Geotechnical Engineering Report

Pinnacle West Apartment Complex

IH–10 and Jorden Road

Houston, Texas

January 22, 2014

Terracon Project No. 92135450

Prepared for:

TRANSWESTERN

Houston, Texas

Prepared by:

Terracon Consultants, Inc.

Houston, Texas

January 22, 2014

Terracon

TRANSWESTERN
1900 West Loop South, Suite 1300
Houston, Texas 77027

Attn: Mr. John Langton
Vice President, Development Services

Re: Geotechnical Engineering Report
Pinnacle West Apartment Complex
IH-10 and Jorden Road
Houston, Texas
Terracon Project No. 92135450

Dear Mr. Langton:

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. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you on this project and look forward to providing additional geotechnical engineering and construction materials testing services in the future.

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

Lacey C. Brady, E.I.T.
Staff Geotechnical Engineer

Ruben Solis-Hernandez, P.E.
Project Engineer

for: Patrick M. Beecher, P.E.
Senior Project Manager

Enclosures
Copies Submitted: Addressee: (3) Bound & (1) Electronic

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EXECUTIVE SUMMARY

This geotechnical engineering report has been prepared for the proposed construction of a multi-family apartment complex on a site located near the northwest corner of the intersection of IH-10 and Jorden Road in Houston, Texas. Three test borings, designated B-1 through B-3, were drilled to depths that ranged from about 50 to 65 feet in the proposed parking garage area, along with six test borings, designated B-4 through B-9, to a depth of approximately 30 feet in the proposed apartment building and swimming pool area, and one test boring, designated B-10, to a depth of approximately 5 feet in the proposed pavement areas.

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.

- Groundwater was initially observed at borings B-1, B-3 through B-5, B-8, and B-9 at depths that ranged from approximately 13 to 18 feet during dry drilling. After a 15-minute monitoring period, water was observed at depths that ranged from approximately 13 to 17 feet at borings B-1, B-3 through B-5, B-8, and B-9. Groundwater was not observed at borings B-2, B-6, B-7, and B-10 during or upon completion of dry drilling.
- The surficial soils observed in portions of this site exhibited an increased silt and sand content. If wet and/or soft conditions are present at the time of construction, remedial efforts may be necessary for preparation of the surficial soils to create a working surface. Remedial effort options are discussed in the **"4.2.2 Wet Weather/Soft Subgrade Considerations"** section of this report.
- Fill soils were observed at the ground surface at borings B-1 through B-10 and extended to depths that ranged from approximately 2 to 13 feet. Support of the foundation elements, slabs, flatworks, and pavements on or above undocumented 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.
- At the time of our field program, three soil mounds with heights varying from about 6 to 10 feet were observed at the site. Boring B-3 was drilled on top of one of the existing soil mounds located in the southeastern portion of the site. We understand that the soil mounds are planned to be removed prior to start of construction activities.
- Expansive soils were observed at this site. Recommendations are provided in this report 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.
- A foundation system consisting of either a post-tensioned (PTI) slab-on-grade or shallow spread/strip footings may be utilized to support the proposed 5-story apartment building planned at this site.
- A foundation system consisting of shallow spread/strip footings may be utilized to support the proposed 6-level parking garage planned at this site.

- 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 3 inches.
- We understand that recommendations for post-tensioned (PTI) slab-on-grade design parameters are requested based on achieving an estimated Potential Vertical Rise (PVR) of about 2 inches and one inch or less using a pad of properly placed and compacted select fill.
- A minimum 48-inch thick select fill building pad should be placed under the proposed apartment building floor slab associated with either a post-tension (PTI) slab-on-grade or shallow spread/strip footings foundation system option to provide uniform support to the grade-supported floor slab and reduce the estimated Potential Vertical Rise (PVR) of the subgrade to approximately one inch or less. In addition, any mechanical areas, elevator lobbies associated with the parking garage or other flatwork areas in the building areas which could be sensitive to post-construction movement should be prepared as stated herein.
- A minimum 30-inch thick select fill building pad should be placed under the proposed apartment building floor slab associated with the post-tensioned (PTI) slab-on-grade foundation system option to provide uniform support to the grade-supported floor slab and reduce the estimated Potential Vertical Rise (PVR) of the subgrade to approximately 2 inches.
- We anticipate that the at-grade parking level of the proposed parking garage structure is planned to be designed as a pavement slab; thus, the recommendations indicated in the **"4.6 Pavements"** section of this report should be utilized for subgrade preparation in this area.
- Based on the soil and groundwater conditions observed at borings B-2 and B-7 through B-9, which were drilled in the area of the proposed swimming pool, we anticipate that the excavations for the proposed swimming pool to the anticipated depth of 6 feet within the clay soils may be performed in the dry. Possible seepage may occur from the inclusions within the clay soils and surficial sand/silt soils and is expected to be minor and likely managed by pumping water collected within sumps 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 **"5.0 GENERAL COMMENTS"** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PINNACLE WEST APARTMENT COMPLEX
IH-10 AND JORDEN ROAD
HOUSTON, TEXAS

Project No. 92135450
January 22, 2014

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) is pleased to submit our geotechnical engineering report for the proposed construction of a multi-family apartment complex on a site located near the northwest corner of the intersection of IH-10 and Jorden Road in Houston, Texas. Three test borings, designated B-1 through B-3, were drilled to depths that ranged from about 50 to 65 feet in the proposed parking garage area, along with six test borings, designated B-4 through B-9, to a depth of approximately 30 feet in the proposed apartment building and swimming pool area, and one test boring, designated B-10, to a depth of approximately 5 feet in the proposed pavement areas. This project was authorized by Mr. John Langton, Vice President, Development Services for Transwestern, through signature of our "Agreement for Services" on November 22, 2013. The project scope was performed in general accordance with Terracon Proposal No. P92132051, dated November 21, 2013.

The purpose of this report is to describe the subsurface conditions observed at the ten test borings drilled for this project, analyze and evaluate the test data, and provide recommendations with respect to:

- Site and subgrade preparation;
- Foundation design and construction;
- Excavation considerations for the swimming pool; and
- Pavement design guidelines.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Project location	See Appendix A, Exhibit A-1, Site Location Plan.
Site layout	See Appendix A, Exhibit A-2, Boring Location Plan.

Item	Description
Continued from page 1	
Proposed improvements[1]	■ 5-story multi-family apartment building with a footprint area of approximately 65,000 feet. ■ 6-level parking garage with a footprint area of about 24,000 square feet. ■ A swimming pool with a maximum depth of 6 feet. ■ Adjacent pavement areas.
Building construction	■ **5-story multi-family apartment building**: Wood-frame construction. ■ **6-level parking garage**: Pre-cast concrete construction.
Finished floor elevation	Within approximately one to two feet above existing grade.

Maximum column loads[1]	■ **5-story multi-family apartment building**:
	  ■ **Column loads:** 300 to 400 kips.
	  ■ **Wall loads:** 2.5 to 3.5 kips per lineal foot.
	  ■ **Floor slab pressure:** 125 pounds per square foot (psf).
	■ **6-level parking garage**:
	  ■ **Column loads**: 1,200 to 1,300 kips.

Planned foundation system[1,2]	■ **5-story multi-family apartment building**: Either post-tension (PTI) slab-on-grade or shallow spread/strip footings. ■ **6-level parking garage**: Shallow spread/strip footings.

1. Information provided by Urban Structure.
2. We understand that recommendations for post-tensioned (PTI) slab-on-grade design parameters are requested based on achieving an estimated Potential Vertical Rise (PVR) of about 2 inches (2-inch PVR option) and an estimated PVR of about one inch or less (one-inch PVR option).

2.2 Site Description

Item	Description
Site location	The project site is within a tract of land located near the northwest corner of the intersection of IH-10 and Jorden Road in Houston, Texas.
Existing conditions	The site was vacant at the time of our field program. In addition, three soil mounds varying in height from approximately 6 to 10 feet were observed at the site at the time of our field program.[1]
Current ground cover	Scattered trees, grass, and weeds.
Existing topography	Gently sloping.

1. Based on our conversations with the client, we understand that these soil mounds are planned to be removed from the site prior to start of construction activities.

3.0 SUBSURFACE CONDITIONS

3.1 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.

3.2 Typical Profile

The particular subsurface stratigraphy, as evaluated from our field and laboratory programs, is shown in detail on the Boring Logs in Appendix A. Stratification boundaries on the Boring Logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual.

Fill soils were observed at the ground surface at borings B-1 through B-10 and extended to depths that range from approximately 2 to 13 feet. At the time of our field program, three soil mounds with heights varying from about 6 to 10 feet were observed at the site. Boring B-3 was drilled on top of one of the existing soil mounds in the southeastern portion of the site. We understand that the soils mounds are planned to be removed prior to start of construction activities. The underlying native subsurface soils generally consisted of sandy lean clay, lean clay, silty clay, fat clay, sand and silt soils to the termination depths of the borings (approximately 5 to 65 feet).

The results of our field and laboratory programs can be summarized as follows:

Description	Plasticity Index (%)	Moisture Content (%)	Moisture Content vs. Plastic Limit[1] (%)	Undrained Shear Strength[2] (psf)	SPT N-Value[3] (bpf)	Percentage of Fines[4] (%)
Fill: Sandy Lean Clay and Lean Clay	12 to 25	12 to 18	-3 to +1	1.25 to 4.5[5]	10 to 11	---
Fill: Silty Sand, Clayey Sand, and Sandy Silt	NP[6] to 1	9 to 16	-2 to 0	---	9 to 18	42 to 49
Sandy Lean Clay, Lean Clay, and Silty Clay	15 to 35	9 to 27	-6 to +2	1,100 to 8,400	12 to 38	50 to 95
SIlty Sand, Sandy Silt, and Poorly-Graded Sand	1	8 to 25	+4	---	11 to 60	7 to 46
Fat Clay	39 to 59	15 to 30	-10 to -1	2,200 to 3,900	29	64 to 75

1. The difference between a soil sample's moisture content and its corresponding plastic limit.
2. Based on unconfined compressive strength tests.
3. bpf = blows per foot.
4. Percent passing the No. 200 sieve.
5. Pocket penetrometer reading in tons per square foot (tsf).
6. NP = Non-plastic.

Hydrometer tests were performed on four soil samples selected from the site. 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-4	2 to 4	Sandy Fat Clay	39	64	38
B-6	2 to 4	Fat Clay	59	75	60
B-8	4 to 6	Sandy Lean Clay	22	50	29

1. Percent passing the No. 200 sieve.
2. Computed clay content of the soils has been used for computation of the edge and center lift movements for the design of post-tensioned slabs-on-grade.

3.3 Groundwater

Borings B-1 through B-9 were advanced using dry drilling techniques to depths that ranged from approximately 15 to 20 feet. Wet rotary methods were used thereafter to the termination depths of the borings (about 30 to 65 feet). Boring B-10 was advanced using dry drilling techniques to the termination depth of the boring (approximately 5 feet). Upon reaching groundwater, drilling was typically suspended for a period of about 15 minutes to allow the groundwater to rise and the groundwater levels to be recorded. The observed groundwater measurements are summarized in the table below.

Summary of Short Term Groundwater Information[1]

Boring No.	Approximate Boring Depth[2] (feet)	Approximate Depth of Dry Auger[2] (feet)	Approximate Groundwater Depth (feet)[2]			
			During Dry Drilling	After 5 Minutes	After 10 Minutes	After 15 Minutes
B-1	50	20	15½	15	15	15
B-2	50	16	---	---	---	---
B-3	65	20	18	17	17	17
B-4	30	20	15½	15½	15½	15½
B-5	30	20	15½	15½	15½	15½
B-6	30	20	---	---	---	---
B-7	30	20	---	---	---	---
B-8	30	15	13	13	13	13
B-9	30	15	15½	15½	15½	15½
B-10	5	5	---	---	---	---

1. Groundwater readings were obtained on December 1, 2, 4, 6, and 7, 2013.
2. Below existing grade at the time of our field program.

Groundwater was not observed at borings B-2, B-6, B-7, and B-10 during or upon completion of drilling. These groundwater observations are considered short-term, since the borings were open for a short time period. On a long-term basis, groundwater may be present at shallower depths. Additionally, groundwater will fluctuate seasonally with climatic changes and should be evaluated just prior to construction.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

The following recommendations are based upon the data obtained in our field and laboratory programs, project information provided to us, and on our experience with similar subsurface and site conditions.

4.1 Geotechnical Considerations

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 structures and pavement areas to create a working surface. Remedial effort options are discussed in the **"4.2.2 Wet Weather/Soft Subgrade Considerations"** section of this report.

As stated previously, fill soils were observed at the ground surface at borings B-1 through B-10 and extended to depths that ranged from approximately 2 to 13 feet. At the time of our field program, three soil mounds with heights varying from about 6 to 10 feet were observed at the site. Boring B-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 B-3 can be attributed to the fill in the soil mound. We understand that the soil mounds are planned to be removed prior to start construction activities. Fill 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.

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 supported by a foundation system terminated below the active zone. Terracon can provide recommendations for a structural floor slab system, if requested.

If the 5-story multi-family apartment building is supported on a post-tensioned (PTI) slab-on-grade foundation, a select fill pad as described in this report will need to be prepared beneath the building for either the "2-inch PVR option" or "One-inch PVR option".

4.2 Earthwork

Construction areas should be stripped of vegetation, topsoil, and other debris/unsuitable surface material. Roots of trees should be grubbed to full depths. Care should be taken to replace or recompact all soil removed or loosened by 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.

Once 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 to detect soft/weak areas 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 the **"4.2.1 Compaction Requirements"** section 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.

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	CL and/or SC (10≤PI≤20)	Must be used to construct the building pad under the multi-family building's floor slab and any other grade-supported slabs sensitive to post-construction movement and for all grade adjustments within the building areas.
On-site soils	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.[1]

1. The utilization of on-site silty/sandy soils may present difficulties during construction due to the increased sand/silt content of these soils, especially during and soon after periods of wet weather. If the utilization of silty/sandy 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 to construct the building pads, 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.

4.2.1 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 D698) maximum dry density. ■ The select fill and on site sandy/silty 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

4.2.2 Wet Weather/Soft Subgrade Considerations

Due to the increased silt and sand content and negligible to low plasticity soils observed in portions of the 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 the most efficient and effective method to increase the supporting value of wet and soft subgrade such as that observed at this site. Chemical treatment may be necessary to depths of approximately one to two feet or greater of the near-surface 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 produce drying and to increase the workability of the soil if the subgrade 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.

4.2.3 Grading and Drainage

All grades must provide effective drainage away from the structures during and after construction. Water permitted to pond next to the structures can result in distress in the structures. 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 structures for at least 10 feet beyond the perimeter of the structures. After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary, as part of the structures' maintenance program.

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

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structures 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.

4.3 Foundation Systems

Based on our conversations with Urban Structure, we understand that the proposed 5-story multi-family apartment building is planned to be supported on a foundation system consisting of either a post-tension (PTI) slab-on-grade or shallow spread/strip footings. In addition, we understand that the proposed 6-level parking garage is planned to be supported on a foundation system consisting of shallow spread/strip footings. Based on the subsurface conditions observed during our field and laboratory programs, these types of foundation systems may be utilized to support the proposed structures 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.

4.3.1 Design Recommendations – Post-Tensioned Slab on-Grade

Based on information provided to us by Urban Structure, we understand that recommendations for post-tensioned (PTI) slab-on-grade design parameters are requested based on an estimated Potential Vertical Rise (PVR) of about one inch and an estimated PVR of approximately 2 inches.

Atterberg Limit tests indicate that the soils present at this site contain near surface strata which generally have a variable expansion potential. Using Texas Department of Transportation (TxDOT) Method TEX-124-E, we estimate that the on-site soils at this site exhibit a Potential Vertical Rise (PVR) of approximately 3 inches. Therefore, as requested, 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 structure 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 floor slab area. 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 reduce the estimated PVR to about one inch or less, the floor slab should be supported on a minimum 48-inch thick pad of properly placed and compacted select fill soils. In addition, to reduce the estimated PVR to about 2 inches, the floor slab should be supported on a minimum 30-inch thick pad of properly placed and compacted select fill soils. The select fill pad should extend a minimum 5 feet beyond the edge of the proposed floor slab area. The final exterior grade adjacent to the structure should be sloped to promote effective drainage away from the structure.

Select fill soils should be utilized for all grade adjustments within the proposed building area. The subgrade and select fill soils should be prepared as outlined in the **"4.2 Earthwork"** section

of this report, which contains material and placement requirements for select fill, as well as other subgrade preparation recommendations.

The subgrade soils for flatwork outside of the building which will be sensitive to movement should be prepared as discussed previously. This preparation will be important on surrounding sidewalks and paving immediately adjacent to the building. If these adjacent flatwork areas are not prepared as stated above for the building area, the estimated PVR for these areas could approach those indicated previously for in-situ conditions. If the soils swell in these areas, this movement could result in significant distress to the adjacent sidewalks and paving and possibly result in reversed drainage (flow of runoff toward the building) around the perimeter of the building.

Based on our analysis of the field and laboratory data, design parameters were computed using Addenda No. 1[1] and No. 2[2] 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 48-inch select fill pad to reduce the estimated PVR of the subgrade to approximately one inch or less. The second option incorporates a 30-inch select fill pad to reduce the estimated PVR of the subgrade to about 2 inches.

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 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 slab at this site should be designed using criteria outlined by the Post-Tensioning Institute using the following parameters.

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.

Description	Design Parameters for an Estimated PVR of about one inch or less	Design Parameters for an Estimated PVR of about two inches
Select fill pad thickness	48 inches	30 inches
Depth of seasonal moisture change	Approximately 9 feet	
Effective Plasticity Index	26	34
Percent finer than 2 microns[1]	29 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**: 8.5 feet **For edge lift**: 4.7 feet	**For center lift**: 8.0 feet **For edge lift**: 4.7 feet
Estimated differential soil movement, y_m[3]	**For center lift**: 0.6 inches **For edge lift**: 0.4 inches	**For center lift**: 0.9 inches **For edge lift**: 0.5 inches
Perimeter grade beam depth[4]	Minimum 18 inches below exterior grade	
Allowable bearing capacity[4]	**Dead load plus sustained live load**: 1,200 psf **Total net load**: 1,800 psf	

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 buildings, 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 **"4.2 Earthwork"** section of this report.

Post construction settlements for the slab-on-grade 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.

4.3.2 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. The bearing surface of the foundation should be evaluated upon completion of the excavation and immediately prior to placing concrete.

4.3.3 Design Recommendations – Shallow Spread/Strip Footings

As previously mentioned, as an alternative to a PTI foundation system, shallow spread/strip footings may be utilized to support the proposed 5-story multi-family apartment building planned at this site. In addition, shallow spread/strip footings may be utilized to support the proposed parking garage structure. Recommendations for a foundation system consisting of shallow spread/strip footings are provided below.

Description	Design Parameters
Minimum embedment depth[1]	5 feet below existing grade (grade at the time of our field program)
Allowable bearing pressures (individual footings)	Net dead plus sustained live load – 4,200 psf Net total load – 6,300 psf
Allowable bearing pressure (strip footing) [2]	Net total load – 4,200 psf
Approximate post-construction settlement[3]	Approximately one inch
Estimated differential settlement[4]	Approximately ½ of post-construction settlement
Allowable passive pressure[5]	1,500 psf
Allowable frictional resistance[6]	350 psf
Uplift resistance[7]	Foundation Weight (150 pcf) & Soil Weight (120 pcf)

1. The footings should extend through the fill soils and bear within the native clay soils.
2. Defined as a footing at least twice as long as it is wide.
3. Based on the provided maximum column loads of 300 to 400 kips and 1,200 kips to 1,300 kips (total load) for the 5-story multi-family apartment building and 6-level parking garage, respectively, and the allowable bearing pressures provided above, the maximum width of individual footings is estimated to range from about 8 to 15 feet under the column loads of the 5-story multi-family apartment building and 6-level parking garage. 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. If the footing depths are planned to be greater than presented herein or if the footings are planned to be in close proximity to each other, Terracon should be contacted to perform a detailed settlement analysis.
4. 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.
5. 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.

Description	Design Parameters
Continued from page 13 6. To be utilized on the base of the footings. 7. 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.	

4.3.4 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 information obtained during our field program (refer to the "**3.3 Groundwater**" section), excavations that extend into the clay soils may occur without advanced dewatering. Seepage within the clay soils is expected to be minor and likely can be handled utilizing a system of sumps and pumps. 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 upon completion of the excavation and immediately prior to placing concrete or a seal slab.

A thin seal slab (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 its excavation.

4.3.5 Foundation Construction Monitoring

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

4.4 Floor Slab Associated with Spread/Strip Footings

Planned finished grades at the site were not available at the time of this report. We have assumed that the final grades at this site are planned to be within one to two feet above existing grade. If cuts and/or significant fills are planned, Terracon should be notified to review and/or modify our recommendations given in this subsection.

We anticipate that the at-grade level of the proposed parking garage is planned to be designed as a pavement slab; thus the recommendations indicated in the **"4.6 Pavements"** section should be utilized for subgrade preparation in this area. Subgrade preparation in any mechanical areas, elevator lobbies, or other flatwork areas in the garage areas which could be sensitive to post-construction movements should be prepared with a select fill pad as outlined in the "**4.3.1 Design Recommendations – Post-Tensioned Slab-on-Grade"** section. In addition, if a foundation system consisting of shallow spread/strip footings and grade-supported floor slab is selected to support the proposed 5-story multi-family apartment building, the at-grade floor slab subgrade should be prepared as outlined in the **"4.3.1 Design Recommendations – Post-Tensioned Slab-on-Grade"** section of this report to reduce the estimated PVR to approximately one inch or less.

4.5 Swimming Pool

We understand that a swimming pool is planned to be constructed at this site. Borings B-2 and B-7 through B-9 were drilled within the vicinity of the proposed swimming pool. We anticipate that the maximum excavation depth will not exceed 6 feet below existing grade. Recommendations for pool construction are provided in the following sections.

4.5.1 Below Grade Excavation Considerations

The sides of the proposed swimming pools may either be sloped or formed with vertical cuts. For vertical cut 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.

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.

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.

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.

4.5.2 Temporary Groundwater Control

As discussed in the "**3.3 Groundwater Conditions**" section of this report, groundwater was initially observed at borings B-1, B-3 through B-5, B-8, and B-9 at depths that ranged from approximately 13 to 18 feet. After a 15 minute monitoring period, water was observed at depths that ranged from approximately 13 to 17 feet at borings B-1, B-3 through B-5, B-8, and B-9. Groundwater was not observed at borings B-2, B-6, B-7, and B-10 during or upon completion of drilling. Based on the soil and groundwater information obtained during our field activities, we anticipate that the excavations for the proposed swimming pool to the anticipated depth of 6 feet within the clay soils may be performed in the dry. Possible seepage may occur from the inclusions within the clay soils and surficial sand/silt soils and is expected to be minor and likely managed by pumping water collected within sumps positioned in the bottom of the excavations.

The suggested method given above serves 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.

As stated previously, groundwater levels will fluctuate with seasonal and climate changes and should be evaluated just prior to construction. To evaluate groundwater conditions at the time of construction, we suggest that piezometers or test pits be excavated just prior to construction. Based on the results, the contractor should determine effective methods of groundwater management prior to starting excavation operations.

4.5.3 Lateral Earth Pressures

The backfill soils adjacent to below grade walls of the proposed pool will impose active to at-rest earth pressures against the wall. The backfill should be compacted to 95 percent of the Standard Effort (ASTM D 698) maximum dry density. Design lateral earth pressures may be computed using an equivalent fluid weight of 110 pcf for on-site clay 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

compacted clay soil should be placed at the top of sand backfill to reduce the amount of infiltration of surface water.

4.6 Pavements

Based on the subsurface conditions, we anticipate that the pavement subgrade will generally consist of on-site low to medium plasticity clay and silty/sandy soils. We recommend that the top 6 inches of the finished subgrade soils directly beneath the pavements be chemically treated with either lime or a mixture of lime and flyash. The decision regarding the type and amount of chemical treatment should be made once the final subgrade elevation has been established. Chemical treatment will increase the supporting value of the subgrade and decrease the effect of moisture on subgrade soils. This 6 inches of treatment is a required part of the pavement design and is not a part of site and subgrade preparation for wet/soft subgrade conditions.

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 parking areas and passenger vehicles combined with garbage trucks and large multi-axle delivery trucks form time-to-time in the driveway areas.

Tabulated in the following table are the assumed traffic frequencies and loads used to design pavement sections for this project.

Pavement Area	Traffic Design Index	Description
Automobile Parking Areas	DI-1	Light traffic (Few vehicles heavier than passenger cars, no regular use by heavily loaded two axle trucks.) (EAL[(1)] < 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] Equivalent daily 18-kip single-axle load applications.

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

We recommend that waste dumpster areas 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 shall meet applicable requirements in the ACI Manual of Concrete Practice. The portland cement concrete mix should have a minimum 28-day compressive strength of 3,500 psi.

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 2004 Standard Specification Item 360.

Dowels at Expansion Joints – The dowels at expansion 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.

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 2004 Standard Specifications Item 340. Specific criteria for the job specifications should include compaction to within an air void range of 5 to 9 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 2004 Standard Specifications Item 247, Type A or D, Grade 1. The base material should be compacted to at least 95 percent of the Modified Effort (ASTM D 1557) maximum dry density at moisture content within 2 percent of the optimum moisture content.

Lime-Flyash Treated Subgrade – Pavement subgrade that consists of on-site sandy/silty and low to medium plasticity clay soils (Plasticity Index (PI)<15 percent) should be treated with lime-flyash in accordance with TXDOT 2004 Standard Specifications Item 265. Based on the classification test results, we recommend that 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 the lime and flyash should be determined at the time of construction based on laboratory testing conducted using bulk samples of the subgrade soils. The subgrade soils should be compacted to a minimum of 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 - Pavement subgrade that consists of medium to high plasticity clay soils (PI≥15 percent) should be treated with lime in accordance with TXDOT 2004 Standard Specifications Item 260. We recommend that approximately 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 laboratory testing conducted using bulk samples of the subgrade soils. The pulverization, mixing, and curing of the lime treated subgrade is of particular importance for the on-site clay soils. 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 about 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 observed 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 economically 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.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

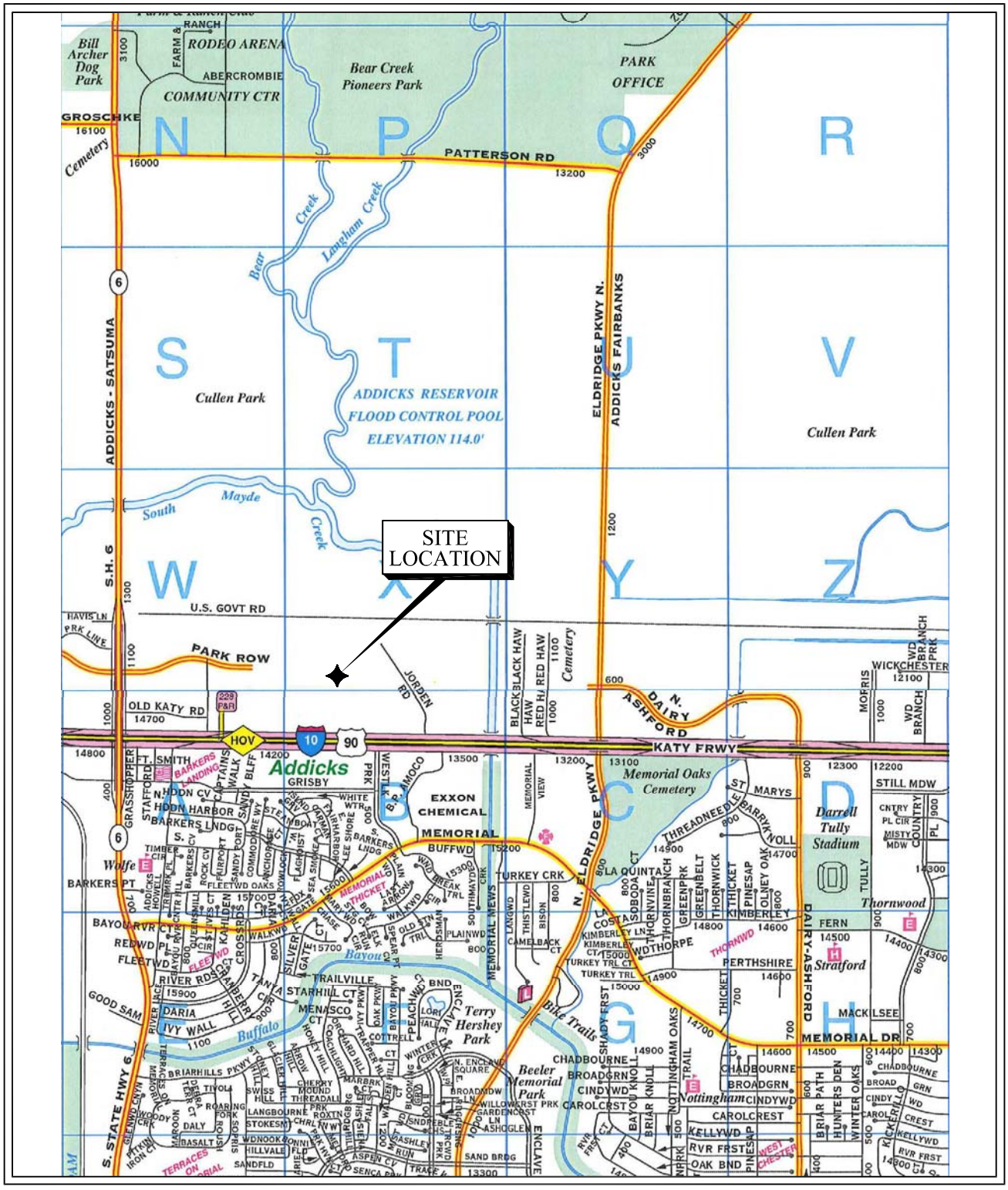
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project 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.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION



SOURCE
2010 HARRIS COUNTY
KEY MAP
Page 448 - X

1/2 0 1/4 1/2
APPROX. SCALE 1"= 1/2 MILE

Project Mng.	LB
Drawn By:	AD
Checked By:	RS
Approved By:	PB

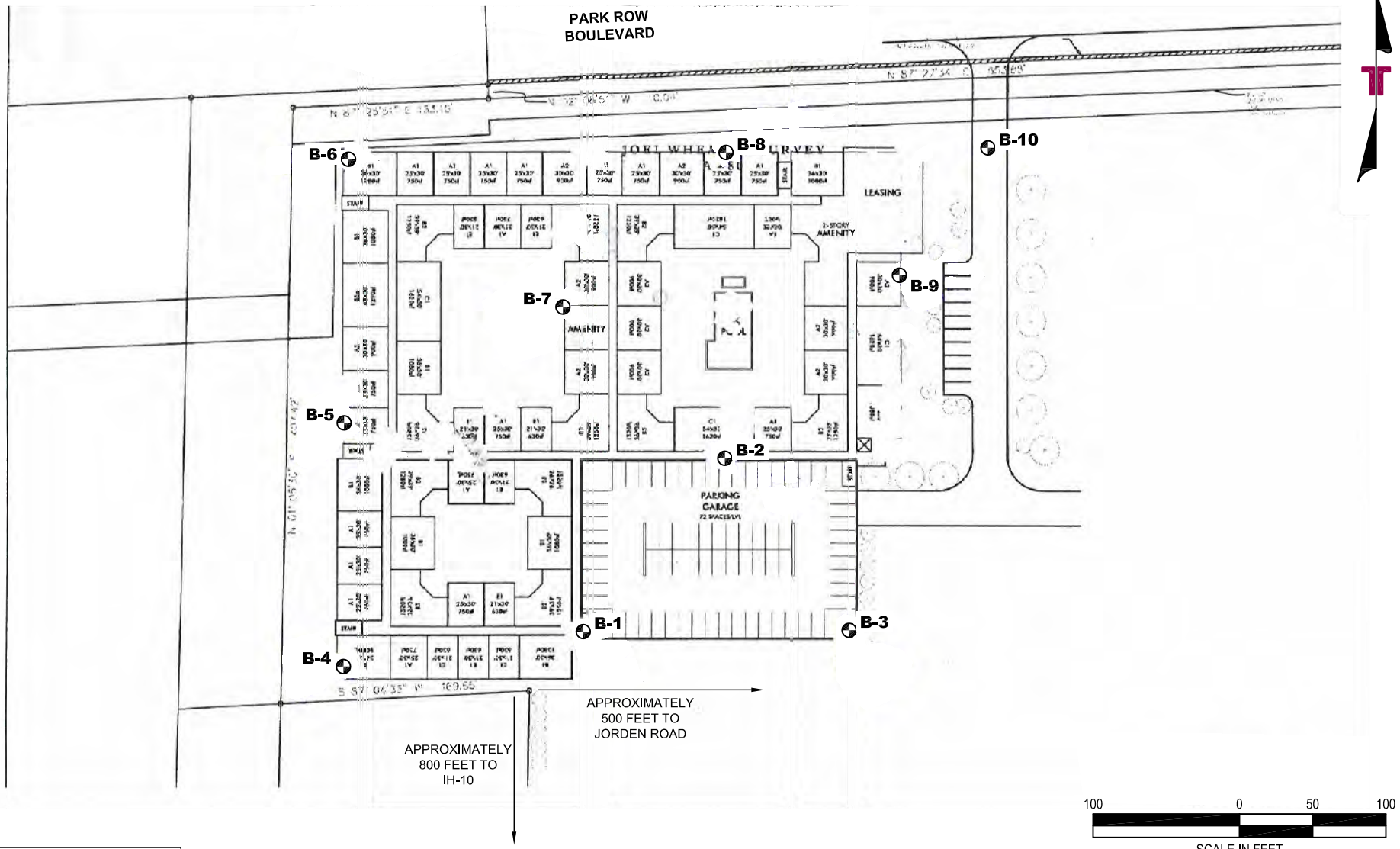
Project No.	92135450
Scale:	AS SHOWN
File No:	92135450
Date:	11/26/2013

Terracon
Consulting Engineers & Scientists
11555 Clay Road Suite 100 Houston, Texas 77043
PH. (713) 690-8989 FAX. (713) 690-8787

SITE LOCATION PLAN

Pinnacle West Apartment Complex
IH-10 and Jorden Road
Houston, Texas

Exhibit
A-1



LEGEND

SOIL BORING LOCATIONS

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

Project Mng: LB	Project No. 92135450
Drawn by: AD	Scale: AS SHOWN
Checked by: RS	File Name: 92135450
Approved by: PB	Date: 11/26/2013

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Consulting Engineers & Scientists
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BORING LOCATION PLAN

Pinnacle West Apartment Complex
IH-10 and Jorden Road
Houston, Texas

Exhibit A-2

Field Exploration Description

Subsurface conditions were evaluated by drilling Three test borings, designated B-1 through B-3, were drilled to depths that ranged from about 50 to 65 feet in the proposed parking garage area, along with six test borings, designated B-4 through B-9, to a depth of approximately 30 feet in the proposed apartment building and swimming pool area, and one test boring, designated B-10, to a depth of approximately 5 feet in the proposed pavement areas. The borings were drilled using all-terrain vehicle (ATV) mounted drilling equipment at the approximate locations shown on the Boring Location Plan, Exhibit A-2 of Appendix A. The borings were located by measuring from existing site features shown on the drawings provided to us without the use of surveying equipment. Boring depths were measured from existing grade at the time of our field program. Upon completion of our field program, the borings were backfilled with soil cuttings.

The Boring Logs, presenting the subsurface soil descriptions, type of sampling used, and additional field data, are presented on Exhibits A-4 through A-13 of Appendix A. The General Notes, which defines the terms used on the logs, are presented on Exhibit C-1 of Appendix C. The Unified Soil Classification System is presented on Exhibit C-2 of Appendix C.

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

Granular soils and soils for which good quality open-tube samples could not be recovered were generally sampled by means of the Standard Penetration Test (SPT). 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.

Samples were removed from samplers in the field, visually classified, and appropriately sealed in sample containers to preserve their in-situ moisture contents. Samples were returned to our laboratory in Houston, Texas.

Samples not tested in the laboratory 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.

BORING LOG NO. B- 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											
	SILTY SAND (SM), reddish brown, very dense				22-25-33 N=58							
		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. B- 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. B- 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 2.0				3-4-5 N=9							
	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							
		20										
	- reddish brown 23 to 28 feet				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. B- 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				3.5 (HP)							
	50.0											
	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. B- 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		▽									
	SILTY SAND (SM), light gray and reddish brown, medium dense				6-7-7 N=14							
		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	
		25										
	28.0											
	SILTY SAND (SM), reddish brown, medium dense				5-6-7 N=13							
		30										
	33.0											
	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. B- 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. B- 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. B- 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. B- 6

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: 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
23.0		20										
	POORLY GRADED SAND WITH SILT (SP-SM), reddish brown, very dense				20-26-27 N=53							
		25										
30.0					20-28-32 N=60							
	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. B- 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				7-8-10 N=18				9			49
	2.0											
	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	10			1.5 (HP)	UC	1.13	7.6	15	117		
	13.0											
	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				11-14-15 N=29							
	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:

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. B- 8

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
2.0	**FILL: SANDY LEAN CLAY (CL)**, dark gray and tan, with sand pockets and ferrous nodules				4.5 (HP)				14		27-15-12	
	SANDY LEAN CLAY (CL), light gray and tan, very stiff, with sand pockets				4.5 (HP)							
	- with ferrous nodules 4 to 8 feet	5			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							
			▼									
					7-8-9 N=17				18			12
		15										
					7-7-13 N=20							
		20										
					10-20-18 N=38							
		25										
	- with clay pockets below 28 feet											
30.0					6-4-13 N=17							
	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 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. B- 9

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: SANDY SILT (ML), dark gray and tan, with scattered roots				1.0 (HP)				14	114	NP	
2.0	**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	10			6-5-6 N=11				8			13
13.0	**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. B-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

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Soil samples were tested in the laboratory to measure their dry unit weight and natural water content. Unconfined compression tests were performed on selected samples and a calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of some cohesive samples. The calibrated hand penetrometer values have been correlated with unconfined compression tests and provide a better estimate of soil consistency than visual examination alone. Selected samples were also classified using the results of Atterberg Limits and grain size analysis testing. Hydrometer tests were performed on selected samples to help determine the percentage of soil finer than 2 microns. The test results are provided on the Boring Logs included in Appendix A and in the "**3.2 Typical Profile**" section of this report.

Descriptive classifications of the soils indicated on the boring logs are in general accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Classification of the soil samples was generally determined by visual manual procedures.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Shelby Tube

Standard Penetration Test

WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

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.

FIELD TESTS

(HP)	**Hand Penetrometer (hand penetrometer values displayed in tsf)**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. 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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

Exhibit: C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [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 $1 > Cc > 3$ [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	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			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	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			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-in. (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.

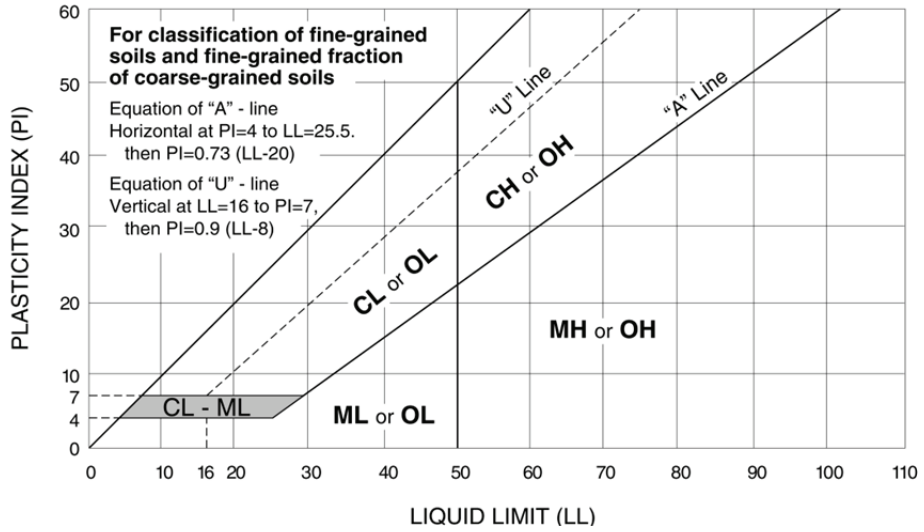

Exhibit C-2