Geotechnical Engineering Study

Hemisfair Parking Lots
Henry B. Gonzalez Convention Center
San Antonio, Texas

Arias Job No. 2016-278

Prepared For:

Ford Engineering, Inc.

July 11, 2016

ARIAS GEOPROFESSIONALS
142 Chula Vista, San Antonio, Texas 78232 • Phone: (210) 308-5884 • Fax: (210) 308-5886

July 11, 2016
Arias Job No. 2016-278

Via Email: Mark@fordengineering.com

Mr. Mark Hill, P.E.
Ford Engineering
10927 Wye Drive, Suite 104
San Antonio, Texas 78217

RE: Geotechnical Engineering Study
Hemisfair Parking Lots
Henry B. Gonzalez Convention Center
San Antonio, Texas

Dear Mr. Hill:

This Geotechnical Engineering Report presents the results of our geotechnical study for the proposed pavement design for the New Parking Area at the Henry B. Gonzalez Convention Center in San Antonio, Texas. This project was performed in general accordance with Arias Proposal No. 2016-278, dated April 26, 2016. Notice to proceed was provided by Mr. Hill in his e-mail dated May 5, 2016.

The purpose of this geotechnical engineering study was to establish pavement engineering properties of the subsurface material(s) and groundwater conditions present at the site. The scope of the study is to provide geotechnical engineering criteria for use by design engineers in preparing the pavement design. Our findings and recommendations should be incorporated into the design and construction documents for the proposed development.

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. The quality of construction can be evaluated by implementing Quality Assurance (QA) testing. As the Geotechnical Engineer of Record (GER), we recommend that the earthwork and foundation construction be tested and observed by Arias in accordance with the report recommendations. A summary of our qualifications to provide QA testing is discussed in the "Quality Assurance Testing" section of this report. Furthermore, a message to the Owner with regard to QA testing is provided in the ASFE publication included in Appendix E.

Thank you for the opportunity to be of service to you.

Sincerely,
Arias & Associates, Inc.
TBPE Registration No: F-32

STATE OF TEXAS
RENE P. GONZALES
86259
LICENSED PROFESSIONAL ENGINEER
7/12/16

Rene P. Gonzales, P.E.
Senior Geotechnical Engineer

Christopher M. Szymczak, P.E.
Senior Geotechnical Engineer

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INTRODUCTION

The results of a Geotechnical Engineering Study for the pavement design for the proposed New Parking Area for the Henry B. Gonzalez Convention Center in San Antonio, Texas are presented in this report. This project was performed in general accordance with Arias Proposal No. 2016-278, dated April 26, 2016. Notice to proceed was provided by Mr. Hill of Ford Engineering in his e-mail dated May 5, 2016.

SCOPE OF SERVICES

The purpose of this geotechnical engineering study was to conduct subsurface exploration and laboratory testing to establish the engineering properties of the subsurface materials present on the project site. This information was used to develop the geotechnical engineering criteria for use by design engineers to aid in preparing the pavement design for the New Parking Area. Environmental, slope stability, drainage, utility, retaining wall analysis and foundation engineering studies of any kind were not a part of our authorized scope of services for this project.

PROJECT AND SITE DESCRIPTION

It is understood that the proposed project is to consist of the design and construction of two (2) new parking areas to be located east of the Tower of Americas. The new surface parking lots, designated as Lots 1 and 2, will provide parking for the Henry B. Gonzalez Convention Center (HBGCC). Lot 1 will be about 116,000 sq-ft and Lot 2 will be about 34,000 sq-ft. Portions of the site were occupied by a parking garage structure that was demolished as part of the upgrades and improvements to the HBGCC. A Vicinity Map and Site Photographs are included in Appendix A.

SOIL BORINGS

Six (6) borings were drilled at the approximate locations shown on the Boring Location Plan included as Figure 2 in Appendix A. Each of the borings was generally drilled to a depth of about ten (10) feet below the existing ground surface at the time of the geotechnical exploration conducted on June 16, 2016.

The start of the field work was delayed due to several rain events that occurred in May 2016. Poor surface drainage resulted in areas of ponded water that made the site inaccessible to a truck mounted drill rig during this time.

Drilling was performed in general accordance with ASTM D 1586 for Split Spoon sampling techniques as described in Appendix C. A truck-mounted drill rig using continuous flight augers together with the sampling tools noted were used to secure the subsurface soil samples. The sample depth intervals are included on the soil boring logs included in

Appendix B. Arias' field representative visually logged each recovered sample and placed a portion of the recovered sample into a plastic bag with zipper-lock for transport to our laboratory. After completion of drilling, the boreholes were backfilled with soil cuttings.

Classifications and borehole logging were conducted during the exploration by our senior field engineering technician (logger) who is under the supervision of the project Geotechnical Engineer. Final classifications, as seen on the attached boring logs, were determined in the laboratory based on laboratory and field test results and applicable ASTM procedures.

LABORATORY TESTING

As a supplement to the field exploration, laboratory testing to determine soil water content, Atterberg Limits, percent passing the US Standard No. 200 sieve, and soluble sulfate content was conducted. The laboratory results, with the exception of the soluble sulfate content tests, are reported on the boring logs included in Appendix B. The soluble sulfate content test results are shown in Table 1 below. A key to the terms and symbols used on the logs is also included in Appendix B. The laboratory testing for this project was done in general accordance with applicable ASTM procedures with the specifications and definitions for these tests listed in Appendix C.

Sulfate Test Results

Laboratory testing was conducted on four (4) selected samples recovered from the borings to determine the soluble sulfate content. Testing was performed in general accordance with TxDOT test method Tex-145-E "Determining Sulfate Content in Soils." The results indicate that the soluble sulfate contents of the samples tested range from about 960 to 3,000 parts per million (ppm). These results are indicative of a moderate to high soluble sulfate content at this site. Therefore, we recommend that the design not include lime, cement, or fly ash treatment of the onsite soils (i.e. calcium based treatment agents should not be utilized due to the risk of sulfate induced heave). A summary of the soluble sulfate test results is provided in the table below.

Table 1: Sulfate Test Results

Boring No.	Approx. Sample Depth (ft.)	Material Description	Sulfate Result (ppm)
B-1	2 - 4	Dark brown fat clay	960
B-2	0 - 2	Tan and dark brown fat clay (fill)	1,720
B-4	0 - 2	Tan and dark brown lean clay (fill)	1,640
B-5	2 – 4	Dark brown fat clay	3,000

Note: Approximate sample depth is referenced from the existing ground surface at the time of the geotechnical field exploration performed on June 16, 2016

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

SUBSURFACE CONDITIONS

The 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 to the depths explored.

Site Stratigraphy and Engineering Properties

The general stratigraphic conditions at the boring locations are summarized below in Table 2. The presence and thickness of the various subsurface materials can be expected to vary away from and between the exploration locations. The descriptions generally conform to the Unified Soils Classification System.

