Registered Professional Engineer (Civil)
CERTIFICATE NO. 35600
PHILIP JAMES NOONAN
Date Signed 4/12/24
ARIZONA U.S.A.

City of Phoenix
Office of the City Engineer
Design and Construction Procurement

LIFT STATION 76 PHASE II EXPANSION
WS90400067

ADDENDUM NO. 2

ISSUE DATE: APRIL 16, 2024

GENERAL

1. **FOR THE LIFT STATION PROJECT IS THERE A SOILS REPORT:** See attached Geotechnical Report by Entellus dated October 13th, 2017 and Geotechnical Report by Speedie dated May 17th, 2017 related to the Lift Station 76 Facility.

LIFT STATION 76 PHASE II EXPANSION

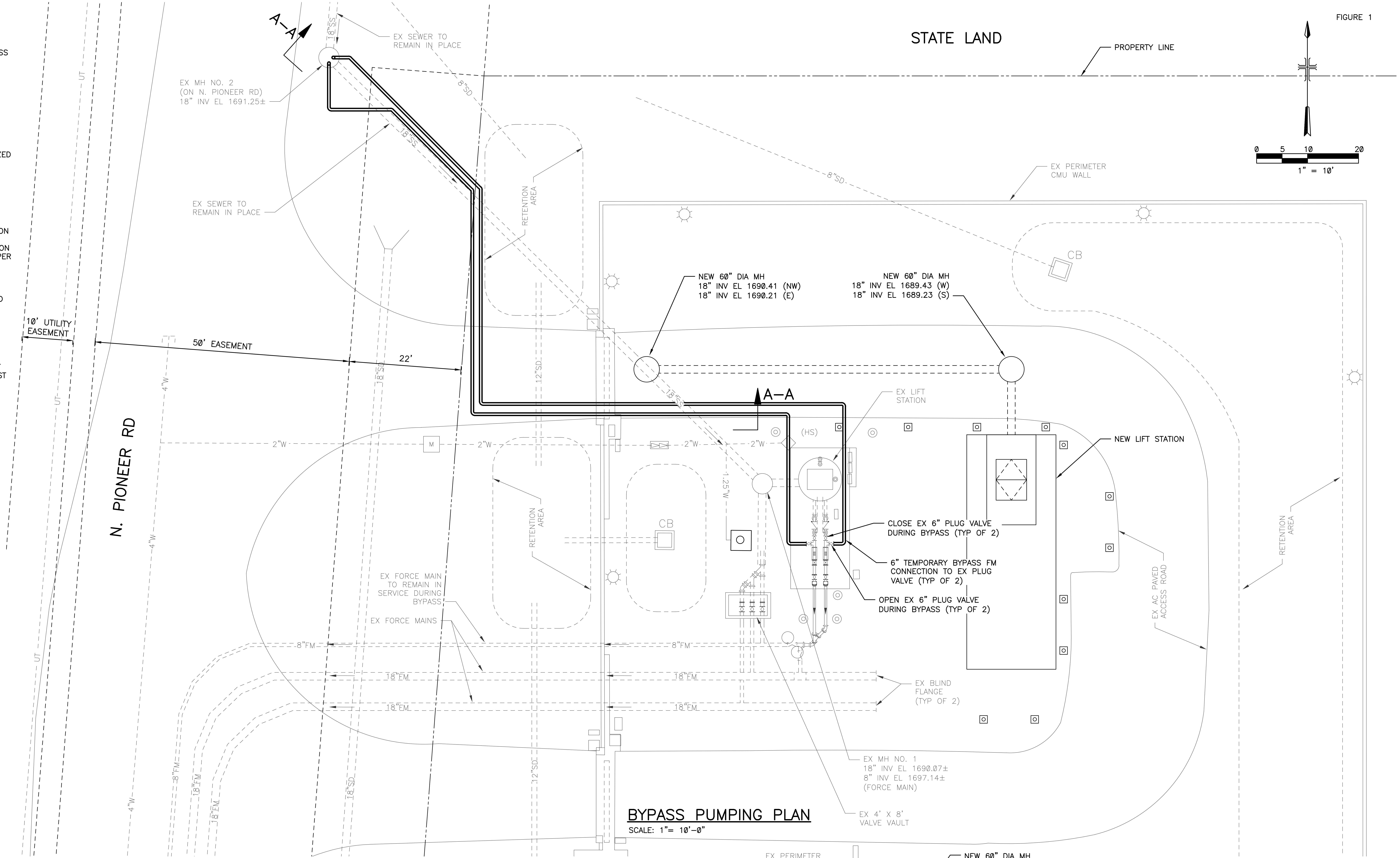
2. **PROJECT TECHNICAL DRAWINGS:** Sheet X01, BYPASS PUMPING PLAN (Sheet 41 of 41), **DELETE** the sheet in it's entirety and **REPLACE** with attached sheet X01, BYPASS PUMPING PLAN.

