

Geotechnical Engineering Report

**Lawton Indian Hospital Diagnostic Imaging &
Emergency Department Addition
1515 Lawrie Tatum Road
Lawton, Oklahoma**

June 10, 2013

Terracon Project No. 03125035 Revised

Prepared for:

James R. Childers Architect, Inc.
Tahlequah, Oklahoma

Prepared by:

Terracon Consultants, Inc.
Oklahoma City, Oklahoma

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June 10, 2013

Revised

Terracon

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Re: Geotechnical Engineering Report
Lawton Indian Hospital Diagnostic Imaging &
Emergency Department Addition
1515 Northeast Lawrie Tatum Road
Lawton, Oklahoma
Terracon Project No. 03125035

Dear Mr. Boren:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our proposal number P03120707 dated January 23, 2012. This geotechnical engineering report presents the results of the subsurface exploration and provides seismic site class, 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.

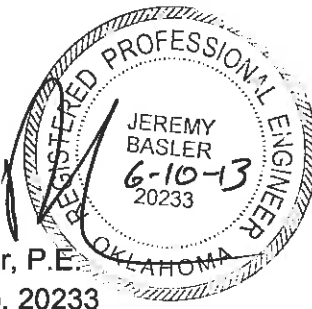
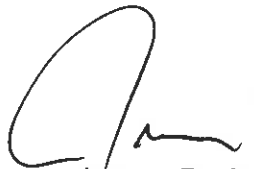
Sincerely,

Terracon Consultants, Inc.

Cert. Of Auth. #CA-4531 exp. 6/30/13



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EXECUTIVE SUMMARY

An additional geotechnical exploration has been performed for the proposed additions at the Lawton Indian Hospital in Lawton, Oklahoma. Terracon's geotechnical scope of work included the advancement of three test borings to approximate depths of 5 to 44.5 feet below existing site grades.

Based on the information obtained from our subsurface exploration, the site is suitable for development of the proposed project. The following geotechnical considerations were identified:

- The borings generally encountered lean to fat clays with varying amounts of sand to a depth of about 13.5 feet, underlain by poorly graded sand with varying amounts of gravel, clay and cobbles to a depth of about 33.5 feet. The overburden soils were underlain by highly weathered to weathered shale from a depth of about 33.5 feet extending to the boring termination depth. Fill materials consisting of sandy lean clay were encountered in boring B-1 to a depth of about 3.5 feet. Groundwater was encountered in boring B-1 at a depth of about 33.5 feet while drilling and at a depth of about 42 feet after boring completion.
- The new building can be supported by drilled pier foundations bearing on the highly weathered to weathered shale encountered approximately 33.5 feet below existing grade.
- The soils encountered within the anticipated depth of seasonal moisture change were generally high plasticity clays. These soils may experience significant volume changes with variation in the subgrade moisture content. A minimum of 4 1/2 feet of low volume change materials are recommended beneath the floor slab.
- Chemical modification of the pavement subgrade is recommended to improve its long-term stability and pavement performance.
- We recommend earthwork on the project be observed and evaluated by a qualified geotechnical engineering company. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during construction.

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

**GEOTECHNICAL ENGINEERING REPORT
LAWTON INDIAN HOSPITAL DIAGNOSTIC IMAGING &
EMERGENCY DEPARTMENT ADDITION
1515 LAWRIE TATUM ROAD
LAWTON, OKLAHOMA
Terracon Project No. 03125035
June 10, 2013**

1.0 INTRODUCTION

Terracon has previously performed a geotechnical exploration at the subject site. Our findings and recommendations are documented in Terracon Report No. 03055150, dated June 10, 2005. The data and recommendations presented herein are intended to supplement those provided in the earlier report.

This report presents the results of our geotechnical engineering services performed for the proposed addition at the Lawton Indian Hospital in Lawton, Oklahoma. The purpose of these services is to provide information and additional geotechnical engineering recommendations relative to:

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

Lateral capacity design recommendations for the foundations can be provided once pier head reaction information and anticipated pier sizes are available.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibit A1

ITEM	DESCRIPTION
Structures	We understand the building addition consists of 1 level and the base level footprint is approximately 13,200 square feet of the new construction and 6,300 square feet of renovation. Associated parking, sidewalk, drive and fire lane areas will also be constructed.
Maximum loads	Columns: 2 to 30 kips (provided) Walls: 1 to 3 klf (provided) Slabs: 125 psf max (assumed)
Maximum allowable settlement	1-inch (assumed)
Grading	Grade changes for the proposed site were not provided to us at the time of this report; however, based on the boring elevations and the existing topography, we anticipate that minimal cut and/or fill will be necessary for this site.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	1515 Lawrie Tatum Road, Lawton, Oklahoma
Current ground cover	Asphaltic parking lot and drives and some vegetation.
Existing topography	Site is relatively flat.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Subsurface Profile

Specific conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs included in Appendix A of this report. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1A	13.5 feet	Lean clays, lean to fat clays and fat clays with varying amounts of sand	Soft to stiff

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1B (Boring B-1)	3.5 feet	Fill materials consisting of sandy lean clay	N/A
Stratum 2	33.5 feet	Poorly graded sand with gravel and cobbles, trace clay	Loose to dense
Stratum 3	below the boring termination depth	Highly weathered to weathered shale	Soft

Laboratory tests were conducted on selected soil samples and the test results are presented on the boring logs in Appendix A.

3.2 Groundwater

The borings were monitored while drilling and immediately after completing the drilling activities for the presence and level of groundwater. As reported in the lower left corner of the boring logs, groundwater was encountered in boring B-1 at a depth of about 33.5 feet while drilling and measured at a depth of about 42 feet after boring completion. Groundwater was not encountered in borings B-2 and B-3 at these times.

To obtain more accurate groundwater level information, longer observations in a monitoring well or piezometer that is sealed from the influence of surface water would be needed. Fluctuations in groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, altered natural drainage paths, and other factors not evident at the time the borings were advanced. Consequently, the designer and contractor should be aware of this possibility while designing and constructing this project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The borings generally encountered high plasticity clays with varying amounts of sand extending to depths of about 13.5 feet. The high plasticity clays encountered at the site may experience significant volume changes with variation in subgrade moisture content. To reduce the potential floor slab movement, some overexcavation and replacement of the on-site soils will be required.

Based on the subsurface conditions encountered and the expected structural loads, the building can be supported on drilled pier foundations.

Because of the potential for strength loss due to moisture increases in the clay soils, we recommend modifying the pavement subgrade with hydrated lime.

Expansive soils are present at this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other cosmetic damage such as uneven floor slabs will probably increase if effective drainage is not developed and maintained throughout the service life of the building, or if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

Existing fill materials were encountered to a depth of approximately 3.5 feet in boring B-1. We are not aware that compaction testing was performed during placement of the fill. The depth, composition and compaction of the existing fill materials can vary greatly over relatively small lateral and vertical distances. Because of the potential variability of fill, it will not be possible to accurately predict the amount of fill that may need to be removed and replaced to develop suitable support for the proposed improvements until site grading is underway. The depth and composition of the fill, observed at the discrete boring location, should only be used for estimating purposes. We encourage the owner to secure a base bid for removing and replacing a specified quantity of the existing fill. The owner should also secure unit rates for adding or deducting quantities from the base bid that includes costs for exporting unsuitable materials and importing approved replacement materials, if required.

Geotechnical engineering recommendations for foundation systems and other earth connected phases of the project are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing (which are presented in Appendices A and B), engineering analyses, and our current understanding of the proposed project.

4.2 Earthwork

The following presents recommendations for site preparation, excavations, subgrade preparation and placement of engineered fills on the project. The recommendations presented for design and construction of earth supported elements including foundations,

slabs, and pavements are contingent upon following the recommendations outlined in this section. All grading for the structure should incorporate the limits of the proposed structure.

We recommend earthwork on the project be observed and evaluated by a qualified geotechnical engineering company. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

4.2.1 Site Preparation

Site preparation for the proposed project should include removing any remaining vegetation, topsoil, remaining foundations, floor slabs, pavements and any other unsuitable surface materials from the areas of new construction. The depressions or excavations created during removal of the existing pavements should be cleaned of loose material and backfilled as outlined in the following paragraphs. We recommend removal depths be determined at the time of construction by a representative of a qualified geotechnical engineering company.

4.2.2 Excavations

Excavations deeper than 4 feet should meet all OSHA and other applicable safety regulations. Grading should develop and maintain effective drainage away from open excavations.

4.2.3 Subgrade Preparation

After removing the existing pavements, vegetation, topsoil and performing any required cuts, but before placing any fill or constructing the floor slabs, we recommend undercutting the building area to allow placing at least 4 1/2 feet of low volume change soil below the design finish subgrade elevation.

After site stripping and completing any required cuts, but before placing any fill, we recommend the building and pavement areas be proofrolled with a loaded, tandem-axle dump truck weighing at least 25 tons (under the observation of a representative of a qualified geotechnical engineering company) to locate any soft or unstable zones. The proofrolling should involve overlapping passes in mutually perpendicular directions. Where rutting or pumping is observed during proofrolling, the unstable soils should be overexcavated and replaced with an approved low volume change soil as described in following sections if it cannot be effectively compacted in-place.

Soft subsurface soils with high moisture contents were encountered at the site. Therefore, it is probable that wet or unstable areas will be encountered during proofrolling that may require drying by aeration or removal and replacement. Scarifying and aerating the soil may

be sufficient to reduce the moisture content during warm, dry weather, but this will be less effective during periods of cool or wet weather. Removing and replacing wet soils should be expected if site preparation is conducted during cool and/or wet conditions. The amount of unstable soil cannot be determined at this time.

After a successful proofroll, we recommend scarifying the exposed subgrade soils to a depth of 8 inches in the building area and in the pavement area if fill is required. The scarified soil should be adjusted to a workable moisture content that is above its optimum value, as determined by test method ASTM D-698 (Standard Proctor), prior to being compacted to at least 95 percent of its maximum dry density.

4.2.4 Fill Materials and Placement

All fill required to develop the design subgrade elevation should be an approved low volume change cohesive material that is free of organic matter and debris.

By our definition, low volume change cohesive soils for this project should meet the following property requirements:

Fill Type¹	Acceptable Location for Placement
Cohesive Low Volume Change Soils with (LL<40, 7<PI<12)	All locations and elevations
On-Site Soils	Pavement areas ²
<ol style="list-style-type: none"> 1. Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory Atterberg Limits and moisture-density testing. The tests will provide a basis for material acceptance and evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained. 2. Provided the top 8 inches are modified with hydrated lime as discussed in the Pavements section of this report. 	

The zone of fill compacted to meet this criteria should extend beyond the building footprint at least 1 foot laterally for each foot of fill required to develop design grade.

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift.

We recommend the exposed subgrade and each lift of compacted fill be tested, evaluated, and reworked, as necessary, until approved by a qualified geotechnical engineering company's representative prior to placement of additional lifts. We recommend that each lift

of fill be tested for density and moisture content at a rate of one test for every 2,500 square feet of compacted fill and one test for every 100 linear feet of compacted utility trench backfill.

4.2.5 Compaction Requirements

Recommended compaction and moisture content criteria for cohesive engineered fill materials are as follows:

ITEM	DESCRIPTION
Fill Lift Thickness	9-inches or less in loose thickness
Compaction Requirements	At least 95% of the material's dry density as determined by the standard Proctor test method, ASTM D-698
Moisture Content	Its optimum value or above as determined by the standard Proctor test method, ASTM D-698 at the time of placement and compaction

4.2.6 Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the development. Infiltration of water into utility trenches or foundation excavations should be prevented during construction. Planters and other surface features which could retain water in areas adjacent to the building should be sealed or eliminated. In areas where sidewalks or paving do not immediately adjoin the structure, we recommend that protective slopes be provided with a minimum grade of approximately five percent for at least 10 feet from perimeter walls. Backfill against footings, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving. Sprinkler systems should not be installed within five feet of foundation walls. Landscaped irrigation adjacent to the foundation systems should be minimized or eliminated.

4.2.7 Utility Trench Backfill

All trenches created for utility access under the building should be effectively sealed to restrict water intrusion and flow along the trenches. We recommend using a clay soil to construct an effective clay trench plug that extends at least 5 feet out from the face of the building. The clay should have a minimum plasticity index (PI) of 15 and be placed in controlled lifts not exceeding 9 inches in loose thickness so as to surround the utility line and fill the trench.

Each lift of clay backfill should be compacted to at least 95 percent of the material's maximum standard Proctor dry density, ASTM 698, at a minimum moisture content that is 2 percentage points above its optimum value.

4.3 Foundations

Design recommendations for drilled pier foundations for the proposed structure and related structural elements are presented in the following paragraphs.

4.3.1 Design Recommendations - Drilled Pier Foundations

DESCRIPTION	VALUE
Foundation Type	Straight-shaft drilled pier foundation system.
Bearing Material	Highly weathered to weathered shale.
Minimum Embedment	At least 2 feet into approved weathered.
Net Allowable Bearing Pressure ¹	15,000 psf
Maximum Allowable Skin Friction ²	1,500 psf
Minimum Shaft Diameter ³	18 inches
Minimum Grade Beam Embedment Depth Below Finished Grade ⁴	30 inches
Minimum Void Space Beneath Grade Beam ⁵	4 inches
Total Estimated Settlement	1/2 inch
Estimated Differential Settlement	Negligible

- ¹. Due to the variations in the quality and depth of the recommended bearing strata between borings, we recommend a qualified geotechnical engineer or his representative be present during pier drilling to verify that suitable bearing material is adequately penetrated.
- ². Use skin friction for the portion of the drilled pier that penetrates the highly weathered to weathered shale at least 2 feet, or one pier diameter, whichever is greater.
- ³. Assumes that enough steel reinforcement is provided to provide adequate structural integrity.
- ⁴. Grade beams should be structurally connected to the top of the piers.
- ⁵. Excavations for grade beams should be free of loose material and protection should be provided to prevent future filling of the void by sloughing soils.

4.3.1.1 Construction Considerations

Our drilling rig used an earth auger to penetrate the overburden soils and weathered shale. However, a rock bit may be required to extend the drilled pier excavations into the weathered shale. We do not expect temporary casing will be needed to prevent caving of the excavation sides; however, the final determination should be made at the time of construction.

Groundwater was encountered in boring B-1 during the field exploration. Therefore, we anticipate dewatering may be needed for this project. However, the need for dewatering will also depend on the actual groundwater conditions at the time of construction. The bottom of the pier excavation should be cleaned of debris, loose or disturbed soil, and water if any prior to placing reinforcing steel and concrete. If water is encountered and cannot be removed, the concrete should be placed using a tremie pipe and placed from the bottom of the pier excavation to the top, displacing the water to the surface. Concrete should be placed as soon as possible after the foundation excavation is completed to reduce the potential for disturbance of the bearing surface. To facilitate pier construction, concrete should be on-site and ready for placement as pier excavations are completed. In no event should the pier excavation be allowed to remain open over night.

4.4 Seismic Data Acquisition and Processing and Site Classification

On January 31, 2012 Terracon used a seismic refraction system (SRS) consisting of a seismograph and 24 geophones to perform a site-specific seismic class survey. Two linear arrays of 24 geophones were placed in an accessible area as illustrated in Appendix A, Exhibit A-1. A computer was used to record refraction microtremors produced by ambient seismic noise. The data was then processed using a wavefield-transformation data-processing technique and an interactive Rayleigh-wave dispersion-modeling tool. The refraction microtremor method exploits aspects of spectral analysis of surface waves (SASW) and multi-channel analysis of surface waves (MASW) to derive a shear wave profile and an average shear-wave velocity along each array for a corresponding depth of about 100 feet.

The International Building Code (IBC) requires structural design to be in accordance with the appropriate site class definition for soil profile type. Based upon the Site Class Definitions in Table 1613.5.2 of the 2009 International Building Code, and the average shear wave velocities of 1325 ft/s (EW array) and 1225 ft/s (NS array) derived from our seismic survey data, Terracon recommends a Class C seismic site classification for design.

The average shear-wave velocity analysis and recommendations presented in this report are based upon the data obtained from the seismic refraction system performed at the indicated location and on the indicated date. This analysis does not reflect variations that may occur across the site, or variations that may occur throughout the year, such as groundwater fluctuations. The refraction microtremor method is an approximate method, and one of many methods that can be used to determine shear-wave velocities. There are other costlier methods that can be used to further increase the accuracy of the seismic site classification and shear-wave profile.

4.5 Floor Slab

4.5.1 Design Recommendations

DESCRIPTION	VALUE
Floor system ¹	Slab-on-grade concrete.
Floor slab support ²	4 1/2 feet of low volume change cohesive soil placed and compacted in accordance with the Earthwork section of this report.

1. Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. We recommend floor slabs subjected to heavy concentrated loads be supported on a 6-inch thickness of ODOT Type "A" crushed aggregate meeting the requirements of Section 703.01. The crushed aggregate should be compacted to at least 95 percent of its maximum dry density, as determined by the standard Proctor test method (ASTM D-698).

In areas of exposed concrete, control joints should be saw cut into the slab after concrete placement in accordance with ACI Design Manual, Section 302.1R-37 8.3.12 (tooled control joints are not recommended). Additionally, dowels should be placed at the location of proposed construction joints. To control the width of cracking (should it occur) continuous slab reinforcement should be considered in all slabs.

Positive separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement. Interior trench backfill placed beneath slabs should be compacted in accordance with recommendations outlined in the Earthwork section of this report. Other design and construction considerations, as outlined in the ACI Design Manual, Section 302.1R are recommended.

The use of a vapor retarder or barrier 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 and slab contractor should refer to ACI 302 and ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder/barrier.

4.5.2 Construction Considerations

Some differential movement of a slab-on-grade floor system is likely over time as the subgrade soils naturally become elevated in moisture content. Such movements are anticipated to be within general tolerance for normal slab-on-grade construction.

To reduce potential slab movements, the subgrade soils should be prepared as outlined in the Earthwork section of this report.

4.6 Pavements

The subgrade and any fill required in the pavement areas should be prepared and placed in accordance with the "Earthwork" section of this report.

To improve long-term support for the proposed pavements, we recommend that the top 8 inches of the subgrade be modified with hydrated lime. Based on past experience with soils similar to those present at the site, we estimate 5 to 7 percent hydrated lime will be needed to adequately modify the on-site soils. We recommend the actual percentage of additive be determined at the time of construction by a qualified geotechnical engineering company. Lime should be blended into the subgrade and allowed to cure for 48 to 72 hours before being remixed and compacted. Before compaction, the modified soil zone should be adjusted to within 2 percent of the material's optimum moisture as determined by test method ASTM D-698. After conditioning the soil to the required moisture content, the modified subgrade should be compacted to at least 98 percent of the material's maximum dry density as determined by test method ASTM D-698.

Two pavement categories have been provided. The light duty parking and drive area and the heavy duty parking and drive area. The light duty category is for areas expected to receive only car traffic and assumes 25,000 ESALs. The truck parking and drive area category assumes 100,000 ESALs. If the traffic loading expected is different than our assumptions, we should be provided the traffic information and allowed to review these pavement sections. The owner/user should consider placing signs at entryways to deter heavy trucks from light duty pavement areas.

4.7.1 Design Recommendations

MINIMUM PAVEMENT RECOMMENDATIONS *		
	Light Duty Parking and Drive	Heavy Duty Parking and Drive
Section I		
Portland Cement Concrete (3,500 psi, Air Entrained)	5.0" Concrete 8.0" Modified Subgrade	6.0" Concrete 8.0" Modified Subgrade
Section II		
Full Depth Asphaltic Concrete	2.0" Type "B" Asphaltic Concrete 3.5" Type "A" Asphaltic Concrete 8.0" Modified Subgrade	2.0" Type "B" Asphaltic Concrete 5.0" Type "A" Asphaltic Concrete 8.0" Modified Subgrade
* All materials should meet the ODOT Standard Specifications for Highway Construction.		

MINIMUM PAVEMENT RECOMMENDATIONS *

Light Duty Parking and Drive

Heavy Duty Parking and Drive

NOTE: Because of the heavy concentrated wheel loads and frequent stopping and turning motions of trash collection trucks, we recommend that reinforced concrete pads be provided in front of and beneath trash receptacles. The dumpster trucks should be parked on the rigid concrete pavement when the trash receptacles are lifted. The concrete pads should be a minimum of 7 inches thick and properly reinforced.

These pavement sections are considered minimal sections based upon the expected traffic and the existing subgrade conditions. However, they are expected to function with periodic maintenance and overlays if good drainage is provided and maintained.

4.7.2 Construction Considerations

Base course or pavement materials should not be placed when the surface is wet. Surface drainage should be provided away from the edge of paved areas to minimize lateral moisture transmission into the subgrade.

Preventative maintenance should generally consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). It should be planned and provided for through an on-going pavement management program to enhance future pavement performance and preserve the pavement investment.

5.0 GENERAL COMMENTS

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

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

Three test borings were drilled at the site on February 1, 2012. The borings were drilled to depths of approximately 5 to 44.5 feet below the ground surface at the approximate locations shown on the attached Boring Location Plan, Exhibit A-1.

Terracon personnel located the borings in the field by taping distances from the references shown on the attached boring location diagrams. The surface elevations at the boring locations were determined using differential leveling procedures. An assumed benchmark elevation of 100.0 feet was used and referenced to the manhole cover located approximately as shown on the boring location diagram. Based on this benchmark, the surface elevations at the boring locations were approximately 100 feet. The elevations on the boring logs have been rounded to the nearest 1/2 foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used to define them.

An all-terrain, rotary drill rig equipped with continuous flight augers was used to advance the boreholes. Representative samples were obtained by the split-barrel procedures.

The split-barrel sampling procedure uses a standard 2-inch O.D. split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound drive hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches, or less, of a typical 18-inch sampling interval or portion thereof, is recorded as the standard penetration resistance value, N. The N value is used to estimate the in-situ relative density of cohesionless soils and, to a lesser degree of accuracy, the consistency of cohesive soils and the hardness of sedimentary bedrock. The sampling depths, penetration distances, and the N values are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

An automatic Standard Penetration Test (SPT) drive hammer was used to advance the split-barrel sampler. The automatic drive hammer achieves a greater mechanical efficiency when compared to a conventional safety drive hammer operated with a cathead and rope. We considered this higher efficiency in our interpretation and analysis of the subsurface information provided with this report.

The drill crew prepared field logs as part of the drilling operations. These boring logs included visual classifications of the materials encountered during drilling and the driller's interpretation of the subsurface conditions between samples. The final boring logs included

Geotechnical Engineering Report

Lawton Indian Hospital Diagnostic Imaging &
Emergency Department Addition ■ Lawton, Oklahoma
June 10, 2013 ■ Terracon Project No. 03135035



with this report represent the engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in the laboratory.

As required by the Oklahoma Water Resources Board, any borings deeper than 20 feet, or borings that encounter groundwater or contaminated materials must be grouted or plugged in accordance with Oklahoma State statutes. One boring log must also be submitted to the Oklahoma Water Resources Board for each 10 acres of project site area. Terracon grouted the borings and submitted a log in order to comply with the Oklahoma Water Resources Board requirements.

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Sedimentary Rock Classification. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil and bedrock samples and the test results are presented on the boring logs. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.












Selected soil and bedrock samples obtained from the site were tested for the following engineering properties:

- In-situ Water Content
- Atterberg Limits

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING			WATER LEVEL		Water Initially Encountered	FIELD TESTS	(HP)	Hand Penetrometer	
	Auger	Split Spoon			Water Level After a Specified Period of Time		(T)	Torvane	
					Water Level After a Specified Period of Time		(b/f)	Standard Penetration Test (blows per foot)	
	Shelby Tube	Pressure Meter		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.			(PID)	Photo-Ionization Detector	
							(OVA)	Organic Vapor Analyzer	
	Texas Cone	Rock Core					(TCP)	Texas Cone Penetrometer	
									
Grab Sample	No Recovery								

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, q_u , psf	Standard Penetration or N-Value Blows/Ft.
	Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1
	Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4
	Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8
	Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15
	Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30
				Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A					Soil Classification	
					Group Symbol	Group Name ^E
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 ≥ 4 and 1 ≤ Cc ≤ 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 ≥ 6 and 1 ≤ Cc ≤ 3 ^E		SW	Well-graded sand ^I
			Cu < 6 and/or 1 > Cc > 3 ^E		SP	Poorly graded sand ^I
		Sands with Fines: More than 12% fines ^D	Fines classify as ML or MH		SM	Silty sand ^{G,H,I}
			Fines classify as CL or CH		SC	Clayey sand ^{G,H,I}
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots on or above "A" line ^J		CL	Lean clay ^{K,L,M}
			PI < 4 or plots below "A" line ^J		ML	Silt ^{K,L,M}
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay ^{K,L,M,N}
			Liquid limit - not dried			Organic silt ^{K,L,M,O}
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above "A" line		CH	Fat clay ^{K,L,M}
			PI plots below "A" line		MH	Elastic Silt ^{K,L,M}
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay ^{K,L,M,P}
			Liquid limit - not dried			Organic silt ^{K,L,M,O}
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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

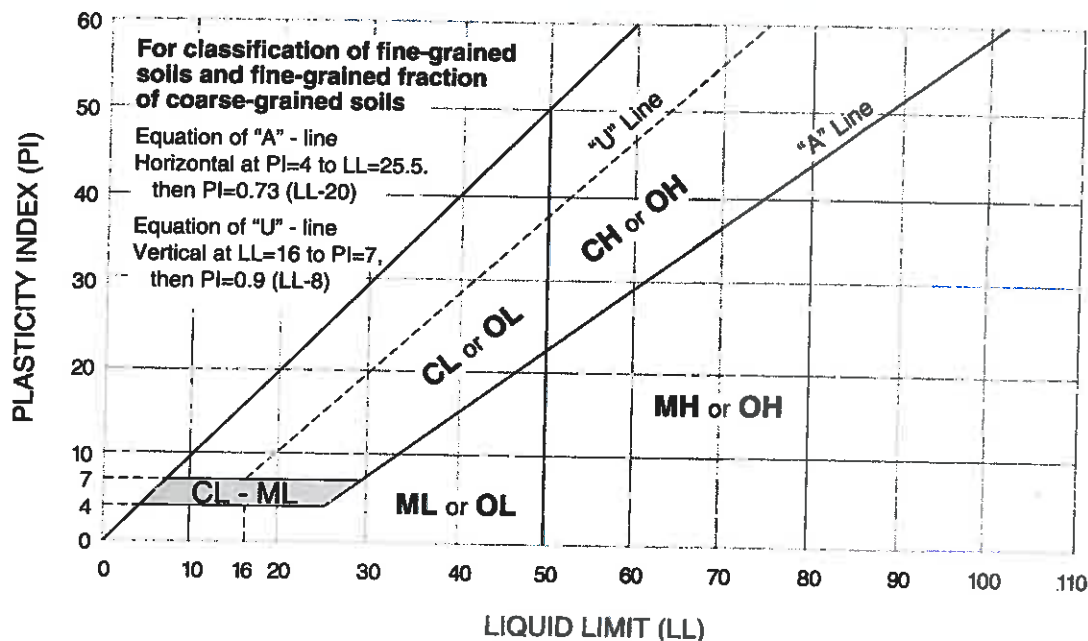
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^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.



GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of CaCO_3 , reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $\text{CaMg}(\text{CO}_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size ($\frac{1}{2}$ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	> 10'
Thick	Wide	3' - 10'
Medium	Moderately Close	1' - 3'
Thin	Close	2" - 1'
Very Thin	Very Close	.4" - 2"
Laminated	—	.1" - .4"
Bedding Plane	A plane dividing sedimentary rocks of the same or different lithology.	
Joint	Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.	
Seam	Generally applies to bedding plane with an unspecified degree of weathering.	

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to $\frac{1}{2}$ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Exhibit C-3

Terracon