# Take 5 Oil Change

## Geotechnical Engineering Report

November 2, 2023 | Terracon Project No. 02225258

**Prepared for:**

Driven Assets, LLC
Boulder, Colorado 80302

Explore with us

Nationwide
Terracon.com

Facilities
Environmental
Geotechnical
Materials

15620 W 113th Street
Lenexa, KS 66219
(913) 492-7777
Terracon.com

November 2, 2023

Driven Assets, LLC
2101 Pearl St
Boulder, Colorado 80302

Attn: Todd Minis
P: 214-597-5088
E: todd@drivenassets.com

Re: Geotechnical Engineering Report
Take 5 Oil Change
SE Langsford Road and Missouri Highway 281
Lee's Summit, Missouri
Terracon Project No. 02225258

Dear Mr. Minis:

We have completed a subsurface exploration and geotechnical engineering evaluation for the referenced project in general accordance with Terracon Proposal No. P02225258 dated September 15, 2023. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the 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**

STATE OF MISSOURI
KOLE C. BERG
NUMBER PE-2002016417
PROFESSIONAL ENGINEER
11/2/2023

David Gudino-Chausse, E.I.
Geotechnical Staff Engineer

Kole C. Berg, P.E.
Principal/Senior Consultant
Missouri: 2002016417

# Table of Contents



# 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 proposed Take 5 to be located at SE Langsford Road and Missouri Highway 281 in Lee's Summit, Missouri. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- IBC seismic site class
- Site preparation and earthwork
- Foundations
- Floor slabs
- Lateral earth pressure parameters
- Pavements

Drawings showing the site and boring locations are shown on the attached **Site Location Plan** and **Exploration Plan**. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs in **Exploration Results**.

# Project Description

| Item | Description |
|---|---|
| **Project Description** | The project includes construction of an oil change building and associated pavements. |
| **Proposed Structure** | The proposed oil change building will be a single-story structure with a footprint of 1,415 square feet. We anticipate the building will be a steel-framed structure with a grade-supported floor slab. |
| **Finished Floor Elevation** | 988 feet |
| **Maximum Loads** | Anticipated structural loads were not provided. We have assumed the following maximum loads based on our experience with similar projects.<br>▪ Columns: 100 kips<br>▪ Walls: 3 kips per linear foot (klf)<br>▪ Slabs: 100 pounds per square foot (psf) |

| Item | Description |
|---|---|
| **Grading** | A site grading plan was not provided. Based on existing topography, we have considered no more than 3 feet of cut/fill will be required to develop final grades. |
| **Below-Grade Structures** | We anticipate the building will have a below-grade service pit that extends to a maximum depth of 10 feet below the building floor. An underground detention basin is also planned. No basement levels or other below-grade structures are planned. |
| **Free-Standing Retaining Walls** | No new free-standing retaining walls are planned. Terracon's scope of services does not include exploration, analyses, or evaluation of the existing retaining wall along the north side of the site. |
| **Pavements** | New pavements will be constructed on each side of the proposed building. No information regarding anticipated vehicle types, axle loads, or traffic volumes was provided. We anticipate the pavements will be utilized primarily by passenger vehicles (cars, pickup trucks, SUV's) with occasional panel delivery trucks and trash collection trucks. |

Terracon should be notified if any of the above information is inconsistent with the planned construction, 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 northwest of the intersection of SE Langsford Road and Missouri Highway 291 in Lee's Summit, Missouri<br>Approximate Latitude/Longitude: 38.9193 N, 94.3621 W<br>See **Site Location** |
| **Existing Site Conditions** | The project site is a vacant lot located north of an existing strip mall building. An existing retaining wall extends along the north side of the lot. |
| **Existing Topography** | A topographic site plan was not provided. Based on our review of topography using an online mapping application, site grades are relatively level, with surface elevations ranging from approximately 985 feet to 986 feet. |

# Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based on the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. Conditions observed at each boring location are indicated on the individual logs. The individual logs are in the **Exploration Results**.

| Model Layer | Layer Name | General Description |
|---|---|---|
| 1 | **Existing Fill** | Fat clay with variable amounts of limestone fragments |
| 2 | **Bedrock** | Highly to moderately weathered sandstone |

The borings were observed during drilling and shortly after completion of drilling for the presence and level of water. Groundwater was not encountered in the other borings at these times. A longer period of time may be required for groundwater to develop and stabilize in a borehole. Longer term observations in piezometers or observation wells, sealed from the influence of surface water, are often required to define groundwater levels.

Groundwater levels may fluctuate due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. "Perched" water could occur above lower permeability soil layers and/or near the soil/bedrock interface, and "trapped" water could be present within existing fill materials. Therefore, groundwater conditions at other times may be different than the conditions encountered in our exploratory borings. The potential for water level fluctuations and perched water should be considered when developing design and construction plans and specifications for the project.

# Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. The Site Class is required to determine the Seismic Design Category for a structure. The Site Class 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 and bedrock encountered in our subsurface exploration, **Seismic Site Class C** can be considered for design of the project. The subsurface exploration at this site extended to a maximum depth of 10 feet and terminated in sandstone bedrock. 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

Existing fill materials were encountered to depths ranging from approximately 3½ to 8½ feet at the boring locations. The existing fill was generally composed of fat clay soils with variable amounts of limestone fragments. Based on field and laboratory test data, it appears some compactive effort was applied to the existing fill. However, no documentation regarding placement and compaction of the fill was provided for our review. Structures supported on or above undocumented fill could experience larger-than-normal settlements, resulting in cracking and other damage to the new building, floor slabs, and pavements. Due to the depth of the existing fill, removal and replacement of the existing fill may not be economically feasible for this project. Provided the owner accepts the potential for unpredictable performance of foundations and in exchange for reduced construction costs, in our opinion, the proposed building can be supported on conventional shallow footing foundations. If the owner is not willing to accept the risk, significantly more expensive methods could be used to reduce or eliminate this risk (e.g., removal/replacement of the fill or support of the building on deep foundations).

Provided the owner accepts the risks associated with support of building floor slabs and pavements over undocumented fill in exchange for reduced construction costs, stable portions of the existing fill could also be left in place for support of the building floor slab and pavements.

Expansive clay soils were encountered at the site. These materials have the potential to shrink and swell with seasonal fluctuations in the soil moisture content. We recommend the floor slabs be supported on at least 24 inches of low volume change (LVC) material. Placement of a layer of LVC material below floor slabs, as recommended in this report, will not eliminate all future subgrade volume change and resultant floor slab movements. However, use of an LVC zone should reduce the potential for subgrade volume change. Details regarding the LVC zone are provided in **Earthwork**.

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

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

Site preparation, excavation, subgrade preparation, and placement of engineered fill should follow the recommendations presented in this section. The recommendations presented for design and construction of earth-supported elements including foundations, slabs, and pavements are contingent upon the recommendations outlined in this section being followed. We recommend earthwork on this project be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of subgrade preparation, engineered fill, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

## Site Preparation

Vegetation, topsoil, and any loose, soft, or otherwise unsuitable soils present within the proposed construction areas should be stripped. Based on information obtained at the boring locations, stripping depths on the order of 4 inches should be anticipated to remove the root zone materials. However, greater stripping depths may be required in areas not explored by the borings. Organic soils removed during site preparation should not be used as fill beneath the proposed new building and pavement areas.

The soils within the planned building area should be further undercut as necessary to accommodate placement of the recommended 24-inch thick LVC layer below floor slabs. The undercut areas should extend a minimum of 5 feet laterally outside the building wall lines. Undercutting to facilitate placement of the LVC layer would not be necessary in areas where more than 2 feet of fill will be placed to develop the floor slab subgrade level.

Following initial stripping and any necessary undercutting, the exposed soils should be proofrolled. A Terracon representative should observe the proofrolling. Proofrolling can be accomplished using a loaded tandem-axle dump truck with a gross weight of at least 20 tons, or similarly loaded equipment. Areas that display excessive deflection (pumping) or rutting during proofroll operations should be improved by scarification/compaction or by removal and replacement with engineered fill.

## Fill Material Types

Fill required to achieve design grade should be classified as engineered fill and general fill. Engineered fill is material used below, or within 10 feet of structures, pavements, or constructed slopes. General fill is material used to achieve grade outside of these areas.

**Reuse of On-Site Soil:** Material property requirements for on-site soil for use as engineered fill are noted in the table below:

| Fill Type | USCS Classification | Acceptable Location for Placement |
|---|---|---|
| Existing Fill | CH | Pavement areas and at depths greater than 24 inches below building finished grade Existing fill should be observed, tested, and approved by Terracon.<br>Organics, rock/rubble fragments larger than 3 inches, debris, or other unsuitable materials should be removed prior to re-use of the existing fill in engineered fill sections. |

Although general site grading operations for the building and pavement areas are expected to encounter primarily fat clay soils, some deeper excavations (such as for utility installation) may encounter sandstone bedrock. Sandstone fragments excavated from on-site should not be re-used as fill material (including as utility trench backfill) below the building footprint or pavement areas. Although rock materials could be re-used if they are processed by crushing to a relatively small (3-inch minus) maximum particle size, it is likely not economical to set up a rock crushing operation on a project site of this size. In addition, quality control (field testing of moisture content and density) of compacted fill is difficult with rock materials. It would be more practical for this project to export any excavated sandstone fragments off-site and replace them with imported crushed stone aggregate or on-site clay, particularly for utility trench backfill.

**Imported Fill Materials:** Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

| Fill Type | USCS Classification | Acceptable Location for Placement |
|---|---|---|
| Low Volume Change (LVC) material | GM [2]<br>or<br>CL (LL<45 and PI<23) | All locations and elevations, except where free-draining material is required |
| Free Draining Granular | GW, GP, SW, SP | Where free-draining material is required |

1. Engineered fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.
2. MoDOT Type 5 or an approved alternate gradation of crushed limestone aggregate
3. Granular materials with less than 5 percent fines (material passing the #200 sieve), such as ASTM C33 Size No. 57 aggregate or an approved alternate gradation

## Fill Placement and Compaction Requirements

Engineered fil and general fill should meet the following compaction requirements.

| Item | Engineered Fill | General Fill |
|---|---|---|
| **Maximum Lift Thickness** | 8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used<br>4 to 6 inches in loose thickness when hand-guided equipment (i.e., a jumping jack or plate compactor) is used | Same as engineered fill |
| **Minimum Compaction Requirements** [1,2,3] | 95% of max. below and above foundations, below floor slabs, and below pavements | 92% of max. |
| **Water Content Range** [1] | Low plasticity cohesive: -2% to +3% of optimum<br>High plasticity cohesive: 0 to +4% of optimum<br>Granular: -3% to +3% of optimum | As required to achieve min. compaction requirements |

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D698)
2. High plasticity cohesive fill should not be compacted to more than 100% of standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D4253 and D4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

## Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with engineered fill or bedding material in accordance with public works specifications for the utility be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

Utility trenches are a common source of water infiltration and migration. Utility trenches that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. Each trench should be provided with 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 clay is used to construct the trench plug, the clay should be placed and compacted in accordance with the water content and compaction recommendations for engineered fill provided in this report.

## Grading and Drainage

The site should be graded to provide effective drainage away from the building during and after construction, and these conditions 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.

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.

## Earthwork Construction Considerations

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation, proofrolling, placement and compaction of engineered fill, backfilling of excavations into completed subgrades, and just prior to construction of foundations, slabs, and pavements.

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

Based on conditions encountered in the borings, significant seepage is generally not expected in excavations for this project (e.g., for footing construction and utility installation). If seepage is encountered in excavations during construction, the contractor is responsible for designing, implementing, and maintaining appropriate dewatering methods to control seepage and facilitate construction. In our experience, dewatering of excavations in clay soils can typically be accomplished using sump pits and pumps. If seepage occurs where sand seams or sand layers are encountered in excavations, a more extensive dewatering system may be required.

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

# Shallow Foundations

Provided the owner accepts the previously discussed risks associated with supporting the building on existing undocumented fill in exchange for reduced construction costs, the proposed building can be supported on conventional spread footing foundations bearing on suitable existing fill that has been tested and approved by Terracon. Where unsuitable conditions are encountered at design footing bearing elevation, the overexcavation and backfill methods described below should be implemented. Design recommendations for shallow foundations to support the proposed building are presented in the following table:

## Shallow Foundation Design Parameters

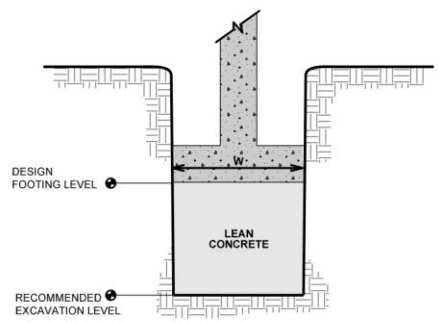
| Item | Description |
|---|---|
| **Maximum Net Allowable Bearing Pressure** [1, 2, 3] | 2,000 psf |
| **Minimum Foundation Dimensions** | Per IBC 1809.7 |
| **Minimum Embedment below Finished Grade** [4] | 3 feet |
| **Estimated Total Settlement from Structural Loads** [5] | See Note 5 |
| **Estimated Differential Settlement** [5] | See Note 5 |

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. Embedment necessary to minimize the effects of frost and/or seasonal water content variations.
5. For foundations designed and constructed as recommended in this report and bearing on/above existing fill that has been observed and tested by Terracon, post-construction foundation settlement due solely to the building loads should be minor (i.e., on the order of 1 inch of total settlement and ¾ inch of differential settlement). However, total and differential settlements of foundations bearing on/above the existing fill will depend on the quality, density, and void content of the underlying existing fill.

## Foundation Construction Considerations

The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. If the soils at the bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. If the excavations must remain open overnight or for an extended period of time, placement of a lean concrete mud-mat over the bearing soils should be considered.

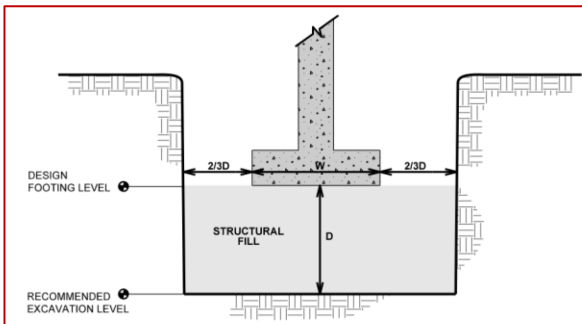
The bearing materials at the base of each footing excavation should be evaluated by a representative of the Geotechnical Engineer. If unsuitable bearing materials are observed, the excavation should be extended deeper to suitable soils. The footings could bear directly on suitable soils at the lower level or on lean concrete backfill as shown on the following figure.




LEAN CONCRETE BACKFILL

**NOTE:** EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

The footings could also bear on properly compacted engineered fill extending down to suitable soils as shown in the following figure. Overexcavation for compacted engineered fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing elevation. The overexcavation should then be backfilled up to the footing base elevation with well graded granular material (e.g., MoDOT Type 5 aggregate or an approved alternate gradation) placed and compacted as recommended in the **Earthwork** section.




OVER-EXCAVATION / BACKFILL ZONE

**NOTE:** EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

# 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.

## Floor Slab Design Parameters

| Item | Description |
|---|---|
| **Floor Slab Support**[1] | At least 24 inches of low volume change (LVC) material over engineered fill and/or approved existing fill |
| **Granular Leveling Course Layer Thickness** [2] | 4 inches (minimum) |
| **Estimated Modulus of Subgrade Reaction** [3] | 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. Well graded crushed stone (e.g., MoDOT Type 5) or open-graded crushed stone (e.g., ASTM C33, Size No. 57 aggregate) can be used as the leveling course.
3. These granular materials can be considered part of the LVC zone.
4. 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.

Joints should be placed in slabs at regular intervals as recommended by ACI to help control the locations of cracks. Joints or any cracks that develop in the floor slab should be sealed with a waterproof, non-extruding compressible compound.

If 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

The subgrade should be maintained within the moisture content range recommended for engineered fill until the floor slab is constructed. If the subgrade becomes desiccated prior to construction of the floor slab, the affected material should be removed or the materials should be scarified, moistened, and compacted. Upon completion of grading operations in the building area, care should be taken to maintain the subgrade within the moisture content and density ranges recommended for engineered fill prior to construction of the building floor slab.

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

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

### Lateral Earth Pressure 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, methods and degree of 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 where wall movement is acceptable. The "at-rest" condition assumes no wall movement and is commonly used for design of 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. The drained parameters do not provide for possible hydrostatic pressure on the walls.

**Lateral Earth Pressure Design Parameters**

| Earth Pressure Condition [1] | Coefficient for Backfill Type [2,3] | Surcharge Pressure [4] $p_1$ (psf) | Equivalent Fluid Unit Weight (pcf) [2,5] | |
|---|---|---|---|---|
| | | | Drained [5] | Undrained [5] |
| Active (Ka) | Granular - 0.3<br>Clay - 0.42 | (0.31)S<br>(0.42)S | 40<br>50 | 80<br>85 |
| At-Rest (Ko) | Granular - 0.47<br>Fine Grained - 0.58 | (0.47)S<br>(0.58)S | 60<br>70 | 90<br>95 |
| Passive (Kp) | Granular - 3.3<br>Clay - 2.4 | ---<br>--- | 420<br>290 | 290<br>200 |

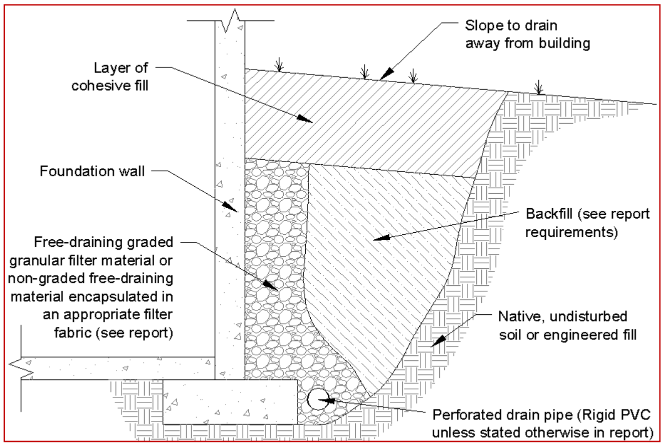
1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, with a maximum unit weight of 120 pcf for clay soils and 130 pcf for granular soils.
3. Granular material backfill phi = 32 degrees (minimum); Clay soil phi = 24 degrees (minimum)
4. Uniform surcharge, where S is surcharge pressure.
5. Loading from heavy compaction equipment is not included.
6. To achieve "Drained" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Undrained" 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 and at-rest cases, and at an angle of 60 degrees from vertical for the passive case. To calculate the resistance to sliding, a value of 0.3 should be used as the ultimate coefficient of friction where the footing bears on native clay soils or engineered fill.

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.

## 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.




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.

# Pavements

## Pavement Subgrade Preparation

Pavement subgrades are expected to consist of newly placed engineered fill and/or tested and approved existing fill. The pavement subgrades should be proofrolled as recommended in **Earthwork**. If soft or otherwise unsuitable areas are observed, additional over-excavation and replacement will be needed.

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

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

Support characteristics of subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as soils observed on this project. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

## Pavement Section Thicknesses

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

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

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

**Opinions of Minimum Pavement Thickness**

| Pavement Type | Parking Lots | Drives |
|---|---|---|
| Full Depth ACC | 2 inches ACC surface<br>4 inches ACC base | 2 inches ACC surface<br>6 inches ACC base |

**Opinions of Minimum Pavement Thickness**

| Pavement Type | Parking Lots | Drives |
|---|---|---|
| ACC over aggregate base | 2 inches ACC surface<br>2 inches ACC base<br>6 inches aggregate base (MoDOT Type 5or similar) | 2 inches ACC surface<br>4 inches ACC base<br>6 inches aggregate base (MoDOT Type 5 or similar) |
| PCC | 5 inches PCC<br>4 inches aggregate base (MoDOT Type 5 or similar) | 6 inches PCC<br>4 inches aggregate base (MoDOT Type 5 or similar) |

1. For trash container pads, we recommend a PCC pavement section be used consisting of 7 inches (minimum) of PCC over 4 inches (minimum) aggregate base (MoDOT Type 5 or similar) on a compacted soil subgrade. The trash container pad should be large enough to support the container and the tipping axle of the collection truck.

PCC pavements will perform better than ACC in areas where short 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.

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

Pavements and subgrades will be subject to freeze-thaw cycles and seasonal fluctuations in moisture content. Pavement thickness design methods are intended to provide adequate thickness of structural materials over a particular subgrade such that wheel loads are reduced to a level that the subgrade can support. The subgrade support parameters for pavement thickness design do not account for shrink/swell movements of a subgrade constructed of expansive clay soils. Therefore, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

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

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

### Pavement Maintenance

The pavement sections represent minimum recommended thicknesses, and periodic maintenance and repairs 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 sealing, 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.

# 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 boring 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.

Support of foundations, floor slabs, and pavements above existing fill is discussed in this report. Even with the construction observation/testing recommended in this report, the owner must accept the risk that unsuitable materials within or buried by the fill will not be discovered. This may result in larger than normal settlement and damage to slabs and pavements supported above existing fill, requiring additional maintenance. This risk cannot be eliminated without removing the existing fill from below the building and pavement areas, but it can be reduced by thorough observation and testing as discussed herein.

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 impact 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, cost estimating, 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 damages 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.

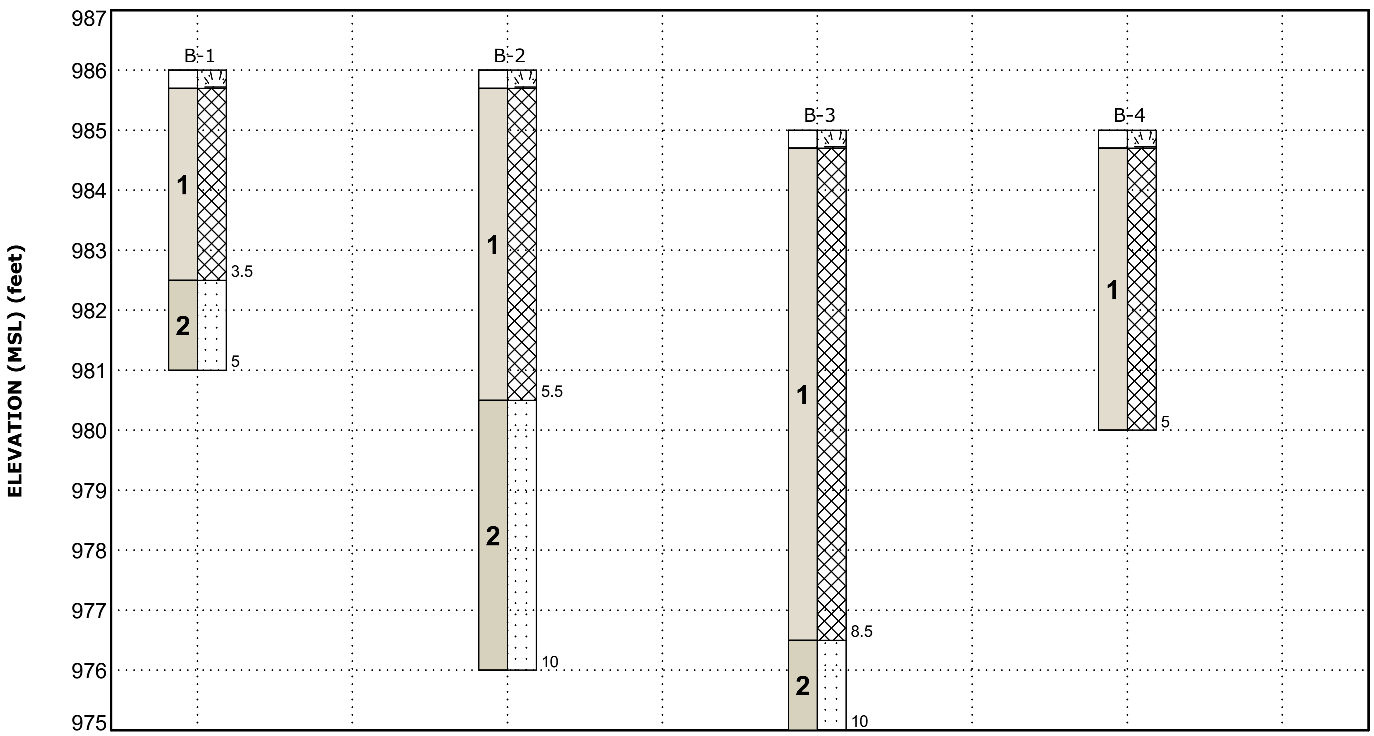
# Figures

**Contents:**

GeoModel

15620 W 113th St
Lenexa, KS

# 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 |
|---|---|---|
| 1 | **Existing Fill** | Fat clay with variable amounts of limestone fragments |
| 2 | **Bedrock** | Highly to moderately weathered sandstone |

**Legend**

Topsoil
Fill
Sandstone

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 |
|---|---|---|
| 2 | 10 | Within the proposed building area |
| 2 | 5 | Within the proposed pavement areas |

**Boring Layout and Elevations:** Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal precision of about ±10 feet) and referencing existing site features. Approximate ground surface elevations were estimated using Google Earth.

**Subsurface Exploration Procedures:** We advanced the borings with a track-mounted rotary drill rig using continuous flight augers. Samples were obtained from the borings using thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. 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. The borings were backfilled with auger cuttings after their completion. The upper few inches of borehole penetrations through pavements were surface patched with cold-mix asphalt and/or pre-mixed concrete.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. Groundwater was not observed in the boreholes at these times.

Our exploration team prepared field boring logs to record the sampling depths, penetration distances, other sampling information, visual classifications of the materials observed during drilling, and our interpretation of the subsurface conditions between samples. The samples were placed in appropriate containers and taken to our laboratory for testing and classification. The final boring logs provided with this report include modifications based on the results of the laboratory tests and observations of the recovered samples.

## Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following tests on selected samples:

- Moisture Content
- Dry Unit Weight
- Unconfined Compressive Strength
- 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 general accordance with the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes; core samples and petrographic analysis may indicate other rock types. The rock classifications on the boring logs were determined using the attached Rock Classification Notes.

# Site Location and Exploration Plans

**Contents:**



Note: All attachments are one page unless noted above.

## Site Location

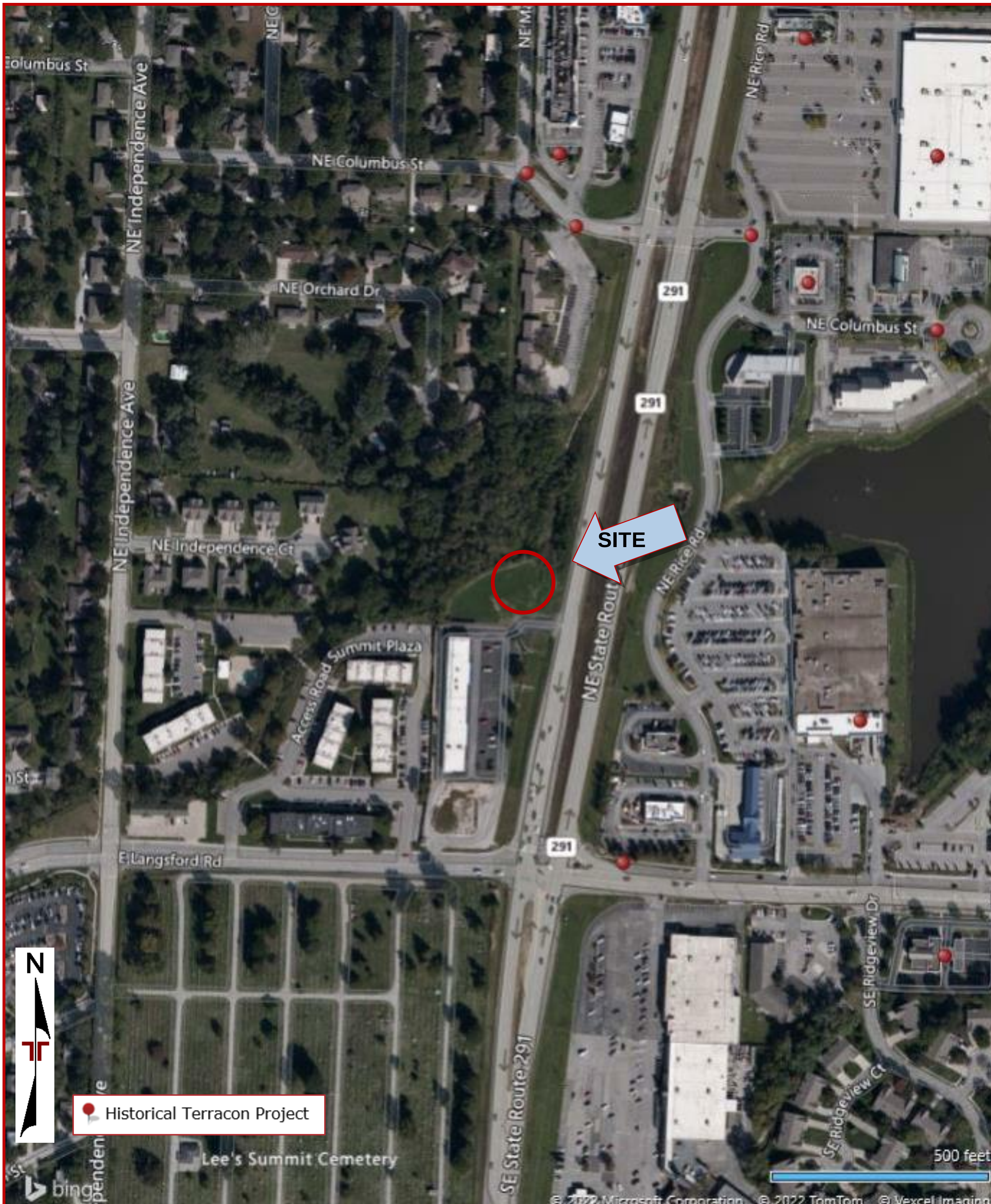



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES
MAP PROVIDED BY MICROSOFT BING MAPS

## Exploration Plan

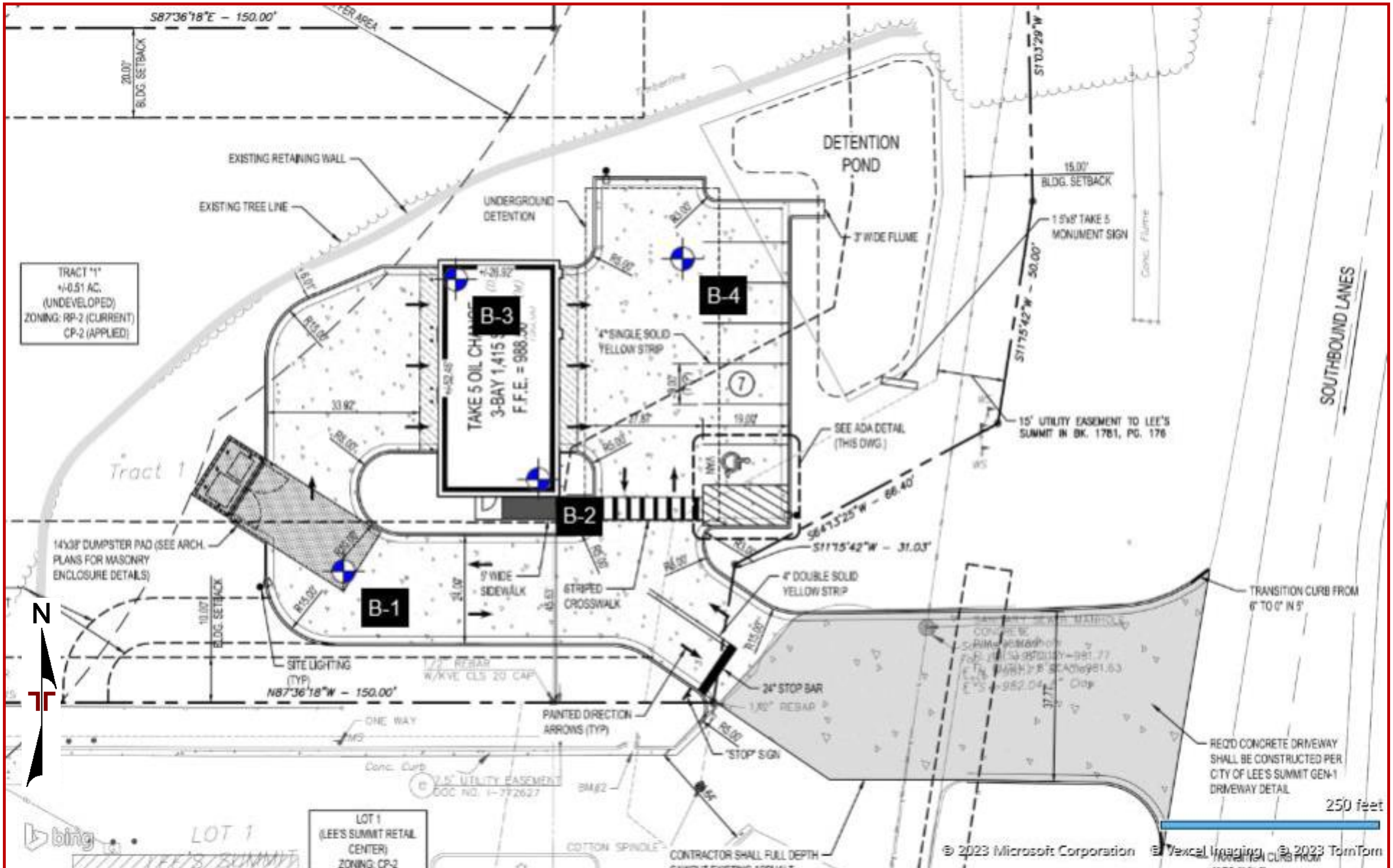



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

# Exploration and Laboratory Results

**Contents:**



Note: All attachments are one page unless noted above.

Terracon
15620 W 113th St
Lenexa, KS

# Boring Log No. B-1

Location: See Exploration Plan

Latitude: 38.9193° Longitude: -94.3624°

| Model Layer | Depth (Ft.) / Material Description | Elevation: 986 (Ft.) +/- | Depth (Ft.) | Water Level Observations | Sample Type | Recovery (In.) | Field Test Results | Strength Test: Test Type | Strength Test: Compressive Strength (psf) | Strength Test: Strain (%) | Water Content (%) | Dry Unit Weight (pcf) | Atterberg Limits LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.3 **4" ROOT ZONE** | 985.7 | | | | | | | | | | | |
| 1 | **FILL - FAT CLAY**, with limestone fragments, brown | | | | | 12 | 6-8-19 N=27 | | | | 9.9 | | |
| | 3.5 | 982.5 | | | | | | | | | | | |
| 2 | **SANDSTONE**, brown, highly to moderately weathered | | | | | 12 | 8-10-8 N=18 | | | | 17.2 | | |
| | 5.0 | 981 | 5 | | | | | | | | | | |

***Boring Terminated at 5 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**
Groundwater not encountered

**Notes**
Elevation Reference: Elevation estimated using Google Earth

Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

**Advancement Method**
Solid-stem augers

**Abandonment Method**
Boring backfilled with Auger Cuttings and/or Bentonite

**Drill Rig**
CME 55

**Hammer Type**
Automatic

**Driller**
LN

**Logged by**
MR

**Boring Started**
10-05-2023

**Boring Completed**
10-05-2023

Terracon
15620 W 113th St
Lenexa, KS

# Boring Log No. B-2

Location: See Exploration Plan

Latitude: 38.9193° Longitude: -94.3624°

Depth (Ft.) Elevation: 986 (Ft.) +/-

| Model Layer | Depth (Ft.) | Material Description | Elevation | Sample Depth (Ft.) | Water Level Observations | Sample Type | Recovery (In.) | Field Test Results | Test Type | Compressive Strength (psf) | Strain (%) | Water Content (%) | Dry Unit Weight (pcf) | Atterberg Limits LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.3 | **4" ROOT ZONE** | 985.7 | | | | | | | | | | | |
| 1 | 5.5 | **FILL - FAT CLAY**, with limestone fragments, brown | 980.5 | 1.5–3.0 | | Split spoon | 11 | 4-5-6 N=11 | | | | 15.6 | | |
| | | | | 3.0–5.0 | | Shelby tube | 11 | | | | | 22.9 | | |
| 2 | 10.0 | **SANDSTONE**, brown, highly to moderately weathered | 976 | 6.5–8.0 | | Split spoon | 14 | 6-7-6 N=13 | | | | 25.2 | | |
| | | | | 8.5–9.8 | | Split spoon | 12 | 4-4-50/4" | | | | 30.2 | | |

***Auger Refusal at 10 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**
Groundwater not encountered

**Notes**
Elevation Reference: Elevation estimated using Google Earth

Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

**Advancement Method**
Solid-stem augers

**Abandonment Method**
Boring backfilled with Auger Cuttings and/or Bentonite

**Drill Rig**
CME 55

**Hammer Type**
Automatic

**Driller**
LN

**Logged by**
MR

**Boring Started**
10-05-2023

**Boring Completed**
10-05-2023

Terracon
15620 W 113th St
Lenexa, KS

# Boring Log No. B-3

Location: See Exploration Plan
Latitude: 38.9193° Longitude: -94.3624°
Depth (Ft.) Elevation: 985 (Ft.) +/-

| Model Layer | Depth (Ft.) | Material Description | Elevation (Ft.) | Sample Depth (Ft.) | Sample Type | Recovery (In.) | Field Test Results | Test Type | Compressive Strength (psf) | Strain (%) | Water Content (%) | Dry Unit Weight (pcf) | Atterberg Limits LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.3 | **4" ROOT ZONE** | 984.7 | | | | | | | | | | |
| 1 | | **FILL - FAT CLAY**, with limestone fragments, brown | | | | | | | | | | | |
| | | | | 1.5–3 | Split spoon | 7 | 4-5-7 N=12 | | | | 18.7 | | |
| | | | | 3–5 | Shelby tube | 24 | | UC | 6611 | 4.6 | 21.6 | 103 | |
| | | | | 6.5–8 | Split spoon | 10 | 4-5-7 N=12 | | | | 21.4 | | |
| | 8.5 | | 976.5 | | | | | | | | | | |
| 2 | | **SANDSTONE**, brown, moderately weathered | | 8.5–8.8 | Split spoon | 3 | 50/4" | | | | 17.0 | | |
| | 10.0 | | 975 | | | | | | | | | | |

***Auger Refusal at 10 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.

**Notes**

Elevation Reference: Elevation estimated using Google Earth

Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

**Water Level Observations**
Groundwater not encountered

**Advancement Method**
Solid-stem augers

**Abandonment Method**
Boring backfilled with Auger Cuttings and/or Bentonite

**Drill Rig**
CME 55

**Hammer Type**
Automatic

**Driller**
LN

**Logged by**
MR

**Boring Started**
10-05-2023

**Boring Completed**
10-05-2023

Terracon
15620 W 113th St
Lenexa, KS

# Boring Log No. B-4

Location: See Exploration Plan

Latitude: 38.9193° Longitude: -94.3624°

| Model Layer | Graphic Log | Depth (Ft.) / Description / Elevation: 985 (Ft.) +/- | Depth (Ft.) | Water Level Observations | Sample Type | Recovery (In.) | Field Test Results | Strength Test: Test Type | Strength Test: Compressive Strength (psf) | Strength Test: Strain (%) | Water Content (%) | Dry Unit Weight (pcf) | Atterberg Limits LL-PL-PI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.3 **4" ROOT ZONE** 984.7 | | | | | | | | | | | |
| 1 | | **FILL - FAT CLAY**, with limestone fragments, brown | | | | 7 | 4-3-6 N=9 | | | | 16.9 | | |
| | | | | | | 12 | 4-3-3 N=6 | | | | 20.8 | | 66-25-41 |
| | | 5.0 980 | 5 | | | | | | | | | | |

***Boring Terminated at 5 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**
Groundwater not encountered

**Notes**
Elevation Reference: Elevation estimated using Google Earth

Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

**Advancement Method**
Solid-stem augers

**Abandonment Method**
Boring backfilled with Auger Cuttings and/or Bentonite

**Drill Rig**
CME 55

**Hammer Type**
Automatic

**Driller**
LN

**Logged by**
MR

**Boring Started**
10-05-2023

**Boring Completed**
10-05-2023

# Supporting Information

**Contents:**



Note: All attachments are one page unless noted above.

Terracon
15620 W 113th St
Lenexa, KS

# General Notes

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

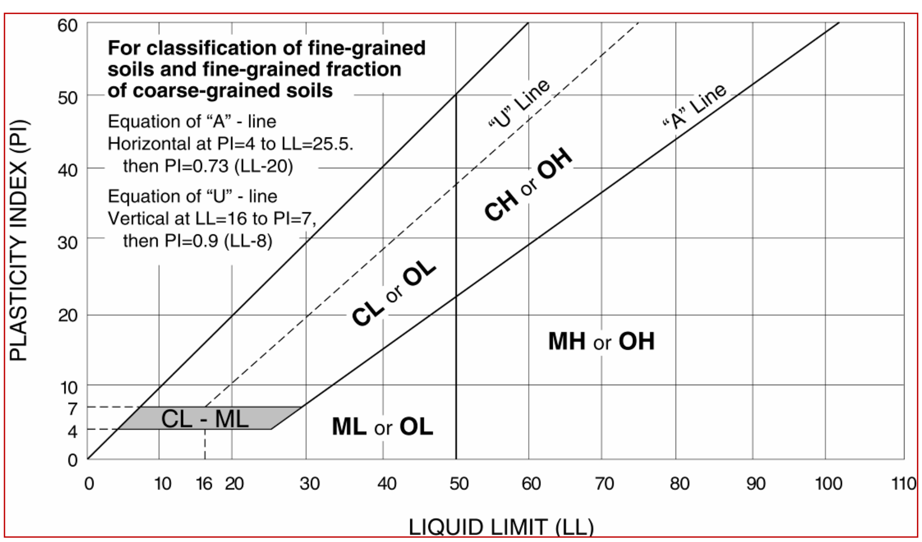
## Relevance of Exploration and Laboratory Test Results

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≥4 and 1≤Cc≤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≥6 and 1≤Cc≤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

| WEATHERING | |
|---|---|
| **Term** | **Description** |
| **Fresh** | Mineral crystals appear bright; show no discoloration. Features show little or no staining on surfaces. Discoloration does not extend into intact rock. |
| **Slightly weathered** | Rock generally fresh except along fractures. Some fractures stained and discoloration may extend <0.5 inches into rock. |
| **Moderately weathered** | Significant portions of rock are dull and discolored. Rock may be significantly weaker than in fresh state near fractures. Soil zones of limited extent may occur along some fractures. |
| **Highly weathered** | Rock dull and discolored throughout. Majority of rock mass is significantly weaker and has decomposed and/or disintegrated; isolated zones of stronger rock and/or soil may occur throughout. |
| **Completely weathered** | All rock material is decomposed and/or disintegrated to soil. The rock mass or fabric is still evident and largely intact. Isolated zones of stronger rock may occur locally. |

| STRENGTH OR HARDNESS | | |
|---|---|---|
| **Description** | **Field Identification** | **Uniaxial Compressive Strength, psi** |
| **Extremely strong** | Can only be chipped with geological hammer. Rock rings on hammer blows. Cannot be scratched with a sharp pick. Hand specimens require several hard hammer blows to break. | >36,000 |
| **Very strong** | Several blows of a geological hammer to fracture. Cannot be scratched with a 20d common steel nail. Can be scratched with a geologist's pick only with difficulty. | 15,000-36,000 |
| **Strong** | More than one blow of a geological hammer needed to fracture. Can be scratched with a 20d nail or geologist's pick. Gouges or grooves to ¼ inch deep can be excavated by a hard blow of a geologist's pick. Hand specimens can be detached by a moderate blow. | 7,500-15,000 |
| **Medium strong** | One blow of geological hammer needed to fracture. Can be distinctly scratched with 20d nail. Can be grooved or gouged 1/16 in. deep by firm pressure with a geologist's pick point. Can be fractured with single firm blow of geological hammer. Can be excavated in small chips (about 1-in. maximum size) by hard blows of the point of a geologist's pick; | 3,500-7,500 |
| **Weak** | Shallow indent by firm blow with geological hammer point. Can be gouged or grooved readily with geologist's pick point. Can be excavated in pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure. | 700-3,500 |
| **Very weak** | Crumbles under firm blow with geological hammer point. Can be excavated readily with the point of a geologist's pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail. | 150-700 |

| DISCONTINUITY DESCRIPTION | | | |
|---|---|---|---|
| **Fracture Spacing (Joints, Faults, Other Fractures)** | | **Bedding Spacing (May Include Foliation or Banding)** | |
| **Description** | **Spacing** | **Description** | **Spacing** |
| **Intensely fractured** | < 2.5 inches | **Laminated** | < ½-inch |
| **Highly fractured** | 2.5 – 8 inches | **Very thin** | ½ – 2 inches |
| **Moderately fractured** | 8 inches to 2 feet | **Thin** | 2 inches – 1 foot |
| **Slightly fractured** | 2 to 6.5 feet | **Medium** | 1 – 3 feet |
| **Very slightly fractured** | > 6.5 feet | **Thick** | 3 – 10 feet |
| | | **Massive** | > 10 feet |

| ROCK QUALITY DESIGNATION (RQD) [1] | |
|---|---|
| **Description** | **RQD Value (%)** |
| **Very Poor** | 0 - 25 |
| **Poor** | 25 – 50 |
| **Fair** | 50 – 75 |
| **Good** | 75 – 90 |
| **Excellent** | 90 - 100 |

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