END OF ADDENDUM

FIGURE 1

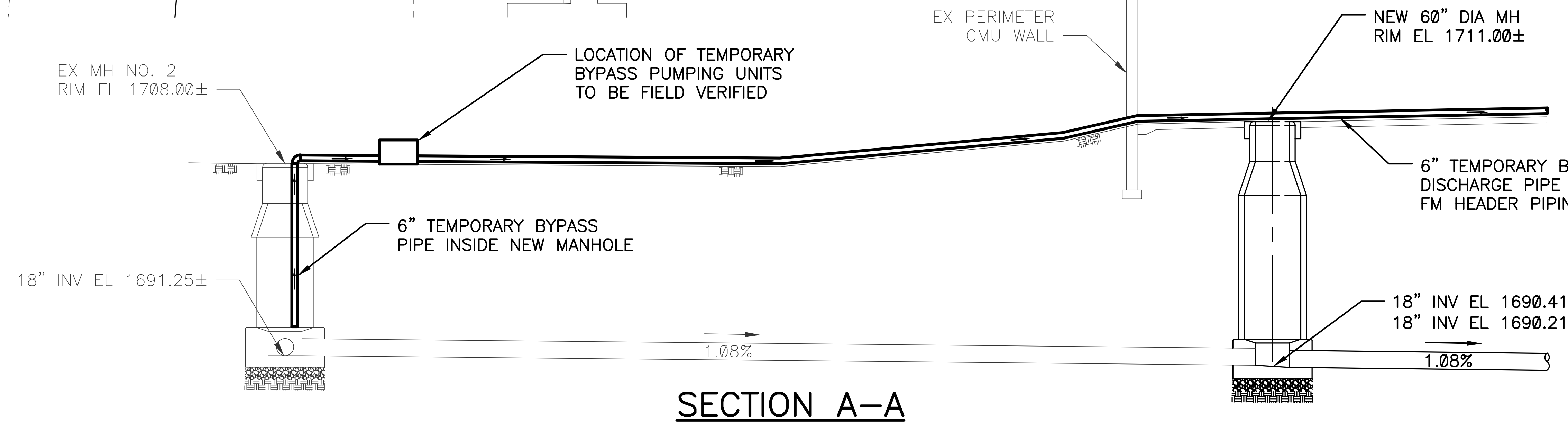
GENERAL NOTES:

1. BYPASS PUMPING DRAWING FOR INFORMATION PURPOSES ONLY, CONTRACTOR TO SUBMIT MAINTENANCE OF PROPOSED OPERATION BEFORE IMPLEMENTING ANY BYPASS WORK.
2. THE CONTRACTOR SHALL FIELD VERIFY THE POINT OF CONNECTION FOR THE TEMPORARY DISCHARGE PIPING.
3. THE CONTRACTOR SHALL REVIEW AND CONFIRM THE FEASIBILITY OF THE BYPASS APPROACH HEREIN, AND REVIEW WITH THE CITY AND ENGINEER PRIOR TO IMPLEMENTATION.
4. CONSTANT MONITORING SHALL BE PROVIDED FOR TEMPORARY BYPASS PUMPS, EQUIPMENT AND PRESSURIZED PIPELINE. PRESSURE TESTING OF THE BYPASS PIPE SHALL BE SUCCESSFULLY COMPLETED PRIOR TO IMPLEMENTATION.
5. THE ALIGNMENT OF THE TEMPORARY PIPING WILL BE CONFIRMED BY THE CONTRACTOR IN COORDINATION WITH FIELD CONDITIONS AND THE CONTRACTORS ON-SITE EQUIPMENT. TEMPORARY PIPING SHALL NOT INTERFERE WITH CONSTRUCTION, DEMOLITION, TESTING AND OPERATION OF THE LIFT STATION. THE CONTRACTOR SHALL TAKE FULL RESPONSIBILITY OF THE BYPASS PUMPING OPERATION AND ANY DELAYS THAT OCCUR AS A RESULT OF IMPROPER IMPLEMENTATION OF THE TEMPORARY BYPASS SYSTEM.
6. THE INTEGRITY OF ANY MANHOLES USED DURING THE BYPASS OPERATION SHALL NOT BE COMPROMISED, ANY DAMAGE SHALL BE REPAIRED AT NO ADDITIONAL COST TO THE CONTRACT. COATING SHALL BE RESTORED IN ACCORDANCE WITH CITY SPECIFICATIONS AND REQUIREMENTS IF DAMAGED.
7. TEMPORARY BYPASS SHALL REMAIN IN PLACE UNTIL THE NEW WET WELL, PUMPS, AND DISCHARGE FORCE MAIN HAVE ALL BEEN COMPLETELY INSTALLED, TESTED, AND ACCEPTED BY THE CITY. SWITCH OVER TO THE NEW LIFT STATION SHALL BE COORDINATED WITH THE CITY AT LEAST 7 DAYS PRIOR TO SCHEDULE FINAL SWITCH OVER.



BYPASS PUMPING PLAN

SCALE: 1"= 10'-0"



SECTION A–A
TEMPORARY BYPASS

SCALE: 1"= 10'-0"

GREELEY AND HANSEN
2800 N. 44TH STREET, SUITE 650
PHOENIX, AZ 85008

X01 SHEET 41 OF 41

APRIL 2024
CITY OF PHOENIX
WATER SERVICES DEPARTMENT
LIFT STATION 76 PHASE II EXPANSION
PROJECT NO. WS90400067-4

Geotechnical Evaluation

West Anthem Water and Wastewater Infrastructure
Phoenix, Arizona

Entellus, Inc.
3033 North 44th Street, Suite 250 | Phoenix, Arizona 85018

October 13, 2017 | Project No. 604929001

Geotechnical | Environmental | Construction Inspection & Testing | Forensic Engineering & Expert Witness

Geophysics | Engineering Geology | Laboratory Testing | Industrial Hygiene | Occupational Safety | Air Quality | GIS

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

Geotechnical Evaluation

West Anthem Water and Wastewater Infrastructure
Phoenix, Arizona
WS85500416 & WS90500276

Mr. Bill Linck
Entellus, Inc.
3033 North 44th Street, Suite 250 | Phoenix, Arizona 85018

October 13, 2017 | Project No. 604929001

Farhad Rahimi
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CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

In accordance with our proposal dated February 16, 2015, and your authorization, we have performed a geotechnical evaluation for the proposed West Anthem Water and Wastewater Infrastructure project in Phoenix, Arizona. The purpose of our evaluation was to assess the subsurface conditions at the site in order to formulate geotechnical recommendations for design and construction of the project. This report presents the results of our evaluation, conclusions, and recommendations regarding the proposed construction.

2 SCOPE OF SERVICES

The scope of our services for the project included the following:

- Performing geologic research by reviewing readily available published and in-house geotechnical literature of the site and the general site area including geologic maps.
- Performing a desktop study and geologic reconnaissance along the project site to evaluate existing geologic hazards.
- Conducting a walking visual reconnaissance of the project area and marking out boring locations based on the drawings provided by your office.
- Notifying Arizona 811 of the boring locations prior to drilling.
- Arranging for appropriate traffic control measures to be implemented during our field work.
- Drilling, logging, and sampling 24, small-diameter exploratory borings to depths of approximately 1.5 to 19 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples obtained from the borings to evaluate in-situ moisture content and dry density, gradation analysis, Atterberg limits, and corrosivity characteristics (including pH, minimum electrical resistivity, soluble sulfates, chlorides, redox, and sulfide). The results of the laboratory testing are presented on the boring logs and Appendix B.
- Preparing this report presenting our findings, conclusions, and recommendations regarding the design and construction of the project.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

3 SITE DESCRIPTION

The project site is located in Section 15, 22, and 27 of Township 6 North, Range 2 East, in Phoenix, Arizona. The approximate location of the site is depicted on Figure 1. The project limits roughly extend along North Pioneer Road between West Opportunity Way and West Sheriffs Pistol Range Road. At the time of our evaluation, North Pioneer Road was an unpaved roadway within undeveloped desert on State of Arizona and private lands. In general, this portion of the project site was covered with scattered vegetation and drainage from Deadman's Wash, which traverses northeast-southwest and is situated near the central portion of the site.

According to the *Biscuit Flat, Arizona-Maricopa Co., 7.5-Minute United States Geological Survey (USGS) Topographic Quadrangle Map (2014),* the elevation along the planned pipeline alignment ranges from approximately 1,710 to 1,850 feet relative to mean sea level. Based on the information from this quadrangle map the project site slopes from the northeast down to the southwest with varying slope differentials throughout the length of the project.

Several aerial photographs from the Flood Control District of Maricopa County were reviewed for this project. A 1953 aerial photograph depicted the site as undeveloped desert land with mountainous terrain. A photograph from 1993 depicted that I-17 had been constructed, Anthem Way had been constructed west of I-17 and some commercial development was under construction at the northwest corner of Anthem Way and I-17. The photograph also depicted a bridge crossing over I-17 at Pioneer Road and that Carefree Highway was a paved roadway. A photograph from 1997 depicted portions of Pioneer Road as a paved roadway. A photograph from 2000 depicted residential development to the east of the site. A photograph from 2001 depicted commercial development at the southeast portion of the site and additional commercial development at the northern portion of the site. A photograph from 2002 depicted the southern portion of North Valley Parkway as a paved roadway. A photograph from 2004 depicted North Daisy Mountain Drive as a paved roadway to the east of I-17. A photograph from 2006 depicted residential development to the northwest of the site. Aerial photographs dated 2009 through 2016 depicted the site as being similar to its current condition.

