Geotechnical Engineering Report

Proposed Medical Center
Bolivar, Missouri
September 22, 2015
Project No. B5155041

Prepared for:
PCI HealthDev
Dallas, Texas

Prepared by:
Terracon Consultants, Inc.
Springfield, Missouri

September 22, 2015

PCI HealthDev
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Attn: Mr. Alan Morris
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Re: Geotechnical Engineering Report
Proposed Medical Center
NW Corner of Highway 32 and Davis Drive – Bolivar, Missouri
Terracon Project Number: B5155041

Dear Mr. Morris:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with Work Order number PB515142g, signed August 21, 2015. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed 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.

STATE OF MISSOURI
TY G. ALEXANDER
NUMBER
PE-2009002087
9/23/15
PROFESSIONAL ENGINEER

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Enclosures
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1 – File

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EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the proposed Medical Center to be located in the northwest corner of the intersection of Highway 32 and Davis Drive in Bolivar, Missouri. Eight (8) borings, designated B-1 through B-8, were performed to depths of approximately 10 to 31 feet below the existing ground surface. The following geotechnical considerations were identified:

- A void was noted in the bedrock material at a depth of approximately 18 to 19½ feet. These features are common in the local geology. Building structures with shallow foundations over areas with known bedrock voids involves some risk of unpredictable settlement beneath the structure. This is a risk common to all structures built in southwest Missouri. If the owner is not willing to accept that risk, Terracon suggests that the owner select a deep foundation system bearing below known voids. If a deep foundation system is selected, Terracon recommends the use of a structural slab supported by the deep foundations be considered.

- Existing undocumented fill and possible fill was encountered to depths of approximately 2 to 4½ feet at all of the boring locations. If the structure is built upon shallow foundations, the foundations for the proposed building should not bear on or above the undocumented fill materials. Any existing fill should be removed and replaced (or improved) so that the foundations and floor slabs for the building bear on medium stiff to very stiff native clay soils or on properly placed and compacted engineered fill extending to the suitable native soils.

- The site was noted to historically contain buildings based on aerial imagery. It is common in such areas to encounter remnants of past structures, such as buried foundations and basements, during construction. If encountered, these elements should be completely removed and replaced with engineered fill as outlined in this report. We recommend the owner budget for this possibility.

- Provided the owner is willing to accept the risk associated with pavements over the existing fill materials in exchange for reduced construction costs, portions of the existing fill could be left in place for support of new pavements. At least 12 inches of new engineered fill or reprocessed existing fill should be placed directly below the pavements with this option.

- The fat clay (CH) soils encountered in the borings are high in plasticity and prone to volume change with variations in moisture content. For this reason, we recommend a 24-inch thick Low Volume Change (LVC) zone be present or constructed beneath grade-supported floor slabs. The borings indicate that about upper 5 feet of soils in the proposed building pad are low plasticity clays; however, during construction, if fat clay soils are observed in the near-surface building pad subgrade soils, they should be removed and replaced with LVC material.

- Some relatively high moisture content soils were encountered in the upper levels of some of the borings, and may be exposed in excavations and cuts. Further, silty clay near surface soils

are prone to instability at moisture contents at, or near, optimum moisture as determined by ASTM D698. These soils may become unstable when disturbed. During periods of dry weather, these soils may be stable upon initial exposure; however, these soils, if exposed, may become relatively soft and unstable under construction traffic. We recommend that the owner budget for the possibility that overexcavation and/or subgrade stabilization may be required and contractors be prepared to handle potentially unstable and/or soft conditions.

- On-site soils are considered suitable for use as engineered fill. However, the fat clay soils encountered do not meet our recommended criteria for LVC and should not be placed within 2 feet of the bottom of the proposed slab-on-grade. Further, the silty clay soils will be highly susceptible to instability during wet weather. If time or weather constraints are prohibitive, stabilization and/or overexcavation and import of suitable soils may be required to facilitate construction of the building pad or pavement subgrade.

- The 2012 International Building Code (IBC) seismic site classification for this site is D.

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. So that variations in subsurface conditions which may affect the design can be addressed as they are encountered, we recommend that Terracon be retained to observe excavation 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 fully developed recommendations and opinions based on our understanding of the project at the time the report was prepared. The report limitations are described in the **GENERAL COMMENTS** section of this report.

GEOTECHNICAL ENGINEERING REPORT
PROPOSED MEDICAL BUILDING
BOLIVAR, MISSOURI

Terracon Project No. B5155041
September 22, 2015

1.0 INTRODUCTION

A geotechnical exploration has been performed for the proposed Medical Center to be located in the northwest corner of the intersection of Highway 32 and Davis Drive in Bolivar, Missouri. Eight (8) borings, designated B-1 through B-8, were performed to depths of approximately 10 to 31 feet below the existing ground surface. Logs of the borings along with a Topographic Map, Location Map, Geologic Map, and Boring Location Diagram are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- foundation design and construction
- slab design and construction
- seismic considerations
- pavement recommendations

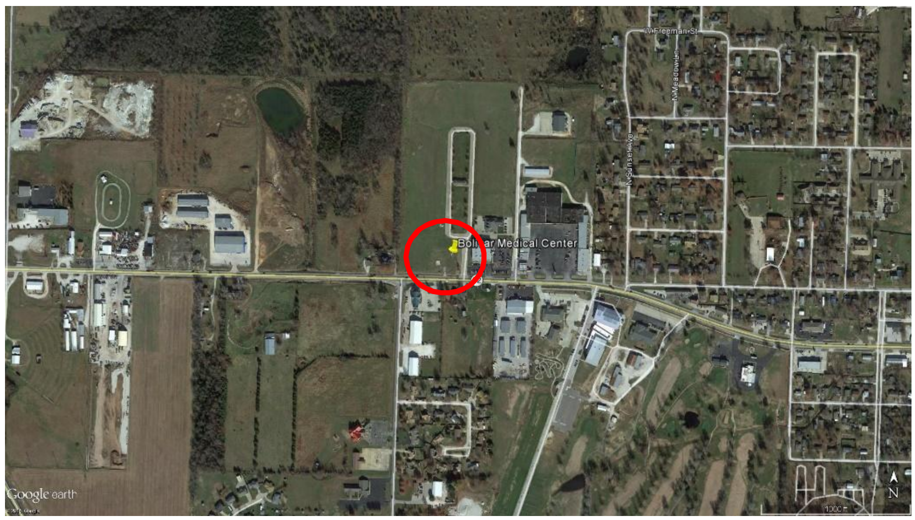
2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-4: Boring Location Diagram
Building information	Single-story office building with a planned footprint of 8,214 s.f.
Finished floor elevation	Not provided.
Maximum building loads (estimated by Terracon)	Columns: 80 kips Walls: 2-4 klf Slabs: 150 psf max
Anticipated traffic	Expected traffic loading was not provided; however, we anticipate the new parking areas will be primarily used by personal vehicles (cars and pick-up trucks). A limited number of delivery trucks and refuse disposal vehicles are expected in the drive lanes and loading areas (estimated maximum of 10 trucks per week).

Item	Description
Site grading	Not provided. Cuts and fills are anticipated to be generally 3 feet or less across the site.
Below-grade walls	None anticipated.
Retaining walls	None anticipated.

2.2 Site Location and Description

Item	Description
Location	NW Corner of Highway 32 and Davis Drive – Bolivar, Missouri  Lat.: 37°36'46.59"N, Long.: 93°26'1.77"W
Existing improvements	Undeveloped land with a small concrete pad. We understand the site was previously developed with a residential structure and the concrete pad is what remains of a garage floor. 

Item	Description
Current ground cover	Site is covered with native grasses/weeds.
Existing topography	A plan of the existing topography was not available. The site generally slopes downward from southeast to northwest.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (feet)	Boring Locations	Material Description	Consistency/ Density
Surface	0.7 to 0.9	All	Topsoil	n/a
1	2 to 4½	All	Undocumented fill[1] and possible fill :Silty Clay with varying amounts of organics and gravel	Variable
2	16 to undetermined[2]	All	Fat clays with varying amounts of sand and gravel	Medium stiff to very stiff
3	Undetermined[3]	B-1, B-4	Limestone and weathered shale	Moderately to completely weathered

1. Undocumented fill is defined as a man placed material that has no documentation or record of how the material was place. These materials can be highly variable in nature if not placed in a properly controlled manner.
2. Borings B-5 through B-8 were terminated within this stratum at their planned termination depths of approximately 10 feet below grade. Borings B-2 and B-3 were terminated on auger refusal materials at depths of approximately 16.5 and 18 feet below the subsurface.
3. Borings B-1 and B-4 were terminated within this stratum at a depths of approximately 31 and 29 feet below grade.

Conditions encountered at each boring location are indicated on the individual boring logs in Appendix A of this report. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; the in-situ transition between materials may be gradual.

3.2 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes are noted on the attached boring logs, and are summarized below:

Boring Number	Depth to groundwater while drilling, ft.	Depth to groundwater after drilling, ft.
B-4	28½	27
All others	Not encountered	Not encountered

The water levels noted above are not necessarily stable groundwater levels. The absence of observed water does not mean that the boring terminated above groundwater. Due to the low permeability of some of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long-term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. In addition, perched water can develop over low permeability soil strata. Therefore, groundwater levels during construction or at other times in the life of the structures may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

3.3 Geology

Based on the Missouri Geologic map from the Missouri Department of Natural Resources (MDNR) the subject site is located on the Jefferson City/Cotter Dolomite. The Jefferson City/Cotter Dolomite primarily consists of Dolomite with some conglomerate, shale, sandstone, and chert. The surrounding area bedrock also consists of the Osagean Series, Kinderhookian Series, and channel sandstones which can contain limestone, dolomite, siltstone, shale, chert, and sandstones. Traces of the surrounding bedrock units may be found on the subject site.

