FUGRO CONSULTANTS, INC.

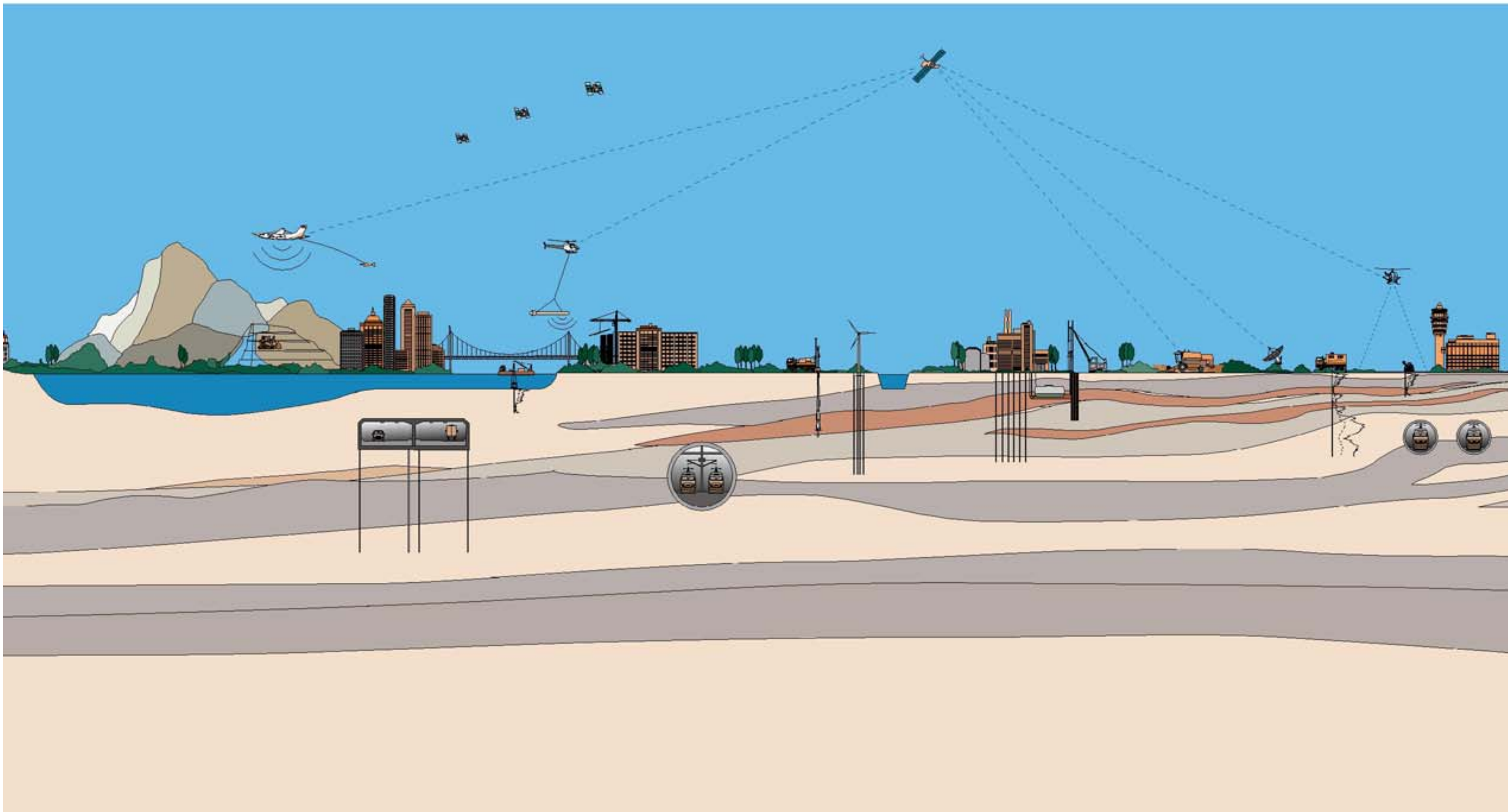
GEOTECHNICAL STUDY

SAWS WESTERN WATERSHED SEWER RELIEF LINE PROJECT

PHASE I - QUINTANA ROAD TO SW LOOP 410

SAN ANTONIO, TEXAS

SAN ANTONIO WATER SYSTEM
c/o CAMP DRESSER & McKEE, INC.
Austin, Texas



FUGRO CONSULTANTS, INC.

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Report No. 04.10070157
September 10, 2010

San Antonio Water System
c/o Camp Dresser & McKee, Inc.
12357-A Riata Trace Parkway, Suite 210
Austin, Texas 78727

Attention: Mr. William T. Reynolds, P.E.

Geotechnical Data Study
SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas

Introduction

Fugro Consultants, Inc. (Fugro) is submitting this report on the geotechnical study for the above-referenced project. Multiple proposed work scopes have been submitted on the project. A near final work scope was issued on February 2, 2009 (Fugro Consultants Inc.'s Project No. 1007-0157). This study was performed in general accordance with the Standard Agreement between Fugro Consultants, Inc. and Camp Dresser & McKee, Inc.(CDM), based on the February 2, 2009 work scope. The contract was signed by Mari Garza-Bird, Associate with CDM, on December 22, 2009. Since that time, several subsequent addendum work scopes were issued to CDM by Fugro reflecting additional scope due to tunneling operations anticipated for the IH 35 and the New Laredo Highway crossings. However, tunneling operations were ultimately not selected for the project and CDM returned to the originally contracted work scope.

Project Description

San Antonio Water System (SAWS) is planning the replacement of approximately 35,000 lineal feet of an existing sanitary sewer line that extends from U.S. Hwy 90 to SW Loop 410 in southwest San Antonio, Texas. This current portion of the project, Phase I, consists of the southern portion of the alignment that extends from Quintana Road to SW Loop 410, approximately 11,000 lineal feet. We understand the proposed sewer line will be installed to various depths typically ranging from 11 to 27 ft. We understand open cut techniques will generally be used to install the line.

Purposes and Scope

The purposes of this geotechnical study were to obtain samples of the subsoils along the alignment to measure the pertinent physical characteristics of the materials. These purposes were accomplished by:

1) advancing nine borings to explore the subsurface conditions, and to obtain soil samples;

2) performing laboratory tests on selected soil samples recovered from the borings to evaluate pertinent physical properties; and

3) preparing a data report.

Field Investigation

As requested by CDM, Fugro performed nine borings, designated as Borings B-1 to B-9, along the pipeline alignment to depths ranging from 15 to 30 ft for this project. As indicated by CDM, the approximate boring locations and depths are presented on the following page.

Boring Number	Depth, ft	Station	Description
B-1	15	1+00	Start of line
B-2	29	23+00	First Siphon
B-3	20	45+00	IH 35, South Side
B-4	20	50+00	IH 35, North Side
B-5	30	60+00	Second Siphon, South Side
B-6	30	80+00	New Laredo Hwy, South Side
B-7	25	81+00	New Laredo Hwy, North Side
B-8	30	84+00	Third Siphon
B-9	20	110+00	End of line

The approximate locations of the borings are illustrated on a Plan of Borings, Plate 2. Boring locations shown on the Plan of Borings should be considered approximate. Surface elevations and coordinates were provided by Ford Engineering, Inc., site surveyor for the project, and are included on the boring logs.

The borings were drilled with a truck-mounted drill rig equipped with 1) continuous flight and hollow stem augers for advancing the holes dry and recovering disturbed samples (ASTM D 1452), 2) seamless push tubes for obtaining relatively undisturbed soil samples of cohesive strata

(ASTM D 1587), and 3) split-barrel samplers and drive-weight assembly for obtaining representative samples and measuring the penetration resistance (N-values) of non-cohesive soil strata (ASTM D 1586). At the completion of the field exploration, the boreholes were observed for groundwater. Any depth to water measurements are recorded on the boring logs. The boreholes were then backfilled with the soil cuttings.

Soil samples were generally obtained at about 2-ft intervals to a depth of about 10 ft and at 5-ft intervals thereafter. After recovery, each sample was removed from the sampler and visually classified by our field technician. Representative portions of each sample were then packaged, sealed, and transported to Fugro's San Antonio laboratory for testing. During drilling and sampling, a record of field observations was maintained in the form of field logs describing the visual identification of the subsurface materials encountered, and other pertinent field data.

To aid in field classification, the compressive strength of cohesive samples was estimated using a pocket penetrometer, and the penetration resistance of the SPT sampler was recorded. The pocket penetrometer values, in tons per square foot (tsf), and the SPT N-values, in blows per foot (bpf), are shown on the logs. The compressive strength estimates in tons per square foot (tsf) obtained with the pocket penetrometer are equivalent to the undrained shear strength of the soil in kips per square foot (ksf).

A record of field observations was maintained in the form of field logs visually describing the subsurface materials encountered, and other pertinent field data. These logs were later edited to incorporate information obtained from laboratory evaluation and testing. The final logs for Borings B-1 through B-9 are presented on Plates 3 through 11. A key to symbols and terms used on the logs is presented on Plate 12.

Laboratory Testing

The laboratory testing program was directed toward identification and classification of the foundation soils. To aid in soil classification, Atterberg limits (ASTM D4318), and the percentage of material passing selected U.S. Standard sieves (ASTM D 422) were performed on selected soil samples. Water content measurements were performed on selected samples. The undrained shear strengths of selected samples were measured by performing unconsolidated-undrained (UU) triaxial compressive tests (ASTM D 2850); moisture content and unit dry weights were measured as routine portions of the compression tests. The results of the laboratory classification tests are presented on the individual boring logs on Plates 3 and 11. Corrosivity testing consisting of pH determination and sulfate and chloride concentrations were performed on selected samples.

Soil Descriptions and Classifications

Descriptions of subsurface materials made in the field at the time the borings were made were modified in accordance with results of laboratory tests and visual evaluation in the laboratory. The recovered soil samples were evaluated and classified in accordance with ASTM D 2487, and described as recommended in ASTM D 2488 and the Unified Soil Classification procedures. Classifications of the soils and finalized material descriptions are shown on the boring logs.

Subsurface Conditions

Geologic Setting. A review of available geologic information,[1] indicates the site is underlain by fluviatile terrace deposits. The alluvium soils are floodplain deposits and consist primarily of clays containing various amounts of silt, sand, and gravel.

Classification and Plasticity. The material encountered in the borings was highly variable among the locations and with depth. The borings generally consisted of sandy low plasticity ‘lean’ clay (CL), highly plastic ‘fat’ clay (CH), gravels (GW-GM, GP-GC, and GC) and clayey sand (SC).

Lean clay (CL) was encountered at various depths in most of the borings. The lean clay material had liquid limits ranging from 31 to 39, plastic limits ranging from 12 to 15, and plasticity indices (the liquid limit minus the plastic limit) ranging from 16 and 27. The percentage passing the U.S. Standard No. 200 Sieve (fines) ranged from 55 to 98. Fat clay (CH) was encountered at various depths in Borings B-5, B-7, and B-8. This material was considered ‘fat’ with liquid limits ranging from 55 to 79, plastic limits ranging from 16 to 26, plasticity indices ranging from 39 to 55, and percent fines ranging from 70 to 99 percent

Gravel and sand layers were encountered in Borings B-2 through B-7 and B-9. The fines encountered in the gravel and sand layers had liquid limits ranging from 28 to 47, plastic limits ranging from 12 to 16, and plasticity indices ranging from 12 to 31. The fines percentage in the gravel and sand layers ranged from 11 to 49 percent. Notes of the observations are included on the boring logs.

Shrink/Swell Potential. Shrink/swell potential has been correlated with material type and the Atterberg limits.[2] Based on the measured liquid limits and the computed plasticity indices, the fat clay (CH) would generally have a very high swell potential. The lean clay (CL) encountered would be expected to have a low to medium swell potential. The granular soils at this site would generally be expected to have a low potential for volumetric change resulting from moisture fluctuations.

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[1] Fisher, W.L. (1974), “Geologic Atlas of Texas, Austin Sheet,” Bureau of Economic Geology. The University of Texas at Austin, map and accompanying explanatory bulletin.

[2] Peck, R.B., Hanson, W.E., and Thornburn, T.H., (1974) Foundation Engineering, Second Edition, John Wiley & Sons, Inc., New York, Pg. 337.

Groundwater Conditions. The borings were advanced using a dry technique; no water or other drilling fluid was introduced. Free water was observed in the open boreholes between depths of 13.7 to 27 ½ ft in Borings B-2, B-6, B-8, and B-9. No free water was observed in the remaining boreholes. It should be noted that groundwater levels may fluctuate with seasonal variations in precipitation.

Variations in Subsurface Conditions. Subsurface conditions have been obtained at the boring locations only. Sound geotechnical practice requires that some mention be given to the fact that since some variation was found in subsurface conditions at the boring locations, all parties should recognize that even more variation may be possible between boring locations. In addition, the soil stratigraphy described above, and on the boring logs, is based on interpretation of our technician's observations during sampling, and classification of the soil samples. The boundaries between soil layers are approximate, and transitions between soil types may be gradual.

Soil Moduli for Buried Flexible Pipe

Based on the subsurface conditions encountered at the boring locations along the alignment of the sewer line, laboratory test results and correlations[3] for native soil moduli and SPT values a native soil moduli of 600 psi (E'_n) is recommended.

The effective soil modulus, E', may be calculated using the following equations[4]. It should be noted that the following parameters are required to calculated E': width of trench at top of pipe, outside diameter of pipe, and pipe embedment material.

$E' = zeta * E'_b$ where

$zeta = 1.44 / (f + (1.44 – f) * E'_b / E'_n)$

$f = (B / d – 1) / (1.154 + 0.444 (B / d – 1))$

B = width of trench at top of pipe

d = outside diameter of pipe

E'_b = modulus of pipe embedment soil

OSHA Soil/Rock Classifications for Temporary Trench Design

Trench safety is the sole responsibility of the contractor and the contractor is required to retain the services of a licensed professional engineer to design the trench safety system to comply with OSHA requirements. Based on proposed excavations for the sewer line up to about 27-ft deep excavations will extend through the soils. As discussed previously, groundwater was encountered at four of the nine boring locations during dry advancement, prior to coring.

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[3] 30 TAC 317 Design Criteria for Sewage Systems (1994), 317.2 Sewage Collection Systems, Exhibit A.

[4] Ibid

Suggestions are set forth below in accordance with OSHA[5] for classifying soil and rock encountered in our investigation. It is stressed that these are suggestions only for preliminary planning based on apparent conditions, and the actual trench safety system design, installation, and performance are the contractor's sole responsibility.

Material	OHSA Classification	OSHA Slope
Soil (CH, CL, SC, GC)	Type B	1H to 1V
Soil (saturated CL, SC, GC, GW-GM, GP, GP-GC)	Type C	1.5H to 1V or flatter
** Sloping and benching for excavation greater than 20 ft deep shall be designed by a registered professional engineer.		

Soil Corrosion Potential

Steel and concrete elements in contact with soil are subject to degradation due to corrosion or chemical attack. Therefore, buried steel and concrete elements should be designed to resist corrosion and degradation based on accepted practices. General discussions regarding the corrosion of steel and the degradation of concrete with respect to the results of the analytical tests are provided in the following sections of this report.

Analytical Test Results. The laboratory testing program also included natural pH, soluble chloride, and soluble sulfate tests. A summary of the analytical laboratory test results is presented in the following table.

Boring Number	Sample Depth (feet)	pH	Soluble * Chloride Content (ppm)	Soluble * Sulfate Content (ppm)
B-1	4 – 6	8.6	125	< 100
B-5	19 – 20	8.0	120	315
B-6	4 – 6	8.7	< 100	< 100
B-8	13.5 – 15	8.5	< 100	155
* based on dry weight of soil				

Corrosion of Steel. Corrosion is a major factor in the life of steel elements in contact with soil. Corrosion is caused by migration of electrons from the steel into the surrounding soil. Three measurable soil properties that indicate the corrosion potential for steel in contact with soil are: 1) soluble chloride, 2) pH, and 3) resistivity. Resistivity testing was not performed as apart of our

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[5] Code of Federal Regulations Title 29 Part 1926 (1989), "Labor", Occupational Safety and Health Administration, Department of Labor, Subpart P - Excavations, pgs 45963-45971.

scope of work. Analytical test results are presented in the previous section. It is generally accepted that corrosion of steel is most likely to occur in environments that have chloride ions (even in low concentrations) and low pH.

The following table presents some general guidelines concerning the corrosion potential of soil on steel pipe as a function of soluble chloride. If the pH is less than 7, the soil is acidic and corrosive conditions are indicated[6].

Soluble Chloride Concentration[7] (ppm)	Corrosion Potential
> 500	Very Severe
100 – 500	Severe
25 – 100	Moderate
10 – 25	Mild
-----	Very Mild

Each variable should be used independently of the others when evaluating soil corrosion potential.

The measured pH varied from 8.0 to 8.7, which indicates the soils have a low corrosion potential; the measured soluble chloride content ranged from less than 100 to 125 ppm, which indicates the soils have a mild corrosion potential. Based on the results of our analyses, the soils at the site appear to exhibit a low to mild tendency to corrode buried steel, such as underground steel piping. A Corrosion Engineer should review the test results discussed herein when designing appropriate methods of protecting buried steel.

Degradation of Concrete. The degradation of concrete is caused by chemical agents in the soil or groundwater that react with concrete to either dissolve the cement paste or precipitate larger compounds which cause cracking and flaking. The concentration of water-soluble sulfates in the soils is a good indicator of the potential for chemical attack of concrete. Table 4.2.1 of ACI 318[8] presents the following guidelines for concrete exposed to water-soluble sulfates:

Exposure Class	Severity	Sulfate (SO_4) in Water, ppm
S0	Not Applicable	$0 \le SO_4 < 150$
S1	Moderate	$150 \le SO_4 < 1500$
S2	Severe	$1500 \le SO_4 \le 10,000$
S3	Very Severe	$SO_4 > 10,000$

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[6] Johnson Division, UOP Inc., (1975), Ground Water and Wells, Saint Paul, Minnesota, pg. 194.

[7] Department of the Navy, Bureau of Yards and Docks, Design Manual, Civil Engineering, NAVDOCKS DM-5, pg. 5-9-53.

[8] ACI 318-08 (2009), Reported by ACI Committee 318, "Building Code Requirements for Structural Concrete", American Concrete Institute, Farmington Hills, MI.

The measured soluble sulfate contents ranged from 100 to 315 ppm. According to ACI, these results indicate a not applicable to moderate (Exposure Class S0 and S1) exposure for sulfate attack for concrete in contact with the subgrade soils at this site. For sites with moderate exposure (Exposure Class S1) to sulfate attack, ACI recommends using Type II Cement with a maximum water-cementitious material ratio of 0.45, with a minimum 28-day compressive strength of 4,500 psi. A Corrosion Engineer should be consulted to determine if sulfate resistant concrete is warranted.,

Conditions

The professional services that form the basis for this report has been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in the same locality. No warranty, express or implied, is made as to the professional advice set forth. Fugro's scope of work does not include the investigation, detection, or design related to the presence of any biological pollutants. The term 'biological pollutants' includes, but is not limited to, mold, fungi, spores, bacteria, and viruses, and the byproducts of any such biological organisms.

Our interpretations of subsurface conditions are based on data obtained at the soil boring locations only. Subsurface variations may exist between the boring locations and at areas not explored by soil borings. Statements in this report as to subsurface variation over given areas are intended only as estimations from the data obtained at specific boring locations. In addition, the condition of the soils may change subsequent to our field exploration. Significant variations in subsurface conditions or changed soil conditions may require changes to our conclusions and recommendations. Observations during construction are recommended to check for variations in subsurface conditions and possible changed conditions.

The results, conclusions, and recommendations contained in this report are directed at, and intended to be utilized within the scope of work contained in this report. This report is not intended to be used for any other purposes. Fugro Consultants, Inc. makes no claim or representation concerning any activity or condition falling outside the specified purposes to which this report is directed, said purposes being specifically limited to the scope of work as defined in said agreement. Inquiries as to said scope of work or concerning any activity or condition not specifically contained therein should be directed to Fugro Consultants, Inc. for a determination and, if necessary, further investigation.

This report was prepared for the sole and exclusive use by the client, as an instrument of service. This report shall remain the property of Fugro Consultants, Inc. No third party may use or rely upon the information provided in this report without our express written consent. We assume no responsibility for the unauthorized use of this report by other parties and for purposes beyond the stated project objectives and scope limitations.

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The following plates are attached and complete this report:

	Plate
Vicinity Map	1
Plan of Borings	2
Boring Logs	3 thru 11
Key to Terms and Symbols Used on Boring Logs for Soil	12

We appreciate the opportunity to be of service to SAWS and CDM on this project. Please call if we can be of additional assistance.

Sincerely,

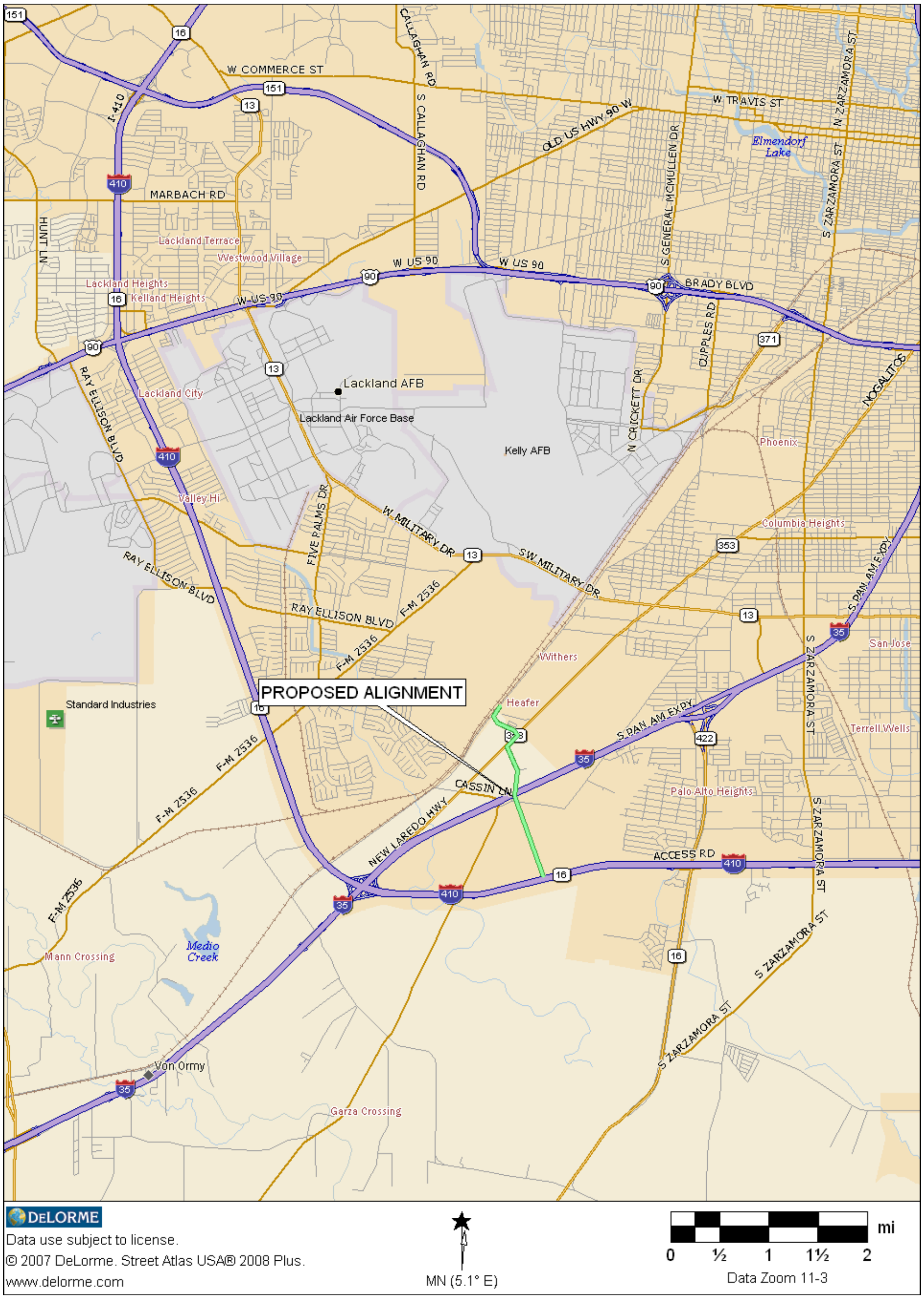
FUGRO CONSULTANTS, INC.
TBPE Firm Registration No. F-299

Adrienne Ford-Mann, E.I.T.
Graduate Engineer

JOHN P. STYRON
89488

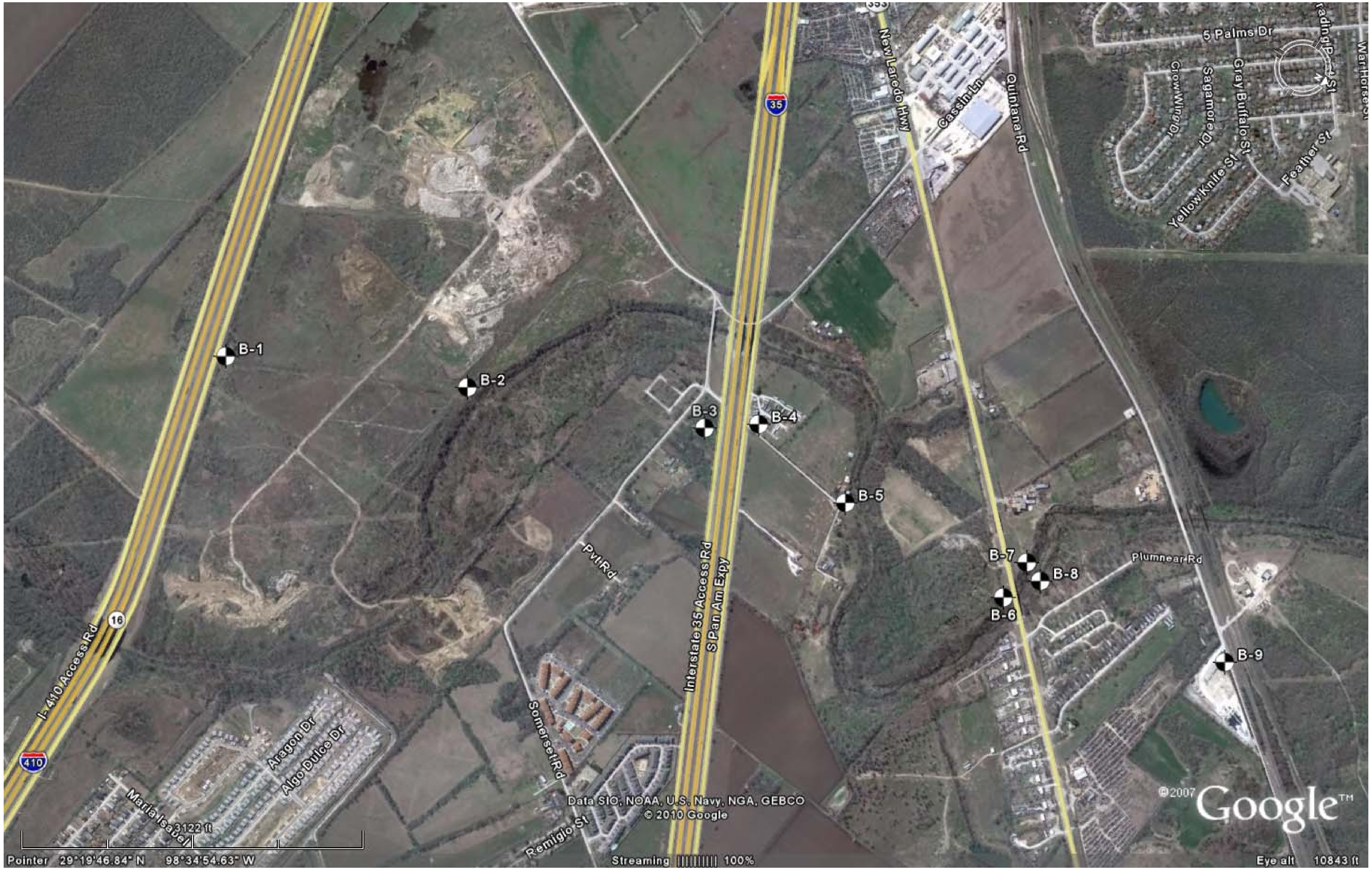
John P. Styron, P.E., LEED® AP
Geotechnical Manager

Copies Submitted: (4)
AFM/JPS(Geotech:\Geotech 2007\10070157 Rpt SAWS Western Watershed Phase I (OSHA) CDM



Vicinity Map
SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas

PLATE 1



Plan of Borings
SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas

PLATE 2

LOG OF BORING NO. B-1

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 582.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
	▨	■	P = 4.5+	LEAN CLAY WITH SAND (CL), brown, hard - with organics to 2' - light brown below 2'		10	31	13	18	71	114	5.0	13.1
	▨	■	P = 4.5+										
					578.0 4.0								
	▨	■	P = 4.5+	SANDY LEAN CLAY (CL), light brown, hard									
5													
	▨	■	P = 4.5+			12	33	13	20	67	117	6.0	10.0
	▨	■	P = 4.5+										
10													
	▨	▩	N = 24	- very stiff below 13.5'									
15					567.0 15.0								
				Note: Elevations and coordinates estimated using hand held GPS.									
20													
25													
30													

Fugro Consultants, Inc.

COMPLETION DEPTH: 15.0
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: Dry
UPON COMPLETION: Dry

LONGITUDE: 98.5767° W
LATITUDE: 29.31882° N

PLATE 3

LOG OF BORING NO. B-2

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 583.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
	▨	■ ■	P = 4.5+ P = 4.5+	LEAN CLAY (CL), brown, hard - with scattered gravel and roots to 2'									
5 10	▨	▩ ▩ ▩	N = 23 N = 21 N = 37	SANDY LEAN CLAY (CL), light brown, very stiff to hard	578.5 4.5	10	33	13	20	58			
15 20	▨	■ ■	P = 4.5+ P = 4.0	LEAN CLAY (CL), light brown, hard	570.0 13.0	12	39	13	26	98	114	10.0	12.7
	▨	■	P = 4.5+	LEAN CLAY WITH SAND (CL), tan and gray, hard, with large gravel	563.0 20.0	19	36	15	21	72			
25	●	▩	N = 50/3"	GRAVEL (GW-GM), gray to reddish brown, very dense	▽ 559.0 24.0								
30				Note: Elevations and coordinates estimated using hand held GPS.	553.7 29.3								

Fugro Consultants, Inc.

COMPLETION DEPTH: 29.3
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: 24.0
UPON COMPLETION: 23.8

LONGITUDE: 98.57967° W
LATITUDE: 29.31882° N

LOG OF BORING NO. B-3

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 597.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
	●	☒ ☒	N = 13 N = 20	CLAYEY GRAVEL WITH SAND (GC), brown, medium dense	592.5 4.5	4	34	14	20	33			
5 10	○	☒ ☒ ☒	N = 22 N = 15 N = 45	POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC), light brown, medium dense to dense	585.0 12.0	2	32	13	19	11			
15	●	☒ ☒	N = 21 N = 49	CLAYEY GRAVEL WITH SAND (GC), light brown, medium dense to dense	577.0 20.0	4	39	15	24	24			
20 25 30				Note: Elevations and coordinates estimated using hand held GPS.									

Fugro Consultants, Inc.

COMPLETION DEPTH: 20.0
DATE DRILLED: 7-19-10
WATER LEVEL / SEEPAGE: Dry
UPON COMPLETION: Dry

LONGITUDE: 98.58467° W
LATITUDE: 29.33025° N

LOG OF BORING NO. B-4

SAWS Western Watershed Sewer Relief Line Project

Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 601.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
0–6 (5)	▨	☒ ☒ ☒	N = 34 N = 19 N = 31	LEAN CLAY (CL), brown, very stiff to hard - with gravel to 1.5'	595.0 6.0								
6–13.5 (10)	▨	☒ ☒	N = 32 N = 50	CLAYEY SAND WITH GRAVEL (SC), light brown, dense to very dense	587.5 13.5	6	35	15	20	37			
13.5–20 (15, 20)	▨	☒ ☒	N = 21 N = 27	SANDY LEAN CLAY (CL), light reddish brown, very stiff	581.0 20.0	12	39	15	24	55			
25, 30				Note: Elevations and coordinates estimated using hand held GPS.									

FUGRO
Fugro Consultants, Inc.

COMPLETION DEPTH: 20.0
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: Dry
UPON COMPLETION: Dry

LONGITUDE: 98.5831° W
LATITUDE: 29.33092° N

LOG OF BORING NO. B-5

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 624.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
	▨	■	P = 4.5+	FAT CLAY (CH), brown, hard, with gravel									
	▨	☒	N = 28	POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC), light reddish brown, dense	621.5 2.5								
5	▨	☒	N = 37			3	28	16	12	11			
	▨	☒	N = 44										
10	▨	☒	N = 34										
	▨	☒	N = 35										
15	▨			FAT CLAY (CH), brown, hard, with ferrous deposits	609.0 15.0								
	▨	■	P = 4.5+			24	75	20	55	89	98	14.0	5.3
20	▨												
	▨	■	P = 4.3										
25	▨												
	▨	☒	N = 50/4"	CLAYEY SAND (SC), dark gray, very dense	595.5 28.5	18	47	16	31	33			
30				Note: Elevations and coordinates estimated using hand held GPS.	594.2 29.8								

Fugro Consultants, Inc.

COMPLETION DEPTH: 29.8
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: Dry
UPON COMPLETION: Dry

LONGITUDE: 98.58262° W
LATITUDE: 29.33398° N

LOG OF BORING NO. B-6

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

SURF. ELEVATION: 607.0

DEPTH, FT	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
	N = 18	CLAYEY SAND (SC), brown, medium dense									
	N = 22										
5	N = 25	- light brown below 4.5'									
	N = 10		599.0	10	42	15	27	49			
10	N = 14	LEAN CLAY WITH SAND (CL), light brown, very stiff	8.0	14	35	13	22	71			
15	N = 16										
20	N = 23		584.0								
25	N = 15	SANDY LEAN CLAY (CL), tan and gray, very stiff	23.0	18	34	13	21	59			
30	N = 17		577.0 30.0								

Note: Elevations and coordinates estimated using hand held GPS.

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COMPLETION DEPTH: 30.0
DATE DRILLED: 7-19-10
WATER LEVEL / SEEPAGE: 27.0
UPON COMPLETION: 27.0

LONGITUDE: 98.58317° W
LATITUDE: 29.3383° N

PLATE 8

LOG OF BORING NO. B-7

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

SURF. ELEVATION: 603.0

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
			N = 8	SANDY CLAY (SC), brown, stiff									
			N = 13		599.0	12	39	13	26	57			
			P = 4.5+	LEAN CLAY WITH SAND (CL), brown, very stiff to hard	4.0								
5													
			P = 4.5+										
			P = 3.0	- light reddish brown below 7.5'		17	37	13	24	76	109	8.0	2.6
10													
			N = 20										
15					584.5								
			N = 55	POORLY GRADED GRAVEL (GP), tan, very dense	18.5 583.0								
20				FAT CLAY (CH), tan and light gray, hard, with ferrous seams	20.0								
			N = 34		578.0	24	55	16	39	95			
25					25.0								
				Note: Elevations and coordinates estimated using hand held GPS.									
30													

Fugro Consultants, Inc.

COMPLETION DEPTH: 25.0
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: Dry
UPON COMPLETION: Dry

LONGITUDE: 98.58393° W
LATITUDE: 29.33865° N

PLATE 9

LOG OF BORING NO. B-8

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 607.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
			N = 16	SANDY FAT CLAY (CH), brown, very stiff									
			N = 24			30	58	17	41	70			
5			N = 22										
			N = 27										
			N = 13	- stiff below 8.5'									
10													
				FAT CLAY (CH), light gray, soft to firm	595.0 12.0								
			N = 3										
15													
			N = 8			40	79	26	53	95			
20													
			N = 4	- gray below 23.5'									
25													
					▼								
			P = 4.5+	- hard below 28.5'		23	63	21	42	99	102	24.0	1.4
30					577.0 30.0								
				Note: Elevations and coordinates estimated using hand held GPS.									

Fugro Consultants, Inc.

COMPLETION DEPTH: 30.0
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: 27.5
UPON COMPLETION: 27.5

LONGITUDE: 98.58368° W
LATITUDE: 29.33918° N

LOG OF BORING NO. B-9

SAWS Western Watershed Sewer Relief Line Project
Phase I - Quintana Road to SW Loop 410
San Antonio, Texas
PROJECT NO. 04.10070157

DEPTH, FT	SYMBOL	SAMPLES	POCKET PEN Blows/ft. REC./RQD, %	STRATUM DESCRIPTION SURF. ELEVATION: 604.0	LAYER ELEV./ DEPTH	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX (PI), %	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	CONFINING PRESSURE, PSI	COMPRESSIVE STRENGTH, TSF
			N = 25	CLAYEY SAND (SC), light brown to brown, medium dense									
			N = 4			15	35	14	21	39			
				- loose below 3'									
			P = 1.5	- tan and gray below 4'									
5					598.0	16	34	13	21	42	109	6.0	1.1
			P = 1.5	SANDY LEAN CLAY (CL), tan and gray, stiff to hard	6.0	20	28	12	16	56	105	6.0	0.7
			N = 38										
10													
					591.0								
			N = 48	CLAYEY GRAVEL WITH SAND (GC), tan and gray, dense ▼	13.0	8	30	12	18	20			
15													
					585.5								
			N = 22	SANDY LEAN CLAY (CL), tan and gray, very stiff	18.5								
20					584.0 20.0								
				Note: Elevations and coordinates estimated using hand held GPS.									
25													
30													

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COMPLETION DEPTH: 20.0
DATE DRILLED: 6-29-10
WATER LEVEL / SEEPAGE: 13.7
UPON COMPLETION: 13.7

LONGITUDE: 98.58452° W
LATITUDE: 29.3442° N

PLATE 11

TERMS AND SYMBOLS USED ON BORING LOGS FOR SOIL

Sampler Types

■ Thin-walled Tube

⊠ Standard Penetration Test (SPT)

▯ Texas Cone Penetration Test (TCP)

▤ Auger Sample

◧ Bag Sample

Material Types

▨ LEAN CLAY (CL)

▨ SANDY LEAN CLAY (CL)

▨ FAT CLAY (CH)

▨ SANDY FAT CLAY (CH)

⁙ WELL-GRADED GRAVEL (GW)

⁙ POORLY-GRADED GRAVEL (GP)

⁙ SILTY GRAVEL (GM)

⁙ CLAYEY GRAVEL (GC)

⁙ WELL-GRADED SAND (SW)

⁙ POORLY-GRADED SAND (SP)

⁙ SILTY SAND (SM)

▨ CLAYEY SAND (SC)

▩ FILL (F)

■ ASPHALT (A)

⁙ CONCRETE (C)

⁙ AGGREGATE BASE (AB)

Consistency

Strength of Fine Grained Soils

Consistency	SPT (# blows/ft)(1)	UCS (TSF)(1)	PP (Fugro DFW)
Very Soft	< 2	< 0.25	0.4
Soft	2 - 4	0.25 - 0.5	0.5 - 0.8
Medium Stiff	4 - 8	0.5 - 1.0	0.9 - 1.6
Stiff	8 - 15	1.0 - 2.0	1.7 - 3.3
Very Stiff	15 - 30	2.0 - 4.0	> 3.4
Hard	> 30	> 4.0	

Density of Coarse Grained Soils

Apparent Density	SPT (# blows/ft)	TCP (# blows/ft)(2)
Very Loose	0 - 4	< 8
Loose	4 - 10	8 - 20
Medium Dense	10 - 30	20 - 60
Dense	30 - 50	60 - 100
Very Dense	> 50	> 100

Moisture

Moisture Content adapted from (3)

Dry	No water evident in sample
Moist	Sample feels damp
Very Moist	Water visible on sample
Wet	Sample bears free water

Grain Size(3)

U.S. Standard Sieve

12” 3” 3/4” 4 10 40 200

Boulders	Cobbles	Gravel		Sand			Silt	Clay
		Coarse	Fine	Coarse	Medium	Fine		

300 75 19 4.75 2.00 0.425 0.075 0.002

Particle Grain Size in Milimeters

Structure(3)

Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

Secondary Components

Criteria for Describing Structure adapted from (3)

Trace	< 5% of sample
Few	5% to 10% of sample
Little	10% to 25% of sample
Some	25% to 50% of sample

Size Modifiers for Inclusions

Pocket	Inclusion of different material that is smaller than the diameter of the sample
Fragment	Pieces of a whole item - often used with shell and wood
Nodule	A concretion, a small, more or less rounded body that is usually harder than the surrounding soil (as in carbonate nodule) and was formed in the soil by a weathering process
Streak	A line or mark of contrasting color or texture. The mark or line should be paper thin, and it should be natural - not a smear caused by extruding or trimming the sample

FUGRO

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Note: Information on each boring log is a compilation of subsurface conditions and soil and rock classificaitons obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.

References:
(1) Peck, Hanson and Thornburn, (1974), Foundation Engineering.
(2) TxDOT, (1999), Tex-142-E, Laboratory Classification of Soils for Engineering Purposes.
(3) ASTM International, ASTM D 2488 Standard Practice for Description and Identification of Soils.

PLATE 12

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.

ASFE
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