4 PROPOSED CONSTRUCTION

The project consists of the design and construction of a new 24-inch and 36-inch diameter waterline and 18-inch sewer line that will extend roughly along North Pioneer Road between West Opportunity Way and West Sheriffs Pistol Range road (See Figure 1). We understand that the invert elevation of the sewer and waterline will be approximately 10 to 18 feet bgs. Generally, the pipeline will be installed using traditional cut-and-cover techniques. We understand that the existing pavement, if there is any, will be restored to match the existing pavement on site.

5 BACKGROUND REVIEW

As part of a previous study performed for this project, we reviewed previously conducted geotechnical explorations along or near this proposed alignment. As-built documentation obtained from the Arizona Department of Transportation (ADOT), and previous explorations performed by Ninyo & Moore, were reviewed and are summarized in the sections below. A summary of this previous study is outlined in our report entitled Alignment Study, West Anthem Water and Waste Water Infrastructure, Phoenix, Arizona (Alignment Study) and dated January 29, 2016.

5.1 Review of As-Built Documentation

Below is a summary of foundation data obtained from as-built plans from ADOT. Exploratory boring logs from the following as-built plan sheets were reviewed and can be found in Appendix A of the Alignment Study.

5.1.1 I-17 -1(74), located at Pioneer Road and I-17

The Station 1303+60 Pioneer T.I. Under Pass foundation data sheet included boring log data from three locations. The boring depths ranged from the ground surface to 8 ½ to 20 feet bgs. The boring locations were shown to be located at the pier and abutment foundations for the bridge at Pioneer Road and I-17. The general subsurface conditions were described caliche, cemented pebbles and cobbles from the ground surface to depths ranging from 8 ½ to 9 feet bgs, and igneous rock from 9 feet bgs to the total depths explored.

5.1.2 State Route 74 to Anthem Way, located at Deadman's Wash and I-17

The Station 1378+ Deadman Wash Bridge Widening foundation data sheets included boring log data from five locations. The boring depths ranged from the ground surface to 80 to 87 feet bgs. The boring locations were shown to be located near the pier and abutment foundations for the bridge at Deadman's Wash and I-17. The general subsurface conditions were described as clayey gravel from the ground surface to depths ranging from 12 to 32 feet bgs, tuff and basalt bedrock was found underlying the clayey gravel ranging from depths of 12 to 80 feet bgs, and sandstone was found underlying the tuff and basalt bedrock from depths of 62 to 80 feet bgs to the total depths explored.

5.1.3 Daisy Mountain Traffic Interchange - I-17 at Daisy Mountain Drive, located at Daisy Mountain Drive and I-17

The Daisy Mountain Drive T.I UP, Ramp A over Deadman Wash, and Ramp B over Deadman Wash Foundation data sheets included boring log data from 12 locations. The boring depths ranged from the ground surface to 41 to 82 feet bgs. The boring locations were shown to be located near the pier and abutment foundations for the traffic interchange at Daisy Mountain Drive and I-17, and ramps over Deadman Wash.

The subsurface conditions at the traffic interchange at Daisy Mountain Drive were generally described as gravelly and clayey sands, gravelly and sandy clays, and clayey and sandy gravels from the ground surface to depths ranging from 24 to 42 feet bgs, Quaternary breccia and conglomerate bedrock was found underlying the soils described above to the total depth explored.

The subsurface conditions at Ramp A over Deadman Wash (Southbound Ramp) were generally described as gravelly and clayey sands, gravelly and sandy clays, and clayey and sandy gravels from the ground surface to depths ranging from 31 to 52 feet bgs, Tertiary basalt and conglomerate bedrock was found underlying the soils described above to the total depth explored, except for the southern-most boring location which included Tertiary sandstone underlying the Tertiary basalt at a depth of 56 feet bgs to the total depths explored.

The subsurface conditions at Ramp B over Deadman Wash (Northbound Ramp) were generally described as gravelly and sandy clays, and sandy gravels from the ground surface to depths ranging from the ground surface to 19 feet bgs, Tertiary basalt and Quaternary breccia bedrock was found under the surface at some boring locations and underlying the soils described above to the total depths explored.

5.2 Previous Ninyo & Moore Geotechnical Evaluation

Ninyo & Moore conducted a Geotechnical Evaluation for the Pioneer Road 16-inch Water Main project, located at Pioneer Road and I-17, project No. 603001001, dated August 26, 2010. The following sections provide a generalized description of the materials encountered during our evaluation.

5.2.1 Subsurface Evaluation

Fill was encountered at the surface of some of our borings. The fill generally ranged in thickness from approximately 1 to 3 feet bgs in our borings. The fill material generally consisted of clayey sand and silty sand. Alluvium was encountered underlying the fill in some of our borings and at the surface other boring locations. The alluvium generally consisted of clay with sand, sandy clay, gravelly silt, clayey sand, silty sand, silty gravel, and poorly graded gravel with sand in our borings. The alluvium thickness in our borings ranged from approximately 2 feet to the total depth explored. Basalt and weathered tuff were encountered in some of our borings and extended to the total explored depths. The basalt was described as dark brown, damp, moderately hard, weathered, and vesicular. The welded tuff was described as white, damp, moderately hard, and weathered in our borings. The boring logs from our Geotechnical Evaluation can be found in Appendix B of the Alignment Study. Depth to bedrock was encountered at the depths shown in Table 1 below:

Table 1 – Summary of Estimated Depth to Bedrock

Previous Boring Designation	Approximate Depth to Bedrock, from Surface of Boring, feet
B-1	7.5
B-2	5
B-3	5
B-4	16
B-5	N/A
B-6	N/A

5.2.2 Geophysical Results

Ninyo & Moore personnel conducted seismic refraction surveys at the site on July 22, 2010 to evaluate the approximate depth to bedrock and rippability characteristics of the near surface materials. In general, seismic wave velocities can be correlated to material density and/or rock hardness. The relationship between rippability and seismic velocity is empirical and assumes a homogenous mass for each detected layer. Areas of differing composition, texture, or structure may affect both the measured data and the actual rippability of the mass. The rippability of a mass is also dependent on the excavation equipment used and the skill and experience of the equipment operator.

The average velocities, depths calculated from the seismic refraction traverses conducted during our evaluation, and rippability characteristics are summarized in the table below:

Table 2 – Seismic Refraction Results

Velocity Feet/Second	Approximate Depth to Bottom of Layer (range in feet bgs)	Rippability
Average V1 = 1,700	1-6	Easy Ripping
Average V2 = 6,000	--	Very Difficult Ripping, Probable Blasting

6 FIELD EXPLORATION AND LABORATORY TESTING

On June 5, and 6, and September 21, 2017, Ninyo & Moore conducted a subsurface exploration at the site in order to observe the existing subsurface conditions and to collect soil samples for laboratory testing. Our exploration consisted of the drilling, logging, and sampling of 24 small-diameter borings, denoted as B-1 through B-24. The borings were advanced using a CME-75 truck-mounted drill rig equipped with hollow-stem augers or ODEX percussion techniques and extended to depths ranging from approximately 1.5 to 19 feet bgs. The approximate locations of our borings are presented on Figure 2A through 2C. Bulk and relatively undisturbed soil samples were collected at selected intervals. Detailed descriptions of the soils encountered are presented on the boring logs in Appendix A.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System and ASTM International (ASTM) D2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions. Similarly, the Standard Penetration Test and bulk samples were sealed in plastic bags to retain their approximate in-place moisture.

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Phoenix, Arizona for geotechnical laboratory testing. The testing included in-situ moisture content and dry density, gradation analysis, Atterberg limits, and corrosivity characteristics (including pH, minimum electrical resistivity, soluble sulfates, chlorides, redox, and sulfide). The results of the in-situ moisture content and dry density testing are presented on the boring logs in Appendix A. A description of each laboratory test method and the remainder of the test results are presented in Appendix B.

7 GEOLOGY AND SUBSURFACE CONDITIONS

The geology and subsurface conditions at the site are described in the following sections.

7.1 Geologic Setting

The project site is located in the Sonoran Desert Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous, sub parallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basin floors consist of alluvium with thickness extending to several thousands of feet.

The basins and surrounding mountains were formed approximately 10 to 18 million years ago during the mid- to late-Tertiary. Extensional tectonics resulted in the formation of horsts (mountains) and grabens (basins) with vertical displacement along high-angle normal faults. Intermittent volcanic activity also occurred during this time. The surrounding basins filled with alluvium from the erosion of the surrounding mountains as well as from deposition from rivers. Coarser-grained alluvial material was deposited at the margins of the basins near the mountains.

The surficial geology of the site has been mapped as bedrock and alluvium. The bedrock along the project alignment has been described as Middle Tertiary age (approximately 10 million years) basalt, basaltic andesite, andesite, tuff, clastic rocks, and sedimentary rocks, and Middle or Early Proterzoic age (approximately 2.5 billion years) granite. Alluvial deposits were described as Late to Early Pleistocene age (approximately 1.8 million years) (Reynolds, S.J. & Grubensky, M.J., 1993).

The majority of the soil units are described as Carefree cobbly clay loam, and Suncity-Cipriano complex which is typically comprised of gravelly clay loam and cemented material by the United States Department of Agriculture. Loam is an agricultural soil classification that refers to a soil comprised of a mixture of clay, silt, and sand. Other minor soil units at the project site are described as Cheriono-Rock outcrop complex, Ebon very gravelly loam, Pinamt-Tremant complex, Schenco-Rock outcrop complex, and Tremant gravelly sandy loams.

7.2 Subsurface Conditions

Our knowledge of the subsurface conditions at the project site is based on our field exploration and laboratory testing, and our understanding of the general geology of the area. The following sections provide generalized descriptions of the materials encountered. More detailed descriptions are presented on the boring logs in Appendix A.