Solution features, including springs, caves, and sinkholes, are commonly present in the Jefferson City and Cotter Formations in this area. These sinkholes and springs are marked on the **Geologic Map** included in the appendix of this report. A 1½ foot void/conduit within the limestone bedrock was noted during the site exploration which is an indication of karst activity at the site. No existing sinkholes were noted at the subject site; however site grading has been performed which often hides visual surface indications of sinkholes. It is difficult to predict future sinkhole activity. Site grading and drainage may alter site conditions and could possibly cause sinkholes in areas that have no history of this activity.

A desktop review of mine information from the Missouri Department of Natural Resources was conducted for the project site. No known underground mining activity was noted on the subject site. Several surface limestone quarries were noted within 1 mile of the subject site; however these quarries should not have an impact on the proposed structure.

Several known fault lines were noted within ½ mile of the subject site. These faults are noted on the **Topographic Map** included in the appendix of this report. The existence of nearby faults may impact the seismic design of the proposed structure.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of the subsurface exploration, laboratory testing, and our analyses, it is our opinion that the proposed building can be supported on shallow foundations bearing on suitable native clay or newly placed compacted structural fill, or a drilled pier foundation system bearing below voids in the bedrock. Geotechnical considerations for this project include:

- Karst conditions;
- Foundation Considerations;
- Bedrock considerations;
- Existing undocumented fill and possible fill;
- Presence of high plasticity clays; and
- Soft subgrade potential.

4.1.1 Karst Conditions

The subject site is located in an area where karst conditions are known to exist. A void within the limestone bedrock was noted within boring B-1 at a depth of 18 to 19½ feet below the ground surface. No existing sinkhole features were noted at the subject site or in the topographic review; however, the void in the bedrock is an indication that solution features are present at the site. The presence of solution features at the site may mean the site has an elevated risk of sinkhole development. Additionally, the site has been regraded which can hide visually observable surface indications of sinkhole activity.

Care should be taken to grade the site so that water does not pond on the site. If solution features beneath the site extend to the top of the bedrock, ponded water may cause water to leach fine grained material into the void causing large settlements or possible sinkhole development.

Additional testing of the subgrade including additional borings, bedrock profiling, and subsurface resistivity testing can aid in the detection of sinkholes and karst conditions. However, this additional testing can be costly and does not guarantee that existing or developing sinkholes will be identified.

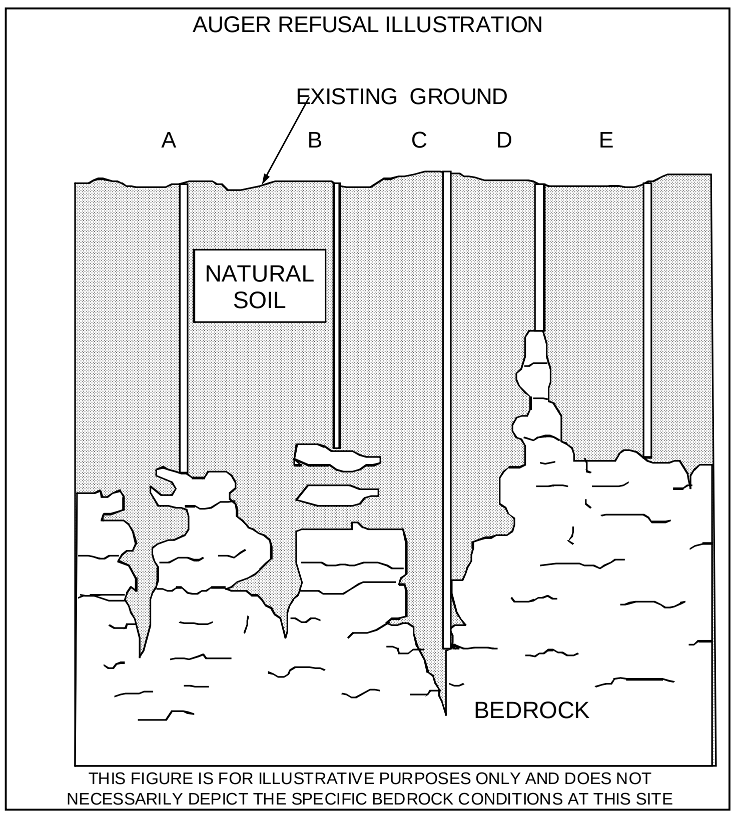
4.1.2 Foundation Considerations

Building structures with shallow foundations over areas with known bedrock voids involves some risk of unpredictable settlement beneath the structure. This is a risk common to all structures built in southwest Missouri. If the owner is not willing to accept these risks Terracon recommends the use of a drilled pier foundation system bearing below any voids and a structural floor slab supported by the deep foundations. The deep foundations would bear on competent bedrock. A structural floor supported by the drilled pier foundation system would bridge settlements caused by karst conditions.

There is a risk that additional voids may be present in areas not explored with soil borings. If deep foundations are selected for support of the structure, Terracon recommends that the bedrock be probed a minimum of 5 feet below the bottom of the drilled pier to verify the structure is bearing on competent bedrock. Deep foundations should be socketed a minimum of 3 feet or 1 pier diameter, whichever is larger, below the bottom of any noted void. Larger than normal grout takes should be anticipated in the area of voids.

4.1.3 Bedrock Considerations

Auger refusal on apparent bedrock was encountered in borings B-1 through B-4 at depths between 16 and 29 feet below present grades. Auger refusal is defined as the depth below the ground surface at which a boring can no longer be advanced with the soil drilling technique being used. Auger refusal is subjective and is based upon the type of drilling equipment used, the types of augers being used, and the effort exerted by the driller. Auger refusal can result on the upper surface of discontinuous bedrock (A), slabs of unweathered rock suspended in the residual soil matrix or "floaters" (B), in widened joints that may extend well below the surrounding bedrock surface (C), on rock "pinnacles" (D) rising above the surrounding bedrock surface, or on the upper surface of continuous bedrock (E). These possible auger refusal conditions are illustrated in the adjacent figure.



When the proposed grading plan is available and prior to foundation construction, borings or auger probes could be performed to obtain more bedrock information. Linear interpolation of apparent bedrock elevations based upon the boring data is often used but can misrepresent actual rock removal quantities where such anomalies exist.

4.1.4 Existing Undocumented Fill

Existing fill was encountered to depths of approximately 2 to 4½ feet in all of the borings. The fill could extend deeper in areas not explored. While the N-values obtained in the undocumented fill materials were generally equal or higher than the existing native soils, no documentation or records regarding the placement of this fill were provided for our review. If records are available, Terracon should be supplied with these documents to better assess the suitability of the existing fill.

The subject site is has been previously developed based on aerial imagery from Google™ Earth. It is common in such areas to encounter remnants of past structures, such as buried foundations, utilities, and basements during construction. If encountered, these elements should be overexcavated and replaced with engineered fill in accordance with the recommendations outlined in this report. We recommend the owner budget for this possibility.

Undocumented fill may contain soft or loose soils or other unsuitable materials; these conditions may not be disclosed by the widely-spaced, relatively small-diameter borings. If these conditions are present and are not discovered and addressed during construction, larger than normal settlement resulting in cracking, differential movement, or other damage could occur in floor slabs, pavements, and utility lines supported on or above the existing fill. Typically, larger than normal settlement of floor slabs results in reflective cracking of overlying rigid floor coverings (if any), unlevel floors, and “bumps” at locations of differential movement.

Foundations for the new building should not bear on or above the undocumented fill materials. The existing fill should be removed and replaced so that the foundations and floor slabs for the new building bear on suitable native soils or on properly placed and compacted engineered fill extending to the suitable native soils. If the fill is completely removed and replaced, it should be removed within the proposed building footprint and extend at least 5 feet outside the building perimeter.

Provided the owner is willing to accept the risks associated with supporting pavements over the existing fill materials in exchange for reduced construction costs, portions of the existing undocumented fill could be left in place for support of new pavements. At least 12 inches of new engineered fill should be placed directly below the pavement sections with this option.

4.1.5 Swell Potential

Based on the depths of the existing fill and the presence of High plastic clays with liquid limits over 50 percent, we recommend a low volume change (LVC) zone be constructed beneath the at-grade floor slab a minimum depth of 24 inches. Using an LVC zone as recommended in this report may not eliminate all future subgrade volume change and resultant floor slab movements. However, the procedures outlined herein should help to reduce the potential for subgrade volume change. Existing soils can be left in place and compacted if they are tested during construction and meet LVC material requirements. Details regarding this LVC zone are provided in section **4.4 Floor Slab.**

4.1.6 Soft Subgrade Potential

Silty clay soils were encountered in the upper levels of the borings and could be exposed in excavations and cuts. These soils may become unstable when disturbed. During periods of dry weather, these soils may be stable upon initial exposure; however, these soils, if exposed, could become relatively soft and unstable under construction traffic. Further, depending upon site conditions during construction, overexcavation or stabilization of the subgrade and/or base of overexcavations may be needed to achieve a suitable working surface. Accordingly, we recommend that the owner budget for the possibility that overexcavation and/or subgrade stabilization may be required and contractors be prepared to handle potentially unstable and/or soft conditions. If time or weather constraints are prohibitive, import of suitable fill material may be required to facilitate construction of the building pad and/or pavement subgrade.

4.1.7 General

We recommend that the exposed subgrade be thoroughly evaluated after stripping of any topsoil and at the base of all cut areas, but prior to the start of any fill operations. We recommend that the geotechnical engineer be retained to evaluate the bearing material for the foundations and subgrade soils. Subsurface conditions, as identified by the field and laboratory testing programs, have been reviewed and evaluated with respect to the proposed project plans known to us at this time.

Karst development is a common occurrence in southwest Missouri due to the dissolution of the native limestone and dolomite bedrock material. The current state of the practice in geotechnical engineering does not allow for the accurate prediction of when or where sinkholes or karst-related subsidence could occur. The owner is advised that construction on this property or essentially any other site within southern Missouri, carries with it some risk that future sinkholes may develop.

4.2 Earthwork

4.2.1 Site Preparation

We anticipate construction will be initiated by the removal of landscaping, topsoil, or vegetation that may be present. At this point, the existing fill should be removed and replaced so that the foundations and floor slab for the new building. The fill should be removed within the proposed building footprint plus at least 5 feet outside of the building perimeter so the foundations and floor slab will bear on medium stiff to stiff native clay soils or on properly placed and compacted engineered fill extending to the suitable native soils.

If the owner is willing to accept the risks of supporting pavements over the existing undocumented fills, portions of the existing fill could be left in place for support of the pavements. At least 12 inches of new engineered fill or reprocessed existing fill (scarified, moisture conditioned and compacted) should be placed directly below the floor pavements with this option. If the owner is not willing to accept the risk of unpredictable settlement within proposed pavement areas, the existing fill should be removed and replaced as an engineered fill.

Any slabs, foundations, other structures, or utilities and associated backfill that are encountered during construction should also be removed to allow evaluation of the underlying soils. Stripping and excavation depths will likely vary across the site. In addition, care should be taken by contractors to protect all existing improvements to remain, such as pavements and utilities.

Fat clay soils should not be placed or remain present in the upper 2 feet below the planned bottom of floor slabs and other flatwork abutting the structure. Suitable materials in this 2-foot-thick zone should meet the LVC requirements defined in section **4.2.3 Material Requirements** of this report.

We recommend that the exposed subgrade be thoroughly evaluated by a geotechnical engineer prior to placement of new fill. The soils on the site may be sensitive to disturbance from construction equipment traffic, particularly during wet periods. Excessively wet or dry material should either be removed or moisture conditioned and recompacted. The exposed subgrade, including areas of existing undocumented fill, should be proofrolled where possible to aid in locating loose or soft areas. Proofrolling can be performed with a loaded, tandem-axle dump truck. If unsuitable areas are observed during construction, subgrade improvement will then be necessary to establish a suitable subgrade support condition. Subgrade stabilization is discussed in section **4.2.2 Soil Stabilization**.

4.2.2 Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics) and chemical stabilization. The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of the area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help to reduce the amount of subgrade stabilization required.

If the exposed subgrade is unstable during proofrolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Compaction** – It may be feasible to scarify, dry, and compact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.

- **Crushed Stone** – The use of crushed stone or gravel is the most common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 6 to 30 inches below finished subgrade elevation with this procedure. The use of high modulus geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should meet the manufacturer's specifications, and generally should not exceed 1½ inches.

- **Chemical Stabilization** – Improvement of subgrades with Portland cement, lime kiln dust, Code L, or Class C fly ash could be considered for improving unstable soils. Chemical modification should be performed by a prequalified contractor having experience with successfully stabilizing subgrades in the project area on similar sized projects with similar soil conditions. Results of chemical analysis of the additive materials should be provided to the geotechnical engineer prior to use. The hazards of chemicals blowing across the site or onto adjacent property should also be considered. Additional testing would be needed to develop specific recommendations to improve subgrade stability by blending chemicals with the site soils. Additional testing could include, but not be limited to, evaluating various admixtures, the optimum amounts required, the presence of sulfates in the soil, and freeze-thaw durability of the subgrade.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

4.2.3 Material Requirements

Materials that will be used as fill should be free of organic matter and debris. Frozen materials should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation.

Fill Type[1]	USCS Classification	Acceptable Location for Placement
Lean Clay	CL (LL<50)	All locations and elevations, except as LVC material unless material explicitly meets LVC requirements.
Moderate to High Plasticity Material[2]	CH or CL (LL≥45 or PI≥25)	> 24 inches below building finished grade
Well-graded Granular[3]	GM, GC, SM, or SC	All locations and elevations
Low Volume Change (LVC) Material [4]	CL (LL<45 & PI<25) or Granular Material [3]	All locations and elevations
On-site Soils	ML-CL	All locations and elevations [5]
	CH	>24 inches below building finished grade

1. Compacted structural fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation.
2. Delineation of moderate to highly plastic clays should be performed in the field by a qualified geotechnical engineer or their representative, and could require additional laboratory testing. If fat clay fill material contains greater than 35 percent granular material retained on a ¾-inch sieve, it may be used in the 24-inch thick low volume change zone.
3. Similar to crushed limestone aggregate or crushed stone containing at least 15% low plasticity fines may also be used. Material should be approved by the geotechnical engineer.
4. Low plasticity cohesive soil or granular soil having low plasticity fines. Material should be approved by the geotechnical engineer.
5. Silty soils are acceptable for use as structural fill. It should be noted that silty soils are highly sensitive to water content. Silty soils can become unstable at or very near to optimum moisture content. Accordingly, if time or weather constraints are prohibitive, silty soils may not be suitable for use near the surface of the building pad or pavement subgrade.

4.2.4 Compaction Requirements

Item		Description
Fill Lift Thickness [1]		9 inches or less in loose thickness
Compaction Requirements [2]		At least 95% of the material's maximum standard Proctor dry density [3]
Moisture Content Clay Soil	**LL<40**	-2% to +2% of optimum moisture content value [3]
	LL>40	0 to 4% above the optimum moisture content value [3]
Moisture Content Granular Material		Workable moisture levels [4]

1. Reduced lift thicknesses are recommended in confined areas (e.g., utility trenches, foundation excavations, and foundation backfill) and when hand-operated compaction equipment is used.
2. We recommend that engineered fill be tested for moisture content and compaction during placement. Should 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. The zone of fill compacted to meet this criteria should extend at least 5 feet horizontally beyond the building footprint. As stated within ASTM D-698, this procedure is intended for soils with 30% or less material larger than ¾". Accordingly, we recommend full time proof roll observation be performed instead of moisture density testing for materials containing more than 30% aggregate retained on the ¾" sieve.

3. As determined by the standard Proctor test (ASTM D 698).
4. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

4.2.5 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, attempts should be made to limit the amount of fine migration into the clean stone. Fine migration into clean granular fill may result in unanticipated localized settlements over a period of time. To help limit the amount of fine migration, Terracon recommends the use of a geotextile fabric that is designed to prevent fine migration in areas of contact between clean stone and fine-grained soils. Terracon also recommends that clean stone be tracked or tamped in place where possible in order to limit the amount of future densification which may cause localized settlements over time.

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 lean clay compacted at a water content at or above the soil's optimum water content. The lean clay fill should be placed to completely surround the utility line and be compacted in accordance with the recommendations in this report.

4.2.6 Grading and Drainage

Final grades should slope away from the structure on all sides to prevent ponding of water. Gutters and downspouts should drain water a minimum of 10 feet beyond the footprint of the proposed structure. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

4.2.7 Earthwork Construction Considerations

In periods of dry weather, the surficial soils may be of sufficient strength to allow fill construction on the stripped and grubbed ground surface. However, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wet or subjected to repetitive construction traffic. The use of low ground pressure construction equipment would aid in reducing subgrade disturbance. The use of remotely operated equipment, such as a backhoe, would be beneficial to perform cuts and reduce subgrade disturbance. If unstable subgrade conditions are encountered, stabilization measures, as described in section **4.2.2 Soil Stabilization** will need to be employed.

Temporary excavations will be required during construction. The contractor is usually 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. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The contractor is responsible for selecting and implementing the appropriate dewatering procedures, if required during construction. Although groundwater was not encountered in the borings at depths expected to affect foundation excavations, it may be encountered during foundation excavation or in other excavation activities. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. The volume of water seepage into shallow isolated excavations may be controllable with an appropriate number of sump pits and pumps; however, more extensive dewatering and/or subgrade stabilization may be required to facilitate construction if larger and/or deeper areas of cut are performed during earthwork operations.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to foundation construction.

Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade and foundation soils should not be planted next to the structure. Trees and shrubbery should be kept away from the exterior of the structure a distance at least equal to their expected mature height.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation, proofrolling, placement and compaction of controlled compacted fills, backfilling of excavations into the completed subgrade, and just prior to construction of slabs.

4.3 Foundations

The proposed building can be supported using a shallow foundation system bearing on suitable native soils, newly placed engineered fill above suitable native soils, or a system of deep foundations bearing on competent bedrock. Shallow foundations bearing over a known void carries with it some risk of unpredictable settlement beneath the structure. If the owner is not willing to accept these risk Terracon suggests the owner consider the use of a drilled pier foundation system bearing below any encountered voids with the use of a structural slab as discussed in section 4.1.2 **Foundation Considerations**. Support of foundations on or over existing fill materials is not recommended. This may require extending some foundation excavations below typical frost depth to reach suitable native soils. Shallow foundation system design recommendations and deep foundation recommendations for the proposed structure are presented in the following sections.

4.3.1 Shallow Foundation System

4.3.1.1 Foundation Design Recommendations

Description	Column	Wall
Suitable bearing materials	Native medium stiff to stiff fat clays or new engineered fill extending to suitable native soil	
Net allowable bearing pressure [1,2]	2,000 psf[2]	
Minimum width	30 inches	16 inches
Maximum dimension	8 feet	3.5 feet
Minimum embedment below finished grade[3]	30 inches	
Estimated total settlement from foundation loads [4]	up to1 inch	
Estimated differential settlement from foundation loads [4]	< ¾ inch	< ¾ inch
Ultimate passive pressure [5]	250 pcf, equivalent fluid density	
Ultimate coefficient of sliding friction [5]	0.32	

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation, and can be increased by 1/3 for transient loads (e.g., wind or seismic). Assumes the bearing material consists of suitable medium stiff to stiff native soil or structural fill.
2. Assumes the owner has accepted the risk of potential karst conditions (as described in sections 4.1.1 and 4.1.2). Assumes any unsuitable existing fill or soft soils, if encountered, will be undercut and replaced with compacted structural fill.
3. For frost protection and to reduce the effects of seasonal moisture variations in the subgrade soils. For perimeter footings and footings beneath unheated areas.

4. Column foundations greater than 8 by 8 feet or strip wall foundations wider than 4 feet are estimated to settle 1 inch or greater. Assumes the foundations do not bear on, or above the existing undocumented fill. Foundation settlement will depend upon variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations.
5. The sides of the spread footing foundation excavations must be nearly vertical and the concrete should be placed neat against the vertical faces for the passive earth pressure values to be valid. If the loaded side is sloped or benched, and then backfilled, the allowable passive pressure will be significantly reduced. Passive resistance in the upper 2½ feet of the soil profile should be neglected. If passive resistance is used to resist lateral loads, base friction should be neglected.

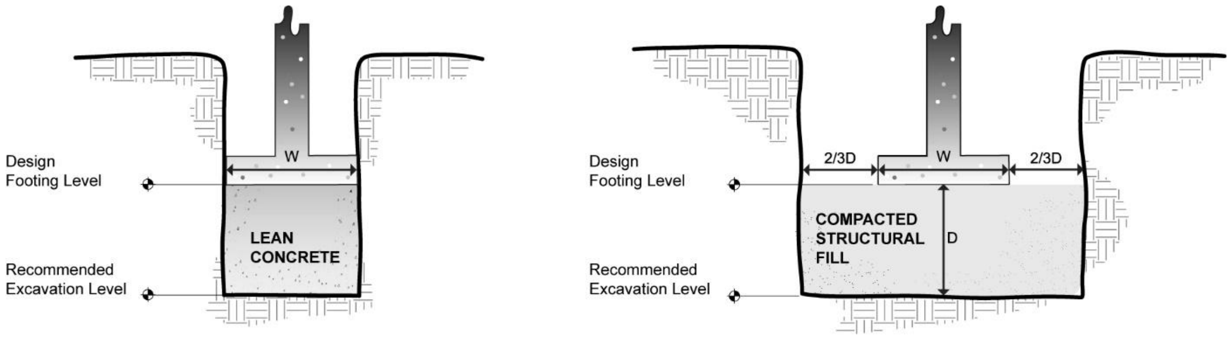
Uplift resistance for spread footing foundations may be computed as the sum of the weight of the foundation element and the weight of the soil overlying the foundation. We recommend using a soil unit weight of 120 pcf for compacted structural fill overlying the footing placed as described in section **4.2 Earthwork**. A unit weight of 150 pcf could be used for reinforced footing concrete. We recommend a minimum factor of safety of 1.5 be utilized for uplift calculations.

4.3.1.2 Foundation Construction Considerations

The base of each foundation excavation should be free of water, undocumented fill, soft native soil, and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. If the soils at bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. A lean concrete mudmat should be placed over the bearing soils if the excavations must remain open for an extended period of time. It is recommended that the geotechnical engineer be retained to observe and test the soil foundation bearing materials.

Although groundwater was not encountered in the borings at depths expected to affect foundation excavations, it may be encountered during foundation excavation or in other excavation activities. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. It is anticipated that any water entering foundation excavations from these sources can be removed using sump pumps or gravity drainage.

If unsuitable bearing soils (e.g., undocumented fill or soft native soils) are encountered in footing excavations, the excavation should be extended deeper to suitable soils. The footing could then bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted structural backfill extending down to the suitable soils. Overexcavation for compacted structural fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled per the recommendations provided in section **4.2 Earthwork** up to the footing base elevation. The overexcavation and backfill procedure is illustrated in the following figure.



Lean Concrete Backfill **Overexcavation / Backfill**

NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

4.3.2 Deep Foundation System

4.3.2.1 Drilled Pier Design Recommendations

Based on the results of the borings, we have developed the following drilled pier design parameters.

Approximate Depth/ Material (feet) [1]	Allowable Skin Friction (psf)	Allowable End Bearing Pressure (psf) [2]	Effective Unit Weight (pcf) [3]	Allowable Passive Pressure (psf)	Cohesion (psf)	Internal Angle of Friction (Degrees)	Strain ε_{50} [4]	Lateral Subgrade Modulus (pci) [4]
Fill 0 – 4½	Ignore	Ignore	Ignore	Ignore	Ignore	Ignore	Ignore	Ignore
Soil [5] Not Applicable 4½ – 29	160	--	95	750	750	--	0.015	125
Limestone Below 18 - 29	1,600	25,000 [2]	68	7,000	7,000	--	0.0005	2,500

1. Pier observation is recommended to adjust pier length if variable soil conditions are encountered.
2. Minimum pier length of 4 diameters required. The drilled pier must extend 3 feet, or one pier diameter, whichever is greater, into the bearing strata to achieve the full listed capacity. Terracon should be contacted if the pier length is less than four times the pier diameter as modifications to our design parameters may be warranted.
3. Assumes water level at 18 feet.
4. Lateral subgrade modulus and ε_{50} values provided above are to be used with LPILE^{plus} software.
5. Not applicable for subject site due to voids in the bedrock.

The above-indicated cohesion and lateral subgrade modulus values are ultimate values without factors of safety. The end bearing is an allowable parameter with a factor of safety of 3. The skin friction and passive resistance are allowable parameters with factors of safety of 2. The values given in the above table are based on our borings and past experience with similar soil types. Lateral resistance and friction in the upper 3 feet should be ignored due to the potential effects of frost action, desiccation, and drilling disturbance.

Long-term settlement of a drilled shaft foundation designed and constructed in accordance with the recommendations presented in this report, should be about ½ inch or less.

Terracon recommends that the drilled pier locations be probed a minimum of 5 feet below any encountered voids to limit the risk of bearing the drilled pier on thin sections of limestone over voids. Long-term settlement of a drilled shaft foundation designed and constructed in accordance with the recommendations presented in this report, should be about ½ inch or less.

4.3.2.2 Drilled Pier Construction Considerations

Pier drilling into the limestone bedrock will be difficult and concentrated effort and/or core barrels may be necessary to advance the shaft excavation through zones of gravel, cobbles, boulders, and/or weathered bedrock overlying competent bedrock. Groundwater was encountered in boring B-4. Therefore, temporary casing may be needed to advance drilled pier excavations. Temporary casing should be installed when personnel enter the shafts to clean and/or test the bearing surface. Additionally, Terracon recommends that casing be used when drilled piers extend through bedrock voids to limit the amount of grout loss in the void. Higher than normal grout takes should also be anticipated when drilling through the bedrock.

The bottom of the pier excavations should be cleaned of any water and loose material before placing reinforcing steel and concrete. A minimum shaft diameter of at least 30 inches is required for entry of construction and testing personnel, and to facilitate clean-out and possible dewatering of the pier excavation.

Concrete should be placed soon after excavating to reduce bearing surface disturbance. It is recommended the geotechnical engineer be retained to observe and test the foundation bearing materials. Any water accumulating in the pier excavation should be pumped from the excavation or the water level should be allowed to stabilize and then concrete should be placed using the tremie method.

If concrete will be placed as the temporary casing is being removed, we recommend the concrete mixture be designed with a slump of about 5 to 7 inches to reduce the potential for arching when removing the casing. While removing the casing from a pier excavation during concrete placement, the concrete inside the casing should be maintained at a sufficient level to resist any earth and hydrostatic pressures outside the casing during the entire casing removal procedure. Additionally, higher than normal grout takes should be anticipated due to the presence of voids in the bedrock material.

We recommend that a representative of Terracon be present during drilling activities to evaluate the materials removed from the drilled pier excavations to evaluate when adequate capacity has been developed, to observe the base of the drilled pier to evaluate that the cuttings have been adequately removed, and also to observe concrete placement.

4.4 Floor Slabs

If undocumented fill is encountered, the undocumented fill should be removed and replaced as previously discussed. If deep foundations are selected for the subject site the use of structural floor slabs supported by the deep foundations is also suggested. The use of structural floor slabs would bridge over settlements that may occur from the collapse of the void or from migration of soils through solution features. If a structural floor slab is selected undocumented fills below the structural slab could be left in place. Grade-supported floor slabs should be supported on a minimum of 24 inches of LVC material. LVC fill should be placed and compacted as recommended in section **4.2 Earthwork**.

4.4.1 Floor Slab Design Recommendations

Item	Description
Floor slab support [1, 2]	A minimum 24-inch thick low volume change (LVC) layer over suitable native clay or engineered fill
Modulus of subgrade reaction	100 pounds per square inch per inch (psi/in) for point loading conditions
Granular course beneath slab [3, 4, 5]	Minimum 4 inches
Capillary break layer thickness [4, 5]	Minimum 4 inches

1. We recommend an LVC layer be present below the floor slab. This layer should be at least 24 inches thick and should meet the LVC material criteria outlined in this report in section **4.2 Earthwork**. Where existing soils meet the LVC criteria, they should be moisture conditioned and recompacted as recommended in this report.
2. We recommend subgrades be maintained in a relatively moist condition until the floor slab is constructed. If the subgrade should become desiccated or saturated prior to construction of the floor slab, the affected material should be removed or the materials be scarified, moisture conditioned, and recompacted. Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slab.
3. 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.
4. If penetration of moisture vapor through the slab is a concern, in our opinion the floor slab design should include a capillary break layer in addition to a vapor retarder (refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of vapor

retarders). In our opinion, 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.

5. These granular materials may be considered part of the LVC zone.

Where appropriate, saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks in floor slabs that develop should be sealed with a water-proof, non-extruding compressible compound specifically recommended for concrete and wet environments.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.4.2 Floor Slab Construction Considerations

On most project sites, the grading is generally accomplished early in the construction phase. However as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, the floor slab subgrade may not be suitable for placement of base rock and concrete, and corrective action may be required.

Prior to placement of the base aggregate, we recommend that the floor slab subgrade be rough graded and then thoroughly evaluated for stability, uniformity and moisture. If there is no conflict with installed utilities, we recommend the subgrade be proofrolled with a loaded, tandem-axle dump truck. During the evaluations, 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 affected material with properly compacted fill. All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the aggregate base and concrete.

4.5 Seismic Considerations

Code Used	Site Classification
2012 International Building Code (IBC) [1]	D [2]

1. In general accordance with the *2012 International Building Code,* Table 1613.5.2.
2. The 2012 International Building Code requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100-foot soil profile determination. Borings for this report extended to a maximum depth of

approximately 31 feet and the site classification assumes that similar or stiffer soils extend to at least 100 feet. Additional exploration to deeper depths or a geophysical exploration could be considered to further evaluate the seismic site class.

4.6 Retaining Walls

It is Terracon's understanding that retaining walls will not be utilized at the subject site for the support of buildings or pavement areas. If retaining walls are planned or needed to support the building or parking areas, Terracon should be contacted before the construction of the retaining wall to provide additional recommendations concerning the retaining wall construction and location of the retaining wall. The improper use and construction of retaining walls may lead to foundation failure, floor slab failure, and overall site instability. Non-reinforced block retaining walls of any height should not be placed within the influence area of the building foundations.

4.7 Pavements

Pavements are typically more tolerant of non-uniform subgrade conditions than foundations and floor slabs. As discussed in section **4.1 Geotechnical Considerations**, portions of existing undocumented fill may remain in the pavement areas if the owner is willing to accept the potential for higher than normal settlement, distress, and/or maintenance in exchange for reduced construction costs. If the owner is not willing to accept the risks of supporting pavements over existing undocumented fill materials, the existing fill should be removed and replaced to support pavements.

4.7.1 Pavement Subgrade Preparation

On most project sites, the grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturate some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose soils to improve stability temporarily. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the upper 9 inches of the subgrade be evaluated and the pavement subgrades be proofrolled within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. 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 material with compacted structural fill.

After proofrolling and repairing deep subgrade deficiencies, the entire subgrade should be scarified and developed as recommended in section **4.2 Earthwork** to provide a more consistent subgrade for pavement construction. Areas that appear desiccated (dry) following site stripping may require further undercutting and moisture conditioning. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.7.2 Pavement Design Considerations

Traffic loading was not provided; however, we anticipate the new parking areas will be primarily used by personal vehicles (cars and pick-up trucks). A limited number of delivery trucks and refuse disposal vehicles are expected in the drive lanes and loading areas (estimated maximum of 10 trucks per week).

Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to parking lots and drives should slope down from pavement edges at a minimum 2 percent;
- The subgrade and the pavement surface should have a minimum 2 percent slope to promote proper surface drainage;
- Drainage should be provided for the pavement base course;
- Joint sealant should be installed and cracks sealed immediately;
- All landscaped areas in, or adjacent to pavements should be sealed to reduce moisture migration to subgrade soils;
- Compacted, low permeability backfill should be placed against the exterior side of curbs and gutters; and,
- To reduce the likelihood of water seeping beneath curbs into the pavement base course; curb, gutter and/or sidewalks should bear directly on clay subgrade soils rather than on unbound granular base course materials.

4.7.3 Estimates of Minimum Pavement Thickness

Asphaltic concrete pavements can be used for pavements such as drive lanes and parking areas. We recommend portland cement concrete (PCC) pavements for entrance aprons, trash container pads, loading docks, drive-through lanes, and in any other areas subjected to heavy wheel loads and/or channelized or turning traffic.

Recommended thicknesses for medium and light-duty areas are provided in the table below.

Pavement Section Thickness (inches)						
Traffic Area	**Alternative**	**Asphalt Concrete**		**Portland Cement Concrete** [1]	**Aggregate Base Course** [2]	**Total Thickness**
		Surface Course	**Base Course**			
Light Duty (car parking)	PCC	--	--	5	4	9
	ACC	2	2	--	6	10
Medium Duty (drives and loading areas)	PCC	--	--	6	4	10
	ACC	2	3	--	6	11
Trash Container Pad [3]	PCC	--	--	7	4	11

1. 4,000 psi at 28 days, 4-inch maximum slump and 5 to 7 percent air entrained. PCC pavements are recommended for trash container pads and in any other areas subjected to heavy wheel loads and/or turning traffic.
2. Crushed stone (MoDOT Type 5 aggregate)
3. The trash container pad should be large enough to support the container and the tipping axle of the collection truck.

Although not required for structural support, a minimum 4 inch thick aggregate base course layer is recommended for the PCC pavements to help reduce the potential for slab curl, shrinkage cracking, and subgrade "pumping" through joints. Proper joint spacing will also be required for PCC pavements to resist excessive slab curling and shrinkage cracking. All joints should be sealed to restrict entry of foreign material and dowelled where necessary for load transfer.

4.7.4 Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrades should be graded to provide positive drainage within the granular base section. We recommend the subgrades beneath the pavement sections be graded to slope toward the storm water catch basins. A drainage collection and removal system (e.g., finger drains) should be used to allow water in the granular base to enter the storm sewers, or otherwise be removed from the granular base.

4.7.5 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a pavement maintenance program.

Additional engineering observation is recommended to determine the type and extent of a cost effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 GENERAL COMMENTS

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

Support of pavements over existing fill is discussed in this report. However, even with the recommended construction testing, there is a risk that unsuitable materials within or buried by the fill will not be discovered. This risk cannot be eliminated without removing the fill but can be reduced by thorough exploration and testing.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, 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. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, 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.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

Field Exploration Description

The boring locations were laid out in the field using a scaled site plan provided by the client and referencing available site features. Angles were estimated. The ground surface elevations at the boring locations were obtained using an engineer's level and survey rod and were rounded to the nearest ½-foot. The elevations are referenced to the foundation of the sign located in the southeast corner of the subject site. The ground surface elevations at the boring locations were estimated using a topographic site plan provided by the client and are rounded 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 an ATV-mounted, rotary drill rig using continuous-flight, hollow-stem augers to advance the boreholes. Samples of the soils encountered in the borings were obtained using the split-barrel procedures. Samples of the material encountered below practical auger refusal were obtained using NQ2-sized diamond bit coring techniques.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance (SPT N-value). This value is used to estimate the in-situ relative density of cohesionless soils and the consistency of cohesive soils.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT N-value. The effect of this efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Selected borings were advanced beyond split-spoon refusal utilizing NQ2-sized diamond bit rock coring techniques. In this process the core barrel is advanced in incremental lengths (runs) of 5 feet. The length of the material recovered as compared to the length of the individual run is calculated as the percent recovery for that run. The rock quality designation (RQD) is calculated as the ratio of pieces of the recovered core that are at least 4 inches long and hard and sound, divided by the total length of the run (not the recovered length). Breaks obviously caused by the coring process are ignored.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further observation, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

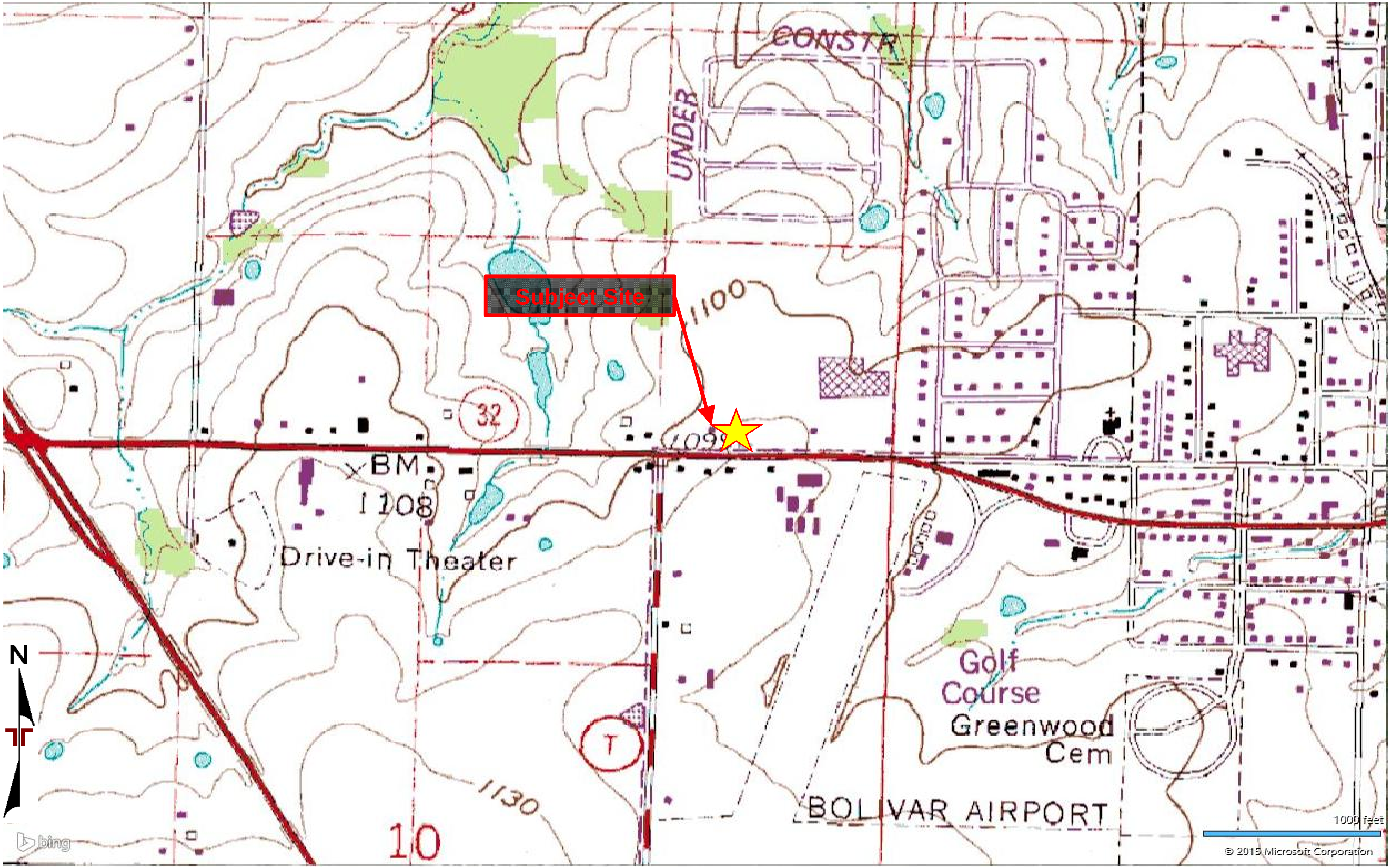


Image from the USGS Topographic Maps and Bing

Project Manager: RTH	Project No. B5155041	Terracon Consulting Engineers & Scientists	TOPOGRAPHIC MAP	Exhibit
Drawn By: RTH	Scale: Noted on Image		Proposed Medical Center	A-2
Checked By: TGA	File Name: B5155041-A.pdf	4765 West Junction Street Springfield, MO 65802	Northwes corner of Highway 32 and Davis Drive	
Approved By: TGA	Date: 9/9/2015	P [417] 864-5100 F [417] 864-0871	Bolivar, Missouri	

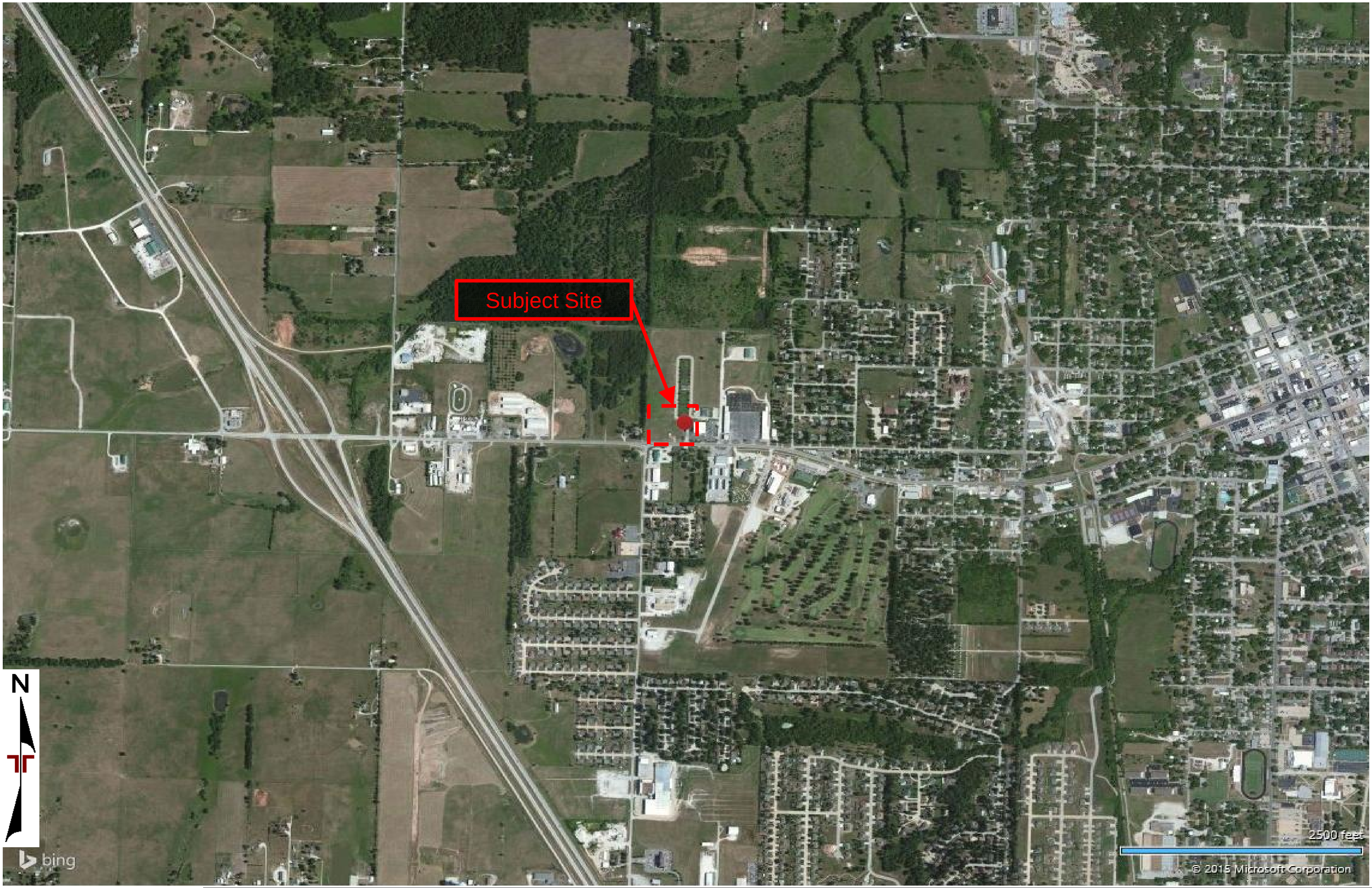


Image from Bing

Project Manager: RTH	Project No. B5155041		
Drawn By: RTH	Scale: NOT TO SCALE		
Checked By: TGA	File Name: B5155041-A.pdf		
Approved By: TGA	Date: 9/9/2015		

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LOCATION MAP

Proposed Medical Center

Northwes corner of Highway 32 and Davis Drive

Bolivar, Missouri

Exhibit

A-3

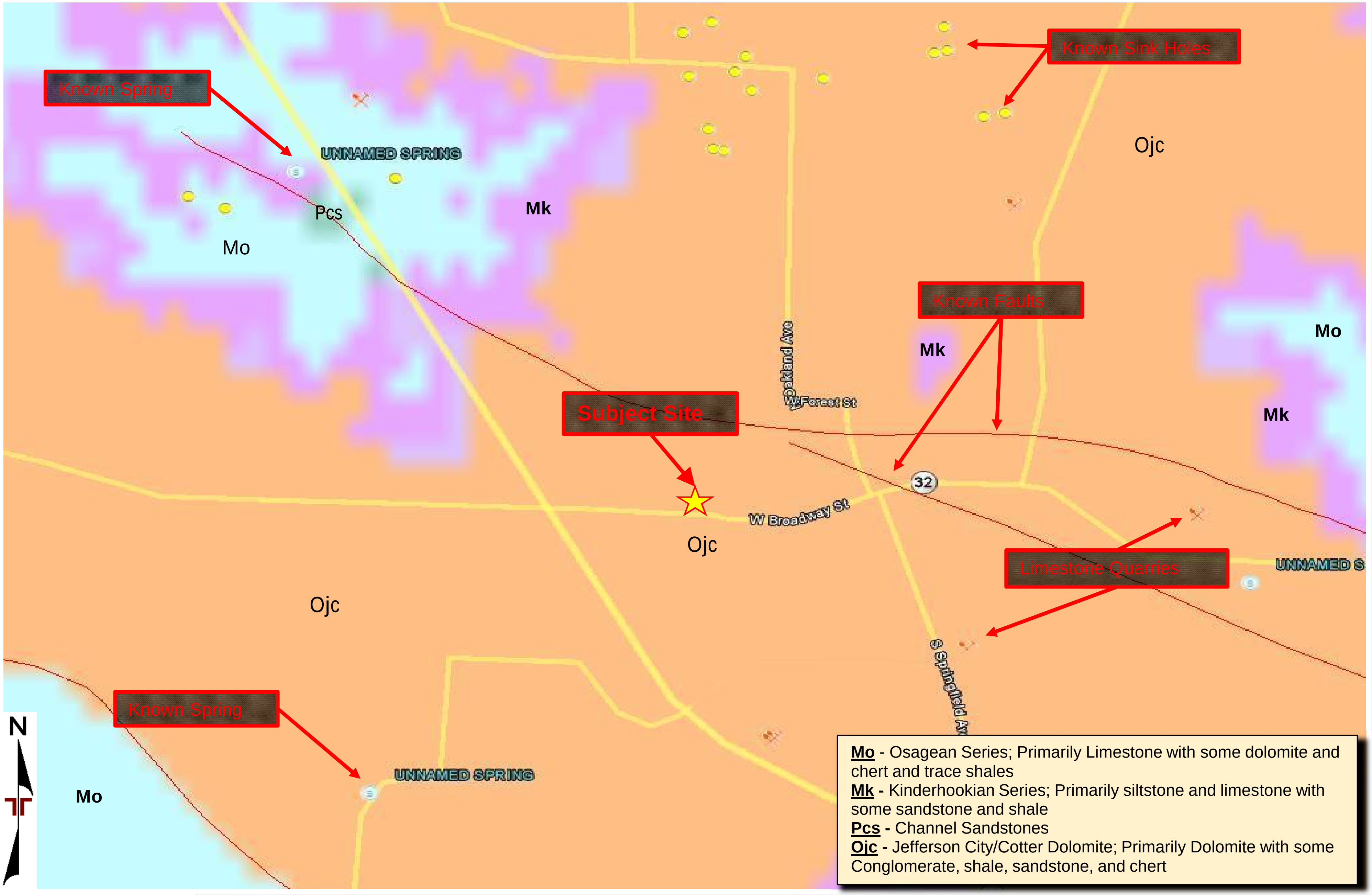

Image and geologic information provided by the MDNR by overlay through Google[TM] Earth Pro.

Project Manager: RTH	Project No. B5155041
Drawn By: RTH	Scale: Noted on Image
Checked By: TGA	File Name: B5155041-A.pdf
Approved By: TGA	Date: 9/9/2015

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GEOLOGIC MAP

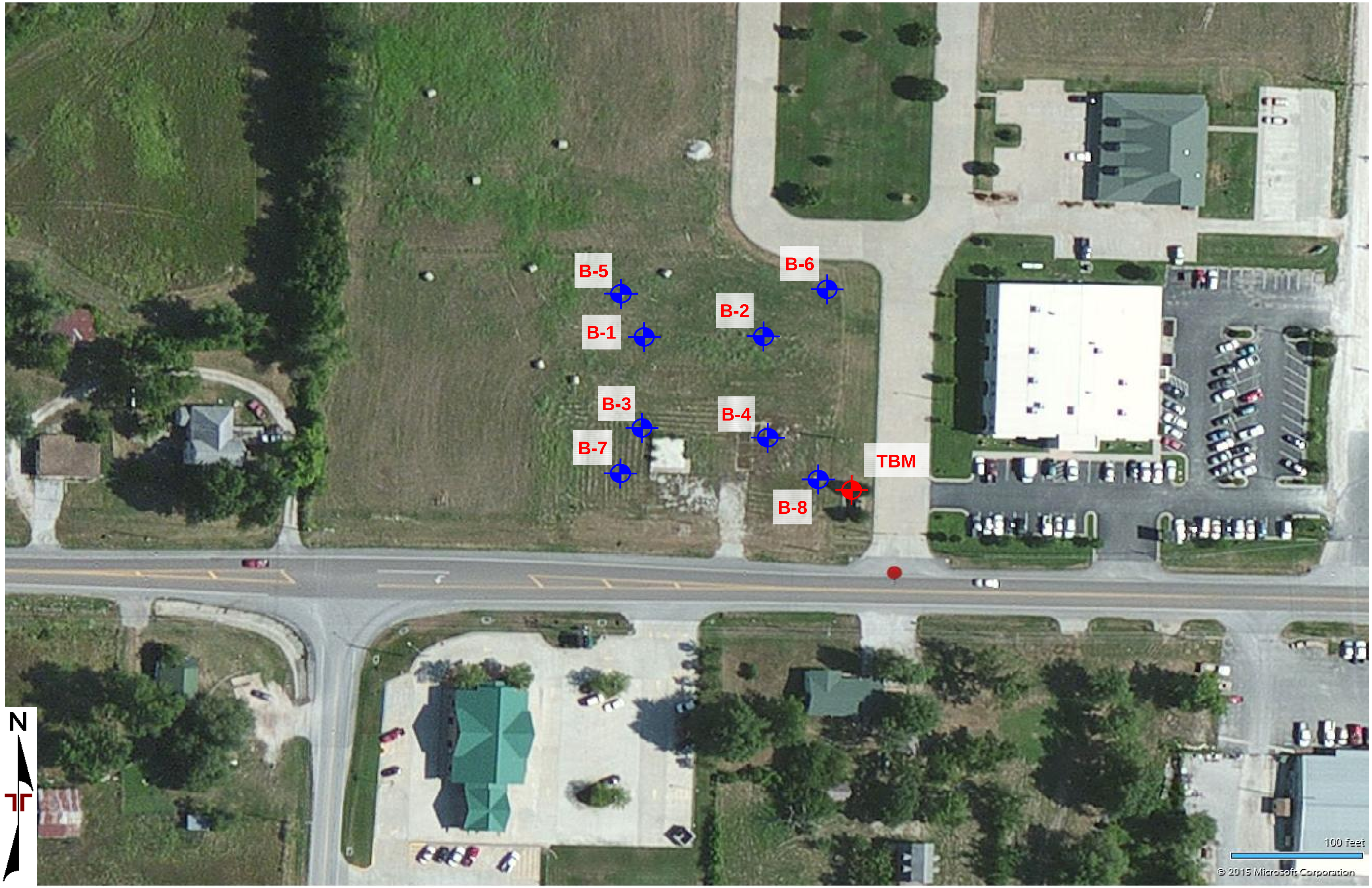
Proposed Medical Center

Northwes corner of Highway 32 and Davis Drive

Bolivar, Missouri

Exhibit

A-4



Temporary Benchmark

Terracon Boring

Image provided by the Bing

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Checked By: TGA	File Name: B5155041-A.pdf		
Approved By: TGA	Date: 9/9/2015		

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BORING LOCATION DIAGRAM

Proposed Medical Center

Northwes corner of Highway 32 and Davis Drive

Bolivar, Missouri

Exhibit

A-5

BORING LOG NO. B-1

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev
Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6131° Longitude: -93.4342°

Approximate Surface Elev: 92.5 (Ft.) +/-

DEPTH	DESCRIPTION	ELEVATION (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.9	**TOPSOIL**	91.5+/-					
2.0	**FILL - SILTY CLAY (CL-ML)**, with sand and gravel,trace organics, dark brown	90.5+/-	10	2-7-12 N=19	3000 (HP)	17	
4.0	**FILL - SANDY SILTY CLAY (CL-ML)**, with gravel, trace organics, dark brown to light brown and red	88.5+/-	12	10-16-7 N=23	7000 (HP)	27	
13.0	**FAT CLAY (CH)**, trace gravel, red with light gray, medium stiff	79.5+/-	18	1-2-4 N=6	2000 (HP)	51	74-26-48
			18	1-2-2 N=4	1000 (HP)	49	
16.0	**FAT CLAY (CH)**, with gravel, light gray and light brown, medium stiff, Residual soil	76.5+/-	16	2-2-5 N=7	4000 (HP)	32	
18.0	**LIMESTONE**, light gray, moderately weathered	74.5+/-	0	50/0"	N/A		
			40	RQD=66%	N/A		
19.5	**VOID**, sudden drop in core barrel	73+/-					
31.0	**LIMESTONE**, light gray, moderately weathered	61.5+/-	48	RQD=60%	N/A		
			60	RQD=66%	N/A		

Boring Terminated at 31 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-6

BORING LOG NO. B-2

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev, Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive, Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6131° Longitude: -93.4339°

Approximate Surface Elev: 96 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7	**TOPSOIL**	95.5+/-								
	FILL - SILTY CLAY (CL-ML), with gravel and organics, dark brown				X	10	2-5-11 N=16	500 (HP)	21	
4.5		91.5+/-			X	6	6-7-6 N=13	6500 (HP)	22	
	FAT CLAY (CH), with gravel, red and light gray, stiff		5		X	18	2-7-7 N=14	3000 (HP)	36	
	medium stiff				X	16	4-2-2 N=4	2500 (HP)	46	
			10							
	medium stiff		15		X	18	2-2-4 N=6	2000 (HP)	33	
18.0		78+/-				0	50/0"	N/A		
	Auger refusal on apparent bedrock or boulder. ***Auger Refusal at 18 Feet***									

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-7

BORING LOG NO. B-3

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev
Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6129° Longitude: -93.4342°

Approximate Surface Elev: 93 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7 **TOPSOIL**	92.5+/-								
FILL - SILTY CLAY (CL-ML), with sand and organics, dark brown				X	10	2-2-7 N=9	3000 (HP)	18	
3.5	89.5+/-								
FAT CLAY (CH), with gravel, trace hair roots, brown and red, stiff				X	12	3-6-7 N=13	7000 (HP)	32	63-28-35
no roots noted below 5 feet		5							
				X	18	3-4-7 N=11	6000 (HP)	42	
				X	14	4-5-8 N=13	6000 (HP)	43	
possible sandstone seem at 9 1/2 feet		10							
14.0	79+/-								
FAT CLAY (CH), with chert seems, light gray with red, stiff, Residual soil		15		X	18	5-7-8 N=15	5000 (HP)	25	
16.6	76.5+/-				1	50/1"	N/A		
Auger refusal on apparent bedrock or boulder.									
Auger Refusal at 16.6 Feet									

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-8

BORING LOG NO. B-4

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev
Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6129° Longitude: -93.4339°

Approximate Surface Elev: 96 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7	**TOPSOIL**	95.5+/-								
3.0	**FILL - SANDY SILTY CLAY (CL-ML)**, with organics, brown	93+/-			X	12	3-9-9 N=18	6000 (HP)	13	19-12-7
5.5	**SANDY LEAN CLAY (CL)**, brown, stiff, possible fill	90.5+/-	5		X	12	5-9-9 N=18	4000 (HP)	4	
13.0	**FAT CLAY (CH)**, trace gravel, reddish brown, stiff	83+/-	10		X	18	3-4-4 N=8	3000 (HP)	17	
					X	18	3-7-9 N=16	6000 (HP)	17	
17.0	**FAT CLAY (CH)**, with sand, trace gravel, red, stiff	79+/-	15		X	18	5-9-9 N=18	5000 (HP)	37	
23.0	**FAT CLAY (CH)**, trace sand and gravel, red, medium stiff	73+/-	20		X	18	2-3-4 N=7	3500 (HP)	43	
28.0	**FAT CLAY (CH)**, trace gravel, yellowish brown and reddish brown, stiff, residual soil	68+/-	25	▽ (while drilling), ▽ (at completion)	X	14	2-4-6 N=10	3500 (HP)	44	
28.9	**SHALE**, gray, completely weathered	67+/-			X	4	50/5"	N/A	17	

Boring Terminated at 28.9 Feet

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

▽ *While drilling*

▽ *At completion of drilling*

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-9

BORING LOG NO. B-5

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev
Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6132° Longitude: -93.4342°

Approximate Surface Elev: 91 (Ft.) +/-

GRAPHIC LOG	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.7	**TOPSOIL**	90.5+/-								
	2.5	**SILTY CLAY (CL-ML)**, brown, stiff, possible fill, classification based on auger cuttings	88.5+/-			X	0	5-5-4 N=9	N/A		
	5.5	**FAT CLAY (CH)**, with silt seems, red with brown, stiff	85.5+/-	5		X	16	3-3-5 N=8	5000 (HP)	42	
	10.0	**FAT CLAY (CH)**, with gravel, trace sand, red with yellowish brown, medium stiff to stiff	81+/-			X	18	2-3-3 N=6	3000 (HP)	54	
				10		X	18	5-5-6 N=11	5000 (HP)	28	

Boring Terminated at 10 Feet

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/28/2015	Boring Completed: 8/28/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-10

BORING LOG NO. B-6

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6132° Longitude: -93.4337°

Approximate Surface Elev: 96 (Ft.) +/-

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.9	**TOPSOIL**	95+/-								
2.0	**FILL - GRAVELLY SILTY CLAY (CL-ML)**, with sand, dark brown	94+/-			X	10	5-5-7 N=12	9000 (HP)	30	
5.5	**GRAVELLY FAT CLAY (CH)**, trace sand, red, very stiff	90.5+/-	5		X	12	5-8-14 N=22	4000 (HP)	27	
10.0	**FAT CLAY (CH)**, with gravel, yellowish red, medium stiff to stiff	86+/-	10		X	16	3-4-7 N=11	3500 (HP)	37	
					X	18	2-4-3 N=7	3000 (HP)	44	

Boring Terminated at 10 Feet

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/28/2015	Boring Completed: 8/28/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-11

BORING LOG NO. B-7

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev
Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6128° Longitude: -93.4343°

Approximate Surface Elev: 93 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7	**TOPSOIL**	92.5+/-								
	FILL - GRAVELLY SILTY CLAY (CL-ML), trace organics, dark brown				X	6	4-6-8 N=14	3000 (HP)	23	
4.0		89+/-			X	8	9-12-8 N=20	6500 (HP)	28	
	GRAVELLY FAT CLAY (CH), with sand, red, stiff		5							
7.0		86+/-			X	12	4-6-5 N=11	4000 (HP)	51	
	FAT CLAY (CH), with gravel, red and yellowish brown, medium stiff				X	18	2-3-4 N=7	2500 (HP)	56	
10.0		83+/-	10							

Boring Terminated at 10 Feet

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-12

BORING LOG NO. B-8

PROJECT: Proposed Medical Center

CLIENT: PCI HealthDev Dallas, Texas

SITE: NW Corner of Highway 32 and Davis Drive Bolivar, Missouri

LOCATION See Exhibit A-2

Latitude: 37.6128° Longitude: -93.4338°

Approximate Surface Elev: 98 (Ft.) +/-

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.7	**TOPSOIL**	97.5+/-								
3.0	**FILL - SILTY CLAY (CL-ML)**, with gravel, sand, and organics, dark brown	95+/-			X	6	4-6-6 N=12	8000 (HP)	19	
5.5	**FAT CLAY (CH)**, trace sand and gravel, red with brown and gray, stiff	92.5+/-	5		X	8	3-3-5 N=8	6000 (HP)	29	
7.0	**FAT CLAY (CH)**, red and light gray, stiff	91+/-			X	18	2-4-6 N=10	6000 (HP)	35	
10.0	**SANDY FAT CLAY (CH)**, reddish brown, stiff, Residual soil	88+/-	10		X	14	8-8-8 N=16	5500 (HP)	17	

Boring Terminated at 10 Feet

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

Hammer Type: Automatic SPT Hammer

Advancement Method:
3 1/4" HSA

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-1 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

No free water observed

Terracon
4765 West Junction Street
Springfield, Missouri

Boring Started: 8/27/2015	Boring Completed: 8/27/2015
Drill Rig: CME-550	Driller: TMc
Project No.: B5155041	Exhibit: A-13

APPENDIX B
SUPPORTING INFORMATION

Laboratory Testing

Soil samples were tested in the laboratory to measure their natural water content (ASTM D4959). A hand penetrometer was used to estimate the unconfined compressive strength of some cohesive samples. The hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. Atterberg limits tests (ASTM D4318) were performed on selected samples. The test results are provided on the boring logs included in Appendix A.

As part of the testing program, samples were examined in our laboratory and classified in accordance with the General Notes and the Unified Soil Classification System (USCS) based on the material's texture and plasticity (ASTM D2487 and ASTM D2488). The USCS group symbol is shown on the boring logs, and a brief description of the USCS is included with this report in Appendix C.

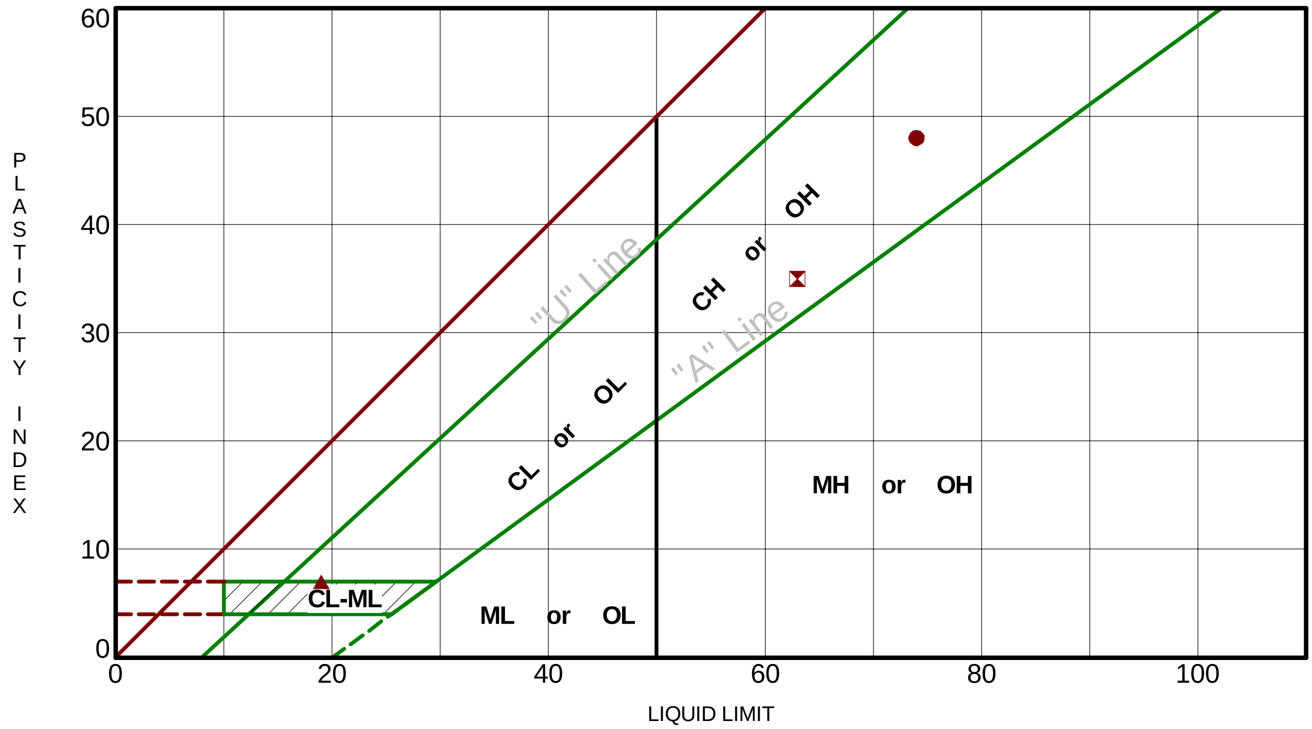
The rock core samples were visually observed and classified in the laboratory. Percent recovery and rock quality designation (RQD) were calculated for these samples and are noted at their depths of occurrence on the boring log.

Classification and descriptions of rock core samples are in general accordance with the General Notes – Rock Properties attached in Appendix C, and were based on visual observations. Petrographic analysis of thin sections may indicate other rock types.

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**B-1**	**6 - 7.5**	**74**	**26**	**48**		**CH**	**High Plastic Clay**
⧗	**B-3**	**3.5 - 5**	**63**	**28**	**35**		**CH**	**High Plastic Clay**
▲	**B-4**	**1 - 2.5**	**19**	**12**	**7**		**CL-ML**	**Silty Clay**

PROJECT: Proposed Medical Center

SITE: NW Corner of Highway 32 and Davis Drive
Bolivar, Missouri

Terracon
4765 West Junction Street
Springfield, Missouri

PROJECT NUMBER: B5155041

CLIENT: PCI HealthDev
Dallas, Texas

EXHIBIT: B-2

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

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

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

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

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

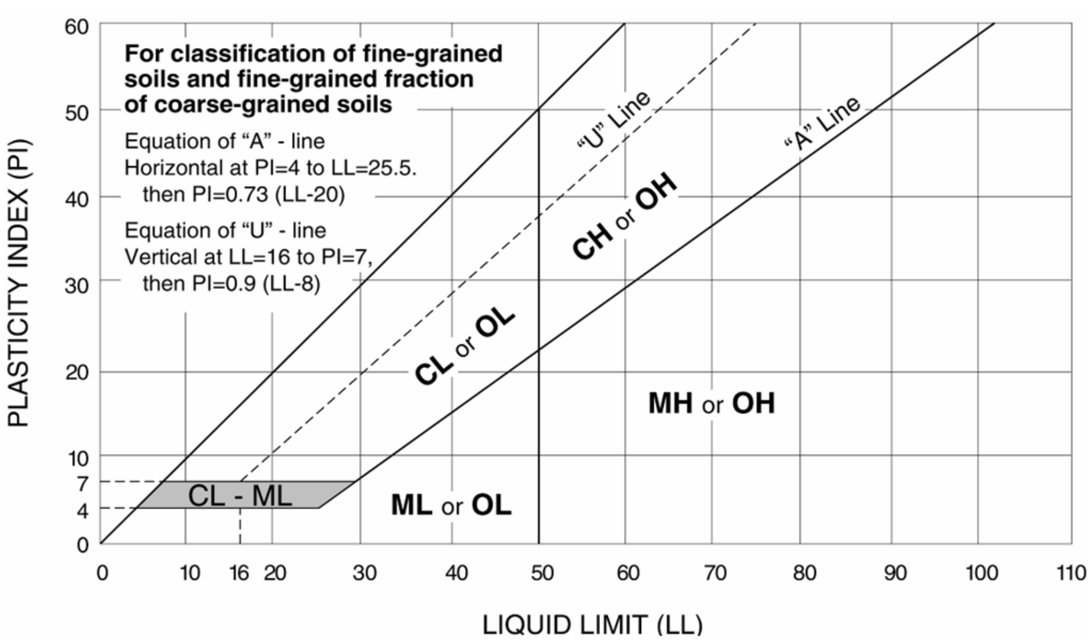
UNIFIED SOIL CLASSIFICATION SYSTEM

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 / Liquid limit - not dried < 0.75	OL	Organic clay [K,L,M,N]
					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 / Liquid limit - not dried < 0.75	OH	Organic clay [K,L,M,P]
					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

Exhibit C-2

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

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