Table 2: Generalized Subsurface Conditions

Stratum	Depth, ft	Material Type	PI range	No. 200 range	N Range
FILL	0 to 2	LEAN CLAY (CL), FAT CLAY (CH), CLAYEY GRAVEL (GC), tan, brown, dark brown, firm to very stiff	13 - 65	27 - 60	5 - 17
I	2 to 4 - 10	FAT CLAY (CH), dark brown, firm to very stiff	52 - 77	50 - 83	7 - 24
II	4 - 6 to 10	LEAN CLAY (CL), CLAYEY SAND (SC), CLAYEY GRAVEL (GC), tan, very stiff, medium dense	9 - 40	30 - 70	8 - 22

Where: Depth - Depth from existing ground surface during geotechnical study, feet
PI - Plasticity Index, %
No. 200 - Percent passing #200 sieve, %
N - Standard Penetration Test (SPT) value, blows per foot
** - Blow counts during seating penetration

The borings drilled in the area of the new parking lot typically encountered about 2-feet of fill soils. We understand that the fill soils were placed on the site as part of the demolition of the former parking garage located at the site. Without proper documentation of fill construction, there are risks that conditions such as buried rubble/debris and/or loose soils could exist within the fill. The conditions could adversely impact the proposed construction. Reportedly, the fill placement was provided in controlled lifts and did not include rubble/debris as part of the backfill. We recommend that existing test reports and project photos that may have been provided during demolition be reviewed to confirm that the fill was placed in moisture-controlled, compacted lifts.

The recommendations provided in this report with regard to proof rolling and compacting the subgrade will help to reduce the risks of potential areas of loose fill. However, these risks can not be eliminated unless the existing fill is completely removed, cleaned of debris, and placed back in compaction-controlled lifts.

Groundwater

A dry sampling method was used to obtain the samples at the project site. Groundwater was not observed in any of the borings during drilling and sampling activities which were performed on June 16, 2016. Following the drilling and sampling operations, the open boreholes were backfilled using cuttings generated from the drilling process.

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. Groundwater levels at the time of construction may differ from the observations obtained during the field exploration because perched groundwater is subject to seasonal conditions, recent rainfall, flooding, drought or temperature affects.

Groundwater levels should be verified immediately prior to construction. Gravels and sand soils, as well as seams of these more permeable type materials, can transmit “perched” groundwater. Granular utility backfills can provide a conduit for water to collect under roadways and can ultimately lead to pavement distress. Provisions to intercept and divert “perched” or subsurface water should be made if subsurface water conditions become problematic. Should groundwater difficulties be encountered during construction, dewatering measures may become necessary. Dewatering, if required, is considered “means and methods” and is therefore, solely the responsibility of the Contractor

PAVEMENT RECOMMENDATIONS

Design Parameters and Assumptions

At the time of this report, the planned parking area consisted of native vegetation. Based on the results of our field study and laboratory testing, it appears likely that the subgrade will consist predominantly of variable fill soil conditions. Based on our experience with similar soil types and correlations with the characteristics of the site soils we have assumed a design California Bearing Ratio (CBR) value of about 2.

It should be noted that the conditions and recommendations contained herein are based on the materials encountered at the time of field exploration. We recommend that a representative of Arias be retained to observe that our recommendations are followed and to assist in determining the actual subgrade material classification at a particular location. Furthermore, we should be given an opportunity to review the final plans to determine if changes to our recommendations are needed.

Recommendations in this section were prepared in accordance with the 1993 AASHTO Guide for Design of Pavement Structure and the ACI 330R (Guide for Design and Construction of Concrete Parking Lots) for concrete. No traffic specific design information was received for this project. Therefore, the following design parameters and assumptions were used in our analysis:

Table 3: Pavement Design Parameters and Assumptions

Traffic Load for Light Duty Pavement	15,000 equivalent single axle loads (ESALs)
Traffic Load for Heavy Duty Pavement	50,000 equivalent single axle loads (ESALs)
Average Daily Truck Traffic vehicle with at least 6 Wheels	One (1)
Concrete Compressive Strength	4,000 psi
Raw Subgrade California Bearing Ratio (CBR)	2.0 for highly plastic clayey subgrade
Raw Subgrade Modulus of Subgrade Reaction, k in pci	75 for highly plastic clayey subgrade

The recommended pavement section for the planned parking and drive area pavements are shown in the table below.

Table 4: Recommended Pavement Sections

Layer	Material	Flexible Asphaltic Concrete				Rigid Concrete	
		Light Duty		Medium Duty		Light Duty	Medium Duty
Surface	HMAC/PCC	2½"		3"		6	7
Base	Flexible Base	10"	8"	12"	10"	--	--
Soil Subgrade	Moisture Conditioned	6"	TX-140	6"	TX-140	6"	6"
	Proof roll all subgrades in accordance with Note 5 below						

Notes:

1. Pavements founded on top of expansive soils will be subject to PVR soil movements estimated and presented in this report (*i.e.,* estimated approximately 2 to 4-inches). These potential soil movements are typically activated to some degree during the life of the pavement. Consequently, pavements can crack and require periodic maintenance. Periodic/preventative maintenance and repair should be planned for to reduce deterioration of the pavement structure while aiding to preserve the paving investment.
2. Light duty areas include parking areas that are subjected to passenger vehicle traffic only.
3. Medium duty areas include entrance aprons and drives into Parking Area and areas that will be subjected to truck traffic. Medium duty areas exclude areas where tractor trailers may travel or park and areas where trash collection vehicles may travel and load or unload.
4. Heavy duty areas (not shown in above Table) include areas subjected to frequent truck traffic, trash collection vehicles, including loading and unloading areas, and areas where truck turning and maneuvering may occur. **Eight (8)-inch thick concrete pavement is recommended for heavy duty areas.**
5. The exposed subgrade should be thoroughly rolled with a heavily loaded dump truck weighing at least 20 tons. A minimum of 20 passes should be performed with passes alternating in directions perpendicular to each other. Any area that yields under the roller loading should be undercut to the depth specified by the geotechnical engineer and replaced with compacted fill as specified by the Geotechnical Engineer. If deleterious material, rubble, or debris is encountered, they should be removed to firmer materials and disposed of properly. The void should then be replaced with properly compacted select fill. It is important that the site preparation operations be observed and tested by one of our representatives to verify that these recommendations are followed.
6. During the paving life, maintenance to seal surface cracks within concrete or asphalt paving and to reseal joints within concrete pavement should be undertaken to achieve the desired paving life. Perimeter drainage should be controlled to reduce the influx of surface water from areas surrounding the paving. Water penetration into base or subgrade materials, sometimes due to irrigation or surface water infiltration leads to premature paving degradation. Curbs should be used in conjunction with paving to reduce potential for infiltration of moisture into the base course. Curbs should extend the full depth of the base course and should extend at least 3 inches into the underlying subgrade. The base layer should be tied into the area inlets to drain water that may collect in the base.
7. For flexible pavements only, Tensar TX-140 geogrid over an 6-inch moisture conditioned subgrade may be considered to provide a reinforced base section to extend the life of the pavements and enhance the long-term performance of the pavements, as well as to reduce the required flexible base section thickness.

Alternate Short-Term Parking Lot Design Alternative

Preliminary information provided to us during the course of this study indicates that the planned parking lots may be re-classified to function as a short-term temporary parking area. The following pavement sections are provided as a short term solution with the understanding that the owner is willing to accept the risk for potential pre-mature cracking in the pavements.

Table 5: HMAC Flexible Section for Temporary Pavements

Material	Thickness
Type "D" HMAC Surface Course	2"
Crushed Limestone Flexible Base Course	6"
Moisture Conditioned Subgrade	6"

Reducing the proposed pavement thickness values to provide a reduced design period will increase the risk for potential pavement distress in the site pavements. Based on the soil conditions encountered in the soil borings, the temporary pavement section shown above should support approximately 4,000 ESALs over the service design period. Significant and frequent maintenance efforts will be required in order to try to extend the design life of the pavements.

Much of the site includes about 2 feet of fill soils near the surface. We recommend that the existing subgrade fill be thoroughly proofrolled once the site is rough graded. Areas that exhibit soft or pumping subgrades should be reviewed at the time of construction. It has been our experience that pre-existing utility trenches and/or areas with poorly compacted soils may become apparent during proofrolling. Soft areas that are not properly repaired will likely result in potential pavement failures and/or reflective surface cracking. These types of failures will be more likely to occur if the short-term alternative section is used. We recommend that the owner be advised of the potential risks of reducing the proposed pavement thickness values for the planned parking lot.

Site Drainage

The favorable performance of any pavement structure is dependent on positive site drainage. Careful consideration should be provided by the designers to maintain positive drainage of all storm waters away from the planned pavements. Ponding should not be allowed either on or along the edges of the pavements.

Performance and Maintenance Considerations

Our pavement recommendations have been developed to provide an adequate structural thickness to support the anticipated traffic volumes. The owner should recognize that over a period of time, pavements may crack and undergo some deterioration and loss of serviceability. Deterioration can occur more rapidly as a result of climatic extremes such as drought conditions, or periods that are wetter than normal. We recommend the project budgets include an allowance for maintenance such as patching of cracks, repairing potholes and other distressed areas, or occasional overlays over the life of the pavement.

It has been our experience that pavement cracking will provide a path for surface runoff to infiltrate through the pavements and into the subgrade. Once, moisture is allowed into the subgrade, the potential for pavement failures and potholes will increase. We recommend the owners implement a routine maintenance program with regular site inspections to monitor the performance of the site pavements. Cracking that may occur on the asphalt surface due to shrink/swell movements should be sealed immediately using a modified polymer hot-applied asphalt based sealant.

Additional crack sealing will likely be required over the design life of the pavements. Crack sealing is a proven, routine, maintenance practice successfully used by TxDOT, and other government agencies to preserve pavements and reduce accelerated wear and deterioration. Failure to provide routine crack-sealing will increase the potential for pavement failures and potholes to develop.

PAVEMENT CONSTRUCTION CRITERIA

Rigid Concrete Pavement Joints

Placement of expansion joints in concrete paving on potentially expansive subgrade or on granular subgrade subject to piping often results in horizontal and vertical movement at the joint. Many times, concrete spalls adjacent to the joint and eventually a failed concrete area results. This problem is primarily related to water infiltration through the joint.

One method to mitigate the problem of water infiltration through the joints is to eliminate all expansion joints that are not absolutely necessary. It is our opinion that expansion or isolation joints are needed only adjacent where the pavement abuts intersecting drive lanes and other structures. Elimination of all expansion joints within the main body of the pavement area would significantly reduce access of moisture into the subgrade. Regardless of the type of expansion joint sealant used, eventually openings in the sealant occur resulting in water infiltration into the subgrade.

The use of sawed and sealed joints should be designed in accordance with current Portland Cement Association (PCA) or American Concrete Institute (ACI) guidelines.

Research has proven that joint design and layout can have a significant effect on the overall performance of concrete pavement.

Recommendations presented herein are based on the use of reinforced concrete pavement. Local experience has shown that the use of distributed steel placed at a distance of 1/3 slab thickness from the top is of benefit in crack control for concrete pavements. Improved crack control also reduces the potential for water infiltration.

Performance Considerations

Our pavement recommendations have been developed to provide an adequate structural thickness to support the anticipated traffic volumes shown in Table 3. Some shrink/swell movements due to moisture variations in the underlying soils, or potential movement from settling utility backfill material, should be anticipated over the life of the pavements. The owner should recognize that over a period of time, pavements may crack and undergo some deterioration and loss of serviceability. We recommend the project budgets include an allowance for maintenance such as patching of cracks or occasional overlays over the life of the pavement.

Pavement Subgrade and Section Materials

Recommendations for the planned pavement subgrade and section materials are as follows:

Table 6: Pavement Subgrade Materials

Subgrade Preparation Prior to Paving Section Construction	
Minimum undercut depth	6 inches or as needed to remove organics and existing pavement/foundations
Reuse excavated soils	Provided they are free of roots and debris and meet the material requirements for their intended use
Horizontal extent for undercut	2 feet beyond the paving limits
Exposed subgrade treatment (before moisture conditioning)	Proof rolling the subgrade is very important. Proof roll with rubber tired vehicle weighing at least 20 tons such as a loaded dump truck with Geotechnical Engineer's representative present during proof rolling (See Note 5 Table 4).
Pumping/rutting areas discovered during proof rolling	Pumping and/rutting should be expected and then remove to firmer materials and replace with compacted general or select fill under direction of Geotechnical Engineer's representative

Table 7: Fill Requirements and Subgrade Treatment Options

Fill Requirements for Grade Increases	
General fill type	Material free of roots, debris and other deleterious material with a maximum rock size of 3 inches; on-site clays having CBR ≥ 2.0 may be used
Minimum general fill thickness	As required to achieve grade
Maximum general fill loose lift thickness	8 inches
General fill compaction and moisture criteria	ASTM D 698 ≥ 95% compaction at 0 to +4 from optimum
Subgrade Treatment Option - Moisture Conditioning	
Depth of moisture conditioning	8 inches (disk in place and moisture condition)
Compaction and moisture criteria	ASTM D 698 ≥ 95% compaction at 0 to +4 from optimum
In-Place Density and Moisture Verification Testing	
Testing frequency (Subgrade)	1 test per 5,000 square feet with minimum of 3 tests

Table 8: Flexible Pavement Requirements

Flexible Pavement Section Requirements	
Flexible Base Material Type	2004 TxDOT Item 247, Type A, Grade 1 or 2
Maximum Flexible Base Loose Lift Thickness	9 inches
Flexible Base Placement Criteria	Compact to ≥ 95% maximum dry density at -2 to +3 percentage points of optimum moisture content (ASTM D 1557)
Hot Mix Asphaltic Concrete (HMAC) Type	2004 TxDOT Item 340, Type D
HMAC Placement Criteria	91% to 95% Theoretical Lab Density (TEX 207 F)

Table 9: Rigid Pavement Section Materials

Portland Cement Concrete Section Requirements	
Minimum compressive strength at 28 days	4,000 psi at 28 days
Desired slump during placement	5 ± 1 inch
Reinforced Steel	#4 @ 18" each way placed D/3 from top of slab
Construction Joint Dowels	• Light duty 6-inch section: 5/8" diameter, 12" long @ 12" on center and lubricated both sides, dowel embedment of 5". • Medium duty 7 -inch section: 3/4" diameter, 14" long @ 12" on center and lubricated both sides, dowel embedment of 6". • Heavy duty 8-inch section: 1" diameter, 14" long @ 12" on center and lubricated both sides, dowel embedment of 6".
Expansion Joints	May be eliminated except at tie-ins with existing concrete and structures
Contraction Joints – transverse and longitudinal	Meet spacing and sawing requirements of ACI 330R (Guide for Design and Construction of Concrete Parking Lots)
Placement	In accordance with ACI 304R (guide for measuring, mixing, transporting, and placing), ACI 305R (hot weather concreting, and ACI 306R (cold weather concreting)

To help reduce degradation of the prepared subgrade, paving preferably should be placed within 14 days. If pavement placement is delayed, protection of the subgrade surface with an emulsion-based sealer should be considered. Alternately, the paving section could be slightly overbuilt so blading performed to remove distressed sections does not reduce the moisture conditioned subgrade thickness.

Table 10: Project Compaction, Moisture and Testing Requirements

Description	Material	Percent Compaction	Optimum Moisture Content	Testing Requirement
		According to Standard Proctor ASTM D 698		
Pavement Areas	Scarified, Moisture Conditioned On-site Soil (Subgrade)	≥ 95%	0 to +4%	1 per 5,000 SF; min. 3 tests
	General Fill (Onsite Material)	≥ 95%	0 to +4%	1 per 5,000 SF; min. 3 per lift
	Base Material	≥ 95% (ASTM D 1557)	-2 to +3	1 per 5,000 SF; min. 3 per lift
	Hot-mix asphaltic concrete	91% to 95% Theoretical Lab Density (TEX 207 F)	Not applicable	1 per 5,000 SF; min. 3 per lift
Non-Structural Areas (Outside Pavement Area)	General Fill (On-site Material)	≥ 95%	0 to +4%	1 per 5,000 SF; min. 3 per lift

Curb and Gutter

It has been our experience that pavements typically perform at a higher level when designed with adequate drainage including the implementation of curb and gutter systems. Accordingly, we recommend that curb and gutters be considered for this project. Furthermore, to aid in reducing the chances for water to infiltrate into the pavement base course and pond on top of the pavement subgrade, we highly recommend that pavement curbs be designed to extend through the pavement base course penetrating at least 3 inches into the onsite subgrade. If water is allowed to infiltrate beneath the site pavements, frequent and premature pavement distress can occur.

Construction Site Drainage

We recommend that construction areas be properly maintained to allow for positive drainage as construction proceeds and to keep water from ponding adjacent to the site pavements. This consideration should be included in the project specifications.

GENERAL COMMENTS

This report was prepared as an instrument of service for this project exclusively for the use of Ford Engineering 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.

Geotechnical Design 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 geotechnical 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.

Subsurface Variations

Subsurface and groundwater conditions may vary between the sample boring locations. Transition boundaries or contacts, noted on the boring logs to separate material 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.

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 (GER), we should be engaged by the Owner to provide Quality Assurance (QA) testing. Our services will be to evaluate the degree to which constructors are achieving the specified conditions they're contractually obligated to achieve, and observe that the encountered materials during earthwork for foundation and pavement installation are consistent with those encountered during this study. In the event that Arias is not retained to provide QA 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. A message to the Owner with regard to the project QA is provided in the ASFE publication included in Appendix E.

Arias has an established in-house laboratory that meets the standards of the American Standard Testing Materials (ASTM) specifications of ASTM E-329 defining requirements for Inspection and Testing Agencies for soil, concrete, steel and bituminous materials as used in construction. We maintain soils, concrete, asphalt, and aggregate testing equipment to provide the testing needs required by the project specifications. All of our equipment is calibrated by an independent testing agency in accordance with the National Bureau of Standards. In addition, Arias is accredited by the American Association of State Highway & Transportation Officials (AASHTO), the United States Army Corps of Engineers (USACE) and the Texas Department of Transportation (TxDOT), and also maintains AASHTO Materials Reference Laboratory (AMRL) and Cement and Concrete Reference Laboratory (CCRL) proficiency sampling, assessments and inspections.

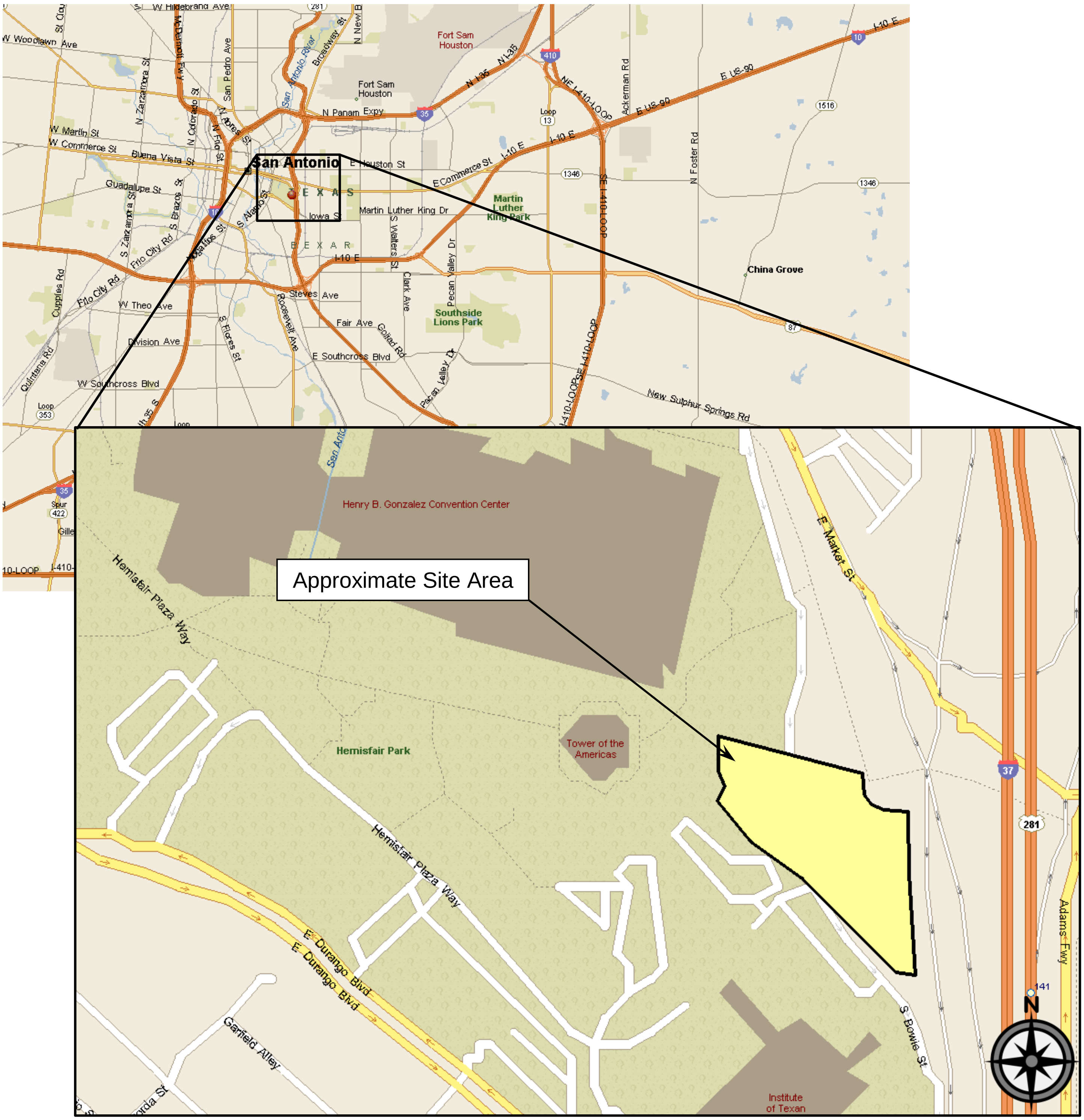
Furthermore, Arias employs a technical staff certified through the following agencies: the National Institute for Certification in Engineering Technologies (NICET), the American Concrete Institute (ACI), the American Welding Society (AWS), the Precast/Prestressed Concrete Institute (PCI), the Mine & Safety Health Administration (MSHA), the Texas Asphalt Pavement Association (TXAPA) and the Texas Board of Professional Engineers (TBPE). Our services are conducted under the guidance and direction of a Professional Engineer (P.E.) licensed to work in the State of Texas, as required by law.

Standard of Care

Subject to the limitations inherent in the agreed scope of services as to the degree of care and amount of time and expenses to be incurred, and subject to any other limitations contained in the agreement for this work, Arias has performed its services consistent with that level of care and skill ordinarily exercised by other professional engineers practicing in the same locale and under similar circumstances at the time the services were performed.

Information about this geotechnical report is provided in the ASFE publication included in Appendix D.

APPENDIX A: FIGURES AND SITE PHOTOGRAPHS



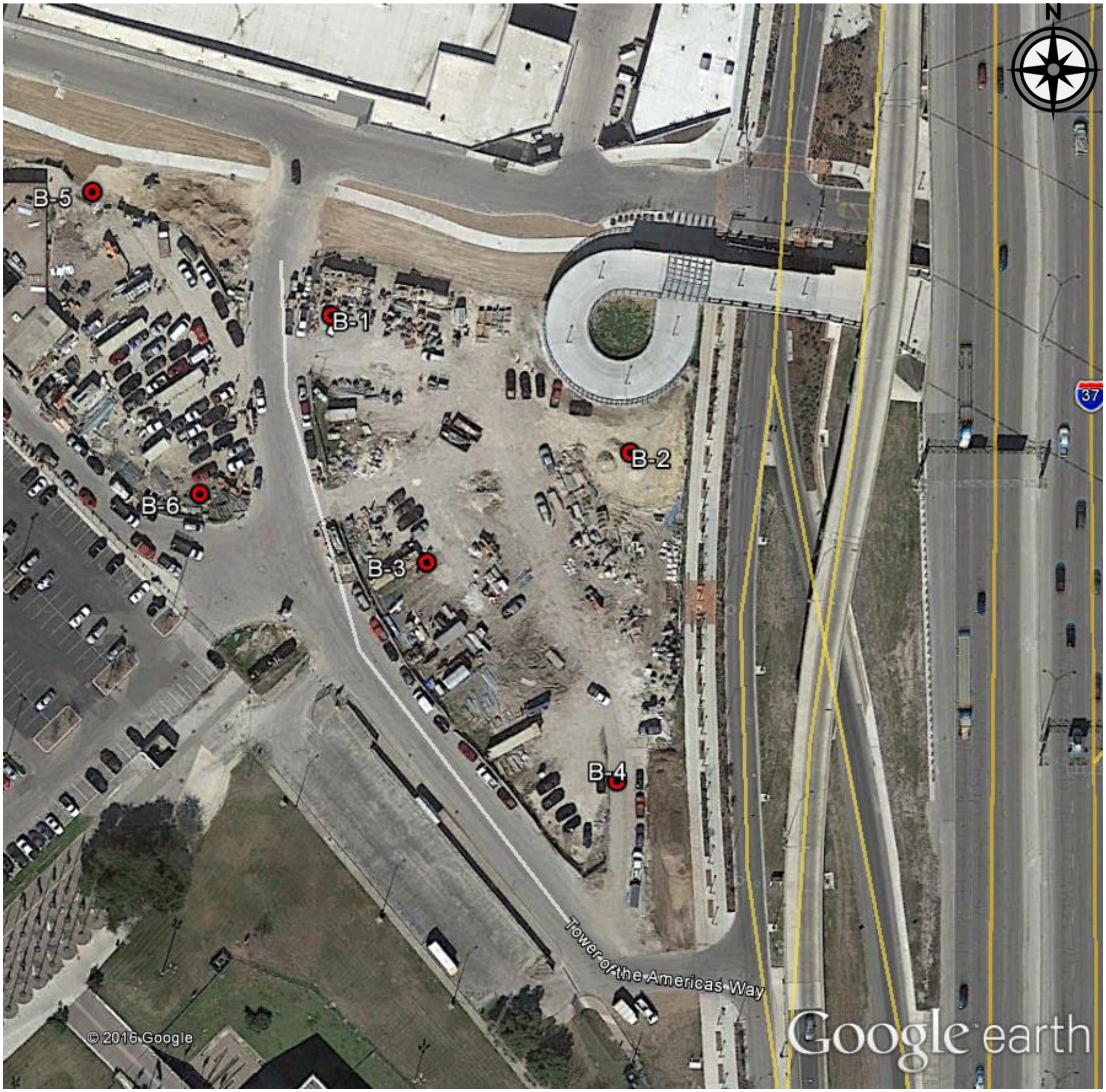
ARIAS GEOPROFESSIONALS
142 Chula Vista, San Antonio, Texas 78232
Phone: (210) 308-5884 • Fax: (210) 308-5886

VICINITY MAP

Proposed South Parking Lots
Henry B. Gonzalez Convention Center
San Antonio, Texas

Date: July 7, 2016	Job No.: 2016-278
Drawn By: TAS	Checked By: RPG
Approved By: CMS	Scale: N.T.S.

Figure 1



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

BORING LOCATION PLAN

Proposed South Parking Lots
Henry B. Gonzalez Convention Center
San Antonio, Texas

Date: July 7, 2016	Job No.: 2016-278
Drawn By: TAS	Checked By: RPG
Approved By: CMS	Scale: N.T.S.

REVISIONS:

No.:	Date:	Description:

Figure 2

Photo 1 – View looking towards the north at the drilling operations of Boring B-1.

Photo 2 – View looking towards the south at the drilling operations of Boring B-3.

ARIAS GEOPROFESSIONALS
142 Chula Vista, San Antonio, Texas 78232
Phone: (210) 308-5884 • Fax: (210) 308-5886

SITE PHOTOS

Proposed South Parking Lots
Henry B. Gonzalez Convention Center
San Antonio, Texas

Date: July 7, 2016	Job No.: 2016-278
Drawn By: TAS	Checked By: RPG
Approved By: CMS	Scale: N.T.S.

Appendix A

Photo 3 – View looking towards the southeast at the drilling operations of Boring B-5.

Photo 4 – View looking towards the northwest at the drilling operations of Boring B-6.

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142 Chula Vista, San Antonio, Texas 78232
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SITE PHOTOS

Proposed South Parking Lots
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Appendix A

APPENDIX B: BORING LOGS AND KEY TO TERMS

Boring Log No. B-1

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 6/16/16

Coordinates: N29°25'7.7" W98°28'55.2"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: LEAN CLAY (CL), very stiff, tan and dark brown, with calcareous nodules	2	SS	20					17	
FAT CLAY (CH), stiff, dark brown, with sand	4	SS	23	18	70	52		10	83
-hard below 4'	6	T	17	23	81	58	4.5+		
CLAYEY SAND (SC), medium dense, tan	8	SS	14					15	
-with gravel and calcareous deposits below 8'	10	SS	15	17	57	40		11	37

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) | Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve

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Boring Log No. B-2

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 6/16/16

Coordinates: N29°25'6.7" W98°28'52.7"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200
FILL: FAT CLAY (CH), stiff, tan and dark brown, sandy, with gravel	2	SS	19	18	83	65		10	52
FAT CLAY (CH), stiff, dark brown and light brown, (possibly fill)	4	SS	23					9	
-very stiff below 4'	6	T	27	20	80	60	2.0		49
LEAN CLAY (CL), very stiff, tan, gravelly, with sand	8	T	18				2.5		
	10	SS	11	15	39	24		22	61

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve

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Boring Log No. B-3

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Sampling Date: 6/16/16

Coordinates: N29°25'5.9" W98°28'54.4"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
FILL: FAT CLAY (CH), firm, tan and dark brown, sandy	0-2	SS	15	17	61	44		5	60		
FAT CLAY (CH), very stiff, dark brown, with sand	2-4	SS	12					24			
-firm at 4'	4-6	SS	24	17	76	59		7	80		
-light brlow below 6'	6-8	T	29				2.5			110	1.94 L/D
	8-10	T	25	21	91	70	3.0		83		

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-4

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Sampling Date: 6/16/16

Coordinates: N29°25'4.3" W98°28'52.8"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
FILL: LEAN CLAY (CL), stiff, tan and dark brown		SS	16					14			
	2										
FAT CLAY (CH), stiff, dark brown		SS	22	23	100	77		13	82		
	4										
		SS	22					15			
	6										
-light brown below 6' -hard at 6'		T	23	21	80	59	4.5+				
	8										
-very stiff below 8'		T	25				3.0			98	2.01 L/D
	10										

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) — Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-5

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Sampling Date: 6/16/16

Coordinates: N29°25'8.6" W98°28'57.2"

Location: See Boring Location Plan

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
FILL: CLAYEY GRAVEL (GC), medium dense, tan and brown, with sand	2	SS	19	14	38	24		15	27		
FAT CLAY (CH), very stiff, dark brown	4	T	23				2.0			99	1.61 L/D
CLAYEY SAND (SC), loose, tan, with gravel	6	SS	19					8	42		
LEAN CLAY (CL), very stiff, tan, with calcareous deposits	8	T	13				3.0				
	10	SS	15	15	24	9		16	70		

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) — Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)

N = SPT Blow Count
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

Boring Log No. B-6

Project: **Hemisfair Parking Lots**
Henry B. Gonzalez Convention Center
San Antonio, Texas

Location: See Boring Location Plan

Sampling Date: 6/16/16

Coordinates: N29°25'6.4" W98°28'56.3"

Backfill: Cuttings

Soil Description	Depth (ft)	SN	WC	PL	LL	PI	PP	N	-200	DD	Uc
FILL: CLAYEY GRAVEL (GC), medium dense, tan and brown	2	SS	3	14	27	13		16			
FAT CLAY (CH), very stiff, dark brown	4	SS	27	21	87	66		11			
-with calcareous deposits below 4'	6	T	23				3.0			101	2.11 L/D
CLAYEY GRAVEL (GC), medium dense, light tan, with sand	8	SS	8					19			
	10	SS	5	14	33	19		17	30		

Borehole terminated at 10 feet

Groundwater Data:
During drilling: Not encountered

Field Drilling Data:
Coordinates: Hand-held GPS Unit
Logged By: Jorge Ramos
Driller: Eagle Drilling, Inc.
Equipment: Truck-mounted drill rig

Single flight auger: 0 - 10 ft

Nomenclature Used on Boring Log

Split Spoon (SS) Thin-walled tube (T)

WC = Water Content (%)
PL = Plastic Limit
LL = Liquid Limit
PI = Plasticity Index
PP = Pocket Penetrometer (tsf)
N = SPT Blow Count
-200 = % Passing #200 Sieve
DD = Dry Density (pcf)
Uc = Compressive Strength (tsf)

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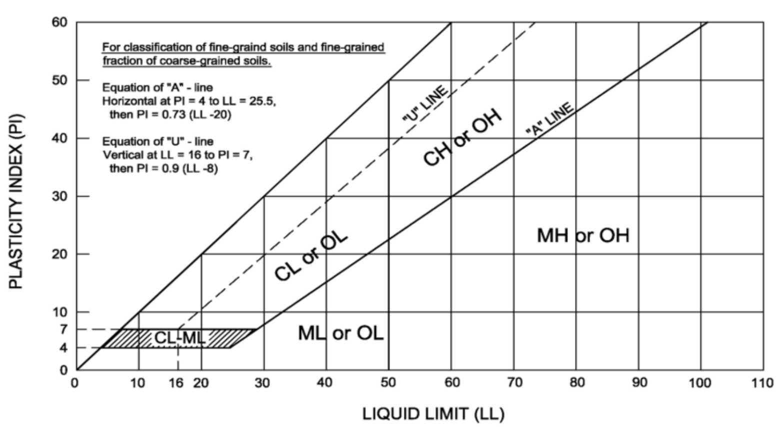
KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

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 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

Density of Granular Soils	
Number of Blows per ft., N	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
Over 50	Very Dense

Consistency and Strength of Cohesive Soils		
Number of Blows per ft., N	Consistency	Unconfined Compressive Strength, q_u (tsf)
Below 2	Very Soft	Less than 0.25
2 - 4	Soft	0.25 - 0.5
4 - 8	Medium (Firm)	0.5 - 1.0
8 - 15	Stiff	1.0 - 2.0
15 - 30	Very Stiff	2.0 - 4.0
Over 30	Hard	Over 4.0

PLASTICITY CHART (ASTM D 2487-11)



KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

TABLE 1 Soil Classification Chart (ASTM D 2487-11)

Criteria of Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels (More than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5% fines[C])	Cu ≥ 4 and 1 ≤ Cc ≤ 3[D]	GW	Well-Graded Gravel[E]
			Cu < 4 and/or [Cc < or Cc > 3][D]	GP	Poorly-Graded Gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty Gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey Gravel[E,F,G]
	Sands (50% or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines[H])	Cu ≥ 6 and 1 ≤ Cc ≤ 3[D]	SW	Well-Graded Sand[I]
			Cu < 6 and/or [Cc < or Cc > 3][D]	SP	Poorly-Graded Sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty Sand[F,G,I]
			Fines classify as CL or CH	SC	Clayey Sand[F,G,I]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean Clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OL	Organic Clay[K,L,M,N] Organi Silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat Clay[K,L,M]
			PI plots on or below "A" line	MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OH	Organic Clay[K,L,M,P] Organic Silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name
[C] Gravels with 5% to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly-graded gravel with silt
- GP-GC poorly-graded gravel with clay

[D] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[E] If soil contains ≥ 15% sand, add "with sand" to group name
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM
[G] If fines are organic, add "with organic fines" to group name
[H] Sand with 5% to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly-graded sand with silt
- SP-SC poorly-graded sand with clay

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay
[K] If soil contains 15% to < 30% plus No. 200, add "with sand" or "with gravel," whichever is predominant
[L] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name
[N] PI ≥ 4 and plots on or above "A" line
[O] PI < 4 or plots below "A" line
[P] PI plots on or above "A" line
[Q] PI plots below "A" line

TERMINOLOGY

Boulders	Over 12-inches (300mm)
Cobbles	12-inches to 3-inches (300mm to 75mm)
Gravel	3-inches to No. 4 sieve (75mm to 4.75mm)
Sand	No. 4 sieve to No. 200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing No. 200 sieve (0.075mm)
Calcareous	Containing appreciable quantities of calcium carbonate, generally nodular

Parting	Inclusion < 1/8-inch thick extending through samples
Seam	Inclusion 1/8-inch to 3-inches thick extending through sample
Layer	Inclusion > 3-inches thick extending through sample

Stratified	Alternating layers of varying material or color with layers at least 6mm thick
Laminated	Alternating layers of varying material or color with the layers less than 6mm thick
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
Homogeneous	Same color and appearance throughout

APPENDIX C: LABORATORY AND FIELD TEST PROCEDURES

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 augers (ASTM D 1452). Samples of encountered materials were obtained using a split-barrel sampler while performing the Standard Penetration Test (ASTM D 1586). 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 designations 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
Determining Soluble Sulfate Content in Soils	Tex-145-E	n/a

The laboratory results are reported on the soil boring logs with the exception of the Soluble Sulfate Content results which are shown in Table 1.

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

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APPENDIX E: PROJECT QUALITY ASSURANCE

A Message to Owners

Construction materials engineering and testing (CoMET) consultants perform quality-assurance (QA) services to evaluate the degree to which constructors are achieving the specified conditions they're contractually obligated to achieve. Done right, QA can save you time and money; prevent unanticipated-conditions claims, change orders, and disputes; and reduce short-term and long-term risks, especially by detecting molehills before they grow into mountains.

Done right, QA can save you time and money; prevent claims and disputes; and reduce risks. Many owners don't do QA right because they follow bad advice.

Many owners don't do QA right because they follow bad advice; e.g., "CoMET consultants are all the same. They all have accredited facilities and certified personnel. Go with the low bidder." But there's no such thing as a standard QA scope of service, meaning that – to bid low – each interested firms *must* propose the cheapest QA service it can live with, jeopardizing service quality and aggravating risk for the entire project team. Besides, the advice is based on misinformation.

Fact: ***Most CoMET firms are not accredited***, and the quality of those that are varies significantly. Accreditation – which is important – nonetheless means that a facility met an accrediting body's minimum criteria. Some firms practice at a much higher level; others just barely scrape by. And what an accrediting body typically evaluates – management, staff, facilities, and equipment – can change substantially before the next review, two, three, or more years from now.

Most CoMET firms are not accredited. It's dangerous to assume CoMET personnel are certified.

Fact: ***It's dangerous to assume CoMET personnel are certified.*** Many have no credentials at all; some are certified by organizations of questionable merit, while others have a valid certification, but *not* for the services they're assigned.

Some CoMET firms – the "low-cost providers" – *want* you to believe that price is the only difference between QA providers. It's not, of course. Firms that sell low price typically lack the facilities, equipment, personnel, and insurance quality-oriented firms invest in to achieve the reliability concerned owners need to achieve quality in quality assurance.

ASFE THE GEOPROFESSIONAL BUSINESS ASSOCIATION
8811 Colesville Road
Suite G106
Silver Spring, Maryland 20910
Voice: 301.565.2733
Fax: 301.589.2017
E-mail: info@asfe.org
Internet: www.asfe.org

Firms that sell low price typically lack the facilities, equipment, personnel, and insurance quality-oriented firms invest in to achieve the reliability concerned owners need to achieve quality in quality assurance.

To derive maximum value from your investment in QA, require the CoMET firm's project manager to serve actively on the project team from beginning to end, a level of service that's relatively inexpensive and can pay huge dividends. During the project's planning and design stages, experienced CoMET professionals can help the design team develop uniform technical specifications and establish appropriate observation, testing, and instrumentation procedures and protocols. They can also analyze plans and specs much as constructors do, looking for the little errors, omissions, conflicts, and ambiguities that often become the basis for big extras and big claims. They can provide guidance about operations that need closer review than others, because of their criticality or potential for error or abuse. They can also relate their experience with the various constructors that have expressed interest in your project.

To derive maximum value, require the project manager to serve actively on the project team from beginning to end.

CoMET consultants' construction-phase QA services focus on two distinct issues: those that relate to geotechnical engineering and those that relate to the other elements of construction.

The geotechnical issues are critically important because they are essential to the "observational method" geotechnical engineers use to significantly reduce the amount of sampling they'd otherwise require. They apply the observational method by developing a sampling plan for a project, and then assigning field representatives to ensure samples are properly obtained, packaged, and transported. The engineers review the samples and, typically, have them tested in their own laboratories. They use the information they derive to characterize the site's subsurface and develop *preliminary* recommendations for the structure's foundations and for the specifications of various "geo" elements, like excavations, site grading, foundation-bearing grades, and roadway and parking-lot preparation and surfacing.

Geotechnical engineers cannot finalize their recommendations until they or their field representatives are on site to observe what's excavated to verify that the subsurface conditions the engineers predicted are those that actually exist.

When unanticipated conditions are observed, recommendations and/or specifications should be modified.

Responding to client requests, many geotechnical-engineering firms have expanded their field-services mix, so they're able to perform overall construction QA, encompassing – in addition to geotechnical issues – reinforced concrete, structural steel, welds, fireproofing, and so on. Unfortunately, that's caused some confusion. Believing that all CoMET consultants are alike, some owners take bids for the overall CoMET package, including the geotechnical field observation. *Entrusting geotechnical field observation to someone other than the geotechnical engineer of record (GER) creates a significant risk.*

Geotechnical engineers cannot finalize their recommendations until they are on site to verify that the subsurface conditions they predicted are those that actually exist. Entrusting geotechnical field observation to someone other than the geotechnical engineer of record (GER) creates a significant risk.

GERs have developed a variety of protocols to optimize the quality of their field-observation procedures. Quality-focused GERs meet with their field representatives before they leave for a project site, to brief them on what to look for and where, when, and how to look. (***No one can duplicate this briefing***, because no one else knows as much about a project's geotechnical issues.) And once they arrive at a project site, the field representatives know to maintain timely, effective communication with the GER, because that's what the GER has trained them to do. By contrast, it's extremely rare for a different firm's field personnel to contact the GER, even when they're concerned or confused about what they observe, because they regard the GER's firm as "the competition."

Divorcing the GER from geotechnical field operations is almost always penny-wise and pound-foolish. Still, because owners are given bad advice, it's commonly done, helping to explain why ***"geo" issues are the number-one source of construction-industry claims and disputes.***

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To derive the biggest bang for the QA buck, identify three or even four quality-focused CoMET consultants. (If you don't know any, use the "Find a Geoprofessional" service available free at www.asfe.org.) Ask about the firms' ongoing and recent projects and the clients and client representatives involved; *insist upon receiving verification of all claimed accreditations, certifications, licenses, and insurance coverages.*

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Once you identify the two or three most qualified firms, meet with their representatives, preferably at their own facility, so you can inspect their laboratory, speak with management and technical staff, and form an opinion about the firm's capabilities and attitude.

Insist that each firm's designated project manager participate in the meeting. You will benefit when that individual is a seasoned QA professional familiar with construction's rough-and-tumble. Ask about others the firm will assign, too. There's no substitute for experienced personnel who are familiar with the codes and standards involved and know how to:

- read and interpret plans and specifications;
- perform the necessary observation, inspection, and testing;
- document their observations and findings;
- interact with constructors' personnel; and
- respond to the unexpected.

Important: Many of the services CoMET QA field representatives perform – like observing operations and outcomes – require the good judgment afforded by extensive training and experience, especially in situations where standard operating procedures do not apply. You need to know who will be exercising that judgment: a 15-year "veteran" or a rookie?

Many of the services CoMET QA field representatives perform require good judgment.

Also consider the tools CoMET personnel use. Some firms are passionate about proper calibration; others, less so. Passion is a good thing! Ask to see the firm's calibration records. If the firm doesn't have any, or if they are not current, be cautious. *You cannot trust test results derived using equipment that may be out of calibration.* Also ask a firm's representatives about their reporting practices, including report distribution, how they handle notifications of nonconformance, and how they resolve complaints.

Scope flexibility is needed to deal promptly with the unanticipated.

For financing purposes, some owners require the constructor to pay for CoMET services. ***Consider an alternative approach*** so you don't convert the constructor into the CoMET consultant's client. If it's essential for you to fund QA via the constructor, have the CoMET fee included as an allowance in the bid documents. This arrangement ensures that you remain the CoMET consultant's client, and it prevents the CoMET fee from becoming part of the constructor's bid-price competition. (Note that the International Building Code (IBC) *requires the owner to pay* for Special Inspection (SI) services commonly performed by the CoMET consultant as a service separate from QA, to help ensure the SI services' integrity. Because failure to comply could result in denial of an occupancy or use permit, having a contractual agreement that conforms to the IBC mandate is essential.)

If it's essential for you to fund QA via the constructor, have the CoMET fee included as an allowance in the bid documents. Note, too, that the International Building Code (IBC) requires the owner to pay for Special Inspection (SI) services.

CoMET consultants can usually quote their fees as unit fees, unit fees with estimated total (invoiced on a unit-fee basis), or lump-sum (invoiced on a percent-completion basis referenced to a schedule of values). No matter which method is used, estimated quantities need to be realistic. Some CoMET firms lower their total-fee estimates by using quantities they know are too low and then request change orders long before QA is complete.

Once you and the CoMET consultant settle on the scope of service and fee, enter into a written contract. Established CoMET firms have their own contracts; most owners sign them. Some owners prefer to use different contracts, but that can be a mistake when the contract was prepared for construction services. *Professional services are different.* Wholly avoidable problems occur when a contract includes provisions that don't apply to the services involved and fail to include those that do.

Some owners create wholly avoidable problems by using a contract prepared for construction services.

This final note: CoMET consultants perform QA for owners, not constructors. While constructors are commonly allowed to review QA reports as a *courtesy*, you need to make it clear that constructors do *not* have a legal right to rely on those reports; i.e., if constructors want to forgo their own observation and testing and rely on results derived from a scope created to meet *only* the needs of the owner, they *must do so at their own risk*. In all too many cases where owners have not made that clear, some constructors have alleged that they did have a legal right to rely on QA reports and, as a result, the CoMET consultant – not they – are responsible for their failure to deliver what they contractually promised to provide. The outcome can be delays and disputes that entangle you and all other principal project participants. Avoid that. Rely on a CoMET firm that possesses the resources and attitude needed to manage this and other risks as an element of a quality-focused service. Involve the firm early. Keep it engaged. And listen to what the CoMET consultant says. A good CoMET consultant can provide great value.

For more information, speak with your ASFE-Member CoMET consultant or contact ASFE directly.

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8811 Colesville Road
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