7.2.1 Alluvium

Native alluvium was encountered at the surface of our borings and extended to depths ranging from approximately 1.5 to 19 feet bgs. The alluvium generally consisted of poorly graded gravel (GP), silty gravel (GM), clayey gravel (GC), clayey sand (SC), silty sand (SM), lean clay (CL), and fat clay (CH) in our borings. Varying amounts of fine to coarse gravel were observed in the silty sand, clayey sand, lean clay and fat clay alluvial material. In addition, weak to strong cementation and scattered caliche nodules as well as gravel, cobbles and/or boulders were observed in our borings.

7.3 Groundwater

Groundwater was not encountered in any of our borings during drilling. Well data provided by the Arizona Department of Water Resources indicates groundwater historically has been encountered at approximately 260 feet bgs. It should be noted that groundwater levels could fluctuate due to seasonal variations, sources of irrigation, groundwater withdrawal or recharge, and in areas adjacent to, and in ephemeral streams, and other factors not apparent at the time of our fieldwork. In general, groundwater is not expected to be a constraint to the construction of the project, except possibly after periods of precipitation.

7.4 Surface Water

Based on the information presented on the Federal Emergency Management Agency Online Map Viewer, the pipe alignment lies within flood Zone X, which is described as an area with 0.2 percent or more chance of flooding each year, in the form of sheet flow with average depths less than 1 foot. However, the Deadman’s Wash stream crossing is considered a Special Flood Hazard area that must be kept free of encroachment so that the flood can be carried without substantial increase in flood height.

As such, surface water flows and/or shallower groundwater levels may be encountered within the project limits during rain events, and may be a constraint during construction. Surface water diversion may need to be considered during construction to mitigate surface water flows.

8 GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site, including land subsidence and earth fissures, and faulting and seismicity.

8.1 Land Subsidence and Earth Fissures

Groundwater depletion, due to groundwater pumping, has caused land subsidence and earth fissures in numerous alluvial basins in Arizona. It has been estimated that subsidence has affected more than 3,000 square miles and has caused damage to a variety of engineered structures and agricultural land (Schumann and Genualdi, 1986). From 1948 to 1983, excessive groundwater withdrawal has been documented in several alluvial valleys where groundwater levels have been reportedly lowered by up to 500 feet. With such large depletions of groundwater, the alluvium has undergone consolidation resulting in large areas of land subsidence.

In Arizona, earth fissures are generally associated with land subsidence and pose an on-going geologic hazard. Earth fissures generally form near the margins of geomorphic basins where significant amounts of groundwater depletion have occurred. Reportedly, earth fissures have also formed due to tensional stress caused by differential subsidence of the unconsolidated alluvial materials over buried bedrock ridges and irregular bedrock surfaces. Differential subsidence can also be caused by facies changes within unconsolidated alluvial deposits, also causing tensional stress (Schumann and Genualdi, 1986).

Based on our field reconnaissance, aerial photograph review, and our review of published literature, earth fissures are not underlying, or adjacent to the property. The closest documented earth fissure to the site is approximately 15 miles southeast of the site. Continued groundwater withdrawal in the area may result in subsidence of the valley and the formation of new fissures or the extension of existing fissures. Because of the unpredictable nature of earth fissures, as well as the difficulty of observing fissures that are not yet projected to the surface, earth fissures may be present within the project limits. If an earth fissure or soil cracking is encountered during construction, specifically during the earthwork operations, Ninyo & Moore should be notified immediately for further recommendations.

8.2 Faulting and Seismicity

The site lies within the Sonoran zone, which is a relatively stable tectonic region located in southwestern Arizona, southeastern California, southern Nevada, and northern Mexico (Euge et al., 1992). This zone is characterized by sparse seismicity and few Quaternary faults. Based on our field observations, review of pertinent geologic data, and analysis of aerial photographs, faults are not located on or adjacent to the property. The closest fault to the site is the Carefree Fault zone, located approximately 16 miles to the east of the site (Pearthree, 1998). The Carefree Fault Zone is a series of northwest-striking discontinuous normal faults that dip to the southwest. Approximately 2 meters of displacement has occurred along this fault within middle Pleistocene deposits (<750,000 years), but the upper Pleistocene and Holocene deposits (<250,000 years) are not displaced. The slip-rate category of this fault is less than 0.2 millimeters per year (Pearthree, 1998).

Seismic parameters recommended for the design of the proposed improvements are presented later in this report.

9 CONCLUSIONS

Based on the results of our subsurface evaluation, laboratory testing, and data analysis, it is our opinion that the proposed construction is feasible from a geotechnical standpoint, provided that the recommendations of this report are incorporated into the design and construction of the proposed project, as appropriate. Geotechnical considerations include the following:

- The on-site surface soils are considered to be rippable to relatively shallow depth with heavy-duty excavation equipment in good working condition. However, cemented alluvial material; gravel, cobbles and/or boulders; and/or bedrock were also encountered in our borings. These layers will be more difficult to excavate and/or will slow the rate of excavation, and will necessitate more aggressive excavation techniques.

- Areas of loose, cohesionless, granular, soils exists onsite. These soils could have a potential for caving and sloughing during excavation, especially if the soils are wet or saturated.

- Due to the heterogeneity of the site soil conditions, sloughing of soils during construction may occur where the alignment crosses existing or relict natural drainages. In addition, fill soils from adjacent utilities may be subject to sloughing due to the new excavations and under the influence of vibration from traffic.

- The pipeline trench may capture surface or subsurface flows because the bedding material may be more pervious than the adjacent native soils. Accordingly, we recommend that trench backfill be well-compacted to discourage the movement of water into and through the trench.

- Pipes and connections should be designed with sufficient flexibility to avoid damage at connections due to settlement of backfill.

- We estimate an earthwork (shrinkage) factor of approximately 10 to 20 percent if the on-site soils are re-used as fill.

- Imported soils and soils generated from on-site excavation activities that exhibit a very low-to low expansion potential can generally be used as engineered fill, provided any oversized materials are either broken down or wasted. Some of the on-site soils observed may meet this criterion.

- Groundwater was not observed in our borings, and depth to groundwater in the area is estimated at 260 feet bgs. Depending on the construction schedule and season(s) in which construction takes place, groundwater or surface flows may need to be mitigated during construction.

- The subgrade soils at the site are considered to be corrosive to ferrous metals and the sulfate content of the soils presents a negligible sulfate exposure to concrete. Corrosion protection should be provided as appropriate.
- Earth fissures are not underlying the project alignment; however, a documented earth fissure is located approximately 15 miles southeast of the project alignment.

10 RECOMMENDATIONS

The following sections present our geotechnical recommendations for the proposed construction. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

10.1 Instrumentation and Documentation

Given the proximity of the planned excavations to existing settlement sensitive features, consideration should be given to implementing documentation and/or instrumentation programs to evaluate design assumptions, existing conditions, and to monitor movements, levels, and deformations of these settlement sensitive features prior to and during construction. The monitoring programs may include the use of inclinometers, convergence points, and/or an array of surface control points. The resulting data should be reviewed and evaluated during construction. These programs should be in-place or conducted prior to the start of construction.

10.1.1 Documentation of Existing Conditions

We recommend that a pre-construction survey be performed prior to construction on/near pavements, residences, and structures within 50 feet of the proposed trench excavations. The pre-construction survey should consist of photographic documentation of the pavement condition, exterior portions of the buildings, including distress features, such as cracks and/or separations that may be present. Consideration may be given to videotaping the survey. In addition, interviews with owners should be conducted to provide knowledge of the age and type of the buildings as well as maintenance history and utility problems.

10.1.2 Lateral Movement Monitoring

We recommend that inclinometers and/or survey points be established behind excavations located in areas where settlement sensitive features are located above a 1:1 (horizontal to vertical [H:V]) plane projected from the bottom of the proposed excavations. The inclinometers or survey points should be monitored and evaluated daily during excavation activities to provide an advanced warning system of potential problems.

10.1.3 Ground Surface Settlement

An array of ground survey points should be installed along the pipeline alignment where trenchless techniques will be used to monitor settlement. The survey points should be installed as close as practical to the pipeline alignment and incrementally away from the alignment. The contractor should be responsible for maintaining the total settlement to less than ½-inch. If settlements reach ¼-inch, we recommend that a review of the contractor's methods be performed and appropriate changes be made, if needed.

Consideration should be given to placing survey monitoring points on nearby settlement sensitive features to monitor the performance of the structures. In this way, a record of the performance of the structures will be maintained and available. This information, in conjunction with pre-construction surveys, may help in reducing potential claims and expediting and limiting settlement of legitimate claims.

10.2 Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the Maricopa Association of Governments (MAG), *Uniform Standard Specifications and Details for Public Works Construction*, and/or any City of Phoenix amendments, are expected to apply, except as noted.

10.2.1 Excavation Characteristics

Our evaluation of the excavation characteristics of the on-site materials is based on the results of 24 exploratory borings, our site observations, and our experience on similar projects. In our opinion, excavation of the surficial on-site materials can generally be accomplished with heavy-duty earthmoving equipment in good operating condition. However, cemented alluvial material; gravel, cobbles and/or boulders; or bedrock were also encountered in our borings. These layers will be more difficult to excavate and/or will slow the rate of excavation, and will necessitate the use of more aggressive excavation techniques. These more aggressive excavation techniques may include the use of rock-saws, hoe-rams and/or blasting.

Due to the heterogeneous nature of the site, and the wide spacing between our borings, soils different than encountered in our borings should be anticipated during construction.

10.2.2 Temporary Slope Stability

The sides of the excavation and trenches that will tie into the pipe at the pit locations, if any, should be stabilized in order to minimize damage to adjacent structures resulting from vertical or lateral movement of the soil. The sides of the trenches may be stabilized by sloping back the sides and/or by using bracing. However, the trench sidewalls may be difficult to stabilize in areas where loose, low cohesion, granular soils exist onsite. These soils could have a potential for caving and sloughing during excavation, especially if the soils are wet or saturated. Additionally, vibrations caused by nearby traffic or construction equipment could accelerate sloughing. The excavations for the jacking and receiving pits are anticipated to be less than 15 feet deep. Excavations that are 20 feet deep or less could be constructed using a sloped excavation in accordance with Occupational Safety and Health Administration ([OSHA], 2011) Standards, based on the soil types encountered.

Soils of low cohesion were encountered during our field exploration. Due to the presence of these soils, we recommend that the OSHA soil "*Type C*" be used for the fill and alluvial soils along the alignment. Based on OSHA standards, this corresponds to a temporary side slope of 1.5:1 (horizontal to vertical), or flatter, in sloped excavations that are less than 20 feet.

Temporary excavations that encounter surface or groundwater seepage may need shoring and/or stabilization by placing sandbags or gravel along the base of the seepage zone. Excavations encountering seepage should be evaluated on a case-by-case basis. Slope stability for trenches deeper than 20 feet, though not anticipated, should be designed by the contractor's engineer based on alignment-specific soil properties and settlement-sensitive features.

10.2.3 Temporary Shoring and Pits

Due to the close proximity of the adjacent roadway and underground utilities, and because of the proposed configurations of the planned excavations, we understand that a temporary earth retention system may be utilized for this project. Temporary earth retention systems may include braced systems, such as trench boxes or shields with internal supports or cantilever systems (e.g., soldier piles and lagging); however, the risk of excessive lateral deflection may render a cantilevered shoring system inappropriate for the project.

Shored or braced trench and pit excavations in alluvial soils may be designed using the parameters on Figure 3, depending on the soil conditions. The recommended design earth pressures are based on the assumptions that the shoring system will be constructed without raising the ground surface elevation behind the shoring system, that there are no stockpiles of soil and/or construction materials, or other loads that act above a 1:1 (horizontal to vertical) plane extending up and back from the dredge line. For earth retention systems subjected to the above-mentioned surcharge loads, the contractor should include the effect of these loads on the design lateral earth pressures. In addition, due to the presence of low cohesion soils encountered in some of our borings, the excavations may not stand open long enough to install the trench boxes. The contractor should be prepared to deal with these soil conditions and plan accordingly. Once installed, some sloughing is possible at the ends of the trench box; therefore, any loose material should be removed prior to backfilling of the trench. We recommend that an experienced structural engineer design the shoring system. The shoring parameters presented in this report should be considered as guidelines.

We anticipate that settlement of the ground surface will occur behind shoring systems during excavation. The amount of settlement will depend on the type of shoring system used, the contractor’s workmanship, and soil conditions. We recommend that roadways, utilities, and other structures in the vicinity of the planned excavation be evaluated with regard to foundation support and tolerance to settlement. To reduce the potential for distress to these structures, we recommend that the shoring system be designed to limit the ground settlement behind it to ½-inch or less. Possible causes of settlement that should be addressed include settlement during excavation, construction vibrations, de-watering (if needed), and removal of the shoring system. We recommend that shoring installation be evaluated carefully by the contractor prior to construction and that ground vibration and settlement monitoring be performed during construction.

The contractor should retain a qualified and experienced engineer to design the shoring system. The contractor should evaluate the adequacy of the shoring parameters presented in this report, and make the appropriate modifications for their design. We recommend that the contractor take appropriate measures to protect the workers. OSHA requirements pertaining to workers’ safety should be observed.

10.2.4 Bottom Stability

The proposed excavations are not anticipated to encounter significant groundwater (with the possible exception of surface run-off or perched zones) during construction. Therefore, trench bottom stability problems during construction are generally not anticipated at this site. However, if excavations are located near drainage ditches, or near a known wash, arroyo, or drainage area that is open during a heavy rain event, or near any leaking utilities, the trench material(s) might become saturated and unstable and a dewatering system may be needed for these conditions. Should this occur, further remedial measures may be needed.

10.2.5 Construction Dewatering

Stream flow, surface run-off, and perched groundwater will vary seasonally depending on rainfall in the site vicinity. Excavations that do encounter surface run-off (if any) could be dewatered by pumping the water out from the bottom and away from the excavation. However, heavily saturated units or perched groundwater zones, if encountered, may call for more aggressive means of dewatering and consultation with a qualified expert. Discharge of water from the excavations to natural drainage channels may entail securing a special permit.

10.2.6 Grading, Fill Placement, and Compaction

The geotechnical consultant should carefully evaluate any areas of soft or wet soils prior to placement of grade-raise fill or other construction. