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Geotechnical Investigation Report
South Phoenix Two Basins Project
27th Avenue and South Mountain Avenue Basin
Maricopa County Flood Control District
(MCFCD) Contract FCD 2011C008
Work Assignment No. 1

A117.928

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(MCFCD) Contract FCD 2011C008
Work Assignment No. 1

Submitted to:

Stanley Consultants, Inc.
Phoenix, Arizona

Submitted by:

AMEC Environment & Infrastructure, Inc.
Phoenix, Arizona

Registered Professional Engineer (Civil)
CERTIFICATE NO.
41937
MARK
HARTIG
Date Signed 7-18-12
ARIZONA, U.S.A.
Expires 3/31/14

July 18, 2012

AMEC Project No. 17-2011-4055

July 18, 2012
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Stanley Consultants, Inc.
1661 East Camelback Road, Suite 400
Phoenix, Arizona 85016

Attn: Mr. Scott Buchanan, PE

Subject: **Geotechnical Investigation**
South Phoenix Two Basins Project
27th Avenue and South Mountain Avenue Basin
Maricopa County Flood Control District
Contract FCD 2011C008
Work Assignment No. 1

AMEC Environment & Infrastructure, Inc. (AMEC) has completed the Geotechnical Investigation for the 27th Avenue and South Mountain Avenue Basin (part of the South Phoenix Two Basins Project) located in Phoenix, Arizona. This work was performed as requested by Stanley Consultants, Inc. (Stanley) and the Maricopa County Flood Control District (the District), and was performed in general accordance with our contract with Stanley dated August 8, 2011. The results of our investigation, along with the boring location plan, laboratory test results, and recommendations are attached.

We at AMEC are committed to providing quality engineering services combined with client satisfaction in order to achieve a continuing relationship with our clients. We appreciate the opportunity to provide these services for you. If you have any questions regarding any of the other engineering and testing services AMEC provides, please do not hesitate to contact us.

Respectfully submitted,

AMEC Environment & Infrastructure, Inc.

Registered Professional Engineer (Civil) CERTIFICATE NO. 41937 MARK HARTIG Date Signed 7-18-12 ARIZONA, U.S.A. Expires 3/31/14

Mark Hartig, PE
Senior Geotechnical Engineer

Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 37284 DANIEL N. FRECHETTE Date Signed 7-18-12 ARIZONA, U.S.A. Expires 03/31/2014

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FIGURE

Figure 1 – Site Map

APPENDICES

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1.0 PURPOSE

AMEC has performed an investigation of geotechnical conditions for the proposed 27th Avenue and South Mountain Avenue Basin located at the northeast corner of 27th Avenue and South Mountain Avenue in Phoenix, Arizona through field subsurface exploration, laboratory testing, and engineering analyses in order to develop pertinent information and recommendations for design and construction of the proposed project. Our investigation was performed in general accordance with the Flood Control District of Maricopa County (the District) issued Scope of Work (Contract FCD 2011C008, Work Assignment No. 1). This report will provide discussions and recommendations for the following items specific to the proposed design and construction:

- Subsurface conditions
- Land subsidence and possible earth fissuring
- Suitability of on-site soils as fill
- Engineered fill and compaction recommendations
- Slope stability and excavations
- Corrosivity

This report does not address any environmental issues related to the site or the project.

Our professional services have been performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical consultants practicing in this or similar localities. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has been prepared exclusively for Stanley and the District for the design of the proposed 27th Avenue and South Mountain Avenue basin project described herein. This report has not been prepared for any other parties and may not contain sufficient information for purposes of other parties. If any of the project information described in Section 2.0 of this report has changed, we should be notified so that we may amend our recommendations and discussions as necessary.

2.0 PROJECT INFORMATION

In accordance with the District's Scope of Work (Work Assignment No. 1) Document, the project consists of a proposed regional detention basin located at the northeast corner of 27th Avenue and South Mountain Boulevard, which is part of the South Phoenix/Laveen Drainage Improvement Project. This proposed basin will be connected to the existing storm drain located in 27th Avenue that extends from Gary Way to Baseline Road. The completed Project will address 100-year stormwater flows in the area. The proposed detention basin will be approximately 20 feet in depth and will have a design storage capacity of approximately 128 acre-feet.

If any of this project information is incorrect, please notify us immediately so we may modify and/or amend our discussions and recommendations as necessary.

3.0 FIELD EXPLORATION AND SITE CONDITIONS

3.1 Data From Existing Geotechnical Reports

Data from an existing geotechnical investigation was reviewed and used in the preparation of this report. The geotechnical investigation was performed by Speedie and Associates in 1999 for the same project currently being considered. The investigation consisted of five soil borings (B-1 through B-5) advanced to depths of 26 feet below the existing ground surface at the proposed basin location. A copy of this investigation is included on CD in Appendix C for convenience, and the boring locations are shown along with AMEC's current boring location (and surficial sample locations) on the Site Map, Figure 1.

3.2 Field Exploration and Laboratory Testing

The geotechnical investigation consisted of one test boring drilled to a depth of 26 feet. The boring (B-6) was located at the northwest corner of the proposed basin, as shown on the Site Map, Figure 1. As part of our investigation, as requested and authorized in Optional Task 8.0.2.a, we also performed surficial sampling at two locations (S-1 & S-2), one along the south perimeter near the center, and the other along the east perimeter near the center, also shown on the Site Map, Figure 1.

The test boring was performed using 6-5/8" inch hollow stem auger (HSA) advanced by a truck-mounted CME-75 drill rig owned and operated by Geomechanics Southwest, Inc. AMEC coordinated with Steve Perez with FST Farms for entry permission to the site prior to field activities. The surficial samples at S-1 and S-2 were sampled by hand with a shovel.

The soils encountered during drilling and surficial sampling were visually classified by our field engineer and recorded on a field log along with notes regarding the general subsurface conditions pertinent to geotechnical design. Penetration testing and sampling of soils to obtain relatively undisturbed samples was performed within the test boring at typical intervals of two samples in the upper 5 feet, and every 5 feet thereafter until boring termination. The Standard Penetration Tests (SPTs) were performed in general accordance with ASTM D 1586. Blow counts of the penetration were not modified for energy delivery or overburden. The "undisturbed" ring samples (2.42-inch inside diameter, 1-inch deep brass rings), soils recovered in the split-spoon type SPT samplers, and/or bulk samples of drill cuttings from the auger borings were obtained and transported to our laboratory for possible laboratory testing. After completion of the laboratory tests on the retrieved samples, the soil classifications and descriptions recorded on the field logs were reviewed and modified where necessary to produce the final boring logs presented in Appendix A. Our field and final soil classifications were in general accordance with ASTM D2487, the Unified Soil Classification System (USCS), a summary of which is presented in Appendix A.

Laboratory tests were performed on the representative bulk and undisturbed samples obtained during our field exploration to evaluate the pertinent engineering properties of the site soils. The following tests were performed in general accordance with the applicable ASTM and Arizona test methods:

- Soil Classification (Gradation/Atterberg Limits) (ASTM C136, C117, and D4318)
- In-Situ Density and Moisture Content Determination (ASTM D2435 and D7263)
- Maximum Density/Optimum Moisture (ASTM D698)
- Soluble Chlorides and Sulfates (Arizona 733/736)

The results of the laboratory tests performed are presented in Table B-1, Summary of Laboratory Test Results, presented in Appendix B.

3.3 Site Description

The project site is situated at the northeast corner of West South Mountain Avenue and South 27th Avenue in Phoenix, Arizona. The project site is approximately 1300 by 1300 feet, and falls within the northwest quadrant of Section 1 of Township 1S, Range 2E (APN 300-17-020).

The project site consists of an existing agricultural field that is bordered to the north by Gary Way, the south by West South Mountain Avenue, the west by 27th Avenue, and the east by an Elementary School and vacant land.

3.4 Site Geotechnical Profile

The native subsurface materials present at the subject site include sandy clays underlain by clayey sands with occasional silty sand zones to the depth explored. The consistency of the native soils ranged from very soft near the surface to very firm near the boring termination depth. Additionally, the soils were generally low to medium in plasticity, with non-plastic soils encountered at the surface in samples S-1 and S-2.

Ground water was not encountered in our test boring. Information available on the Arizona Department of Water Resources (ADWR) website (http://www.azwater.gov/adwr/) indicates that the depth to ground water recorded in several wells located in the vicinity of the project site ranges from approximately 60 to 80 feet below existing ground surface. The moisture content of the soils encountered were typically described as being slightly moist to moist, with the moisture contents of tested samples ranging from 7.5 to 13.4 percent.

Information available through the Arizona Geological Survey indicates there are no mapped earth fissures near the project site (http://www.azgs.az.gov).

Land subsidence maps for various regions in Arizona have been prepared by the Arizona Department of Water Resources (http://www.azwater.gov). Based on our review of these maps, significant subsidence has not been reported within the project boundaries.

Continued groundwater withdrawal in the area could potentially cause new earth fissures, existing fissures to extend to the site, and may result in land subsidence at the project site. Land subsidence and fissures cannot be accurately predicted at this time; however they are not expected to be a constraint to the construction of this project.

4.0 RECOMMENDATIONS

4.1 General

The discussions and recommendations contained in this report were based on the soils and conditions encountered in the test boring performed for the field investigation of the proposed 27th Avenue and South Mountain Avenue Basin. We have assumed that the soils and conditions encountered within the test boring advanced at the project site are also representative of the characteristics of other portions of the site. If soil conditions different than those presented herein are encountered during construction operations, we should be notified so that we may amend or revise our recommendations as necessary.

4.2 Permanent Slopes

Based on the site map provided by Stanley, planned basin slopes at this site are approximately 8H:1V (horizontal:vertical). Based on the information received from our soil boring, our review of soil borings performed by others, and our experience with similar projects and conditions, maximum basin slopes (8H:1V) are acceptable as planned. Protection of these slopes from water erosion should be taken into account during design.

4.3 Soil Corrosivity

Corrosivity test results are presented in Table B-1, Summary of Laboratory Test Results. In general, the Soluble Sulfates ranged from 38 to 59 parts per million (ppm). In accordance with ACI 318, Section 4.2, this classifies as "S0" or "Not applicable". Therefore, Type II cement may be used for construction of concrete structures at this site. These findings are consistent with previous testing at the site performed by Speedie and Associates (report dated September 2, 1999, included on CD in Appendix C).

	Severity	Class	Water-Soluble Sulfate (SO_4) in Soil (percent by weight)	Dissolved Sulfate (SO_4) in water (ppm)
S Sulfate	Not Applicable	S0	$SO_4 < 0.10$	$SO_4 < 150$
	Moderate	S1	$0.10 \leq SO_4 < 0.20$	$150 \leq SO_4 < 1500$
	Severe	S2	$0.20 \leq SO_4 \leq 2.00$	$1500 \leq SO_4 \leq 10{,}000$
	Very Severe	S3	$SO_4 > 2.00$	$SO_4 > 10{,}000$

Excerpt from Table 4.2.1 from ACI 318, Exposure Categories and Classes

Additionally, while not included in AMEC's scope of services, it should be noted that the above referenced Speedie and Associates report tested for and indicated a potential for corrosiveness of metal pipes. Special consideration should be given to the use of corrosion protected pipes (if planned). If metal pipes are used, AMEC recommends the pipe type and/or coating be selected in accordance with Figure 203.04-5 of the ADOT Preliminary Engineering and Design Manual (ADOT 1989).

4.4 Excavation

Based on our observations of the near-surface soils and the results of our soil boring, we anticipate that conventional equipment will be able to perform shallow excavations for the proposed construction. However, while not encountered in the soil boring AMEC performed, the Speedie and Associates report referenced above noted some cemented soils encountered. These cemented soils may impede progress and necessitate the use of heavier excavation equipment. Contractors should draw their own conclusions based on their own evaluation of the site for the purpose of estimating excavation requirements.

Temporary excavation slopes for the proposed construction should be performed in accordance with OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, Subpart P. While some of the site soils would classify as Type B soils, they are intermixed throughout the site with sandy soils that would classify as Type C soils. Therefore, for excavations of less than 20 feet in depth, Subpart P, Appendix B allows maximum allowable unshored slope inclinations of 1.5H:1V for Type C soils.

4.5 Earth Factors

This section presents a discussion of the procedure for estimating earthwork factors for the planned project excavations. Development of earthwork factors was based on evaluation and analysis of data from in-situ density tests (undisturbed ring samples) and laboratory moisture-density relationships.

Earthwork factors were calculated by the following equation:

$$\% \text{ Shrink} = \left[1 - \frac{\gamma_{ex}}{\gamma_{emb}}\right] 100$$

where:

γ_{ex} = in-place dry density of material to be excavated
γ_{emb} = dry density of compacted embankment material

AMEC used 97 percent of the maximum dry density (ASTM D698) as the compacted embankment density. The shrink or swell conditions at different locations were estimated based on the above equation.

The table below presents the calculated earthwork factors for the soil boring we performed. There were no negative earthwork factors which would indicate swell; test results indicated a shrink potential.

Shrink / Swell Data - B-6									
Boring Number	Begin Depth (feet)	End Depth (feet)	USCS/ Group Symbol	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	In-Place Dry Density (pcf)	In-Place Moisture Content (%)	Value Compacted to 97%	Shrink (+) Swell (-)
B-6	0.0	5.0	CL	120.8	12.1	111.4	7.5	117.2	5%
B-6	5.0	10.0	SC	118.3	13.1	109.0	13.4	114.8	5%
					MEAN	**110.2**	**10.5**		**5%**
					STANDARD DEVIATION	**1.7**	**4.2**		**0%**
					MAXIMUM	**111.4**	**13.4**		**5%**
					MINIMUM	**109.0**	**7.5**		**5%**

4.6 Compaction

The placement and compaction of fill in horizontal lifts should be performed using methods that will produce uniform moisture contents and densities throughout the lift. The thickness of uncompacted fill lifts should not exceed 8 inches. Materials shall be compacted to the following densities and moistures:

Material Type		Compaction Requirement (ASTM D698)	Moisture Specification
Utility Trench Backfill			
	Within 2' of FSG[1]	95% Minimum	*/- 3% of Optimum
	More than 2' Below FSG	90% Minimum	*/- 3% of Optimum
Embankment Slopes			
	Subgrade	95% Minimum	*/- 3% of Optimum
Aggregate Base Course			
	Below Slabs	95% Minimum	*/- 2% of Optimum
Landscape Areas			
	Landscape Areas	90% Minimum	*/- 3% of Optimum

[1] FSG = Finished Subgrade

Prepared subgrade soils should not be allowed to dry out prior to placing concrete for slabs or aggregate base course in order to minimize the potential for future expansion of compacted clayey subgrade soils.

4.7 Materials

Based on the results of our laboratory testing, some site soils have the potential for low to moderate expansion. We recommend that soils placed as engineered fill within 24 inches of slabs, footings, retaining walls, and any other structures possess an expansion potential of 1.5 percent or less. Regular expansion potential testing during construction operations will be necessary to identify the expansive soils. Existing site soils and imported soils to be used as engineered fill within 24 inches of slabs-on-grade, footings, retaining walls, and any other structures should conform to the following criteria:

Gradation (ASTM C 136)	
Particle Size	Percent Finer by Weight
6"	100
2"	70-100
No. 4 Sieve	50-100
No. 200 Sieve	75 or less
Plasticity Index (ASTM D 4318)	
15 or less	
Expansion Potential (ASTM D 4546)	
1.5 % or less (when placed within 24 inches of structures)	

The expansion potential specification is based on a low temperature oven-dried sample compacted to approximately 95 percent of the maximum dry density determined by ASTM Standard D698 at a moisture content about 3 percent below optimum, and tested under saturation with a surcharge load of 100 psf.

5.0 BASIS FOR RECOMMENDATIONS

The recommendations provided in this report are based on our understanding of the project described herein and on our interpretation of the data collected during the subsurface exploration. We have made our recommendations based on experience with similar subsurface conditions under similar loading conditions. These recommendations apply to the specific project discussed in this report; therefore, any changes in load conditions or site grades should be provided to us so that we may review our conclusions and recommendations and make any necessary modifications.

Regardless of the thoroughness of the geotechnical exploration, there is always a possibility that conditions between the test borings will be different than those encountered in the test borings, or that soil conditions may change subsequent to our investigation. Therefore, an experienced geotechnical engineer or qualified technical representative should monitor the earthwork and subgrade construction to confirm that the soil conditions encountered in the field conform to those described in this report.

6.0 REFERENCES

American Concrete Institute, Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary. Reported by ACI Committee 318.

Arizona Department of Transportation, Preliminary Engineering Design Manual, Third Edition, March, 1989

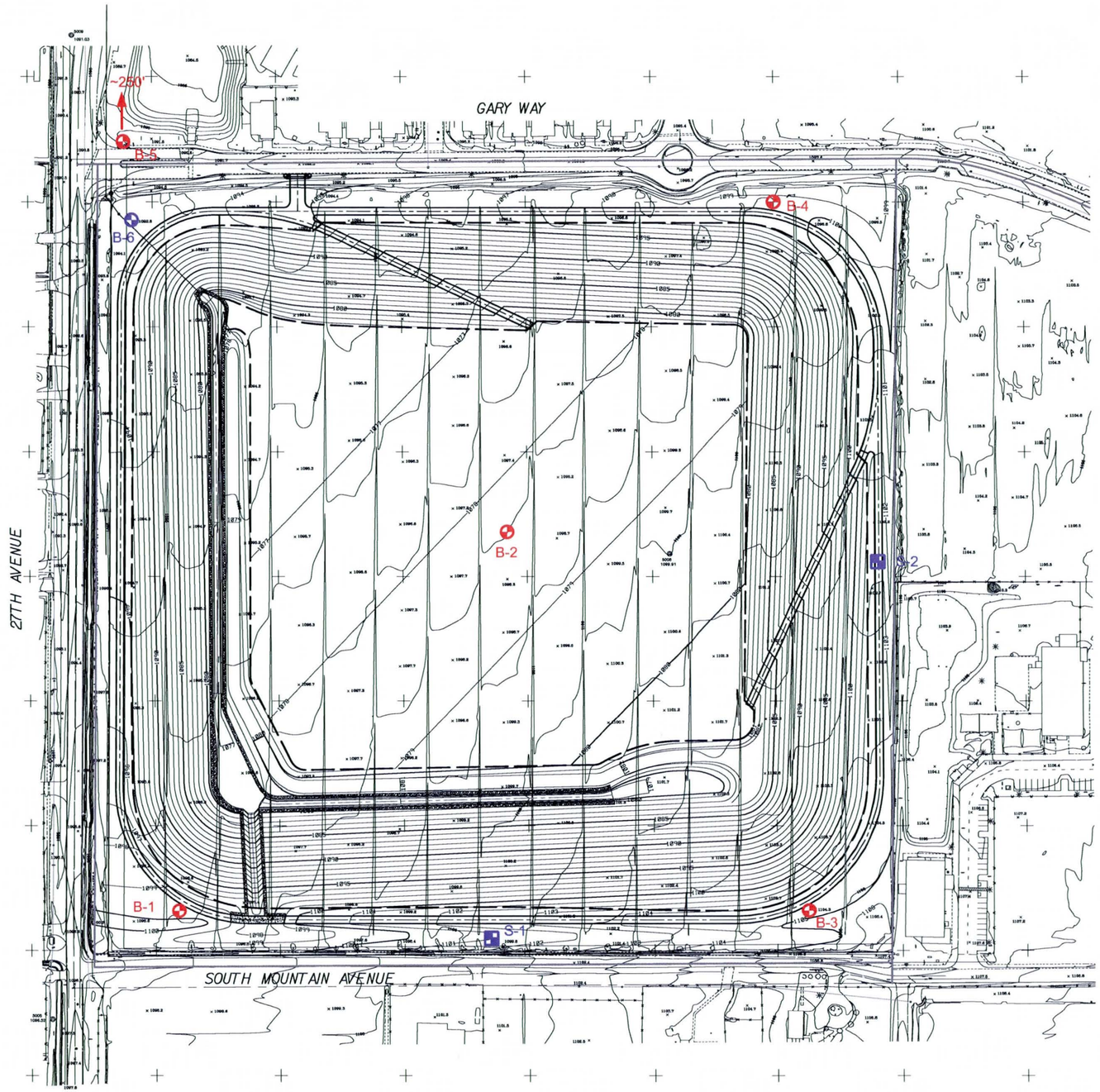
Arizona Department of Water Resources, http://www.azwater.gov/azdwr/default.aspx

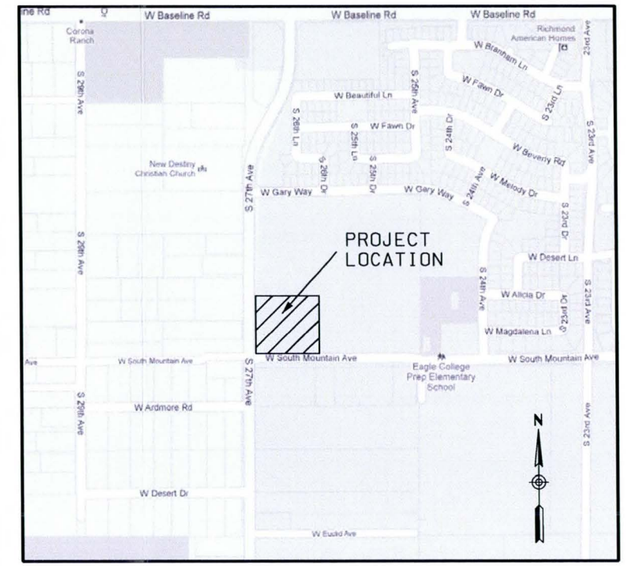
Arizona Geological Survey (AZGS), http://www.azgs.az.gov

Maricopa Association of Governments – Uniform Standard Specifications for Public Works Construction (revised January 2012)

Speedie and Associates – Report on Geotechnical Investigation, Project No. 970186SC, dated September 2, 1999

FIGURE





VICINITY MAP

N

0 50 100 200

SCALE: 1"= 200

LEGEND

- APPROXIMATE SPEEDIE BORING LOCATIONS
- APPROXIMATE AMEC BORING LOCATIONS
- APPROXIMATE AMEC SURFICIAL SAMPLE LOCATIONS

JOB NO.	17-2011-4055
DESIGN:	MH
DRAWN:	GWH
DATE:	6/2012
SCALE:	AS SHOWN

SITE MAP
SHOWING BORING LOCATIONS

27TH AVENUE AND SOUTH MOUNTAIN AVENUE BASIN
SOUTH PHOENIX TWO BASINS PROJECT

FIGURE 1

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APPENIDX A

Field Investigation

TEST DRILLING EQUIPMENT AND PROCEDURES

Description of Subsurface Exploration Methods

Auger Boring Drilling through overburden soils is performed with 6 5/8-inch O.D., 3 1/4-inch I.D. hollow stem auger or 4 1/2-inch solid stem continuous flight auger. Carbide insert teeth are normally used on bits so they can penetrate soft rock or very strongly cemented soils. A CME-75 truck-mounted drill rig is used to advance the auger. The drill rigs are powered with six-cylinder Cummins diesel engines capable of delivering about 11.4 kN-m torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 90 kN (20,000 pounds) downward force.

Generally, refusal to penetration of the auger is adopted as top of the SGC or "river-run" material or harder bedrock, which require other techniques for penetration. Grab samples or auger cuttings may be taken as necessary. Standard penetration tests or 2.42-inch diameter ring samples are taken in conjunction with the auger borings as needed, with the sampling interval and type being indicated on the boring logs.

Hammer Drill Drilling with the Hammer drill is accomplished with a Drill Systems AP-1000 drill rig advancing a double-walled drive casing with a link-belt 180 diesel pile driving hammer, having a rated energy of 8,100 foot-pounds per blow. Where noted on the boring log, the hammer is equipped with a supercharger which can boost the energy to approximately 12,000 foot-pounds per blow. The supercharger is used only in portions of the boring where blow counts are relatively high. Cuttings are removed with compressed air by a reverse circulation process, and are collected in a cyclone from which grab samples are obtained. The drive casing is either 9-inch O.D. by 6-inch I.D. or 6 5/8-inch O.D. by 4-inch I.D. and employs an expendable bit of slightly larger diameter than the O.D. of the casing. Hammer blows required to advance the drive casing are recorded in 1-foot increments, as noted on the boring logs. Standard penetration tests or 2.42-inch diameter ring samples taken are noted on the boring logs.

Core Boring Rock core samples are retrieved using a CME-75 drill rig, SAITECH GH 3 rig or Burley 2500, 4500 or 4000. The GH 3 is a portable hydraulic core drill. The GH 3 is powered by a Kohler two-cylinder 25-horsepower engine. The hydraulics motor which feeds a two-speed transmission and powers the BW spindle. This unit has a 3-foot stroke and is hand-fed with a 2,000 pound push-pull capability. The GH 3 has the capability of drilling with either B- or N-size core steel using standard or wireline systems. N-size core is the preferred size and it has a nominal O.D. of about 2 inches. The Burley 2500 and 4500 series are portable hydraulic core drills. The 4500 series is capable of a track-mounted or skid-type chassis. The Burley 2500 and 4500 series are powered by 44 and 75 HP power units, respectively, provide up to 2,000 foot-pounds (ft.-lbs.) of torque and in excess of 1,000 revolutions per minute (RPM) of spindle speed. Both rigs are capable of retrieving either N- or H-sized core using wireline systems. The N-size core has a nominal O.D. of about 2 inches and the H-size of about 2.4 inches. The Burley 4000 is a track-mounted core drill.

The CME-75 utilizes a wireline core drilling system that takes N-size cores. Using the NQ wireline system, core is recovered quickly by retrieving the core-laden inner tube through the drill string.

TEST DRILLING EQUIPMENT AND PROCEDURES (Cont.)

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 test procedure. In many cases, 2-inch O.D., 1 3/8-inch I.D. samples are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3-inch O.D. samples lined with 2.42-inch I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140-pound, 30-inch free fall drop hammer required to advance the samples in 6-inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2- or 3-inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per 6 inches on the boring logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587), pitcher samplers, Denison samplers or continuous CME samplers. Where samples of rock are required, they are obtained by NQ diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings. Also, representative samples are obtained from the cuttings from the hammer and Schramm drill rig.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares the boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487), with appropriate group symbols being shown on the boring logs.

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. **Relative Density.** Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. **Relative Consistency.** Terms for description of clays which are saturated or near saturation.

N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. **Relative Firmness.** Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

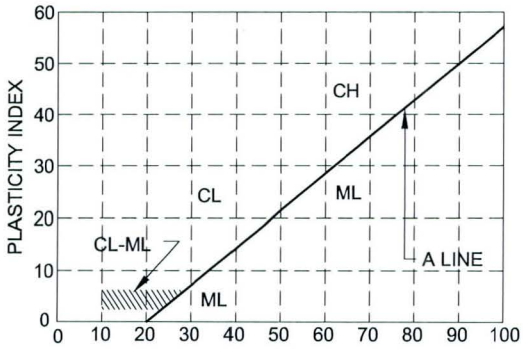
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Soils are visually classified by the United Soil Classification System on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see " The Unified Soil Classification System " ASTM Designation: D2487

MAJOR DIVISION				GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	**GRAVELS** (50% or less of coarse fraction passes No. 4 sieve)	**CLEAN GRAVELS** (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sized mixtures or sand-gravel-cobble mixture.
					GP	Poorly graded gravels, gravel-sized mixtures or sand-gravel-cobble mixture.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixture.
			Limits plot below "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixture.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	**CLEAN SANDS** (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot below "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	**SILTS** LIMITS PLOT BELOW "A" LINE & HATCH ZONE ON PLASTICITY CHART	**SILTS OF LOW PLASTICITY** (Liquid limit less than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid limit more than 50)			MH	Inorganic silts of high plasticity, silty soils, elastic silts.
	CLAYS LIMITS PLOT BELOW "A" LINE & HATCH ZONE ON PLASTICITY CHART	**CLAYS OF LOW PLASTICITY** (Liquid limit less than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid limit more than 50)			CH	Inorganic clays of high plasticity, fat clays, silty and sandy clays of high plasticity.

NOTE: Coarse-grained soils with between 5% to 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone on the plasticity chart to have dual symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 300mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Gravel	75mm (3in.) to No. 4 sieve
Coarse gravel	75mm to 19mm (3in to 3/4in.)
Fine gravel	19mm (3/4in.) to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

PROJECT South Phoenix Two Basins Project
27th Avenue & South Mountain Avenue
Phoenix, Arizona

JOB NO. 17-2011-4055 **DATE** 6/18/12

LOCATION See Site Map

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1094'±
DATUM Stanley Base Map

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	3-2-2			CL	slightly moist to moist	**SANDY CLAY,** trace silt, considerable fine to medium grained, subangular to subrounded sand, uncemented, low to medium plasticity, brown to light brown
				A						
				S	2-3-4				very soft to soft	note: vegetation roots
								SC	slightly moist to moist	**CLAYEY SAND,** occasional fine grained, subangular to subrounded gravel, predominantly fine to medium grained, subangular to subrounded, uncemented, medium plasticity, light brown to beige
5				U	18	111	8			
				A						
									moderately firm to firm	note: increase in fines from 5' to 18'
10				S	2-5-8					note: some predominantly fine grained, subangular gravel at 11'
15				U	36	109	13			
20				S	6-10-13					
								SC	slightly moist	**CLAYEY SAND,** predominantly fine grained, subangular to subrounded, uncemented, low to medium plasticity, light brown to beige
									very firm	
25				S	10-16-21					

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽		none	
▼			
▽			
▼			

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
P - Pressuremeter Test
NR - No Recovery

LOG OF TEST BORING NO. B-6

PROJECT South Phoenix Two Basins Project
27th Avenue & South Mountain Avenue
Phoenix, Arizona

JOB NO. 17-2011-4055 **DATE** 6/18/12

LOCATION See Site Map

RIG TYPE CME-75
BORING TYPE 6 5/8" Hollow Stem Auger
SURFACE ELEV. 1094'±
DATUM Stanley Base Map

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25								SC		**CLAYEY SAND,** continued
										Stopped Auger at 24'6" Stopped Sampler at 26' Backfilled with drill cuttings
30										
35										
40										
45										
50										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽		none	
▼			
▽			
▼			

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
P - Pressuremeter Test
NR - No Recovery

LOG OF TEST BORING NO. B-6

PROJECT South Phoenix Two Basins Project
27th Avenue & South Mountain Avenue
Phoenix, Arizona

JOB NO. 17-2011-4055 **DATE** 6/18/12

LOCATION See Site Map

RIG TYPE Hand Excavated
BORING TYPE
SURFACE ELEV. 1101'±
DATUM Stanley Base Map

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				A				SM	slightly moist to moist	**SILTY SAND,** considerable fines, nonplastic, light brown to brown
										Stopped Hand Excavation at 2'
5										
10										
15										
20										
25										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽		none	
▼			
▼			
▼			

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
P - Pressuremeter Test
NR - No Recovery

LOG OF TEST BORING NO. S-1

PROJECT South Phoenix Two Basins Project
27th Avenue & South Mountain Avenue
Phoenix, Arizona

JOB NO. 17-2011-4055 **DATE** 6/18/12

LOCATION See Site Map

RIG TYPE Hand Excavated
BORING TYPE
SURFACE ELEV. 1103'±
DATUM Stanley Base Map

Depth in Feet	Drill Rate Min/ft.	Graphical Log	Sample	Sample Type	Blow Count	Dry Density lbs. per Cubic ft.	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				A				SM	slightly moist to moist	**SILTY SAND,** considerable fines, nonplastic, light brown to brown
										Stopped Hand Excavation at 2'
5										
10										
15										
20										
25										

GROUNDWATER

	DEPTH(ft)	HOUR	DATE
▽		none	
▼			
▽			
▼			

SAMPLE TYPE

A - Drill cuttings
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
P - Pressuremeter Test
NR - No Recovery

LOG OF TEST BORING NO. S-2

APPENDIX B

Laboratory Test Results

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS

Project Location	Boring Number	Depth (ft)		USCS/Group Symbol	Percent Fines (minus 200)	Liquid Limit	Plasticity Index	Moisture Content (%)	In Place Dry Density (pcf)[1]	Optimum Moisture Content (%) (by ASTM D698A)	Maximum Dry Density (pcf) (by ASTM D698A or D698C)	Chlorides (ppm)[2]	Soluble Sulfates (ppm)[2]
		Begin	End										
27th Avenue and South Mountain Avenue	B-6	0.0	5.0	CL	54	31	12			12.1	120.8		
27th Avenue and South Mountain Avenue	B-6	4.5	5.5					7.5	111.4				
27th Avenue and South Mountain Avenue	B-6	5.0	10.0	SC	46	37	18			13.1	118.3		
27th Avenue and South Mountain Avenue	B-6	14.5	15.5					13.4	109.0			132	59
27th Avenue and South Mountain Avenue	B-6	19.5	21.0									56	38
27th Avenue and South Mountain Avenue	S-1	0.0	2.0	SM	42	NV	NP						
27th Avenue and South Mountain Avenue	S-2	0.0	2.0	SM	44	NV	NP						
MEAN[1]					46.5	34.0	15.0	10.5	110.2	12.6	119.6	94.0	48.5
STDEV[1]					5.3	4.2	4.2	4.2	1.7	0.7	1.8	53.7	14.8
MAXIMUM[1]					54	37	18	13.4	111.4	13	121	132	59
MINIMUM[1]					42	31	12	7.5	109.0	12	118	56	38
COUNT[1]					4	4	4	2	2	2	2	2	2

[1] Does not include nonplastic soils in calculations

Notes: 1(pcf) = pounds per cubic foot
2(ppm) = parts per million

amec

PROJECT:	South Phoenix Two Basins Project	**JOB NO:**	17-2011-4055
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	1
MATERIAL:	Onsite Soil	**LAB NO:**	SEE BELOW
SAMPLE SOURCE:	SEE BORING	**DATE ASSIGNED:**	6/19/12

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD(ASTM D2937)

LAB #	BORING	MOISTURE WET WT. (g)	MOISTURE DRY WT. (g)	MOISTURE MOISTURE CONTENT	NUMBER OF RINGS	WET WEIGHT & RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (pcf)
5	B-6 @ 4.5-5.5	842.6	784.0	7.5%	6	1,118.7	250.9	111.4
7	B-6 @ 14.5-15.5	471.2	415.6	13.4%	5	969.1	223.1	109.0

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amec

PROJECT:	South Phoenix Two Basins Project	**JOB NO:**	17-2011-4055
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	1
MATERIAL:	Onsite Soil	**DATE ASSIGNED:**	6/19/12
SAMPLE SOURCE:	SEE BELOW		

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

				Silt or	SAND							GRAVEL									COBBLES	
				Clay	Fine			Medium			Coarse		Fine				Coarse					
Location & Depth	**USCS**	**LL**	**PI**	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**	**#8**	**#4**	**1/4"**	**3/8"**	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**	**3"**	**6"**	**Lab #**

PERCENT PASSING BY WEIGHT

B-6 @ 0-5	CL	31	12	54	63	70	73	77	84	90	92	97	98	99	100	100	100	100	100	100	100	100	1
B-6 @ 5-10	SC	37	18	46	54	61	65	69	78	86	88	95	97	99	100	100	100	100	100	100	100	100	2
S-1 (0-2')	SM	NV	NP	42	53	62	67	71	80	86	89	95	96	98	99	99	100	100	100	100	100	100	19
S-2 (0-2')	SM	NV	NP	44	56	64	68	72	79	85	87	93	94	96	98	99	100	100	100	100	100	100	20

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amec

PROJECT:	South Phoenix Two Basins Project	**JOB NO:**	17-2011-4055
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	1
MATERIAL:	Onsite Soil	**LAB NO:**	See Below
SAMPLE SOURCE:	See below	**DATE ASSIGNED:**	6/19/12

MOISTURE CONTENT OF SOIL (ASTM D2216)

LAB #	BORING & DEPTH	WET WT. (gram)	DRY WT. (gram)	MOISTURE CONTENT
5	B-6 @ 4.5-5.5	842.6	784.0	7.5%
7	B-6 @ 14.5-15.5	471.2	415.6	13.4%

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MOTZZ LABORATORY, INC.

Soil Analysis Report

AMEC
Mr. Cliff Metz
3630 E Weir Avenue
Phoenix AZ 85040

Project: 1720114055 WO1
Sampler:
Date Received: 6/25/2012
Date Reported: 7/2/2012
PO Number: 1720114055

Lab Number: 905581-01 **Lab#7 B6 @ 14.5-15.5'**

Sulfate & Chloride	Method	Result	Units	Levels
Sulfate, SO4	ARIZ 733	59	ppm	
Chloride, Cl	ARIZ 736	132	ppm	

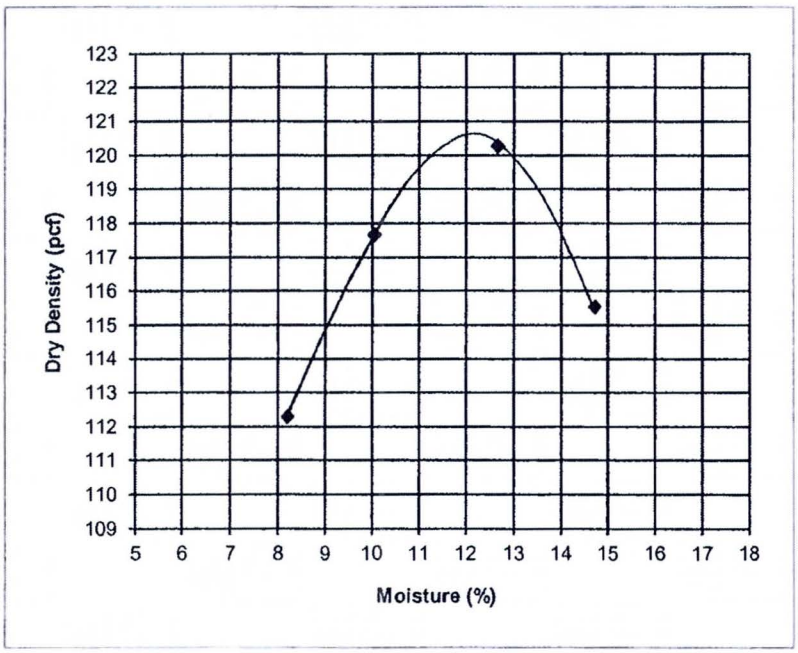
Lab Number: 905581-02 **Lab#8 B6 @ 19.5-21'**

Sulfate & Chloride	Method	Result	Units	Levels
Sulfate, SO4	ARIZ 733	38	ppm	
Chloride, Cl	ARIZ 736	56	ppm	

PROJECT:	South Phoenix Two Basins Project	**JOB NO:**	17-2011-4055
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	1
MATERIAL:	Onsite Soil	**LAB NO:**	1
SAMPLE SOURCE:	B-6 @ 0-5'	**DATE SAMPLED:**	6/19/12

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MAXIMUM DRY DENSITY (pcf):	120.8
OPTIMUM MOISTURE (%):	12.1



SIEVE SIZE	PERCENT PASSING
6"	100
4"	100
3"	100
2"	100
1 1/2"	100
1 1/4"	100
1"	100
3/4"	100
1/2"	100
3/8"	99
1/4"	98
#4	97
#8	92
#10	90
#16	84
#30	77
#40	73
#50	70
#100	63
#200	54

ATTERBERG LIMITS

LL:	31
PL:	19
PI:	12
USCS:	CL

NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.751 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

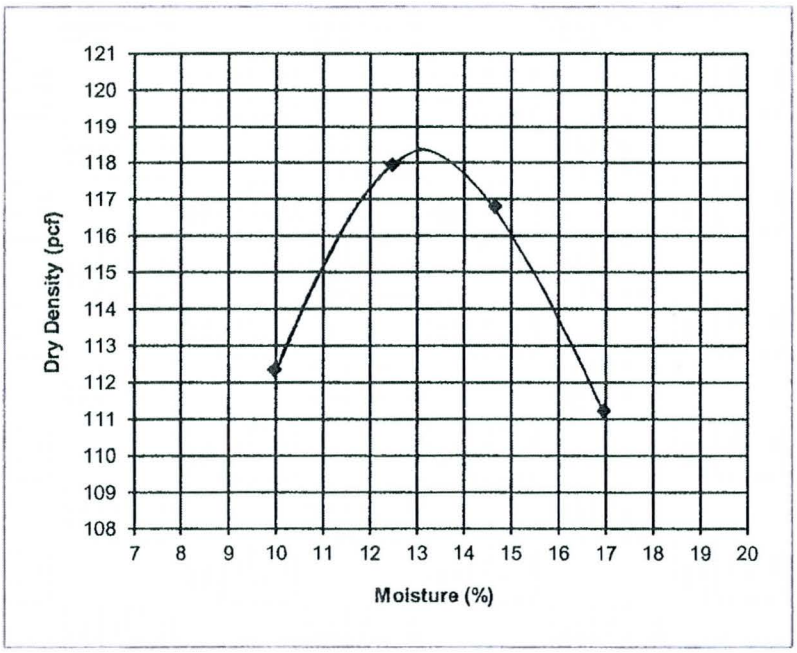
AASHTO R18

REVIEWED BY

PROJECT:	South Phoenix Two Basins Project	**JOB NO:**	17-2011-4055
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	1
MATERIAL:	Onsite Soil	**LAB NO:**	2
SAMPLE SOURCE:	B-6 @ 5-10'	**DATE SAMPLED:**	6/19/12

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING STANDARD EFFORTS (12,400ft-lb-ft/cu.ft) (ASTMD698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)

MAXIMUM DRY DENSITY (pcf):	118.3
OPTIMUM MOISTURE (%):	13.1



SIEVE SIZE	PERCENT PASSING
6"	100
4"	100
3"	100
2"	100
1 1/2"	100
1 1/4"	100
1"	100
3/4"	100
1/2"	100
3/8"	99
1/4"	97
#4	95
#8	88
#10	86
#16	78
#30	69
#40	65
#50	61
#100	54
#200	46

ATTERBERG LIMITS

LL:	36
PL:	19
PI:	17
USCS:	SC

NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.751 ASSUMED.

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDE ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

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APPENDIX C

Previous Geotechnical Investigation