Geotechnical Engineering Report

Pinnacle West Multi-Family
Houston, Texas
April 28, 2022
Terracon Project No. 92225144

Prepared for:
Transwestern Development Company
Houston, Texas

Prepared by:
Terracon Consultants, Inc.
Houston, Texas

April 28, 2022

Transwestern Development Company
1900 West Loop South, Suite 1400
Houston, Texas 77027

Attn: Mr. Coy McKinney
Senior Vice President

Re: Geotechnical Engineering Report
Pinnacle West Multi-Family
Park Row Drive and Jorden Road
Houston, Texas
Terracon Project No. 92225144

Dear Mr. McKinney:

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the project referenced above in Houston, Texas. We trust that this report is responsive to your project needs.

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

Sincerely,
Terracon Consultants, Inc.
(Texas Firm Registration No.: F-3272)

Blake R. Goben, P.E.
Project Engineer

Yongwan Kwon, P.E.
Project Engineer

Patrick M. Beecher, P.E.
Geotechnical Services Manager

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange 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 ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Pinnacle West Multi-Family
Park Row Drive and Jorden Road
Houston, Texas

Terracon Project No. 92225144
April 28, 2022

INTRODUCTION

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the proposed multi-family development planned at the southwest corner of the intersection of Park Row Drive and Jorden Road in Houston, Texas. This project was authorized by Mr. Coy McKinney, Senior Vice President for Transwestern Development Company, through electronic correspondence on March 18, 2022. This project was performed in general accordance with Terracon Proposal No. P92215144, dated March 17, 2022.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Site and subgrade preparation;
- Foundation design and construction;
- Swimming pool construction considerations;
- Siesmic site class (based on IBC 2012); and
- Pavement design guidelines.

The geotechnical engineering Scope of Services for this project included the advancement of nine test borings to depths ranging from approximately 5 to 20 feet below existing grade.

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

Terracon previously provided a Geotechnical Engineering Report (Terracon Project No. 92135450, dated January 22, 2014). The layout of the planned structures has been revised since the 2013 report was completed. We utilized the available field and laboratory information from borings B-1 through B-10 that were drilled to depths ranging from approximately 5 to 65 feet below existing grade to develop our geotechnical engineering recommendations for this project. These borings have been relabeled as PB-1 through PB-10 for ease of reference.

SITE CONDITIONS

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

Item	Description
Project size and location	The project site, approximately 10 acres in size, was located near the southwest corner of the intersection of Park Row Drive and Jorden Road in Houston, Texas. See **Site Location**.
Existing improvements	■ **2022 field program:** The site was vacant at the time of our 2022 field program. Two soil mounds with a maximum height of approximately 5 feet were located in the northwest portion of the site. [1] In addition, the northwestern and northeastern portions of the site were partially wooded. ■ **2013 field program:** The site was vacant at the time of our 2013 field program. In addition, three soil mounds varying in height from approximately 6 to 10 feet were observed. Boring PB-3 was drilled on top of one of the existing soil mounds in the southeastern potion of the site. [2]
Current ground cover	Grass, weeds, and scattered trees.
Existing topography	Relatively level outside the limits of the soil mounds.

1. We understand the existing soil mounds are planned to be removed from the site prior to construction activities.
2. We understand no major grade changes have been performed since our previous report was completed in 2013.

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
Proposed improvements[1]	■ Three buildings consisting of 3 levels of multi-family over tuck under garages with a footprint area of approximately 28,500 square feet each. ■ A swimming pool with a maximum depth of 6 feet located in the northeast portion of the site. ■ Associated surface pavements and driveways.
Building construction[1]	Wood-frame construction.
Finished floor elevation	Within approximately one to two feet above existing grade.

Item	Description
(Continued from page 2).	
Maximum loads	■ **Column loads**: 100 to 200 kips. **Floor slab pressure**: 125 pounds per square foot (psf).
Planned foundation systems[2]	Either shallow spread/strip footings or post-tensioned (PTI) slab-on-grade.
Pavements	We assume both rigid (concrete) and flexible (asphalt) pavement sections are being considered. We anticipate that traffic will consist primarily of passenger vehicles in the parking areas and passenger vehicles combined with garbage trucks and large multi-axle delivery trucks from time-to-time in driveway areas.

1. Based on information provided by the client.
2. Based on conversations with the client, we understand the design parameters for a post-tensioned slab-on-grade are requested based on achieving an estimated Potential Vertical Rise (PVR) of about one inch for less using a pad of properly placed and compacted select fill as well as based on existing subgrade conditions (estimated PVR of about 2 inches).

GEOTECHNICAL CHARACTERIZATION

Geology

Based on the geologic maps published by the Bureau of Economic Geology, the site for the proposed construction is located on the Beaumont formation, a deltaic nonmarine Pleistocene deposit. The Beaumont formation is heterogeneous containing thick interbedded layers of clay, fine sand, and silt.

The clay fraction is primarily composed of montmorillonite, illite, kaolinite, and finely ground quartz. The clay present in the formation has been preconsolidated by a process of desiccation. Numerous wetting and drying cycles have produced a network of small randomly oriented, closely-spaced joints within some depth zones. These small joints frequently have a shiny appearance and the clays are called slickensided in these cases. The joint pattern may have an influence on the construction and engineering behavior of the soil.

The coastal plain in this region has a complex tectonic geology, several major features of which are: Gulf Coastal geosyncline, salt domes, and major sea level fluctuations during the glacial stages, subsidence and geologic faulting activities. Most of these geologic faulting activities have ceased for millions of years, but some are still active. A detailed geologic fault investigation and study of the site geology are beyond the scope of this report.

Subsurface Profile

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 site preparation and foundation options. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section 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	**Fill: Sandy Lean Clay and Lean Clay**	gray, dark gray, and tan, with sand and silt pockets and scattered gravel
2	**Fill: Silty Sand and Sandy Silt**	dark gray, light gray, and tan, with clay pockets and scattered roots
3	**Silty Clay**	gray, medium stiff to hard, with silt pockets and scattered roots
4	**Sandy Silt**	gray, light gray, and reddish brown, loose to medium dense, with clay pockets and scattered roots
5	**Sandy Fat Clay and Fat Clay**	light gray, gray, tan, and reddish brown, stiff to very stiff, with sand/silt pockets and seams, ferrous stains and nodules, and slickensides
6	**Sandy Lean Clay and Lean Clay**	light gray, gray, and tan, soft to hard, with sand/silt seams and ferrous stains
7	**Silty Sand, Clayey Sand, and Poorly Graded Sand with Silt**	reddish brown, tan, and light gray, very loose to very dense, with clay pockets

Laboratory Testing

Hydrometer tests were performed on five soil samples. Results of the hydrometer tests are presented in the table below.

Hydrometer Analyses					
Boring No.	**Sample Depth (feet)**	**Description**	**Plasticity Index**	**Percentage of Fines [1] (%)**	**Percent Finer Than 2 Microns[2]**
B-1	2 to 4	Sandy Fat Clay	38	63	18
B-4	6 to 8	Sandy Lean Clay	18	56	21
PB-4[3]	2 to 4	Sandy Fat Clay	39	64	38
PB-6[3]	2 to 4	Fat Clay	59	75	60
PB-8[3]	4 to 6	Sandy Lean Clay	22	50	29

Hydrometer Analyses					
Boring No.	**Sample Depth (feet)**	**Description**	**Plasticity Index**	**Percentage of Fines [1] (%)**	**Percent Finer Than 2 Microns[2]**

(Continued from page 4).

1. Percent passing the No. 200 sieve.
2. Computed clay content of the soils has been used for the computation of the edge and center lift movements for the design of post-tensioned slabs-on-grade.
3. Hydrometer tests were performed as part of our previous Geotechnical Engineering Report (Terracon Project No. 92135450, dated January 22, 2014).

Groundwater Conditions

Borings PB-1 through PB-9 were advanced using dry drilling techniques to depths that ranged from approximately 15 to 20 feet in an effort to evaluate groundwater conditions at the time of our field program. Wet rotary techniques were used thereafter to the termination depths of these borings (about 30 to 65 feet). Borings B-1 through B-9 and PB-10 were advanced using dry drilling techniques to their termination depths (approximately 5 to 20 feet) in an effort to evaluate groundwater conditions at the time of the field program. Upon reaching groundwater, drilling was suspended for a period of about 15 minutes to allow the groundwater to rise and the groundwater levels to be recorded. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results** and are summarized below.

Summary of Groundwater Level Observations						
Boring No.	**Approximate Boring Depth (feet) [1]**	**Approximate Depth of Dry Drilling (feet) [1]**	**Approximate Depth of Groundwater (feet)[1]**			
			Initial/During Dry Drilling	**After 5 Minutes**	**After 10 Minutes**	**After 15 Minutes**
B-1[2]	20	20	15	11[3]	---	---
B-2[2]	20	20	15	13[3]	---	---
B-3[2]	20	20	20	13[3]	---	---
B-4[2]	20	20	10	9[3]	---	---
B-5[2]	20	20	12	8[3]	---	---
B-6[2]	20	20	No free water observed.			
B-7[2]	20	20	12	9[3]	---	---
B-8[2]	5	5	No free water observed.			

Summary of Groundwater Level Observations						
Boring No.	Approximate Boring Depth (feet) [1]	Approximate Depth of Dry Drilling (feet) [1]	Approximate Depth of Groundwater (feet)[1]			
			Initial/During Dry Drilling	After 5 Minutes	After 10 Minutes	After 15 Minutes
(Continued from page 5).						
B-9[2]	5	5	No free water observed.			
PB-1[4]	50	20	15½	15	15	15
PB-2[4]	50	16	No free water observed.			
PB-3[4]	65	20	18	17	17	17
PB-4[4]	30	20	15½	15½	15½	15½
PB-5[4]	30	20	15½	15½	15½	15½
PB-6[4]	30	20	No free water observed.			
PB-7[4]	30	20	No free water observed.			
PB-8[4]	30	15	13	13	13	13
PB-9[4]	30	15	15½	15½	15½	15½
PB-10[4]	5	5	No free water observed.			

1. Below existing grade at the time of our previous and current field programs.
2. Groundwater readings were obtained on March 26, 2022.
3. Caved-in.
4. Groundwater readings were obtained on December 1, 2, 4, 6, and 7, 2013.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the proposed improvements may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project and should be evaluated prior to construction.

GEOTECHNICAL OVERVIEW

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. A summary of our findings and recommendations is provided below.

- Fill soils were observed at the ground surface at borings B-5, B-8, and PB-1 through PB-10 and extended to depths that ranged from about 2 to 13 feet. At the time of our 2013 field program, three soil mounds with heights varying from about 6 to 10 feet were observed at the site. Boring PB-3 was drilled on top of one of the existing soil mounds in the southeastern portion of the site. Most of the fill observed at boring PB-3 can be attributed to the fill in the soil mound. We understand this soil mound has since been removed, and that two soil mounds were observed to still remain in place at the time of our 2022 field program. We understand these additional soil mounds are planned to be

removed prior to start construction activities. Fill soils may be present at varying depths and at other locations not explored during our field program. Support of the foundation elements, slabs, flatworks, and pavements on or above fill soils is discussed in this report. However, even with the recommended construction testing services, an inherent risk exists for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill.

- If post-tensioned (PTI) slab-on-grade foundations are planned, the fill soils should be over-excavated and completely removed within the proposed building areas to expose the underlying native subsurface soils.

- The surficial soils observed in portions of the site exhibited negligible to low plasticities and an increased silt and sand content. These soils are moisture sensitive and may become weak with elevated moisture contents and present construction difficulties. If wet and/or soft conditions are present at the time of construction, remedial efforts may be necessary for preparation of the surficial soils in the building and pavement areas to create a working surface. Remedial effort options are discussed in the **Wet Weather/Soft Subgrade** section of this report.

- Expansive soils were observed at this site. This report provides recommendations to help reduce the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and distress in the buildings should be anticipated. The severity of distress will increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement associated with expansive soils may not be feasible. However, this risk can be significantly reduced if the buildings are designed as a structural slab over a void space with the structural loads supported by a foundation system terminated below the active zone. Terracon can provide recommendations for this option, if requested.

- A foundation system consisting of either shallow spread/strip footings or a post-tensioned (PTI) slab-on-grade may be utilized to support the proposed buildings planned at this site.

- Based on conversations with the client, we understand the design parameters for a post-tensioned slab-on-grade are requested based on achieving an estimated Potential Vertical Rise (PVR) of about one inch for less using a pad of properly placed and compacted select fill as well as based on existing subgrade conditions (estimated PVR of about 2 inches).

- A minimum 36-inch thick select fill building pad should be placed under the proposed buildings to provide uniform support to the floor slabs and reduce the estimated Potential Vertical Rise (PVR) of the subgrade to approximately one inch or less.

- Based on the soil and groundwater conditions observed at borings B-3 through B-5 which are located in the vicinity of the proposed swimming pool, we anticipate that the excavations for the swimming pool to the anticipated excavation depth of 6 feet within the clay soils may be performed in the dry. Possible seepage that occurs from surficial sandy/silty soils and inclusions within the clay soils is expected to be minor and likely can be handled utilizing a system of sumps and pumps positioned in the bottom of the excavation.

- Flexible pavement sections vary from 2.0 to 2.5 inches of asphaltic concrete over 8.0 to 10.0 inches of base material with chemically treated subgrade.

- Rigid pavement sections vary from 5.0 to 7.0 inches of reinforced concrete with chemically treated subgrade.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **General Comments** should be read for an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and 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

Construction areas should be stripped of vegetation, topsoil, trees, and other debris/unsuitable surface material. Roots of trees to be removed within the construction areas should be grubbed to full depths. Care should be taken to replace or recompact all soil removed or loosened by the removal of tree roots and stumps as recommended in subsequent paragraphs. 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.

If post-tensioned (PTI) slab-on-grade foundations are planned, the fill soils should be over-excavated and completely removed within the proposed building areas to expose the underlying native subsurface soils.

Once the existing soil mounds are removed and final subgrade elevations have been achieved, the exposed subgrade should be carefully proofrolled with a 20-ton pneumatic roller or equivalent

equipment, such as a fully loaded dump truck, to detect weak zones in the subgrade. Special care should be exercised when proofrolling areas containing fill soils in an attempt to observe soft/weak zones within the fill soils. Weak areas detected during proofrolling, as well as zones of fill containing organic matter and/or debris, should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils. Proofrolling should be performed under the direct observation of the geotechnical engineer or his/her representative.

Subsequent to proofrolling, and just prior to placement of fill, the exposed subgrade within the construction area should be evaluated for moisture and density. If the moisture and/or density do not meet the criteria described in **Fill Compaction Requirements** for on-site soils, the subgrade should be scarified to a minimum depth of 6 inches, moisture adjusted, and compacted to at least 95 percent of the Standard Effort (ASTM D 698) maximum dry density.

Fill Material Types

Select fill and on-site soils to be used at this site for grade adjustments should meet the following criteria:

Fill Type	USCS Classification	Acceptable Location for Placement
Select fill soils	CL and/or SC (10≤PI≤20)	Must be used to construct the select fill building pad under the floor slab and any grade-supported slabs sensitive to post-construction movements, and for all grade adjustments within the building areas if either shallow spread/strip footings are planned or if the estimated 1-inch PVR option is selected.
On-site soils[1]	Varies	■ The on-site soils, including the undocumented fill soils, appear suitable for use as fill within the pavement areas, provided they are free of organics and debris. ■ The on-site soils may be used to raise grade under the PTI slab-on-grade foundation if the estimated 2-inch PVR option is selected, provided they are free of organics and debris.

1. The utilization of on-site silt/sand soils and low plasticity clay soils may present difficulties during construction due to the increased sand and silt content of these soils, especially during and soon after periods of wet weather. If the utilization of the silt/sand soils and low plasticity clay soils as fill is planned in the pavement areas, treatment of these soils with lime-flyash should produce a material that would be more suitable for use as fill.

If blended or mixed soils are intended for use as select fill, Terracon should be contacted to provide additional recommendations. Blended or mixed soils do not occur naturally. These soils are a blend of sand and clay and will require mechanical mixing at the site with a pulvimixer. If these soils are not mixed thoroughly to break down the clay clods and blend-in the sand to produce a uniform soil matrix, the fill material may be detrimental to the slab performance. If

blended soils are used, we recommend that additional samples of the blended soils as well as the clay clods, be obtained prior to and during earthwork operations to evaluate if the blended soils can be used in lieu of select fill. The actual type and amount of mechanical mixing at the site will depend on the amount of clay and sand, and properties of the clay.

Fill Compaction Requirements

Item	Description
Fill lift thickness	The fill soils should be placed on prepared surfaces in lifts not to exceed 8 inches loose measure, with compacted thickness not to exceed 6 inches.
Compaction requirements	■ The select fill and on-site soils should be compacted to at least 95 percent of the Standard Effort (ASTM D 698) maximum dry density. ■ The select fill soils should be moisture adjusted to within 2 percent of the optimum moisture content. ■ The on-site clay soils should be moisture conditioned to between optimum and +4 percent of the optimum moisture content.

Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

Utility Trench Backfill

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structure should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the buildings. We recommend constructing an effective clay “trench plug” that extends at least 5 feet out from the face of the building exterior. The plug material should consist of clay compacted at a water content at or above the soils optimum water content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report.

Grading and Drainage

All grades must provide effective drainage away from the buildings during and after construction. Water permitted to pond next to the buildings can result in distress in the buildings. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. Building slab and foundation performances described in this report are based on effective drainage for the life of the structures and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped away from the buildings for at least 10 feet beyond the perimeter of the buildings. After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the buildings should also be periodically inspected and adjusted as necessary, as part of the building's maintenance program.

Planters located within 10 feet of the proposed buildings should be self-contained to prevent water accessing the building and pavement subgrade soils. Locate sprinkler mains and spray heads a minimum of 5 feet away from the building lines. Low-volume, drip-style landscaped irrigation should not be used near the buildings. Collect roof runoff in drains or gutters. Discharge roof drains and downspouts onto pavements and/or flatworks which slope away from the proposed buildings or extend down spouts a minimum of 10 feet away from buildings.

Flatworks and pavements will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent water from ponding. Allowances in final grades should also consider post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts the buildings, effectively seal and maintain joints to prevent surface water infiltration.

Wet Weather/Soft Subgrade Considerations

Due to the elevated silt and sand content and negligible to low plasticities of the surficial soils observed at this site, proper compaction may be difficult to achieve. In addition, construction during and soon after wet weather periods may encounter difficulties due to wet and soft surficial soils becoming a general hindrance to equipment as a result of rutting and/or pumping of the soil surface. This condition is primarily due to their lack of cohesion (low clay content) and little to no confining pressure near the ground surface. If the subgrade cannot be adequately compacted to the minimum densities as described above, one of the following methods should be used to improve the soils: 1) removal and replacement with select fill, 2) chemical treatment of the soil to dry the subgrade, or 3) drying by natural means if the schedule allows.

Based on our experience with similar soils, chemical treatment is an efficient and effective method to improve the condition of wet and soft subgrade such as that observed at this site. Chemical treatment may be necessary to depths of approximately one to 2 feet or greater of the surficial silty/sandy soils, depending on the condition of the subgrade at the time of construction. We suggest that a cost be included in the construction budget for chemical treatment of the soils using a lime-flyash mixture to aid drying and improve the condition of the soil if the soil is wet and/or soft at the time of construction. We recommend that this cost be in the form of a contingency or allowance to be used if needed.

FOUNDATION SYSTEMS

Based on the subsurface conditions observed during our field and laboratory programs, a foundation system consisting of either shallow spread/strip footings or post-tensioned (PTI) slab-on-grade may be utilized to support the proposed buildings planned at this site, provided the subgrade is properly prepared as described in this report. Recommendations for these types of foundation systems are provided in the following sections, along with other geotechnical considerations for this project.

Design Recommendations – Shallow Spread/Strip Footings

Item	Description
Minimum embedment depth [1]	4 feet below existing grade (grade at the time of our field program)
Allowable bearing pressures (individual footings) [2]	Net dead plus sustained live load – 4,200 psf Net total load – 6,300 psf
Allowable bearing pressure (strip footing) [3]	Net dead plus sustained live load – 3,400 psf Net total load – 5,100 psf
Approximate post-construction settlement [4]	Approximately one inch
Estimated post-construction differential settlement [5]	Approximately ½ of post-construction settlement
Allowable passive pressure [6]	750 psf
Allowable frictional resistance [7]	250 psf
Uplift resistance [8]	Foundation Weight (150 pcf) & Soil Weight (120 pcf)

1. The footings should extend through the fill soils and bear upon native undisturbed clay soils.
2. Whichever condition yields a larger bearing area.
3. Defined as a footing at least twice as long as it is wide.
4. This estimated post-construction settlement of the shallow footings is without considering the effect of stress distribution from adjacent foundations and assuming proper construction practices are followed. A clear distance between footings of one footing size of the larger of the two footings should not produce overlapping stress distributions and would essentially behave as independent foundations.
5. The post-construction differential settlements may result from variances in subsurface conditions, loading conditions, and construction procedures. The settlement response of the footings will be more dependent upon the quality of construction than upon the response of the subgrade to the foundation loads.
6. The passive pressure along the exterior face of the footings should be neglected within the upper 4 feet due to surface effects and the presence of fill and expansive soils unless pavement is provided up to the edge of the buildings. For interior footings, the allowable passive pressure may be used for the entire depth of the footing.
7. To be utilized on the base of the footings.
8. Structural uplift loads on the shallow footings may be resisted by the weight of the foundation plus the weight of any soil directly above the foundation. The ultimate uplift capacity of shallow footings should be reduced by an appropriate factor of safety to compute allowable uplift capacity.

Construction Considerations – Shallow Spread/Strip Footings

Excavations for shallow footings should be performed with equipment capable of providing a relatively clean bearing area. The bottom 6 inches of the foundation excavations should be completed with a smooth-mouthed bucket or by hand labor. The excavations should be neatly excavated and properly formed. Debris in the bottom of the excavation should be removed prior to steel placement. Based on the groundwater observations obtained during our field program (refer to **Groundwater Conditions**), significant groundwater seepage is not anticipated for shallow footings at the recommended bearing depth. However, water should not be allowed to accumulate at the bottom of the foundation excavations. To reduce the potential for groundwater seepage into the excavations and to minimize disturbance to the bearing area, we recommend that concrete and steel be placed as soon as possible after the excavations are completed. Excavations should not be left open overnight. The bearing surface of the shallow footings should be evaluated immediately prior to placing concrete or a seal slab.

A thin seal slab of lean concrete (approximately 2 to 4 inches thick) should be placed at the bottom of the footing excavation to protect the bearing surface of the footings from disturbance and/or infiltration of ground/surface water if the footing cannot be poured within the same day of excavation.

Design Recommendations – Post-Tensioned (PTI) Slab-on-Grade

As previously stated, a post-tensioned slab-on-grade foundation system may also be considered to support the proposed buildings planned at the site. Based on conversations with the client, we understand the design parameters for a post-tensioned slab-on-grade are requested based on achieving an estimated Potential Vertical Rise (PVR) of about one inch for less using a pad of properly placed and compacted select fill as well as based on existing subgrade conditions (estimated PVR of about 2 inches).

If post-tensioned (PTI) slab-on-grade foundations are planned, the fill soils should be over-excavated and completely removed within the proposed building areas to expose the underlying native subsurface soils. The exposed subgrade after over-excavation should be thoroughly proofrolled and prepared as outlined in the **Earthwork** section of this report (including evaluated for moisture and density).

The near surface soils observed at this site generally exhibit a variable expansion potential. These soils can subject the interior floor slab of the buildings to significant movements (due to shrinking and swelling) with fluctuations in their moisture content. This movement potential is influenced primarily by the properties of the subgrade soils, as well as the moisture content of the subgrade at the time of construction, overburden pressures, and the stability of the moisture contents throughout the life of the buildings. 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) of up to approximately 2 inches. Therefore, if the option to reduce the estimated PVR to about one inch or less is selected, the subgrade should be prepared as stated herein to reduce potential soil movements to more tolerable levels and provide uniform support to the floor slab system. The actual movements could be greater if poor drainage, ponded water, and/or other unusual sources of moisture are allowed to infiltrate beneath the structures after construction.

The most common method of subgrade preparation to reduce potential expansion of the subgrade would be to provide a pad of properly placed and compacted select fill beneath the PTI slab-on-grade foundations. The corresponding decrease in the potential soil movements is primarily a function of the fill pad thickness and the moisture levels of the underlying clay subgrade. While the indicated preparations do not eliminate the potential for soil movement, the magnitude of such movements should be reduced to more acceptable levels. To provide uniform support to the slabs and to reduce the estimated PVR to approximately one inch or less, we recommend that a minimum 36 inches of properly placed and compacted select fill material be constructed immediately beneath the PTI slab-on-grade foundations. The select fill pad should extend a minimum of 5 feet beyond the edge of the building areas. The final exterior grade adjacent to the structures should be sloped to promote effective drainage away from the structures.

The subgrade and select fill soils should be prepared as outlined in the **Earthwork** section of this report, which contains material and placement requirements for select fill, as well as other subgrade preparation recommendations.

Based on our analysis of the field and laboratory data, design parameters were computed using Addenda No. 11 and No. 22 to the 2004 Post-Tensioning Institute (PTI) method for slab-on-grade design. As requested, we have computed two options for the PTI design parameters at this site. The first option incorporates a minimum 36-inch select fill pad to reduce the estimated PVR of the subgrade to approximately one inch or less. The second option was evaluated based on the existing subgrade conditions (estimated PVR of up to approximately 2 inches). If option two is planned Atterberg Limit tests indicate that the soils observed in the proposed building areas contain near-surface strata which generally have variable expansion potential. A PTI slab-on-grade foundation will be subject to vertical movements due to seasonal moisture variations within the variable plasticity soils. The construction of a foundation of this type will be feasible if the foundation is properly designed to resist bending moments induced by the estimated soil movements.

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1. *Post-Tensioning Institute, "Addendum No. 1 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground", Post-Tensioning Institute, Phoenix, AZ, May 2007.*
2. *Post-Tensioning Institute, "Addendum No. 2 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground", Post-Tensioning Institute, Phoenix, AZ, May 2008.*

The moisture beneath a shallow foundation will change in response to wetting and drying conditions around the foundation perimeter. The maximum moisture variation distance is termed the edge moisture variation distance, e_m, and is an important factor governing the design of a post-tensioned floor slab. The e_m is related to percent fine clay and climatic conditions as well as other parameters, such as soil fabric factor and unsaturated diffusion coefficient.

The plasticity index of the soil, type and amount of clay mineral in the soil, and the moisture conditions from the time of construction through the life of the structure are parameters that should be considered in design of a slab-on-grade. The plasticity index and the clay mineral are values of the soil that can be estimated by laboratory tests and, although variable from location to location, remain relatively constant with time. The moisture condition has a significant effect on slab behavior and is highly variable with time, changing seasonally, with annual climate conditions, drainage patterns, ground cover, and vegetation (trees and shrubs).

Based on our laboratory test data and on our experience with similar soils, the post-tensioned slabs at this site should be designed using criteria outlined by the Post-Tensioning Institute using the following parameters:

Design Parameters		
Description	**Estimated PVR of about one inch or less**	**Estimated PVR of about 2 inches (existing conditions)**
Select fill pad thickness	Minimum of 36 inches	---
Depth of seasonal moisture change	Approximately 9 feet	
Effective Plasticity Index	27	29
Percent finer than 2 microns [1]	18 to 60	
Soil fabric factor	1.0	
Approximate Thornthwaite Moisture Index [2]	+15	
Estimated constant soil suction, pF	3.5 pF	
Range of soil suction, pF [2]	3.0 to 4.5 pF	
Estimated edge moisture variation distance, e_m [3]	**For center lift**: 9.0 feet **For edge lift**: 4.7 feet	**For center lift**: 9.0 feet **For edge lift**: 4.7 feet
Estimated differential soil movement, y_m [3]	**For center lift**: 0.7 inches **For edge lift**: 0.4 inches	**For center lift**: 0.8 inches **For edge lift**: 0.5 inches
Perimeter grade beam depth [4]	Minimum 24 inches below exterior grade	
Allowable bearing capacity [4]	**Dead load plus sustained live load**: 1,700 psf **Total net load**: 2,500 psf	

Design Parameters		
Description	**Estimated PVR of about one inch or less**	**Estimated PVR of about 2 inches (existing conditions)**

(Continued from page 15).

1. For varying soil properties to 9 feet.
2. The differential movements were calculated by modeling the soil profile using the commercial software program VOLFLO as recommended by the PTI manual. Based on a Thornthwaite Index of +15 for this site, we considered the Post-Equilibrium Case to determine the Stress Change Factor (SCF). As recommended by the PTI manual, a suction change of 1.5 pF was used for the analysis for the Post- Equilibrium Case.
3. The estimated movements do not consider the effects of non-climatic factors which might arise from conditions beyond the control of Terracon. The conditions include, but are not limited to, location of planters and trees around the building, poor drainage, and operations of the owner/contractor on the site subsequent to our explorations.
4. Provided the subgrade is prepared as recommended in the **Earthwork** section of this report. The grade beams should bear within either properly placed and compacted select fill soils or upon native undisturbed clay soils.

Post construction settlements for the slab foundation described in this subsection should be one inch or less, provided the site is prepared as described in this report. Settlement response of the foundation system is expected to be influenced more by the quality of construction and fill placement than by soil-structure interaction.

Construction Considerations – Post-Tensioned Slab-on-Grade

The excavations for grade beams should be performed with equipment capable of providing a relatively clean bearing area. The bottom 6 inches of the planned foundation excavations should be performed using a smooth-mouthed excavation bucket or hand labor. The excavations should be neatly excavated and properly formed. Debris in the bottom of the excavations should be removed prior to steel placement. Water should not be allowed to infiltrate foundation excavations. To reduce the potential for groundwater seepage into the excavations and to minimize disturbance to the bearing area, we recommend that steel and concrete be placed as soon as possible after the excavations are completed and properly cleaned. Excavations should not remain open overnight. The bearing surface of the foundation should be evaluated upon completion of the excavation and immediately prior to placing concrete.

Foundation Construction Monitoring

The performance of the foundation systems for the proposed structures will be highly dependent upon the quality of construction. Thus, we recommend that fill pad compaction and foundation installation be observed full time by an experienced Terracon soil technician under the direction of our geotechnical engineer. During foundation installation, the base of the foundations should be observed to evaluate the condition of the subgrade. We would be pleased to develop a plan for compaction and foundation installation observation to be incorporated in the overall quality control program.

FLOOR SLABS ASSOCIATED WITH SHALLOW SPREAD/STRIP FOOTINGS

As stated previously, we anticipate that the finished floor elevation for the proposed buildings will be within approximately one to two feet above existing grade. Terracon should be contacted if the planned grading is changed so that we may review and/or modify the recommendations presented in this report.

As mentioned in **Design Recommendations – Post-Tensioned Slab-on-Grade**, the subgrade soils at the site are estimated to exhibit a PVR of up to approximately 2 inches. A minimum 36-inch thick select fill building pad should be placed under the proposed building areas to provide uniform support to the floor slabs and reduce the estimated Potential Vertical Rise (PVR) of the subgrade to approximately one inch or less. The building pad area associated with shallow spread/strip footings should be constructed as discussed in the **Design Recommendations – Post-Tensioned Slab-on-Grade** section of this report.

Select fill should be used for all grade-adjustments in the building areas. The subgrade and select fill beneath the floor slabs should be prepared as outlined in the **Earthwork** section of this report, which contains material and placement requirements for select fill, as well as other subgrade preparation recommendations.

SWIIMING POOL

Based on the information provided, we understand that a swimming pool is planned to be constructed in the northeast portion of this site. We understand that the maximum depth of the swimming pool is planned to be 6 feet below final grade. Recommendations for pool construction are provided in the following sections.

Below-Grade Excavation Considerations

The sides of the excavations may either be sloped or formed with vertical cuts. For vertical sided excavations greater than 5 feet in depth, the excavations will require the use of shoring, bracing or some form of retention to prevent sloughing and caving of the soil into the excavation.

The contractor should use a trench box or shoring and bracing as necessary to maintain a safe and clean excavation which meets with the Occupational Safety and Health Administration (OSHA) requirements. Excavations must be performed and inspected under the supervision of a contractor designated Competent Person. The Competent Person, as defined by the OSHA Standard, 29 CFR Part 1926.650 to .652, Subpart P – Excavations, must evaluate the excavations at the time of construction activity to safeguard workers.

In lieu of shoring, bracing, or trench boxes for excavations greater than 5 feet, OSHA standards provide recommendations for the design of temporary sloped excavations with a depth more than 5 feet and less than 20 feet. The OSHA standards provide maximum allowable slopes contingent on three designated soil types: Type A, Type B, and Type C. According to OSHA standards, temporary sloped excavations should be no steeper than 0.75-horizontal on 1-vertical (0.75H:1V) for Type A soils, 1H:1V for Type B soils, and 1.5H:1V for Type C soils. The surface soils should be protected from deterioration and weathering if they are left open for significant periods of time.

Excavations should be performed with equipment capable of providing a relatively clean bearing area. Excavating equipment should not disturb the soil beneath the design excavation bottom and should not leave large amounts of loose soil in the excavation.

As a safety measure, no equipment should be operated within 5 feet of the edge of the excavation and no materials should be stockpiled within 10 feet of the excavation. Excavations should not approach closer than 10 feet from existing structures/facilities without some form of protection for the facilities. Proper berming or ditching should be performed to divert any surface runoff away from the excavation.

Temporary Groundwater Control

Based on the soil and groundwater conditions observed at borings B-3 through B-5, which was drilled in the vicinity of the proposed swimming pool area, we anticipate that the bottom of the excavation will be located in the clay soils and the excavation to the maximum depth of 6 feet can be performed without advanced dewatering. Possible seepage from surficial sandy/silty soils and from inclusions within the clay soils is expected to be minor and likely can be handled utilizing a system of sumps and pumps positioned in the bottom of the excavation. Care should be taken to slope the excavation towards the sumps such that water can be collected and removed from the excavation.

The suggested method given above serve as a guideline for groundwater control; other appropriate means may be required for groundwater control during construction. Control of groundwater should be accomplished in a manner that will preserve the strength of the soils, will not cause instability of the excavation, and will not result in damage to existing structures, if any.

As stated previously, the groundwater levels will fluctuate with seasonal and climatic changes and should be evaluated just prior to construction. To evaluate the groundwater conditions in the area of the swimming pool, piezometers may be installed, or test pits may be excavated to the planned excavation depth. Based on the observed water levels, the contractor should determine effective methods of groundwater management prior to starting excavation operations.

Lateral Earth Pressures

The backfill soils adjacent to the below grade walls of the proposed pool will impose active to at-rest earth pressures against the wall. Design lateral earth pressures may be computed using an equivalent fluid weight of 110 pcf for on-site soils. This pressure includes hydrostatic pressures but does not include surcharge forces imposed by construction or vehicular loading. The lateral pressure produced by surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of the wall. A 2-foot layer of compacted clay soil should be placed at the top of sand backfill, if any, to reduce the amount of infiltration of surface water.

SEISMIC CONSIDERATIONS

Description	Value
2012 International Building Code (IBC) [1]	D [2]

1. In general accordance with the *2012 International Building Code,* Table 1613.3.2 and *ASCE 7,* Chapter 20.
2. The 2012 International Building Code (IBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope did not include a 100-foot deep soil boring. Borings for the building extended to a maximum depth of approximately 65 feet. Based on the International Building Code (IBC) 2012, "When the soil properties are not known in sufficient detail to determine the Site class, Site Class D shall be used unless the building official or Geotechnical data determines that Site Class E or F is likely to be present at the site." Therefore, based on our knowledge and experience with the local site geology and a review of available field and laboratory data, the seismic site class in accordance with the IBC 2012 should be assumed to be Site Class D.

PAVEMENTS

Once the subgrade is properly prepared, both flexible pavement systems (consisting of asphaltic concrete and base material) and rigid pavement systems may be considered for this project. Detailed traffic loads and frequencies were not available. However, we anticipate that traffic will consist primarily of passenger vehicles in the parking areas and passenger vehicles combined with garbage trucks and large multi-axle delivery trucks from time-to-time in driveway areas.

Tabulated in the following table are the assumed traffic frequencies and loads used to design pavement sections for this project. When actual traffic conditions have been determined Terracon should be contacted to review the information to consider a need for revision of the pavement designs and related recommendations.

Pavement Area	Traffic Design Index [1]	Description
Automobile Parking Areas	DI-1	Light traffic (Few vehicles heavier than passenger cars, no regular use by heavily loaded two axle trucks.) (EAL [2] < 6)
Driveways (Light Duty)	DI-2	Medium to light traffic (Similar to DI-1 including not over 50 loaded two axle trucks or lightly loaded larger vehicles per day. No regular use by heavily loaded trucks with three or more axles.) (EAL = 6-20)
Driveways and Truck Traffic Areas (Medium Duty)	DI-3	Medium traffic (Including not over 300 heavily loaded two axle trucks plus lightly loaded trucks with three or more axles and no more than 30 heavily loaded trucks with more than three axles per day.) (EAL = 21-75)

1. Based on NSSGA traffic design indices.
2. Equivalent daily 18-kip single-axle load applications.

The top 6 inches of the finished subgrade soils directly beneath the pavements be chemically treated with either lime or a mixture of lime-flyash. The decision about the type and proper amount of additive should be made after the subgrade is open for inspection. Chemical treatment will increase the supporting value of the subgrade and decrease the effect of moisture on subgrade soils. These 6 inches of treatment is a required part of the pavement design and is not a part of the site and subgrade preparation for wet/soft subgrade conditions.

Listed below are pavement component thicknesses, which may be used as a guide for pavement systems at the site for the traffic classifications stated herein. 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.

Flexible Pavement System		
Component	Material Thickness, Inches	
	DI-1	DI-2
Asphaltic concrete	2.0	2.5
Base material	8.0	10.0
Treated subgrade	6.0	6.0

Rigid Pavement System			
Component	Material Thickness, Inches		
	DI-1	DI-2	DI-3
Reinforced concrete	5.0	6.0	7.0
Treated subgrade	6.0	6.0	6.0

Waste dumpster areas should be constructed of at least 7 inches of reinforced concrete pavement. The concrete pad areas should be designed so that the vehicle wheels of the collection

truck are supported on the concrete while the dumpster is being lifted to support the large wheel loading imposed during waste collection.

Presented below are our recommended material requirements for the various pavement sections.

Reinforced Concrete Pavement – The materials and properties of reinforced concrete pavement should meet applicable requirements in the ACI Manual of Concrete Practice. The portland cement concrete mix should have a minimum 28-day compressive strength of 3,500 psi.

If river gravel is planned to be utilized in the portland cement concrete mix, Terracon should be contacted for additional services. The presence of river gravel in the portland cement concrete mix can result in excessive cracking and distress to the concrete pavement as a result of differing thermal expansion properties between the river gravel and cement paste. Special care should be taken in developing the project's portland cement concrete mix design, joint layout, and placement to help reduce the potential for excessive cracking and distress if river gravel is planned to be utilized for the project.

Reinforcing Steel – ACI recommendations indicate that distributed steel reinforcement is not necessary when the pavement is properly jointed to form short panel lengths that will help reduce intermediate cracking. Provided the concrete pavement is designed and constructed as stated herein, the installation of reinforcing steel is optional and should be evaluated by the design team. Proper layout and installation of the joints within the pavement is critical to help control intermediate cracking.

If reinforcing steel is planned to be utilized in the concrete pavement by the design team, the following amount of reinforcing steel should be used as a guideline:
DI-1: #3 bars spaced at 18 inches or #4 bars spaced at 24 inches on centers in both directions.
DI-2: #3 bars spaced at 12 inches or #4 bars spaced at 18 inches on centers in both directions.
DI-3: #4 bars spaced at 18 inches on centers in both directions.

Control Joint Spacing – ACI recommendations indicate that control joints should be spaced at a maximum spacing of 30 times the thickness of the pavement for unreinforced parking lot pavements. Furthermore, ACI recommends a maximum control joint spacing of 12.5 feet for 5-inch pavements and a maximum control joint spacing of 15 feet for 6-inch or thicker pavements. Sawcut control joints should be cut within 4 to 12 hours of concrete placement to help control the formation of plastic shrinkage cracks as the concrete cures. The depth of the joint should be at least one-quarter of the slab depth when using a conventional saw or one inch when using early entry saws. The width of the cut should be in accordance with the joint sealant manufacturer recommendations.

Expansion Joint Spacing – ACI recommendations indicate that regularly spaced expansion joints may be deleted from concrete pavements. Therefore, the installation of expansion joints is optional and should be evaluated by the design team.

Construction Joints – When concrete is planned to be placed at different times, we recommend the use of a construction joint between paving areas. The construction joint should consist of a butt joint (not a keyway joint).

Concrete Curing Compound – A concrete curing compound, such as a Type 2 membrane curing compound conforming to TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants" or equivalent, should be applied to the concrete surface immediately after placement of the concrete in accordance with TxDOT 2014 Standard Specifications Item 360.

Dowels at Expansion/Construction Joints – The smooth dowels at expansion/construction joints should be spaced at 12-inch centers and consist of the following:
DI-1: 5/8-inch diameter, 12-inches long with 5-inch embedment.
DI-2: 3/4-inch diameter, 14-inches long with 6-inch embedment.
DI-3: 7/8-inch diameter, 14-inches long with 6-inch embedment.

One end of the dowels should either be greased or sleeved to allow for lateral movement to occur.

Hot Mix Asphaltic Concrete Surface Course – The asphaltic concrete surface course should be plant mixed, hot laid Type D (Fine Graded Surface Course) meeting the requirements in TxDOT 2014 Standard Specifications Item 340. Specific criteria for the job specifications should include compaction to within an air void range of 3.8 to 8.5 percent calculated using the maximum theoretical specific gravity of the 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.

Base Material – Base material should be composed of crushed limestone or crushed concrete meeting the requirements of TxDOT 2014 Standard Specifications Item 247, Type A or D, Grade 1 or 2. The base material should be compacted to at least 95 percent of the Modified Effort (ASTM D1557) maximum dry density at moisture content within 2 percent of the optimum moisture content.

Lime-Flyash Treated Subgrade – The surficial sands/silts and low to medium plasticity clay soils (PI≤15) should be treated with lime-flyash in accordance with TxDOT 2014 Standard Specifications Item 265. Based on the classification test results, we recommend about 2 to 3 percent lime and 7 to 8 percent flyash by dry weight be used for estimating and planning. The percentages are given as application by dry weight and are typically equivalent to about 10 to 15

pounds of lime and 35 to 40 pounds of flyash per square yard per 6-inch depth. Lime-flyash is also available pre-mixed, typically in percentages of 20 to 30 percent lime and 70 to 80 percent flyash. These pre-mixed products may be used if preferred at a rate of 50 pounds per square yard per 6-inch depth. The actual quantity of lime-flyash should be determined at the time of construction based on laboratory testing conducted using bulk samples of the subgrade soils. The subgrade should be compacted to at least 95 percent of the Standard Effort (ASTM D 698) maximum dry density at a moisture content within 2 percent of the optimum moisture content.

Lime Treated Subgrade – The medium to high plasticity clay soils (PI>15) should be treated with lime in accordance with the TXDOT 2014 Standard Specifications Item 260. The amount of lime should be determined for subgrade soils by conducting laboratory tests just prior to construction. Based on the classification test results, we recommend that about 5 to 7 percent lime by dry weight be used for estimating and planning. The percentages are given as application by dry weight and are typically equivalent to about 25 to 35 pounds of lime per square yard per 6-inch depth. The actual quantity of lime should be determined at the time of construction based on lime determination tests conducted using bulk samples of the subgrade soils. The pulverization, mixing and curing of the lime treated subgrade is of particular importance in these clays. The subgrade should be compacted to a minimum of 95 percent of the Standard Effort (ASTM D 698) maximum dry density at a moisture content between optimum and 4 percent wet of the optimum moisture content.

Preferably, traffic should be kept off the treated subgrade for 7 days to facilitate curing of the soil-chemical mixture. In addition, the subgrade is not suitable for heavy construction traffic prior to paving.

The pavement design methods described above are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade such as the soils encountered at this site. 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. Post-construction subgrade movements and some cracking of pavements are not uncommon for clay subgrade conditions such as those observed at this site. Reducing moisture changes in the subgrade is important to reduce shrink/swell movements. Although chemical treatment will help to reduce such movement/cracking, this movement/cracking cannot be feasibly eliminated.

Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance. The following recommendations should be implemented to help promote long-term pavement performance:

- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2 percent;
- Install joint sealant and seal cracks immediately;
- Extend curbs into the treated subgrade for a depth of at least 4 inches to help reduce moisture migration into the subgrade soils beneath the pavement section; and
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter.

Preventative maintenance should be planned and provided for the pavements at this site. Preventative maintenance activities are intended to slow the rate of pavement deterioration, and consist of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Prior to implementing any maintenance, additional engineering observations are recommended to determine the type and extent of preventative maintenance.

GENERAL COMMENTS

Our work is conducted with the understanding of the project as described in the proposal and incorporates collaboration with the design team as we completed our services to verify assumptions. Revision of our understanding to reflect actual conditions important to our work was based on these verifications and it is reflected in this report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. 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 services 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 only. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

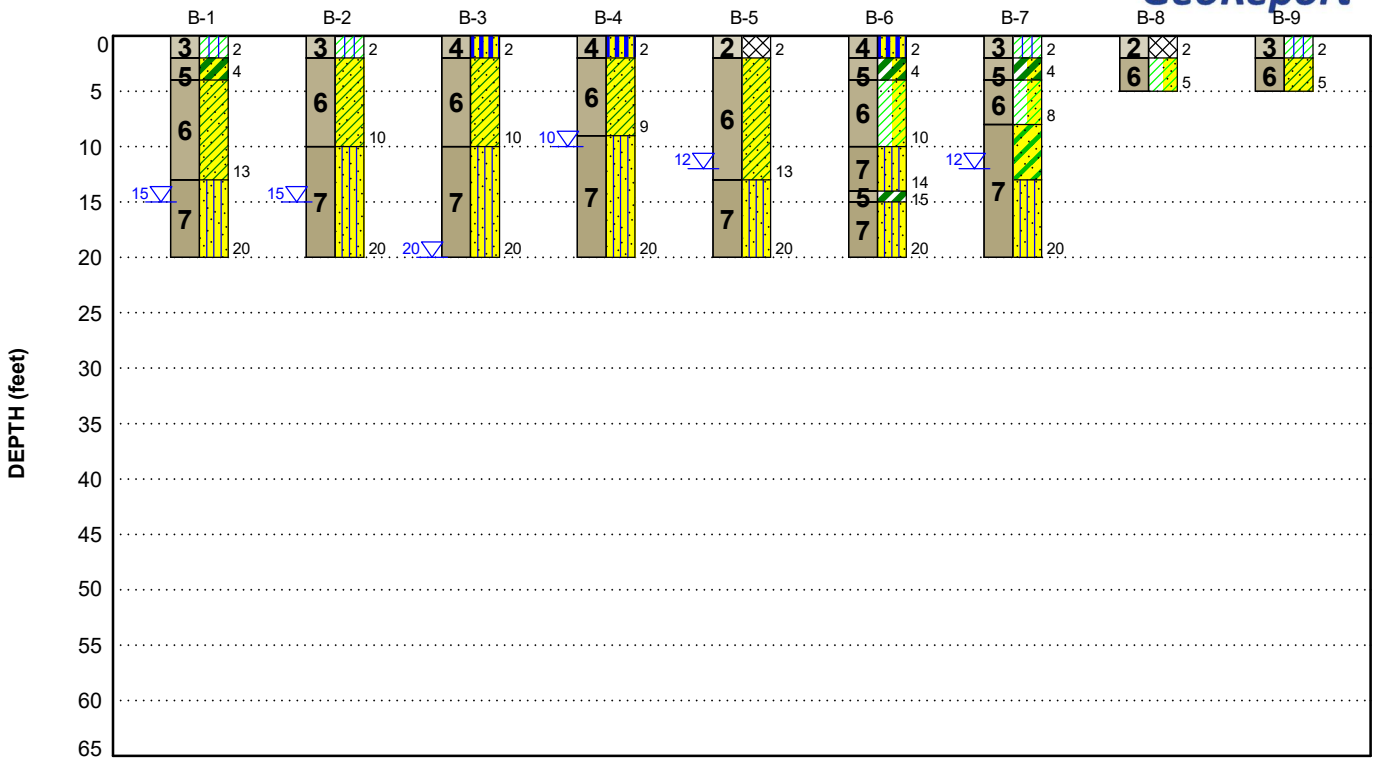
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation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

FIGURES

Contents:

GEOMODEL

Pinnacle West Multi-Family ■ Houston, Texas
Terracon Project No. 92225144



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	Fill: Sandy Lean Clay and Lean Clay	gray, dark gray, and tan, with sand and silt pockets and scattered gravel
2	Fill: Silty Sand and Sandy Silt	dark gray, light gray, and tan, with clay pockets and scattered roots
3	Silty Clay	gray, medium stiff to hard, with silt pockets and scattered roots
4	Sandy Silt	gray, light gray, and reddish brown, loose to medium dense, with clay pockets and scattered roots
5	Sandy Fat Clay and Fat Clay	light gray, gray, tan, and reddish brown, stiff to very stiff, with sand/silt pockets and seams, ferrous stains and nodules, and slickensides
6	Sandy Lean Clay and Lean Clay	light gray, gray, and tan, soft to hard, with sand/silt seams and ferrous stains
7	Silty Sand, Clayey Sand, and Poorly Graded Sand with Silt	reddish brown, tan, and light gray, very loose to very dense, with clay pockets

LEGEND

- Silty Clay
- Sandy Fat Clay
- Sandy Lean Clay
- Silty Sand
- Sandy Silt
- Fill
- Fat Clay with Sand
- Lean Clay with Sand
- Fat Clay
- Clayey Sand

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.

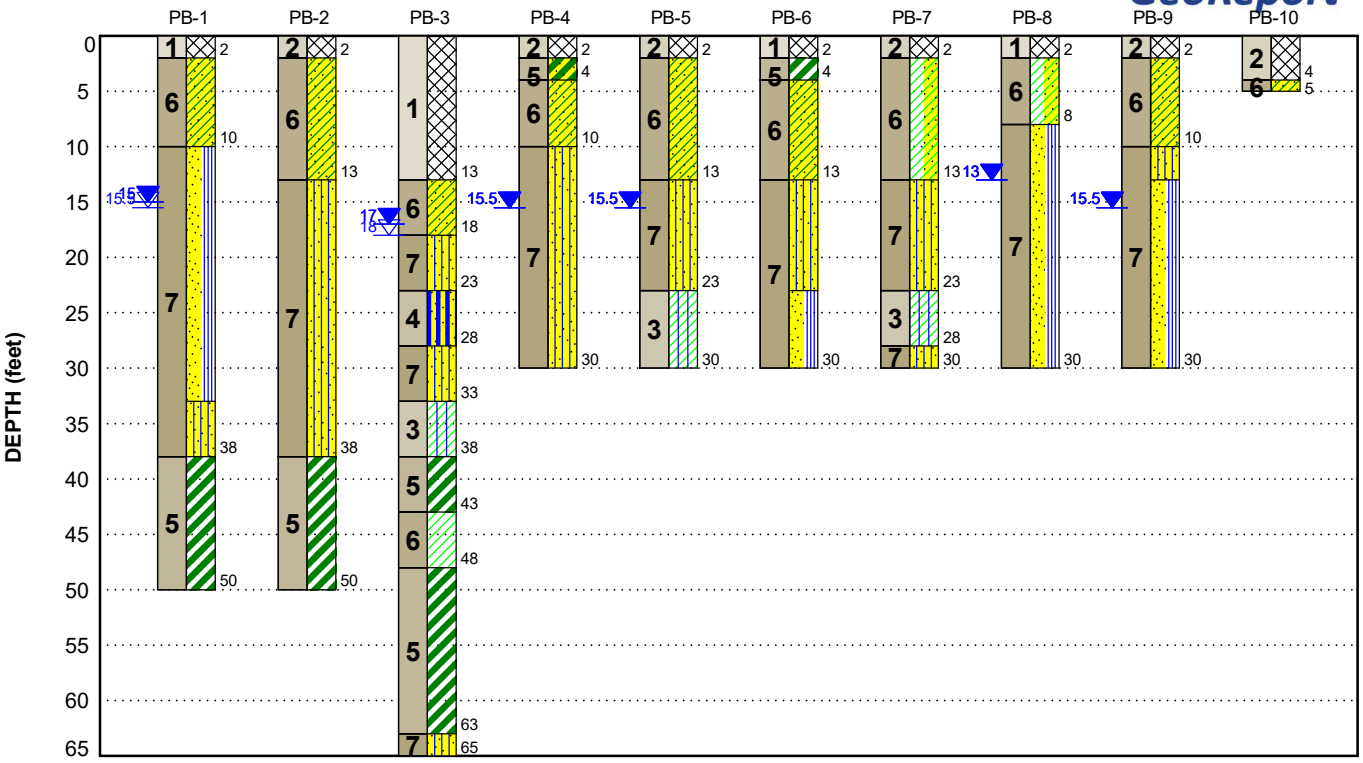
▽ First Water Observation

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

GEOMODEL

Pinnacle West Multi-Family ■ Houston, Texas
Terracon Project No. 92225144

Terracon GeoReport



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4	Sandy Silt	gray, light gray, and reddish brown, loose to medium, with clay pockets and scattered roots
5	Sandy Fat Clay and Fat Clay	light gray, gray, tan, and reddish brown, stiff to very stiff, with sand/silt pockets and seams, ferrous stains and nodules, and slickensides
6	Sandy Lean Clay and Lean Clay	light gray, gray, and tan, soft to hard, with sand/silt seams and ferrous stains
7	Silty Sand, Clayey Sand, and Poorly Graded Sand with Silt	reddish brown, tan, and light gray, loose to very dense, with clay pockets

LEGEND

- Fill
- Poorly-graded Sand with Silt
- Fat Clay
- Silty Clay
- Sandy Fat Clay
- Sandy Lean Clay
- Silty Sand
- Sandy Silt
- Lean Clay
- Lean Clay with Sand

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.

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

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

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Boring Location[1]	Number of Borings	Approximate Boring Depth[2] (feet)
Building and pool areas	7 (B-1 through B-7)	20
	6 (PB-2, PB-3, and PB-7 through PB-10) [3]	30 to 65
Pavement areas	2 (B-8 and B-9)	5
	4 (PB-1 and PB-4 through PB-6) [3]	30 to 50
Total	**19**	**500**

1. The layout of the planned structures has been revised since the 2013 report was completed.
2. Below grade at the time of our field program.
3. Terracon previously provided a Geotechnical Engineering Report (Terracon Project No. 92135450, dated January 22, 2014) at this site for Transwestern.

Boring Layout and Elevations: We used handheld Global Positioning System (GPS) equipment to locate the approximate latitude and longitude of the borings with an accuracy of +/-25 feet. The boring depths were measured from the existing ground surface at the time of our field activities.

Subsurface Exploration Procedures: We advanced soil borings with an all-terrain vehicle (ATV) mounted drill rig using solid stem continuous flight augers. Samples were obtained at 2-foot intervals in the upper 12 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was typically performed using open-tube and/or split-barrel sampling procedures.

Cohesive soil samples were generally recovered using open-tube samplers. Hand penetrometer tests were performed on samples of cohesive soils in the field to serve as a general measure of consistency.

Granular soils and soils for which good quality open-tube samples could not be recovered were sampled by means of the Standard Penetration Test (SPT) during our previous and current field programs. This test consists of measuring the number of blows (N) required for a 140-pound hammer free falling 30 inches to drive a standard split-spoon sampler 12 inches into the subsurface material after being seated six inches. This blow count or SPT “N” value is used to evaluate the stratum.

The samples were placed in appropriate containers, taken to our soil laboratory for testing, and classified by a geotechnical engineer. In addition, we observed and recorded groundwater levels during drilling and sampling.

Our exploration team prepared field boring logs as part of standard drilling operations including sampling depths, penetration distances, and other relevant sampling information. Field logs include

visual classifications of materials observed during drilling, and our interpretation of subsurface conditions between samples. Final boring logs, prepared from field logs, represent an interpretation of the field logs by a geotechnical engineer and include modifications based on laboratory observation and tests on select samples.

Property Disturbance: We backfilled borings with auger cuttings upon completion. Our services do not include repair of the site beyond backfilling our borings. Excess auger cuttings were dispersed in the general vicinity of the boring. Because backfill material often settles below the surface after a period, we recommend borings be periodically checked and backfilled, if necessary. We can provide this service, or grout the borings for additional fees, at your request.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. The laboratory testing program consisted of the following:

- Moisture content
- Unit weight
- Atterberg limits
- Percent finer than No. 200 sieve
- Unconfined compressive strength
- Hydrometers

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

Samples not tested in the laboratory for the current field program will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless we are notified otherwise.

SITE LOCATION AND EXPLORATION PLAN

Contents:

SITE LOCATION

Pinnacle West Multi-Family ■ Houston, Texas
April 28, 2022 ■ Terracon Project No. 92225144

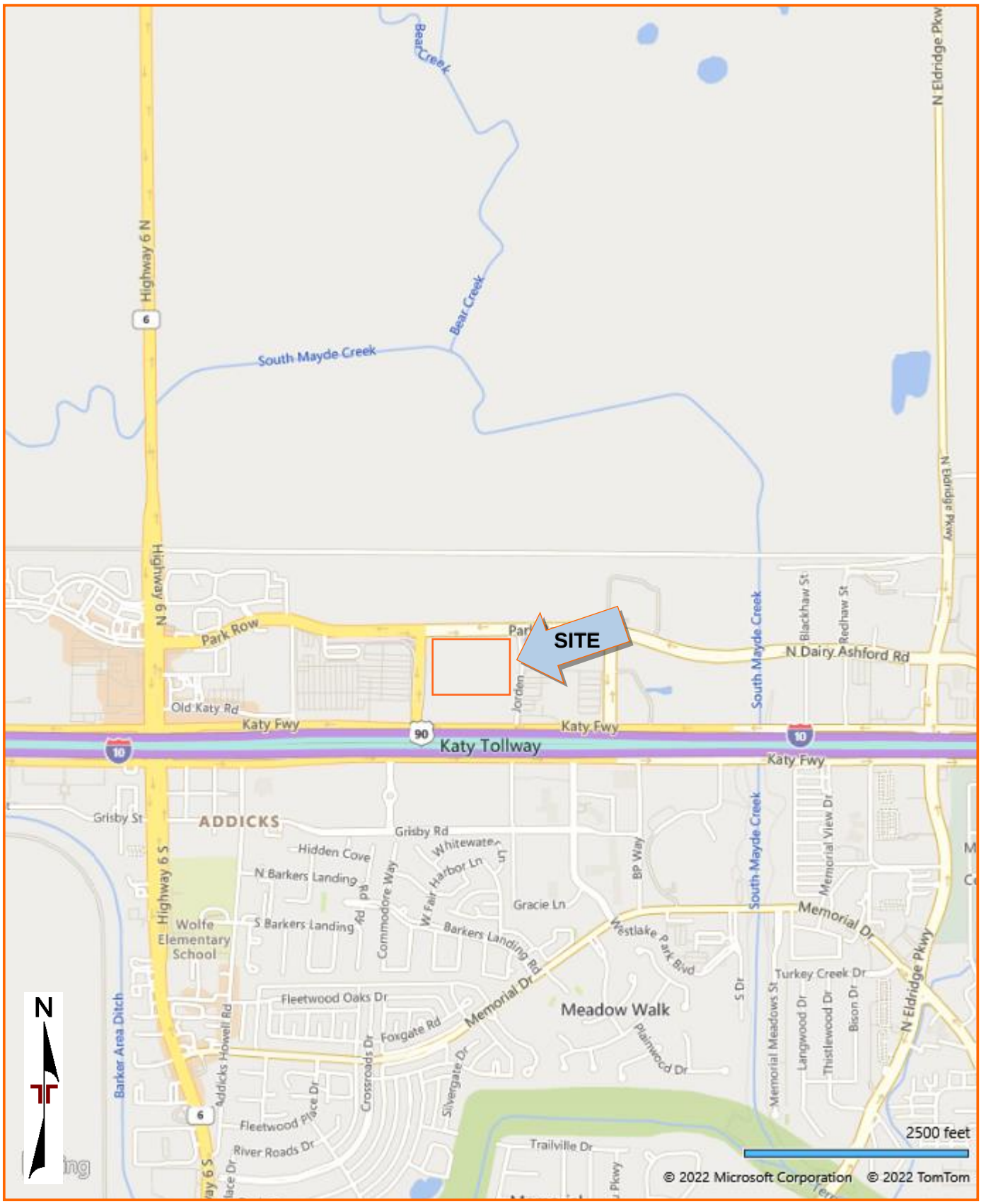

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Pinnacle West Multi-Family ■ Houston, Texas

April 28, 2022 ■ Terracon Project No. 92225144

Terracon GeoReport

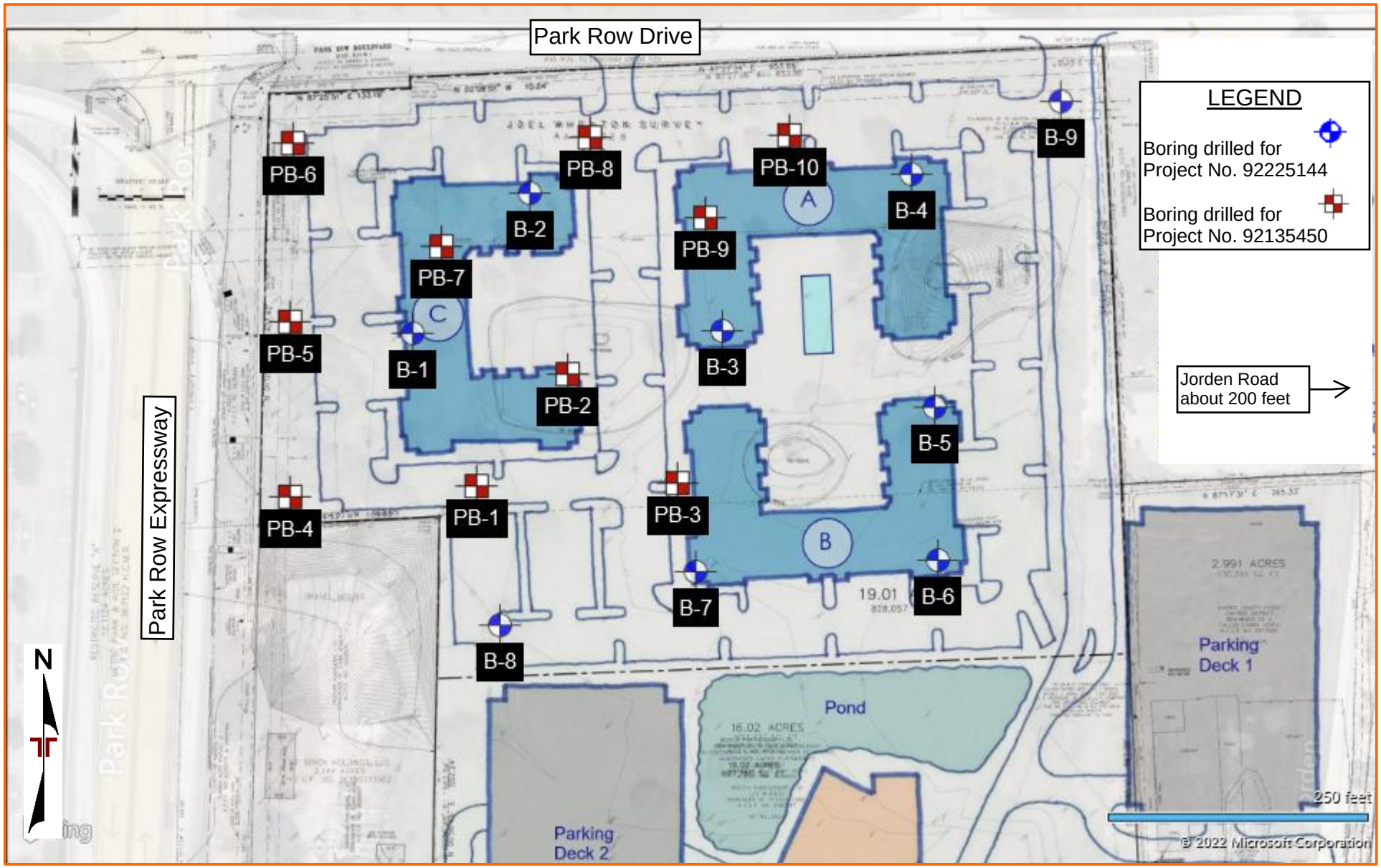

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through B-9 and PB-1 through PB-10)

BORING LOG NO. B-1

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7875° Longitude: -95.6348°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
3		**SILTY CLAY (CL-ML)**, gray, stiff, with silt pockets and scattered roots				2.0 (HP)							
		2.0											
5		**SANDY FAT CLAY (CH)**, gray and tan, very stiff, with sand seams and ferrous stains				3.0 (HP)				13.0		52-14-38	63
		4.0											
6		**SANDY LEAN CLAY (CL)**, gray and tan, very stiff to hard, with sand seams	5			4.5 (HP)	UC	6.77	3.8	11.1	123		
						4.5 (HP)							
						4.5 (HP)							
			10			4.5 (HP)							
7		**SILTY SAND (SM)**, reddish brown, loose, with clay pockets				1.0 (HP)							
			15										
						0.5 (HP)							
		20.0	20										
		Boring Terminated at 20 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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:
Percent finer than 2 microns at 2 to 4 feet is 18 percent.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Caved-in

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-2

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7878° Longitude: -95.6345°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
3		**SILTY CLAY (CL-ML)**, gray, medium stiff, with silt pockets and scattered roots				1.0 (HP)							
		2.0											
6		**SANDY LEAN CLAY (CL)**, gray and tan, very stiff to hard, with sand seams and ferrous stains				3.0 (HP)	UC	4.75	4	11.2	123		
			5			4.5 (HP)				15.0		40-14-26	
						4.5 (HP)							
						4.5 (HP)							
			10			0.5 (HP)							
7		**SILTY SAND (SM)**, tan, loose, with clay pockets											
			15										
		20.0											
		Boring Terminated at 20 Feet	20										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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:

Blow counts for samples 13 to 15 feet and 18 to 20 feet could not be accurately recorded at the time of drilling.

WATER LEVEL OBSERVATIONS

While drilling

Caved-in

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-3

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7875° Longitude: -95.6339°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
4		**SANDY SILT (ML)**, gray, loose, with clay pockets and scattered roots				1.0 (HP)							
		2.0				1.25 (HP)							
6		**SANDY LEAN CLAY (CL)**, gray and tan, stiff to very stiff, with sand seams	5			4.5 (HP)	UC	3.10	6.5	15.6	116		
						4.5 (HP)							
						4.0 (HP)				16.3		30-14-16	51
		10.0	10			4.5 (HP)							
7		**SILTY SAND (SM)**, light gray and tan, medium dense to dense - with clay pockets 10 to 13 feet		▨		6-6-15 N=21							
			15										
		20.0		▽		8-12-14 N=26							
		Boring Terminated at 20 Feet	20										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

▽ *While drilling*

▨ *Caved-in*

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-4

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7879° Longitude: -95.6333°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
4		**SANDY SILT (ML)**, gray, loose, with clay pockets and scattered roots				0.5 (HP)							
		2.0											
6		**SANDY LEAN CLAY (CL)**, gray and tan, soft to very stiff, with sand seams				4.5 (HP)							
			5			1.5 (HP)	UC	1.45	3.9	14.9	116		
						2.0 (HP)				19.3		32-14-18	56
		9.0				0.5 (HP)							
7		**SILTY SAND (SM)**, tan, medium dense to dense, with clay pockets	10			6-6-13 N=19							
						6-6-7 N=13							
			15										
						6-12-19 N=31							
		20.0	20										
		Boring Terminated at 20 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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:
Percent finer than 2 microns at 6 to 8 feet is 21 percent.

WATER LEVEL OBSERVATIONS

▽ *While drilling*

Caved-in

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-5

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7873° Longitude: -95.6333°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
2		**FILL - SANDY LEAN CLAY (CL)**, gray, with sand pockets and scattered gravel				1.5 (HP)				13.5		29-14-15	
		2.0											
6		**SANDY LEAN CLAY (CL)**, gray and tan, soft to very stiff, with sand seams				1.5 (HP)	UC	1.54	6.9	12.8	116		
			5			0.5 (HP)							
		- with ferrous stains 6 to 10 feet				2.0 (HP)							
						3.5 (HP)							
			10			4.5 (HP)							
		13.0											
7		**SILTY SAND (SM)**, tan, medium dense, with clay pockets				9-14-16 N=30							
			15										
						8-12-16 N=28							
		20.0	20										
		Boring Terminated at 20 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

▽ *While drilling*

Caved-in

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-6

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7869° Longitude: -95.6333°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
4		**SANDY SILT (ML)**, gray, loose, with clay pockets and scattered roots				0.5 (HP)							
		2.0											
5		**FAT CLAY WITH SAND (CH)**, light gray and reddish brown, stiff, with ferrous stains				2.0 (HP)				25.3		65-18-47	
		4.0											
6		**LEAN CLAY WITH SAND (CL)**, gray and tan, stiff to very stiff, with ferrous stains	5			4.5 (HP)	UC	1.73	9	14.5	117		
						4.0 (HP)							
						3.0 (HP)							
		10.0	10										
7		**SILTY SAND (SM)**, tan, loose, with clay pockets				0.5 (HP)				21.9			48
		14.0											
5		**FAT CLAY (CH)**, light gray and reddish brown, very stiff				7-9-7 N=16							
		15.0	15										
7		**SILTY SAND (SM)**, reddish brown, medium dense, with clay pockets											
		20.0				6-8-12 N=20							
		Boring Terminated at 20 Feet	20										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-7

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7869° Longitude: -95.6340°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
3		**SILTY CLAY (CL-ML)**, gray, soft, with silt pockets and scattered roots				0.5 (HP)							
		2.0											
5		**FAT CLAY WITH SAND (CH)**, light gray and reddish brown, very stiff, with ferrous stains				3.0 (HP)							
		4.0											
6		**LEAN CLAY WITH SAND (CL)**, gray and tan, very stiff, with ferrous stains	5			2.5 (HP)	UC	2.17	8.7	17.2	115		
						2.5 (HP)				18.1		34-14-20	
		8.0											
7		**CLAYEY SAND (SC)**, light gray and tan, medium dense				4.0 (HP)				18.0			40
			10			2.5 (HP)							
		13.0											
		SILTY SAND (SM), light gray, medium dense, with clay pockets				10-12-13 N=25							
			15										
						10-11-12 N=23							
		20.0	20										
		Boring Terminated at 20 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

▽ *While drilling*

Caved-in

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022

Drill Rig: ATV | Driller: DAS

Project No.: 92225144

BORING LOG NO. B-8

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 29.7867° Longitude: -95.6346° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
2		**FILL - LEAN CLAY WITH SAND (CL)**, gray and tan, with sand pockets 2.0				2.0 (HP)				13.3		33-14-19	
6		**LEAN CLAY WITH SAND (CL)**, gray and tan, medium stiff, with sand seams and ferrous stains 5.0				1.0 (HP)							
						1.0 (HP)							
		Boring Terminated at 5 Feet	5										

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 5 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022
Drill Rig: ATV | Driller: DAS
Project No.: 92225144

BORING LOG NO. B-9

PROJECT: Pinnacle West Multi-Family

CLIENT: Transwestern Development Company
Houston, Texas

SITE: Park Row & Jorden Road
Houston, Texas

LOCATION See Exploration Plan

Latitude: 29.7881° Longitude: -95.6329°

MODEL LAYER	GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
3		**SILTY CLAY (CL-ML)**, gray, stiff, with silt pockets				2.0 (HP)				14.7		21-14-7	
		2.0											
6		**SANDY LEAN CLAY (CL)**, gray, stiff to very stiff, with sand seams				2.0 (HP)							
						3.0 (HP)							
		5.0	5										
		Boring Terminated at 5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Dry augered to 5 feet.

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
11555 Clay Rd, Ste 100
Houston, TX

Boring Started: 03-25-2022 | Boring Completed: 03-25-2022
Drill Rig: ATV | Driller: DAS
Project No.: 92225144

BORING LOG NO. PB- 1

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: LEAN CLAY (CL), dark gray, with scattered roots				1.5 (HP)				12	111	28-15-13	
	2.0											
	SANDY LEAN CLAY (CL), light gray and tan, very stiff to hard, with ferrous nodules - with sand pockets from 2 to 4 feet - with calcareous nodules 4 to 6 feet				1.75 (HP)							
		5			4.0 (HP)	UC	7.97	5.3	14	121		
	- with sand pockets 6 to 8 feet				3.0 (HP)				19		38-17-21	
	10.0				4.5 (HP)	UC	2.36	4.2	16	117		
	POORLY GRADED SAND WITH SILT (SP-SM), light gray and tan, medium dense to dense	10			5-6-7 N=13							
					6-6-6 N=12							
		15	▽									
	- reddish brown 18 to 33 feet		▽		8-11-17 N=28							
		20										
					16-20-24 N=44				24			7
		25										
					4-5-10 N=15							
		30										
	33.0				22-25-33 N=58							
	SILTY SAND (SM), reddish brown, very dense	35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *18 ft While Drilling*
- ▽ *15.5 ft at 5 Minutes*
- ▼ *15 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/6/2013 | Boring Completed: 12/6/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-4

BORING LOG NO. PB- 1

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), reddish brown, very dense *(continued)* 38.0											
	FAT CLAY (CH), reddish brown, very stiff - with silt seams and slickensides 38 to 43 feet	40			2.5 (HP)	UC	2.16	4.1	28	99		
					3.25 (HP)							
		45										
					2.5 (HP)							
	50.0	50										
	Boring Terminated at 50 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *18 ft While Drilling*
- *15.5 ft at 5 Minutes*
- *15 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/6/2013 | Boring Completed: 12/6/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-4

BORING LOG NO. PB- 2

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SILTY SAND (SM), light gray and tan, with clay pockets				3-4-5 N=9							
	2.0											
	SANDY LEAN CLAY (CL), light gray and tan, very stiff to hard, with silt seams				4.5 (HP)				9	116	47-15-32	
		5			4.5 (HP)	UC	5.74	5.8	11	125		
					4.5 (HP)				16		31-16-15	
					3.0 (HP)	UC	2.53	5.5	10	121		
		10			2.25 (HP)							
	13.0											
	POORLY GRADED SAND WITH SILT (SP-SM), light gray, medium dense to very dense				8-14-15 N=29				21			10
		15										
					15-27-31 N=58							
	- reddish brown 23 to 28 feet	20										
					14-26-29 N=55							
	28.0	25										
	SILTY SAND (SM), light gray and reddish brown, medium dense to dense				8-9-8 N=17							
		30										
	- with clay pockets 33 to 38 feet				30-19-18 N=37							
		35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 16 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-5

BORING LOG NO. PB- 2

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), light gray and reddish brown, medium dense to dense *(continued)* 38.0											
	FAT CLAY (CH), reddish brown, very stiff				4.25 (HP)							
		40										
	- with slickensides 43 to 48 feet				4.5 (HP)	UC	3.35	7.2	22	104		
		45										
	- with ferrous nodules below 48 feet 50.0				3.5 (HP)							
	Boring Terminated at 50 Feet	50										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 16 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-5

BORING LOG NO. PB- 3

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SANDY LEAN CLAY (CL), dark gray, with silt and sand pockets				4-5-6 N=11							
					1.5 (HP)				17	111	35-16-19	
		5			1.25 (HP)							
					1.50 (HP)				14		41-16-25	
					1.5 (HP)							
		10			1.5 (HP)				18	91		
	13.0											
	CLAYEY SAND (SC), light gray, dense, with clay pockets				13-16-15 N=31				21			46
		15	▼									
			▽									
	18.0				6-7-7 N=14							
	SILTY SAND (SM), light gray and reddish brown, medium dense	20										
	23.0											
	SANDY SILT (ML), light gray and reddish brown, medium dense, with clay pockets				1.5 (HP)	UC	0.69	8.1	25	107	22-21-1	
	28.0	25										
	SILTY SAND (SM), reddish brown, medium dense				5-6-7 N=13							
	33.0	30										
	SILTY CLAY (CL-ML), reddish brown, hard				8-16-22 N=38							
		35										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *18 ft While Drilling*
- *17 ft at 5 Minutes*
- *17 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-6

BORING LOG NO. PB- 3

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	SILTY CLAY (CL-ML), reddish brown, hard *(continued)*											
	38.0											
	FAT CLAY (CH), reddish brown, very stiff, with ferrous nodules and slickensides				2.75 (HP)	UC	2.30	2.9	27	99		
		40										
	43.0											
	LEAN CLAY (CL), reddish brown, very stiff, with ferrous nodules				4.5 (HP)				23		48-21-27	
		45										
	48.0											
	FAT CLAY (CH), light gray and reddish brown, very stiff - with ferrous nodules and slickensides 48 to 53 feet				4.0 (HP)	UC	3.88	5.3	30	97		
		50										
	- with silt pockets 53 to 58 feet				2.5 (HP)							
		55										
					4.5 (HP)							
		60										
	63.0											
	SILTY SAND (CL), light gray and tan, medium dense				5-7-7 N=14							
	65.0	65										
	Boring Terminated at 65 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *18 ft While Drilling*
- *17 ft at 5 Minutes*
- *17 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-6

BORING LOG NO. PB- 4

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SILTY SAND (SM), dark gray and tan, with scattered roots				3-4-5 N=9							
	2.0											
	SANDY FAT CLAY (CH), light gray and tan, stiff, with sand and silt pockets				2.0 (HP)				15	115	55-16-39	64
	4.0											
	SANDY LEAN CLAY (CL), light gray and tan, very stiff to hard, with ferrous nodules	5			4.5 (HP)	UC	5.23	6.7	13	120		
					4.5 (HP)							
	- with sand pockets 8 to 10 feet				4.5 (HP)	UC	2.25	5	20	111		
	10.0	10										
	SILTY SAND (SM), light gray and reddish brown, medium dense to dense				5-6-6 N=12							
					7-6-5 N=11				16			22
		15	▼									
			▽									
		20			7-7-14 N=21							
					10-15-16 N=31							
		25										
					13-11-12 N=23							
	30.0	30										
	Boring Terminated at 30 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Percent finer than 2 microns from 2 to 4 feet is 38 percent.

WATER LEVEL OBSERVATIONS

- ▽ *18 ft While Drilling*
- ▽ *15.5 ft at 5 Minutes*
- ▼ *15.5 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/6/2013 | Boring Completed: 12/6/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-7

BORING LOG NO. PB- 5

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

DEPTH	LOCATION See Exhibit A-2	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SILTY SAND (SM), dark gray, with clay pockets				2-4-5 N=9				16			42
2.0	**SANDY LEAN CLAY (CL)**, light gray and tan, stiff to hard, with silt seams - with sand and silt pockets 2 to 4 feet - with ferrous nodules 4 to 13 feet				3-5-8 N=13							
		5			4.5 (HP)				12		44-14-30	
					4.5 (HP)	UC	5.02	7	13	121		
					4.5 (HP)							
	- with sand and silt pockets 10 to 12 feet	10			1.75 (HP)	UC	1.57	11.3	17	115		
13.0												
	SILTY SAND (SM), light gray and reddish brown, medium dense				10-11-12 N=23							
		15	▼									
			▽									
					7-9-18 N=27							
		20										
23.0												
	SILTY CLAY (CL-ML), reddish brown, stiff to very stiff				9-8-9 N=17				27			95
		25										
					4-5-7 N=12							
30.0		30										
	Boring Terminated at 30 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *17 ft While Drilling*
- ▽ *15.5 ft at 5 Minutes*
- ▼ *15.5 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-8

BORING LOG NO. PB- 6

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SANDY LEAN CLAY (CL), dark gray and tan, with scattered roots				3-5-5 N=10							
	2.0											
	FAT CLAY (CH), light gray and tan, very stiff, with sand pockets and ferrous nodules				4.5 (HP)				15	119	84-25-59	75
	4.0											
	SANDY LEAN CLAY (CL), light gray, tan, and reddish brown, stiff to hard, with ferrous nodules	5			4.5 (HP)	UC	8.42	5.5	11	128		
					4.5 (HP)				12		41-15-26	
					4.5 (HP)							
	- with sand pockets 10 to 12 feet	10			2.0 (HP)	UC	1.78	6.7	15	116		
	13.0											
	SILTY SAND (SM), light gray and reddish brown, medium dense to dense				11-12-15 N=27							
		15										
					8-14-18 N=32				23			41
		20										
	23.0											
	POORLY GRADED SAND WITH SILT (SP-SM), reddish brown, very dense				20-26-27 N=53							
		25										
					20-28-32 N=60							
	30.0											
	Boring Terminated at 30 Feet	30										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Percent finer than 2 microns from 2 to 4 feet is 60 percent.

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-9

BORING LOG NO. PB- 7

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: CLAYEY SAND (SC), dark gray and tan, with clay pockets 2.0				7-8-10 N=18				9			49
	LEAN CLAY WITH SAND (CL), light gray and tan, stiff to very stiff, with with silt seams				4.5 (HP)				15		49-14-35	
	- with sand pockets 4 to 6 feet	5			4.5 (HP)							
	- with ferrous nodules 6 to 13 feet				4.5 (HP)	UC	2.41	11.7	15	117		
					4.5 (HP)							
	- with sand and silt pockets 10 to 12 feet 13.0	10			1.5 (HP)	UC	1.13	7.6	15	117		
	SILTY SAND (SM), light gray and reddish brown, medium dense to dense				8-10-11 N=21				22			27
		15										
					10-17-20 N=37							
		20										
	23.0											
	SILTY CLAY (CL-ML), light gray and reddish brown, stiff, with silt pockets				1.25 (HP)							
		25										
	28.0											
	SILTY SAND (SM), reddish brown, medium dense, with clay pockets 30.0				11-14-15 N=29							
	Boring Terminated at 30 Feet	30										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/4/2013 | Boring Completed: 12/4/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-10

BORING LOG NO. PB- 8

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

DEPTH	LOCATION See Exhibit A-2	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
0	**FILL: SANDY LEAN CLAY (CL)**, dark gray and tan, with sand pockets and ferrous nodules	4.5 (HP)				14		27-15-12	
2.0	**SANDY LEAN CLAY (CL)**, light gray and tan, very stiff, with sand pockets	4.5 (HP)							
	- with ferrous nodules 4 to 8 feet	4.5 (HP)				14	116	37-15-22	50
8.0		4.5 (HP)	UC	3.67	3.2	12	117		
	POORLY GRADED SAND WITH SILT (SP-SM), reddish brown, medium dense	6-6-7 N=13							
10		6-7-8 N=15							
15		7-8-9 N=17				18			12
20		7-7-13 N=20							
25		10-20-18 N=38							
	- with clay pockets below 28 feet								
30.0		6-4-13 N=17							
	Boring Terminated at 30 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 15 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Percent finer than 2 microns from 4 to 6 feet is 29 percent.

WATER LEVEL OBSERVATIONS

- 13 ft While Drilling
- 13 ft at 5 Minutes
- 13 ft at 15 Minutes

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/2/2013 | Boring Completed: 12/2/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-11

BORING LOG NO. PB- 9

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 / DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SANDY SILT (ML), dark gray and tan, with scattered roots 2.0				1.0 (HP)				14	114	NP	
	SANDY LEAN CLAY (CL), light gray and tan, medium stiff to hard, with sand pockets and ferrous nodules				4.5 (HP)							
		5			4.5 (HP)	UC	4.10	4.5	14	119		
					4.5 (HP)				14		39-14-25	
	10.0				1.0 (HP)				12	111		
	SILTY SAND (SM), light gray and tan, medium dense 13.0	10			6-5-6 N=11				8			13
	POORLY GRADED SAND WITH SILT (SP-SM), reddish brown, medium dense				7-7-8 N=15							
		15	▼									
					4-5-11 N=16							
		20										
					6-8-12 N=20							
	- with clay pockets below 28 feet	25										
	30.0				8-9-13 N=22							
	Boring Terminated at 30 Feet	30										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 20 feet; wet rotary thereafter.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *15.5 ft While Drilling*
- *15.5 ft at 5 Minutes*
- *15.5 ft at 15 Minutes*

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/7/2013 | Boring Completed: 12/7/2013
Drill Rig: Standard Truck | Driller: Malibu Drilling
Project No.: 92135450 | Exhibit: A-12

BORING LOG NO. PB-10

PROJECT: Pinnacle West Apartment Complex

CLIENT: Transwestern
Houston, Texas

SITE: IH-10 and Jorden Road
Houston, Texas

GRAPHIC LOG	LOCATION See Exhibit A-2 DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	FILL: SANDY SILT (ML), dark gray				3-4-5 N=9				13		16-15-1	
	- with clay pockets 2 to 4 feet				5-4-5 N=9							
	4.0											
	5.0 **SANDY LEAN CLAY (CL)**, light gray and tan, very stiff, with sand pockets and ferrous nodules	5			4.5 (HP)							
	Boring Terminated at 5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Dry augered to 5 feet.

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
11555 Clay Road, Suite 100
Houston, Texas

Boring Started: 12/7/2013 | Boring Completed: 12/7/2013

Drill Rig: Standard Truck | Driller: Malibu Drilling

Project No.: 92135450 | Exhibit: A-13

SUPPORTING INFORMATION

Contents:

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS
Pinnacle West Multi-Family ■ Houston, Texas
Terracon Project No. 92225144

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Shelby Tube Standard Penetration Test	**Water 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

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (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 SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K, L, M, N] / Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K, L, M, P] / Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

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

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

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

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

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

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.