Geotechnical Engineering Study

SAWS Service Road
Brackish Desalinization Production Well Services – Package I
Bexar County, Texas

Arias Job No. 2009-1122

ARIAS & ASSOCIATES
Geotechnical • Environmental • Testing

Prepared For
LBG Guyton & Associates

March 9, 2011

ARIAS & ASSOCIATES
Geotechnical • Environmental • Testing

March 9, 2011
Arias Job No. 2009-1122

Mr. John Seifert, Jr., P.E.
LBG Guyton & Associates
11111 Katy Freeway, Suite 850
Houston, Texas 77079

RE: Geotechnical Engineering Study
SAWS Service Road
Brackish Desalinization Production Well Services – Package I
Near Intersection of CR 126 and CR 161
Bexar County, Texas

Dear Mr. Seifert:

Arias & Associates, Inc. (Arias) is pleased to submit the results of a Geotechnical Engineering Study for the proposed San Antonio Water System (SAWS) Service Road to be constructed as part of the Brackish Desalinization Production Well Services – Package I project in Bexar County, Texas. Our findings and recommendations should be incorporated into the design and construction documents for the proposed development. Please consult with us as needed during any part of the design or construction process.

The long-term success of the project will be affected by the quality of materials used for construction and the adherence of the construction to the project plans and specifications. We recommend that the site work and construction be tested and observed by one of our representatives in accordance with the report recommendations.

We appreciate the opportunity to serve you during this phase of design. If we may be of further service, please call.

Sincerely,
ARIAS & ASSOCIATES, INC.
TBPE Registration No. F-32

SPENCER ASHLEY HIGGS
90172
3-9-2011

Spencer A. Higgs, P.E.
Director of Engineering

Dexter Bacon

Dexter Bacon, P.E.
Senior Vice President

cc: 3 – Addressee

1295 Thompson Rd
Eagle Pass, Texas 78852
(830) 757-8891
(830) 757-8899 Fax

142 Chula Vista
San Antonio, Texas 78232
(210) 308-5884
(210) 308-5886 Fax

5233 IH 37, Suite B-12
Corpus Christi, Texas 78408
(361) 288-2670
(361) 288-4672 Fax

TABLE OF CONTENTS

Tables

Figures in Appendix A

INTRODUCTION

The results of a Geotechnical Engineering Study for the proposed San Antonio Water System (SAWS) Service Road as part of the Brackish Desalinization Production Well Services – Package I project are presented in this report. The site is located near the intersection of County Road (CR) 126 and CR 161 as shown on the Vicinity Map included in Appendix A.

This project was authorized on July 6, 2010, by Mr. John Seifert, P.E. with LBG Guyton & Associates (LBG) through completion of a Subconsultant Agreement between LBG and Arias & Associates, Inc. (Arias). Our scope of work was performed in general accordance with the original service scope (Task 450) outlined in Arias Proposal No. 2009-1122, dated October 9, 2009, and revised October 14, 2009. We should note that an additional boring, Boring B-6, not outlined in our service scope was drilled adjacent to an existing stock pond at the request of LBG.

SCOPE OF SERVICES

The objective of this geotechnical engineering study was to assess the subsurface soil and groundwater conditions present at the site and to provide geotechnical design criteria and construction recommendations regarding the service road subgrade and limestone base section, and the subgrade preparation for a proposed concrete-lined or culvert-bridge low water crossing. Environmental studies and surface fault evaluations of any kind were not a part of our authorized service scope.

PROJECT DESCRIPTION AND SITE DESCRIPTION

The project will consist of the construction of approximately 15,000 linear feet of a new aggregate-surfaced roadway to aid in the construction of four (4) production wells and to service post-construction SAWS operational and maintenance vehicles. We understand that an existing low water crossing will be upgraded to either a concrete-lined or culvert-bridge low water crossing to improve site access. Pipe culverts will also be incorporated in the drainage design of the new roadway.

Geographically, the project area is situated within an area of low, well-rounded hills and ridges along the south side of the San Antonio River. Approximately five small southeast trending drainages cross the proposed road development paralleling the existing water line. A much larger main drainage for the area trending to the northeast crosses the proposed access road for the project near the intersection of County Roads 161 and 126. Locally, the existing ground surface is gently sloping within the project area.

At the time of our investigation, with the exception of the existing water line features the property was in a near natural condition and currently in use for pasture grazing of livestock and other agricultural purposes. Existing vegetation consisted generally of scattered clusters of oak trees and a light to sparse ground cover of wild grasses and weeds. Site photographs are included in Appendix A of this report.

SOIL BORINGS AND LABORATORY TESTING

Nineteen (19) soil test borings were drilled at the approximate locations shown on the attached Boring Location Plan included in Appendix A. The test borings were drilled to depths ranging between 6 feet and 20 feet below the existing ground surface on July 13, 2010. The boreholes were advanced using solid stem, dry auger drilling techniques. Soil samples were obtained at continual 2-foot intervals. For boring depths greater than 6 feet below grade, the soils were continuously sampled to 12-foot depths, at a 13.5-foot depth, and then at 5-foot depth intervals thereafter. After completion of drilling, the boreholes were backfilled using cuttings generated during the drilling process.

Soils were sampled as part of the Standard Penetration Test (SPT) by driving a 2-inch diameter, split-barrel sampler in accordance with ASTM D 1586. The sampler was driven 18 inches by a 140-lb hammer falling 30 inches. Arias' field representative recorded the number of blows required to drive the sampler through three consecutive 6-inch intervals. The sum of the blows required to penetrate the final 12 inches is the SPT N-value.

For each sample, Arias' field representative visually classified the soil within the split-barrel sampler and placed a portion into a plastic bag with zipper seal. The samples were then placed into wax-coated cardboard sample boxes designed for transporting soil specimens to the laboratory.

Soil classifications and borehole logging were conducted during the exploration by one of our Professional Geologists working under the supervision of the project Geotechnical Engineer. Final soil classifications, as seen on the attached boring logs, were determined in the laboratory based on laboratory and field test results and applicable ASTM procedures.

As a supplement to the field investigation, laboratory testing to determine soil water content, Atterberg Limits, and percent passing the No. 200 sieve was conducted. The laboratory results are reported in the attached boring logs included in Appendix B. A key to the terms and symbols used on the logs is also included in Appendix B. The soil laboratory testing for this project was done in accordance applicable ASTM procedures with the specifications and definitions for these tests listed in Appendix C.

Remaining soil samples recovered from this exploration will be routinely discarded following submittal of this report.

SUBSURFACE CONDITIONS

Geology, generalized stratigraphy, and groundwater conditions at the project site are discussed in the following sections. The subsurface and groundwater conditions are based on conditions encountered at the boring locations and to the depths explored.

Geology

The earth materials underlying the project site have been regionally mapped as both the Carrizo Sand and Reklaw Formations of Eocene age (approximately 50 million years before present). Locally, the materials encountered in the test borings consist primarily of fine sands with scattered beds of clays.

Generalized Site Stratigraphy and Engineering Properties

The generalized stratigraphy and soil properties for the interpreted strata are summarized in the following table.

Table 1 Generalized Soil Conditions

Stratum	Depth, ft	Material Type	PI range	No. 200 range	N Range
			PI average	No. 200 average	N Average
IA	0 to 2 - 4	FILL: CLAY (CH) and Native CLAY (CH), with sand, dark brown, firm to stiff; *Encountered only in Borings B-1 and B-2.*	26 - 36	--	6 -10
			31	74	8
IB	0 - 2 to 2 - 8.5	CLAYEY SAND (SC), SILTY SAND (SM), and/or SAND (SP-SM), tan or reddish brown, very loose to loose, or medium dense to loose; *Encountered in each boring except Borings B-1, B-2, and B-8.*	NP - 18	9 - 18	2 - 14
			<13	13	6
II	0 - 4 to 4 - 13	LEAN CLAY (CL), with sand, dark brown, reddish brown, dark gray to gray, soft to stiff; *Encountered only in Borings B-1, B-2, B-3, B-5, and B-8.*	15 - 23	60 - 78	3 - 34
			19	69	11

Stratum	Depth, ft	Material Type	PI range	No. 200 range	N Range
			PI average	No. 200 average	N Average
III	3.5 - 13 to 4.5 - 15	SILTY SAND (SM) or CLAYEY SAND (SC), gray brown, light gray brown to tan, medium dense; Encountered only in Borings B-1, B-2, B-6, B-8, and B-19. Not encountered in many of the shallower 6-foot deep borings.	NP - 19	18 - 47	10 - 55
			<15	33	23

Where:

Depth	-	Depth from existing ground surface during geotechnical investigation, feet
PI	-	Plasticity Index, %
No. 200	-	Percent passing #200 sieve, %
N	-	Standard Penetration Test (SPT) value, blows per foot
--	-	No sample selected for testing

Groundwater

A dry soil sampling method was used to obtain the soil samples. With the exception of Boring B-6 drilled next to the existing stock pond, groundwater was not observed within the borings drilled at this site. Groundwater was encountered at a depth of approximately 6.5 feet in Borings B-6 during drilling operations on July 13, 2010. It should be noted that water levels in open boreholes may require several hours to several days to stabilize depending on the permeability of the soils. The installation of temporary piezometers can be performed to obtain more accurate groundwater data.

The clay soils encountered at this site are generally not conducive to transmit groundwater. However, seams, pockets or layers of gravels and sands, or soft/loose soils can store and transmit "perched" groundwater flow or seepage. The granular sandy soils at this can readily transmit subsurface water. Groundwater levels will likely be subject to seasonal conditions, recent rainfalls, drought and temperature affects.

ENGINEERING EVALUATION FOR SITE IMPROVEMENTS

The project will consist of the construction of approximately 15,000 linear feet of a new aggregate-surfaced roadway and either a concrete-lined or culvert-bridge low water crossing. Pipe culverts will be incorporated in the drainage design of the new aggregate roadway

Geotechnical engineering evaluation and recommendations are presented in the following sections of this report regarding:

1. Pipe culverts that will traverse the new aggregate-surfaced roadway,
2. Low water crossing subgrade preparation, and
3. Pavement section design and construction recommendations for the proposed aggregate-surfaced roadways.

Pipe Culverts

We understand that pipe culverts will be constructed at this site to help facilitate drainage of storm water runoff from low drainage areas that traverse the proposed service road. Excavations for the planned culverts should preferably be neat-excavated. The excavation may need to be over-excavated to allow for the placement of bedding material that may be required by the pipe manufacturer and/or project civil engineer.

Excavation equipment may disturb the bearing soils and loose pockets can occur at the pipe culvert's bearing elevation. Accordingly, we recommend that the upper 6 inches of the base of the excavations be compacted to achieve a density of at least 95 percent of the maximum dry density as determined by ASTM D-698. Hand operated type compaction equipment should be utilized. It may also be desirable to construct a working platform comprised of a lean concrete "mudmat" at the bearing level.

Bedding and Embedment Backfill

Well-graded, free-draining gravel bedding and embedment backfill material is typically used to surround pipe culverts. A common backfill and embedment material consists of 1-inch clean TXDOT concrete gravel Grade #5 (ASTM C-33 #67).

A filter fabric should be provided between the free-draining gravel backfill and adjacent soil to aid in preventing finer-grained soils from infiltrating into the free-draining gravel, which could lead to ground loss and distress to the overlying roadway. An Arias' representative should observe the backfill and compaction processes.

Lateral Earth Pressures for Culvert Pipes

Lateral earth pressures that may act on the buried pipes can be evaluated using an equivalent fluid weight (EFW) of 105 pcf for onsite backfill soils. Pressures from surcharge loads including equipment loads, traffic and soil stockpiles should also be considered in the analysis of the pipe.

Low Water Crossings

We understand that an existing low water crossing presently located in the vicinity of Borings B-1 and B-2 is planned to be upgraded to a concrete-lined low water crossing. We understand that the concrete low water crossing will likely be designed to allow surface water runoff to flow across the road. Furthermore, the concrete-lined low water crossing may be constructed to include pipe culverts designed to accommodate relatively small runoff events. It may be advantageous to use a “turned down” perimeter beam on each side of the crossing to provide some anchorage and protection against erosion. Erosion control is recommended on each side of the crossing.

We also understand that some consideration may be given to upgrading the existing low water crossing to a precast culvert-bridge system. In either case of the potential upgrade, we recommend that the subgrade be prepared as recommended below.

Subgrade preparation should be prepared prior to steel placement and concreting, or prior to the placement of precast culverts, whichever is applicable. The subgrade in the area of the improvement and extending at least 2 feet horizontally in each direction should be stripped of organic material and topsoil. Topsoil or soils containing organic material should not be reused as fill within the area of the proposed site improvements. Following stripping operations, the existing soils should be over-excavated vertically at least 2 feet. After excavating at least 2 feet, a fully-loaded dump truck weighing at least 15 tons should be used to proof roll over the given subgrade area using at least 5 passes to assess the competency of the subgrade. Proof rolling operations should be observed by a representative of the Geotechnical Engineer.

If competent soils are encountered, the exposed soils should be compacted to at least 95 percent of the maximum dry density determined by ASTM D-698. Provided that the previously excavated soils are clean of organics and deleterious material, the soils can then be placed back in maximum 8-inch loose lifts to restore grade to within 8 inches of the base of the concrete slab or bottom of the precast culverts, whichever is applicable. The soils should be moisture conditioned to between optimum and plus three (+3) percentage points of optimum moisture content and compacted to at least 95 percent of ASTM D-698. The final 8 inches should be completed using compacted import flexible base material meeting the criteria presented in the following report section.

If soft weak soils are encountered at the base of the excavation, the soils can be bridged using Tensar TX-140 geogrid and import flexible base material. The geogrid should be installed over the soft subgrade as per the manufacturer’s recommendations. The import flexible base material should meet the criteria presented in the following report section. The base material should be placed over the geogrid until the excavation base is suitable to receive compacted fill soils. The upper 8 inches of the base material should be compacted to at least 95 percent of the maximum dry density determined by ASTM D-1557. Care should be taken not to damage the grid during placement of the base material.

Aggregate-Surfaced Roadways

Aggregate-surfaced roadways are planned to be constructed for use during the construction of the proposed production wells, and to service post-construction SAWS operational and maintenance vehicle traffic. During construction of the production wells, the roadways will be exposed to temporary high loads and maneuvering requirements associated with material and equipment transport trucks. We understand that the construction operations are anticipated to last about 12 months.

Presented in the following table are estimated traffic criteria for a 12-month construction period provided to us by LBG.

Table 2 Construction Traffic Estimates – 12 Month Period

Truck Type	Truck Frequency	Total Trucks
18-Wheeled Tractor-Trailers	25-35 per Well	100-140
¾-ton Pick-up Trucks	4 Daily	1250
3-ton Trucks	4 Daily	1250

After construction of the production wells, we understand that the roadway will primarily service light operational and maintenance pick-up trucks. Based on the traffic noted in the above table and in the criteria provided in Chapter 4 Low-Volume Road Design of the 1993 AASHTO Guide for Design of Pavement Structures, the estimated level of traffic for the proposed roadway would be considered as “Low”. A “Low” traffic level would correlate to an 18-kip equivalent single axle load (ESAL) application of 10,000 to 30,000 ESAL’s.

Section 4.2.3 Aggregate Surfaced Road Design Catalog of the 1993 AASHTO Guide for Design of Pavement Structures was used in our pavement analysis of the roadway sections for the planned low-volume roadway. Based on the soil conditions encountered in our borings, we estimate the relative quality of the subgrade soil to be **very poor.** The recommended pavement sections to accommodate the estimated traffic loading are presented in the following table.

Table 3 Aggregate-Surfaced Roadway Section Options

Material	Option 1	Option2
Import Flexible Base	8”	12”
Tensar TX-140 Geogrid	Yes	No
Compacted Subgrade	12”	12”

Note:

1. CBR of 2 to 3 for compacted subgrade soils.
2. Tensar geogrid TX-140 installed on top of a 12-inch thick compacted subgrade can be considered to result in an approximate 30% reduction in the base thickness. Geogrid should be installed as per the manufacturer’s guidelines.
3. The proposed pavement sections are based on a 1.5- to 2-inch rut criterion for the noted traffic.

A CBR of value of 2 to 3 was selected for subgrade soils that are compacted as recommended in this report. The CBR value is based on typical values for the materials encountered at the project site, our experience with similar soils, and based on a laboratory CBR test (ASTM D 1883) conducted on a bulk sample specimen collected from the project site. The performance of the proposed roadway section will depend on the proper preparation of the subgrade as well as proper selection, quality, and placement of the flexible base material and geogrid (if applicable).

Recommendations for each of these items are discussed below.

> Subgrade Preparation - Topsoil stripping should be performed as needed to remove existing organic materials, vegetation, roots, and stumps. A minimum depth of 3 to 4 inches should be planned. Additional excavation may be required due to encountering deleterious materials such as organics and deleterious debris.
>
> Following stripping, the exposed subgrade should be compacted to a depth of at least 12 inches to at least 95 percent of the maximum dry density determined by ASTM D 698. In sandy soils, a 10-ton roller should be used to proof roll over the given subgrade area using at least 15 passes prior to the placement of base material. Proof rolling over sandy areas should initially be performed in the static mode for the first 5 passes and then in the vibration mode for the final 10 passes. Proof rolling in clay areas should be performed using a fully-loaded dump truck weighing at least 15 tons using at least 5 passes. A representative of the Geotechnical Engineer should be present to observe proof rolling operations and evaluate areas of instability should they occur.

Variable surface and near-surface soil types and conditions were encountered in the borings drilled at this site. Where clayey subgrade soils are encountered at the ground surface, scarification and low to moderate moisture conditioning along with the use of sheepsfoot rollers are commonly used to achieve similar compaction criteria as that recommended in this report. **We should note, however, that loose to very loose sands were predominately encountered along the project alignment. These very loose to loose sandy soils were often encountered to depths of 6 feet or more. Construction equipment can become stuck in these soil conditions.** For these sandy soils, low to high moisture conditioning followed by the use of a 10-ton vibratory smooth-wheeled roller in multiple passes can be considered to achieve the recommended compaction criteria. **We should warn that excessive moisture from earthwork conditioning or wet weather combined with vibrations from compaction equipment may create a "quick" condition in sands that: (1) contain little clay and appreciable silt, or (2) are immediately underlain by less permeable clayey sand or clay soils allowing the moisture to pond on top of the clay soils. This "quick" condition may also cause equipment to become stuck. The decision on what type of earthwork equipment to use and the means and methods to achieve the required compaction is the sole responsibility of the earthwork contractor. We strongly recommend that the earthwork contractor evaluate the soil boring data included in this report and conduct a pre-bid site visit to assess the existing surface soil conditions.**

Geogrid – The geogrid used for the subgrade should be Tensar geogrid TX-140 installed per the manufacturer's recommendations. The subgrade should be leveled and smoothed prior to geogrid placement on top of the compacted subgrade.

Import Flexible Base Material – Consideration can be given to constructing the roadway sections using an import flexible base material meeting all of the criteria of 2004 TXDOT Standard Specifications Item 247, Type A or B, Grade 1 or 2 including the triaxial compressive strength requirements. The base should be placed in maximum 8 inch loose lifts that are moisture conditioned to between minus two (-2) and plus three (+3) percentage points of optimum moisture content, and then compacted to at least 95 percent of the maximum dry density determined by ASTM D 1557.

The proposed pavements will be aggregate-surfaced and will be exposed to wet-dry climatic cycles. Therefore, the pavements will display various degrees of wear and deterioration which will be dependent on the section materials used for construction and on the drainage conditions provided for the pavements. Some ongoing maintenance will be required for the pavements and will likely include the repair, filling, and/or re-grading of rutted areas and potholes. We estimate a rut depth of 1.5 to 2 inches for the proposed pavement section options and the anticipated traffic. We should note, however, that deeper rutting than 2 inches can occur, particularly if the roadway is exposed to heavy construction equipment soon after rain events before the ground and roadway have had adequate time to dry. Furthermore, we anticipate that notable costs can be incurred as a result of construction delays due to accessibility issues. As a result, we highly recommend that the contractor proof roll over the surface of the aggregate roadways following heavy precipitation events just prior to exposing the roadway to truck traffic. Proof rolling operations for pavement surface should be performed using a fully-loaded dump truck weighing at least 15 tons and using at least 5 passes. Any areas which show excessive rutting, cracking, pumping or rolling of the compacted aggregate upon proof rolling should be recompacted and/or reconstructed and proof rolled again prior to acceptance. A representative of the Geotechnical Engineer should be present to observe proof rolling operations.

Consideration can be given to cement treating the import flexible base material with at least 5 percent cement dry weight in accordance with TXDOT Item 275, Cement Treatment (Road-Mixed). A cement-treated base will be more resistant to the effects of both wet weather and erosion. The compaction criteria provided for an unbound flexible base material would also apply for a cement-treated base.

Following construction, the pavement surface can be re-graded and recompacted as needed to aid in providing a better ride quality for future maintenance and service passenger vehicles. As previously noted, some ongoing pavement maintenance will be required and will likely include the repair, filling, and/or re-grading of rutted areas and potholes. Following the well construction period, consideration can be given to providing a wearing surfacing such as chipseal to further improve ride quality while also helping to lessen the occurrence of pavement distress.

The chipseal process typically involves spraying the surface of the compacted base material with an emulsified asphalt then spreading 2 layers of aggregate (commonly referred to as chips) with each layer also being sprayed with asphalt, and finally compacting and embedding the aggregate in the asphalt with the use of rubber-tired (pneumatic) rollers. The aggregate used generally consists of a maximum size of 3/8-inch in diameter. In some cases, the maximum aggregate size in the layers of rock is different to help result in more uniform coverage of the pavement surface. The chipseal process should be conducted in accordance with the specification requirements of 2004 TxDOT Standard Specification Item 316.

Drainage and Erosion Control

The performance of the proposed improvements will each be directly related to the control of drainage and erosion. Providing positive drainage, sloping the surface of the roadways, and including drainage ditches and culverts where needed to direct surface water will each be critical in the performance of the proposed improvements. Water should not be allowed to pond on the roadway surfaces.

Additionally, erosion control should be provided, where appropriate, such as for embankment slopes, drainage ditches, low water crossings, culvert inlets/outlets etc. Some potential erosion control methods are presented below. Actual measures for drainage and erosion control should be determined by the project civil engineer.

- Rock Riprap
- Gabions and Slope Mattresses
- Concrete Lining
- Erosion Control Mats

Consideration should be given to using “turn-downs” and “cut-off-walls” with the erosion control methods. Care should be taken to provide adequate anchorage for the erosion control methods. Vegetation would further add stability to the earth once root systems mature and become established.

GENERAL COMMENTS

This report was prepared as an instrument of service for this project exclusively for the use of LBG Guyton & Associates and the project design team. If the development plans change relative to layout, anticipated traffic loads, or if different subsurface conditions are encountered during construction, we should be informed and retained to ascertain the impact of these changes on our recommendations. We cannot be responsible for the potential impact of these changes if we are not informed.

Review

Arias should be given the opportunity to review the design and construction documents. The purpose of this review is to check to see if our recommendations are properly interpreted into the project plans and specifications. Please note that design review was not included in the authorized scope and additional fees may apply.

Quality Assurance Testing

The long-term success of the project will be affected by the quality of materials used for construction and the adherence of the construction to the project plans and specifications. As Geotechnical Engineer of Record, we should be engaged by the Owner to provide quality assurance testing. Our services, as a minimum, will be to observe and confirm that the encountered materials during earthwork for site subgrade improvement and roadway (including low water crossing) installation are consistent with those encountered during this study. We also should verify that the materials used as part of subgrade improvement, roadway installation, and other pertinent elements conform to the project specifications and that placement of these materials is in conformance with the specifications. In the event that Arias is not retained to provide quality assurance testing, we should be immediately contacted if differing subsurface conditions are encountered during construction. Differing materials may require modification to the recommendations that we provided herein.

Subsurface Variations

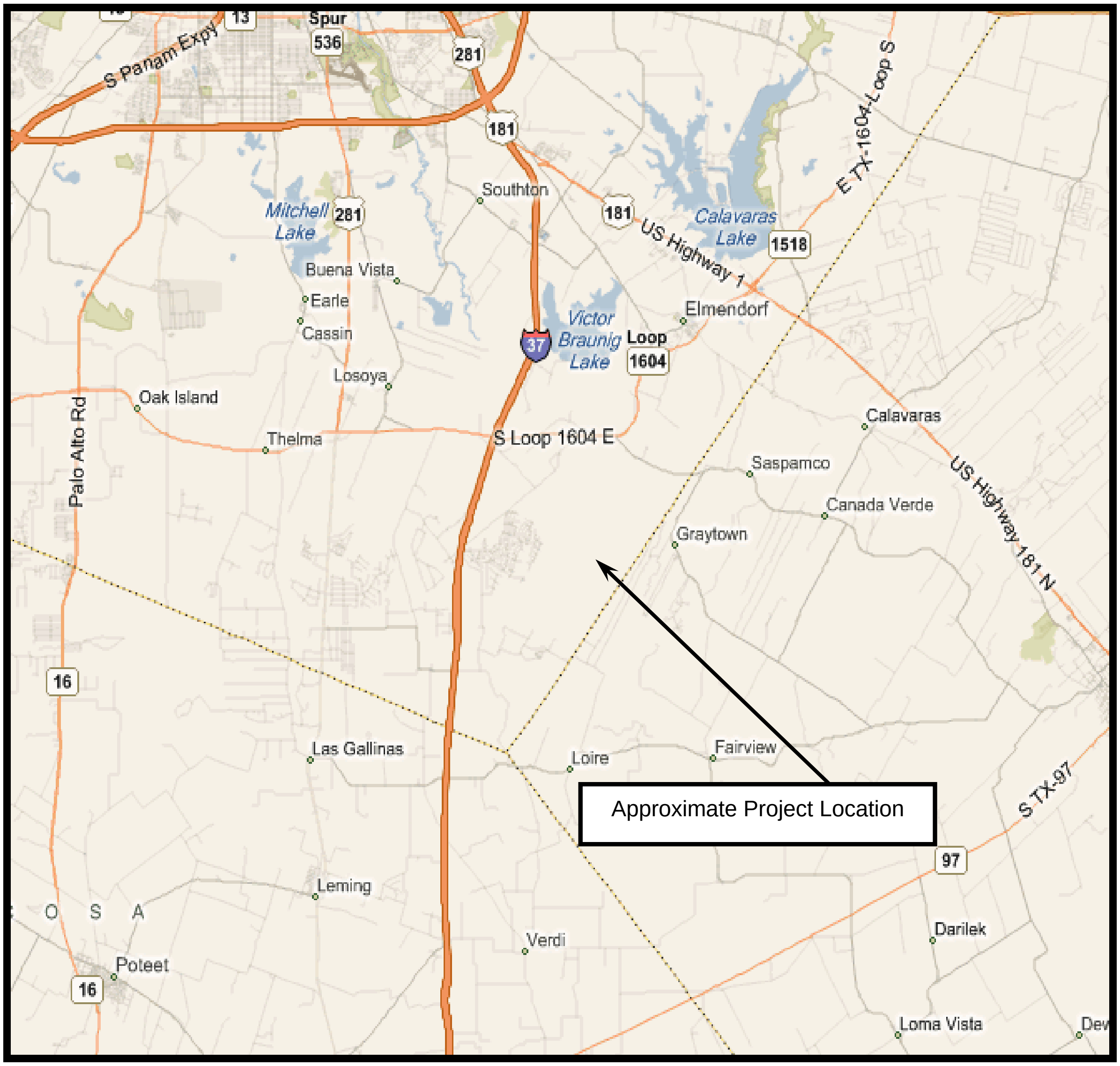
Soil and groundwater conditions may vary away from the sample boring locations. Transition boundaries or contacts, noted on the boring logs to separate soil types, are approximate. Actual contacts may be gradual and vary at different locations. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions or highly variable subsurface conditions are encountered during construction, we should be contacted to evaluate the significance of the changed conditions relative to our recommendations.

Standard of Care

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

APPENDIX A: FIGURES AND SITE PHOTOGRAPHS

SITE VICINITY MAP



Proposed SAWS Service Road
Near Intersection of CR 126 and CR 161
Bexar County, Texas

Arias & Associates, Inc.

Arias Job No.: 2009-1122

BORING LOCATION PLAN

NOTE: Locations are approximate. Drawing is not to scale.

BORING LOCATION PLAN

<u>NOTE:</u> Locations are approximate. Drawing is not to scale.

BORING LOCATION PLAN

NOTE: Locations are approximate. Drawing is not to scale.

BORING LOCATION PLAN

NOTE: Locations are approximate. Drawing is not to scale.

Site Photographs of Project Area
Proposed SAWS Service Road

Site Photo 1 – Near Boring B-1

Site Photo 2 –Boring B-2 Drilled Left of Stake Shown

Site Photographs of Project Area
Proposed SAWS Service Road

Site Photo 3 – Proposed Roadway Alignment and Existing Pipeline

Site Photo 4 – Very Loose Sand at Ground Surface

APPENDIX B: SOIL BORING LOGS AND KEY TO TERMS

Boring Log No. 1

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
FILL: CLAY (CH), with sand, dark brown, firm to stiff		1: SS	26				8	74
CLAY (CH), with sand, dark brown, stiff		2: SS	29	19	55	36	10	
LEAN CLAY (CL), with sand, dark gray to gray, firm to stiff	5	3: SS	29	25	48	23	6	78
		4: SS	31				9	
	10	5: SS	20	15	35	20	6	
		6: GB	20	16	36	20		
Silty SAND (SM), gray brown, medium dense	15	7: SS	9				21	
Boring terminated at about 15 feet	20							

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
GB = Grab Bag Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 2

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
FILL: CLAY (CL), with sand, dark brown, firm		1: SS	27	19	45	26	6	
LEAN CLAY (CL), with sand, dark brown to dark gray, firm		2: SS	21				7	
Clayey SAND (SC), light gray brown to tan, medium dense	5	3: SS	22	28	47	19	10	47
		4: SS	8				17	
		5: SS	11	12	20	8	10	
	10	6: SS	12				10	
		7: SS	12				10	
Boring terminated at about 15 feet	15							
	20							

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 3

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
Silty SAND (SM), tan, very loose		1: SS	5				3	
		2: SS	12				2	16
LEAN CLAY (CL), sandy, tan, firm	5	3: SS	15	11	26	15	8	
Boring terminated at about 6 feet								
	10							
	15							
	20							

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▥ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 4

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	N	-200
SAND (SP-SM), tan, very loose		1: SS	4	2	
		2: SS	4	2	12
	5	3: SS	4	3	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▨ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

Boring Log No. 5

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
Silty SAND (SM), tan, loose		1: SS	8				6	
LEAN CLAY (CL), sandy, dark brown, soft to stiff		2: SS	13				3	60
	5	3: SS	17	14	32	18	12	
Boring terminated at about 6 feet	10 15 20							

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Arias & Associates, Inc.

Job No.: 2009-1122

Boring Log No. 6

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
SAND (SP-SM), tan, very loose to loose								
		1: SS	4				2	
		2: SS	7				2	
	5	3: SS	13				2	
▽								
		4: SS	21				6	9
Silty SAND (SM), tan, medium dense								
		5: SS	14				35	
	10							
		6: SS	13				35	18
- partially cemented zone at about 13½ feet		7: SS	8	13	31	18	50/5"	
	15							
		8: GB	20					
	20							
Boring terminated at about 20 feet								

Groundwater encountered during drilling: 6.5 feet

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
GB = Grab Bag Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 7

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	N	-200
Silty SAND (SM), tan, medium dense to loose		1: SS	4	12	13
		2: SS	5	8	
	5	3: SS	5	4	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▨ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 8

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
LEAN CLAY (CL), sandy, reddish brown, very stiff to hard		1: SS	11	15	34	19	15	
- Clayey SAND (SC) zone at about 2½ feet		2: SS	10				34	39
Silty SAND (SM), tan, very dense	5	3: SS	12				55	
Boring terminated at about 6 feet								
	10							
	15							
	20							

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▨ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 9

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	N	-200
SAND (SP-SM), tan, loose to very loose		1: SS	4	9	
		2: SS	5	6	9
	5	3: SS	4	5	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▨ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 10

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	N	-200
SAND (SP-SM), tan, very loose		1: SS	3	4	
		2: SS	4	4	
	5	3: SS	5	3	10
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▨ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 11

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	N	-200
Silty SAND (SM), tan, very loose to loose	0	1: SS	5	5	
		2: SS	7	3	
	5	3: SS	16	5	14
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 12

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	N	-200
Clayey SAND (SC), tan, medium dense	0	1: SS	7	14	
SAND (SP-SM), tan, medium dense to loose		2: SS	5	11	12
	5	3: SS	6	6	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

Arias & Associates, Inc.

Job No.: 2009-1122

Boring Log No. 13

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
Clayey SAND (SC), tan, medium dense		1: SS	4	14	22	8	12	
SAND (SP-SM), tan, medium dense to loose		2: SS	4				10	9
	5	3: SS	4				5	
Boring terminated at about 6 feet								
	10							
	15							
	20							

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 14

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	N	-200
Clayey SAND (SC), tan, medium dense	0	1: SS	5	11	16
Silty SAND (SM), tan, loose		2: SS	6	8	
	5	3: SS	16	6	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▮ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

Boring Log No. 15

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	N	-200
Silty SAND (SM), tan, medium dense to very loose	0	1: SS	4	13	
		2: SS	5	4	
	5	3: SS	7	5	16
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

☒ Grab Bag Sample (GB)
■ Shelby Tube Sample (ST)
▨ Split Spoon Sample (SS)
▽ Water encountered during drilling
▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

Arias & Associates, Inc.

Job No.: 2009-1122

Boring Log No. 16

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	N	-200
Silty SAND (SM), tan, medium dense to very loose		1: SS	3	11	18
		2: SS	5	6	
	5	3: SS	6	3	
Boring terminated at about 6 feet					
	10				
	15				
	20				

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▨ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

Boring Log No. 17

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth 0 ft	SN	WC	PL	LL	PI	N	-200
Clayey SAND (SC), reddish brown, medium dense		1: SS	10	18	36	18	9	
SAND (SP-SM), tan, loose to very loose		2: SS	3				7	11
	5	3: SS	6				3	
Boring terminated at about 6 feet								
	10							
	15							
	20							

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

Boring Log No. 18

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	N
Clayey SAND (SC), reddish brown, medium dense	0	1: SS	5	14
SAND (SP-SM), tan, loose to very loose		2: SS	5	7
	5	3: SS	13	3
Boring terminated at about 6 feet				
	10			
	15			
	20			

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts

Boring Log No. 19

Address: **Brackish Desalinization Production Well Site**
Bexar County, TX
Location: **See Boring Location Plan**

Project: **SAWS Service Road**
Logged By: **JLK** Elev.:
Sampling Date: **7/13/10**

Soil Description	Depth ft	SN	WC	PL	LL	PI	N	-200
SAND (SP-SM), tan, very loose to loose	0	1: SS	5				3	11
		2: SS	8				7	
Clayey SAND (SC), tan, medium dense	5	3: SS	8	12	28	16	28	
Boring terminated at about 6 feet	10							
	15							
	20							

Groundwater encountered during drilling: None Observed

- ☒ Grab Bag Sample (GB)
- ■ Shelby Tube Sample (ST)
- ▮ Split Spoon Sample (SS)
- ▽ Water encountered during drilling
- ▼ Delayed water reading

Refer to Appendix for Additional Information

SN = Sample Type and No.
SS = Split Spoon Sample
WC = Water Content (%)
N = SPT Blow Counts
PL = Plastic Limit (%)
LL = Liquid Limit (%)
PI = Plasticity Index
-200 = % Passing #200 Sieve

BORING LOG 2009-1122.GPJ ARIAS.GDT 8/2/10

KEY TO CLASSIFICATION SYMBOLS USED ON BORING LOGS

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

Arias & Associates, Inc.

APPENDIX C: FIELD AND LABORATORY EXPLORATION

FIELD AND LABORATORY EXPLORATION

The field exploration program included drilling at selected locations within the site and intermittently sampling the encountered materials. The boreholes were drilled using single flight auger (ASTM D 1452). Samples of encountered materials were obtained using a split-barrel sampler while performing the Standard Penetration Test (ASTM D 1586), or by taking material from the auger as it was advanced (ASTM D 1452). The sample depth interval and type of sampler used is included on the soil boring log. Arias' field representative visually logged each recovered sample and placed a portion of the recovered sampled into a plastic bag for transport to our laboratory.

SPT N-values and blow counts for those intervals where the sampler could not be advanced for the required 18-inch penetration are shown on the soil boring log. If the test was terminated during the 6-inch seating interval or after 10 hammer blows were applied used and no advancement of the sampler was noted, the log denotes this condition as blow count during seating penetration.

Arias performed soil mechanics laboratory tests on selected samples to aid in soil classification and to determine engineering properties. Tests commonly used in geotechnical exploration, the method used to perform the test, and the column designation on the boring log where data are reported are summarized as follows:

Test Name	Test Method	Log Designation
Water (moisture) content of soil and rock by mass	ASTM D 2216	wc
Liquid limit, plastic limit, and plasticity index of soils	ASTM D 4318	PL, LL, PI
Amount of material in soils finer than the No. 200 sieve	ASTM D 1140	-200
California Bearing Ratio of Laboratory-Compacted Soil	ASTM D 1883	Noted in soil description body

The laboratory results are reported on the soil boring log.

APPENDIX D: ASFE INFORMATION – GEOTECHNICAL REPORT

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
THE BEST PEOPLE ON EARTH

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org