Geotechnical Engineering Study

Proposed Garden Creek Apartments

110 Bluebonnet Circle

Boerne, Texas

O'CONNOR & KEZAR

Geotechnical • Testing

Building on Trust

Prepared For

E3 Development, LLC
Boerne, Texas

O&K Report 326-18738

March 14, 2018

O'CONNOR & KEZAR
Geotechnical • Testing
Building on Trust

March 14, 2018
Project #: 326-18738

Mr. Rene Gonzalez
E3 Development, LLC
110 Bluebonnet Circle
Boerne, Texas

Geotechnical Engineering Study
Proposed Garden Creek Apartments
110 Bluebonnet Circle
Boerne, Texas

Dear Mr. Gonzalez:

The results of our Geotechnical Engineering Study for the subject project are presented in this report. Our findings and recommendations should be incorporated into the design and construction documents for the proposed development. Please consult with us, as needed, during any part of the design or construction process. No environmental studies of any kind were performed during this phase.

We recommend that all foundation construction be tested and observed by one of our representatives in accordance with the report recommendations. In addition, we can and would like to provide complete construction observation and materials testing services during construction.

Thank you for the opportunity to be of service to you.
Sincerely,
O'Connor & Kezar,
TX Firm F12235,

Mark J. O'Connor, P.E.
Vice President

STATE OF TEXAS
MARK J. O'CONNOR
79252
REGISTERED
PROFESSIONAL ENGINEER

March 14, 2018

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Table of Contents

Enclosures:

Vicinity Map, Figure 1
Boring Location Plan, Figure 2
Boring Logs B-1 thru B-4
Appendix

INTRODUCTION

The results of the Geotechnical study for the proposed Garden Creek Apartments are presented in this report. The project is located on 110 Bluebonnet Circle, Boerne, Texas. This project was authorized by Ms. Erin Hudson of E3 Development, LLC by means of O&K Proposal No. 326-18738 dated February 16, 2018.

SCOPE OF SERVICES

The purpose of this engineering study was to establish foundation-engineering properties of the subsurface soil, rock, or groundwater conditions present at the site sufficient to provide geotechnical engineering criteria for use by design engineers and architects in preparing the foundation design. Three borings were performed for the project. The borings were located in the field by pacing and taping. No environmental studies of any kind were included under our scope of work.

This report is not intended for use in determining construction means and methods. The recommendations submitted in this report are based on the data obtained from the site borings. If the project information described in this report is incorrect, is altered or if new information is available, we should be retained to review and modify our recommendations. No grading plan was available at the time of this writing.

This report may not reflect the actual variations of the subsurface conditions across the site. This is particularly true of the site with respect to the presence and depth of the expansive soils encountered in our borings. The nature and extent of variations across the site may not become evident until construction commences especially the detection of groundwater and/or soft soils. The construction process itself may also alter subsurface conditions. If variations appear evident at the time of constructions, it may be necessary to reevaluate our recommendations after performing site observations and tests to establish the engineering impact of the variations.

PROJECT DESCRIPTION

The proposed project consists of three, multi-story, apartment buildings with associated pavements. We assume the facility will consist of light frame construction. The site has a gentle slope down to the north and is covered with grass. Beam and slab on grade foundations are to be used as per the client. A grading plan was not provided during the time of this writing.

SOIL BORINGS AND LABORATORY TESTS

Four borings were performed for the building in this report. The borings were performed to 15' deep.

The borings were drilled at the approximate locations as shown on the Boring Location Plan in general accordance with ASTM D1586 and ASTM D1587 procedures for shelby tube and split spoon sampling techniques. A truck mounted drill rig using continuous flight augers together with the sampling tools noted were used to secure the subsurface soil and rock samples.

Soil classifications and borehole logging was conducted during the exploration by our Professional Engineer. Final soil or rock classifications were determined in the laboratory by our Professional Engineer based on laboratory and field test results and applicable ASTM procedures. Final classifications are shown on the boring logs.

Pocket penetrometer values in tons per square foot, standard penetration test N-values in blows per foot are also noted on the boring logs.

As a supplement to the field investigation, laboratory testing to determine soil water content, Atterberg Limits, swell potential, grain size, density, and strength was conducted. The laboratory results are reported in the attached boring logs. The soil laboratory testing for this project was done in accordance with the specifications and definitions listed in the Appendix of this report.

Sample Disposal

Remaining soil samples recovered from this exploration will be stored in our laboratory for a period of thirty days following submittal of this report. After this time, the samples will be routinely discarded unless requested otherwise.

SOIL AND GROUNDWATER CONDITIONS

Groundwater Conditions

A dry soil sampling method was used to obtain the soil samples at the project site. Groundwater was not observed within the sampling boreholes. The soil materials encountered are generally not conducive to the presence of groundwater; however, undiscovered soil layers could transmit groundwater. These types of materials can store and transmit groundwater flow or seepage thru seams and lenses.

Seasonal weather conditions may dictate actual shallow groundwater conditions at the time of construction. Excavations left open for prolonged periods may also exhibit groundwater seepage. Generally, sump pumping may be used to remove water from excavations.

SUBSURFACE CONDITIONS

Stratigraphy

The subsurface soils found at the project site are categorized below into several major strata as described below.

General Stratum Depth Limits as indicated by Borings

Depth (ft.)	Stratum No. & Description	N Value, Blows per foot	PI
0 to 3	**Stratum I** –Dark Brown CLAY, (CH) trace sand	7- 13	61
1 to 15	**Stratum II –** Tan White MARL	50/4”- 50/1”	Non-plastic
3 to 12	**Stratum IIa-** Tan White Sandy Silty CLAY (CL), with gravel	17 to 37	24

Stratum I: This stratum is comprised of highly plastic Clays. These soils are in a moist and stiff condition. These soils are considered to have a high expansive potential.

Stratum II: This stratum is comprised of non-plastic Marls. These materials are in a very dense condition and are not expansive.

Stratum IIa: This stratum is comprised of moderately plastic sandy silty Clays. These materials are in a moist and stiff condition. These soils are considered to have a low to moderate expansive potential.

Expansive clays shrink when they lose water and swell or grow in volume when they gain water content. Highly expansive clays are commonly described as fat clays. The potential of expansive clays to shrink and swell is related to the Plasticity Index.[1]

Variations

Soil conditions vary between the sample boring locations. Transition boundaries noted on the boring logs are approximate. Actual contacts may be gradual and vary at different locations.

ENGINEERING ANALYSIS AND DISCUSSION

The type of foundation most appropriate for a given structure depends on several factors: the function of the structure and the loads it may carry, the subsurface conditions, and the cost of the foundation in comparison with the cost of the superstructure.[2] In addition, the performance criteria for the structure is significant relative to the foundation system selected.

Deep drilled piers are best suited to buildings with moderate to heavy loading conditions over expansive soils where little to no cracking can be tolerated. The piers, when properly founded, can minimize foundation movement of the superstructure. Grade beams isolated from the soil

[1]Terzaghi, K. and Peck, R. B., 1948 Soil Mechanics in Engineering Practice, Second Edition, John Wiley and Sons Inc., New York, page 457.

[2]Peck, R. B., Hanson, W.E., and Thornburn, T. H., 1953 Foundation Engineering, Second Edition, John Wiley and Sons Inc., New York, Page 263.

typically span between the piers and a structurally supported slab is used at the ground floor level. The structurally suspended slab option is used when excellent performance is expected from the structure in terms of minimal aesthetic distress, such as tile, dry wall or masonry cracking.

A shallow foundation type consisting of a structural beam and slab-on-grade is a common less costly alternative approach for small to moderate sized buildings. This foundation type is commonly used for light to moderate loading conditions and is much more cost-effective than a deep foundation system with a suspended floor slab. Some aesthetic distress and cracking in the floors and walls are normally acceptable to the owner and design team with this foundation alternative.

Each approach has its advantages and disadvantages in terms of cost and overall performance. Positive drainage away from the foundation can play a key role in reducing the possibility of differential foundation movement and related aesthetic distress. Structures founded on expansive clayey soils can be expected to experience some aesthetic distress even with soil improvement measures performed.

The presence of expansive clays at the project site is a major factor in the foundation design details for this structure. Geotechnical design criteria applicable to expansive soil conditions are presented herein. Reductions of potential distress can be accomplished by following our recommendations.

In consideration of the following factors: the function of the structure and the site conditions; a beam and slab-on-grade foundation system is considered a suitable foundation system for the new buildings provided the client can accept the potential risks as previously described.

Soil Shrink-Swell Potential

The expansive soils found at this site can swell and shrink in volume dependent on potentially changing soil water content conditions during or after construction. The term swelling soils implies not only the tendency to increase in volume when water is available, but also to decrease in volume or shrink if water is removed.[3] Shrinkage is merely the reverse process of swelling.
Several methods such as the AASHTO or TXDOT methods are available to estimate possible soil shrink -swell movements. These methods provide an estimate of potential vertical rise, PVR. These methods use the liquid limits, plasticity indices, and existing water contents for soils in the seasonally active zone, estimated to be about ten feet in this area of Texas.

Our PVR is estimated to be approximately 2” based on average conditions. Soil movements greater than this estimated value can result if they are subject to isolated soil moisture content changes, such as flooding, poor drainage, or leaking plumbing, which allow them to approach soil saturation. Actual soil movement will depend on the degree of moisture content change.

[3]Peck, R. B., Hanson, W.E., and Thornburn, T. H., 1953 Foundation Engineering, Second Edition, John Wiley and Sons Inc., New York, Page 337.

FOUNDATION TYPE AND CAPACITY- Beam and Slab-on-Grade

The structure may be supported on structural beam and slab-on-grade foundations designed to resist the effects of expansive soils. Guidelines for this foundation type are provided by the International Building Code and this report.

Subgrade improvements are also recommended for use in order to reduce the effect of the PVR. The intent of this type of foundation is to be reinforced so as to act as a rigid unit. Therefore, if subjected to differential movement, the slab should impart minimal stresses to the superstructure itself. If minimal movements are not acceptable, then we should be informed for additional recommendations.

