



Hidalgo County Head Start Program Policy Council Agenda

DATE: February 22, 2023

SUBJECT: Request Approval of Application and Certificate for Payment for Invoice #TI03880 in the Amount of \$10,000.00 for Professional Services Submitted by Terracon Engineering, Geotechnical Engineer, Through Contract C-21-006-11-02-AS for the Hidalgo County Head Start Program Outdoor Learning Environments and Discovery Classrooms

RATIONALE/NEED: This is the second payment request for Geotechnical Engineering Services for the Hidalgo County Head Start Program Outdoor Learning Environment and Discovery Classrooms.

RECOMMENDATION: Administration recommends approval.

COST: Head Start Funds are available for this project.

RELATED INFORMATION INCLUDED: Invoice #TI03880

INITIATED BY: Ambrosio Tovar, Procurement Director *Ambrosio Tovar*

REVIEWED BY: Mr. Edmundo Garcia, Assistant Director

PROGRAM DIRECTOR'S APPROVAL: _____.



INVOICE

Pharr, TX
956-283-8254

Project Mgr: Martin Reyes

Project: HCHSP Outdoor Learning Environments and Discovery
Park
1901 West State Highway 107
McAllen, TX

To: Hidalgo County Head Start Program
Attn: Teresa Flores
1901 W, State Highway 107
McAllen, TX 78504

REMIT TO:
Invoice Number: TI03880
Terracon Consultants, Inc.
PO Box 959673
St Louis, MO 63195-9673
Federal E.I.N.: 42-1249917

Project Number:	88215151
Invoice Date:	1/30/2023
For Period:	12/05/2021 to 1/28/2023

Partial Invoice

Description	Total
Geotechnical Engineering Services	\$10,000.00

Invoice Total	\$10,000.00
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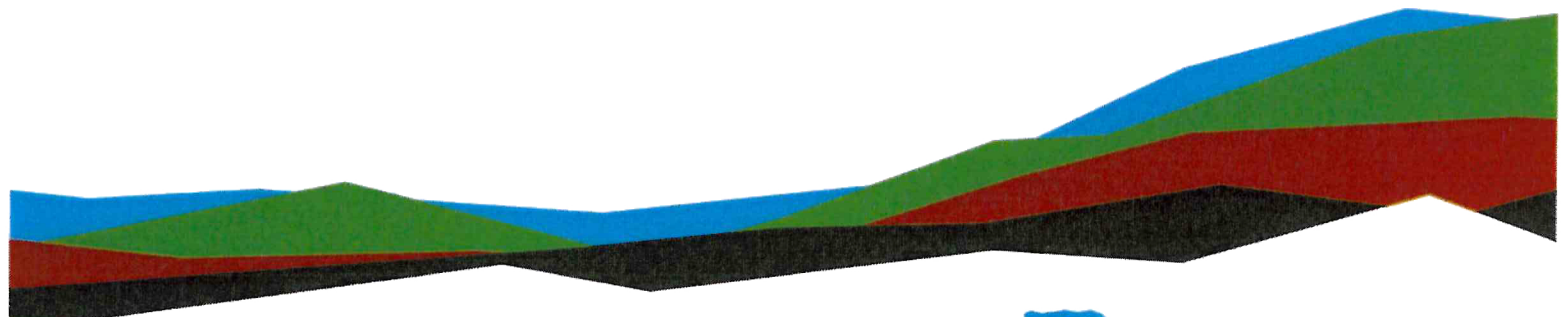
HCHSP Outdoor Learning Environments and Discovery Park

Geotechnical Engineering Report

February 15, 2023 | Terracon Project No. 88215151

Prepared for:

Hidalgo County Head Start Program
1901 W. State Highway 107
McAllen, TX 78504



Nationwide
Terracon.com

- Facilities
- Environmental
- Geotechnical



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Pharr, Texas 78577
P (956) 283 8254
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February 15, 2023

Hidalgo County Head Start Program
1901 W. State Highway 107
McAllen, TX 78504

Attn: Mr. Edmundo Garcia
P: (956) 383 0706
E: Edmundo.garcia@hchsp.org

Re: Geotechnical Engineering Report (Base Option)
HCHSP Outdoor Learning Environments and Discovery Park
1901 West State Highway 107
McAllen, Texas
Terracon Project No. 88215151

Dear Mr. Garcia:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P89215151 dated October 14, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, the design and construction of foundations, floor slabs and pavements for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon
(Texas Firm Registration No. F-3272)

Martin Reyes
Group Manager



Alfonso A. Soto, P.E., D.GE., F. ASCE
Senior Principal

2/15/23

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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 which direct the reader to that section and clicking on the  Terracon logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic ¹	Overview Statement ²
Project Description	HCHSP Outdoor Learning Environments and Discovery Park.
Geotechnical Characterization	<p>The subsurface soils at this site generally consist of Sandy Lean Clay (CL) and Clayey Sand (SC).</p> <p>Groundwater was observed in the borings at depths ranging from 7 to 11 feet below existing grade (beg) during drilling and after a 15-minute wait period.</p>
Shallow Foundations	A shallow or deep foundation system would be appropriate to support the structural loads of the proposed structure, provided the pad is prepared as recommended in this report.
Pavements	Flexible and rigid pavement systems are considered for this project. We anticipate traffic may consist of typical small / midsize vehicles, school buses and occasional garbage trucks.
Earthwork	Existing on-site soils may be used for general fill or select fill, as appropriate.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed HCHSP Outdoor Learning Environments and Discovery Park facility to be located at 1901 West State Highway 107 in McAllen, Texas. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Frost considerations
- Floor slab design and construction
- Seismic site classification per IBC
- Pavement design and construction

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

Drawings showing the site and boring locations are shown on the [Site Location](#) and [Exploration Plan](#), respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs 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	By HCHSP on November 7, 2022
Project Description	HCHSP Outdoor Learning Environments and Discovery Park The project may consist of design and construction of the following structures:
Proposed Structures	<ul style="list-style-type: none">■ Future Large Pavilion - 11,963 square feet (sf);■ Seven (7) Small Pavilions - 972 sf each structure; and■ Bus parking areas.

Item	Description
Construction Type	Based on information provided to us, we understand that the Large and Small Pavilions will likely consist of pre-engineered metal structures with metal wall panels supported by a shallow or deep foundation system.
Finished Floor Elevation (FFE)	We anticipate that FFE may be about 2 feet above existing grade.
Maximum Loads (assumed)	Estimated maximum loads: <ul style="list-style-type: none"> ■ Columns: 30 kips ■ Walls: 3 kips per linear foot ■ Slabs: 250 pounds per square foot (psf)
Grading/Slopes	Up to 4 feet of cut and 5½ feet of fill may be required to develop final grade.
Pavements	Flexible and rigid pavement sections may be considered for this project.

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 1901 West State Highway 107 in McAllen, Texas. Approx. GPS coordinates of boring B-1: Latitude: 26.308440° N Longitude: 98.223000° W. See Site Location
Existing Improvements	Undeveloped land
Current Ground Cover	Native grass, bare soils and dense vegetation. Site clearing will likely be needed prior construction.
Existing Topography	Relatively flat and level

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the [Exploration and Laboratory 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	Clay	Sandy Lean Clay (CL); very soft to very stiff
2	Sand	Clayey Sand (SC); very loose to very dense

Groundwater Conditions

The borings were advanced in the dry using a dry augered drilling technique that allow short term groundwater observations to be made while drilling. Groundwater seepage was encountered at the time of our field exploration.

The borings were observed during and after completion of drilling for the presence and level of groundwater. The water levels observed are noted on the attached boring logs and are summarized below.

Boring Number	Approximate Depth to Groundwater, feet ¹	
	While Drilling	After a 15-Minute Wait Period
B-1	8	7
B-2	9	7
B-3	10	8
B-4	9	8
B-5	11	8
B-6	8	7



Boring Number	Approximate Depth to Groundwater, feet ¹	
	While Drilling	After a 15-Minute Wait Period
P-1	--	--
P-2	7	6
P-3	--	--

1. Below ground surface

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 groundwater monitoring was outside the scope of services for this project. The boreholes were backfilled with on-site soil cuttings after completion of the groundwater level observations.

Geology

The Geologic Atlas of Texas (1976), McAllen - Brownsville Sheet has mapped the Lissie Formation (Ql) of the Pleistocene Period of the Quaternary age at or near this site. The Lissie Formation (Ql) soils are mostly composed of clay, silt, sand, gravel and caliche. The soils are gray to brown to pale yellow in color. The gravel is mainly siliceous and locally cemented by and inter-bedded with sandy caliche. The caliche is massive to nodular. The surface is characterized by many undrained circular to irregular depressions, by relic clay dunes, and by stabilized northwest-trending longitudinal dunes.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Class is required to determine the Seismic Design Category for a structure. The Site Class is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil properties observed at the site and as described on the exploration logs and results, our professional opinion is for that a **Seismic Site Class C**; however, the upper 10 feet will be considered as **Site Class E**. Subsurface explorations at this site were extended to a maximum depth of 25 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of 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

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations in this report are implemented in the design and construction phases of this project. The subsurface materials generally consisted of sandy lean clay and clayey sand.

Based on the conditions encountered and estimated load-settlement relationships, the proposed structures can be supported on a conventional shallow or deep foundation system. The **Shallow Foundations** section addresses support of the structure directly bearing on improved native soils or engineered fill.

The foundations being considered to provide support for the planned structure must satisfy two independent engineering criteria with respect to the subsurface conditions encountered at this site. One criterion is the foundation system must be designed with an appropriate factor of safety to reduce the possibility of a bearing capacity failure of the soils underlying the foundation. The other criterion is movement of the foundation system due to compression (consolidation or shrinkage) or expansion (swell) of the underlying soils must be within tolerable limits for the structure.

The suitability and performance of a soil supported foundation for a structure depends on many factors including the magnitude of soil movement expected, the type of structure, the intended use of the structure, the construction methods available to stabilize the soils, and our understanding of the owner's expectations of the completed structure's performance.

Moderately expansive, soft and loose compressible soils are present on this site. This report provides recommendations to help mitigate the effects of soil settlement, shrinkage and expansion. However, even if these procedures are followed, some movement in the structure should be anticipated. Eliminating the risk of movement may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

Swell

Swell tests were performed on soil samples from borings drilled at the site. After surcharge pressures were applied the samples were inundated with water for about 72 to 96 hours while measurements of vertical displacement were taken. The magnitude of swell is recorded as a function of the change in thickness during the test in relation to the initial thickness of the sample.

Based on our laboratory results, the samples tested exhibited negligible free swell between depths of 6 and 8 feet. When equivalent overburden pressure was applied, negligible swell

was also obtained. The summary of test results is presented in the **Exploration and Laboratory Results** section of this report.

Our opinion of pavement section thickness design has been developed based on our understanding of the intended use, traffic loads, and subgrade preparation recommended herein using methodology contained in ACI 330 "Guide to Design and Construction of Concrete Parking Lots" / NAPA IS-109 "Design of Hot Mix Asphalt Pavements" and adjusted with consideration to local/TxDOT design manuals. The **Pavements** section includes minimum pavement component thickness. The **Pavements** section includes our recommended parameters for subgrade support for surfacing design by others.

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

Earthwork

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

Site Preparation

Prior to placing fill, existing vegetation and topsoil should be removed. Complete stripping of the topsoil should be performed in the proposed construction areas. Additional excavation as recommended in this report or as needed should be performed within the proposed construction areas. Proper site drainage should be maintained during construction, so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access.

We have provided the following subgrade preparation options that are intended to establish a working platform and allow proper construction of the subbase or embankment.

Building Pad Preparation

Finished Floor Elevation (FFE) was not available at the time this report was prepared. Existing topography is relatively flat and level and cut/fill within the building areas will be ranging between 1 and 2 feet to achieve the Finished Building Pad Elevation (FBPE), and assuming 6 inches of concrete slab.

The following building pad preparation recommendations should be performed for the proposed building pad areas prior to foundation construction.

Option 1: Geogrid

- Strip vegetation and loose topsoil from the building areas as discussed in the Site Preparation section of this report. The building pad area is defined as the area that extends at least 5 feet (horizontal) beyond the perimeter of the proposed building and to the outside edge of any movement sensitive flatwork.
- Prior placing of any fill, excavate to a minimum depth of 4 feet below current existing grade and stockpile for later reuse.
- Install geogrid. Grid should be covered with at least 12 inches of granular base material before equipment can be operated over it.
- The excavated soils or imported select fill can be used to restore grade provided that the material is relatively clean and free of deleterious material or materials exceeding 2 inches in maximum dimension. The select fill should be placed in 6-inch compacted lifts to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 and moisture-conditioned within 2 percent of the optimum moisture content. If grades are to be raised further, select fill should be used.
- To provide a more uniform slab support and create a more all-weather working surface, we recommend constructing the final 6 inches of the building pad with granular select fill material. Granular select fill material will be less prone to damage by rain, and thus, less weather-related delays should be expected. This layer is for working surface purposes only and it is not a requirement.

Option 2: Bull Rock

- Strip vegetation and loose topsoil from the building areas as discussed in the Site Preparation section of this report. The building pad area is defined as the area that extends at least 5 feet (horizontal) beyond the perimeter of the proposed building and to the outside edge of any movement sensitive flatwork.
- Prior placing of any fill, excavate to a minimum depth of 4 feet below current existing grade and stockpile for later reuse.
- Place "Bull-rock" material or crushed concrete at the bottom of the exposed excavation where unsuitable and weak soils are present. The bull-rock/crushed concrete should consist of poorly-graded gravel measuring about 4 inches in diameter and should be pressed into the weak subgrade soils with appropriate equipment until a firm working platform is created.

- The excavated soils or imported select fill can be used to restore grade provided that the material is relatively clean and free of deleterious material or materials exceeding 2 inches in maximum dimension. The select fill should be placed in 6-inch compacted lifts to at least 95 percent of the maximum dry density as evaluated by ASTM D 698 and moisture-conditioned within 2 percent of the optimum moisture content. If grades are to be raised further, select fill should be used.
- To provide a more uniform slab support and create a more all-weather working surface, we recommend constructing the final 6 inches of the building pad with granular select fill material. Granular select fill material will be less prone to damage by rain, and thus, less weather-related delays should be expected. This layer is for working surface purposes only and it is not a requirement.

Excavation

We anticipate that 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 prior to backfill placement and/or construction.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 3 feet of structure. General fill is material used to achieve grade outside of these areas.

Reuse of On-Site Soil: Excavated on-site soil may be suitable for reuse as fill below the concrete slab on grade areas.

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

Property	General Fill	Structural Fill
Composition	Free of deleterious material	Free of deleterious material
Maximum particle size	6 inches (or 2/3 of the lift thickness)	2 inches
Fines content	Not limited	Less than 85% Passing No. 200 sieve

Property	General Fill	Structural Fill
Plasticity	Not limited	Plasticity Index (PI) between 7 and 20
GeoModel Layer Expected to be Suitable ¹	1 and 2	1 and 2

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

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, if applicable.

Soil Type ^{1, 2, 3}	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity Cohesive	CL and/or SC	Liquid Limit less than 40 Plasticity Index (PI) between 7 and 20 Less than 85% Passing No. 200 sieve
Granular	SC, GC, Caliche, Crushed Limestone and Crushed Concrete	Less than 50% passing No. 200 sieve
Flowable Fill	---	Confined areas and backfill for utility trenches

1. Structural and general fill should consist of approved materials free of organic matter and debris. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site. Additional geotechnical consultation should be provided prior to use of uniformly graded gravel on the site.
2. Crushed limestone and crushed concrete material should meet the requirements of 2014 TxDOT Item 247, Type A, or D, Grade 1-2 or 3. The structural fill materials should be free of organic material and debris and should not contain stones larger than 2 inches in the maximum dimension. The clayey gravel and caliche materials should meet the gradation requirements of Item 247, Type B, Grade 1-2 or 3 as specified in the 2014 TxDOT Standard Specifications Manual and a Plasticity Index between 7 and 20.
3. Flowable fill should have a 28-day strength between 80 and 200 psi and meet the requirements for 2014 TxDOT Item 401. Although usually more costly, flowable fill does not require placement in lifts or mechanical compaction.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches 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.	Same as structural fill
Minimum Compaction Requirements ^{1,2,3}	95% of MDD below foundations and within 1 foot of finished building or pavement subgrade. 95% of MDD above foundations, below floor slabs, and more than 1 foot below finished building or pavement subgrade	92% of MDD
Water Content Range ¹	Low plasticity cohesive: -2% to +2% of optimum High plasticity cohesive: 0 to +4% of optimum Granular: -2% to +2% of optimum	As required to achieve minimum compaction requirements

1. Maximum Dry Density (MDD) and optimum water content as determined by the Standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100% of Standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). The caliche, crushed limestone and crushed concrete should be compacted to at least 95% of the Standard Proctor test (ASTM D 698). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

Wet Weather/Soft Subgrade Considerations

Construction operations may encounter difficulties due to the wet or soft surface soils becoming a general hindrance to equipment due to rutting and pumping of the soil surface, especially during and soon after periods of wet weather.

If the subgrade cannot be adequately compacted to minimum densities as described above, one of the following measures will be required:

- Removal and replacement with select fill,
- Chemical treatment of the soil to dry and increase the stability of the subgrade,
- Drying by natural means if the schedule allows.

In our experience with similar soils in this area, chemical treatment is an efficient and effective method to increase the supporting value of wet and weak subgrade. Terracon should be contacted for additional recommendations if chemical treatment of the soils is needed.

Prior to placing any fill, all surface vegetation, topsoil, possible fill material and any otherwise unsuitable materials should be removed from the construction areas. Wet or dry material should either be removed, or moisture conditioned and recompacted. After stripping and grubbing, the subgrade should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a 15-ton roller or fully loaded dump truck. Soft, dry and low-density soil should be removed or compacted in place prior to placing fill.

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 in accordance with 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 foundations without engineering review of shoring requirements and geotechnical observation during construction.

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

Trench backfills 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 engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

Utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the structure should be effectively sealed to restrict water intrusion

and flow through the trenches, which could migrate below the structure. The trench should provide an effective trench plug that extends at least 5 feet from the face of the structure 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 structure during and after construction and should be maintained throughout the life of the structure. Water retained next to the structure 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 structure.

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

Earthwork Construction Considerations

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

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

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

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

Construction Observation and Testing

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

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas, if any. Where not specified by local ordinance, one density and water content test should be performed for every 50 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

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 (strip/spread footings) foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure ^{1, 2}	2,000 psf - foundations bearing upon structural fill
Required Bearing Stratum ³	GeoModel Layer 1 or undisturbed native soils or structural fill extending to undisturbed native soils.
Minimum Foundation Dimensions	Per IBC 1809.7
Allowable Passive Resistance ⁴ (Equivalent Fluid Pressures)	300 psf (cohesive backfill)
Sliding Resistance ⁵	0.40 coefficient of friction
Minimum Embedment below Finished Grade ⁶	Exterior footings: 30 inches Interior footings: 24 inches
Estimated Total Settlement from Structural Loads ²	About 1 inch
Estimated Differential Settlement ^{2, 7}	About 1/2 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. The net allowable bearing pressure provided above include a factor of safety of at least 3.
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. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed, and compacted structural fill be placed against the

Item	Description
	vertical footing face. Assumes no hydrostatic pressure. The passive pressure provided above include a factor of safety of at least 2.
5.	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.
6.	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.
7.	Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.

Design Parameters – Overturning and Uplift Loads

Shallow foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., $e < b/6$, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the IBC basic load combinations.

Item	Description
Soil Moist Unit Weight	120 pcf
Soil Effective Unit Weight¹	58 pcf
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of 20 degrees from vertical to ground surface.
1.	Effective (or buoyant) unit weight should be used for soil above the foundation level and below a water level. The high groundwater level should be used in uplift design as applicable.

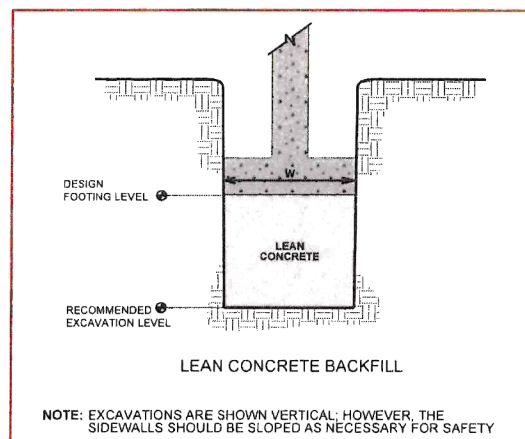
Foundation Construction Considerations

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

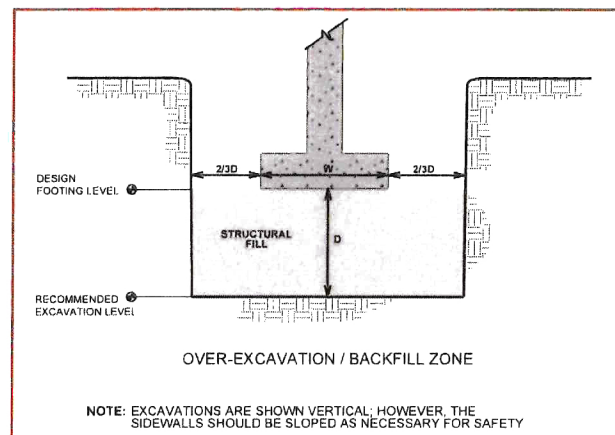
material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

Sensitive soils exposed at the surface of footing excavations may require surficial compaction with hand-held dynamic compaction equipment prior to placing structural fill, steel, and/or concrete. Should surficial compaction not be adequate, construction of a working surface consisting of either crushed stone or a lean concrete mud mat may be required prior to the placement of reinforcing steel and construction of foundations.

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



Overexcavation for structural fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with imported fill placed, as recommended in the [Earthwork](#) section.



Slab on Grade Foundations

A slab on grade beam foundation may be considered to support the structures at this site. Parameters commonly used to design this type of foundation are provided on the table below. The slab foundation design parameters presented are based on the criteria published by the Wire Reinforcement Institute (WRI) and Conventional methods. These are essentially empirical design methods and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the WRI design manuals.

Conventional Method Parameters	Value
Net Allowable Bearing Pressures ¹	2,000 psf
Select Fill Subgrade Modulus (k)	90 pci
Base Course Material Subgrade Modulus (k)	125 pci
Potential Vertical Rise (PVR)	Less than 1 inch
WRI Method Parameters	
Effective Plasticity Index (PI) ²	19
Climatic Rating (Cw)	15
Soil – Climate Support Index (I _c)	0.95

1. The net allowable bearing pressure provided above includes a Factor of Safety (FS) of at least 3. Based on building pad preparation recommended in this report.
2. The WRI effective PI is the weighted average of the PI values in the upper 15 feet of the soil profile. The upper 5 feet has a weight factor of 3; the depth range from 5 to 10 feet has a weight factor of 2; the depth range of 10 to 15 feet has a weight factor of 1.

We recommend that exterior grade beams be at least 24 inches below the finished exterior grade. These recommendations are for a proper development of bearing capacity for the continuous beam sections of the foundation system and to reduce the potential for water to migrate beneath the slab foundation. These recommendations are not based on structural considerations. Grade beam depths may need to be greater than recommended herein for structural considerations and should be properly evaluated and designed by the Structural Engineer. The grade beams or slab portions may be thickened and widened to serve as spread footings at concentrated load areas.

For a slab on grade foundation system designed and constructed as recommended in this report, post construction consolidation settlements should be less than 1 inch. Settlement response of a slab on grade foundation is influenced more by the quality of construction than by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the pad and foundation.

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

Flatwork

Grade-supported flatwork, or sidewalks, adjacent to the building will be subject to the movements unless proper measures are taken. Differential movement between the flatwork and building slab may result in a trip hazard. Doweling the flatwork to the foundation at common openings will help limit differential movements and trip hazards. Heaving of the soils beneath the flatwork may also change drainage patterns and direct water towards the buildings. The flatwork can be prepared as the building pad if performance of the flatwork similar to the building is desired as is recommended. All joints in the flatwork surrounding the structure should be kept sealed and properly maintained.

The flatwork immediately adjacent to the structures should be sloped as much as possible to maintain positive drainage away from the structure. If measures are not taken to address differential movement in the design stage, this issue may become a constant maintenance issue during the life of the building.

Deep Foundations

Drilled Shaft Design Parameters

Soil design parameters are provided below in the **Drilled Shaft Design Summary** table for the design of drilled shaft foundations. The values presented for allowable side friction and end bearing include a factor of safety.

Drilled Shaft Design Summary ¹

Layer (ft)	Stratigraphy ²		Allowable Skin Friction (psf) ³	Allowable End Bearing Pressure (psf) ⁴
	No.	Material		
0 - 4	1	Sandy Lean Clay	---	---
4 - 7	1	Sandy Lean Clay	250	---
7 - 15	1	Sandy Lean Clay	500	---
15 - 25	1	Clayey Sand	250	10,000

1. Design capacities are dependent upon the method of installation and quality control parameters. The values provided are estimates and should be verified when installation protocol have been finalized.
2. See Subsurface Profile in [Geotechnical Characterization](#) for more details on stratigraphy.
3. Applicable for compressive loading only. Reduce to 2/3 of values shown for uplift loading. The effective weight of the shaft can be added to uplift load resistance to the extent permitted by IBC. These allowable skin friction values include a minimum factor of safety of 2. The side shear should be neglected for the upper 4 feet of soil in contact with the pier shaft.
4. Shafts should extend at least one diameter into the bearing stratum (or to a depth equal to the bell diameter for belled shafts) for end bearing to be considered. The bearing pressures include a factor of safety against a bearing capacity failure of approximately 3.

Shafts should be adequately reinforced as designed by the Structural Engineer for both tension and shear to sufficient depths. Buoyant unit weights of the soil and concrete should be used in the calculations below the highest anticipated groundwater elevation.

Drilled shaft should have a minimum (center-to-center) spacing of three diameters. Closer spacing may require a reduction in axial load capacity. Axial capacity reduction can be determined by comparing the allowable axial capacity determined from the sum of individual drilled shafts in a group versus the capacity calculated using the perimeter and base of the drilled shaft group acting as a unit. The lesser of the two capacities should be used in design.

Drilled shafts should have a minimum length of 15 feet and should extend into the bearing strata at least one shaft diameter for the allowable end-bearing pressures listed in the above table. Drilled shafts should bear no deeper than 20 feet below Finished Building Pad Elevation (FBPE) without contacting our office.

Post-construction settlements of drilled shafts designed and constructed as described in this report are estimated to range from about 1/2 to 3/4 inch. Differential settlement between individual shafts is expected to be 1/2 to 2/3 of the total settlement.

Drilled Shaft Lateral Loading

The following table lists input values for use in LPILE analyses. Such analysis should be considered if lateral loads exceed 10 kips. Modern versions of LPILE provide estimated default values of k_h and E_{50} based on strength and are recommended for the project. Since deflection or a service limit criterion will most likely control lateral capacity design, no safety/resistance factor is included with the parameters.

Stratigraphy ¹		L-Pile Soil Model	S_u (psf) ²	ϕ ²	γ' (pcf) ²	E_{50}	K (pci)	
Layer, ft	Material						Static	Cyclic
0 - 4	Sandy Lean Clay	Stiff Clay w/o Free Water	250	---	105	Use Default Value		
4 - 7	Sandy Lean Clay	Stiff Clay w/o Free Water	500	---	110	Use Default Value		
7 - 15	Sandy Lean Clay	Stiff Clay w/o Free Water	1,500	---	115	Use Default Value		
15 - 25	Clayey Sand	Sand (Reese)	---	32	120	Use Default Value		

1. See Subsurface Profile in **Geotechnical Characterization** for more details on Stratigraphy.

2. Definition of Terms:

S_u : Undrained shear strength

ϕ : Internal friction angle

γ' : Effective unit weight

Spacing closer than 3D (where D is the diameter of the shaft) is not recommended without additional geotechnical consultation due to potential for the installation of a new shaft disturbing an adjacent installed shaft likely resulting in axial capacity reduction.

The load capacities provided herein are based on the stresses induced in the supporting soil strata. The structural capacity of the shafts should be checked to assure they can safely accommodate the combined stresses induced by axial and lateral forces. Lateral deflections of shafts should be evaluated using an appropriate analysis method, and will depend upon the shaft's diameter, length, configuration, stiffness and "fixed head" or "free

head" condition. We can provide additional analyses and estimates of lateral deflections for specific loading conditions upon request. The load-carrying capacity of shafts may be improved by increasing the diameter and possibly the length.

Drilled Shaft Construction Considerations

The drilling contractor should be experienced in the subsurface conditions observed at the site, and the excavations should be performed with equipment capable of providing a clean bearing surface. The drilled straight-shaft foundation system should be installed in general accordance with the procedures presented in "Standard Specification for the Construction of Drilled Piers", ACI Publication No. 336.1-01. or "Drilled Shafts: Construction Procedures and Design Methods," FHWA Publication No. FHWA-NHI 18-024.

The contractor is generally expected to use conventional "dry" techniques for installation of the drilled shaft. Groundwater was encountered during the drilling activities. See boring logs for detailed information. Groundwater levels are influenced by seasonal and climatic conditions, which result in fluctuations in groundwater elevations. Additionally, it is common for water to be present after periods of significant rainfall. Casing or slurry drilling procedures could be required in soils zones of higher sand content to reduce the potential for excavation sidewall collapse.

The drilling contractor should remove all soft and disturbed soils from the base of the drilled pier prior to placing concrete. The drilled shaft installation process should be performed under the observation of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil and groundwater conditions observed, consistency with expected conditions, and details of the installed shaft.

The use of temporary steel casing and/or slurry drilling procedures should be anticipated at this site during drilled shaft construction to reduce the potential for collapse of the sidewalls within sand seams and layers and control groundwater seepage. If casing is removed during concrete placement, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures present on a casing exterior. Water or loose soil should be removed from the bottom of the drilled shafts prior to placement of the concrete.

Care should be taken to not disturb the sides and bottom of the excavation during construction. The bottom of the shaft excavation should be free of loose material before concrete placement. Concrete should be placed as soon as possible after the foundation excavation is completed, to reduce potential disturbance of the bearing surface.

While withdrawing casing, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures acting on the casing exterior. Arching of the concrete, loss of seal and other problems can occur during casing removal and result in contamination of the drilled shaft. These conditions should be considered

during the design and construction phases. Placement of loose soil backfill should not be permitted around the casing prior to removal.

The drilled shaft installation process should be performed under the observation of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil and groundwater conditions observed, consistency with expected conditions, and details of the installed shaft.

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 structures and positive drainage of the aggregate base beneath the floor slab.

The subsurface soils at this site generally exhibit moderate expansion potential. Based on the information developed from our field and laboratory programs and on method TEX-124-E in the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, we estimate that the subgrade soils at this site exhibit a Potential Vertical Rise (PVR) in present conditions of less than 1 inch.

The subgrade soils are comprised of moderate plasticity clays exhibiting the potential to swell with increased water content. Construction of the floor slab and revising site drainage creates the potential for gradual increased water contents within the on-site soils. Increases in water content will cause the on-site soils to swell and damage the floor slab. To maintain the swell potential to less than about 1 inch, follow building pad preparation recommendations provided in the Building Pad Preparation section prior to foundation construction. This recommendation applies to pad area and flatwork that abuts the structure such as sidewalks.

Soils below the specified water contents within this zone should be moisture conditioned or replaced with structural fill as stated in our **Earthwork** section.

Floor Slab Design Parameters

Item	Description
Floor Slab Support¹	Minimum 4 feet of moisture conditioned and compacted reused native soils over geogrid or bull rock layer plus 12 inches of select fill as needed to achieve Finished Building Pad Elevation (FBPE) and a 6-inch-thick layer of granular base course material. This recommendation applies to pad areas and flatwork that abuts the structure such as sidewalks. Subgrade compacted to recommendations in Earthwork

Item	Description
Estimated Modulus of Subgrade Reaction ²	90 pounds per square inch per inch (psi/in)
Estimated Modulus of Base Course Material Reaction ²	125 pounds per square inch per inch (psi/in) for a 6-inch-thick granular base layer beneath the concrete slab.
<ol style="list-style-type: none"> 1. Floor slabs should be structurally independent of structure footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation. 2. Modulus of reaction is an estimated value based upon our experience with the subgrade or granular base condition, the requirements noted in Earthwork, and the floor slab support as noted in this table. 	

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

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

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

Settlement of floor slabs cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, 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

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist

condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

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

Pavements

Both flexible and rigid pavements may be considered for this project. Pavement subgrade preparations are included in this section to limit changes in soil moisture conditions to help mitigate the effects of soil movement.

General Pavement Comments

A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

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

Subgrade Preparation

Prior to construction, any vegetation, loose topsoil, and any otherwise unsuitable materials should be removed from the new pavement areas. After stripping, the subgrade should be proof rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a fully loaded dump truck. Wet, soft, low-density, or dry material should either be removed, or moisture conditioned and recompacted to the moisture contents and densities described in section **Fill Placement and Compaction Requirements** prior to placing fill.

Pavement Design Parameters

Traffic patterns and anticipated loading conditions were not available at the time this report was prepared. However, we anticipate that traffic loads will be produced primarily

by light traffic, midsize trucks, school buses and trash removal trucks. Pavement thickness can be determined using AASHTO, Asphalt Institute and NAPA IS-109 "Design of Hot Mix Asphalt Pavements" and/or other methods if specific wheel loads, axle configurations, frequencies, and desired pavement life are provided.

Terracon can provide thickness recommendations for pavements subjected to loads other than the above-mentioned traffic if this information is provided.

Listed below are pavement component thicknesses, which may be used as a guide for pavement systems at this site. These systems were derived based on general characterization of the subgrade. Specific testing (such as CBR's, resilient modulus tests, etc.) was not performed for this project to evaluate the support characteristics of the subgrade.

Pavement Section Thicknesses

The following table provides a minimum thickness for a flexible pavement section:

Flexible Pavement System

Component ¹	Minimum Thickness (inches)	
	Light Traffic	Light - Medium Traffic
HMAC Fine Surface, Type C or D	2	2½
Granular Base Material	6	8
Treated Subgrade ²	6	6

1. All materials should meet the current Department of Transportation (TxDOT) Standard Specifications for Highway and Bridge Construction. Hot Mix Asphalt Concrete (HMAC) 2014 TxDOT, Item 340.
2. It is recommended to induce microcracking within the first 24 to 48 hours, but not sooner than 24 hours.
3. Geogrid may be used instead of 6 inches of treated subgrade. If used, the geogrid may be Tensar InterAx or equivalent material and should be placed on top of the moisture conditioned and compacted subgrade.

Alternative Flexible Pavement System

Component ¹	Minimum Thickness (inches)	
	Light Traffic	Light - Medium Traffic
HMAC Fine Surface, Type C or D ²	2½	3

Alternative Flexible Pavement System

Component ¹	Minimum Thickness (inches)	
	Light Traffic	Light - Medium Traffic
Granular Base Material	8	10
Moisture Conditioned Subgrade	6	6

1. All materials should meet the current Department of Transportation (TxDOT) Standard Specifications for Highway and Bridge Construction. Hot Mix Asphaltic Concrete (HMAC) 2014 TxDOT, Item 340.

The following table provides a minimum thickness for a rigid pavement section:

Rigid Pavement System

Component ¹	Minimum Thickness (inches)	
	Light Traffic	Heavy Traffic
Reinforced PC Concrete ^{2, 3}	5	7
Granular Base Material	4	4
Moisture Conditioned Subgrade	6	6

1. All materials should meet the current Department of Transportation (TxDOT) Standard Specifications for Highway and Bridge Construction. Concrete Pavement - TxDOT Portland Cement Concrete (PCC) Class P or applicable ACI standards.
2. In areas of anticipated heavy traffic, fire trucks, delivery trucks, school buses or concentrated loads (e.g. dumpster pads), and areas with repeated turning or maneuvering of heavy vehicles. Six (6) inches of treated subgrade may be used instead of 4 inches of granular base material.
3. If treated subgrade is selected as an alternate, Hot Mix Asphaltic Concrete (HMAC) 2014 TxDOT Standard Specifications Item 340 or Asphalt Treated Base (ATB) Item 292 should be used as bond breaker between the concrete slab and the treated subgrade.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e. concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles.

Although not required for structural support, a minimum 4-inch-thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign

material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavement Section Materials

Presented below are selection and preparation guidelines for various materials that may be used to construct the pavement sections. Submittals should be made for each pavement material. The submittals should be reviewed by the Geotechnical Engineer and appropriate members of the design team and should provide test information necessary to verify full compliance with the recommended or specified material properties.

- **Reinforced PC Concrete:** The materials and properties of reinforced Portland cement concrete pavement shall meet applicable requirements in the ACI Manual of Concrete Practice. The portland cement concrete mix should have a minimum 28-day compressive strength of 4,000 psi.
- **Hot Mix Asphaltic Concrete Surface Course:** The asphaltic concrete surface and base courses should be plant mixed, hot laid Type C or D (Fine Surface) or Type B (Fine Base) meeting the specifications requirements in 2014 TxDOT Standard Specifications Item 340 or 341. Specific criteria for the job specifications should include compaction to within an air void range of 5 to 9 percent (91 to 95 percent compaction) calculated using the maximum theoretical gravity mix measured by TxDOT TEX-227-F. The asphalt cement content by percent of total mixture weight should be within ± 0.5 percent asphalt cement from the job mix design.

- **Granular Base Material:** Granular base material should be composed of crushed limestone or crushed concrete meeting the requirements of 2014 TxDOT Standard Specifications Item 247, Type A or D, Grade 1-2 or 3.

As an alternate to the Type A base, treated "caliche" material meeting the requirements of 2014 TxDOT Standard Specification Manual Item 247, Type B, Grade 1-2 or 3 may be used. The granular base material (caliche) may be treated with about 2 percent by dry weight of cement (modifier).

- The base material should be compacted to at least 95 percent of the maximum dry density determined in accordance with the modified moisture-density relationship test (ASTM D 1557), or applicable ASTM standard and moisture conditioned within 2 percent of the optimum moisture content.
- **Prime Coat:** The prime coat should consist of sealing the base with prime oil such as an MC-30 or an emulsion. The prime coat should be applied at a rate of about 0.2 to 0.5 gallons per square yard with materials which meet 2014 TxDOT Standard Specifications, Item 300 Asphalts, Oils and Emulsions. The prime coat will help to reduce penetration of rainfall and other moisture which penetrates the base. However, due to weathering and traffic, treatment will probably be necessary on a periodic basis to protect the base. In addition, isolated areas of the base which have developed potholes or other distress may need to be removed and replaced prior to application of a prime coat for maintenance. The prime coat without additional surface treatment may not be very effective when using non-treated base material.
- **Treated Subgrade:** The subgrade soils may be treated with cement (modifier) in accordance with 2014 TxDOT Standard Specifications Item 275. The recommended percentage of modifier is for estimating and planning. The actual quantity of modifier required should be determined at the time of construction by laboratory tests on bulk samples of the subgrade soils.

We anticipate that the on-site surficial soils be treated with about 2 percent of modifier. This percentage is given as application by dry weight and is typically equivalent to about 11 pounds of modifier per square yard per 6-inch depth. The subgrade should be compacted to a minimum of 95 percent of the maximum dry density determined in accordance with the Standard Moisture-Density relationship test (ASTM D 698) or applicable ASTM standard at moisture content within 2 percentage points of the optimum moisture content. Preferably, traffic, should be kept off the treated subgrade for about 3 to 5 days to facilitate curing of the soil -

chemical mixture; in addition, the subgrade is not suitable for heavy construction traffic prior to paving.

Post-construction subgrade movements and some cracking of the pavements are not uncommon for subgrade conditions such as those observed at this site. Although chemical treatment of the subgrade will help to reduce such movement/cracking, this movement/cracking cannot be economically eliminated.

- **Moisture Conditioned Subgrade:** The subgrade should be scarified to a depth of 8 inches and moisture conditioned within 2 percent of the optimum moisture content. The subgrade should then be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698. This should result in a compacted, moisture conditioned layer about 8 inches thick.

Details regarding subgrade preparation, fill materials, placement and compaction are presented in **Earthwork** section under subsections **Fill Material Types** and **Fill Compaction Requirements**.

Pavement Joints and Reinforcement

The following is recommended for all concrete pavement sections in this report. Refer to ACI 330 “Guide for Design and Construction of Concrete Parking Lots” and “TxDOT Standard Specifications” for additional information.

Item	Description
Reinforcing Steel	No 3 reinforcing steel bars at 12 inches on-center-each-way, Grade 60. No 4 reinforcing steel bars at 18 inches on-center-each-way, Grade 60. 12.5 feet each way for pavement thickness of 5 to 5.5 inches.
Contraction Joint Spacing	15 feet each way for pavement thickness of 6 inches or greater.
Contraction Joint Depth	Saw cut control joints should be cut within 6 to 12 hours of concrete placement.
Contraction Joint Width	At least ¼ of pavement thickness.
Construction Joint Spacing	One-fourth inch or as required by joint sealant manufacturer. To attempt to limit the quantity of joints in the pavement, consideration can be given to installing construction joints at contraction joint locations, where it is applicable.

Item	Description
Construction Joint Depth/Width	Full depth of pavement thickness. Construct sealant reservoir along one edge of the joint. Width of reservoir to be ¼ inch or as required by joint sealant manufacturer. Depth of reservoir to be at least ¼ of pavement thickness.
Isolation Joint Spacing	As required to isolate pavement from structures, etc.
Isolation Joint Depth	Full depth of pavement thickness.
Isolation Joint Width	½ to 1 inch or as required by the joint sealant manufacturer.
Expansion Joint	In this locale, drying shrinkage of concrete typically significantly exceeds anticipated expansion due to thermal affects. As a result, the need for expansion joints is eliminated provided all joints (including saw cuts) are sealed. Construction of an unnecessary joint may be also become a maintenance problem. All joints should be sealed. If all joints, including saw cuts, are not sealed then expansion joints should be installed.

All construction joints have dowels. Dowel information varies with pavement thickness as presented as follows:

Pavement Thickness, inches	5	7
Dowels Diameter, inches	5/8	7/8
Dowel Spacing on Center, inches	12	12
Dowel Length, inches	12	14
Dowel Embedment, inches	5	6

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.

Based on the possibility of shallow and/or perched groundwater, we recommend installing a pavement subdrain system to control groundwater, improve stability, and improve long-term pavement performance.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack, and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

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

Frost Considerations

Based on ACI 362 and IBC standards, the project site is located in Zone I (negligible), which represents the mildest conditions where freezing temperatures never occur, and deicing salts are not used, and the effects of frost penetration should be considered negligible.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration.

Geotechnical Engineering Report (Base Option)

HCHSP Outdoor Learning Environments and Discovery Park | McAllen, Texas
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Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

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

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Geotechnical Engineering Report (Base Option)

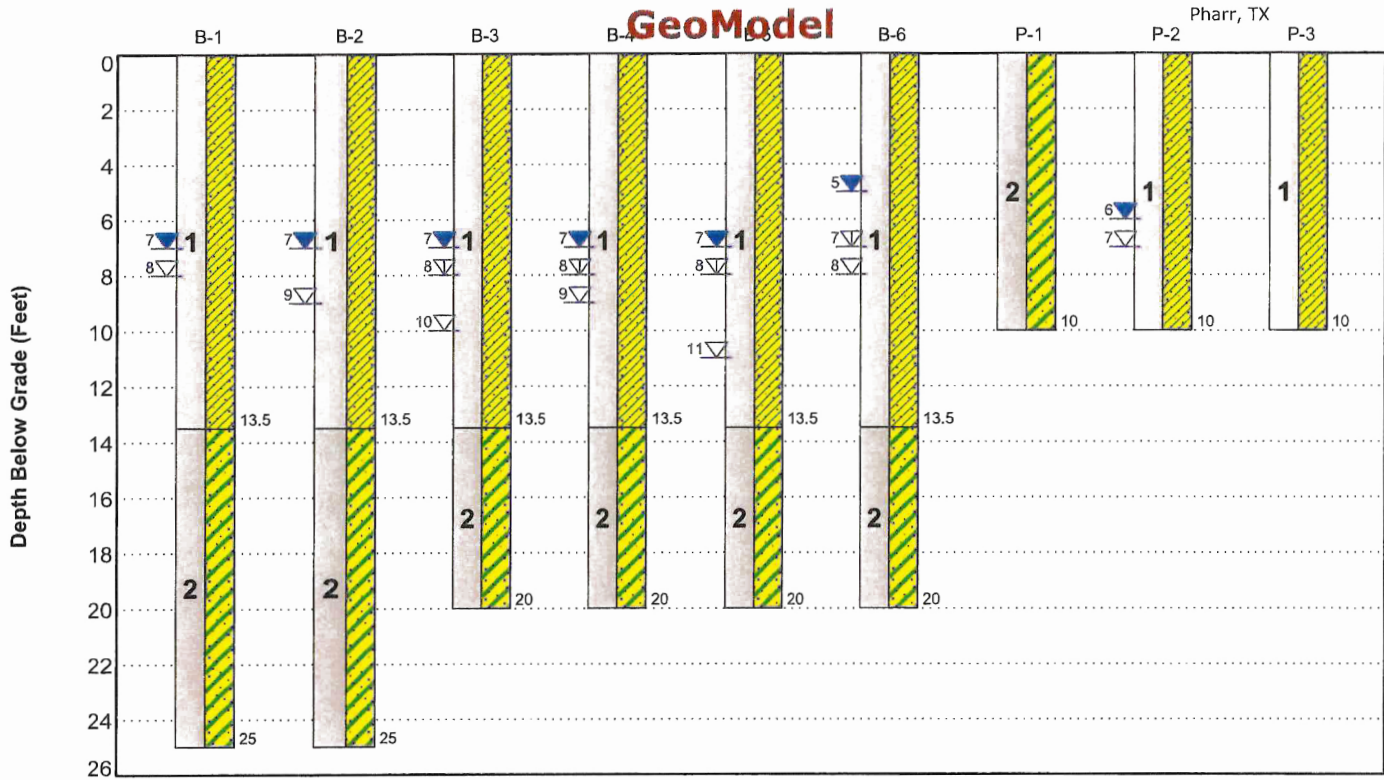
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Figures

Contents:

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	Clay	Sandy Lean Clay (CL); very soft to very stiff
2	Sand	Clayey Sand (SC); very loose to very dense

LEGEND

- Sandy Lean Clay
- Clayey Sand

- First Water Observation
- Second Water Observation
- Third Water Observation

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

NOTES:

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

Geotechnical Engineering Report (Base Option)

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Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
2	25	Large Pavilion
4	20	Small Pavilions
3	10	Pavement Areas

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ± 10 feet) and referencing existing site features. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted, drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Five samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. A 3-inch O.D. split-barrel sampling spoon with 2.5-inch I.D. ring lined sampler was used for soil sampling. For safety purposes, all borings were backfilled with auger cuttings after the groundwater observations were completed.

The sampling depths, penetration distances, and other sampling information was 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.

Geotechnical Engineering Report (Base Option)

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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
- Grain Size Analysis
- Atterberg Limits

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

Geotechnical Engineering Report

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Site Location and Exploration Plans

Contents:

Site Location Plan

Exploration Plan

SITE LOCATION

HCHSP Outdoor Learning Environments and Discovery Park ■ McAllen, Texas
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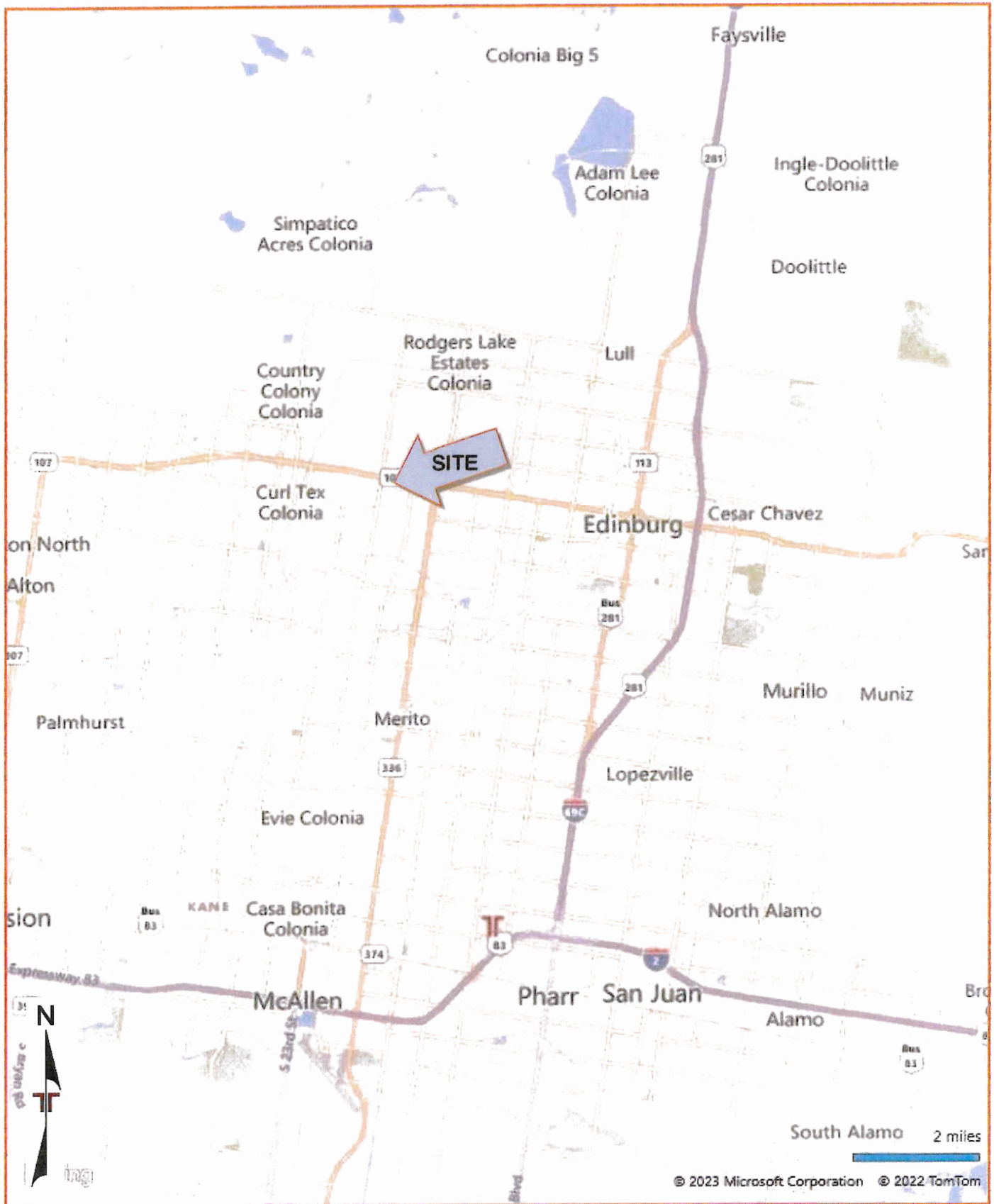


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

EXPLORATION PLAN

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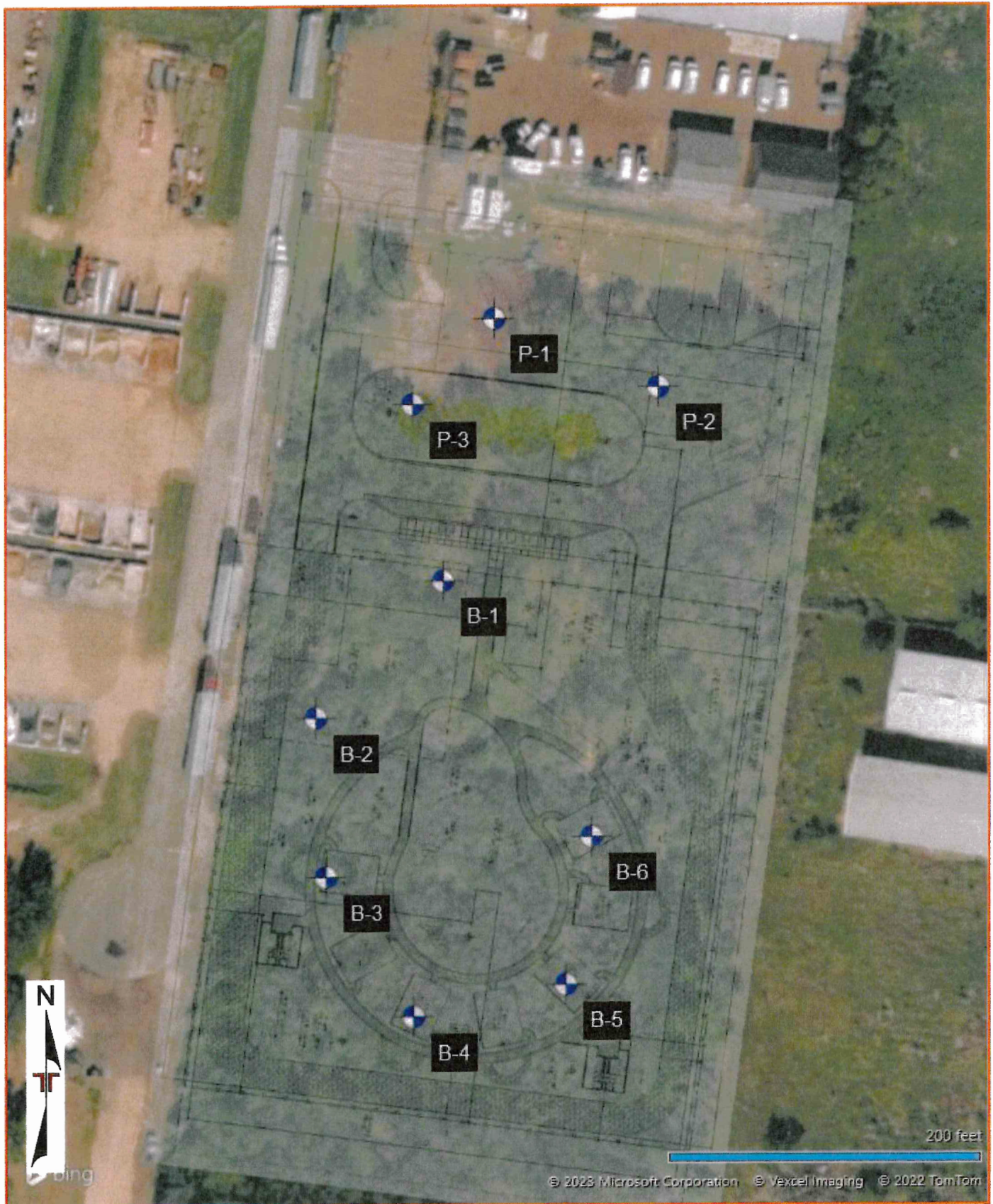


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Geotechnical Engineering Report

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Exploration and Laboratory Results

Contents:

Boring Logs

Boring Log No. B-1

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.308440° Longitude: -98.223000°	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		
							Test Type	Compressive Strength (tsf)	Strain (%)			LL-PL-PI	Percent Fines	
1		SANDY LEAN CLAY (CL) , brown, very soft to very stiff - Clayey Sand (SC), very loose at 2½ feet - light brown below 4½ feet	5			5-4-4 N=8				12.5		37-19-18		
						3-2-1 N=3				13.3			45	
						WOH					23.9		30-18-12	
				▼		3-1-2 N=3					24.7			
						4-6-12 N=18					24.4			60
2		CLAYEY SAND (SC) , light brown, medium dense to very dense - strong cementation below 18½ feet	13.5			7-8-10 N=18				27.3		35-25-10		
			20			50/5" N=ref/5"				29.9		39		
			25			36-50/2" N=50/2"				25.4		34-24-10		
		Boring Terminated at 25 Feet	25											

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
 Example: N=ref/2", sampler could only be driven 2 inches of the 6-inch seating penetration before the 50-blow limit was reached.
 WOH = Weight of Hammer

- Water Level Observations**
- ▽ 8 feet - While drilling
 - ▽ 7 feet - After 15 minutes
 - ▼ 7 feet - At completion of drilling
 - Cave-In Depth

Advancement Method
 Dry augered from 0 to 25 feet

Abandonment Method
 Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig
 CME 75

Driller
 RGVD

Logged by
 DP

Boring Started
 01-03-2023

Boring Completed
 01-03-2023

Boring Log No. B-2

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.308200° Longitude: -98.223250° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits	
							Test Type	Compressive Strength (tsf)	Strain (%)			LL-PL-PI	Percent Fines
1		SANDY LEAN CLAY (CL) , brown, soft to stiff - Sandy Silty Clay (CL-ML) to 2 feet				5-2-2 N=4			7.0		21-15-6		
						1-1-1 N=2			20.5			54	
						0.5 (HP)			22.2		30-15-15		
				▼		1.5 (HP)			20.8				
				▽		1.5 (HP)			21.5		31-21-10		
				13.5									
2		CLAYEY SAND (SC) , light brown, very dense, strong cementation				21-50/5" N=50/5"			25.9			27	
						50/4" N=ref/4"			25.2		34-24-10		
						50/5" N=ref/5"			21.0				
		Boring Terminated at 25 Feet	25										

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
 Example: N=ref/2", sampler could only be driven 2 inches of the 6-inch seating penetration before the 50-blow limit was reached.

- Water Level Observations**
- ▽ 9 feet - While drilling
 - ▽ 7 feet - After 15 minutes
 - ▼ 7 feet - At completion of drilling
 - Cave-In Depth

Advancement Method
 Dry augered from 0 to 25 feet

Abandonment Method
 Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig
 CME 75

Driller
 RGV D

Logged by
 DP

Boring Started
 01-03-2023

Boring Completed
 01-03-2023

Boring Log No. B-3

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.307920° Longitude: -98.223230°	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
1		SANDY LEAN CLAY (CL) , brown, soft to very stiff - light brown below 4½ feet	5	▽	X	5-2-1 N=3			12.8		24-16-8		
			5	▽	X	1-1-2 N=3			19.3			56	
			5	▽	X	1-2-2 N=4			22.4				
			8	▽	X	2-1-2 N=3			27.8		35-18-17		
			10	▽	X	2-9-14 N=23			25.4				
			13.5	▽	X								
2		CLAYEY SAND (SC) , light brown, medium dense to very dense - strong cementation at 18½ feet	15	▽	X	4-6-8 N=14			25.6		34-26-8		
			20	▽	X	38-50/5" N=50/5"			23.8			29	
		Boring Terminated at 20 Feet	20										

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

Example: N=ref/2", sampler could only be driven 2 inches of the 6-inch seating penetration before the 50-blow limit was reached.

Water Level Observations

- ▽ 10 feet - While drilling
- ▽ 8 feet - After 15 minutes
- ▽ 7 feet - At completion of drilling
- Cave-In Depth

Advancement Method

Dry augered from 0 to 20 feet

Abandonment Method

Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig

CME 75

Driller

RGVD

Logged by

DP

Boring Started

01-03-2023

Boring Completed

01-03-2023

Boring Log No. B-4

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.307674° Longitude: -98.223058°	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits	
							Test Type	Compressive Strength (tsf)	Strain (%)			LL-PL-PI	Percent Fines
1		Location: See Exploration Plan Latitude: 26.307674° Longitude: -98.223058° Depth (Ft.) SANDY LEAN CLAY (CL) , brown, medium stiff to stiff - light brown below 4½ feet	9	▽		4-3-2 N=5			15.9		25-15-10		
			10			1-2-2 N=4			18.3			56	
			11			2-2-2 N=4			22.9		38-16-22		
			12	▼		2-2-2 N=4			23.6				
			13	▽		2-5-8 N=13			25.0			56	
			13.5										
2		CLAYEY SAND (SC) , light brown, medium dense to very dense - strong cementation at 18½ feet	15	■		5-5-5 N=10			30.8		38-22-16		
			20			50/5" N=ref/5"			29.3				
		Boring Terminated at 20 Feet	20										

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

Example: N=ref/2", sampler could only be driven 2 inches of the 6-inch seating penetration before the 50-blow limit was reached.

Water Level Observations

- ▽ 9 feet - While drilling
- ▽ 8 feet - After 15 minutes
- ▼ 7 feet - At completion of drilling
- Cave-In Depth

Advancement Method
 Dry augered from 0 to 20 feet

Abandonment Method
 Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig
 CME 75

Driller
 RGVD

Logged by
 DP

Boring Started
 01-03-2023

Boring Completed
 01-03-2023

Boring Log No. B-5

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.307730° Longitude: -98.222760°	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
1		SANDY LEAN CLAY (CL) , brown, soft to medium stiff - light brown below 4½ feet	4	▽	X	4-1-1 N=2			17.6	25-15-10	57		
			5	▽	X	1-1-1 N=2			21.0				
			5	▽	X	1-2-2 N=4			23.5				
			8	▽	X	2-3-3 N=6			22.4				
			10	▽	X	3-2-3 N=5			24.8				
2		CLAYEY SAND (SC) , light brown, medium dense to very dense - strong cementation at 18½ feet	13.5	▽	X	6-8-21 N=29			30.2	36-21-15	33		
			20.0	▽	X	50/5" N=ref/5"			22.9				
		Boring Terminated at 20 Feet	20										

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

Example: N=ref/2", sampler could only be driven 2 inches of the 6-inch seating penetration before the 50-blow limit was reached.

Water Level Observations

- ▽ 11 feet - While drilling
- ▽ 8 feet - After 15 minutes
- ▽ 7 feet - At completion of drilling
- Cave-In Depth

Advancement Method

Dry augered from 0 to 20 feet

Abandonment Method

Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig
CME 75

Driller
RGVD

Logged by
DP

Boring Started
01-03-2023

Boring Completed
01-03-2023

Boring Log No. P-1

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.308900° Longitude: -98.222900° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
2		CLAYEY SAND (SC) , brown, loose to medium dense - very loose at 4½ feet	5		X	3-5-5 N=10			18.1		39-18-21		
					X	5-4-4 N=8			15.8			47	
					X	1-1-1 N=2			24.0		32-16-16		
					X	1-2-3 N=5			23.2				
					X	4-6-6 N=12			23.8		46-27-19		
			10.0										
		Boring Terminated at 10 Feet	10										

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

Notes

Water Level Observations
 Groundwater was not encountered

Drill Rig
 CME 75

Cave-In Depth
Advancement Method
 Dry augered from 0 to 10 feet

Driller
 RGVD
Logged by
 DP

Abandonment Method
 Boring backfilled with soil cuttings upon completion.

Boring Started
 01-03-2023
Boring Completed
 01-03-2023

Boring Log No. P-2

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.308780° Longitude: -98.222580° Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
							Test Type	Compressive Strength (tsf)	Strain (%)				
1	SANDY LEAN CLAY (CL), brown, soft to medium stiff - light brown below 4½ feet		5	▽	X	2-1-1 N=2			19.1		37-16-21		
			5		X	2-2-2 N=4			17.2			62	
			5	▽	X	1-1-1 N=2			26.2		33-13-20		
			7	▽	X	1-2-3 N=5			26.2				
			10	▽	X	2-2-5 N=7			24.4		40-17-23		
		Boring Terminated at 10 Feet	10										

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

Notes

Water Level Observations

- ▽ 7 feet - While drilling
- ▽ 6 feet - After 15 minutes
- ▽ 6 feet - At completion of drilling
- ⊠ Cave-In Depth

Advancement Method
 Dry augered from 0 to 10 feet

Abandonment Method
 Boring backfilled with soil cuttings after delayed water levels were measured.

Drill Rig
 CME 75

Driller
 RGVD

Logged by
 DP

Boring Started
 01-03-2023

Boring Completed
 01-03-2023

Boring Log No. P-3

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 26.308750° Longitude: -98.223060°	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test			Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits	
							Test Type	Compressive Strength (tsf)	Strain (%)			LL-PL-PI	Percent Fines
1	SANDY LEAN CLAY (CL), brown, very stiff to stiff - soft at 4½ feet	Depth (Ft.)	5		X	9-8-10 N=18			15.4	39-14-25			
						5-6-6 N=12			12.6		56		
						1-1-1 N=2			23.6	32-15-17			
						2-2-4 N=6			23.4		62		
						2-4-7 N=11			24.7	34-14-20			
						10.0							
		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 encountered

Drill Rig
 CME 75

Notes

Cave-In Depth
Advancement Method
 Dry augered from 0 to 10 feet

Driller
 RGVD
Logged by
 DP

Abandonment Method
 Boring backfilled with soil cuttings upon completion.

Boring Started
 01-03-2023
Boring Completed
 01-03-2023

Geotechnical Engineering Report

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


Supporting Information

Contents:

General Notes
Unified Soil Classification System
L-PILE Analyses

General Notes

Sampling	Water Level	Field Tests
 Shelby Tube  Split Spoon	 Water Level Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer 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

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

Relevance of Exploration and Laboratory Test Results

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

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A			Soil Classification		
			Group Symbol	Group Name ^B	
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines ^C	$Cu \geq 4$ and $1 \leq Cc \leq 3$ ^E	GW	Well-graded gravel ^F
			$Cu < 4$ and/or [$Cc < 1$ or $Cc > 3.0$] ^E	GP	Poorly graded gravel ^F
		Gravels with Fines: More than 12% fines ^C	Fines classify as ML or MH	GM	Silty gravel ^{F, G, H}
			Fines classify as CL or CH	GC	Clayey gravel ^{F, G, H}
		Clean Sands: Less than 5% fines ^D	$Cu \geq 6$ and $1 \leq Cc \leq 3$ ^E	SW	Well-graded sand ^I
			$Cu < 6$ and/or [$Cc < 1$ or $Cc > 3.0$] ^E	SP	Poorly graded sand ^I
		Sands with Fines: More than 12% fines ^D	Fines classify as ML or MH	SM	Silty sand ^{G, H, I}
			Fines classify as CL or CH	SC	Clayey sand ^{G, H, I}
		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}
Fine-Grained Soils: 50% or more passes the No. 200 sieve		Organic: $\frac{LL \text{ oven dried}}{LL \text{ not dried}} < 0.75$	OL	Organic clay ^{K, L, M, N}	
		Inorganic: PI plots on or above "A" line	CH	Fat clay ^{K, L, M}	
		Organic: $\frac{LL \text{ oven dried}}{LL \text{ not dried}} < 0.75$	MH	Elastic silt ^{K, L, M}	
		Inorganic: PI plots below "A" line	OH	Organic clay ^{K, L, M, P}	
		Organic: $\frac{LL \text{ oven dried}}{LL \text{ not dried}} < 0.75$	PT	Peat	

Highly organic soils:

Primarily organic matter, dark in color, and organic odor

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

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

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

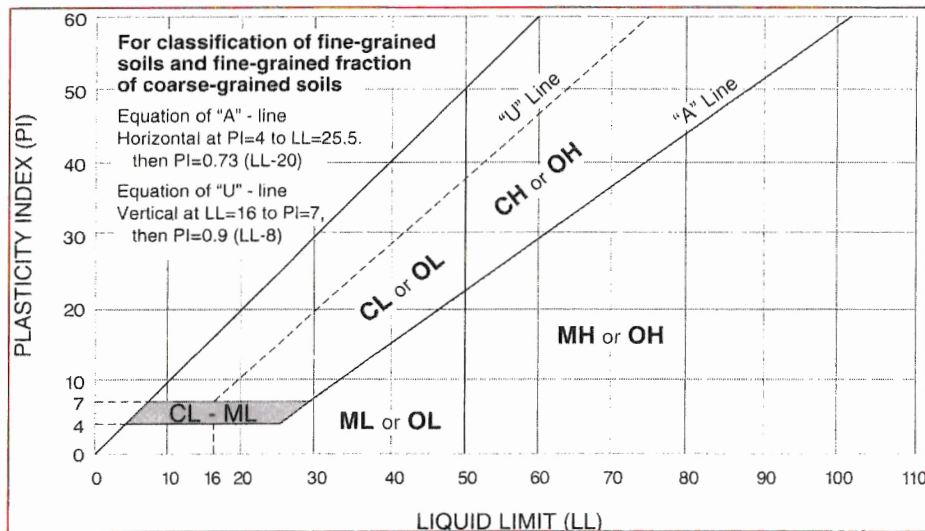
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.



**LATERAL AND AXIAL CAPACITY ANALYSES
DESIGN SOIL PARAMETERS FOR UNDRAINED CONDITIONS**

Boring B-1 thru B-5

Layer	Depth to Bottom of Layer (feet)	Total Unit Weight (pcf)	Effective Unit Weight (pcf)	Undrained Shear Strength (psf)	Strain Factor (e50)	LPILE Soil Type	Friction Angle (degrees)	Adhesion Factor (a)	Horizontal Stress Coefficient K	Subgrade Modulus ks (pci)	Bearing Capacity Factors		
											Nc ⁵	Nq	Ng
1	4	105	105	250	0.023	3	0	----	----	283	6	1	0
2	7	110	110	500	0.015	3	0	1.00	----	332	6	1	0
3	15	115	53	1,500	0.008	3	0	0.58	----	525	6	1	0
4	25	120	58	0	----	4	32	----	0.75	81	35	23	30

1. Design depth to subsurface water is about 7 feet.
2. For uplift conditions, the computed skin friction should be multiplied by 0.9 for clays and 0.7 for sands.
3. Stratigraphy shown above is based on our interpretation of soil strength and may not correspond with the descriptive classifications shown on the boring
4. The lateral load criteria shown above are for use in the computer programs LPILE.
5. The depth to diameter ratio must exceed 4 to use Nc = 9. Otherwise, use Nc = 6.
6. The unit allowable end bearing should not exceed 100 kips per square foot.
7. There are nine soil/rock types available to LPILE. These are as follows: