradual accumulation of capillary moisture, which would otherwise evaporate if the floor slab had not been constructed. The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.5.2 Floor Slab Construction Considerations

If the LVC layer is comprised of low-plasticity clay soils, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slab. If the subgrade becomes desiccated prior to construction of the floor slab, the affected materials should be removed or the materials should be scarified, moistened, and compacted.

On most project sites, site grading is generally accomplished early in the construction phase. However, as construction proceeds, subgrades may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, the floor slab subgrade soils may not be suitable for placement of granular leveling course material and/or concrete at the time of building construction, and corrective action may be required.

Terracon should review the condition of the floor slab subgrade immediately prior to placement of the granular leveling course and construction of the floor slab. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas containing backfilled trenches. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly moisture conditioned and compacted fill placed according to the recommendations in this report.

4.6 Pavements

Pavement subgrades are expected to consist of on-site native clay soils and/or engineered fill (depending on final grades). Recommendations included in Section **4.2** should be followed to develop the pavement area subgrade.

4.6.1 Pavement Subgrade Preparation

Grading and paving operations are commonly performed by separate contractors and there is often a time lapse between the end of grading operations and the commencement of paving. Subgrades prepared early in the construction process may become disturbed by construction traffic. Non-uniform subgrades often result in poor pavement performance and local failures relatively soon after pavements are constructed. Depending on the paving equipment used by the contractor, measures may be required to improve subgrade strength to greater depths for support of heavily loaded concrete/asphalt trucks.

We recommend the moisture content and density of the subgrade be evaluated and the pavement subgrades be proofrolled (using a loaded tandem-axle dump truck with a minimum gross weight of 20 tons or similarly loaded rubber-tire equipment) within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be scarified, moisture conditioned, and compacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. The subgrade should be in its finished form at the time of the final review.

4.6.2 Opinions of Minimum Pavement Thickness

Pavement thickness depends upon many factors including, but not limited to:

- applied wheel/axle loads and number of repetitions,
- subgrade and pavement material characteristics,
- climate conditions, and
- site and pavement drainage.

Specific information regarding anticipated vehicle types, axle loads and traffic volumes was not provided at the time of this report. The "Parking Lots" pavement section considers 4-tire, 2-axle personal vehicle traffic only (cars, vans, pickups and SUVs). The "Drives" pavement section considers personal vehicle traffic and a maximum of ten delivery trucks/trash collection trucks per week. Our recommendations for full depth asphaltic cement concrete (ACC) pavement, ACC pavement over aggregate base, and Portland cement concrete (PCC) pavement sections are outlined in the following table.

Pavement Type	Parking Lots	Drives
Full depth ACC	2 inches ACC surface 4 inches ACC base	2 inches ACC surface 6 inches ACC base
ACC over aggregate base	2 inches ACC surface 2 inches ACC base 6 inches aggregate base (MoDOT Type 5 or similar)	2 inches ACC surface 4 inches ACC base 6 inches aggregate base (MoDOT Type 5 or similar)
PCC	5 inches PCC 4 inches open graded rock (ASTM C 33 Size No. 57 aggregate or similar)	6 inches PCC 4 inches open graded rock (ASTM C 33 Size No. 57 aggregate or similar)

1. For trash container pads, we recommend a PCC pavement section be used consisting of 7 inches (minimum) of PCC over 4 inches (minimum) of open graded rock (ASTM C 33 Size No. 57 aggregate or similar) on a compacted soil subgrade. The trash container pad should be large enough to support the container and the tipping axle of the collection truck.

PCC pavements will perform better than ACC in areas where short-radii turning and braking are expected (i.e., entrance/exit aprons) due to better resistance to rutting and shoving. In addition, PCC pavement will perform better in areas subject to heavy static loads.

Construction traffic on the pavements was not considered in developing our opinions of minimum pavement thickness. If the pavements will be subject to construction equipment/vehicles, the pavement sections should be revised to consider the additional loading.

Pavements and subgrades will be subject to freeze-thaw cycles and seasonal fluctuations in moisture content. The pavement sections provided in the tables above were developed based on local soil and climate conditions.

4.6.3 Pavement Drainage and Maintenance

The pavement sections provided above consider that the subgrade soils will not experience significant increases in moisture content. Paved areas should be sloped to provide rapid drainage of surface water and to drain water away from the pavement edges. Pavements should be designed so water does not accumulate on or adjacent to the pavement, since this could saturate and soften the subgrade soils and subsequently accelerate pavement deterioration.

Periodic maintenance of the pavements will be required. Cracks should be sealed, and areas exhibiting distress should be repaired promptly to help prevent further deterioration. Even with periodic maintenance, some movement and related cracking may still occur and repairs may be required.

4.7 Seismic Considerations

Code	Site Classification
2012 International Building Code (IBC)	C [1]

1. The 2012 International Building Code (IBC) seismic site class definitions are based on average properties of the subsurface profile to a depth of 100 feet. The exploratory borings extended to bedrock at a maximum depth of approximately 17 feet. Our opinion of site classification is based on boring data and our knowledge of local geological and geotechnical conditions.

5.0 GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from the site exploration performed and from our understanding of the project. Variations will occur between boring locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Therefore, Terracon should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

Our services and any correspondence are intended for the exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for that specific purposes to obtain the specific level of detail necessary for cost estimating. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. In the event that changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

APPENDIX A
FIELD EXPLORATION

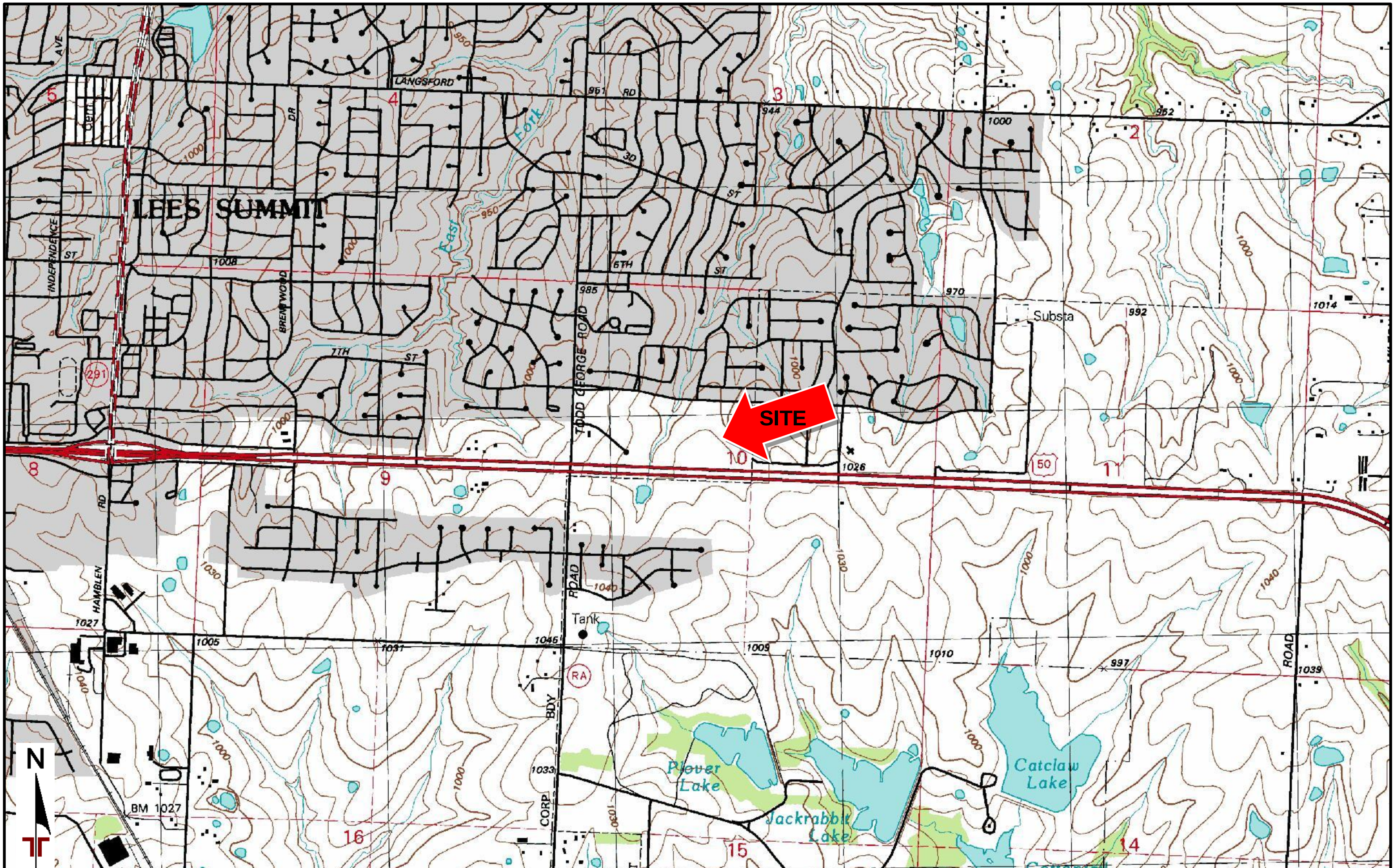
Field Exploration Description

The borings were laid out at the site by Terracon personnel using a hand held GPS device. The ground surface elevations indicated on the boring logs were obtained using an engineer's level and grade rod and were referenced to the finished floor elevation of the existing medical office building (1006.0 feet). The elevations at the surface of each boring are reported to the nearest ½ foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a track-mounted, rotary drill rig using solid-stem, continuous flight augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outside diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. The drill crew backfilled the borings with auger cuttings after completion of drilling/sampling and prior to leaving the site.

The drill crew prepared a field log of each boring to record data including visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the subsurface conditions at the borings based on field and laboratory data and observation of the samples.



