Express Oil Change – Owasso, OK

Geotechnical Engineering Report

October 3, 2024 | Terracon Project No. 04245169

Prepared for:

Express Oil Change, LLC
1800 Southpark Drive
Birmingham, AL 35244

Explore with us

Nationwide

Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

9522 East 47th Place, Unit D
Tulsa, Oklahoma 74145
P (918) 250-0461
Terracon.com

October 3, 2024

Express Oil Change, LLC
1800 Southpark Drive
Birmingham, AL 35244

Attn: Mr. Tyler Hendon
P: (205) 337-2967
E: tyler.hendon@expressoil.com

Re: Geotechnical Engineering Report
Express Oil Change – Owasso, OK
East side of North Garnett Rd, South of Ranch Creek
Owasso, Oklahoma
Terracon Project No. 04245169

Dear Mr. Hendon:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P04245169 dated August 21, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations 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
Cert. Of Auth. #CA-4531 exp. 6/30/25

Ali Vafaei, E.I.
Senior Staff Engineer

Nate Braithwaite, P.E.
Oklahoma No. 29249

10/03/2024

LICENSED PROFESSIONAL ENGINEER
NATHAN E. BRAITHWAITE
29249
OKLAHOMA

Michael H. Homan, P.E.
Senior Principal

Table of Contents

Figures

Attachments

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the Express Oil Change on the East side of North Garnett Rd, South of Ranch Creek in Owasso, Oklahoma. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressure
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. Our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Tyler Hendon on August 14th, 2024. The request included a Parcel Map and conceptual plan drawing of the layout of the planned development and proposed boring locations and depths.
Proposed Structure	The structure associated with the project is an approximately 5,900 square foot single-story building with a below-grade oil change pit, paved area, and parking.

Item	Description
Finished Floor Elevation	Not provided.
Maximum Loads (assumed)	Anticipated structural loads: ▪ Columns: 25 kips ▪ Walls: 2.5 kips per lineal foot (klf) ▪ Floor Slabs: 150 pounds per square feet (psf), uniform If this information is not correct, we should be notified to assess the impact of the new information on our recommendations.
Grading/Slopes	A grading plan was not provided at the time of this report. Thus, we have assumed maximum cut and fill depths of 2 feet, relative to the existing grades, will be required to develop the final subgrade elevations for the building and pavements.
Below-Grade Structures	Oil change "Pit" area under the center bay of the building. Pit typically extends 10 feet below finish floor slab.
Free-Standing Retaining Walls	No free-standing retaining walls are planned.
Pavements	Both rigid and flexible pavement sections are considered for this site. Anticipated traffic is as follows: **Light Duty:** ▪ Autos/light trucks: 500 vehicles per day **Heavy Duty:** (in addition to autos/light trucks) ▪ Trucks: 5,000 vehicle per year
Building Code	2018 IBC

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Parcel Information	The project is located on the East side of North Garnett Rd, South of Ranch Creek in Owasso, Oklahoma. Latitude/Longitude (approximate) 36.2907° N/95.8472° W See **Site Location**

Item	Description
Existing Improvements	None
Current Ground Cover	Grass and trees
Existing Topography	About 11 foot of maximum elevation difference between the borings throughout the site.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Soil**	Silty Lean Clay
2	**Rock**	Sandstone

The boreholes were observed while drilling and immediately after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results** and are summarized below.

Boring	Approximate Depth to Groundwater while Drilling[1] (feet)	Approximate Depth to Groundwater after Drilling[1] (feet)	Approximate Depth to Groundwater after 48 hours[1] (feet)
B-1	15	18	11
B-2	8.5	Not encountered	Not measured
B-6	6.5	Not encountered	Not measured

Boring	Approximate Depth to Groundwater while Drilling[1] (feet)	Approximate Depth to Groundwater after Drilling[1] (feet)	Approximate Depth to Groundwater after 48 hours[1] (feet)

1. Below ground surface

Groundwater was not observed in the remaining borings while drilling, or for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater, or the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils and rock encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. 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. Therefore, groundwater levels during construction or at other times in the life of the structure 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.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC).

Based on the soil/bedrock properties observed at the site and as described on the exploration logs and results, and the anticipated fill depths to grade the site, our professional opinion is that a **Seismic Site Classification of C** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 18.5 feet. The site properties below the maximum boring depth were estimated based on our experience and knowledge of geologic conditions of the general area. Upon request, we could perform deeper borings or geophysical testing to confirm the conditions below the current maximum boring depth.

Geotechnical Overview

Based on the results of our borings, the proposed building can be supported on footing foundations. Considering the anticipated grade changes and results of the borings, footings could bear on poorly cemented to well cemented sandstone bedrock or new engineered fill. Observation and testing will be required during construction to evaluate that suitable bearing materials are encountered in footing excavations. The **Shallow Foundations** section addresses the design and construction of footing foundations for the building.

The on-site soils have relatively low plasticity with variations in moisture content. Because of the variable support characteristics of the on-site materials, we recommend that a minimum 12-inch-thick layer of Low Volume Change fill be constructed below the floor slab. The **Floor Slabs** section addresses slab-on-grade support of the proposed building.

Our opinion of pavement section thickness design has been developed based on our understanding of the intended use, assumed traffic, and subgrade preparation recommended herein. The **Pavements** section includes minimum pavement component thickness.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing, grubbing, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs and pavements.

Site Preparation

Site preparation for the proposed project should include stripping and clearing to remove any buildings, utilities, pavements, trees, surface vegetation, topsoil, debris, and any other unsuitable surface materials from the areas of planned construction. Tree stumps and major root systems and foundations and utilities from the residential structure that previously occupied the site should be removed full depth. The depressions or excavations created during removal of trees, old foundations and underground utilities should be cleaned of loose material and water and backfilled as outlined in the following paragraphs. Actual removal depths should be determined at the time of construction by a representative of the geotechnical engineer.

Subgrade Preparation

After stripping and completing necessary cuts, the building area should be undercut to allow at least 12 inches below the final subgrade elevation for construction of the LVC fill layer (see the **Floor Slabs** section for additional commentary). The area to be undercut and backfilled with the recommended thickness of LVC should extend at least 5 feet laterally beyond the building foundation footprint.

Sandstone rock was encountered at a depth of about 0.5 feet below existing grade in all of our borings except B-6. Sandstone rock was encountered in boring B-6 at a depth of 1.5 feet. Based on our experience, bedrock materials that can be penetrated by the flight augers used in our drilling operation can usually be excavated with large, heavy-duty, track-mounted excavation equipment equipped with rock excavation attachments. However, in the more competent bedrock materials represented by standard penetration resistance blow count values (N-values) of 50 blows for 4 inches or less penetration, it should be expected that excavation of the bedrock will be more difficult and require special rock excavation techniques, such the use of pneumatic rock breakers, rock splitters, jackhammers, or blasting. Excavation of rock in confined areas (such as footing excavations and utility trench excavations) is usually difficult.

After site stripping and completing any required cuts and overexcavations, 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 to locate any zones that are soft or unstable. 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 material as described herein if it cannot be adequately compacted in-place. Rock exposed at the subgrade level will not require proofrolling, but the Geotechnical Engineer should observe the rock surface prior to placing fill.

After proofrolling and correcting any unstable subgrade, the exposed subgrade soils should be scarified to a depth of 9 inches. The scarified soil should be moisture conditioned and compacted as recommended in the Placement and Compaction Requirements section.

Fill Material Types

Fill materials should meet the following material property requirements.

Fill Type[1]	USCS Classification	Acceptable Location for Placement
Imported Low Volume Change (LVC) material[2] (8≤PI≤18; ≥ 15% material passing No. 200 sieve)	CL; SC	▪ All locations and elevations ▪ Required to construct the LVC fill layer recommended blow building floor slab
On-Site Soils (8≤PI≤18; ≥ 15% material passing No. 200 sieve)	CL	▪ All locations and elevations ▪ Required to construct the LVC fill layer recommended blow building floor slab
ODOT Type A Aggregate Base[3]	GW-GC, GW-GM	▪ Aggregate base course of recommended pavement sections

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris and contain maximum rock size of 3 inches. 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 the geotechnical engineer for evaluation prior to its use.
2. Approved, imported, low plasticity cohesive soil having a plasticity index (PI) of 8 to 18 and containing at least 15% fines (material passing the No. 200 sieve, based on dry weight). An approved, ODOT Type A aggregate base can be used as LVC fill material.
3. Subsection 703.01 of the ODOT Standard Specifications for Highway Construction.

Fill Placement and Compaction Requirements

The scarified and compacted subgrade soil and engineered fill should meet the following compaction requirements.

Item	Engineered Fill
Subgrade Scarification Depth	9 inches (May not be possible in sandstone)
Maximum Lift Thickness[1]	9 inches or less in loose thickness
Minimum Compaction Requirements[2]	At least 95% of the material's maximum standard Proctor dry density (ASTM D698)
Moisture Content[3]	**Imported LVC Material and On-Site Soils:** -2% to +2% of the material's optimum moisture content (ASTM D698) **Aggregate Base:** Workable moisture Content[3]

Item	Engineered Fill

1. Thinner lifts are recommended in confined areas or when hand-operated compaction equipment is used.
2. We recommend that engineered fill (including scarified compacted subgrade) 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.
3. Workable moisture content is the moisture content sufficient to achieve the specified compaction without causing pumping when proofrolled.

Utility Trench Backfill

Utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for engineered fill stated previously in this report.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Accumulation of water adjacent to the structure could contribute to significant moisture increases in the subgrade soils and subsequent softening/settlement or expansion/heave, which could result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks.

Exposed ground should be sloped and maintained at a minimum 5% away from the building addition for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Planters located within 10 feet of the building should be self-contained to prevent water accessing the building subgrade soils. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the building lines. Low-volume, drip style landscaped irrigation should not be used near the building. Roof runoff should be collected in drains or gutters. Roof drains and downspouts should be discharged onto pavements which slope away from the buildings or downspouts should be extended a minimum of 10 feet away from structure.

Earthwork Construction Considerations

Sandstone rock was encountered at a depth of about 0.5 feet below existing grade in all of our borings except B-6. Sandstone rock was encountered in boring B-6 at a depth of 1.5 feet. Based on our experience, bedrock materials that can be penetrated by the flight augers used in our drilling operation can usually be excavated with large, heavy-duty, track-mounted excavation equipment equipped with rock excavation attachments. However, in the more competent bedrock materials represented by standard penetration resistance blow count values (N-values) of 50 blows for 4 inches or less penetration, it should be expected that excavation of the bedrock will be more difficult and require special rock excavation techniques, such the use of pneumatic rock breakers, rock splitters, jackhammers, or blasting. Excavation of rock in confined areas (such as footing excavations and utility trench excavations) is usually difficult.

The near surface soils are moisture sensitive and subject to strength loss and instability at elevated moisture levels. If wet conditions exist during construction, the near surface soils could be unstable and need to be overexcavated or stabilized to develop adequate support for new fills, footings, floor slabs, and pavements; and to allow construction to proceed. Wet conditions preceding or occurring during construction will exacerbate the extent of unstable soils.

It is not possible to accurately predict until construction is underway the actual quantity of unsuitable fill soils that will need to be removed. We encourage the owner to secure a base bid for removing a specified quantity of the unsuitable fill soils. 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.

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and pavements), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas, with at least two tests per lift. Where not specified by local ordinance, each lift of backfill should be tested for density and water content at a frequency of at least one test for every 50 linear feet of compacted utility trench backfill, with at least two tests per lift.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

The proposed building can be supported by footing foundations bearing in properly constructed new engineered fill or poorly cemented to well cemented sandstone rock. Design and construction recommendations for footing foundations are presented in the following paragraphs.

Shallow Foundation Design Recommendations

Item	Description
Maximum Net Allowable Bearing Pressure [1]	2,500 psf
Required Bearing Material	▪ Poorly cemented to well cemented sandstone rock ▪ New engineered fill
Minimum Foundation Dimensions	Columns: 30 inches Continuous: 16 inches
Minimum Depth (below Lowest Finished Grade) [2]	24 inches
Estimated Total Settlement	About 1 inch
Estimated Differential Settlement	About ¾ inch or less

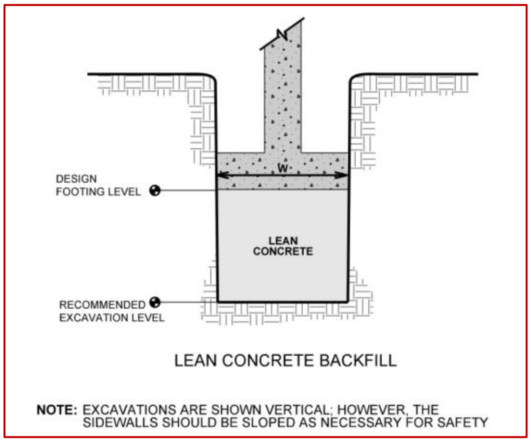
1. The net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Individual footing elements should be founded on either sandstone rock or structural fill, not on both materials.
2. To provide frost protection. Minimum depth applies to perimeter footings and footings in unheated areas.

Shallow Foundation Construction Considerations

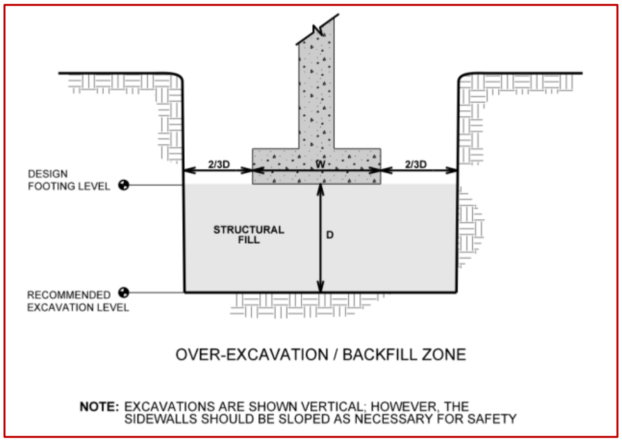
Footing excavations should be free of loose or disturbed material and water when concrete is placed. Concrete should be placed as soon as possible after excavation is completed to reduce the potential for wetting, drying, or disturbance of the bearing materials.

To verify that suitable bearing materials are encountered, we recommend the base of all footing excavations be observed and evaluated by the Geotechnical Engineer prior to placing reinforcing steel and concrete. Footing bearing material evaluations should include random hand auger probes at the bottom of footing excavations.

If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The lean concrete replacement zone is illustrated in the sketch below.



Alternatively, for footings designed to bear in engineered fill, the unsuitable soils can be overexcavated and replaced with tested and approved, engineered fill. Overexcavation for engineered fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation with approved engineered fill constructed, as recommended in the **Earthwork** section.



Floor Slabs

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

We recommend that the floor slab not be installed on the sandstone rock. To provide a more uniform subgrade for the floor slab, the upper 12 inches of subgrade below the floor slab should be an approved Low Volume Change (LVC) material consisting of lean clays.

Floor Slab Design Recommendations

Item	Description
Floor Slab Support[1]	At least 12-inches of low volume change (LVC) material prepared in accordance with **Earthwork**
Estimated Modulus of Subgrade Reaction[2]	100 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, 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.

Saw-cut contraction 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 should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing, or other means.

Floor Slab Construction Considerations

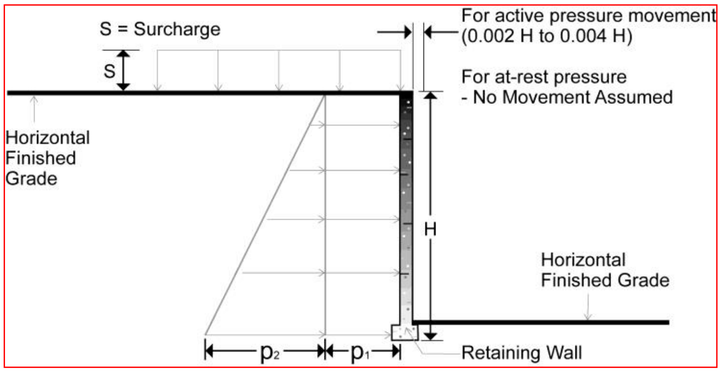
Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Lateral Earth Pressures

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters

Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3] p_1 (psf)	Equivalent Fluid Pressures (psf) [2,4]	
			Unsaturated [5]	Submerged [5]
Active (Ka)	Granular - 0.33 Fine Grained - 0.41	(0.33)S (0.41)S	(42)H (48)H	(83)H (85)H
At-Rest (Ko)	Granular - 0.47 Fine Grained - 0.58	(0.50)S (0.58)S	(63)H (68)H	(94)H (95)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance. Fat clay or other expansive soils should not be used as backfill behind the wall.
2. Uniform, horizontal backfill, compacted to at least 98% of the ASTM D 698 maximum dry density, with a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

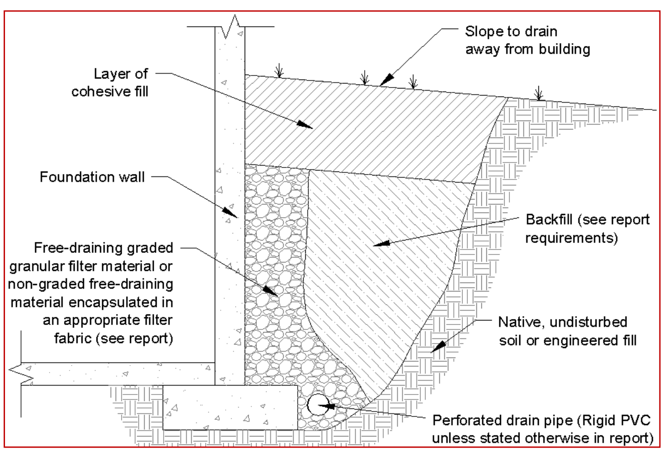
Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 degrees from vertical for the active case.

Footings, floor slabs or other loads bearing on backfill behind walls may have a significant influence on the lateral earth pressure. Placing footings within wall backfill and in the zone of active soil influence on the wall should be avoided unless structural analyses indicate the wall can safely withstand the increased pressure.

The lateral earth pressure recommendations given in this section are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill walls (also termed MSE walls). Recommendations covering these types of wall systems are beyond the scope of services for this assignment. However, we would be pleased to develop a proposal for evaluation and design of such wall systems upon request.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system. Compacted on-site clayey sand (SC) or sandy lean clay (CL) should be suitable for the cohesive fill layer shown in the figure below.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill. Prefabricated drainage structures are typically proprietary products that require installation in accordance with manufacturer's installation instructions.

Below-Grade Structures

The project may require an excavation 12 to 14 feet below natural grade. The primary geotechnical considerations affecting the design and construction of the service pit is excavation stability and providing reliable drainage of the underdrain system to prevent hydrostatic uplift conditions. Uplift of the service pit from hydrostatic forces is perhaps the governing factor in design of the proposed structure, and not bearing capacity or settlement. The soils and rock at the site are considered low permeability, so the rate of groundwater infiltration into and out of the service pit excavation should be low. The post construction settlement of the service pit should be minimal.

Typically, subsurface features like the service pit, should be designed to provide at least a factor of safety of 1.2 for uplift with groundwater considered to be at the top of ground, unless a reliable means to maintain the groundwater below the service pit is provided. It is understood that a gravel underdrain system will be provided below the service pit to collect water that infiltrates into the service pit area to prevent a hydrostatic uplift condition. The bottom of the service pit excavation should be sloped to drain water to a collection gallery and a duplex pump system in a sump designed to remove the water to the storm drain system. The underdrain gravel should consist of crushed clean No. 57 gravel that is contained within a non-woven geotextile fabric (Mirafi 140 N or equivalent).

The soil placed above the drainage layer should consist of a compacted, imported lean clay to provide an effective low permeability blanket to minimize surface water infiltration. The soil should be compacted as recommended for General Fill in the **Earthwork** section of this report. The surface grades above the service pit should be appropriately sloped to drain water from the area.

Pavements

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

Pavement Subgrade Preparation

We anticipate the subgrade soils in the pavement areas could consist of site grading to include construction of structural fill within all pavement areas. Due to engineering properties and variable support characteristics of the anticipated on-site subgrade materials, subgrade improvement should be performed beneath pavements at this site.

Pavement Section Thicknesses

The following table provides our opinion of minimum thickness for Asphaltic Concrete and Portland Cement Concrete sections:

Minimum Pavement Recommendations[1]

Pavement Type[1]	Light Duty[2]	Heavy Duty[2]
Full Depth ACC	2.0" Type "B" Asphaltic Concrete 3.0" Type "A" Asphaltic Concrete 8.0" Structural Fill **OR** 2.0" Type "B" Asphaltic Concrete 3.0" Type "A" Asphaltic Concrete 6.0" Type "A" Aggregate Base[3]	2.0" Type "B" Asphaltic Concrete 5.0" Type "A" Asphaltic Concrete 6.0" Type "A" Aggregate Base[3] 8.0" Structural Fill **OR** 2.0" Type "B" Asphaltic Concrete 5.0" Type "A" Asphaltic Concrete 6.0" Type "A" Aggregate Base[3] Approved ODOT Type II Geogrid
PCC	5.0" Concrete 8.0" Structural Fill **OR** 5.0" Concrete 6.0" Type "A" Aggregate Base[3]	8.0" Concrete [4] 8.0" Structural Fill **OR** 8.0" Concrete [4] 6.0" Type "A" Aggregate Base[3]

1. All materials should meet the current Oklahoma Department of Transportation (ODOT) Standard Specifications for Highway and Bridge Construction.
2. See **Project Description** for more specifics regarding traffic assumptions.
3. ODOT Type "A" aggregate base should meet the requirements of Section 703.01. The aggregate should be spread and densified to at least 98 percent of the material's maximum dry density as determined by the standard Proctor test method ASTM D698.
4. Doweled joint concrete

Note: 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, properly reinforced and constructed on at least 6 inches of Type "A" aggregate base.

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

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.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. 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. Pavement care consists of both localized (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation 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.

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 paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations 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. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others.

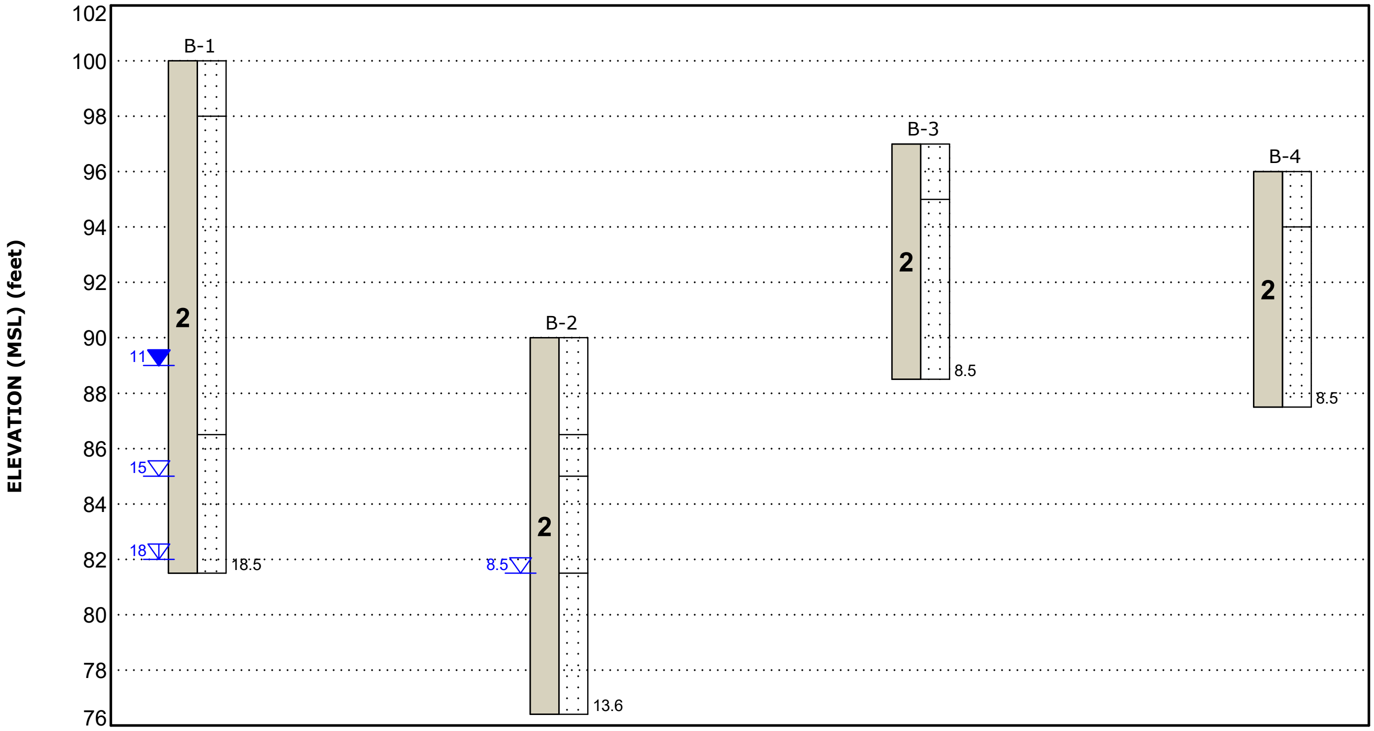
Construction and site development have the potential to affect adjacent properties. Such impacts can include damage due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

Contents:

9522 E 47th Pl, Ste D
Tulsa, OK

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

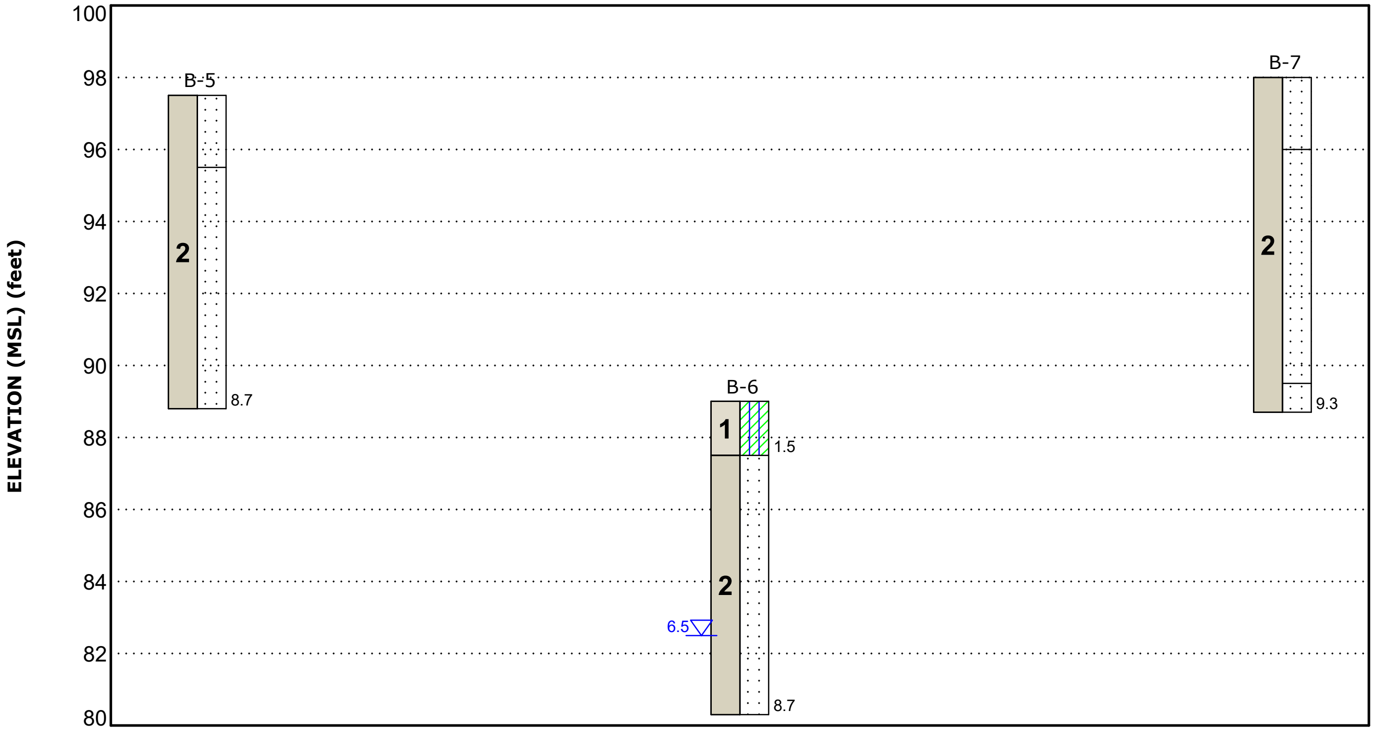
Model Layer	Layer Name	General Description	Legend
1	**Native Soils**	Silty Lean Clay (CL-ML)	Sandstone
2	**Bedrock**	Sandstone	

First Water Observation
Second Water Observation
Third Water Observation
Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

9522 E 47th Pl, Ste D
Tulsa, OK

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description	Legend
1	Native Soils	Silty Lean Clay (CL-ML)	Sandstone; Silty Clay
2	Bedrock	Sandstone	

First Water Observation
Second Water Observation
Third Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.

Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location [1]
2 (B-1 and B-2)	13.5 to 18.5	Proposed building area
5 (B-3 to B-7)	8.5 to 9.5	Proposed paved/driveway area

1. The boring locations are shown on the attached **Exploration Plan.**

Boring Layout and Elevations: Terracon personnel staked the boring locations in the field using a handheld GPS unit (estimated horizontal accuracy of about ±25 feet). Terracon determined relative elevations of the borings. Elevations are also approximate and were obtained using an engineer's level from a convenient reference point. For this exploration, the boring surface elevations were referenced to the top of a fire hydrant located at the northwest side of the site, which was assumed to have an arbitrary elevation of 100.0 feet. The approximate ground surface elevations at the borings, rounded to the nearest 0.5 feet, are shown near the top of the boring logs. The locations and elevations of the borings should be considered accurate only to the degree implied by these methods. Terracon personnel coordinated borehole access with an on-site contractor who was using the proposed site as an active laydown yard for an adjacent construction project.

Subsurface Exploration Procedures: We advanced the borings with an ATV-mounted rotary drill rig using continuous flight augers. Five samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split barrel sampling procedure, a standard 2-inch outer diameter split barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. A temporary piezometer was installed in boring B-1, and water levels were recorded over a 48 hour period.

The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Atterberg Limits

The laboratory testing program included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification was determined using the Description of Rock Properties.

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

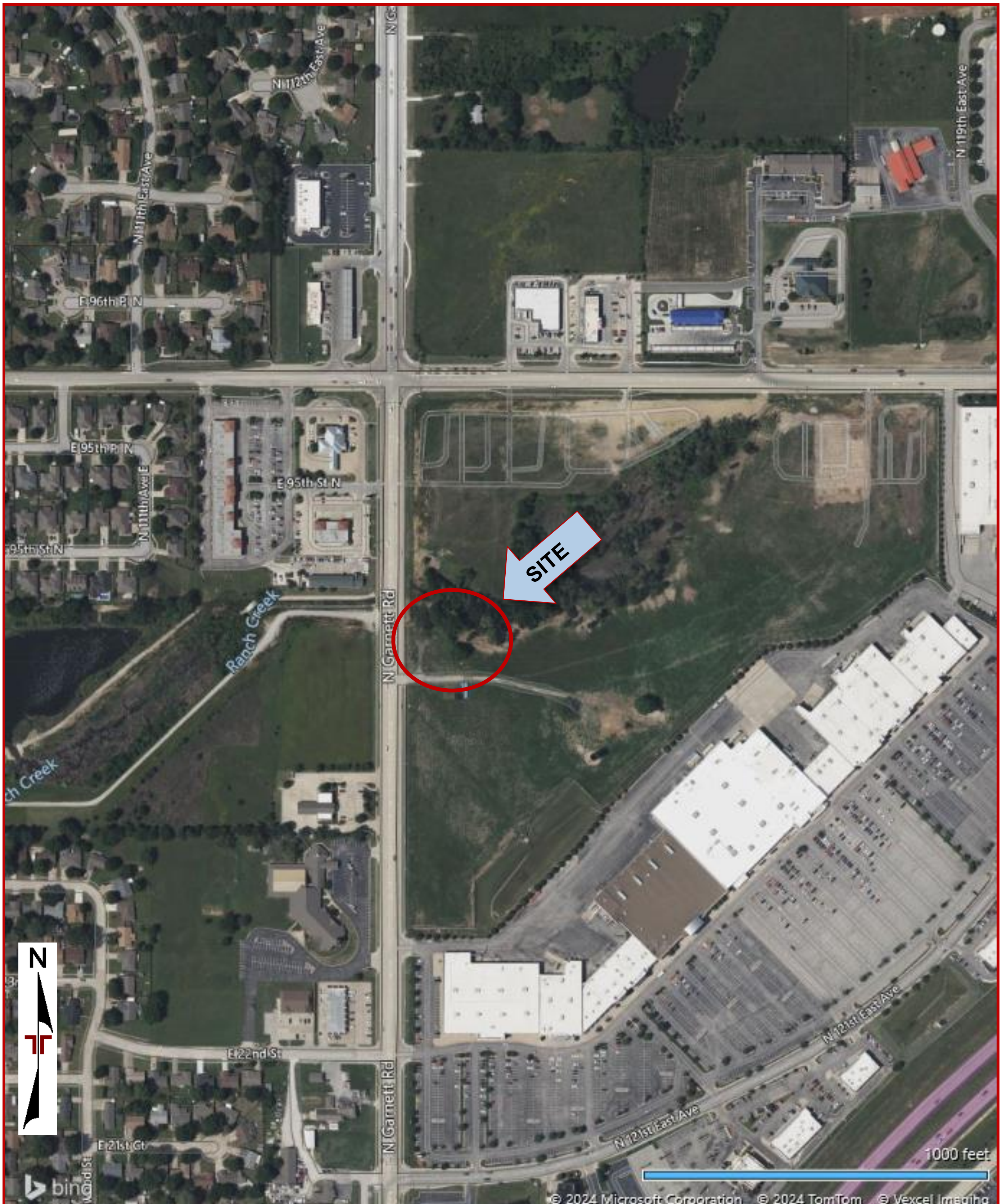


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

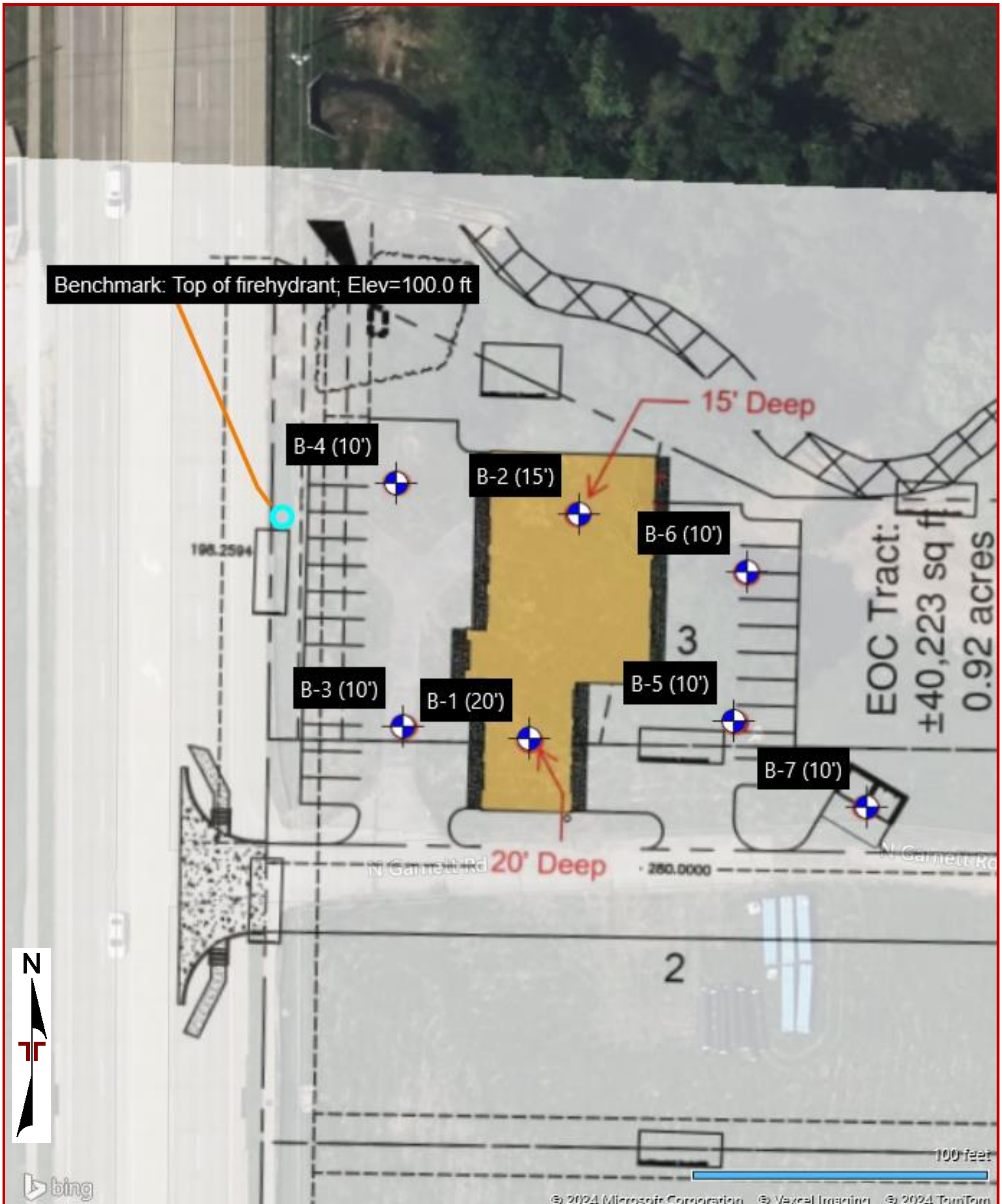


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 36.2908° Longitude: -95.8427°

Depth (Ft.) Elevation: 100 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**SANDSTONE**, with silty sand seams, brown, cemented				3	50/4"		5.6			
		2.0 — 98										
		SANDSTONE, brown, well cemented				1	50/1"		5.6			
						1	50/1"		5.5			
			5			0	50/0"					
						0	50/2"					
			10									
		13.5 — 86.5										
		SANDSTONE, olive brown, well cemented				1	50/2"		14.2			
			15									
		18.5 — 81.5										
		Boring Terminated at 18.5 Feet				0	50/0"					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
- 15' While drilling
- 18' After boring
- 11' 48 hours after boring

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 36.2910° Longitude: -95.8427°

Depth (Ft.) Elevation: 90 (Ft.) +/-

Model Layer	Depth (Ft.) / Description	Elevation	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2	**SANDSTONE**, with silty sand seams, brown, poorly cemented to cemented				18	12-13-27 N=40		7.8			
					15	20-25-50/3"		16.2			
	3.5	86.5			2	50/2"		13.8			
	SANDSTONE, brown, well cemented										
	5.0	85									
	SANDSTONE, clay with silt lenses seams, brown and olive brown, poorly cemented to cemented				12	34-50/6"		13.6		29-20-9	
	8.5	81.5	▽		0	50/1"					
	SANDSTONE, brown, well cemented										
	13.6	76.4			0	50/1"					

Boring Terminated at 13.6 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ 8.5' While drilling

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 36.2903° Longitude: -95.8479°

Depth (Ft.) Elevation: 97 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**SANDSTONE**, with silty sand seams, brown, poorly cemented				18	13-32-45 N=77		9.4			
		2.0 — 95										
		SANDSTONE, brown, cemented to well cemented				0	50/1"					
						0	50/1"					
			5			3	50/3"		6.6			
		8.5 — 88.5										
		Boring Terminated at 8.5 Feet				0	50/0"					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes

Water Level Observations
No free water observed

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 36.2910° Longitude: -95.8478°

Depth (Ft.) Elevation: 96 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**SANDSTONE**, with silty sand seams, brown, poorly cemented to cemented				12	13-50/6"		3.6			
		2.0 — 94										
		SANDSTONE, brown, well cemented				1	50/1"		5.8			
						1	50/1"		7.1			
			5			0	50/2"					
		8.5 — 87.5										
		Boring Terminated at 8.5 Feet				0	50/0"					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
No free water observed

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 36.2907° Longitude: -95.8435°

Depth (Ft.) Elevation: 97.5 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**SANDSTONE**, with sand seams, brown, poorly cemented to cemented				16	16-50/6"		6.5			
		2.0 — 95.5										
		SANDSTONE, brown, well cemented				1	50/1"		7.9			
						0	50/1"					
			5			1	50/1"		6.8			
		8.7 — 88.8				2	50/2"		8.4			
		Boring Terminated at 8.7 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
No free water observed

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-6

Location: See Exploration Plan

Latitude: 36.2909° Longitude: -95.8474°

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation: 89 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SILTY LEAN CLAY (CL-ML)**, brown, medium stiff				18	3-2-30 N=32		17.0		27-23-4	
		1.5 — 87.5										
2		**SANDSTONE**, brown, poorly cemented to well cemented				6	50/6"		15.7			
						3	50/3"		14.6			
			5			2	50/2"		15.6			
				▽								
		8.7 — 80.3				0	50/2"					
		Boring Terminated at 8.7 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
▽ 6.5' While drilling

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Log No. B-7

Location: See Exploration Plan

Latitude: 36.2407° Longitude: -95.8473°

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation: 98 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**SANDSTONE**, with silty sand seams, brown, cemented				1	50/4"		8.2			
		2.0 — 96										
		SANDSTONE, brown, well cemented				1	50/1"		13.9			
						1	50/1"		6.5			
			5			0	50/1"					
		8.5 — 89.5										
		SANDSTONE, with sand seams, brown and olive brown, poorly cemented to cemented				12	36-50/4"		13.1			
		9.3 — 88.7										
		Boring Terminated at 9.3 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
No free water observed

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings and bentonite chips upon completion.

Drill Rig
CME 550

Hammer Type
Automatic

Driller
TS

Logged by
JP

Boring Started
09-13-2024

Boring Completed
09-13-2024

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

General Notes

Sampling	Water Level		Field Tests	
Split Spoon		Water Initially Encountered	N	Standard Penetration Test Resistance (Blows/Ft.)
		Water Level After a Specified Period of Time	(HP)	Hand Penetrometer
		Water Level After a Specified Period of Time	(T)	Torvane
		Cave In Encountered	(DCP)	Dynamic Cone Penetrometer
	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.		UC	Unconfined Compressive Strength
			(PID)	Photo-Ionization Detector
			(OVA)	Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM 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.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**Consistency of Fine-Grained Soils** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

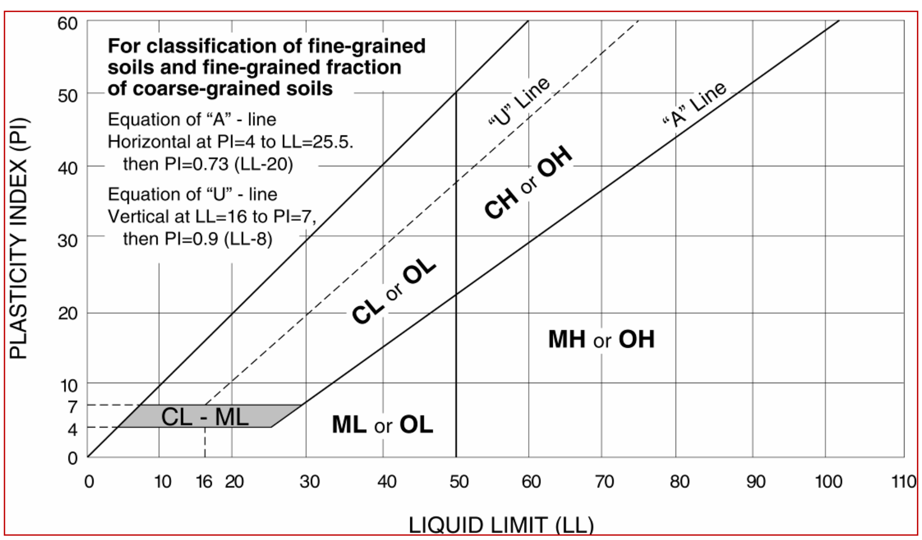
Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**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 $[Cc < 1$ or $Cc > 3.0]$ [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 $[Cc < 1$ or $Cc > 3.0]$ [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 above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[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.



Rock Classification Notes

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 shaley, 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 $CaMg(CO_3)_2$, 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 (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 a knife.
Moderately Hard	Can be scratched easily with a knife, cannot be scratched with a fingernail.
Soft	Can be scratched with a fingernail.
Shale, Siltstone and Claystone	
Hard	Can be scratched easily with a knife, cannot be scratched with a fingernail.
Moderately Hard	Can be scratched with a fingernail.
Soft	Can easily be dented but not molded with fingers.
Sandstone and Conglomerate	
Well Cemented	Capable of scratching a knife blade.
Cemented	Difficult to scratch with a knife.
Poorly Cemented	Can be broken apart easily with fingers.

Bedding and Joint Characteristics[1]

Bed Thickness	**Joint Spacing**	**Dimensions**
Laminated	---	.1 in. – .4 in.
Very thin	Very close	.4 in. – 2 in.
Thin	Close	2 in. – 1 ft.
Medium	Moderately close	1 ft. – 3 ft.
Thick	Wide	3 ft. – 10 ft.
Very thick	Very wide	More than 10 ft.

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

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 ½ 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.