An allowable soil bearing capacity 2,300 pounds per square foot may be utilized for the beams and column pads, respectively when founded in select fill materials. In addition, if planters and landscaping are planned, they should be self-contained in boxes as described below.

Grade beams should be a minimum of ten inches wide to prevent local shear failure and to inhibit the flow of exterior surface water beneath the foundation. The perimeter and interior concrete beams should be spaced and reinforced in accordance with the soil design criteria provided. A vapor barrier such as Stego Wrap, 10 mil minimum, should be placed beneath the floor slab in order to break the rise of capillary moisture.

Recommended Building Subgrade Improvement for the Structure

The 1" PVR design option is presented in this report. The subgrade improvements described in this section will reduce the PVR or soil shrink swell potential of the subsurface soils to approximately 1" or less. If this amount of soil and related foundation movement is not acceptable to the overall future performance of the structure and client, we should be consulted for additional recommendations.

1. Strip away the topsoil, tree roots, and grass.

2. All of the upper Dark Brown clays should be removed over the white tan materials. A minimum of 3' beyond the footprint dimension from the building area should be removed and discarded. The boring logs indicate these materials to be approximately 1' to 3' thick. These materials can be used in the parking areas to raise the grades if required. Select structural fill should be used to raise the foundations. O&K should witness and confirm the extent of the removals on the site.

3. The subgrade below surficial clays should then be proofrolled with a loaded water truck to confirm all the dark clays have been removed over the tan white materials. The subgrade should be scarified 8" deep minimum and be moisture conditioned and compacted to 95% Standard proctor density within 0% to 5% of Optimum Moisture. The filling with select fill should extend a minimum of 3' beyond the building perimeter, however, building entryway slabs should not be placed over highly expansive clays.

4. Pavement and/or flatwork should be placed against the building perimeter to protect the select fill from wetting and drying. Any planters against the building should be placed in watertight boxes. The intent of these recommendations is to reduce potential soil movements while minimizing potential surface water seepage into the select fill. Future seepage of water into the select fill can create a "bathtub" effect.

5. The overlying select fill should be compacted and tested to 95% of standard proctor density within 3% of optimum moisture in 8" loose lifts. At least three density tests should be conducted per area, per lift, for all select fill and subgrade.

6. The Select Structural fill should have a PI between 7 to 20 with a liquid limit not exceeding 40. Clean sands with little to no fines are not acceptable. Off-site pit run borrow fills should be tested for conformance with Plasticity requirements on a daily basis. Silts are not acceptable as select fill. Rocks are limited to 3" size or smaller. Eight inch loose lifts should be placed and tested as per the above recommendations.

BRAB/WRI design Criteria

BRAB/WRI design parameters for the design of slabs-on-grade for the 1" PVR improved site conditions are provided below for use as needed:

Parameter	**BRAB**	**WRI**
Desired Design PVR	1"	1"
Climatic Rating (Cw)	17	17
Effective PI	25	25
Support Index (C)	0.88	--
Soil/Climatic Rating Factor (1-C)	--	0.12
Unconfined Strength (PSF)	2,300	--

Post-Tensioned Institute Design Criteria

Post Tensioning Institute Design Parameters for the design of slabs-on-grade for the 1" PVR improved site conditions are provided below for use as needed:

Post-Tensioned Institute (PTI) Design Criteria (3rd Edition)

Desired Design PVR	**1”**
Predominant Clay Mineral	Montmorillonite
Thornthwaite Moisture Index	-14
Depth to Constant Soil Suction (ft.)	9
Constant Soil Suction	3.3 pF
Edge Moisture Variation Distance Center Lift, e_m Edge Lift, e_m	 7.0 Feet 4.5 Feet
Differential Soil Movement Center Lift, y_m Edge Lift, y_m	 -0.55 inches 0.95 inches
Net Allowable Bearing Pressure	2,300 psf

Building Supplemental Design Criteria

The following preventative measures are recommended in order to minimize potential soil shrink, swell, and other related foundation movements.

1. Roof drainage should be controlled by gutters and carried well away from the structure. The grade surface adjacent to the building perimeter should be sloped a minimum of two percent away from the building sufficient to cause positive surface flow or drainage away from the building perimeter and entryway slabs.

2. Trees should not be planted closer to structures than a distance equal to their estimated mature height. Shrubs or other plants which require large quantities of water should not be planted close to structures.

3. Paved and flatwork areas around the perimeter of the structure are recommended to maintain an equilibrium soil water content.

4. Flower bed curbing and planter boxes should be sealed at the bottom and sides to prevent trapped water near the building perimeter and prevent the Bathtub effect. If grass areas are against the building, a minimum clay liner of 16” thick is recommended below the topsoil over the select fill.

5. Site work excavations should be protected and backfilled without delay in order to minimize changes in the natural moisture regime.

Control and Construction Joints

Concrete, mortar, grout, and concrete or clay masonry units as well as numerous other construction materials shrink and swell upon a loss or gain of moisture in much the same manner as expansive soils. Accordingly, material volume changes can cause wall or slab cracking to occur. In general, however, unsightly cracking can normally be eliminated by controlling crack locations and making them inconspicuous so that they do not detract from the appearance of the building. Crack control should typically be implemented in the overall building design by the implementation of control or contraction joints in the structure at proper intervals. [4]

Slab Bearing Walls & Flooring

Slab bearing walls and brittle floor tiles are susceptible to various degrees of cracking due to potential slab and foundation movements. It must be realized by the client and design team that even with site improvements to reduce the site PVR, some aesthetic distress in the floors and walls should be expected. If this type of distress cannot be tolerated, then we should be contacted for additional recommendations.

