Boys and Girls Club – Price Hill

Geotechnical Engineering Final Report

January 17, 2024 | Terracon Project No. N1235143A

Prepared for:

JS Held, LLC
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Cincinnati, Ohio, 45227

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January 17, 2024

JS Held, LLC
3950 Virginia Ave
Cincinnati, Ohio, 45227

Attn: Nicholas Keyes – Vice President Support Services
P: (513)-838-3904
E: nkeyes@jsheld.com

Re: Geotechnical Engineering Final Report
Boys and Girls Club – Price Hill
1213 Dewey Ave
Cincinnati, Ohio
Terracon Project No. N1235143A

Dear Mr. Keyes:

We have completed the scope of Geotechnical Engineering services for the above-referenced project in general accordance with Terracon Proposal No. PN1235143 dated April 26, 2023. This report supersedes our preliminary report dated September 8, 2023, and presents the findings of the subsurface exploration, and provides final geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs 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

STATE OF OHIO
JEFFREY D.
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E-63301
REGISTERED
PROFESSIONAL ENGINEER

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1/17/2024

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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 that 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 structure and parking lot to be located at 1213 Dewey Ave in Cincinnati, Ohio. 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
- Lateral earth pressure
- Floor slab design and construction
- Pavement subgrade support 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 final report. A preliminary geotechnical report was provided on September 8, 2023, and the recommendations in this report supersede the recommendations in our September 8, 2023 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 in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email was provided from JS Held LLC on April 20, 2023, which provided a request for proposal and plans for both Roll Hill and Price Hill. The Price Hill plans were printed on March 21, 2023. An updated phone conversation and email chain was discussed and provided on July 21, 2023. A permit set of plans including Grading Plan dated 1/8/2024 and Site Utility Plan prepared by Abercrombie & Associates and Emboss design, was provided by Abercrombie & Associates on January 8, 2024 and January 15, 2024.
Project Description	The Price Hill property consists of 0.898 acres of land which is bounded by Glenway Avenue to the south and is bounded by Dewey Avenue to the east and Rosemont Ave to the west. The project consists of a proposed two-story structure with a parking lot.
Proposed Structure	The two-story structure at the Price Hill property has plan dimensions of approximately 79 feet by 204 feet.
Building Construction	We anticipate that the buildings will be constructed using concrete slab-on-grade construction with load-bearing masonry walls with potential interior columns.
Finished Floor Elevation	The FFE will be at Elevation 886 feet, which is the approximate elevation at B-4 based on the approximate ground surface elevation of our boring and based on the provided grading plan.
Maximum Loads	In the absence of information provided by the design team, we will use the following loads in estimating settlement based on our experience with similar projects. These loads will need to be confirmed by the design team. ▪ Columns: 125 kips ▪ Walls: 6 kips per linear foot (klf) ▪ Slabs: 125 pounds per square foot (psf)
Grading/Slopes	There is about 10 feet of grade change across the site. As much as about 9 feet of fill and 7 feet of cut will be required to achieve anticipated final site grades.
Foundation Walls	A foundation wall supporting the anticipated fill along Glenway Avenue going west along the proposed south building wall and the west building wall along Rosemont Avenue is anticipated. It will also need to turn along Rosemont St.

Item	Description
Free-Standing Retaining Walls	There is an existing free-standing rock wall along the north property line near the northwest property corner that separates the house to the north from the site. We understand that this free-standing wall will be removed. A segmental retaining wall with a maximum exposed height of about 5 feet is planned in the northwest corner of the site. The grade below the retaining wall is relatively level. The grade above the retaining wall is about 3H:1V with maximum slope height of about 4 feet. The length of the proposed retaining wall is about 140 feet. A second segmental retaining wall with a maximum exposed height of 3.5 feet is proposed at the northeast corner of the site. Proposed grades at the toe and crest of the retaining wall are relatively level. The length of the retaining wall appears to be about 20 to 25 feet.
Below-Grade Structures	The grading plan shows a below-grade stormwater detention system. The invert of this system is at about Elevation 875.45 feet. This invert is approximately 15 feet below existing surface grades of about Elevation 890 feet at the proposed location. This stormwater system was not shown on site plans when we performed our test borings.
Pavements	Light-duty pavement is anticipated on the north side of the proposed building.

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 and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	■ The project site is located at 1213 Dewey Ave in Cincinnati, Ohio. ■ Price Hill Site 0.8 acres, Lat/Long (approx.) 39.1145, -84.5824 ■ See **Site Location**
Existing Improvements	The Price Hill site has been cleared of all previously existing structures and has been rough graded. Previous structures in the southwest corner of the site reportedly contained pits associated with hydraulic lifts. The previous structure in the east portion of the site may or may not have had a basement. There is an existing retaining wall along the north side of the property line near the northwest corner of the site that supports a stucture on the adjacent north property.
Existing Topography	The property slopes downward from north to south towards Glenway Avenue. Based on the site grading plan, grades at the site range between about Elevation 877 feet and 893 feet.
Geology	Soils at the site were formed in loess and residuum weathered from the underlying parent interbedded calcareous shale and limestone. Evidence of previous development was encountered in several of the recent test borings in the form of man-placed fill. Based on the review of published geologic literature and archive borings, the bedrock at this site belongs to the Ordovician Age Waynesville and Arnheim Formations and consists of 70% shale and 30% limestone.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based on 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	Existing Fill	Lean clay and gravel, with brick and limestone fragments, brown, gray, and black
2	Cohesive	Lean clay (CL), brown and gray, stiff to very stiff
3	Residuum	Lean clay (CL), with relic bedding planes, brown and olive, very stiff to hard
4	Interbedded Shale and Limestone	Shale, gray and brown, slightly to moderately weathered, very weak Limestone, gray and brown, slightly weathered, weak to medium strong

Existing fill soils were encountered in Borings B-1, B-2, B-3, B-4, B-6, P-1 and P-2 to depths ranging from about 3.5 to 8.5 feet below existing surface grades. Standard penetration test (SPT) N-values of the fill samples ranged from 3 to 21 blows per foot and were typically less than 10 blows per foot. Moisture contents of tested existing fill samples ranged from about 9% to 35%. Based on the variable moisture contents and SPT N-values, it does not appear the existing fill was placed using density and moisture control. As a result, it is our opinion that the existing fill should be considered uncontrolled in nature and not suitable for direct foundation and floor slab support.

An Atterberg limit test performed on a sample of existing fill from Boring P-2 indicated a liquid limit of 41 and a plastic limit of 17. Typically the plastic limit is an indicator of the soil's optimum moisture content. The moisture contents of the tested cohesive existing fill samples ranged from about 14% to 35%, which are anticipated to be about 3% below to 18% above optimum moisture content. As a result, moisture correction of the existing fill soils will be required before reusing them as structural fill.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater seepage was not encountered within the maximum drilling depths at the time of our field exploration. Groundwater conditions may be different at the time of construction. Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling.

Long-term observations in piezometers or observation wells sealed from the influence of surface water, are often required to define groundwater levels in profiles of this type. Long-term groundwater monitoring was outside the scope of services for this project. The presence of wet sand/silt seams and layers containing perched groundwater within existing fill, at the existing fill/native soil interface, at the native soil/bedrock interface or within fractures and seams within the bedrock is common. The flow and volume of groundwater in these perched zones depends upon the areal extent of the interconnected zones, and the amount of recharge of these higher permeability zones or where permeability changes occur in the subsurface profile.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on the 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 by 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 in the exploration logs and results, our professional opinion is for that a **Seismic Site Classification of C** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 15 feet. The site properties below the boring depth of 100 feet were estimated based on our experience and knowledge of the geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

Geotechnical Overview

This report provides information based on the data collected and recommendations related to geotechnical aspects of the project including subsurface conditions, earthwork, and foundations for the proposed building and development. Our geotechnical exploration included a total of 9 borings drilled to depths between about 10 feet and 15 feet below the existing ground surface. The borings were drilled in the vicinity of the proposed building and anticipated pavement areas. The building borings were terminated in shale and limestone bedrock. The pavement borings were terminated in either bedrock or native cohesive soil.

The B-borings were drilled in the vicinity of the proposed building. The P-borings were drilled in the proposed parking and pavement areas. Seven of the nine borings encountered existing fill, which is associated with the previous development at the site. The deepest existing fill was encountered in the northern portions of the site. The remaining two borings encountered native lean clay soil underlain by a layer of residual soil and then shale bedrock with traces of interbedded limestone layers.

The upper 3.5 to 8.5 feet of the soil profile in seven of the nine borings was described as existing fill. Please note the depth of existing fill will vary at locations away from the borings. We have been provided no records to indicate the degree of compaction and moisture control used during the placement of this existing fill. The moisture content of the tested existing fill samples varied from about 9% to 35% and the plastic limit was 17%. SPT N-values of the existing fill samples ranged from 3 to 21 blows/foot. Considering the lack of compaction documentation, the wide range of moisture content, and the variable SPT N-values of the tested existing fill samples, it is our opinion that the existing fill should be considered uncontrolled/undocumented fill and not suitable for direct support of building foundations and floor slabs. Reuse of the undocumented fill should be evaluated in the field for suitability by a Geotechnical engineer or Geologist for its use as a structural fill, due to the presence of limestone and brick fragments in the collected samples, it is uncertain at the time of drilling the exact concentration of the fragments. Performing test pits to further evaluate the distribution and quantity of limestone fragments, bricks, and other debris in the existing fill prior to construction is recommended. The test pits can also provide additional data regarding the depth of fill at locations away from our test borings.

The stiff to hard native soils (GeoModel Layers 2 and 3) are suitable for direct foundation support of the building. Typically, the native cohesive soils (GeoModel Layers 2 and 3) have moisture contents ranging from about 9% to 30% with typical values less than about 22%. The liquid limit of the tested native soil samples varied from 26 to 37% with a plasticity index values ranging from 13 to 19. The laboratory test results, and descriptions of the recovered soil samples are presented on the boring logs in the **Exploration Results** section.

Due to the depth and quality of existing fill soils in the building footprint, which are not suitable for the direct support of the proposed building foundations, we have evaluated two options to support the proposed building on shallow foundations. For Option 1, it is recommended that all existing fill soils encountered within the proposed building footprint and 10 feet beyond the lateral limits of the building footprint should be completely undercut and replaced with new structural fill. For Option 2, we recommend partially undercutting the existing fill soils for the floor slabs about 2.5 feet below floor slab design subgrade elevation and replacing with new controlled fill. For Option 2, the new fill and any existing fill would need to be completely undercut below the foundation locations until firm native soil is encountered and replacing the foundation undercuts with lean concrete to the design bearing elevation.

The excavated existing fill can be reused as the structural fill for both Options 1 and 2, provided it is properly moisture conditioned and construction debris and other deleterious items are culled from the excavated soils. The moisture conditioning would require laying the soils out and allowing them to air dry and this method would be dependent on the weather conditions at the time of construction and the amount of room on site to air dry the soils. If weather conditions are such that air drying the soils is not feasible or limited space does not allow the air drying of soils, then chemical drying using lime kiln dust with excess lime could be considered.

In the pavement areas, some of the existing fill materials may be used for support of pavement subgrade if they pass the proof-roll testing program performed under the supervision of a geotechnical engineer. Due to the low SPT N-values of the existing fill at the time the borings were performed, some partial undercut of the existing fill and replacement with new fill in the pavement areas should be anticipated.

The existing fill soils (GeoModel Layer 1) and the native soils (Geomodel Layer 2) near the surface could become unstable with typical earthwork and construction traffic, especially after precipitation events or during historically wetter periods of the year (generally winter, spring, and possibly early summer). If possible, grading should be performed during the warmer and drier times of the year. If grading is performed during the winter/spring or wet periods, an increased risk for possible undercutting and replacement or chemical modification/drying of unstable subgrade will persist. The chemical modification of the subgrade to a depth of about 12 inches with additives such as lime, lime kiln dust with excess lime or cement will provide the benefits of reducing water infiltration/absorption and increasing the strength/survivability of the finished subgrade during construction. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the **Earthwork** section.

The **Floor Slabs** section addresses slab-on-grade support of the building using overexcavation and replacement techniques. The **Pavements** section includes our recommended parameters for subgrade support for pavement thickness design by others. We can provide pavement section thickness design if traffic information is made available if so requested, as an addition to our current scope and budget. The recommendations contained in this report are based on 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’s limitations.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, partial or complete overexcation and replacement of existing fill soils, 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. During earthwork activities, care must be taken to avoid undermining the existing stone retaining wall along the north side of the property line near the northwest corner of the site. An additional new retaining wall may be required to avoid undermining the existing wall.

Site Preparation

Site preparation should begin with utility location and stripping of topsoil and vegetation. All existing underground utilities within the footprint of the proposed development area should be located. Existing underground utilities within the proposed building footprint should be completely removed (including trench backfill) or relocated at least 10 feet beyond the perimeter of the proposed building. Any planned abandoned utilities outside of the proposed building footprint should preferably be removed or grouted full (with cementitious grout) in place to prevent future collapse, which could result in the subsidence of overlying elements. The resulting excavations from utility removal should be backfilled with structural fill as recommended in this report, or with low-strength mortar otherwise known as flowable fill. If lean concrete is used as removed utility trench backfill, the contractor should refer to the Mechanical-Electrical-Plumbing (MEP) plan and foundation details for the new structures to confirm that the lean concrete backfill material will not conflict with any new installations, floor slabs, and utilities associated with the proposed structures.

Stripped asphalt/concrete pavement and construction rubble are not suitable for re-use as structural fill without further evaluation and/or processing. Unsuitable materials should be hauled off-site. The proposed construction area for the new building and pavement subgrade should be thoroughly cleaned of any demolition debris or concrete remnants or any other deleterious materials before placing new structural fill to bring the site to the desired subgrade elevation.

Areas in the proposed building where existing fill soils are anticipated should be prepared as recommended in the **Existing Fill** section of this report.

Subgrade Preparation

Where new fill is required to achieve proposed finished grades, after stripping and any undercutting of undocumented fills, the subgrade should be proof-rolled with an adequately loaded vehicle such as a fully loaded tandem-axle dump truck (minimum 20 tons) akin to the heaviest anticipated construction traffic load. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed and replaced with new structural fill, aerated and recompacted, or chemically modified. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted.

As previously mentioned, the near-surface native clay and existing fill soils tend to become easily disturbed when subjected to precipitation and construction traffic. If earthwork is performed during wet periods or after precipitation events, the risk of deeper undercuts and replacement with new fill increases. A method to improve construction and earthwork during wet periods is chemical drying or modification using lime kiln dust with excess lime, quick lime, or cement to dry soils during a wetter period or improve the trafficability of subgrade soils during wetter periods. This chemical drying or modification can also be used to reduce the volume change potential of the final subgrade soils where fat clay soils are encountered, instead of undercutting and replacing them with low-volume change materials. Earthwork construction during the wet and cold winter and early spring months should be avoided if possible since cold weather can cause chemical additives to not properly react with the encountered cohesive soils.

Existing Fill

As noted in **Geotechnical Characterization**, Borings B-1 through B-4, B-6, P-1, and P-2 encountered previously placed undocumented fill to depths ranging from about 3.5 to 8.5 feet below existing grade. We have no records to indicate the degree of control, and consequently, the fill is considered unreliable for support of foundation loads. Support of floor slabs and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction procedures, inherent risk exists for the owner that compressible existing fill or unsuitable material, within or buried by the existing fill will, not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report.

The table below shows the depth of existing fill encountered during our field exploration within or near the proposed building location. Please note that the depth of existing fill soils may vary at locations away from our borings and variations should be anticipated. Reports of pits in the previously existing building near the southwest corner of the site and the reported basement in the previously existing building on the east side of the site could result in deeper fill zones not revealed by our borings. In addition, buried cisterns, wells, or other buried structures could be encountered at locations away from our borings due to previous development at the site.

Boring ID	Approximate Depth of Existing Fill (feet)
B-1	6
B-2	8.5
B-3	8.5
B-4	6
B-6	3.5

For Option 1 in the building pad area, which has the least risk of potential floor slab settlement, we recommend completely undercutting the existing fill within and 10 feet beyond the perimeter of the proposed building footprint. The undercut existing fill soil should be replaced with new structural fill compacted in thin lifts as recommended in this report. Performing a complete undercut along the existing sidewalks and streets could result in undermining of the existing sidewalks, streets and underground utilities, and possible shoring of the excavations may be required for Option 1. The exposed soil at the base of the undercut should be proofrolled as previously recommended in this report. Any weak or disturbed soils indicated by the proofroll should be further undercut or stabilized in place. Areas of native soil do not need to be undercut unless they do not pass a proofroll. Preparation of the building pad using Option 1 will allow the building footings and floor slab to be supported directly on the new structural fill or firm native soil at minimum depth.

For Option 2 in the building pad area, which has greater risk of floor slab settlement due to existing fill being left below the floor slab area, we recommend that the entire building footprint and 5 feet beyond the building footprint be partially undercut to a depth of about 2.5 feet below design floor slab subgrade elevation. If firm native soil is encountered at depths less than 2.5 feet below design floor slab subgrade elevation, the partial undercut can be terminated at shallower depth. The exposed subgrade at the partial undercut elevation should be proofrolled as previously recommended in this report. Any weak or disturbed soils indicated by the proofroll should be further undercut or stabilized in place. The partial undercut should then be backfilled with structural fill. For Option 2, the existing fill and new fill beneath the building footings would need to be completely undercut until firm native soil is exposed in the bottom of the undercut. The complete overexcavation beneath the footings would then need to be replaced with lean concrete from the bottom of the undercut to the original bearing elevation. Please note that the granular existing fill encountered in Boring B-2 will be difficult to trench through, since it will want to cave and will likely not support a vertical excavation wall. For Option 2, if the owner elects to construct the floor slabs above the existing fill to reduce initial construction costs, the owner must be willing to accept the risk for increased potential longer-term distress in the floor slab.

For both Options 1 and 2, the existing undocumented fill that was removed can be evaluated for reuse as structural fill. As a minimum, some moisture correction of the excavated existing fill soils should be anticipated. Excavated existing fill soils containing organics, construction debris or other deleterious items should not be reused as new structural fill.

If the owner elects to construct pavements on the existing fill, the following protocol should be followed. Once the planned subgrade elevation has been reached, the entire pavement area should be proofrolled. Areas of soft or otherwise unsuitable material should be undercut and replaced with either new structural fill or suitable, existing on-site materials or stabilized in-place.

Excavation

We anticipate that the majority of the excavations for the proposed construction can be accomplished with conventional earthmoving equipment. The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials before backfill placement and/or construction. If Option 1 (complete undercut of existing fill) is performed, the excavation along Glenway and Rosemont Avenues could require temporary excavation support to avoid undermining of the existing sidewalks, streets and underground utilities. For Option 2, care will need to be taken during the complete undercut of foundations along Glenway and Rosemount Avenues to avoid undermining of sidewalks, streets and existing underground utilities. Trench boxes or limiting the length of undercut prior to backfill at foundation undercut excavations may be required to avoid undermining of existing sidewalks, streets and underground utilities.

Based on the provided plans and anticipated excavation depths for the proposed underground detention system, shale and limestone bedrock near P-1 may be encountered even though the Boring P-1 did not encounter bedrock. We believe heavy-duty construction equipment, such as tracked excavators or tracked excavators with a hoe ram, may be required to perform the excavation for the proposed underground detention system and any deeper underground utilities. Utility trenches extending into the bedrock may benefit by using a rock trencher.

The table below shows the anticipated depths of cut and fill at each boring location to achieve final site grades.

Boring ID	Approximate Depth of Cut (feet)	Approximate Depth of Fill (feet)
B-1	-	-
B-2	1	-
B-3	5	
B-4	-	-
B-5	-	8
B-6	-	5
B-7	-	2
P-1	6/15[1]	-
P-2	3	-

1. Up to 15 feet of excavation is anticipated for construction of the proposed underground detention system and shale and limestone bedrock could be encountered in the excavation for the underground detention system.

Soil Stabilization

Due to the encountered soil profile, we anticipate that there will be some areas where the existing soil subgrade may need to be stabilized in place if the subgrade soils cannot be completely undercut and replaced with new structural fill. Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and recompaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics), and chemical stabilization. The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size of the area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help reduce the amount of subgrade stabilization required.

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

- **Scarification and Recompaction** - It may be feasible to scarify, dry, and recompact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.
- **Crushed Stone** - The use of crushed stone is a common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 24 to 36 inches below the finished subgrade elevation. The use of geogrid could also be considered after underground work such as utility construction is completed. Before placing the geogrid, we recommend that all below-grade construction, such as utility line installation, be completed to avoid damaging the geogrid. Equipment should not be operated above the geogrid until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over geogrid should not exceed 1-1/2 inches.
- **Chemical Modification** - Improvement of subgrades with Portland cement, quick lime or lime kiln dust could be considered for improving unstable soils. The chemical modification should be performed by a pre-qualified contractor having experience with successfully stabilizing subgrades in the project area on similar-sized projects with similar soil conditions. Results of chemical analysis of the additive materials should be provided to the geotechnical engineer before use. The hazards of chemicals blowing across the site or onto adjacent property should also be considered. Additional testing would be needed to develop specific recommendations to improve subgrade stability by blending chemicals with the site soils. Additional testing could include, but not be limited to, determining the

most suitable stabilizing agent, the optimum amounts required, the presence of sulfates in the soil, and the freeze-thaw durability of the subgrade.

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

Fill Material Types

Fill required to achieve design grade should be classified as structural fill. Structural fill is material used below, or within 10 feet of building perimeters and within 5 feet of other structures and pavements.

Reuse of On-Site Soil: Excavated on-site soil may be selectively reused as fill below building areas and pavement areas.

Material property requirements for on-site soil for use as structural fill are noted in the table below:

Property [1]	Structural Fill
Composition	Free of deleterious material
Maximum particle size	3 inches
Plasticity	Maximum liquid limit of 40 Maximum plasticity index of 20

1. Based on subsurface exploration. Actual material suitability should be determined in the field at the time of construction. Some moisture correction should be anticipated.

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.

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity Cohesive	CL (LL ≤ 40, PI ≤ 20)	All elevations and locations
High Plasticity Cohesive	CL and CH (LL>40, PI>20)	Not recommended for this project
Granular	GW, GM [2]	All elevations and locations

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)

1. Structural fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation before use on this site. Additional geotechnical consultation should be provided before the uniformly graded gravel on the site. Excavated shale and limestone bedrock should not be used as imported fill for this site due to the extra effort required to properly place and compact the material.
2. Similar to ODOT 304 crushed limestone aggregate or granular materials such as sand, gravel, or crushed stone containing no more than 10% low plasticity fines.

Fill Placement and Compaction Requirements

Structural fill should meet the following compaction requirements.

Item	Structural Fill
Maximum Lift Thickness	▪ 8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used ▪ 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction Requirements [1,2,3]	**Structural Areas**: 98% of the material's Standard Proctor maximum dry density **Non-Structural/Landscape Areas**: 95% of the material's Standard Proctor maximum dry density provided long-term plans do not include a structure in these areas. Based on the site plan, it appear that the majority of the site consists of structural areas.
Water Content Range [1]	▪ Low plasticity cohesive: -3% to +3% of optimum ▪ Granular: -2% to +2% of optimum

1. Maximum dry density and optimum water content as determined by the standard Proctor test (ASTM D 698). Fat clay and elastic silt soils are not recommended for structural fill.
2. If the granular material is a coarse sand or gravel, 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 D 4253 and D 4254). 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 structural fill or bedding material by public works specifications for the utility to 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 or proposed foundations without an 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 and has been properly moisture conditioned.

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 gradation and expansion index requirements of the engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

For low permeability subgrades, 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 structural 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. Water retained next to the building can 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. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

The exposed ground should be sloped and maintained at a minimum of 5% away from the building 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 that 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

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content before 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 before floor slab construction.

As a minimum, excavations should be performed by OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and by 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 a 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 before 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 before the placement of additional lifts. Each lift of fill should be tested for density and water content.

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

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations. As previously mentioned, if Option 1 is selected for site preparation in the building pad, the footings can bear directly on the new structural fill overlying the firm native soil or on firm native soil. If Option 2 is selected for the building pad site preparation, then the footing excavations will need to penetrate the new structural fill and any underlying existing fill soils until firm native soil is exposed. For Option 2, the footings can then bear at the lower elevation, or the undercut can be replaced with lean concrete from the bottom of the undercut to the design footing bearing elevation. Please note that the granular existing fill soil encountered in Boring B-2 will make trenching through the existing fill difficult since granular soils will not hold a vertical excavation face and will likely collapse into the excavation.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	2,500 psf - foundations bearing upon structural fill underlain by firm native soil or directly on firm native soil

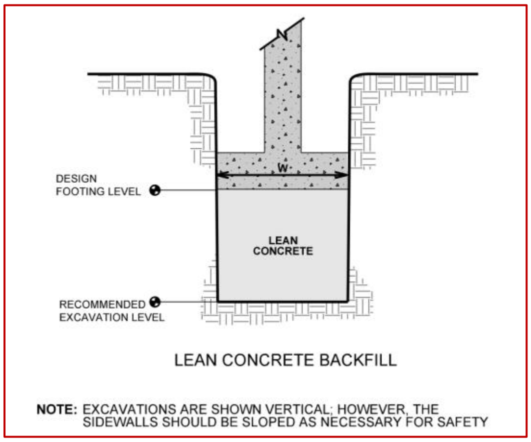
Item	Description
Required Bearing Stratum [3]	GeoModel Layer 2 or 3 (undisturbed native cohesive soils) or structural fill supported directly on undisturbed and firm native soil
Minimum Foundation Dimensions	Per IBC 1809.7
Sliding Resistance [4]	0.35 allowable coefficient of friction – stiff or better native clay or new structural fill
Minimum Embedment below Finished Grade [5]	Exterior footings in unheated areas: 30 inches Interior footings in heated areas: 12 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2, 6]	About 2/3 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
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. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations. For fine-grained materials, lateral resistance using cohesion should not exceed ½ the dead load.
5. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
6. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet or between adjacent isolated column footings.

Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. 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. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are observed at the base of the planned footing excavation or for the partial undercut (Option 2) building pad site preparation, 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 (28-day f’c=2,000 psi) placed in the excavations to the design bearing elevation. The lean concrete replacement zone is illustrated on the sketch below.



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.

Existing undocumented fill materials were observed at the site to depths of 3.5 to 8.5 feet below existing grades. As previously described, any existing fill present beneath floor slabs should be either completely undercut and replaced with structural fill (Option 1) or partially undercut such that a minimum of 2.5 feet of new structural fill is present below the floor slab subgrade elevation (Option 2). As previously discussed Option 1 has less risk of future floor slab settlement since all of the undocumented/uncontrolled fill has be removed and replaced beneath the floor slab. Whereas, Option 2 has some risk of settlement below the floor slab, since some existing undocumented/uncontrolled fill will remain below the slab-on-grade floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1]	▪ New structural fill underlain by firm native soil-Option 1 ▪ Minimum 2.5 feet of structural fill-Option 2 ▪ Minimum 4 inches of relatively free draining (less than 10% passing the U.S. No. 200 sieve) crushed aggregate

Item	Description
	(as compared to the cohesive subgrade soil) compacted to at least 98% of ASTM D 698 ▪ Subgrade compacted to recommendations in **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 the 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 the use of sufficient control joints, appropriate reinforcing, or other means.

Settlement of floor slabs supported on or above existing fill materials (Option 2) cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in **Existing Fill** within **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams, and/or post-tensioned elements.

Floor Slab Construction Considerations

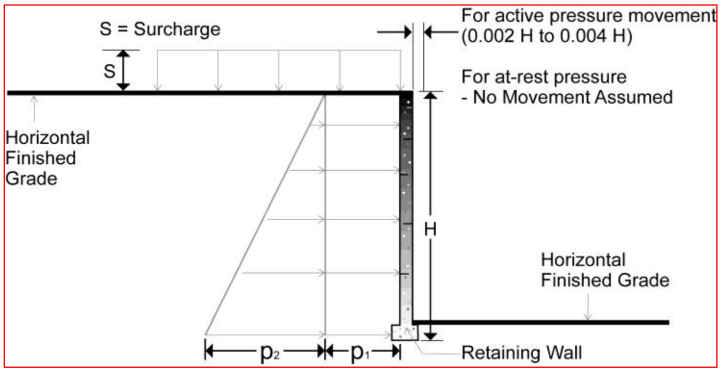
The finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated before the construction of 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 before placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately before 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

A foundation wall will be require along portions of the south building wall and the east building wall to support new structural fill to establish the proposed finished floor elevation. In addition some free-standing retaining walls may be required in other protions of the site due to topography at the site. Structures with unbalanced backfill levels on opposite sides, such as the anticipated foundation wall and any free-standing retaining walls, 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. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. At rest earth pressures are typically used to design walls that are restrained at their top, similar to the anticipated foundation wall along poortions of the proposed building. 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 - 0.31 Fine Grained - 0.41	(0.31)S (0.41)S	(40)H (50)H	(80)H (85)H
At-Rest (Ko)	Granular - 0.47 Fine Grained - 0.58	(0.47)S (0.58)S	(55)H (70)H	(90)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, rendering a maximum moist unit weight of 120 pcf. Values based on Fine-grained soil internal angle of friction = 25 degrees and granular soil internal angle of friction = 32 degrees.
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 or concrete foundation 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.

In addition, no specific borings were performed for the proposed retaining walls. Test pits prior to construction or additional borings should be considered to investigate the bearing soils and retained soil conditions at the proposed retaining wall locations.

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 or a concrete slab to reduce infiltration of surface water into the drain system.

Pavements

General Pavement Comments

Sufficient information is not available for us to provide an opinion of the minimum pavement thickness for the project. Minimum pavement designs will need to be provided by others based on traffic loads provided by the developer or owner. A critical aspect of pavement performance is site preparation, and the site should be prepared as recommended in the **Earthwork** section.

Pavement Subgrade Support Characteristics

A California Bearing Ratio (CBR) of 3 is recommended for subgrade support for the asphaltic concrete (AC) pavement designs that will be performed by others. A modulus of subgrade reaction of 100 pci is recommended for subgrade support for Portland cement concrete (PCC) pavement designs that will be performed by others. The values were empirically derived based on our experience with existing fill sites, the lean clay subgrade soils anticipated and our expectation of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in the **Earthwork** section.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections designed by others will represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an ongoing 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 of 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 the 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 on 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 by 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 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 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 is commonly associated with contractor means and methods and is not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of the surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and

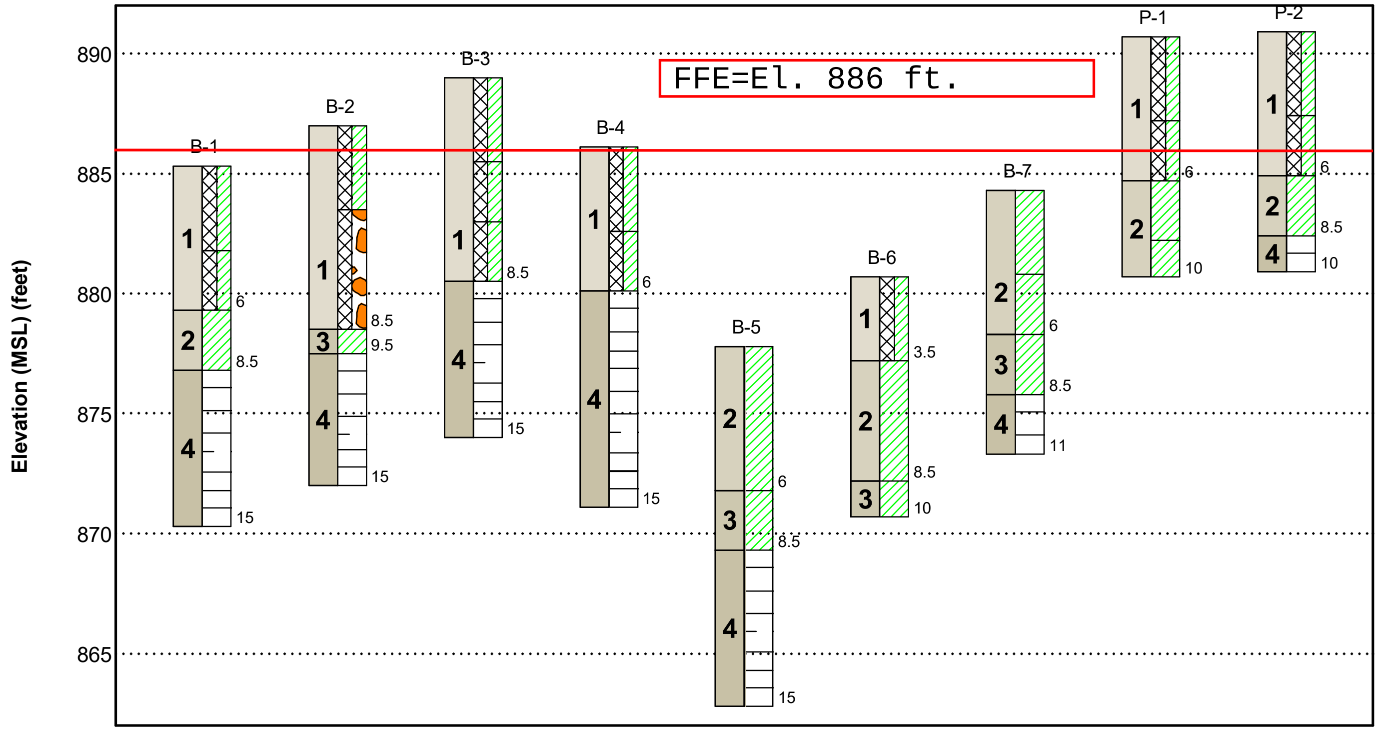
recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

Contents:

611 Lunken Park Dr
Cincinnati, OH

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	Lean clay and gravel, with brick and limestone fragments, brown, gray, and black
2	Cohesive	Lean clay (CL), brown and gray, stiff to very stiff
3	Residuum	Lean Clay (CL), with relic bedding planes, brown and olive, very stiff to hard
4	Interbedded Shale and Limestone	Shale, gray and brown, slightly to moderately weathered, very with interbedded limestone

LEGEND

- Lean Clay
- Interbedded Shale or Limestone 1
- Poorly-graded Gravel

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
5	15	Building
1	10	
1	11	
2	10	Pavement

Boring Layout and Elevations: Terracon personnel provided the boring layout using a handheld Leica Zeno GPS unit (estimated horizontal accuracy of about ±2 feet). The location and surface elevations of the test borings should only be considered accurate to the degree implied by the means and methods used to define them. If more accurae locations and ground surface elevations are required for the boring locations, we recommend that they be surveyed by a professional surveyor. Terracon called Ohio 811 to mark public utilities on-site and employed a private utility locating subcontractor for GPR scanning of private utilities around the boring locations before performing the boreholes.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted, rotary drill rig using hollow-stem continuous-flight augers. Four 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 after drilling for the presence of groundwater. The groundwater levels are shown on the attached boring logs.

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 the examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples by the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes. Boring log rock classification was determined using the Rock Classification Notes.

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

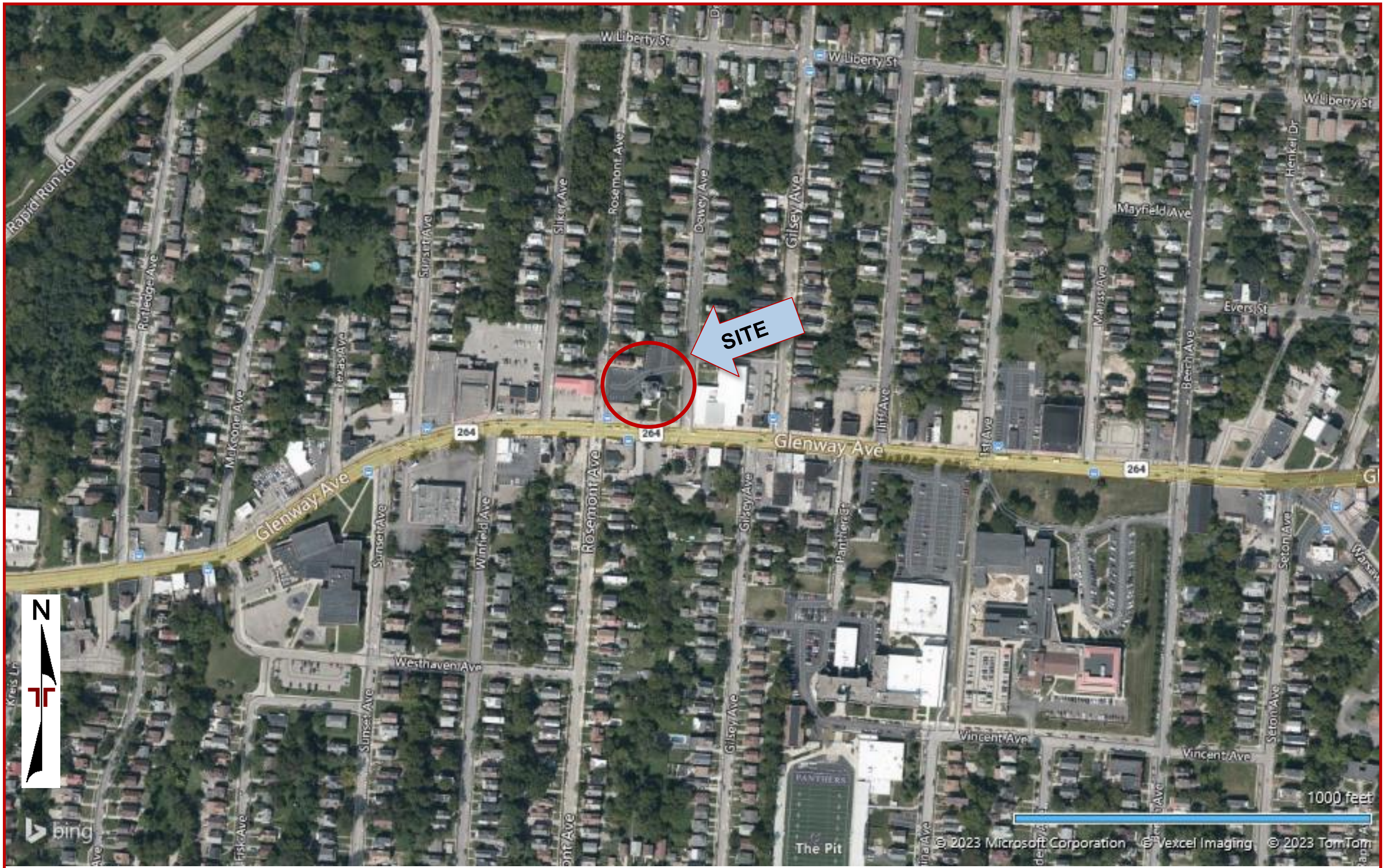


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

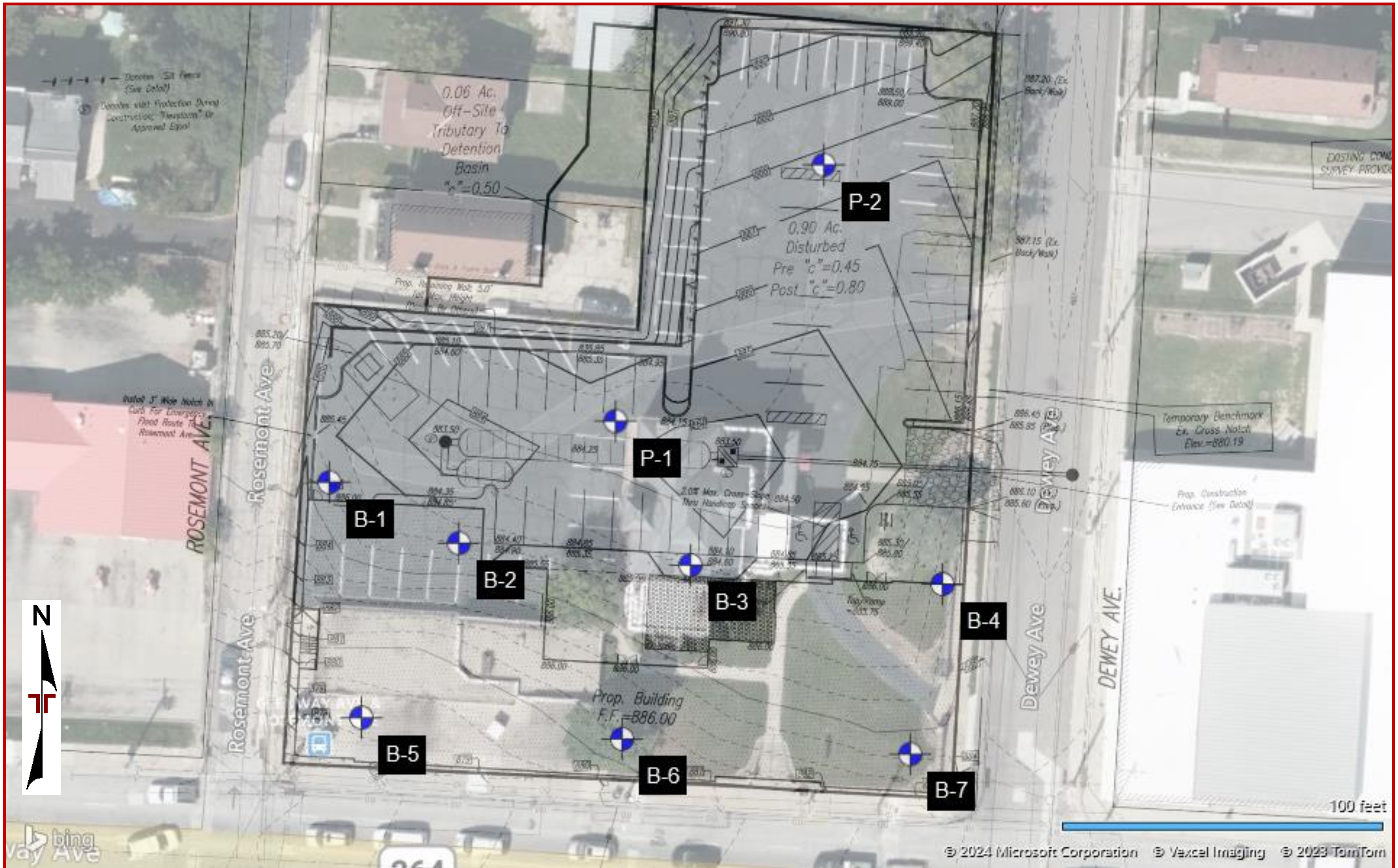


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 39.1147° Longitude: -84.5829°

Model Layer	Depth (Ft.)	Description	Elevation.: 885.3 (Ft.)	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1	3.5	**FILL - LEAN CLAY**, with bricks, trace gravel, brown with grayish brown	881.8			X	100	1-2-2 N=4		24.4	
1	6.0	**FILL - LEAN CLAY**, with bricks, trace limestone fragments, brown	879.3	5		X	94	7-10-8 N=18		18.2	
2	8.5	**LEAN CLAY (CL)**, brown and dark brown, stiff to very stiff	876.8			X	100	4-2-4 N=6	3.0 (HP)	25.2	
4	13.5	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Highly Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	871.8	10		X	100	17-31-42 N=73		10.7	
4	15.0	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak to Medium Strong	870.3	15		X	100	14-28-31 N=59		15.2	

Boring Terminated at 15 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 was not observed during drilling

Groundwater was not observed after drilling

Notes

Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 39.1146° Longitude: -84.5827°

Elevation.: 887.0 (Ft.)

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)	Sample Depth (Ft.)	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1	0-3.5	**FILL - LEAN CLAY**, with limestone fragments, brown	883.5	1.0-2.5	100	5-10-11 N=21		14.0	
1	3.5-8.5	**FILL - GRAVEL**, with sand, trace silt, gray and brown	878.5	3.5-5.0	100	6-9-11 N=20		9.6	
				6.0-7.5	100	6-7-8 N=15		8.8	
3	8.5-9.5	**LEAN CLAY (CL)**, with limestone fragments, trace relic bedding planes, brown to light brown, hard, (RESIDUUM)	877.5	8.5-9.9	94	25-27-50/5"		9.7	26-13-13
4	9.5-13.5	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Highly Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	873.5						
4	13.5-15.0	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak to Medium Strong	872	13.5-15.0	100	11-21-25 N=46		13.4	

Boring Terminated at 15 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: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Water Level Observations

Groundwater was not observed during drilling

Groundwater was not observed after drilling

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 39.1146° Longitude: -84.5825°

Elevation.: 889.0 (Ft.)

Model Layer	Depth (Ft.) / Elevation (Ft.)	Description	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1	0.0–3.5 / 885.5	**FILL - LEAN CLAY**, trace bricks, trace gravel, dark brown	1.0–2.5		X	100	3-4-5 N=9		20.0	
1	3.5–6.0 / 883	**FILL - LEAN CLAY**, trace gravel, trace rock fragments, brown to dark brown	3.5–5.0		X	100	3-4-4 N=8		27.2	
1	6.0–8.5 / 880.5	**FILL - LEAN CLAY**, trace bricks, trace root hairs, trace gravel, trace sand, brown to black	6.0–7.5		X	100	4-2-4 N=6		30.0	
4	8.5–13.5 / 875.5	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Highly Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	8.5–10.0		X	100	4-7-9 N=16		14.4	
4	13.5–15.0 / 874	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Slightly to Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	13.5–15.0		X	100	39-29-27 N=56		15.7	

Boring Terminated at 15 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: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Water Level Observations

Groundwater was not observed during drilling

Groundwater was not observed after drilling

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Boy and Girls Club Price Hill
4122 Glenway Ave | Cincinnati, OH
Terracon Project No. N1235143A

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 39.1146° Longitude: -84.5822°

Elevation.: 886.1 (Ft.)

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1	0.0–3.5	**FILL - LEAN CLAY**, trace root hairs, orangish brown	882.6	X	100	2-1-2 N=3		34.8	
1	3.5–6.0	**FILL - LEAN CLAY**, trace root hairs, trace brick fragments, brown to dark brown	880.1	X	100	2-2-5 N=7		28.9	
4	6.0–8.5	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Highly Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	877.6	X	100	2-14-15 N=29		12.7	
4	8.5–13.5	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak	872.6	X	94	17-32-50/5"		10.7	
4	13.5–15.0	**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown and Gray, Slightly to Moderately Weathered, Very Weak to Weak Limestone, Gray to Brown, Slightly Weathered, Weak	871.1	X	33	50		14.4	

Boring Terminated at 15 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 was not observed during drilling
Groundwater was not observed after drilling

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Notes

Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 39.1145° Longitude: -84.5829°

Elevation.: 877.8 (Ft.)

Model Layer	Depth (Ft.)	Description	Elevation (Ft.)	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
2		**LEAN CLAY (CL)**, trace sand, trace limestone fragments, brown and gray, very stiff							
				X	100	1-2-2 N=4	4.5 (HP)	14.1	
				X	100	2-3-5 N=8	4.5 (HP)	21.4	
	6.0		871.8						
3		**LEAN CLAY (CL)**, trace relic bedding planes, brown with gray, very stiff to hard, (RESIDUUM)		X	100	9-10-14 N=24	4.5 (HP)	18.7	37-18-19
	8.5		869.3						
4		**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Highly Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak		X	100	22-21-29 N=50		12.5	
	13.5		864.3						
		INTERBEDDED SHALE AND LIMESTONE, Shale, Brown to Gray, Slightly to Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak		X	100	21-25-36 N=61		15.9	
	15.0		862.8						

Boring Terminated at 15 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 was not observed during drilling
Groundwater was not observed after drilling

Notes
Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit
Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-6

Location: See Exploration Plan

Latitude: 39.1145° Longitude: -84.5826°

Elevation.: 880.7 (Ft.)

Model Layer	Graphic Log	Depth (Ft.) / Material Description	Elevation (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1		**FILL - LEAN CLAY**, trace sand, trace root hairs, trace gravel, light brown to brown								
					X	100	3-1-3 N=4		18.3	
		3.5	877.2							
2		**LEAN CLAY (CL)**, trace limestone fragments, trace gravel, brown and gray, very stiff			X	100	7-7-8 N=15	4.5 (HP)	18.9	
					X	100	7-8-9 N=17	3.25 (HP)	18.0	
		8.5	872.2							
3		**LEAN CLAY (CL)**, trace limestone fragments, trace relic bedding planes, olive brown to brown, hard, (RESIDUUM)			X	100	9-13-24 N=37	4.5 (HP)	20.0	
		10.0	870.7							

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 was not observed during drilling
Groundwater was not observed after drilling

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Notes
Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit
Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. B-7

Location: See Exploration Plan

Latitude: 39.1144° Longitude: -84.5823°

Elevation.: 884.3 (Ft.)

Model Layer	Depth (Ft.)	Description	Elevation	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
		LEAN CLAY (CL), trace gravel, brown to gray, stiff to very stiff				X	100	2-1-2 N=3	4.5 (HP)	30.9	
	3.5		880.8								
2		**LEAN CLAY (CL)**, trace limestone fragments, brown, very stiff				X	100	8-9-15 N=24	4.5 (HP)	12.0	32-15-17
	6.0		878.3	5							
3		**LEAN CLAY (CL)**, with limestone fragments, trace relic bedding planes, brown to light brown, hard, (RESIDUUM)				X	100	9-12-21 N=33		22.1	
	8.5		875.8								
4		**INTERBEDDED SHALE AND LIMESTONE**, brown and gray, moderately weathered, very weak, Shale, Brown to Gray, Slightly to Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak		10		X	100	13-20-35 N=55		11.1	
	11.0		873.3								
		Auger Refusal at 11 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 was not observed during drilling
Groundwater was not observed after drilling

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Notes

Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Terracon
611 Lunken Park Dr
Cincinnati, OH

Boring Log No. P-1

Location: See Exploration Plan

Latitude: 39.1147° Longitude: -84.5826°

Elevation.: 890.7 (Ft.)

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1		3.5	**FILL - LEAN CLAY**, trace brick fragments, trace rock fragments, trace sand, brown to dark gray	887.2			X	89	8-5-2 N=7		22.5	
1		6.0	**FILL - LEAN CLAY**, light brown	884.7	5		X	100	4-4-6 N=10		18.8	
2		8.5	**LEAN CLAY (CL)**, brown, stiff to very stiff	882.2			X	100	4-4-5 N=9	3.25 (HP)	34.6	
2		10.0	**LEAN CLAY (CL)**, trace limestone fragments, brown to dark brown, very stiff	880.7	10		X	100	6-9-11 N=20	2.75 (HP)	22.7	

Boring Terminated 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 was not observed during drilling
Groundwater was not observed after drilling

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

Boring Started
08-02-2023

Boring Completed
08-02-2023

Notes
Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit
Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Boy and Girls Club Price Hill
4122 Glenway Ave | Cincinnati, OH
Terracon Project No. N1235143A

611 Lunken Park Dr
Cincinnati, OH

Boring Log No. P-2

Location: See Exploration Plan

Latitude: 39.1149° Longitude: -84.5823°

Model Layer	Depth (Ft.)	Material Description	Elevation.: 890.9 (Ft.)	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (%)	Field Test Results	HP (tsf)	Water Content (%)	Atterberg Limits LL-PL-PI
1		**FILL - LEAN CLAY**, trace limestone fragments, trace gravel, brown				X	28	2-1-2 N=3		32.9	
	3.5		887.4								
1		**FILL - LEAN CLAY**, trace root hairs, trace brick fragments, trace gravel, trace limestone fragments, brown to dark brown				X	22	4-4-7 N=11		15.7	41-17-24
	6.0		884.9	5							
2		**LEAN CLAY (CL)**, brown to gray, very stiff				X	100	4-5-5 N=10	4.0 (HP)	30.8	
	8.5		882.4								
4		**INTERBEDDED SHALE AND LIMESTONE**, Shale, Brown, Moderately Weathered, Very Weak Limestone, Gray to Brown, Slightly Weathered, Weak to Medium Strong				X	100	16-34-37 N=71		10.3	
	10.0		880.9	10							

Boring Terminated 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 was not observed during drilling

Groundwater was not observed after drilling

Notes

Elevation Reference: Elevations and coordinates were measured by using Leica Zeno GPS Unit

Energy Transfer Ratio (ETR) = 92.7% +/- 2.9%

Advancement Method
2 1/4-inch Continous-Flight Hollow-Stem Auger, 2 inch Split Spoon

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
Geoprobe #628

Hammer Type
Automatic

Driller
AR

Logged by
J.Hughes

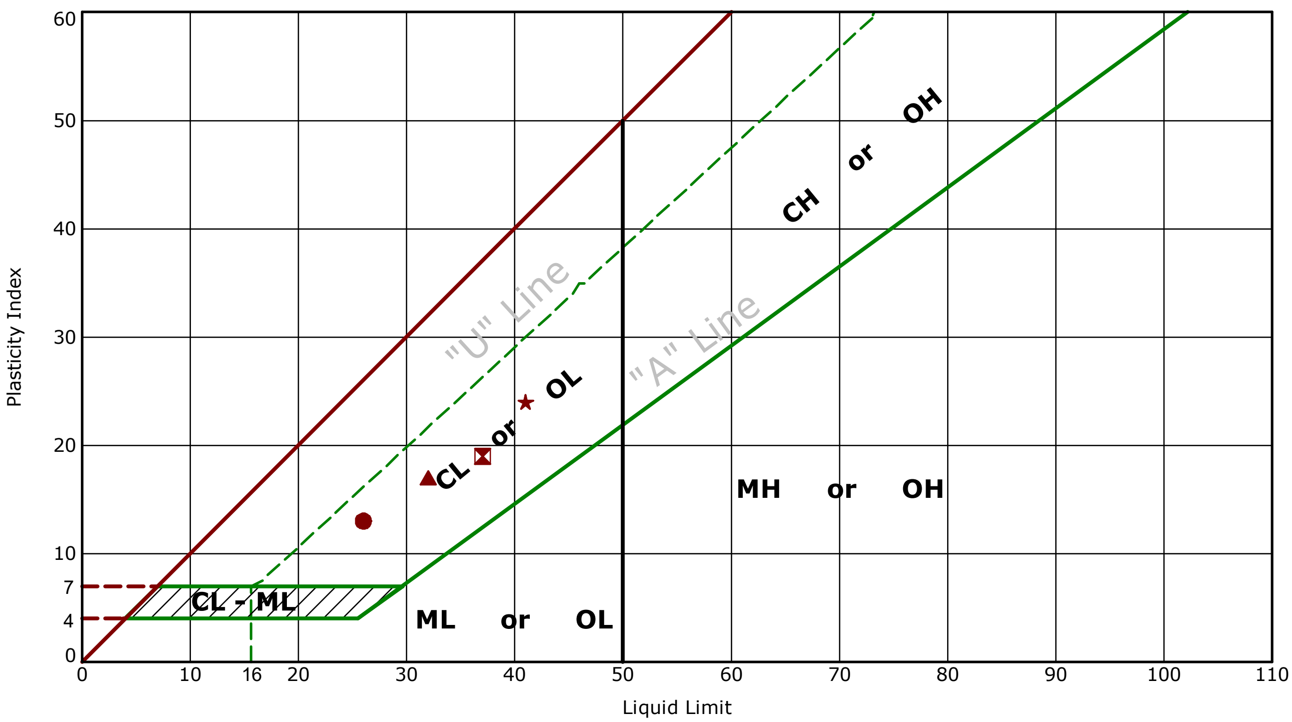
Boring Started
08-02-2023

Boring Completed
08-02-2023

Terracon
611 Lunken Park Dr
Cincinnati, OH

Atterberg Limit Results

ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-2	8.5 - 9.9	26	13	13		CL	
⊠	B-5	6 - 7.5	37	18	19		CL	
▲	B-7	3.5 - 5	32	15	17		CL	
★	P-2	3.5 - 5	41	17	24		CL	

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

611 Lunken Park Dr
Cincinnati, OH

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

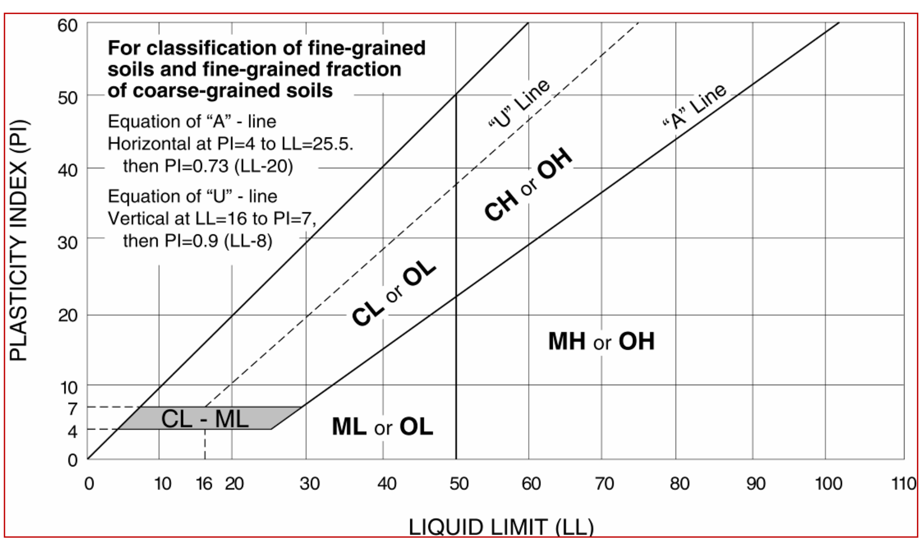
Relevance of Exploration and Laboratory Test Results

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≥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 now 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.