CITY OF AUSTIN
AUSTIN WATER UTILITY

PROJECT MANUAL
Geotechnical Engineering Study

VOLUME 2 of 4

Taylor Lane 0.1 MGD Wastewater Treatment Plant Project

IFB Number: IFB6100 CLMC600
CIP PROJECT NUMBER: 3353.095
FDU NUMBER: 4570-2307-4876

CITY OF AUSTIN
Austin Water Utility
625 East 10th Street, Suite 715
Austin, TX 78701

September 5, 2016

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Project No. AAA11-031-01
June 13, 2016

Ms. Susan Turrieta, P.E.
Smith Turrieta Engineering
P.O. Box 5902
Austin, Texas 78763

RE: Seismic Coefficients
Whisper Valley Interceptor & Wastewater Treatment Plant
Travis County, Texas

Dear Ms. Turrieta

Based on an email received on Friday, June 3rd, 2016 from Susan Turrieta, PE, we understand clarification is needed in regards to seismic coefficients presented in our geotechnical report RKCI Whisper Valley Interceptor & Wastewater Treatment Plant, Project No. AAA11-031-01, dated June 12, 2012. We have been asked to update our geotechnical report to be consistent with the 2012 version of the International Building Code (IBC), we understand the City of Austin has adopted the 2012 version of the IBC code.

It should be noted, the seismic coefficients presented in our original 2012 geotechnical report which presents values in accordance with the 2009 IBC also remain valid for the new 2012 IBC version.

We appreciate the opportunity to be of service to you and your process of making a bid. Should any additional questions arise, please do not hesitate to call.

Very truly yours,

RABA KISTNER CONSULTANTS, INC.

Gabriel Ornelas, Jr., P.E., PMP
Vice President

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Project No. AAA11-031-01
June 12, 2012

Mr. Jason Roberts, P.E.
Bury + Partners
221 West 6th Street, Suite 600
Austin, Texas 78701

RE: Geotechnical Engineering Study
Whisper Valley Interceptor & Wastewater Treatment Plant
Travis County, Texas

Dear Mr. Roberts:

Raba Kistner Consultants Inc. (RKCI) is pleased to submit the report of our Geotechnical Engineering Study for the above-referenced project. This study was performed in accordance with **RKCI** Proposal No. PAA12-013-00, dated January 17, 2012. Authorization for this study was received by our firm on February 4, 2012. The purpose of this study was to drill borings within the vicinity of the proposed wastewater treatment plant facility and along the alignment of the wastewater interceptor, to perform laboratory testing to classify and characterize subsurface conditions, and to prepare an engineering report presenting foundation and pavement design recommendations and construction guidelines for the wastewater treatment plant facility, as well as provide pipeline installation and construction guidelines for the interceptor.

The following report contains our design recommendations and considerations based on our current understanding of finished floor elevations, design tolerances and structural loads. There may be alternatives for value engineering of the foundation and pavement systems, and **RKCI** recommends that a meeting be held with the Owner and design team to evaluate these alternatives.

We appreciate the opportunity to be of service to you on this project. Should you have any questions about the information presented in this report, or if we may be of additional assistance with value engineering or on the materials testing-quality control program during construction, please call.

Very truly yours,

RABA KISTNER CONSULTANTS, INC.

6/12/2012

STATE OF TEXAS
GABRIEL ORNELAS, JR.
87851
LICENSED
PROFESSIONAL ENGINEER

Yvonne L. Garcia, P.E.
Project Engineer

Gabriel Ornelas, Jr., P.E., PMP
Vice President

Attachments

Copies Submitted: Mr. Jason Roberts, P.E. – Bury + Partners (3-Bound, 1-Electronic)

GEOTECHNICAL ENGINEERING STUDY

For

WHISPER VALLEY INTERCEPTOR & WASTEWATER TREATMENT PLANT
TRAVIS COUNTY, TEXAS

Prepared for

BURY + PARTNERS
221 West 6th Street, Suite 600
Austin, Texas 78701

Prepared by

RABA KISTNER CONSULTANTS, INC.
Austin, Texas

PROJECT NO. AAA11-031-01

June 12, 2012

RABAKISTNER

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Preliminary Results of Soil Analyses
Important Information About Your Geotechnical Engineering Report

INTRODUCTION

Raba Kistner Consultants Inc. (RKCI) has completed the authorized subsurface exploration and foundation analysis for the proposed wastewater interceptor and wastewater treatment facility to be located between FM 973 and Taylor Lane just north of Decker Lake Road in Travis County, Texas. This geotechnical report briefly describes the procedures utilized during our study and presents our findings along with our recommendations for foundation design and construction guidelines for the wastewater treatment plant structures, as well as pavement design recommendations and construction guidelines for a private drive associated with the facility. Furthermore, this report provides recommendations and construction guidelines for the installation of a wastewater interceptor.

PROJECT DESCRIPTION

A wastewater treatment plant facility and wastewater interceptor are being considered for development in Travis County, Texas. The 30-inch wastewater interceptor is planned to extend between FM 973 and Taylor Lane approximately 3 miles (STA 0+00 to 166+00) to a proposed lift station and wastewater treatment plant facility. The lift station and wastewater treatment facility will be located west of Taylor Lane, approximately ¼ of a mile from its intersection with Glass Road.

Based on our review of the Whisper Valley 30-inch Wastewater Interceptor Phase I, II, & III plans, dated April 27, 2012, and information provided to us by the project civil engineer, Mr. Jason Roberts P.E. of Bury + Partners, we understand the wastewater interceptor will be installed by means of open-cut trench methods. Furthermore, we understand the invert elevation for the interceptor varies from approximate 15 to 35 feet below the existing ground surface.

RKCI also reviewed the 30 percent submittal plans for the Taylor Lane Wastewater Treatment Plant, dated April 6, 2012. We understand the wastewater plant will consist of a main operations building and a number of process structures. Structures for the wastewater treatment plant facility considered in this study and proposed finished floor elevations have been provided below.

Location	Finished Floor Elevation** (ft)	Approximate Depth Below Ground Surface (ft)
Lift Station	394.5	33
Headworks	436.95	7½
Soda Ash Building	445.0	at grade
Blower Building	445.0	at grade
BNR Basin	430.5	12½
IR Pump Station	442.25	at grade
RAS Pump Station	442.0	at grade
Clarifier	432.5	10
Filtration	434.5	6½

Location	Finished Floor Elevation** (ft)	Approximate Depth Below Ground Surface (ft)
Disinfection	436.5	at grade
Chlorine Contact Basin	434.5	at grade
Cascade	424.5	13
Sludge Holding Basin	TBD	8*
Operations Building	TBD	at grade*
Alum Building	TBD	at grade*
Outfall	406	-
Box Culvert	422	-
-	-	-

*Assumed depth based on 30 percent submittal plans
**Finished floor elevation also refers to elevation of surface at bottom of basins, lift stations, etc.

Information pertaining to the private drive associated with the wastewater treatment plant facility was provided to us by Mr. Casey Wauters P.E. of Bury + Partners. We understand the private drive will be subjected to a total of 93 heavy trucks per month (averaging 3.1 heavy trucks per day). The approximate weight of heavy trucks being considered is approximately 45,000 lbs. This information was utilized to estimate the single equivalent axle loads (ESAL's) anticipated for a 20 year design life in the design of pavement sections for the wastewater treatment plant private drive.

LIMITATIONS

This engineering report has been prepared in accordance with accepted Geotechnical Engineering practices in the region of central Texas and for the use of Bury + Partners and its representatives for design purposes. This report may not contain sufficient information for purposes of other parties or other uses. 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 10 preliminary borings drilled at this site, 18 recently drilled borings, 30 percent submittal plans for the Taylor Lane Wastewater Treatment Plant, Whisper Valley 30-inch Wastewater Interceptor Phase I, II, and III plans, our understanding of the project information provided to us, and the assumption that site grading will result in only minor changes in the existing topography. 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. 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 construction, it may be necessary to reevaluate our recommendations after performing on-site observations and tests to establish the engineering impact of the variations.

The scope of our Geotechnical Engineering Study does not include an environmental assessment of the air, soil, rock, or water conditions either on or adjacent to the site. No environmental opinions are presented in this report.

If final grade elevations are significantly different from existing grades (more than plus or minus 1 ft), our office should be informed about these changes. If needed and/or if desired, we will reexamine our analyses and make supplemental recommendations.

PREVIOUS STUDIES

RKCI performed a preliminary geotechnical engineering study at this site in 2011 (**RKCI** Project No. AAA11-031-00, dated October 5, 2011), the results of which are on file in our office. Our previous data was used as supplementary information in the preparation of this report. The ten boring logs prepared during our preliminary geotechnical engineering study have been included as attachments at the end of this document, reference Figures 22 through 31. Their field coordinates and approximate boring completion depths are provided below. Refer to Figure 1 for approximate locations of our preliminary borings.

Preliminary Phase Borings				
Boring No.	Depth (ft)	Latitude	Longitude	Location
B-1	25	30.27647	-97.55846	Interceptor
B-2	25	30.28690	-97.56024	Interceptor
B-3	25	30.29491	-97.56226	Interceptor
B-4	25	30.29972	-97.56465	Interceptor
WWTP-1	25	30.27056	-97.55023	Treatment Plant
WWTP-2	25	30.27014	-97.55234	Treatment Plant
WWTP-3	25	30.26982	-97.55233	Treatment Plant
WWTP-4	25	30.27009	-97.55264	Treatment Plant
T-1	50	30.26849	-97.55338	Lift Station
T-2	50	30.26669	-97.55473	Lift Station

BORINGS AND LABORATORY TESTS

In addition to information developed from a preliminary soil exploration, subsurface conditions at the site were evaluated by 18 borings drilled at the approximate locations shown on the Boring Location Map, Figure 1. The following predetermined borings locations were staked in the field by an **RKCI** representative. Field coordinates and boring numbers were provided by Bury + Partners. It should be noted that there are no boring numbers B-5, B-6, B-7, B-8 and B-9. The following table summarizes the staked boring locations, station numbers, and boring depths.

Boring No.	Boring Depth (ft)	Location	Latitude	Longitude	Station No.
B-10	40	Interceptor	N30°16’12”	W97°33’23”	36+50
B-11	20	Interceptor	N30°16’20”	W97°33’26”	45+00
B-12	20	Interceptor	N30°16’45”	W97°33’32”	71+50
B-13	20	Interceptor	N30°16’56”	W97°33’32”	83+00
B-14	20	Interceptor	N30°17’24”	W97°33’37”	111+50
B-15	20	Interceptor	N30°17’31”	W97°33’35”	118+50
B-16	30	Interceptor	N30°17’55”	W97°33’51”	147+50
B-17	30	Interceptor	N30°18’13”	W97°33’51”	166+00
WWTP-5	50	Headworks	N30°16’13”	W97°33’12”	-
WWTP-6	25	Aeration No.1	N30°16’12”	W97°33’11”	-
WWTP-7	25	Aeration No.2	N30°16’11”	W97°33’10”	-
WWTP-8	25	Clarifier	N30°16’11”	W97°33’09”	-
WWTP-9	50	Sludge	N30°16’10”	W97°33’09”	-
WWTP-10	25	Cascade	N30°16’09”	W97°33’07”	-

Boring Designation	Boring Depth (ft)	Location	Latitude	Longitude	Station No.
WWTP-11	50	Lift Station	N30°16'07"	W97°33'12"	14+00
WWTP-12	25	Outfall	N30°16'01"	W97°33'15"	21+52
WWTP-13	5	Road	N30°16'05"	W97°33'02"	-
WWTP-14	5	Road	N30°16'02"	W97°32'56"	-

The borings were drilled to their targeted completion depths using a truck-mounted drilling rig. During drilling operations, the following samples were collected:

Type of Sample	Number Collected
Split-Spoon (with Standard Penetration Test)	30
Undisturbed Shelby Tube	120

Each sample was visually classified in the laboratory by a member of our Geotechnical Engineering staff. The geotechnical engineering properties of the strata were evaluated by the following tests:

Type of Test	Number Conducted
Natural Moisture Content	150
Atterberg Limits	37
Unconfined Compression	24
Unit Dry Weight	24
Percent Passing a No. 200 Sieve	9
Pocket Penetrometer	107
pH	6
Sulfate	6
Chloride	6
Resistivity	6

The results of all laboratory tests are presented in graphical or numerical form on the boring logs illustrated on Figures 2 through 19. A key to classification terms and symbols used on the logs is presented on Figure 20. The results of the laboratory and field testing are also tabulated on Figure 21 for ease of reference.

Standard penetration test results are noted as "blows per ft" on the boring logs and Figure 21, where "blows per ft" refers to the number of blows by a falling hammer required for 1 ft of penetration into the soil/weak rock. Where hard or dense materials were encountered, the tests were terminated at 50 blows per number of inches of penetration even if one foot of penetration had not been achieved.

Samples will be retained in our laboratory for 30 days after submittal of this report. Other arrangements may be provided at the request of the Client.

GENERAL SITE CONDITIONS

SITE DESCRIPTION

The project site primarily consists of open pastures of agriculture land bounded by Taylor Lane to the South and FM 973 to the north. The topography generally slopes from east to west with a visually estimated vertical relief of greater than 50 feet across the site. There are patches of densely wooded areas throughout the property. However, the majority of the site consists of active pasture land. There are no structures present although there are remnants of old feeding barns and ranch trails that lead throughout the property.

GEOLOGY

A review of the *Geologic Atlas of Texas, Austin Sheet*, indicates that this site is naturally underlain with the soils of the Navarro Group and Marlbrook Marls and fluviatile terrace deposits. The Navarro Group and Marlbrook Marls formation typically consists of clays and marly clays and can contain hard layers of marl, sandstone, and siltstone. The clays of this formation are typically highly expansive, montmorillonitic clays. A key geotechnical engineering concern for development supported on this formation is expansive, soil-related movements.

Fluviatile terrace deposits consist of stream bed deposits typically consisting of clays, sands, silts, and gravels. Such deposits can contain point bars, cutbanks, oxbows, and abandoned channel segments associated with variations in stream bed activity. As a result, soil profiles in terrace deposit areas may vary greatly over relatively short distances. Key geotechnical engineering concerns for development supported on this formation are the expansive nature of the clays, the consistency or relative density of the deposits, and the absence/presence as well as thickness of potentially water-bearing gravels.

SEISMIC COEFFICIENTS

Based upon a review of Section 1613 *Earthquake Loads – Site Ground Motion* of the 2009 International Building Code, the following information has been summarized for seismic considerations associated with this site.

- Site Class Definition (Table 1613.5.2): **Class D**. Based on the soil borings conducted for this investigation, the upper 100 feet of soil may be characterized as stiff soil profile.
- Mapped Maximum Considered Earthquake Ground Motion for a 0.2 sec Spectral Response Acceleration (Figure 1613.5(1)): $\mathbf{S_s = 0.083g}$. Note that the value taken from Figure 1613.5(1) is based on Site Class B and is adjusted per 1613.5.3 below.
- Mapped Maximum Considered Earthquake Ground Motion for a 1 sec Spectral Response Acceleration (Figure 1613.5(2)): $\mathbf{S_1 = 0.033g}$. Note that the value taken from Figure 1613.5(2) is based on Site Class B and is adjusted per 1613.5.3 below.
- Values of Site Coefficient (Table 1613.5.3(1)): $\mathbf{F_a = 1.6}$
- Values of Site Coefficient (Table 1613.5.3(2)): $\mathbf{F_v = 2.4}$

The Maximum Considered Earthquake Spectral Response Accelerations are as follows:

- 0.2 sec, adjusted based on equation 16-36: $\mathbf{S_{ms} = 0.133}$
- 1 sec, adjusted based on equation 16-37: $\mathbf{S_{m1} = 0.080}$

The Design Spectral Response Acceleration Parameters are as follows:

- 0.2 sec, based on equation 16-38: $\mathbf{S_{DS} = 0.089}$
- 1 sec, based on equation 16-39: $\mathbf{S_{D1} = 0.053}$

Based on the parameters listed above, Tables 1613.5.6(1) and 1613.5.6(2), and calculations performed using a Java program titled, "Seismic Hazard Curves and Uniform Hazard Responses Spectra" published by the United States Geological Survey (USGS), the Seismic Design Category for both short period and 1 second response accelerations is **A**. However without more information we are not able to discern the Seismic Use Group, which is expected to be one of the following four choices; I, II, III, or IV.

STRATIGRAPHY

The subsurface stratigraphy at this site can be described by three generalized strata. Each stratum has been designated by grouping soils that possess similar physical and engineering characteristics. The lines designating the interfaces between strata on the boring logs represent approximate boundaries. Transitions between strata may be gradual.

Stratum I consists of highly expansive fat (CH) clays. The fat clays vary in color from dark gray near the surface transitioning in color to tan, tan and gray, and red-brown. At the interceptor borings, B-10 through B-17, the clays extended to our boring completion depths ranging from 20 to 40 feet below the ground surface. At the wastewater treatment plant borings, WWTP-5 through WWTP-14, the fat clays generally extended to depths ranging from about 12 to 17 feet below the ground surface in our borings, with the exception of Boring WWTP-5 the clays extended to a depth of about 27 feet.

Highly expansive clays encountered at this site had measured plasticity indices (PI) ranging from 36 to 70. Measured moisture contents ranged from 10 to 37 percent. Pocket penetrometer test estimated shear strength values ranging from 0.75 to in excess of 2.25 tons per square foot (tsf). Unconfined compression tests estimated shear strength values ranging from 1.0 to 5.8 tsf. Unit dry weights ranged from 96 to 117 pound per cubic foot (pcf). A sample in this stratum containing sand and gravel was washed through a No. 200 sieve, approximately 77 percent of the fines passed.

Stratum II consists of light brown to tan lean (CL) clay. The lean clays were encountered at the wastewater treatment plant borings, WWTP-5 through WWTP-10, within the upper 10 feet of our borings. These clays are classified as moderately plastic to plastic with PI's ranging from 22 to 33. Measured moisture contents generally ranged from 12 to 20 percent. Pocket penetrometer test estimated shear strength values ranging from 0.75 to in excess of 2.25 tsf. Unconfined compression tests in this stratum yielded shear strength values of 2.5 and 2.8 tsf. Unit dry weights were measured at 117 and 122 pcf.

Stratum III generally consists of tan clayey sand (SC) becoming silty with depth transitioning to silty, clayey sand (SC-SM). This material was encountered beneath the upper lean (CL) and fat (CH) clays at the

wastewater treatment plant borings, WWTP-5 through WWTP-12, and extended to their boring completion depths. Moisture contents of the clayey sand and silty, clayey sand ranged from 1 to 11 percent. PI's ranged from 4 to 21. Standard Penetration Test (SPT) N-values ranged from 22 to refusal for 3 inches of penetration or less. Approximately 6 to 32 percent of the fines passed a No. 200 sieve.

Clayey sand (SC) and sand with clay (SP-SC) was also observed at interceptor Boring B-14 at approximate depths ranging from 3 to 8 feet below the ground surface in our boring.

At wastewater treatment plant boring WWTP-9, silty sand (SM) was encountered at approximate depths ranging from about 33 to 42 feet below the existing ground surface in our boring. This material is non-plastic.

CORROSIVITY CHARACTERISTICS

The corrosivity characteristics of the subsurface soils were evaluated using a pH test, resistivity test, sulfate content test, and chloride content test. These tests were conducted on soil specimens obtained from the subsurface soils at depths ranging from 2 to 15 feet below the ground surface. The results are summarized in the following table:

Sample Location	Sample Depth (ft)	Electrical Resistivity (ohm-cm)	pH	Sulfate Content (ppm)	Chloride Content (ppm)
B-10	13 to 15	1,840	7.6	69.8	Not Detected
B-15	8 to 10	2,380	7.3	37.2	Not Detected
WWTP-6	13 to 15	1,460	7.5	96.7	Not Detected
WWTP-8	6 to 8	1,290	7.5	75.4	25.4
WWTP-10	8 to 10	1,590	8.0	36.8	23.7
WWTP-14	2 to 4	1,240	7.8	76.2	14.9

Where ppm = parts per million

The electrical resistivity and the chloride content laboratory test results indicate the soils have a mild to severe corrosion potential to buried metals per FHWA-SA-96-072 titled "*Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls & Reinforced Soil Slopes.*" According to the American Concrete Institute (ACI) document titled "Guide to Durable Concrete" (ACI 201), concrete usually provides protection against rusting of adequately embedded steel because of the highly alkaline environment of the Portland cement paste. The adequacy of that protection is dependent upon the amount of concrete cover, the quality of the concrete, the details of the construction, and the degree of exposure to chlorides from concrete-making components and external sources. It is recommended that no chloride-containing admixtures be utilized in the concrete mixes for this project. Consideration should also be given to implementing corrosion protection measures for buried metals in direct contact with the soil, such as coating metal structural elements, pipings, and/or fittings. The pH laboratory test result indicates that the native soils at this site are moderately alkaline. The measured water-soluble sulfate concentration for the soils tested indicated negligible exposure. According to this laboratory test result

and ACI, the native clay soils result in a Class 0 severity of potential exposure of concrete to corrosion. The ACI 201.2R-08 "*Guide to Durable Concrete*," indicates no special cementitious material requirements for sulfate resistance for a Class 0 exposure. Therefore, Portland Cement Concrete planned to be placed directly in contact with native soils may be designed for low sulfate exposure conditions.

GROUNDWATER

Free water was encountered at Borings B-12 and WWTP-11 at approximate depths of 17 and 48 feet below the ground surface in our borings, respectively. All other borings remained dry during the field exploration phase. It is possible for groundwater to exist beneath this site at shallow depths on a transient basis. Fluctuations in groundwater levels occur due to variation in rainfall and surface water run-off. The construction process itself may also cause variations in the groundwater level.

Based on the findings in our borings and on our experience in this region, we believe that groundwater seepage encountered during site earthwork activities and foundation construction may be controlled using temporary earthen berm and conventional sump-and-pump dewatering methods. For excavations to depths greater than about 15 feet, provisions should be made to handle water entering excavations during construction. This could include the use of temporary casing to reduce groundwater seepage and sloughing of the clay soils during deep foundation excavations.

FOUNDATION ANALYSIS

EXPANSIVE SOIL-RELATED MOVEMENTS

Anticipated ground movements due to swelling of the underlying soils at the site were estimated for various wastewater treatment plant structures based on their proposed depths below the ground surface using the empirical procedure, Texas Department of Transportation (TxDOT) Tex-124-E, Method for Determining the Potential Vertical Rise (PVR). The PVR values provided below were evaluated for conditions in which holding structures were empty. A surcharge load of 1 psi (concrete slab and sand cushion), an active zone of 15 ft below the final grade, and dry moisture conditions were assumed in estimating the PVR values. Finished floor elevations for below grade structures were also taken into consideration in evaluation of PVR.

Location	Estimated PVR (in.)
Lift Station, BNR Basin*, Cascade	< 1
Clarifier	1
Sludge Holding Basin	1¼
Headworks & Filtration	2
Chlorine Contact Basin & Outfall	3 ½
Soda Ash*, Blower*, IR Pump Station*, RAS Pump Station*, Disinfection*, Operations & Alum Building*, Box Culvert	4 ½
Structures at existing grade (i.e. mechanical pads and other ancillary structures)	3 ½ to 4 ½
Private Drive	4 ½

*PVR based on structures at existing ground surface at the time of our field exploration.

It is anticipated that this project will also include small stand-alone ancillary structures, such as mechanical pads, that will not be attached to the facility structures. These types of small structures will also be subject to potential soil-related movements.

The TxDOT method of estimating expansive soil-related movements is based on empirical correlations utilizing the measured plasticity indices and assuming typical seasonal fluctuations in moisture content. If desired, other methods of estimating expansive soil-related movements are available, such as estimations based on swell tests and/or soil-suction analyses. However, the performance of these tests and the detailed analysis of expansive soil-related movements were beyond the scope of the current study. It should also be noted that actual movements can exceed the calculated PVR values due to isolated changes in moisture content (such as due to leaks, landscape watering....) or if water seeps into the soils to greater depths than the assumed active zone depth due to deep trenching or excavations.

Overexcavation and Select Fill Replacement

Consideration was given to other methods of reducing the swell potential of expansive clay soils at this site utilizing other methods such as chemical injection. The ability to chemically treat the soils is most conducive when the soils are at a relatively dry state with desiccation cracks and fracturing. These ideal conditions allow the soils to absorb the treatment more readily than soils in a moist condition of state. Also the presence of more permeable layers of soil, such as sandy clay, sands, and gravels make uniform distribution of the chemical infeasible and require multiple doses of treatment that can be costly. Furthermore, this chemical can be corrosive to underground metallic utility piping.

After further evaluation, we have determined that overexcavation and select fill replacement is the most suitable approach for reducing expansive soil-related movements based on existing site conditions and our experience dealing with similar soils. To reduce expansive soil-related movements, a portion of the upper highly expansive subgrade clays in the building areas can be removed by overexcavating and backfilling with suitable select fill material. Fill placed in the building area should consist of select fill material in accordance with the *Select Fill* section of this report. Recommendations for the selection and placement of select backfill materials are addressed in a subsequent section of this report. The above estimated PVR values have been evaluated for various overexcavation and select fill replacement depths below the lowest levels of the structures to reduce estimated PVR values to the following estimated values.

Location	Estimated PVR (in.)	Removal & Select Fill Replacement Depth for 1 in. PVR (ft)	Removal & Select Fill Replacement Depth for 2 in. PVR (ft)	Removal & Select Fill Replacement Depth for 3 in. PVR (ft)
Lift Station, BNR Basin, Cascade	< 1*	-	-	-
Clarifier	1*	-	-	-
Sludge Holding Basin*	1¼	1	-	-
Headworks & Filtration	2	3	-	-
Chlorine Contact Basin & Outfall	3 ½	6	3	1
Soda Ash, Blower, IR Pump Station, RAS Pump Station, Disinfection, Operations & Alum Building, & Box Culvert	4 ½	10	6	3

Location	Estimated PVR (in.)	Removal & Select Fill Replacement Depth for 1 in. PVR (ft)	Removal & Select Fill Replacement Depth for 2 in. PVR (ft)	Removal & Select Fill Replacement Depth for 3 in. PVR (ft)
Structures at existing grade (i.e. mechanical pads and other ancillary structures)	3 ½ to 4 ½	10	6	3
Private Drive	4 ½	10	6	3

* A 1 ft minimum thickness of select fill is required beneath the foundation.
**PVR values estimated relative to depth of the structure based on 30 percent submittal plans.

Drainage Considerations When overexcavation and select fill replacement is selected as a method to reduce the potential for expansive soil-related movements at any site, considerations of surface and subsurface drainage may be crucial to construction and adequate foundation performance of the soil-supported structures. Filling an excavation in relatively impervious plastic clays with relatively pervious select fill material creates a "bathtub" beneath the structure, which can result in ponding or trapped water within the fill unless good surface and subsurface drainage is provided.

Water entering the fill surface during construction or entering the fill exposed beyond the building lines after construction may create problems with fill moisture control during compaction and increased access for moisture to the underlying expansive clays both during and after construction.

Several surface and subsurface drainage design features and construction precautions can be used to limit problems associated with fill moisture. These features and precautions may include but are not limited to the following:

- Installing berms or swales on the uphill side of the construction area to divert surface runoff away from the excavation/fill area during construction;
- Sloping of the top of the subgrade with a minimum downward slope of 1.5 percent out to the base of a dewatering trench located beyond the building perimeter;
- Sloping the surface of the fill during construction to promote runoff of rain water to drainage features until the final lift is placed;
- Sloping of a final, well maintained, impervious clay or pavement surface (downward away from the building) over the select fill material and any perimeter drain extending beyond the building lines, with a minimum gradient of 6 in. in 5 ft;
- Constructing final surface drainage patterns to prevent ponding and limit surface water infiltration at and around the building perimeter;
- Locating the water-bearing utilities, roof drainage outlets and irrigation spray heads outside of the select fill and perimeter drain boundaries; and
- Raising the elevation of the ground level floor slab.

Details relative to the extent and implementation of these considerations must be evaluated on a project-specific basis by all members of the project design team. Many variables that influence fill drainage considerations may depend on factors that are not fully developed in the early stages of design. For this reason, drainage of the fill should be given consideration at the earliest possible stages of the project.

FOUNDATION RECOMMENDATIONS

FOUNDATION OPTIONS

The following recommendations are based on the data obtained from our field and laboratory studies, our past experience with geotechnical conditions similar to those at this site, and our engineering design analyses.

The following alternatives are available to support the structures:

- Rigid-engineered beam and slab foundation;
- Drilled-and-underreamed piers;
- Drilled, straight-shaft piers.

The owner may select either one of these foundation systems depending on the performance criteria established for the structures. Cost analyses have not been conducted for any foundation system and are beyond the scope of this study.

SITE GRADING

Site grading plans can result in changes in almost all aspects of foundation recommendations. We have prepared all foundation recommendations based on finished floor elevations as provided in the 30 percent submittal documents, and the stratigraphic conditions encountered at the time of our study. If site grading plans differ from those discussed in this report by more than plus or minus 1 foot, **RKCI** must be retained to review the site grading plans prior to bidding the project for construction. This will enable **RKCI** to provide input for any changes in our original recommendations that may be required as a result of site grading operations or other considerations.

RIGID-ENGINEERED BEAM AND SLAB FOUNDATION

The proposed structures may be founded on a rigid-engineered beam and slab foundation, provided the selected foundation type can be designed to withstand the anticipated soil-related movements (see *Expansive Soil-Related Movements*) without impairing either the structural or the operational performance of the structures. If shallow foundations are to be considered, we recommend reducing expansive soil related movements to 1 inch or less. This will require overexcavation and select fill replacement of the upper highly expansive subgrade clays in the structure areas. Refer to *Overexcavation and Select Fill Replacement* section of this report for approximate depths of overexcavation of each structure. For those instances where overexcavation is not required to reduce expansive soil related movements to 1 inch or less, we recommend a minimum of 1 feet of *Select Fill* beneath the shallow foundations.

Allowable Bearing Capacity

Shallow foundations founded on compacted, select fill should be proportioned using the design parameters tabulated below.

Location	Maximum Allowable Bearing Pressure for Grade Beams (psf)	Maximum Allowable Bearing Pressure for Widened Beams (psf)
Lift Station	2,100	2,600
BNR Basin, Headworks, Soda Ash Building, Blower Building, IR Pump Station, & RAS Pump Station, Clarifier, Filtration, Disinfection, Chlorine Contact Basin, Cascade, Sludge Holding Basin, Operations Building, Alum Building, Box Culvert & Outfall	2,500	3,100

Shallow foundations should be constructed at a minimum depth of 18 inches below final grade with a minimum beam width of 12 inches. The above presented maximum allowable bearing pressures will provide a factor of safety of about 3 with respect to the measured shear strength, provided the subgrade is prepared and the select fill is placed in accordance with the recommendations outlined in the *Site Preparation* and *Select Fill* section of this report.

Split-Level Foundation Differential Settlement Reduction Considerations

The headworks, BNR basin, cascade structures are planned to have split-level foundations. The bottom of these split-level foundations will have step-downs that could range from 3 to 8 ft. These split-level foundations are susceptible to experiencing differential foundation settlements associated with the foundations bearing at different elevations in addition to some portions of the foundation bearing on a greater thickness of fill as compared to the lowest foundation elevation. To help reduce these differential settlements, we recommend placing a non-compressible fill, such as Controlled Low Strength Material (CSLM) beneath the upper foundation level down to at least the elevation of the lower foundation level. This option will result in the split-level foundation system being supported on a common bearing elevation as well as a uniform pad thickness, thus resulting in more uniform settlement conditions.

Refer to the *Controlled Low Strength Material* section of this report for standard specifications.

POST CONSTRUCTION ANTICIPATED MOVEMENT CONSIDERATIONS

There are multiple structures completing the wastewater treatment plant. The foundations of these structures will be founded at various depths below the ground surface. As such, excavations varying in depth up to 13 ft will be required to construct the basins and structures. The construction process itself is anticipated to be constructed in phases. The first of which will be to perform the excavation, followed by the construction of the structure, and finally placing the structures in service, which will require filling the basins with fluids. Due to the consolidated nature of the soil, it is anticipated that the soils will undergo upheaval ("rebound") as the underlying soils recognize unloading of the overburden soil. This rebounding effect will continue to occur over time until it has reached a state of equilibrium or a surcharge load is applied to either counter act the rebound or consolidate and cause settlement. As the subgrade of the excavation is surcharged with the concrete foundations and then the weight of the structure plus the weight of water, some consolidation (settlement) is estimated to occur. The magnitude of vertical soil

movements is dependent upon the duration between construction stages, the underlying soils, the amount of phased surcharge, permeability of the soils, and drainage conditions during construction.
While there are many different methods of settlement analysis and numerous available computer programs, we have selected the program Settle 3D, a consolidation and settlement computer program, developed by Rocscience, Inc. to evaluate the anticipated movements experienced throughout the stages of construction for the foundation structures founded to depths ranging from about 6 to 12 ft below proposed final grades, including the two clarifiers, the two filtration basins, the BNR basin, and headworks structure.

Based on our analysis, we anticipate that the soil will begin to heave (rebound) immediately upon completion of the excavation and will continue to heave.

It is also estimated that the soils will continue to heave following construction of the structures until the basins are filled to their service capacities. It is estimated that the loaded structures will begin to consolidate the underlying soil and experience settlement of about 2 inches over a period of 5 to 10 years relative to the time in which the structure was constructed.

FLATWORK & ANCILLARY STRUCTURES

It should be noted that ground supported flatwork and ancillary structures (at grade) such as mechanical pads and pipe support pads will be subject to the same magnitude of potential soil-related movements as discussed previously (see *Expansive Soil-Related Movement* section). Thus, where these types of elements abut structures that are either founded to deeper depths below the ground surface or expansive, soil-related reduction options have been implemented, differential movements should be anticipated.

Based on our review of the 30 percent submittal plans, there will be many instances where pipe connections transition from being supported on at-grade mechanical pads to structures. At these transitional areas, we recommend overexcavation and select fill replacement of the expansive clay soils to reduce PVR values at these areas. The PVR values of mechanical pads and flatwork at grade should be designed to match the PVR of adjacent below grade structures, but more importantly, we recommend that the utility pipes be constructed to have a degree of flexibility and/or constructed with oversize sleeves when entering the structures.

DRILLED-AND-UNDERREAMED PIERS

Drilled-and-underreamed piers bearing in highly expansive red-brown and yellow-brown clay may be considered to support the soda ash, blower, operations and alum building structures. Piers should extend to a minimum depth of 25 ft below the ground surface existing at the time of our study. The piers should be designed as end bearing units using a maximum allowable bearing pressure of 12,000 psf. This bearing pressure was evaluated using a factor of safety of 3 with respect to the design shear strength.

Based on the 25 ft maximum depth of exploration in the vicinity of these structures, precautions should be taken during construction not to exceed maximum 25 feet depth explored. This specified 25 feet is relative to the ground surface existing at the time of our study. Piers extending past this depth have a potential to encounter sands and/or clayey sands making construction of the bell pier non-feasible. If

sand and/or clayey sand are encountered shallower than anticipated during construction, deeper drilled straight-shaft piers may be required. For bid purposes, the owner should anticipate that deeper piers will be required in some areas. Consequently, contractors bidding on the job should include unit costs for various depths of additional pier embedment.

However, without further knowledge of anticipated subsurface conditions below the 25 feet depth explored penetration depths will have to be evaluated on a case by case basis in the field during construction. **RKCI** must be present at the time of pier construction to determine if field conditions are similar to those previously specified and to assist in determining the need for conversion of drilled-and-underreamed piers to drilled, straight-shaft piers, To reduce the uncertainties of subsurface conditions, we recommend conducting deeper soil borings to depths of at least 40 feet in the vicinity of the soda ash, blower, operations and alum building structures to determine if drilled-and-underreamed pier are best suited prior to construction.

Pier Shafts

The pier shafts will be subject to potential uplift forces if the surrounding expansive soils within the active zone are subjected to alternate drying and wetting conditions. The maximum potential uplift force acting on the shaft may be estimated by:

$$F_u = 105*D$$

where:

F_u = uplift force in kips; and
D = diameter of the shaft in feet.

Allowable Uplift Resistance

Resistance to uplift forces exerted on the drilled piers will be provided by the sustained axial compressive force (dead load) plus the allowable uplift resistance provided by the soil. The resistance provided by the soil depends on the bearing capacity of the soils located above the pier underream (bell) and below the active zone. The allowable uplift resistance for underreamed piers founded at the depth recommended above may be estimated using:

$$R_u = 12*(B^2 - D^2)$$

where:

R_u = uplift resistance in kips;
B = diameter of the underream in feet; and
D = diameter of the shaft in feet.

We recommend that the bell-to-shaft diameter ratio be a minimum of 2, and not exceed 3. Reinforcing steel will be required in each pier shaft to withstand a net force equal to the uplift force minus the sustained compressive load carried by the pier. We recommend that each pier be reinforced to

withstand this net force or an amount equal to 1 percent of the cross-sectional area of the shaft, whichever is greater.

DRILLED, STRAIGHT-SHAFT PIERS

Drilled, straight-shaft piers may be considered to support the IR pump station; RAS pump station, disinfection and chlorine contact basin. Straight-shaft piers should be designed as friction units using an allowable side shear resistance of 700 psf for the portion of the shaft extending below a depth of 15 feet. Based on the 50 feet maximum depth of exploration, pier depths should not exceed a depth of 50 feet below the ground surface existing at the time of our study.

To proportion the drilled piers for axial compression, the side shear resistance should be neglected along the portion of the shaft located one shaft diameter from the bottom of the pier.

Drilled, straight-shaft piers bearing at a minimum depth of 15 feet below the existing ground surface may also be proportioned using a maximum allowable end bearing pressure of 12,000 psf. However, we recommend that a minimum of 70 percent of the applied load be carried in side shear.

Final shaft depths will be based on interpretation of conditions in the field at the time of construction. Due to the variable conditions at this site, **RKCI** must be present at the time of pier construction to verify the field conditions are similar to those assumed in the preparation of our recommendations. Representatives from **RKCI** must be present at the time of construction to verify that conditions are similar to those encountered in our borings and that sufficient penetration into the limestone is achieved. For bid purposes, the owner should anticipate that deeper piers will be required in some areas. Consequently, contractors bidding on the job should include unit costs for various depths of additional pier embedment. Unit costs should include those for both greater and lesser depth in soil.

Pier Shafts

The pier shafts will be subject to potential uplift forces if the surrounding expansive soils within the active zone are subjected to alternate drying and wetting conditions. The maximum potential uplift force acting on the shaft may be estimated by:

$$Fu = 105*D$$

where:

Fu = uplift force in kips; and
D = diameter of the shaft in feet.

Allowable Uplift Resistance

Resistance to uplift forces exerted on the drilled, straight-shaft piers will be provided by the sustained compressive axial force (dead load) plus the allowable uplift resistance provided by the soil. The resistance provided by the soil depends on the shear strength of the soils adjacent to the pier shaft and below the depth of the active zone. The allowable uplift resistance provided by the soils at this site may

be estimated using 450 psf for the portion of the shaft extending below a depth of 15 feet. This value was evaluated using a factor of safety of 2.

Reinforcing steel will be required in each pier shaft to withstand a net force equal to the uplift force minus the sustained compressive load carried by that pier. We recommend that each pier be reinforced to withstand this net force or an amount equal to 1 percent of the cross-sectional area of the shaft, whichever is greater.

PIER SPACING

Where possible, we recommend that the piers be spaced at a center to center distance of at least three shaft diameters on-center for straight-shaft piers and three bell-diameters for underreamed piers. Such spacing will not require a reduction in the load carrying capacity of the individual piers.

If design and/or construction restraints require that piers be spaced closer than the recommended three shaft and three bell diameters, **RKCI** must re-evaluate the allowable bearing capacities presented above for the individual piers. Reductions in load carrying capacities may be required depending upon individual loading and spacing conditions.

GRADE BEAMS

We recommend that the grade beams interconnecting the piers be structurally suspended due to the anticipated ground movements. A positive void space of at least 12 inches should be provided between the soffits of grade beams and the underlying soils.

FLOOR SLABS

Two alternatives are available to construct the floor slab system. The Owner may select the alternative best satisfying the required performance criteria.

> **Alternative No. 1:** Floor slabs which have high performance criteria or which are movement sensitive in nature, should be structurally suspended because of the anticipated ground movements. A positive void space of at least 12 inches, should be provided between the slab and the underlying soils (see also *Crawl Space Considerations*).
>
> **Alternative No. 2:** Floor slabs within the superstructure may be ground supported provided the anticipated movements discussed under the *Expansive Soil-Related Movements* section of this report will not impair the performance of the floor, frame, or roof systems.
>
> If differential movements between the slab and the structure are objectionable, soil-supported floor slabs could be dowelled to the perimeter grade beams. Dowelled slabs that are subjected to heaving will typically crack and develop a plastic hinge along a line which will be approximately 5 to 10 ft inside and parallel to the grade beams. Slabs cast independent of the grade beams, interior columns and partitions should experience

minimum cracking, but may create difficulties at critical entry points such as doors and may impact interior partitions that are secured to exterior walls.

We recommend that a vapor barrier comprised of polyethylene or polyvinyl chloride (PVC) sheeting be placed between the supporting select fill and the concrete floor slab.

RETAINING STRUCTURES

It is our understanding several of the wastewater treatment plant building structures, including manholes, lift stations, and culverts will extend to various depths below the ground surface ranging from about 6 to 33 feet below grade. The below-grade walls will act as retaining structures and should be designed for lateral earth pressures. Drainage conditions will also need to be considered in design.

LATERAL EARTH PRESSURES

Equivalent fluid density values for computation of lateral soil pressures acting on retaining walls were evaluated for various types of backfill materials that may be placed behind the retaining walls. These values, as well as corresponding lateral earth pressure coefficients and estimated unit weights, are presented below in preferential order for use as backfill materials.

Back Fill Type	Estimated Total Unit Weight (pcf)	Active Condition		At Rest Condition	
		Earth Pressure Coefficient, k_a	Equivalent Fluid Density (pcf)	Earth Pressure Coefficient, k_o	Equivalent Fluid Density (pcf)
Washed Gravel	135	0.29	40	0.45	60
Crushed Limestone	145	0.24	35	0.38	55
Clean Sand	120	0.33	40	0.5	60
Pit Run Clayey Gravels or Sands	135	0.32	45	0.48	65
Clays	120	0.59	70	0.74	90

The values tabulated above under “Active Conditions” pertain to flexible retaining walls free to tilt outward as a result of lateral earth pressures. For rigid, non-yielding walls the values under “At-Rest Conditions” should be used.

The values presented above assume the surface of the backfill materials to be level. Sloping the surface of the backfill materials will increase the surcharge load acting on the structures. The above values also do not include the effect of surcharge loads such as construction equipment, vehicular loads, or future storage near the structures. Nor do the values account for possible hydrostatic pressures resulting from groundwater seepage entering and ponding within the backfill materials. However, these surcharge loads and groundwater pressures should be considered in designing any structures subjected to lateral earth pressures.

Effective unit weights and equivalent fluid densities have been provided below for conditions in which hydrostatic conditions will be present behind retaining wall structures.

Back Fill Type	Effective Unit Weight (pcf)	Active Condition		At Rest Condition	
		Earth Pressure Coefficient, k_a	Equivalent Fluid Density (pcf)	Earth Pressure Coefficient, k_o	Equivalent Fluid Density (pcf)
Washed Gravel	74	0.29	84	0.45	96
Crushed Limestone	84	0.24	82	0.38	94
Clean Sand	58	0.33	81	0.5	91
Pit Run Clayey Gravels or Sands	74	0.32	86	0.48	98
Clays	58	0.59	96	0.74	105

The on-site Stratum I clays exhibit significant shrink/swell characteristics. The use of these soils as backfill against the proposed retaining structures is not recommended. These soils generally provide higher design active earthen pressures, as indicated above, but may also exert additional active pressures associated with swelling. Controlling the moisture and density of these materials during placement will help reduce the likelihood and magnitude of future active pressures due to swelling, but this is no guarantee.

BACKFILL COMPACTION

Placement and compaction of backfill behind the retaining walls will be critical, particularly at locations where backfill will support adjacent near-grade foundations and/or flatwork. If the backfill is not properly compacted in these areas, the adjacent foundations/flatwork can be subject to settlement.

To reduce potential settlement of adjacent foundations/flatwork, the backfill materials should be placed and compacted as recommended in the *Select Fill* section of this report. Each lift or layer of the backfill should be tested during the backfilling operations to document the degree of compaction. Within at least a 5-ft zone of the walls, we recommend that compaction be accomplished using hand-guided compaction equipment capable of achieving the maximum density in a series of 3 to 5 passes.

DRAINAGE

The use of drainage systems is a positive design step toward reducing the possibility of hydrostatic pressure acting against the retaining structures. Drainage may be provided by the use of a drain trench and pipe. The drain pipe should consist of a slotted, heavy duty, corrugated polyethylene pipe and should be installed and bedded according to the manufacturer's recommendations. The drain trench should be filled with gravel (meeting the requirements of ASTM D 448 coarse concrete aggregate Size No. 57 or 67) and extend from the base of the structure to within 2 ft of the top of the structure. The bottom of the drain trench will provide an envelope of gravel around the pipe with minimum dimensions consistent with the pipe manufacturer's recommendations. The gravel should be wrapped with a suitable geotextile fabric (such as Mirafi 140N or equivalent) to help minimize the intrusion of fine-grained soil particles into the

drain system. The pipe should be sloped and equipped with clean-out access fittings consistent with state-of-the-practice plumbing procedures.

As an alternative to a full-height gravel drain trench behind the proposed retaining structures, consideration may be given to utilizing a manufactured geosynthetic material for wall drainage. A number of products are available to control hydrostatic pressures acting on earth retaining structures, including Amerdrain (manufactured by American Wick Drain Corp.), Miradrain (manufactured by Mirafi, Inc.), Enkadrain (manufactured by American Enka Company), and Geotech Insulated Drainage Panel (manufactured by Geotech Systems Corp.). The geosynthetics are placed directly against the retaining structures and are hydraulically connected to the gravel envelope located at the base of the structures.

COEFFICIENTS OF FRICTION

A coefficient of sliding friction should be used to evaluate the factor of safety against sliding of foundation elements (footing and retaining walls). A coefficient of sliding friction of 0.35 for clay and 0.7 for select fill may be assumed in evaluation of the factor of safety against sliding.

ALLOWABLE BEARING CAPACITY

Retaining wall structures may be supported on spread or continuous footings at a minimum depth of 18 inches below existing grade. Footings bearing on a minimum of 1 foot of select fill may be designed using the maximum allowable bearing pressures presented in the *Allowable Bearing Capacity* section.

FOUNDATION CONSTRUCTION CONSIDERATIONS

SITE DRAINAGE

Drainage is an important key to the successful performance of any foundation. Good surface drainage should be established prior to and maintained after construction to help prevent water from ponding within or adjacent to the building foundation and to facilitate rapid drainage away from the building foundation. Failure to provide positive drainage away from the structure can result in localized differential vertical movements in soil supported foundations and floor slabs. (which can in turn result in cracking in the sheetrock partition walls, and shifting of ceiling tiles, as well as improper operation of windows and doors).

Current ordinances, in compliance with the Americans with Disabilities Act (ADA), may dictate maximum slopes for walks and drives around and into new buildings. These slope requirements can result in drainage problems for buildings supported on expansive soils. We recommend that, on all sides of the building, the maximum permissible slope be provided away from the building.

Also to help control drainage in the vicinity of the structure, we recommend that roof/gutter downspouts and landscaping irrigation systems not be located adjacent to the building foundation. Where a select fill overbuild is provided outside of the floor slab/foundation footprint, the surface should be sealed with an impermeable layer (pavement or clay cap) to reduce infiltration of both irrigation and surface waters. Careful consideration should also be given to the location of water bearing utilities, as well as to provisions for drainage in the event of leaks in water bearing utilities. All leaks should be immediately repaired.

Other drainage and subsurface drainage issues are discussed in the *Expansive Soil-Related Movements* section of this report and under *Pavement Construction Considerations*.

SITE PREPARATION

Building areas and all areas to support select fill should be stripped of all vegetation and organic topsoil, extending a minimum of five feet beyond the outer limits of the building footprint to allow for construction of the building pad. Furthermore, as discussed in a previous section of this report, we recommend overexcavation with select fill placement to maintain required PVR values Refer to *Overexcavation and Select Fill Replacement* section of this report for approximate depths.

In general fill areas outside the building footprints (i.e. sidewalk, parking and drive areas) where Stratum I & II clay subgrade will remain, exposed subgrades should be thoroughly proofrolled. A minimum of 5 passes of a fully loaded dump truck or a similar heavily-loaded piece of construction equipment should be used for planning purposes or other methods approved by the Geotechnical Engineer. The Geotechnical Engineer or his representative to document subgrade condition and preparation should observe Proofrolling operations. Weak or soft areas identified during proofrolling should be removed and replaced with suitable, compacted on-site clays, free of organics, oversized materials, and degradable or deleterious materials.

Upon completion of the proofrolling operations and just prior to fill placement, the clay subgrade shall be moisture conditioned by scarifying to a minimum depth of 6 inches and re-compacting to a minimum of 95 percent of the maximum density as determined by TxDOT, Tex-114-E Compaction Test. The moisture content of the clay subgrade should be maintained within the range of optimum moisture content to 3 percentage points above optimum moisture content until permanently covered.

SELECT FILL

Materials used, as select fill for final site grading in building areas should be crushed stone or gravel aggregate. We recommend that materials specified for use as select structural fill meet the Texas Department of Transportation 2004 Standard Specification for Construction of Highways, Streets, and Bridges, Item 247: Type A and B, Grade 2 (crushed stone), or better.

Select fill should be placed in loose lifts not exceeding 8 inches in thickness and compacted to the maximum density as determined by TxDOT, Tex-113-E Compaction Test. The moisture content of the fill should be maintained within the range of 2 percentage points below to 2 percentage points above the optimum moisture content until final compaction. The water content of the fill also should be maintained within the specified range until the fill is permanently covered.

SHALLOW FOUNDATION EXCAVATIONS

Shallow foundation excavations should be observed by the Geotechnical Engineer or his representative prior to placement of reinforcing steel and concrete. This is necessary to verify that the bearing soils at the bottom of the excavations are similar to those encountered in our borings and that excessive loose materials and water are not present in the excavations. If soft pockets of soil are encountered in the

foundation excavations, they should be removed and replaced with a compacted non-expansive fill material or lean concrete up to the design foundation bearing elevations.

DRILLED PIERS

Each drilled pier excavation must be examined by an **RKCI** representative who is familiar with the geotechnical aspects of the soil stratigraphy, the structural configuration, foundation design details and assumptions, prior to placing concrete. This is to observe that:

- The shaft and/or bell has been excavated to the specified dimensions at the correct depth established by the previously mentioned criteria;
- The bell is concentric with the pier shaft;
- The shaft has been drilled plumb within specified tolerances along its total length; and
- Excessive cuttings, buildup and soft, compressible materials have been removed from the bottom of the excavation.

Reinforcement and Concrete Placement

Reinforcing steel should be checked for size and placement prior to concrete placement. Placement of concrete should be accomplished as soon as possible after excavation to reduce changes in the moisture content or the state of stress of the foundation materials. No foundation element should be left open overnight without concreting.

EXCAVATION SLOPING AND BENCHING

If utility trenches or other excavations extend to or below a depth of 5 ft below construction grade, the contractor or others shall be required to develop a trench safety plan to protect personnel entering the trench or trench vicinity. The collection of specific geotechnical data and the development of such a plan, which could include designs for sloping and benching or various types of temporary shoring, are beyond the scope of the current study. Any such designs and safety plans shall be developed in accordance with current OSHA guidelines and other applicable industry standards.

EXCAVATION EQUIPMENT

Our boring logs are not intended for use in determining construction means and methods and may therefore be misleading if used for that purpose. We recommend that earth-work and utility contractors interested in bidding on the work perform their own tests in the form of test pits to determine the quantities of the different materials to be excavated, as well as the preferred excavation methods and equipment for this site.

CORROSION PROTECTION

The results of our laboratory pH and resistivity analyses indicate that protection will be required to reduce corrosion of buried metal utilities. As a minimum, polyethylene encasement should be considered. Consideration should also be given to providing cathodic protection for buried metal

utilities. Refer to the *Corrosivity Characteristics* section of this report for the results of the analytical testing.

CRAWL SPACE CONSIDERATIONS

If the structurally suspended floor system described as Alternative No. 1 under the *Floor Slab* section of this report is selected, several special design issues should be considered for the resulting subfloor crawl space. These issues are discussed below.

Ventilation

Observations by members of our firm of open crawl spaces have indicated a need for adequate subfloor ventilation. Such ventilation helps promote evaporation of subgrade moisture which may accumulate in spite of special surface and subsurface drainage features. As a minimum, free flowing passive vents may need to be installed along the perimeter beam to provide cross ventilation. If structural configurations will limit the free flow of air through passive vents, forced air, power vents should be installed. All vents should be designed such that they will not allow the drainage of surface water into the crawl space.

A minimum clearance of 12 inches has been recommended between both the grade beams and floor slab and the underlying finished subgrade. Such a minimum clearance is also recommended between the subgrade and any utilities which may be suspended from the underside of the floor. This clearance will allow swell-related subgrade movements without damaging the utilities. It is recommended that the utility clearance not be provided by the addition of narrow trenches running parallel to and immediately below the utilities, unless proper slopes and drainage outlets are provided to prevent ponding of water in the trenches.

Drainage

As discussed throughout this report, positive drainage is a key factor in the long term performance of any foundation. This is not only critical around the perimeter of the structure, but also in any subfloor crawl spaces. In crawl areas, surface drainage should be established that will direct water away from and will prevent water from ponding adjacent to piers. This positive drainage should be maintained both prior to and after construction.

Compaction control of the backfill around the perimeter of the building following the placement of soil retainer blocks is critical to the drainage away from the building following construction. Materials for the backfill around the perimeter of the building should be the on site clays. These materials should be compacted in uniformly thin lifts (8-inch maximum loose thickness) to at least 90 percent of the maximum dry density as determined by TxDOT Test Method TEX-114-E. These clays should be placed and compacted at optimum to plus 3 percent above optimum moisture content. Compaction by hand operated mechanical tampers will help to avoid damage to the soil retainer blocks. Following backfilling operations the soil retainer blocks should be checked to see that they have not been broken or collapsed during the compaction operations. Any soil retainer blocks that are broken or collapsed should be repaired or replaced.

Carton Forms

When carton forms are used to form subfloor void spaces, the forms often get wet or sometimes absorb water from humid air. This can result in collapse of the forms during the placement of concrete, thus diminishing the design void space. Conversely, if the carton forms are too strong and do not decompose sufficiently with time, they may not collapse as soil heave occurs, resulting in heave damage to the floor slab. Where there is sufficient moisture to cause the appropriate deterioration after construction, there may be a resulting moisture problem in the floor slab as a result of poor ventilation and the accumulation of condensation within the resulting unventilated void space. The lack of ventilation may also result in increased soil movements that will diminish the design void space. For these reasons, we recommend that where possible, consideration be given to methods other than the use of carton forms to form the recommended void space beneath floor slabs. If project specifics require the use of carton forms, then as a minimum, care should be taken to ensure that the carton forms are designed for use in the project location, and that carton forms are properly stored, protected, and installed during construction.

INTERIOR WALLS

It is not uncommon for cracking to occur in interior partition walls that are supported by a "floating" floor slab and structurally tied to either an interior column or an exterior wall supported by deep foundations. This should be taken into account during the design phase of the project if a "floating" slab foundation is used to support the proposed building.

UTILITIES

Utilities which project through slab-on-grade, slab-on-fill, "floating" floor slabs, or any other rigid unit should be designed with either some degree of flexibility or with sleeves. Such design features will help reduce the risk of damage to the utility lines as vertical movements occur. These types of slabs will generally be constructed as monolithic, grid type beam and slab foundations or as a "floating" floor slab.

Our experience indicates that significant settlement of backfill can occur in utility trenches, particularly when trenches are deep, when backfill materials are placed in thick lifts with insufficient compaction, and when water can access and infiltrate the trench backfill materials. The potential for water to access the backfill is increased where water can infiltrate flexible base materials due to insufficient penetration of curbs, and at sites where geological features can influence water migration into utility trenches (such as fractures within a rock mass or at contacts between rock and clay formations). It is our belief that another factor which can significantly impact settlement is the migration of fines within the backfill into the open voids in the underlying free-draining bedding material.

To reduce the potential for settlement in utility trenches, we recommend that consideration be given to the following:

- All backfill materials should be placed and compacted in controlled lifts appropriate for the type of backfill and the type of compaction equipment being utilized and all backfilling procedures should be tested and documented.
- Curbs should completely penetrate base materials and be installed to a sufficient depth to reduce water infiltration beneath the curbs into the pavement base materials.

- Consideration should be given to wrapping free-draining bedding gravels with a geotextile fabric (similar to Mirafi 140N) to reduce the infiltration and loss of fines from backfill material into the interstitial voids in bedding materials.

WASTEWATER INTERCEPTOR & EFFLUENT PIPELINE INSTALLATION & CONSTRUCTION METHODS

PRE-INSTALLATION CONSIDERATIONS

It is the responsibility of the contractor to locate and identify all existing underground utilities prior to commencing work. Care should be taken to avoid contact and damage to existing utilities. In the event that an existing utility line has been damaged as a result of work in progress it is the responsibility of the Contractor to notify the owner of the utility so that necessary measures are taken to repair damages. If the standard of care cannot be met with open cut construction other methods may need to be considered.

Trenching for pipeline excavations should be in accordance with provisions and direction of a licensed engineer. All excavation and backfilling should be in compliance with City of Austin Standard Specification, Section 510.

Should any existing utility branch connections, sewers, drains, conduits, ducts, pipes or structures present obstruction to the grade and alignment of the pipe, the Contractor in cooperation with the owner should consider permanently supporting, removing, relocating or reconstructing the obstruction. If relocation or reconstruction is impractical, the Engineer of Record should be retained for direction.

Other considerations for pipeline installation should include adequate spacing between water and neighboring wastewater lines in accordance to city regulations. Appropriate consideration should also be given to pipe that crosses under a utility structure or storm sewer, which will require encasing the pipe.

EXCAVATION EQUIPMENT

Based on our subsurface exploration along the alignment of the wastewater interceptor and effluent line, the soils likely to be encountered are comprised of very stiff to hard clays of the Navarro Group and Marlbrook Marls. Proposed bearing elevations, indicate that the wastewater interceptor line will be installed approximately 15 to 35 feet below existing ground surface, while the horizontal alignment of the effluent line will be 6 to 8 ft below the proposed final grading. We anticipate the interceptor and effluent lines will bear on highly expansive clay soils (Stratum I) similar to those described in the *Statigraphy* section of this report. Due to the nature of the soils encountered in our borings, excavations at this site are not anticipated to encounter rock. Thus, the need of rock excavation equipment is not anticipated for construction at this site. However, the contractor is responsible in determining the type of construction equipment to be utilized.

Our boring logs are not intended for use in determining construction means and methods and may therefore be misleading if used for that purpose. We recommend, when possible that earth-work and utility contractors interested in bidding on the work perform their own tests in the form of test pits to determine the quantities of the different materials to be excavated, as well as the preferred excavation methods and equipment for this site.

TRENCH SAFETY CONDITIONS

If excavations extend to or below a depth of 5 ft below construction grade, the contractor or others shall be required to develop a trench safety plan to protect personnel entering the trench or trench vicinity. The collection of specific geotechnical data and the development of such a plan, which could include designs for sloping and benching or various types of temporary shoring, are beyond the scope of the current study. Any such designs and safety plans shall be developed in accordance with current OSHA guidelines and other applicable industry standards.

The wastewater line installation should be in accordance with City of Austin Standard Specifications Item No. 509 S, "Excavation Safety Systems." After pipe has been laid and backfill has been placed and compacted at least 12 inches above the pipe, sheeting, shoring or bracing may be removed. Provisions should be made to prevent sides of trench from caving in by filling and compacting the trench with suitable backfill material.

CONTROL OF GROUNDWATER

During drilling operations, groundwater was detected at approximately 17 feet in Boring B-12 along the interceptor alignment and below the anticipated depth of construction in the vicinity of Boring WWTP 11. Groundwater may be encountered during construction depending on precipitation levels. It is not anticipated that ground water elevations will require dewatering procedures prior to excavation; however, the contractor should be prepared to perform dewatering if required. Dewatering methods may include sump and pump, well points or a single well or a combination of these. Contractors should refer to the physical test data included on the logs of borings and not the stratigraphic nomenclature to select construction means, methods, and sequencing.

OPEN CUT TRENCH CONSTRUCTION

Trench Width

Trenches should extend a minimum of 6 inches beyond the outside diameter of the proposed wastewater line but no more than 12 inches.

Trench Preparation

The trench should be excavated giving careful attention to the trench bottom, sides and widths. The trench bottom requires adequate provisions to maintain grade and attention to see that the subsurface conditions do not change radically. The exposed subgrade should be slightly overexcavated and raked with the teeth of the backhoe to loosen the subgrade soils. The bottom of the trench should then be backfilled with a minimum of 6 inches of gravel subgrade filler. The gravel subgrade filler should consist of ¾ inch gravel and placed in accordance with the recommendations presented under the *Bedding Material* section of this report.

Bedding Material

Materials used as bedding material around the pipe preferably should be crushed stone or gravel aggregate. Materials used should conform to standard bedding material as specified in City of Austin Standard Specification Item 510 Section *Standard Bedding Materials* or pipe manufactures recommendations. We recommend the gravel be wrapped with a suitable geotextile fabric (such as Mirafi 140N or equivalent) to help minimize the intrusion of fine-grained soil particles into the drain system. The bedding material should be installed in a continuous envelope extending the full width of the trench. Bedding depth should extend 6-inches below the bottom of the pipe. Consideration shall also be given to construct impervious cutoff collars to minimize particle migration from, into or through the bedding material.

Initial backfill should extend from the bedding material to a depth no less than 12 inches above the top of the pipe. The gravel should be placed in 12 inch maximum loose lifts and vibrated. Due to the clay soil encountered along the pipeline alignment, it is not recommended that water jetting be allowed to consolidate the backfill for this project.

Backfill

Above the gravel backfill, natural on-site clays (trench spoils) should be used as secondary backfill. The secondary backfill should be placed in loose lifts not exceeding 12 inches in thickness and compacted to at least 95 percent of the maximum dry density as determined by TxDOT, Tex-114-E, Compaction Test. Refer to City of Austin Standard Specification Item No. 510 section titled *Backfill in Street Right-of-Way* and *Backfill in Easements* for additional details. The use of a geotechnical filter fabric, such as Mirafi 140N, shall be considered between the gravel and the on-site fill material to prevent the long-term migration of the fine grained soil particles into the voids in the compacted gravel backfill.

Placement and compaction of backfill around the pipes will be critical. If the backfill is not properly compacted, the ground above the pipeline could be subject to significant settlements. Flowable fill may be considered for use as backfill in restricted work areas that prevent proper compaction of granular backfill materials. The flowable fill should be relatively low strength (less than 100 psi) for ease of excavation for repairs.

Special backfill provisions will need to be implemented for trenches with deep fills within the street right-of-way to prevent excessive settlement.

Settlement

Deep backfill of utility trenches may be prone to settlement if the material is not compacted in controlled lifts. We recommend that a technician or inspector be employed full-time to monitor the backfill of the trench. It has been our experience that little oversight and intermittent testing leads to large gaps in documented results and excessive settlement especially with deep trenches. Depending on the type of fill material utilized, the thickness of the lifts, and moisture control, we estimate the fill will experience on the order of two to four percent settlement.

Other than a proposed crossing at the future Braker Lane extension alignment, we understand that the majority of the trench backfill will occur in the public utility easement. Furthermore, we understand that there are no plans to place sensitive structures over the utility line alignment, such as buildings, bridges, culverts, or other structures. Therefore, it may be prudent to implement one of the alternates to reduce settlement in the area of the proposed roadway crossing as described in the following section.

Alternatives to Reduce Trench Backfill Settlement

To reduce the potential for settlement in utility trenches, bore pits, or around manholes at areas sensitive to excessive settlement, we recommend that consideration be given to the following:

- Consider using Controlled Low Strength Material (CSLM) as backfill to minimize settlements along trench alignments and around manhole structures. The CSLM shall meet the City of Austin Standard Specification, Item 402S.
- Consider Cement Stabilized sand in lieu of CSLM for use as backfill to minimize settlements along trench alignments and manhole structures. The cement stabilized sand shall meet the City of Austin Standard Specification Item 403S.
- The use of wrapping free-draining bedding gravels with a geotextile fabric (similar to Mirafi 140N) to reduce the infiltration and loss of fines from backfill material into the interstitial voids in bedding materials will also minimize trench backfill settlements.
- If trench backfill spoils are utilized, we recommend a combination of reducing the maximum lift thickness to 8 inches and increasing the compactive effort to 100 percent of the laboratory determined maximum dry density.

Controlled Low Strength Material Controlled Low Strength Material (CSLM) shall meet the City of Austin Standard Specification, Item 402S. The CSLM strength shall have a minimum 28-day compressive strength of 300 psi.

Cement Stabilized Sand Cement Stabilized Sand shall be proportioned by mixing 2 bags of Portland cement to one cubic yard of sand. The sand shall meet the "Fine Aggregates" requirement specified in the City of Austin Standard Specification, Item 403S.

MANHOLE FOUNDATION DESIGN CRITERIA

We understand that manholes will be installed along the alignment of the wastewater interceptor and effluent lines. Based on our review of the profile plans and the anticipated invert elevation depths, the manholes are anticipated to bear on clay or clayey sand. An allowable bearing capacity of 2,100 pounds per square foot (psf) may be utilized for support of the manholes.

Since the manhole structures will act as below grade structures, the designer should also refer to the *Retaining Structures* section of this report.

PAVEMENT RECOMMENDATIONS

Recommendations for both flexible and rigid pavements are presented in this report. The Owner and/or design team may select either pavement type depending on the performance criteria established for the project. In general, flexible pavement systems have a lower initial construction cost as compared to rigid pavements. However, maintenance requirements over the life of the pavement are typically much greater for flexible pavements. This typically requires regularly scheduled observation and repair, as well as overlays and/or other pavement rehabilitation at approximately one-half to two-thirds of the design life. Rigid pavements are generally more "forgiving", and therefore tend to be more durable and require less maintenance after construction.

For either pavement type, drainage conditions will have a significant impact on long term performance, particularly where permeable base materials are utilized in the pavement section. Drainage considerations are discussed in more detail in a subsequent section of this report.

SUBGRADE CONDITIONS

We have assumed the subgrade in pavement areas will consist of the Stratum I or II on-site clays, placed and compacted as recommended in the *On-Site Clay Fill* section of this report. Based on our experience with similar subgrade soils, we have assigned a California Bearing Ratio (CBR) value of 2.5 for use in pavement thickness design analyses.

VEHICLE FREQUENCY INFORMATION

Based on information provided to us by Bury + Partners, we understand that a total of 93 heavy trucks per month (3.1 heavy trucks per day) will frequent the wastewater treatment plant facility. The approximate weights of the heavy trucks being considered is approximately 45,000 lbs. In addition, we have assumed a passenger car frequency of no more than 75 vehicles per day.

EQUIVALENT 18-KIP SINGLE AXLE LOAD

Design equivalent 18-kip single axle loads were estimated for the private drive utilizing the AASHTOWare DARWin 3.1.01, Pavement Design and Analysis System. DARWin is a software program published by the American Association of State Highway and Transportation Officials (AASHTO) and is based on the 1993 edition of the AASHTO “Guide for the Design of Pavement Structures.” The estimated values have been provided in the table below.

Location	Performance Period	Two Way Traffic (ADT)	Percent of Trucks in Design Lane	Percent of Trucks in Design Direction	Truck Factor	Percent Growth	Design Equivalent 18-kip Single Axle Load
Wastewater Treatment Plant Road	20 years	80	3%	100%	1.6	2%	50,000

Structural Number

To determine the required design structural number (SN) values, the DARWin program was utilized. The values presented below are based upon the traffic loading and subgrade conditions as well as the other design inputs as shown in the table.

The required structural numbers related to the CBR value of the pavement subgrade and the amount of traffic that the pavement will carry over its service life. The CBR provides an estimate of the relative strength of the subgrade and consequently indicates the ability of the pavement section to carry load. This site specific CBR value is utilized in conjunction with the above specified parameters to determine the required SN for use in the design of the pavement section. The following pavement design parameters provided below were also utilized in our analysis.

Location	Design Equivalent 18-kip Single Axle Load	Serviceability Initial/Terminal	Standard Deviation	Structural Number
Wastewater Treatment Plant Road	50,000	4.2/2.2	0.44	2.60

FLEXIBLE PAVEMENT

The following flexible pavement sections are applicable for parking and drive areas associated with the wastewater treatment plant facility.

FLEXIBLE PAVEMENTS SECTION	
Layer Description	**Layer Thickness**
HMAC Surface Course, Type "D"	2.0 in.
Flexible Base, Grade 2 or Better	9.0 in.*
Lime Treated Subgrade	8.0 in.
Combined Total	19.0 in.

*Geogrid reinforcement to be placed below the flexible base layer

We recommend the use of a geogrid base reinforcement (such as Tensar TriAx TX 5), which provides considerable tensile strength to the pavement section. This tensile strength is achieved without making the section more brittle, as occurs with many other subgrade or base stabilization methods. The added tensile strength and flexibility allows the pavement section to move and flex, as the expansive clay subgrade undergoes the normal shrink and swell with changes in climatic conditions, with considerably less cracking and premature deterioration than otherwise typically occurs. Our experience indicates that the additional cost of the geogrid will be recovered several times over in decreased maintenance costs.

Although geogrid has been provided as an option to increase tensile strength in the pavement section and longitudinal cracking, the underlying expansive clay soils will still be subjected to the same expansive

soil-related movements previously discussed. For better performance enhancement and ride ability of the private drive deep soil stabilization will be required such as overexcavation and select fill replacement will be required.

LONGITUDINAL CRACKING

It should be understood that asphalt pavement sections in highly expansive soil environments, such as those encountered at this site, can develop longitudinal cracking along unprotected pavement edges. In the semi-arid climate of central Texas this condition typically occurs along the unprotected edges of pavements where the adjoining grounds are not developed, i.e. not landscaped/irrigated or otherwise maintained.

The longitudinal cracking generally occurs between 2 to 4 feet inside of and parallel to the unprotected edges of the pavement. The occurrence of these cracks can be more prevalent in the absence of lateral restraint and steep embankments. Differential drying and shrinkage of the highly expansive clay subgrade between the exposed pavement edge and that beneath the pavement section commonly causes the cracking. This problem can best be addressed by providing either a horizontal or vertical moisture barrier at the unprotected pavement edge.

A horizontal barrier is commonly in the form of a paved shoulder extending 8 feet or greater beyond the edge of the pavement. Other methods of shoulder treatment, such as using geofabrics beyond the edge of the roadway, are sometimes used in an effort to help reduce longitudinal cracking. Although this alternative does not eliminate the longitudinal cracking phenomenon, the location of the cracking is transferred to the shoulder rather than within the traffic lane.

Vertical barriers installed along the unprotected edges of roadway pavements are also effective in preventing non-uniform drying and shrinkage of the subgrade clays. These barriers are typically in the form of a vertical moisture barrier/membrane extending a minimum of 6 feet below the top of the subgrade at the pavement edge. Both types of barriers must be sealed at the edge of the pavement to prevent a crack that would facilitate the drying of the subgrade clays.

A more economical alternative, which will not limit the shrinkage of the underlying subgrade clays but may reduce the occurrence of longitudinal, cracking, is the use of a geogrid base reinforcement in the pavement section. Geogrid gives the pavement section a tensile strength component that is not otherwise inherent in a typical flexible base pavement section.

OPTIONS FOR REDUCING EXPANSIVE SOIL RELATED MOVEMENTS

Subgrade soils that are highly expansive when water is introduced (i.e. highly plastic soils) will heave, causing the pavement to become rough or uneven over time. Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle costs, fuel consumption, and maintenance costs. Pavement heave can be reduced through various measures but cannot be totally eliminated without full removal of the problematic soil. Measures available for reducing heave include:

- Soil Stabilization with Lime or Other Pozzolans
- Removal and Replacement of High PI Soils
- Drains or Barriers to Collect or Inhibit Moisture Infiltration

Soil stabilization with lime is typically used to reduce the swelling potential of the upper portion of the pavement subgrade containing moderately plastic soils. Lime and water are mixed with the top 6 to 12 inches (or possibly more) of the subgrade and allowed to mellow or cure for a period of time. After mellowing the soil-lime mixture is compacted to form a strong soil matrix that can improve pavement performance and potentially reduce soil heave. However, in highly plastic soils, lime stabilization of only the top portion of the expansive subgrade may not provide an acceptable reduction in PVR. For a more substantial reduction in PVR, removal and replacement of the high PI soil may be the only method available to reduce the potential vertical rise of the pavement to an acceptable level. As stated previously though, it must be recognized that partial removal of expansive clay soil only reduces the potential (or risk) of the damage swell can cause to a pavement and does not completely eliminate this risk.

In addition, capturing water infiltration via French drains, pavement edge drains, or inhibiting water through the use of vertical moisture barriers would reduce the potential for heave since one important component of the heaving mechanism, water, would be reduced.

The pavement sections derived in the previous sections are structurally adequate for the given traffic levels and existing clay subgrade strength, but are not intended be able to overcome the long-term effects of pavement roughness due to heave, which can only be addressed by the measures discussed in this section.

RIGID PAVEMENT

We recommend that rigid pavements be considered in areas of channelized traffic, particularly in areas where truck traffic is planned, and particularly where such traffic will make frequent turns. We recommend that rigid pavement sections at this site consist of the following:

Traffic Type	Portland Cement Concrete	Lime Treated Subgrade
Waste Water Treatment Plant Road	5 in.	8 in.

We recommend that the concrete pavements be reinforced with welded wire mats or bar mats. As a minimum, the bar mats should be No. 3 reinforcing bars spaced 18 inches on center in both directions. The concrete reinforcing should be placed approximately 1/3 the slab thickness below the surface of the slab, but not less than 2 in. The reinforcing should not extend across expansion joints.

Joints in concrete pavements aid in the construction and control the location and magnitude of cracks. Where practical, lay out the construction, expansion, control and sawed joints to form square panels, but not to exceed ACI 302.69 Code recommendations. The ratio of slab length-to-width should not exceed 1.25. Recommend maximum joint spacings are 12 ft longitudinal and 12 ft transverse.

All control joints should be formed or sawed to a depth of at least 1/4 the thickness of the concrete slab. Sawing of control joints should begin as soon as the concrete will not ravel, generally the day after placement. Control joints may be hand formed or formed by using a premolded filler. We recommend that all longitudinal and transverse construction joints be dowelled to promote load transfer. Isolation joints are needed to separate the concrete slab from fixed objects such as drop inlets, light standards and buildings. Expansion joint spacings are not to exceed a maximum of 75 ft and no expansion or construction joints should be located in a swale or drainage collection locations.

If possible, the pavement should develop a minimum slope of 0.015 ft/ft to provide surface drainage. Reinforced concrete pavement should cure a minimum of 3 and 7 days before allowing automobile and truck traffic, respectively.

PAVEMENT CONSTRUCTION CONSIDERATIONS

SUBGRADE PREPARATION

Areas to support pavements should be stripped of all vegetation and organic topsoil and the exposed subgrade should be proofrolled in accordance with the recommendations in the *Site Preparation* section under *Foundation Construction Considerations*.

DRAINAGE CONSIDERATIONS

As with any soil-supported structure, the satisfactory performance of a pavement system is contingent on the provision of adequate surface and subsurface drainage. Insufficient drainage which allows saturation of the pavement subgrade and/or the supporting granular pavement materials will greatly reduce the performance and service life of the pavement systems.

Surface and subsurface drainage considerations crucial to the performance of pavements at this site include (but are not limited to) the following:

1. Any known natural or man-made subsurface seepage at the site which may occur at sufficiently shallow depths as to influence moisture contents within the subgrade should be intercepted by drainage ditches or below grade French drains.
2. Final site grading should eliminate isolated depressions adjacent to curbs which may allow surface water to pond and infiltrate into the underlying soils. **Curbs should completely penetrate base materials and should be installed to sufficient depth to reduce infiltration of water beneath the curbs**.
3. Pavement surfaces should be maintained to help minimize surface ponding and to provide rapid sealing of any developing cracks. These measures will help reduce infiltration of surface water downward through the pavement section.

ON-SITE CLAY FILL

As discussed previously, the pavement recommendations presented in this report were prepared assuming that on-site soils will be used for fill grading in proposed pavement areas. If used, we recommend that on-site soils be placed in loose lifts not exceeding 8 inches in thickness and compacted to

at least 95 percent of the maximum density as determined by TxDOT, Tex-114-E. The moisture content of the fill should be maintained within the range of optimum water content to 3 percentage points above the optimum water content until permanently covered. We recommend that fill materials be free of roots and other organic or degradable material. We also recommend that the maximum particle size not exceed 4 in. or one half the lift thicknesses, whichever is smaller.

LIME TREATMENT OF SUBGRADE

Lime treatment of the subgrade soils, if utilized, should be in accordance with the TxDOT Standard Specifications, Item 260. A sufficient quantity of hydrated lime should be mixed with the subgrade soils to reduce the soil-lime mixture plasticity index to 15 or less. For estimating purposes, we recommend that 6 percent lime by weight be assumed for treatment. For construction purposes, we recommend that the optimum lime content of the subgrade soils be determined by laboratory testing. Lime-treated subgrade soils should be compacted to a minimum of 95 percent of the maximum density at a moisture content within the range of optimum moisture content to 3 percentage points above the optimum moisture content as determined by Tex-114-E.

If lime treatment is considered as a method to improve pavement subgrade conditions, it is also recommended to perform additional laboratory testing to determine the concentration of soluble sulfates in the subgrade soils, in order to investigate the potential for a recently reported adverse reaction to lime in certain sulfate-containing soils. The adverse reaction, referred to as sulfate-induced heave, has been known to cause cohesive subgrade soils to swell in short periods of time, resulting in pavement heaving and possible failure.

GEOGRID REINFORCEMENT

The geogrid reinforcement should be Tensar TriAx TX 5. An approved source of geogrid is The Tensar Corporation, Morrow, GA or their designated representative. The geogrid component shall be integrally formed and produced from a punched sheet of polypropylene which is then oriented in three substantially equilateral directions so that the resulting ribs shall have a high degree of molecular orientation, which continues at least in part through the mass of the integral node. The resulting geogrid structure shall have apertures that are triangular in shape, and shall have ribs with a depth-to-width ratio greater than 1.0.

The geogrid shall have the nominal characteristics shown in the table below, and shall be certified in writing by the manufacturer to be TX5:

Properties	Longitudinal	Diagonal	Transverse	General
Rib pitch, mm(in)	40 (1.60)	40 (1.60)	--	--
Mid-rib depth, mm (in)	--	1.3 (0.05)	1.2 (0.05)	--
Mid-rib width, mm (in)	--	0.9 (0.04)	1.1 (0.045)	--
Rib Shape	--	--	--	rectangular
Aperture Shape	--	--	--	triangular

Prior to placing the geogrid, the subgrade shall be prepared as indicated in the *Site Preparation* section of this report. The geogrid shall be placed at the proper elevation and orientation as presented in the plans and the manufacturer's recommendations. The geogrid shall be placed to provide a minimum of 1-ft overlap or as directed by the plans or manufacturer's recommendations. The geogrid may be temporarily secured using stakes, sand bags, pins, zip ties, or other means necessary to keep the geogrid at place until fill placement operations are implemented. Other means of temporarily securing the geogrid may be directed by the Engineer.

The aggregate shall be placed over the geogrid according to the construction plans and at the specified lift depth. The aggregate shall be placed, spread and compacted in a manner that minimizes the development of wrinkles and movement in the geogrid. A 6-inch minimum thickness of loose fill shall be placed prior to operation of tracked vehicles over the geogrid. The construction equipment should keep turning to a minimum to prevent displacement of the fill and damage to the geogrid. Rubber tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) avoiding sudden braking and sharp turning movements. Repair any damage caused during placement or by vehicles.

The geogrid should be placed at the bottom of the flexible (granular) base section in all cases. An alternative to the above geogrid should not be considered without approval from **RKCI**.

FLEXIBLE BASE COURSE

The flexible base course should be crushed limestone conforming to TxDOT Standard Specifications, Item 247, Type A, Grades 1 or 2. Base course should be placed in lifts with a maximum thickness of 8 inches and compacted to a minimum of 100 percent of the maximum density at a moisture content within the range of 2 percentage points below to 2 percentage points above the optimum moisture content as determined by Tex-113-E.

ASPHALTIC CONCRETE SURFACE COURSE

The asphaltic concrete surface course should conform to TxDOT Standard Specifications, Item 340, Type D. The asphaltic concrete should be compacted to a minimum of 92 percent of the maximum theoretical specific gravity (Rice) of the mixture determined according to Test Method Tex-227-F. Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method Tex-207-F. The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from project roadway specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required roadway specimens at their expense and in a manner and at locations selected by the Engineer.

PORTLAND CEMENT CONCRETE

The Portland cement concrete used for pavement construction should meet the TxDOT, Standard Specifications. We have estimated the rigid concrete pavement thicknesses utilizing a concrete compression strength of 4,000 psi. A liquid membrane-forming curing compound should be applied as soon as practical after broom finishing the concrete surface. The curing compound will reduce the loss of water from the concrete. The reduction in the rapid loss in water will reduce shrinkage cracking of the concrete.

MISCELLANEOUS PAVEMENT RELATED CONSIDERATIONS

Drainage Considerations

As with any soil-supported structure, the satisfactory performance of a pavement system is contingent on the provision of adequate surface and subsurface drainage. Insufficient drainage which allows saturation of the pavement subgrade and/or the supporting granular pavement materials will greatly reduce the performance and service life of the pavement systems.

Surface and subsurface drainage considerations crucial to the performance of pavements at this site include (but are not limited to) the following:

- Any known natural or man-made subsurface seepage at the site which may occur at sufficiently shallow depths as to influence moisture contents within the subgrade should be intercepted by drainage ditches or below grade French drains.
- Final site grading should eliminate isolated depressions adjacent to curbs, which may allow surface water to pond and infiltrate into the underlying soils. Curbs should be installed to a sufficient depth to reduce infiltration of water beneath the curbs and into the pavement base materials.
- Pavement surfaces should be maintained to help minimize surface ponding and to provide rapid sealing of any developing cracks. These measures will help reduce infiltration of surface water downward through the pavement section.

Utilities

Our experience indicates that significant settlement of backfill can occur in utility trenches, particularly when trenches are deep, when backfill materials are placed in thick lifts with insufficient compaction, and when water can access and infiltrate the trench backfill materials. The potential for water to access the backfill is increased where water can infiltrate flexible base materials due to insufficient penetration of curbs, and at sites where geological features can influence water migration into utility trenches (such as fractures within a rock mass or at contacts between rock and clay formations). It is our belief that another factor which can significantly impact settlement is the migration of fines within the backfill into the open voids in the underlying free-draining bedding material.

To reduce the potential for settlement in utility trenches, we recommend that consideration be given to the following:

- All backfill materials should be placed and compacted in controlled lifts appropriate for the type of backfill and the type of compaction equipment being utilized and all backfilling procedures should be tested and documented.
- Consideration should be given to wrapping free-draining bedding gravels with a geotextile fabric (similar to Mirafi 140N) to reduce the infiltration and loss of fines from backfill material into the interstitial voids in bedding materials.

Curb and Gutter

It is good practice to construct curbs such that the depth of the curb extends through the entire depth of the granular base material to act as a protective barrier against the infiltration of water into the granular base. Pavements that do not have this protective barrier to moisture are more susceptible to develop longitudinal cracks 1 to 2 ft from the edge of the pavement. Once these cracks develop, further degradation and weakening of the underlying granular base may occur due to water seepage through the cracks.

Pavement Maintenance

Regular pavement maintenance is critical in maintaining pavement performance over a period of several years. All cracks that develop in asphalt pavements should be regularly sealed. Areas of moderate to severe fatigue cracking (also known as alligator cracking) should be sawcut and removed. The underlying base should be checked for contamination or loss of support and any insufficiencies fixed or removed and the entire area patched.

Construction Traffic

Construction traffic on prepared subgrade, granular base should be restricted as much as possible until the protective asphalt surface pavement is applied. Significant damage to the underlying layers resulting in weakening may occur if heavily loaded vehicles are allowed to use these areas.

CONSTRUCTION RELATED SERVICES

CONSTRUCTION MATERIALS TESTING AND OBSERVATION SERVICES

As presented in the attachment to this report, *Important Information About Your Geotechnical Engineering Report*, subsurface conditions can vary across a project site. The conditions described in this report are based on interpolations derived from a limited number of data points. Variations will be encountered during construction, and only the geotechnical design engineer will be able to determine if these conditions are different than those assumed for design.

Construction problems resulting from variations or anomalies in subsurface conditions are among the most prevalent on construction projects and often lead to delays, changes, cost overruns, and disputes. These variations and anomalies can best be addressed if the geotechnical engineer of record, **RKCI** is retained to perform construction observation and testing services during the construction of the project. This is because:

- **RKCI** has an intimate understanding of the geotechnical engineering report's findings and recommendations. RKCI understands how the report should be interpreted and can provide such interpretations on site, on the client's behalf.
- **RKCI** knows what subsurface conditions are anticipated at the site.
- **RKCI** is familiar with the goals of the owner and project design professionals, having worked with them in the development of the geotechnical workscope. This enables RKCI

to suggest remedial measures (when needed) which help meet the owner's and the design teams' requirements.

- **RKCI** has a vested interest in client satisfaction, and thus assigns qualified personnel whose principal concern is client satisfaction. This concern is exhibited by the manner in which contractors' work is tested, evaluated and reported, and in selection of alternative approaches when such may become necessary.
- **RKCI** cannot be held accountable for problems which result due to misinterpretation of our findings or recommendations when we are not on hand to provide the interpretation which is required.

BUDGETING FOR CONSTRUCTION TESTING

Appropriate budgets need to be developed for the required construction testing and observation activities. At the appropriate time before construction, we advise that **RKCI** and the project designers meet and jointly develop the testing budgets, as well as review the testing specifications as it pertains to this project.

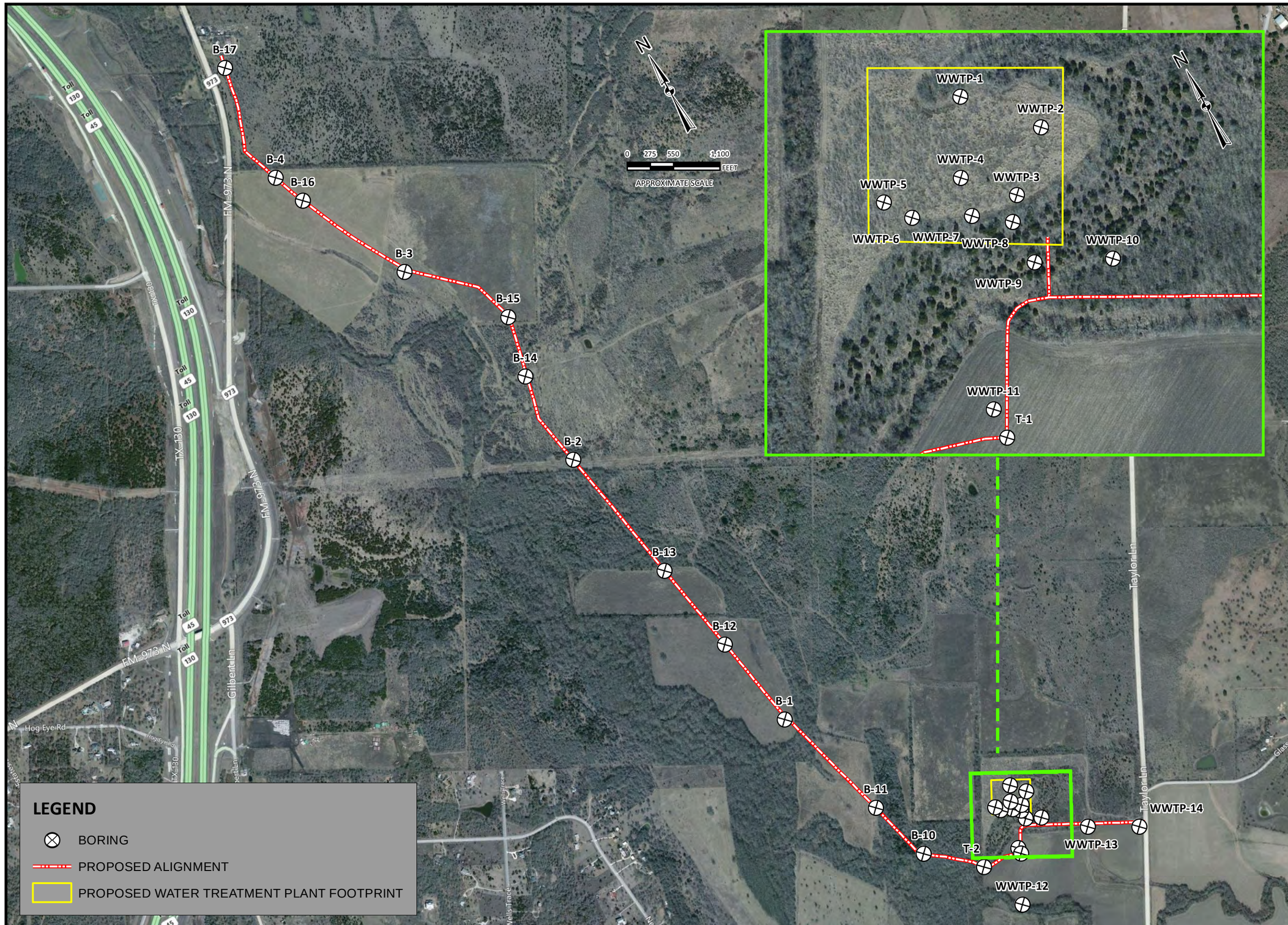
Once the construction testing budget and scope of work are finalized, we encourage a preconstruction meeting with the selected contractor to review the scope of work to make sure it is consistent with the construction means and methods proposed by the contractor. **RKCI** looks forward to the opportunity to provide continued support on this project, and would welcome the opportunity to meet with the Project Team to develop both a scope and budget for these services.

* * * * * * * * * * * * * * * * * * *

The following figures are attached and complete this report:

Figure 1	Boring Location Map
Figures 2 through 19	Logs of Borings
Figure 20	Key to Terms and Symbols
Figure 21	Results of Soil Analyses
Figures 22 through 31	Preliminary Log of Borings
Figure 32	Preliminary Results of Soil Analyses

ATTACHMENTS



NOTE: This Drawing is Provided for Illustration Only, May Not be to Scale and is Not Suitable for Design or Construction Purposes

RABA KISTNER CONSULTANTS

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TBPE Firm Number 3257

SOURCE: 2011 Aerial Photograph Provided by Bing Maps

BORING LOCATION MAP

WHISPER VALLEY INTERCEPTOR & WASTE WATER TREATMENT PLANT
TRAVIS COUNTY, TEXAS

REVISIONS:

No.	DATE	DESCRIPTION	

PROJECT No.: AAA11-031-01

ISSUE DATE:	06/07/2012
DRAWN BY:	CCL
CHECKED BY:	YLG
REVIEWED BY:	GO

FIGURE

1

© 2012 by Raba Kistner Consultants, Inc.

LOG OF BORING NO. B-10

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 36+50

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Dark Gray, Moist				37	
5			**CLAY (CH),** Fat, Hard, Tan, Moist					
			- damp, 8 to 15 ft					
10								
							40	
15								
20								
					117	6.00		
25								
30								
			CLAY (CH), Fat, Hard, Red-Brown, Moist					
					113	5.00		
35								
40								
45			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
50								
55								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	40.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/28/2012	**DATE MEASURED:**	3/28/2012	**FIGURE:**	2

LOG OF BORING NO. B-11

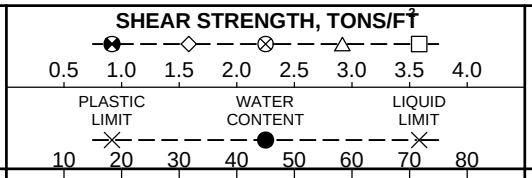
Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 45+00

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Stiff to Very Stiff, Dark Gray to Gray, Moist			44	
5			- hard below 4 ft		113		
			- with calcareous nodules below 8 ft			42	
10			**CLAY (CH),** Fat, Very Stiff, Tan and Gray, Moist				
15							
20					106		
25			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
30							
35							
40							
45							
50							
55							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	20.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	3

LOG OF BORING NO. B-12

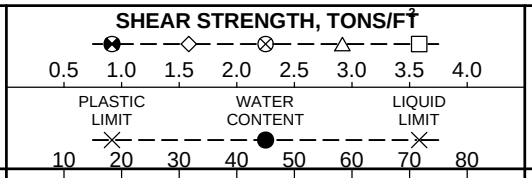
Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 71+50

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff to Hard, Dark Gray to Gray, Moist				
5			- with calcareous nodules below 4 ft			41	
			CLAY (CH), Fat, Hard, Tan, Damp			36	
10							
			CLAY (CH), Fat, Hard, Red-Brown, Moist, with sand and gravel	ref/6"			77
15							
			CLAY (CH), Fat, Very Stiff, Tan and Gray, Moist		104		
20							
25			NOTES: 1. Free water was encountered at a depth of 17 ft during drilling operations. 2. Borehole was backfilled with auger cuttings.				
30							
35							
40							
45							
50							
55							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	20.0 ft	**DEPTH TO WATER:**	17 ft	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	4

LOG OF BORING NO. B-13

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 83+00

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff to Hard, Dark Gray to Gray, Moist				39	
5					113			
			- damp below 6 ft					
			CLAY (CH), Fat, Hard, Tan, Moist					
10								
			CLAY (CH), Fat, Very Stiff, Tan and Gray, Moist			96	70	
15								
			- with gypsum crystals at 18 ft		96			
20								
25			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
30								
35								
40								
45								
50								
55								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	20.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	5

LOG OF BORING NO. B-14

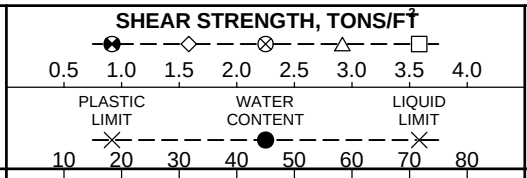
Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 111+50

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Moist to Damp, with calcareous deposits			45	
5			**CLAYEY SAND (SC),** Medium Dense, Tan, Dry, with gravel				28
			SAND (SP), Medium Dense, Red-Brown, Dry, with clay	27			6
10			**CLAY (CH),** Fat, Very Stiff to Hard, Tan and Gray, Moist			49	
15					112		
20							
25			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
30							
35							
40							
45							
50							
55							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	20.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	6

LOG OF BORING NO. B-15

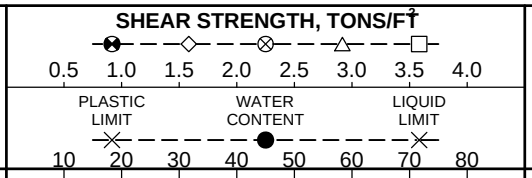
Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 118+50

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Dark Gray, Moist			44	
5			**CLAY (CH),** Fat, Hard, Tan, Moist			40	
10			**CLAY (CH),** Fat, Hard, Tan and Gray, Moist				
15							
20					110		
25			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
30							
35							
40							
45							
50							
55							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	20.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	7

LOG OF BORING NO. B-16

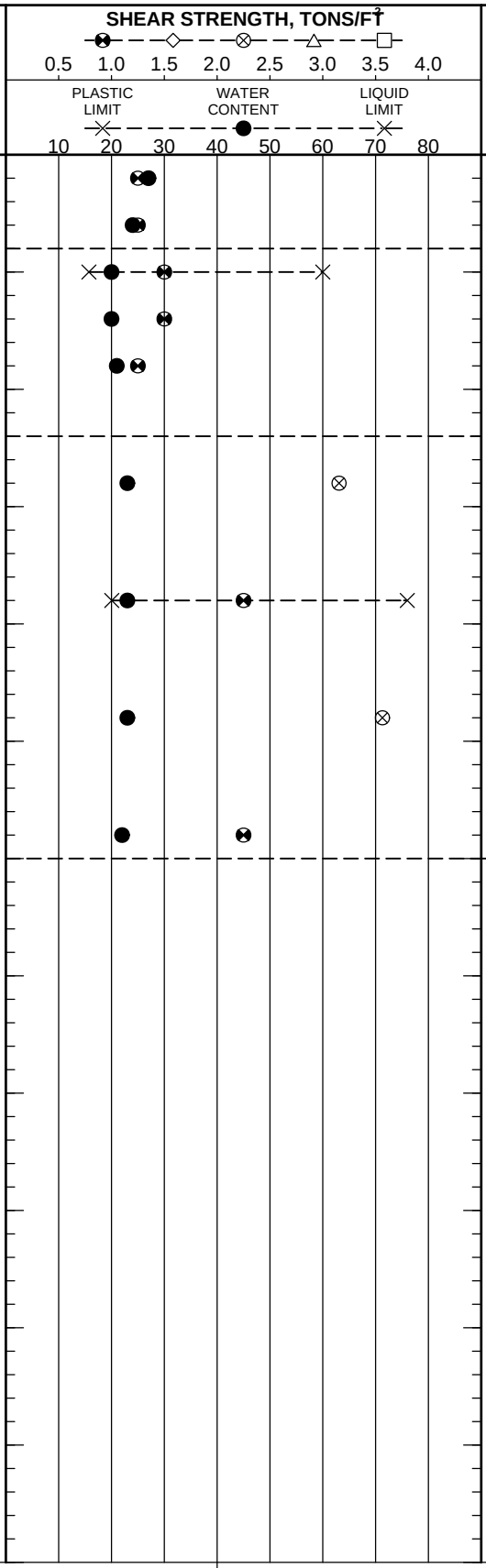
Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 147+50

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Dark Gray, Moist				
5			**CLAY (CH),** Fat, Very Siff, Tan, Moist			44	
10							
			CLAY (CH), Fat, Hard, Tan and Gray, Moist				
15					101		
20						56	
25					103		
30							
35			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
40							
45							
50							
55							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	30.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	8

LOG OF BORING NO. B-17

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: 166+00

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0; PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT; 10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Stiff to Hard, Dark Gray to Gray, Moist				39	
5			- damp below 6 ft					
10			**CLAY (CH),** Fat, Hard, Tan, Damp to Moist				40	
15								
20					115			
			CLAY (CH), Fat, Hard, Tan and Gray, Moist					
25								
30					113	6.00		
35			NOTES: 1. Free water was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
40								
45								
50								
55								

DEPTH DRILLED:	30.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	9

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

LOG OF BORING NO. WWTP-5

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27028; W 97.55333

SURFACE ELEVATION: 444.75 ft

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	CLAY (CH), Fat, Hard, Dark Gray, Moist				
	CLAY (CL), Lean, Hard, Light Brown to Tan, Moist, with calcareous nodules			25	
5			122		
				32	
10					
	CLAY (CH), Fat, Hard, Red-Brown, Moist				
15					
				46	
20					
			116		
25					
	CLAYEY SAND (SC), Very Dense, Tan, Dry	ref/5"		8	30
30					
	SILTY, CLAYEY SAND (SC-SM), Very Dense, Tan, Dry	ref/5"			
35					
		ref/4.5"			
40					
		ref/4"		7	32
45					
		ref/4"			
50					
55					

SYMBOL

SAMPLES

SHEAR STRENGTH, TONS/FT^2: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10, 20, 30, 40, 50, 60, 70, 80

6.00

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	50.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	10

LOG OF BORING NO. WWTP-6

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27000; W 97.55306

SURFACE ELEVATION: 442.5 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0; PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT; 10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff to Hard, Dark Gray to Gray, Moist				44	
			CLAY (CH), Fat, Hard, Red-Brown, Moist		117	6.00		
			CLAYEY SAND (SC), Medium Dense, Tan, Damp		128	5.00	21	
			SILTY, CLAYEY SAND (SC-SM), Very Dense, Tan, Dry	50/5"				

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	11

LOG OF BORING NO. WWTP-7

Raba Kistner
TBPE Firm Registration No. F-3257

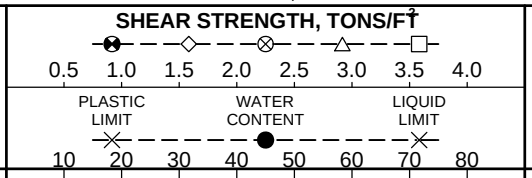
Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26972; W 97.55278

SURFACE ELEVATION: 442.5 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Gray, Moist, with roots and gravel				
			CLAY (CL), Lean, Very Stiff to Hard, Tan, Moist, with calcareous deposits			33	
5					117		
			CLAY (CH), Fat, Hard, Red-Brown, Moist			46	
10							
15							
20					132		
			SILTY, CLAYEY SAND (SC-SM), Very Dense, Tan, Dry	50/5.5"			
25							
30							
35							
40							
45							
50							
55							



NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/7/2012	**DATE MEASURED:**	3/7/2012	**FIGURE:**	12

LOG OF BORING NO. WWTP-8

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26972; W 97.55250

SURFACE ELEVATION: 442.5 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Gray, Moist, with calcareous deposits					
			CLAY (CH), Very Stiff to Hard, Tan, Moist		113			
5							38	
			CLAY (CH), Fat, Hard, Red-Brown, Moist					
10							49	
					115	6.00		
15								
			CLAYEY SAND (SC), Medium Dense, Tan, Damp	ref/4"				
20								
			SILTY, CLAYEY SAND (SC-SM), Very Dense, Tan, Dry	ref/3"				
25								
30								
35								
40								
45								
50								
55								

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	13

LOG OF BORING NO. WWTP-9

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26944; W 97.55250

SURFACE ELEVATION: 434 ft

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	CLAY (CL), Lean, Stiff to Very Stiff, Tan, Moist			22	
5	**CLAY (CH),** Fat, Hard, Red-Brown, Moist		109		
10					
15					
20	**CLAYEY SAND (SC),** Very Dense, Tan, Dry	ref/5.5"		15	
25	**SILTY, CLAYEY SAND (SC-SM),** Very Dense, Tan, Dry	50/1"			
30		50/11"			
35	**SILTY SAND (SM),** Very Dense, Tan, Dry	50/5.5"			
40		50/5"		NP	
45	**SILTY, CLAYEY SAND (SC-SM),** Very Dense, Tan, Dry	50/1.5"			
50		50/1"			
55					

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

DEPTH DRILLED:	50.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/28/2012	**DATE MEASURED:**	3/28/2012	**FIGURE:**	14

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

LOG OF BORING NO. WWTP-10

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26917; W 97.55194

SURFACE ELEVATION: 433.5 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CL), Lean, Very Stiff, Gray, Moist			25	
			CLAY (CH), Fat, Very Stiff, Gray, Moist		111	44	
			CLAY (CH), Fat, Hard, Tan, Damp				
			SILTY, CLAYEY SAND (SC-SM), Very Dense, Tan, Dry	ref/6"			
				ref/4"			
				ref/4"			

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/8/2012	**DATE MEASURED:**	3/8/2012	**FIGURE:**	15

LOG OF BORING NO. WWTP-11

Raba Kistner
TBPE Firm Registration No. F-3257

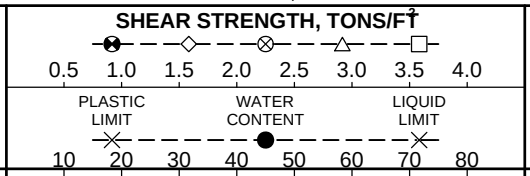
Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26861; W 97.55333

SURFACE ELEVATION: 427.5 ft

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0–12.5	**CLAY (CH),** Fat, Very Stiff, Dark Gray, Moist				
12.5–22.5	**CLAY (CH),** Fat, Very Stiff, Brown, Moist				
22.5–42.5	**CLAYEY SAND (SC),** Dense to Medium Dense, Tan, Damp	30	122	9	46
42.5–50	**SILTY, CLAYEY SAND (SC-SM),** Dense to Very Dense, Tan, Dry	50/11"			
		35		4	28
		40			
		50			
50–55	**CLAYEY SAND (SC),** Dense to Medium Dense, Tan, Damp	36		10	16
		22			



NOTES:
1. Free water was encountered at a depth of 48 ft during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	50.0 ft	**DEPTH TO WATER:**	48 ft	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	4/9/2012	**DATE MEASURED:**	4/9/2012	**FIGURE:**	16

LOG OF BORING NO. WWTP-12

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26694; W 97.55417

SURFACE ELEVATION: 422 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Very Stiff, Dark Gray, Moist					
			CLAY (CH), Fat, Very Stiff, Brown to Tan, Damp					
5			- hard below 6 ft				36	
10								
15			**CLAYEY SAND (SC),** Very Dense to Medium Dense, Tan, Dry					
20				50/11"				14
25				27				
30								
35								
40								
45								
50								
55								

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	4/9/2012	**DATE MEASURED:**	4/9/2012	**FIGURE:**	17

LOG OF BORING NO. WWTP-13

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26806; W 97.55056

SURFACE ELEVATION: 424 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT^2 (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Moist					
			CLAY (CH), Fat, Very Stiff to Hard, Brown, Moist					
5								
10								
15								
20								
25								
30								
35								
40								
45								
50								
55								

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	5.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	4/9/2012	**DATE MEASURED:**	4/9/2012	**FIGURE:**	18

LOG OF BORING NO. WWTP-14

Raba Kistner
TBPE Firm Registration No. F-3257

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26722; W 97.54889

SURFACE ELEVATION: 425 ft

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT^2 (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Stiff to Very Stiff, Tan, Wet					
			CLAY (CH), Fat, Hard, Red-Brown, Moist				44	
5								
10								
15								
20								
25								
30								
35								
40								
45								
50								
55								

NOTES:
1. Free water was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	5.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-01
DATE DRILLED:	3/28/2012	**DATE MEASURED:**	3/28/2012	**FIGURE:**	19

KEY TO TERMS AND SYMBOLS

MATERIAL TYPES

SOIL TERMS

- CALCAREOUS
- CALICHE
- CLAY
- CLAYEY
- GRAVEL
- GRAVELLY
- PEAT
- SAND
- SANDY
- SILT
- SILTY
- FILL

ROCK TERMS

- CHALK
- CLAYSTONE
- CLAY-SHALE
- CONGLOMERATE
- DOLOMITE
- IGNEOUS
- LIMESTONE
- MARL
- METAMORPHIC
- SANDSTONE
- SHALE
- SILTSTONE

OTHER

- ASPHALT
- BASE
- CONCRETE/CEMENT
- BRICKS / PAVERS
- WASTE
- NO INFORMATION

WELL CONSTRUCTION AND PLUGGING MATERIALS

- BLANK PIPE
- SCREEN
- BENTONITE
- CEMENT GROUT
- BENTONITE & CUTTINGS
- CONCRETE/CEMENT
- CUTTINGS
- GRAVEL
- SAND
- VOLCLAY

SAMPLE TYPES

- AIR ROTARY
- GRAB SAMPLE
- CORE
- GEOPROBE SAMPLER
- ROTOSONIC -DAMAGED
- MUD ROTARY
- NO RECOVERY
- NX CORE
- PITCHER
- ROTOSONIC -INTACT
- SHELBY TUBE
- SPLIT BARREL
- SPLIT SPOON
- TEXAS CONE PENETROMETER
- DISTURBED

STRENGTH TEST TYPES

- POCKET PENETROMETER
- TORVANE
- UNCONFINED COMPRESSION
- TRIAXIAL COMPRESSION UNCONSOLIDATED-UNDRAINED
- TRIAXIAL COMPRESSION CONSOLIDATED-UNDRAINED

NOTE: VALUES SYMBOLIZED ON BORING LOGS REPRESENT SHEAR STRENGTHS UNLESS OTHERWISE NOTED

PROJECT NO. AAA11-031-01

Raba-Kistner

REVISED 08/2011

FIGURE 20a

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-06 and D2488-00, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2005.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Depth measurements may be presented in a manner that implies greater precision in depth measurement, i.e 6.71 meters. The reader should understand and interpret this information only within the stated half-foot tolerance on depth measurements.

RELATIVE DENSITY

Penetration Resistance Blows per ft	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
> 50	Very Dense

COHESIVE STRENGTH

Resistance Blows per ft	Consistency	Cohesion TSF
0 - 2	Very Soft	0 - 0.125
2 - 4	Soft	0.125 - 0.25
4 - 8	Firm	0.25 - 0.5
8 - 15	Stiff	0.5 - 1.0
15 - 30	Very Stiff	1.0 - 2.0
> 30	Hard	> 2.0

PLASTICITY

Plasticity Index	Degree of Plasticity
0 - 5	None
5 - 10	Low
10 - 20	Moderate
20 - 40	Plastic
> 40	Highly Plastic

ABBREVIATIONS

B = Benzene
T = Toluene
E = Ethylbenzene
X = Total Xylenes
BTEX = Total BTEX
TPH = Total Petroleum Hydrocarbons
ND = Not Detected
NA = Not Analyzed
NR = Not Recorded/No Recovery
OVA = Organic Vapor Analyzer
ppm = Parts Per Million

Qam, Qas, Qal = Quaternary Alluvium
Qat = Low Terrace Deposits
Qbc = Beaumont Formation
Qt = Fluviatile Terrace Deposits
Qao = Seymour Formation
Qle = Leona Formation
Q-Tu = Uvalde Gravel
Ewi = Wilcox Formation
Emi = Midway Group
Mc = Catahoula Formation
El = Laredo Formation
Kknm = Navarro Group and Marlbrook Marl
Kpg = Pecan Gap Chalk
Kau = Austin Chalk

Kef = Eagle Ford Shale
Kbu = Buda Limestone
Kdr = Del Rio Clay
Kft = Fort Terrett Member
Kgt = Georgetown Formation
Kep = Person Formation
Kek = Kainer Formation
Kes = Escondido Formation
Kew = Walnut Formation
Kgr = Glen Rose Formation
Kgru = Upper Glen Rose Formation
Kgrl = Lower Glen Rose Formation
Kh = Hensell Sand

KEY TO TERMS AND SYMBOLS (CONT'D)

TERMINOLOGY

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

SAMPLING METHODS

RELATIVELY UNDISTURBED SAMPLING

Cohesive soil samples are to be collected using three-inch thin-walled tubes in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587) and granular soil samples are to be collected using two-inch split-barrel samplers in general accordance with the Standard Method for Penetration Test and Split-Barrel Sampling of Soils (ASTM D1586). Cohesive soil samples may be extruded on-site when appropriate handling and storage techniques maintain sample integrity and moisture content.

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-in.-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARRELL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME:

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-01.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-10	0.0 to 2.0		37							1.00	PP
	2.0 to 4.0		23	52	15	37				1.00	PP
	4.0 to 6.0		18							2.00	PP
	6.0 to 8.0		16							2.25	PP
	8.0 to 10.0		12							2.25	PP
	13.0 to 15.0		12	54	14	40				2.25	PP
	18.0 to 20.0		15							2.25	PP
	23.0 to 25.0		15					117		5.80	UC
	28.0 to 30.0		16							2.25	PP
	33.0 to 35.0		18					113		4.69	UC
	38.0 to 40.0		18							2.25	PP
B-11	0.0 to 2.0		29							0.75	PP
	2.0 to 4.0		27	61	17	44				1.00	PP
	4.0 to 6.0		19							2.25	PP
	6.0 to 8.0		17					113		5.22	UC
	8.0 to 10.0		18	57	15	42				2.25	PP
	13.0 to 15.0		21							1.75	PP
	18.0 to 20.0		21					106		1.22	UC
B-12	0.0 to 2.0		22							1.00	PP
	2.0 to 4.0		25							2.25	PP
	4.0 to 6.0		17	56	15	41				2.25	PP
	6.0 to 8.0		17							2.25	PP
	8.0 to 10.0		10	50	14	36				2.25	PP
	13.5 to 15.0	ref/6"	16						77		
	18.0 to 20.0		23					104		1.50	UC
B-13	0.0 to 2.0		24	57	18	39				1.00	PP
	2.0 to 4.0		22							2.25	PP
	4.0 to 6.0		16					113		3.86	UC
	6.0 to 8.0		15							2.25	PP
	8.0 to 10.0		15							2.25	PP
	13.0 to 15.0		28	96	26	70				1.75	PP
	18.0 to 20.0		27					96		1.01	UC
B-14	0.0 to 2.0		18							2.25	PP
	2.0 to 3.0		13	63	18	45					
	3.0 to 4.0		4								
	4.0 to 6.0		8						28		
	6.5 to 8.0	27	3						6		
	8.0 to 10.0		23	66	17	49				1.50	PP
	13.0 to 15.0		19					112		3.30	UC

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-01

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME:

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-01.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-14	18.0 to 20.0		19							2.25	PP
B-15	0.0 to 2.0		18							1.25	PP
	2.0 to 4.0		23	61	17	44				1.25	PP
	4.0 to 6.0		18							2.25	PP
	6.0 to 8.0		16	54	14	40				2.25	PP
	8.0 to 10.0		16							2.25	PP
	13.0 to 15.0		15							2.25	PP
	18.0 to 20.0		20					110		2.09	UC
B-16	0.0 to 2.0		27							1.25	PP
	2.0 to 4.0		24							1.25	PP
	4.0 to 6.0		20	60	16	44				1.50	PP
	6.0 to 8.0		20							1.50	PP
	8.0 to 10.0		21							1.25	PP
	13.0 to 15.0		23					101		3.15	UC
	18.0 to 20.0		23	76	20	56				2.25	PP
	23.0 to 25.0		23					103		3.56	UC
	28.0 to 30.0		22							2.25	PP
B-17	0.0 to 2.0		20							0.75	PP
	2.0 to 4.0		25	55	16	39				1.25	PP
	4.0 to 6.0		19							2.25	PP
	6.0 to 8.0		15							2.25	PP
	8.0 to 10.0		14							2.25	PP
	13.0 to 15.0		14	55	15	40				2.25	PP
	18.0 to 20.0		20					115		2.39	UC
	23.0 to 25.0		17							2.25	PP
	28.0 to 30.0		17					113		6.35	UC
WWTP-5	0.0 to 2.0		21							2.25	PP
	2.0 to 4.0		18	43	18	25				2.00	PP
	4.0 to 6.0		12					122		2.81	UC
	6.0 to 8.0		20	47	15	32				2.25	PP
	8.0 to 10.0		12							2.25	PP
	13.0 to 15.0		17							2.25	PP
	18.0 to 20.0		17	63	17	46				2.25	PP
	23.0 to 25.0		16					116		5.77	UC
	28.5 to 30.0	ref/5"	1	18	10	8	SC		30		
	33.5 to 35.0	ref/5"	1								
	38.5 to 40.0	ref/4.5"	1								
	43.5 to 45.0	ref/4"	3	16	9	7	SC-SM		32		
	48.5 to 50.0	ref/4"	2								

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-01

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME:

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-01.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
WWTP-6	0.0 to 2.0		30							1.00	PP
	2.0 to 4.0		25							1.00	PP
	4.0 to 6.0		20							2.25	PP
	6.0 to 8.0		18	61	17	44				2.25	PP
	8.0 to 10.0		16					117		5.57	UC
	13.0 to 15.0		18							2.25	PP
	18.0 to 20.0		7	31	10	21		128		5.20	UC
	23.5 to 24.4	50/5"	4								
WWTP-7	0.0 to 2.0		18							1.75	PP
	2.0 to 4.0		17	46	13	33				1.75	PP
	4.0 to 6.0		17					117		2.54	UC
	6.0 to 8.0		15							2.25	PP
	8.0 to 10.0		16	62	16	46				2.25	PP
	13.0 to 15.0		18							2.25	PP
	18.0 to 20.0		11					132		5.66	UC
	23.5 to 24.5	50/5.5"	2								
WWTP-8	0.0 to 2.0		18							1.25	PP
	2.0 to 4.0		18					113		1.09	UC
	4.0 to 6.0		17	51	13	38				2.25	PP
	6.0 to 8.0		17							2.25	PP
	8.0 to 10.0		18	66	17	49				2.25	PP
	13.0 to 15.0		17					115		6.09	UC
	18.5 to 18.8	ref/4"	8								
	23.5 to 23.8	ref/3"	3								
WWTP-9	0.0 to 2.0		19	38	16	22				0.75	PP
	2.0 to 4.0		19							1.25	PP
	4.0 to 6.0		23					109		1.51	UC
	6.0 to 8.0		19							2.25	PP
	8.0 to 10.0		19							2.25	PP
	13.0 to 15.0		19							2.25	PP
	18.5 to 19.0	ref/5.5"	5	27	12	15					
	23.5 to 24.1	50/1"	0								
	28.5 to 30.0	50/11"	2								
	33.5 to 34.5	50/5.5"	2								
	38.5 to 39.5	50/5"	1			NP					
	43.5 to 44.1	50/1.5"	2								
	48.5 to 49.1	50/1"	2								
WWTP-10	0.0 to 2.0		18	41	16	25				1.25	PP
	2.0 to 4.0		18							1.25	PP

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-01

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME:

Wasteline Interceptor & Wastewater Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-01.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
WWTP-10	4.0 to 6.0		19					111		1.24	UC
	6.0 to 8.0		17	60	16	44				2.25	PP
	8.0 to 10.0		12							2.25	PP
	13.5 to 14.0	ref/6"	2								
	18.5 to 18.8	ref/4"	2								
	23.5 to 23.8	ref/4"	2								
WWTP-11	0.0 to 2.0		27							1.00	PP
	2.0 to 4.0		30							1.25	PP
	4.0 to 6.0		30							1.25	PP
	6.0 to 8.0		31							1.25	PP
	8.0 to 10.0		27							1.25	PP
	13.5 to 15.0	30	12	23	14	9	SC		46		
	18.0 to 20.0		11					122		0.58	UC
	23.0 to 24.4	50/11"	2								
	28.5 to 30.0	35	2	14	10	4	SC-SM		28		
	33.5 to 35.0	40	3								
	38.5 to 40.0	50	4								
	43.5 to 45.0	36	6	25	15	10	SC		16		
	48.5 to 50.0	22	11								
WWTP-12	0.0 to 2.0		24							1.25	PP
	2.5 to 4.5		24							1.25	PP
	4.5 to 6.5		22							1.75	PP
	6.5 to 8.5		20	54	18	36				2.25	PP
	8.5 to 10.5		14							2.25	PP
	13.0 to 14.4		14							2.25	PP
	18.5 to 19.9	50/11"	2						14		
	23.5 to 25.0	27	3								
WWTP-13	0.0 to 2.0		26							2.25	PP
	2.0 to 4.0		28							1.50	PP
	4.0 to 5.0		19							2.25	PP
WWTP-14	0.0 to 2.0		31							0.75	PP
	2.0 to 4.0		31							1.75	PP
	4.0 to 5.0		23	62	18	44				2.25	PP

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-01

PRELIMINARY
LOG OF BORINGS

LOG OF BORING NO. B-1

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27647; W 97.55846

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0; PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT; 10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray to Gray, Damp to Moist, with calcareous deposits				39	
5					112	6.00		
10								
			CLAYEY SAND (SC), Medium Dense, Light Gray, Damp, with traces of gravel				46	24
15								
			CLAY (CH), Fat, Very Stiff, Red-Brown and Yellow-Brown, Moist		105			
20								
25								
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/17/2011	**DATE MEASURED:**	8/17/2011	**FIGURE:**	22

LOG OF BORING NO. B-2

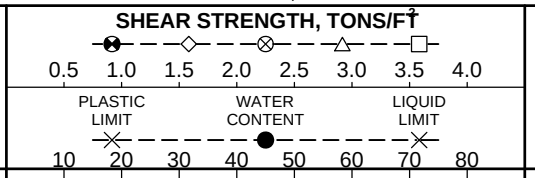
Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.28690; W 97.56024

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Moist, with calcareous deposits - with roots at the surface - damp below 4 feet				
5			**CLAY (CH),** Fat, Hard, Yellow-Gray, Damp, with calcareous deposits		123	34	
10							
15			**CLAY (CL),** Silty, Lean, Hard, Light Brown, Damp	50			
20			**CLAY (CH),** Fat, Hard, Light Brown to Tan and Gray, Moist, with calcareous deposits			45	
25			- very stiff below 23.5 feet		107		
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
35							
40							
45							
50							
55							
60							



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/18/2011	**DATE MEASURED:**	8/18/2011	**FIGURE:**	23

LOG OF BORING NO. B-3

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.29491; W 97.56226

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Moist, with calcareous deposits					
5			- with gravel 4 to 6 feet				43	
			CLAY (CH), Fat, Hard, Tan, Damp					
10								
			- hard gravel layer, 13 to 14 feet	50/5"				
15								
			CLAY (CH), Fat, Hard, Olive-Gray, Moist				64	
20								
			- very stiff below 23 ft		95			
25								
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/18/2011	**DATE MEASURED:**	8/18/2011	**FIGURE:**	24

LOG OF BORING NO. B-4

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.29972; W 97.56465

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Damp, with calcareous deposits				37	
5								
			CLAY (CH), Fat, Very Stiff, Light Gray, Moist					
10			- gravel layer, 10 to 10.5 feet					
			- hard, olive gray below about 13 feet				53	
15								
			CLAY (CH), Fat, Hard, Gray, Moist		102	5.00		
20								
25				50				
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/18/2011	**DATE MEASURED:**	8/18/2011	**FIGURE:**	25

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

LOG OF BORING NO. T-1

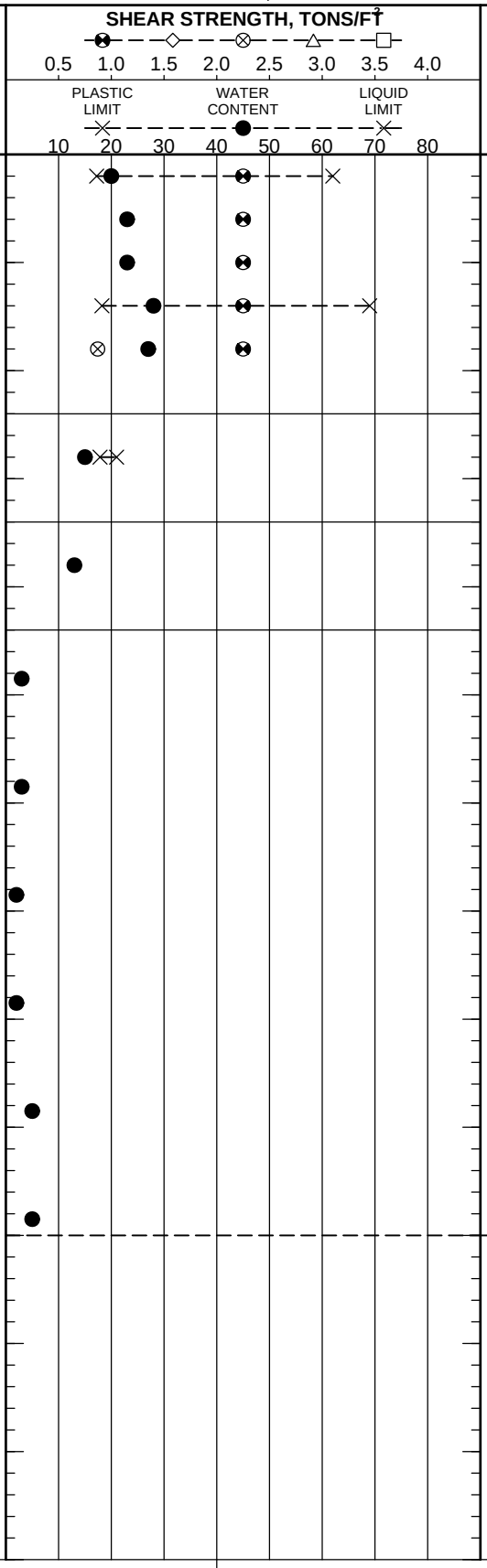
Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26849; W 97.55338

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	CLAY (CH), Fat, Hard, Dark Gray to Gray, Moist			45	
5					
				51	
	- light gray below 8 feet		98		
10					
	SILT (ML), Medium Dense, Brown, Damp, with sand			3	83
15					
	CLAYEY SAND (SC), Medium Dense, Light Brown, Damp				
20					
	SAND (SP), Dense, Tan, Dry, with gravel - with traces of gravel at 23 feet	35			
25					
		42		NP	11
30					
	- medium dense below 33.5 feet	22			
35					
		25			
40					
		25			12
45					
		22			
50					
55	NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.				
60					



NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	50.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/18/2011	**DATE MEASURED:**	8/18/2011	**FIGURE:**	26

LOG OF BORING NO. T-2

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

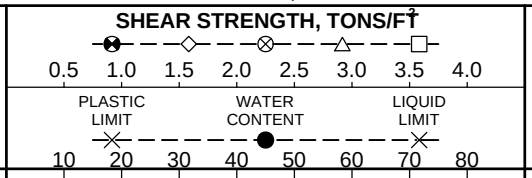
Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26669; W 97.55473

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
	CLAY (CH), Fat, Hard, Dark Gray, Damp to Moist - with roots at the surface			49	
5			110		
	CLAY (CH), Fat, Hard, Light Brown, Moist - with gypsum crystals at about 6 feet			49	
10					
	- damp below about 13 feet				
15					
	CLAY (CL), Silty, Lean, Hard, Light Brown, Damp			15	
20					
	CLAY (CL), Sandy, Lean, Hard, Light Brown, Damp, with ferrous stains				64
25					
	- gravel layer, 26 to 27 feet				
30					
	SAND (SP), Dense, Tan, Dry, with gravel				
35		37			10
40		42			
45		47			8
50		43			
55					
60					

SYMBOL / SAMPLES



NOTES:
1. Groundwater was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	50.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/17/2011	**DATE MEASURED:**	8/17/2011	**FIGURE:**	27

LOG OF BORING NO. WWTP-1

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27056; W 97.55023

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0; PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT; 10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CH), Fat, Hard, Dark Gray, Damp to Moist - with roots at the surface - with sand seams, 2 to 4 feet				37	
5					110	7.00		
			CLAY (CH), Fat, Hard, Olive-Gray, Moist, with calcareous deposits				45	
10								
			CLAY (CH), Fat, Hard, Red-Brown and Yellow-Brown, Moist, with calcareous deposits					
15								
20					112			
25								
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/17/2011	**DATE MEASURED:**	8/17/2011	**FIGURE:**	28

LOG OF BORING NO. WWTP-2

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27014; W 97.55234

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CL), Chalky, Lean, Hard, Light Gray to Olive Gray, Damp				23	
5			**CLAY (CL),** Silty, Lean, Hard, Light Brown, Damp, with sand				20	72
10			**CLAY (CH),** Fat, Hard, Olive-Gray, Damp					
15			**CLAY (CH),** Fat, Hard, Red-Brown and Yellow-Brown, Moist, with calcareous deposits					
20							50	
25					114	5.00		
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/19/2011	**DATE MEASURED:**	8/19/2011	**FIGURE:**	29

LOG OF BORING NO. WWTP-3

Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.26982; W 97.55233

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
			CLAY (CL), Silty, Lean, Hard, Light Gray, Dry to Damp, with calcareous deposits			20	
			CLAY (CL), Sandy, Lean, Hard, Olive-Gray, Moist	36			55
			CLAY (CL), Silty, Lean, Hard, Light Gray, Damp, with sand	33			
			CLAY (CH), Fat, Hard, Red-Brown and Yellow-Brown, Moist, with calcareous deposits		113	46	

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

NOTES:
1. Groundwater was not encountered during drilling operations.
2. Borehole was backfilled with auger cuttings.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/19/2011	**DATE MEASURED:**	8/19/2011	**FIGURE:**	30

LOG OF BORING NO. WWTP-4

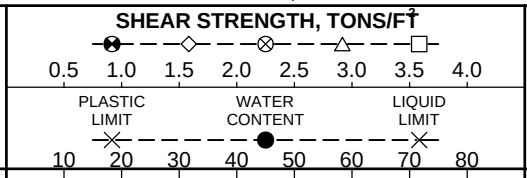
Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

Raba Kistner
TBPE Firm Registration No. F-3257

DRILLING METHOD: Straight Flight Auger

LOCATION: N 30.27009; W 97.55264

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	SHEAR STRENGTH, TONS/FT² (0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0) / PLASTIC LIMIT, WATER CONTENT, LIQUID LIMIT (10 20 30 40 50 60 70 80)	PLASTICITY INDEX	% -200
			CLAY (CL), Silty, Chalky, Lean, Hard, Light Gray, Damp		109			
5			**CLAYEY SAND (SC),** Medium Dense, Light Brown, Damp, with calcareous deposits				33	37
10			**CLAY (CH),** Fat, Hard, Red-Brown and Yellow-Brown, Damp to Moist, with calcareous deposits - damp above 10 ft					
15								
20							52	
25								
30			NOTES: 1. Groundwater was not encountered during drilling operations. 2. Borehole was backfilled with auger cuttings.					
35								
40								
45								
50								
55								
60								



DEPTH DRILLED:	25.0 ft	**DEPTH TO WATER:**	Dry	**PROJ. No.:**	AAA11-031-00
DATE DRILLED:	8/19/2011	**DATE MEASURED:**	8/19/2011	**FIGURE:**	31

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-00.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
B-1	0.0 to 2.0		13							2.25	PP
	2.0 to 4.0		17	55	16	39	CH			2.25	PP
	4.0 to 6.0		17							2.25	PP
	6.0 to 8.0		16					112		5.54	UC
	8.0 to 10.0		17							2.25	PP
	13.0 to 15.0		10	63	17	46	SC		24		
	18.0 to 20.0		21					105		1.22	UC
	23.0 to 25.0		22							1.63	PP
B-2	0.0 to 2.0		20							2.25	PP
	2.0 to 4.0		17							2.25	PP
	4.0 to 6.0		14							2.25	PP
	6.0 to 8.0		11	50	16	34	CH			2.25	PP
	8.0 to 10.0		11					123		7.45	UC
	13.5 to 15.0	50	15								
	18.5 to 20.0		17	61	16	45	CH			2.25	PP
	23.5 to 25.0		18					107		1.58	UC
B-3	0.0 to 2.0		19							2.25	PP
	2.0 to 4.0		20							2.25	PP
	4.0 to 6.0		20	62	19	43	CH			2.25	PP
	6.0 to 8.0		17							2.25	PP
	8.0 to 10.0		14							2.25	PP
	13.0 to 13.9	50/5"	14								
	18.0 to 20.0		29	87	23	64	CH			2.25	PP
	23.0 to 25.0		28					95		1.28	UC
B-4	0.0 to 2.0		11							2.25	PP
	2.0 to 4.0		13	55	18	37	CH			2.25	PP
	4.0 to 6.0		14							2.25	PP
	6.0 to 8.0		13							2.25	PP
	8.0 to 10.0		19							1.25	PP
	13.0 to 15.0		28	76	23	53	CH			2.00	PP
	18.0 to 20.0		22					102		5.00	UC
	23.5 to 25.0	50	16								
T-1	0.0 to 2.0		20	62	17	45	CH			2.25	PP
	2.0 to 4.0		23							2.25	PP
	4.0 to 6.0		23							2.25	PP
	6.0 to 8.0		28	69	18	51	CH			2.25	PP
	8.0 to 10.0		27					98		0.87	UC
	13.0 to 15.0		15	21	18	3	ML		83		
	18.0 to 20.0		13								

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-00

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-00.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
T-1	23.5 to 25.0	35	3								
	28.5 to 30.0	42	3			NP			11		
	33.5 to 35.0	22	2								
	38.5 to 40.0	25	2								
	43.5 to 45.0	25	5						12		
	48.5 to 50.0	22	5								
T-2	0.0 to 2.0		14							2.25	PP
	2.0 to 4.0		17	68	19	49	CH			2.25	PP
	4.0 to 6.0		18					110		6.51	UC
	6.0 to 8.0		21	70	21	49	CH			2.25	PP
	8.0 to 10.0		18							2.25	PP
	13.0 to 15.0		15							2.25	PP
	18.0 to 20.0		10	29	14	15	CL			2.25	PP
	23.0 to 25.0		7						64	2.25	PP
	28.0 to 30.0		13							2.25	PP
	33.5 to 35.0	37	2						10		
	38.5 to 40.0	42	2								
	43.5 to 45.0	47	4						8		
	48.5 to 50.0	43	4								
WWTP-1	0.0 to 2.0		10	52	15	37	CH			2.25	PP
	2.0 to 4.0		15							2.25	PP
	4.0 to 6.0		16					110		7.22	UC
	6.0 to 8.0		16							2.25	PP
	8.0 to 10.0		16	60	15	45	CH			2.25	PP
	13.0 to 15.0		18							2.25	PP
	18.0 to 20.0		18					112		4.04	UC
	23.0 to 25.0		17							2.25	PP
WWTP-2	0.0 to 2.0		7							2.25	PP
	2.0 to 4.0		8	37	14	23	CL			2.25	PP
	4.0 to 6.0		8							2.25	PP
	6.0 to 8.0		8	36	16	20	CL		72	2.25	PP
	8.0 to 10.0		10							2.25	PP
	13.0 to 15.0		18							2.25	PP
	18.0 to 20.0		18	68	18	50	CH			2.25	PP
	23.0 to 25.0		18					114		4.71	UC
WWTP-3	0.0 to 2.0		6							2.25	PP
	2.0 to 4.0		8							2.25	PP
	4.0 to 6.0		6	36	16	20	CL			2.25	PP
	6.5 to 8.0	36	9						55		

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-00

RESULTS OF SOIL SAMPLE ANALYSES

PROJECT NAME: Whisper Valley Inteceptor & Waste Water Treatment Plant
Travis County, Texas

FILE NAME: AAA11-031-00.GPJ 6/12/2012

Boring No.	Sample Depth (ft)	Blows per ft	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS	Dry Unit Weight (pcf)	% -200 Sieve	Shear Strength (tsf)	Strength Test
WWTP-3	8.5 to 10.0	33	11								
	13.0 to 15.0		18	64	18	46	CH			2.25	PP
	18.0 to 20.0		18					113		4.34	UC
	23.0 to 25.0		18							2.25	PP
WWTP-4	0.0 to 2.0		8					109		3.77	UC
	2.0 to 4.0		8							2.25	PP
	4.0 to 6.0		9							2.25	PP
	6.0 to 8.0		7	46	13	33	SC		37		
	8.0 to 10.0		15							2.25	PP
	13.0 to 15.0		18							2.25	PP
	18.0 to 20.0		18	69	17	52	CH			2.25	PP
	23.0 to 25.0		17							2.25	PP

PP = Pocket Penetrometer TV = Torvane UC = Unconfined Compression FV = Field Vane UU = Unconsolidated Undrained Triaxial

CU = Consolidated Undrained Triaxial

PROJECT NO. AAA11-031-00

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

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