Seismic Design Information

Based on the soil profile, it is our opinion that the Site Class is "A" as defined by 2012 IBC, Table 1613.5.2, for the project site. The following maximum values of Ss and S1 may be used.

Earthquake 0.2 second Acceleration (Ss)	0.099 g
Earthquake 1.0 second Acceleration (S1)	0.027 g

PAVEMENT RECOMMENDATIONS

Recommendations in this section were prepared in general accordance with the 1986 AASHTO Guide for the Design of Pavement Structures for asphalt and the ACI Design Guide SCM-28 (95) for concrete. The following conditions influence pavement design for this job:

1. The CBR of the subgrade for asphalt pavement and K value of the subgrade for concrete pavement.
2. The traffic loads in terms of number and frequency of vehicles and their range of axle loads.
3. Probable increase in vehicular use over the life of the pavement.
4. The availability of suitable materials to be used in the construction of the pavement and their relative costs.

Since traffic counts and design vehicles have not been provided, it is possible to provide a non-engineered pavement section suitable for light, and heavy-duty services based on pavement sections that have provided adequate serviceability for other projects in the area. Accumulation of water beneath the asphaltic surface course or concrete can cause progressive and rapid deterioration of the pavement section. Similarly, pavement surfaces should be well drained to eliminate ponding with a minimum of one percent slope. Curb and gutter sections should extend to penetrate native soils to prevent lateral seepage behind the curbs into the base materials. The thickness provided will adequately handle the anticipated traffic loads. However, any rational pavement thickness design cannot always counter the detrimental shrink-swell behavior of the

[4] Building Movements and Joints, Portland Cement Association, First Addition, 1982

expansive soils. Successful long-term performance will depend in part on the implementation of good drainage, proper subgrade preparation, and good construction practices.

Flexible Asphaltic Concrete Pavement

Option/ Traffic Type	Moisture Conditioned Subgrade (in.)	Geogrid	Base Course (in.)	Surface Course (in.)
Option 1- Parking Area Light Auto Traffic	6	Yes	6	2
Option 1- Truck/Bus Traffic	6	Yes	9	2.5
Option 2- Parking Area Light Auto Traffic	6	No	8	2
Option 2- Truck/Bus Traffic	6	No	12	2.5

A truck/bus traffic section is recommended for use at all entrances, driveways and channelized traffic areas. Subgrade should be moisture conditioned to within optimum to plus three percent of optimum moisture and compacted to 95% density per ASTM D698.

Areas subjected to truck/bus traffic stopping, starting loading, unloading, or turning should not utilize asphalt pavement. For these areas, a concrete section should be considered.

If the Geogrid option is chosen, TENSAR Geogrid Triax TX5, or equivalent, should be placed on top of the subgrade, beneath the base course, per manufacturers recommendations.

Rigid Pavement

Traffic Type	Moisture Conditioned Subgrade (in.)	Portland Cement Concrete (in.)
Light Auto Traffic	6	5
Truck/Bus Traffic	6	6

Concrete pavement is recommended beneath all garbage dumpster areas. Reinforcing steel (#4 bars at 16" oc) is recommended to reduce tensile cracking. Care should be taken to place this steel about 1/3 the slab thickness below the surface. The use of sawed and sealed joints should be designed in accordance with current Portland Cement Association (PCA) or American Concrete Institute (ACI) guidelines.

Pavement Construction

Moisture Conditioned Subgrade Subgrade should be moisture conditioned to within optimum to plus three percent of optimum moisture and compacted to 95% density per ASTM D698. A compaction test should be done per 10,000 square feet of subgrade area. If fills are required to raise the parking lot grades, compaction and testing in 8” loose lifts should be performed. Site clays may be used for filling.

Flexible Base Course Use TXDOT Standard Specifications Item 247 Type A Grade 2 base compacted in maximum nine inch loose lift to 95% density per ASTM D1557 within plus or minus two percent of optimum moisture content. A compaction test should be done per 10,000 square feet of base course placed per lift.

Asphaltic Concrete Surface Course Use TXDOT Standard Specifications Item 340 Type D compacted to 93% minimum of the theoretical density. Asphalt Density should be monitored during placement by means of at least one density test per 5,000 square feet.

Portland Cement Concrete Concrete with a minimum 28-day compressive strength of 3000 psi and maximum 5 inch slump should be used. Higher concrete compressive strengths may be warranted by project specifications and design criteria. Proper concrete curing practices in accordance with ACI and PCA recommendations should be conducted.

CONSTRUCTION CRITERIA

Building Site Preparation and Subsoil Preparation

To help reduce the heaving effects of the subgrade “bathtub” effect, it is recommended that all dark clays be removed over the tan white materials. Testing should be performed as previously outlined.

We recommend that one of our representatives be scheduled to observe that extent of site preparations conducted are in accordance with are recommendations. Also, if additional existing structures are discovered during excavation, we should be informed immediately to determine the impact of those structures on our recommendations.

Placement of Select Fill

Select fills should be placed under the building pad in 8” loose lifts and should extend 3’ from the building perimeter. Compaction of the select fill should be done in maximum 8 inch loose lifts to a 95% density within 3 percent of optimum moisture tested in accordance with ASTM D698. At least three density tests should be conducted per area for all fills per lift. We should be present to witness and test the placement of all fill materials in order to confirm that our recommendations are being followed.

Drainage
Good positive drainage during and after construction is very important to minimize expansive soil volume changes which can detrimentally affect the performance of the planned development. Proper attention to drainage details during the design and construction phase of development can prevent many potential soil shrink-swell related problems during and following the completion of the project.

Excavations
All excavations should comply with local, state, and federal OSHA safety regulations for such factors as slope height, slope angle, or depth. OSHA guidelines require that excavations greater than five feet in depth have a separate Trench Excavation Safety Plan approved by a Registered Engineer.

Excavated materials should not be placed close to the top of slope of the excavation so as not to cause slope instability.

Quality Control
As Geotechnical Engineer of record, we should be engaged to observe and evaluate the foundation installation and earthwork for site paving activities to determine that the actual bearing materials are consistent with those encountered during the field exploration and to monitor and test the paving components. It is also important that we be retained to review the design and construction documents. The purpose of this review is to check to see if our recommendations are properly interpreted into the project plans and specifications.

GENERAL COMMENTS

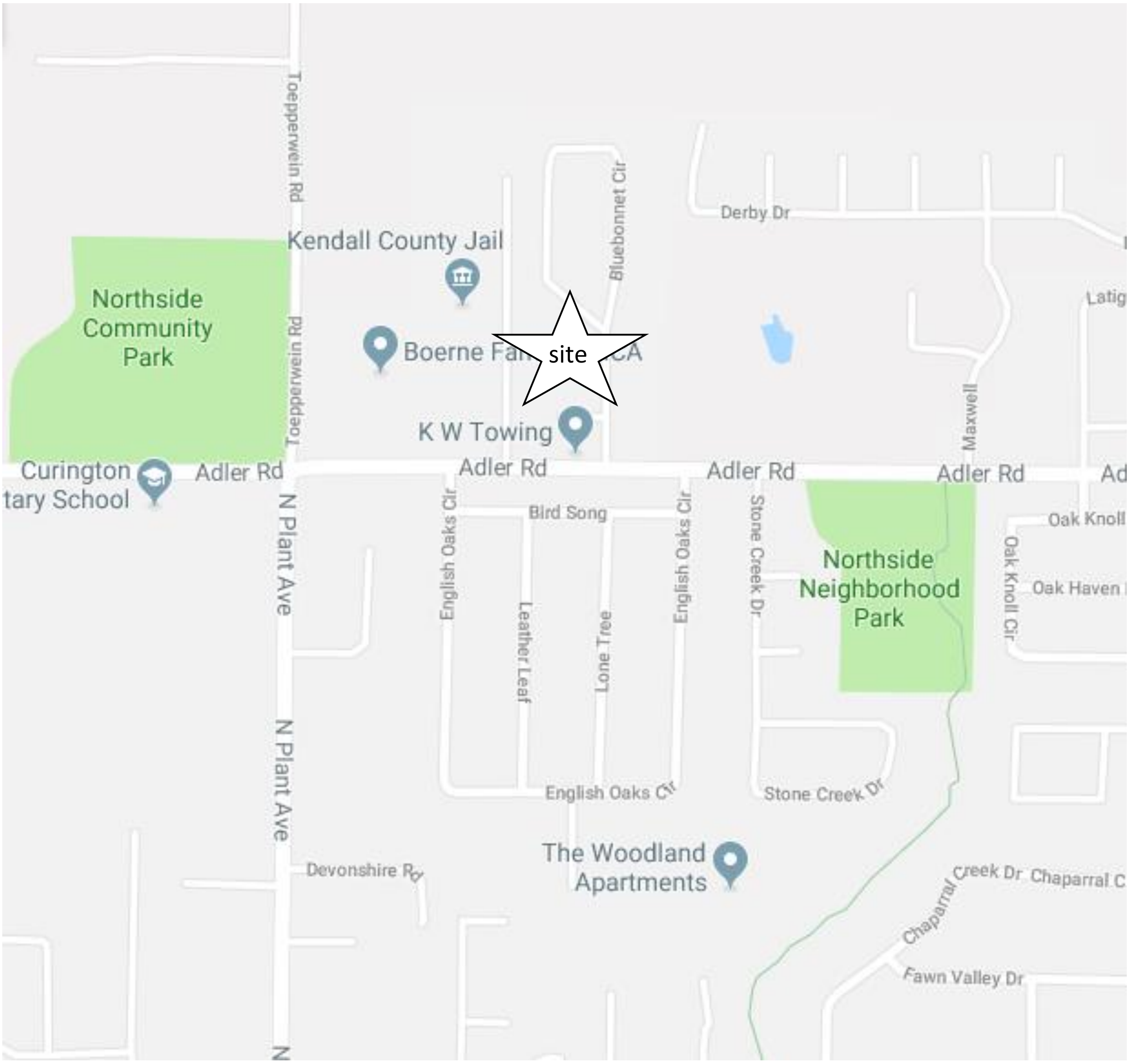
This report was prepared for this project for Ms. Erin Hudson and her design team. If the development plans change relative to building layout, size or anticipated loads, or if different subsurface conditions are encountered, we should be informed and retained to ascertain the impact of these changes on our recommendations. We cannot be responsible for the potential impact of these changes if we are not informed.

This report has been prepared in accordance with generally accepted geotechnical engineering practice with a degree of care and skill ordinarily exercised by reputable geotechnical engineers practicing in this area.

The scope of subsurface exploration and analysis conducted is considered sufficient to form a reasonable basis for the recommended foundation design criteria. No environmental studies or studies of utilities of any kind were performed under our scope of work.

This report is not intended for use in determining construction means and methods. The recommendations submitted in this report are based on the data obtained from the site borings. If the project information described in this report is incorrect, is altered or if new information is available, we should be retained to review and modify our recommendations.

This report may not reflect the actual variations of the subsurface conditions across the site. This is particularly true of the site with respect to the presence and depth of expansive soils. The nature and extent of variations across the site may not become evident until construction commences. The construction process itself may also alter subsurface conditions. If variations appear evident at the time of constructions, it may be necessary to reevaluate our recommendations after performing site observations and tests to establish the engineering impact of the variations. It is important that the precautions recommended in this report, regarding avoiding the Bathtub effect, be followed.



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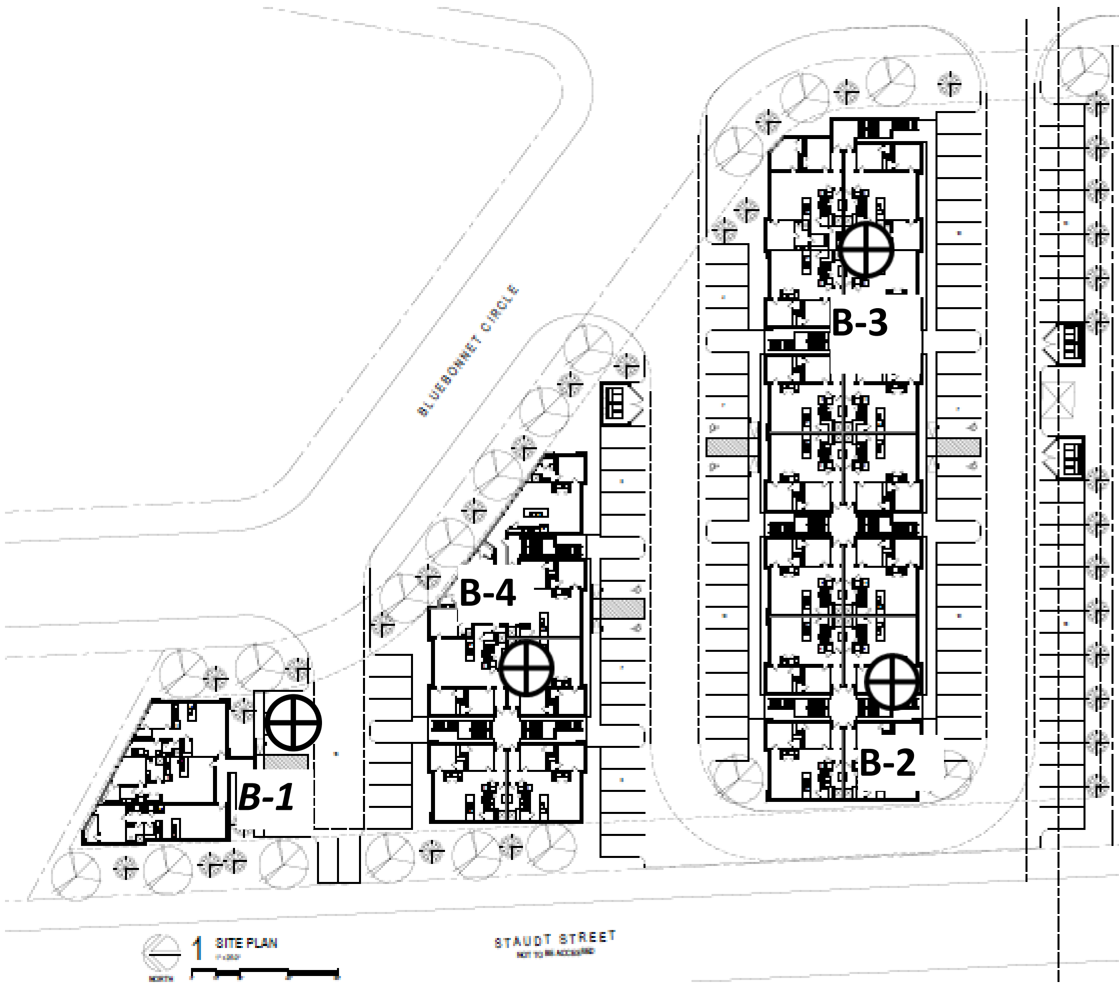
Site Location Plan

By: MJO	Date: 3/13/18
Scale: NTS	Checked: MJO
Approved: MJO	Proj: 326-18738

Proposed Garden Creek Apts.
110 Bluebonnet Circle
Boerne, Texas

Figure 1



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Boring Location Plan

By: MJO	Date: 3/13/18
Scale: NTS	Checked: MJO
Approved: MJO	Proj: 326-18738

Proposed Garden Creek Apts.
110 Bluebonnet Circle
Boerne, Texas

Figure 2

Boring Log No. B-1

Address: BlueBonnet circle
Boerne, Texas
Location: See Boring Location Plan

Project: Garden Creek Apts.

Sampling Date: 3-5-18

Soil Description	Depth	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
Dark Brown CLAY (CH), trace sand, moist stiff		1:SS	24	19	80	61		7	86		
Tan White MARL, dry, very dense		2:SS	6					50/2"			
	5	3:SS	8					50/5"			
		4:SS	7					50/2"			
	10 Feet	5:SS	4					50/2"			
	15	6:SS	5					50/1"			

Completion Depth: 15'

Groundwater: Not Encountered

Grab Bag Sample (GB)
Shelby Tube Sample (ST)
Split Spoon Sample (SS)
Water encountered during drilling
Quassi-static/24 hr. reading elevation

File: 326-18738

Refer to Appendix for Additional Information

SN=Sample No. and Type
ST=Shelby Tube Sample
WC=Water Content, %
LL=Liquid Limit, %
NP=Non-Plastic
PP=Pocket Penetrometer, tsf
-200=% Pass # 200 Sieve
DD=Dry Density, pcf
SS=Split Spoon Sample
GB=Grab Bag Sample
PL=Plastic Limit, %
PI=Plasticity Index
N=SPT Blow Counts
**=Blow Counts During Seating Penetration
Uc=Unconfined Compression Test, tsf

Boring Log No. B-2

Address: BlueBonnet circle
Boerne, Texas
Location: See Boring Location Plan

Project: Garden Creek Apts.
Sampling Date: 3-5-18

Soil Description	Depth	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
Dark Brown CLAY (CH), trace sand, moist stiff		1:SS	22					13			
Tan White Sandy Silty CLAY (CL), with gravel moist, stiff		2:SS	13					17			
	5	3:SS	15	23	47	24		28			
		4:SS	12					28			
	10 Feet	5:SS	4					37			
Tan White MARL, dry, very dense	15	6:SS	5					50/1"			

Completion Depth: 15'

Groundwater: Not Encountered

⊠ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Quassi-static/24 hr. reading elevation

File: 326-18738

Refer to Appendix for Additional Information

SN=Sample No. and Type
ST=Shelby Tube Sample
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-200=% Pass # 200 Sieve
DD=Dry Density, pcf
SS=Split Spoon Sample
GB=Grab Bag Sample
PL=Plastic Limit, %
PI=Plasticity Index
N=SPT Blow Counts
**=Blow Counts During Seating Penetration
Uc=Unconfined Compression Test, tsf

Boring Log No. B-3

Address: BlueBonnet circle
Boerne, Texas
Location: See Boring Location Plan

Project: Garden Creek Apts.
Sampling Date: 3-5-18

Soil Description	Depth	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
Dark Brown CLAY (CH), trace sand, moist, stiff				20	74	54					
		1:SS	5					27			
Tan White MARL, dry, very dense											
		2:SS	7					50/2"			
	5										
		3:SS	8					50/2"			
		4:SS	11					50/1"			
	10 Feet	5:SS	14					50/2"			
	15	6:SS	13					50/1"			

Completion Depth: 15'

Groundwater: Not Encountered

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Quassi-static/24 hr. reading elevation

File: 326-18738

Refer to Appendix for Additional Information

SN=Sample No. and Type
ST=Shelby Tube Sample
WC=Water Content, %
LL=Liquid Limit, %
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PP=Pocket Penetrometer, tsf
-200=% Pass # 200 Sieve
DD=Dry Density, pcf
SS=Split Spoon Sample
GB=Grab Bag Sample
PL=Plastic Limit, %
PI=Plasticity Index
N=SPT Blow Counts
**=Blow Counts During Seating Penetration
Uc=Unconfined Compression Test, tsf

Boring Log No. B-4

Address: BlueBonnet circle
Boerne, Texas
Location: See Boring Location Plan

Project: Garden Creek Apts.
Sampling Date: 3-5-18

Soil Description	Depth	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
Dark Brown CLAY (CH), trace sand, moist, stiff											
Tan White MARL, dry, very dense		1:SS	6					74			
		2:SS	11					50/1"			
	5	3:SS	12					50/1"			
		4:SS	9					50/1"			
	10 Feet	5:SS	11					50/2"			
	15	6:SS	11					50/1"			

Completion Depth: 15'

Groundwater: Not Encountered

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Quassi-static/24 hr. reading elevation

File: 326-18738

Refer to Appendix for Additional Information

SN=Sample No. and Type
ST=Shelby Tube Sample
WC=Water Content, %
LL=Liquid Limit, %
NP=Non-Plastic
PP=Pocket Penetrometer, tsf
-200=% Pass # 200 Sieve
DD=Dry Density, pcf
SS=Split Spoon Sample
GB=Grab Bag Sample
PL=Plastic Limit, %
PI=Plasticity Index
N=SPT Blow Counts
**=Blow Counts During Seating Penetration
Uc=Unconfined Compression Test, tsf

KEY TO CLASSIFICATION SYMBOLS USED ON BORING LOGS

MAJOR DIVISIONS			GROUP SYMBOLS	DESCRIPTIONS
COARSE-GRAINED SOILS More Than Half of Material LARGER Than No. 200 Sieve size	GRAVELS More Than Half of Coarse Faction is LARGER Than No. 4 Sieve Size	Clean Gravels (Little or no Fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
			GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
		Gravels With Fines (Appreciable Amount of Fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More Than Half of Coarse Fraction is SMALLER Than No. 4 Sieve Size	Clean Sands (Little or no Fines)	SW	Well-Graded Sands, Gravelly Sands, Little or no Fines
			SP	Poorly-Graded Sands, Gravelly Sands, Little or no Fines
		Sands With Fines (Appreciable Amount of Fines)	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size.	SILTS & CLAYS	Liquid Limit Less Than 50	ML	Inorganic Silts & Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticty
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
	SILTS & CLAYS	Liquid Limit Greater Than 50	MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils, Elastic Silts
			CH	Inorganic Clays of High Plasticity, Fat Clays
FORMATIONAL MATERIALS	SANDSTONE			Massive Sandstones, Sandstones with Gravel Clasts
	MARLSTONE			Indurated Argillaceous Limestones
	LIMESTONE			Massive or Weakly Bedded Limestones
	CLAYSTONE			Mudstone or Massive Claystones
	CHALK			Massive or Poorly Bedded Chalk Deposits
	MARINE CLAYS			Cretaceous Clay Deposits
	GROUNDWATER		▼	Indicates Final Observed Groundwater Level
			▽	Indicates Initial Observed Groundwater Location

O'Connor & Kezar

APPENDIX

Laboratory and Field Test Procedures

Soil Classification per ASTM D2487

This soil testing standard was used for classifying soils according the Unified Soil classification System. The classifications of the earth materials encountered are as noted in the attached boring logs.

Soil Water Content per ASTM D2216

This test determines the water content of soil or rock expressed as a percentage of the solid mass of the soil. The test results are listed under WC in the attached boring logs.

Soil Liquid Limit per ASTM D4318

The soil Liquid Limit identified the upper limit soil water content at which the soil changes from a moldable physical state to a liquid state. The Liquid Limit water content is expressed as a percentage of the solid mass of the soil. The test results are listed under LL in the attached boring logs.

Soil Plastic Limit per ASTM D4318

The soil Plastic Limit identified a lower limit soil water content at which the soil changes from a moldable physical state to a non-moldable physical state. The Plastic Limit water content is expressed as a percentage of the solid mass of the soil. The test results are listed under PL in the attached boring logs.

Plasticity Index per ASTM D4318

This is the numeric difference between the Liquid Limit and Plastic limit. This index also defines the range of water content over which the soil water system acts as a moldable material. High Plasticity Index values indicate that the soil has a greater ability to change in soil volume or shrink and swell with lower or higher water contents, respectively. The test results are listed under PI in the attached boring logs.

Standard penetration Test (SPT) and split Spoon Sampler (SS) per ASTM D1586

This is the standard test method for both the penetration test and split barrel (spoon) sampling of soils. This sampling method is used for soils or rock too hard for sampling using Shelby Tubes. The method involves penetration of a split spoon sampler into soil or rock through successive blows of a 140 pound hammer in a prescribed manner.

Blow counts (N) per ASTM D1586

This is the number of blows required to drive a Split Spoon sampler by means of a 140 pound hammer for a distance of 12 inches in accordance with the variables stated in the test procedures.

Shelby Tube (ST) per ASTM D1587

This procedure is for using a thin walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of physical properties.

Dry Density (DD) per ASTM D 2937

This procedure is for the determination of in-place density of soil. The test results are measured in pounds per cubic foot, pcf.

Unconfined Compression Test (Uc) per ASTM D2166

This test method covers the determination of the unconfined compressive strength of cohesive soil in the undisturbed remolded or compacted condition using strain controlled application of the axial load.

Minus No. 200 Sieve per ASTM D1140

This method covers determination of the amount of material finer than a Number 200 sieve by washing. The results are stated as a percent of the total dry weight of the sample.

Pocket penetrometer (PP)

This test method is an accepted modification of ASTM D1558 test method for establishing the moisture penetration resistance relationships of fine grained soils. The test results are measured in tons per square foot, tsf. The strength values provided by this method should be considered quantitatively.

Rock Quality Designation (RQD)

The measure of the quality of a rock mass defined by adding intact rock core pieces greater than four inches in length by the total length of core advance.

Recovery Ratio (REC)

The Recovery ratio is equal to the total length of core recovered divided by the total length of core advance.

Boring Logs

This is a summary of the above described information at each boring location.