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: LAKE JACOMO, MO (1/1/1996).

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

Project Manager: KDF	Project No. 02175168
Drawn by: KDF	Scale: 1"=2,000'
Checked by: MWL	File Name: A2-A3
Approved by: MWL	Date: 6/1/17

Terracon
13910 W 96th Ter
Lenexa, KS 66215-1228

SITE LOCATION

Lee's Summit Medical Office Building
2100 SE Blue Parkway
Lee's Summit, MO

Exhibit
A-2

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager: KDF	Project No. 02175168
Drawn by: KDF	Scale: AS SHOWN
Checked by: MWL	File Name: A2-A3
Approved by: MWL	Date: 6/1/17

Terracon
13910 W 96th Ter
Lenexa, KS 66215-1228

EXPLORATION PLAN

Lee's Summit Medical Office Building
2100 SE Blue Parkway
Lee's Summit, MO

Exhibit
A-3

BORING LOG NO. B-1

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903822° Longitude: -94.334242°

Surface Elev.: 1001.0 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1000.5										
0.9	**5" AGGREGATE BASE COURSE**	1000										
3.0	**FILL - FAT CLAY**, with limestone fragments, brown and gray	998			Split spoon	18	4-6-8 N=14			25		
	FAT CLAY (CH), dark brown to red brown, stiff to very stiff				Split spoon	18	4-6-12 N=18			24		
			5		Split spoon	18	3-4-6 N=10			26		
10.0	- light brown with limestone fragments below 8 feet	991			Split spoon	18	5-6-6 N=12			42		
12.3	**LIMESTONE**, light brown, completely to highly weathered, with shale seams - gray, moderately weathered below 11.5 feet	989	10									
14.8	**SHALE**, gray to brown, highly to moderately weathered	986.5			Rock core		REC = 82% RQD = 75%		6070			
17.0	**LIMESTONE**, gray to dark gray, slightly weathered	984	15									

Boring Terminated at 17 Feet

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Hollow stem augered to 12 feet, NX Coring therafter.

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-4

BORING LOG NO. B-2

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903806° Longitude: -94.333817°

Surface Elev.: 1003.7 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1003										
0.9	**5" AGGREGATE BASE COURSE**	1003										
	FAT CLAY (CH), dark brown to red brown, stiff to very stiff					18	3-7-12 N=19			23		
						14		3.0		27	95	
			5									
8.5		995				18	3-3-5 N=8			29		
	LIMESTONE, light brown, completely to highly weathered, with shale seams					11	11-50/5"			16		
			10									
12.3	- moderately weathered below 11.5 feet	991.5										
13.5	**SHALE**, gray to brown, highly weathered	990							5850			
	LIMESTONE, gray to dark gray						REC = 100% RQD = 84%					
	slightly weathered, - 4-inch shale layer at 14.5 feet		15									
17.0		986.5										

Boring Terminated at 17 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Hollow stem augered to 12 feet, NX Coring therafter.

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-5

BORING LOG NO. B-3

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903652° Longitude: -94.334033°

Surface Elev.: 1003.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1003										
0.9	**5" AGGREGATE BASE COURSE**	1002.5										
2.0	**FILL - FAT CLAY**, with limestone fragments, brown and gray	1001.5										
	FAT CLAY (CH), dark brown to red brown, medium stiff to stiff					18	2-3-4 N=7			27		58-22-36
						18	3-3-3 N=6			30		
			5									
9.0		994.5				18	2-3-5 N=8			29		
	SHALE, light brown, highly weathered					17	7-15-50/5"			23		
10.5		993	10									
11.0	**LIMESTONE**, gray, moderately weathered	992.5										
	Auger Refusal at 11 Feet											

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-6

BORING LOG NO. B-4

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903488° Longitude: -94.334332°

Surface Elev.: 1001.5 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1001										
0.9	**5" AGGREGATE BASE COURSE**	1000.5										
	FILL - FAT CLAY, with limestone fragments					18	3-4-8 N=12			25		
3.5		998										
	FAT CLAY (CH), dark brown to red brown, medium stiff to stiff					8		2.75		27	96	
			5									
						18	2-2-4 N=6			26		
	- light brown with limestone fragments below 9 feet					18	2-2-13 N=15			39		
10.0		991.5	10									
	LIMESTONE, light brown, completely to highly weathered, with shale seams											
13.0		988.5										
	SHALE, olive brown to light brown, highly weathered					5	50/5"			18		
14.0		987.5										
14.5	**LIMESTONE**, gray, moderately weathered	987										
	Auger Refusal at 14.5 Feet											

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

Hammer Type: Automatic

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-7

BORING LOG NO. B-5

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.90351° Longitude: -94.333795°

Surface Elev.: 1004.9 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)
0.4	**5" ASPHALT CONCRETE**	1004.5
0.8	**5" AGGREGATE BASE COURSE**	1004
8.0	**FAT CLAY (CH)**, dark brown to red brown, medium stiff to stiff	997
12.0	**SHALE**, light brown, completely to highly weathered, with limestone seams	993
12.5	**LIMESTONE**, gray, moderately weathered	992.5
	Auger Refusal at 12.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		X	18	2-3-6 N=9			27		
		X	18	3-4-5 N=9					
5									
		X	18	2-3-4 N=7			32		
		X	8	18-50/2"			14		
10									

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-8

BORING LOG NO. B-6

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903387° Longitude: -94.333745°

Surface Elev.: 1005.4 (Ft.)

DEPTH	Material description	ELEVATION (Ft.)
0.5	**6" ROOT ZONE**	1005
7.0	**FAT CLAY (CH)**, dark brown to red brown, stiff	998.5
10.0	**LIMESTONE**, light brown to gray, completely to highly weathered, with shale layers	995.5
12.0	**SHALE**, brown to light brown, highly weathered	993.5
15.0	**LIMESTONE**, gray, highly to moderately weathered	990.5
	Auger Refusal at 15 Feet	

SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
Split spoon	18	3-7-9 N=16			25		
Shelby tube	24		2.0		27	97	
Split spoon	18	6-21-15 N=36			48		
Split spoon	3	50/3"			13		
Split spoon	0	50/1"					

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-9

BORING LOG NO. B-7

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.90324° Longitude: -94.334301°

Surface Elev.: 1000.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1000.5										
0.9	**5" AGGREGATE BASE COURSE**	1000										
	FAT CLAY (CH), dark brown to red brown, medium stiff to stiff											
					X	18	3-5-6 N=11			26		
					X	18	2-1-3 N=4					
			5									
	- light brown with limestone fragments below 6 feet											
					X	10	6-6-3 N=9			18		
8.0		993										
	LIMESTONE, light brown to gray, completely to highly weathered, with shale seams				X	2	20-50/0"			31		
10.5		990.5	10									
	SHALE, light brown to gray, highly to moderately weathered											
12.0		989										
	LIMESTONE, gray to dark gray, slightly weathered				Core		REC = 77% RQD = 58%		17990	20		
15.0		986	15									
	Boring Terminated at 15 Feet											

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Hollow stem augered to 10 feet, NX Coring therafter.

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-10

BORING LOG NO. B-8

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.90322° Longitude: -94.333816°

Surface Elev.: 1002.6 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT CONCRETE**	1002										
1.0	**6" AGGREGATE BASE COURSE**	1001.5										
3.0	**FAT CLAY (CH)**, brown and gray, medium stiff to stiff	999.5				18	1-2-3 N=5			29		
						14		4.5+		29	95	
6.0	**SHALE**, light brown, completely to highly weathered	996.5	5									
9.0	**LIMESTONE**, gray, highly to moderately weathered	993.5				0	50/0"					
						18	50/1"		6200	10		
9.5	**SHALE**, gray to brown, highly weathered	993										
13.5	**LIMESTONE**, gray to dark gray, slightly weathered	989	10			98	REC = 98% RQD = 90%					

Boring Terminated at 13.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Hollow stem augered to 8.5 feet, NX Coring therafter.

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-11

BORING LOG NO. B-9

PROJECT: Lee's Summit MOB

**CLIENT: Hereford Dooley Architects
Nashville, TN**

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.904181° Longitude: -94.333808°

Surface Elev.: 1004.6 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1004										
		FAT CLAY (CH), dark brown to red brown, medium stiff to stiff											
						X	18	5-6-8 N=14			21		56-20-36
						X	18	2-4-7 N=11			25		
				5									
						X	18	4-5-7 N=12			25		
						X	18	2-2-4 N=6			29		
	10.0		994.5	10									
		Boring Terminated at 10 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/24/2017	Boring Completed: 5/24/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-12

BORING LOG NO. B-10

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.903635° Longitude: -94.334502°

Surface Elev.: 995.6 (Ft.)

GRAPHIC LOG	DEPTH / MATERIAL DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	8" ROOT ZONE										
	0.7 — 995										
	FAT CLAY (CH), dark brown, medium stiff to stiff										
					10	2-4-6 N=10			26		
	- dark brown to red brown below 3 feet				19		3.25		24	100	
		5									
					18	3-4-5 N=9			24		
	- light brown, with limestone fragments below 8 feet		▽								
					12	1-2-2 N=4			33		
	10.0 — 985.5	10									
	Boring Terminated at 10 Feet										

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

▽ *8.5' while drilling*

▽ *8.5' after completion of drilling*

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-13

BORING LOG NO. B-11

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.902979° Longitude: -94.334543°

Surface Elev.: 1000.3 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.7	**8" ROOT ZONE**	999.5										
	FAT CLAY (CH), dark brown to red brown, medium stiff to stiff				X	6	2-4-6 N=10			21		
					X	16	1-2-2 N=4			25		
			5									
8.0		992.5			X	16	5-5-11 N=16			42		
	SHALE, light brown, completely weathered			∇ (8.5') ▼ (9')								
10.0		990.5	10		X	4	0-1-1 N=2			27		
	Boring Terminated at 10 Feet											

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

∇ *8.5' while drilling*

▼ *9' after completion of drilling*

Terracon

13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-14

BORING LOG NO. B-12

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.902826° Longitude: -94.334998°

Surface Elev.: 997.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	12" ROOT ZONE											
1.0	**FILL - FAT CLAY**, with limestone fragments, dark brown	996.5										
						14	1-1-2 N=3			30		
						16		4.5+		25	97	
5.0	**FAT CLAY (CH)**, dark brown	992.5	5									
7.0	**SHALE**, light brown, completely weathered	990.5										
						18	3-3-4 N=7			30		
	- with limestone seams below 8.5 feet			▽								
						8	28-16-14 N=30			10		
10.0		987.5	10	▽								
	Boring Terminated at 10 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

▽ *8.5' while drilling*

▽ *10' after completion of drilling*

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-15

BORING LOG NO. B-13

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.902743° Longitude: -94.334189°

Surface Elev.: 1003.9 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ROOT ZONE**	1003.5										
	FAT CLAY (CH), red brown, medium stiff to stiff				X	10	2-3-5 N=8			24		64-24-40
					X	18	1-2-3 N=5			26		
7.0		997	5									
	LIMESTONE, light brown, completely weathered				X	18	4-6-22 N=28			26		
8.5	- gray, moderately weathered below 8 feet	995.5										
	Auger Refusal at 8.5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-16

BORING LOG NO. B-14

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.902722° Longitude: -94.333561°

Surface Elev.: 1008.7 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ROOT ZONE**	1008										
	FAT CLAY (CH), red brown, stiff				Split spoon	16	2-4-5 N=9			24		
					Shelby tube	13		3.5		26	97	
6.5		1002	5									
7.0	**LIMESTONE**, light brown to gray, moderately weathered	1001.5				0	50/0"					
	Auger Refusal at 7 Feet											

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-17

BORING LOG NO. B-15

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects Nashville, TN

SITE: Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.90271° Longitude: -94.33302°

Surface Elev.: 1011.1 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1010.5										
		FAT CLAY (CH), red brown, medium stiff to stiff											
						X	8	2-4-4 N=8			21		
						X	18	1-2-3 N=5			43		
				5									
		- light brown, with limestone fragments below 6 feet											
	7.0		1004			X	6	6-50/1"			48		
	7.3	**LIMESTONE**, gray, moderately weathered	1004										
		Auger Refusal at 7.3 Feet											

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

**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-18

BORING LOG NO. B-16

PROJECT: Lee's Summit MOB

CLIENT: Hereford Dooley Architects
Nashville, TN

SITE:
Lee's Summit, Missouri

LOCATION See Exhibit A-2

Latitude: 38.90266° Longitude: -94.332086°

Surface Elev.: 1009.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	HAND PENETROMETER (tsf)	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ROOT ZONE**	1008.5										
	FAT CLAY (CH), brown and gray, medium stiff to stiff											
						12	2-4-5 N=9			26		65-24-41
						10		1.75		27	96	
			5									
						18	2-2-4 N=6			40		
8.0		1001										
	SHALE, light brown, highly weathered					8	6-50/2"					
9.2		1000										
	Auger Refusal at 9.2 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
**Classification estimated from disturbed or core samples. Petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Backfilled with Auger Cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS
Groundwater not encountered

Terracon
13910 W 96th Ter
Lenexa, KS

Boring Started: 5/23/2017	Boring Completed: 5/23/2017
Drill Rig: 908	Driller: SF
Project No.: 02175168	Exhibit: A-19

APPENDIX B
LABORATORY TESTS

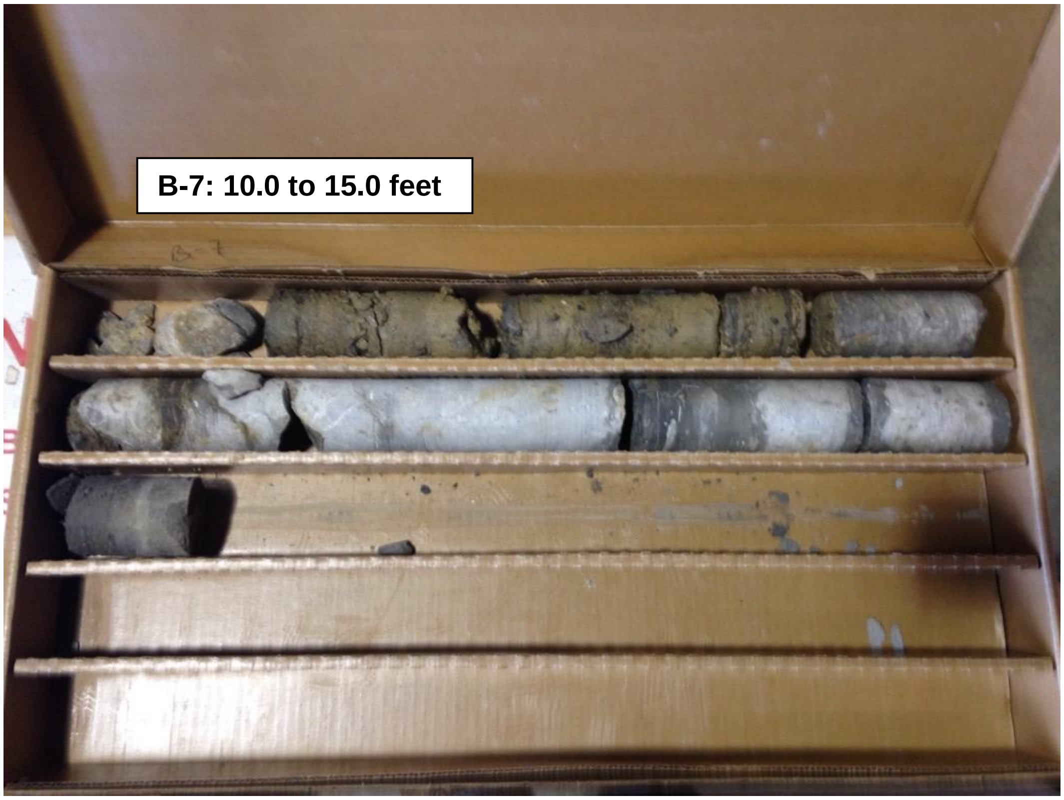
Laboratory Test Summary

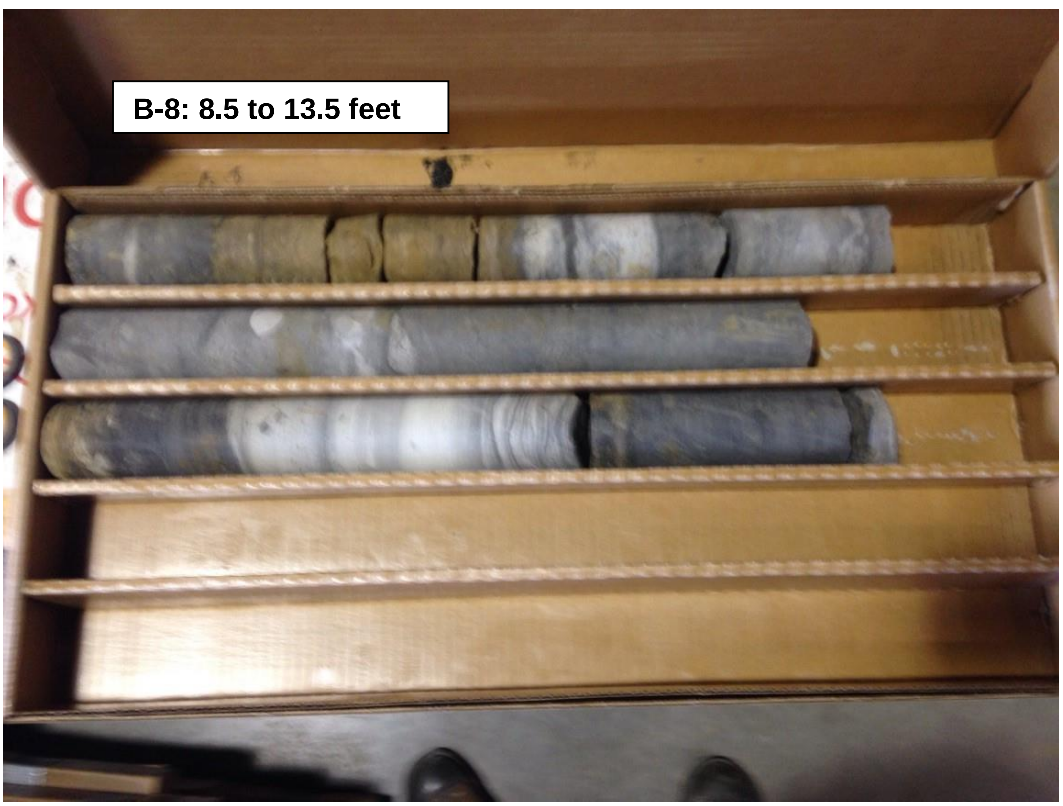
Representative soil samples were tested in the laboratory to measure their natural water content, dry unit weight, and Atterberg limits. A pocket penetrometer was used to estimate the approximate unconfined compressive strength of selected samples. The test results are provided on the boring logs included in Appendix A.

The soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the laboratory testing described above. The soil descriptions presented on the boring logs are in accordance with the enclosed General Notes and Unified Soil Classification System (USCS). The estimated USCS group symbols for native soils are shown on the boring logs, and a brief description of the USCS is included in this report.

The bedrock materials encountered in the borings were described in accordance with the appended Description of Rock Properties on the basis of visual classification of core samples, disturbed auger cuttings, and drilling characteristics. Petrographic analysis may indicate other rock types.

Project Manager: KDF	Project No. 02175168	Terracon	ROCK CORE PHOTOGRAPHS – BORING B-1 AND B-2
Drawn by: KDF	Scale: N/A		Lee's Summit Medical Office Building
Checked by: MWL	File Name: RC	13910 W 96th Terrace	2100 Southeast Blue Parkway Lee's Summit, Missouri
Approved by: MWL	Date: 6/9/2017	Lenexa, Kansas 66215-1228	Exhibit B-2





Project Manager: KDF	Project No. 02175168	Terracon 13910 W 96th Terrace Lenexa, Kansas 66215-1228	ROCK CORE PHOTOGRAPHS – BORING B-7 and B-8
Drawn by: KDF	Scale: N/A		Lee's Summit Medical Office Building 2100 Southeast Blue Parkway Lee's Summit, Missouri
Checked by: MWL	File Name: RC		
Approved by: MWL	Date: 6/9/2017		Exhibit B-3

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Rock Core

Shelby Tube

Split Spoon

WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

Exhibit: C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

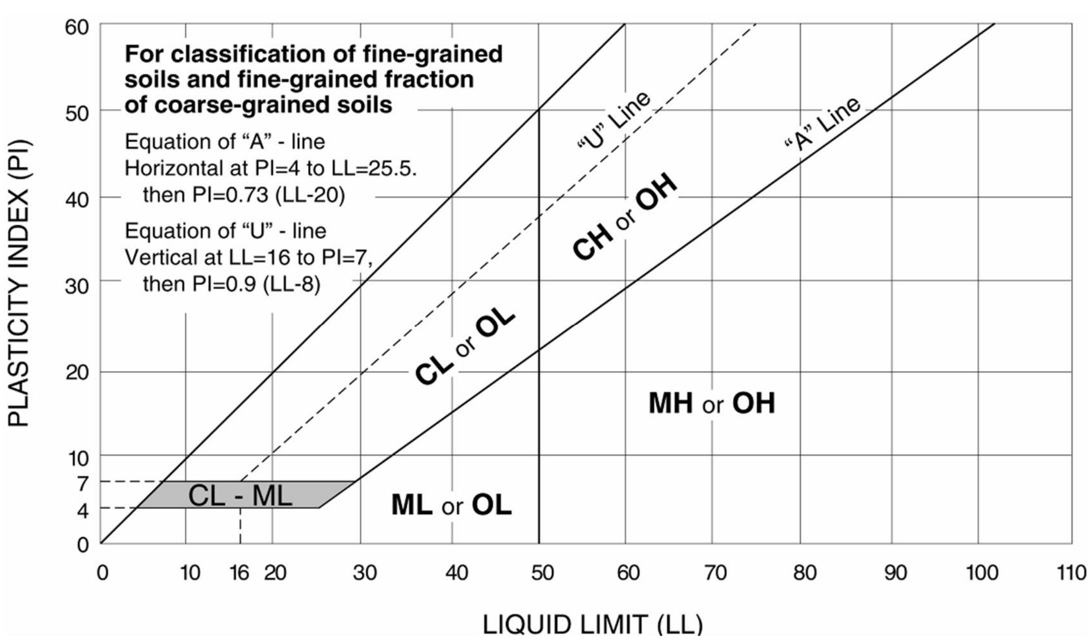
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, PSI (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft (50 – 300 mm)
Moderate	8 in – 2 ft (200 – 600 mm)	**Medium**	1 ft – 3 ft (300 – 900 mm)
Wide	2 ft – 6 ft (600 mm – 2.0 m)	**Thick**	3 ft – 10 ft (900 mm – 3 m)
Very Wide	6 ft – 20 ft (2.0 – 6 m)	**Massive**	> 10 ft (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0 degree angle.

ROCK QUALITY DESIGNATION (RQD*)	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

*The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements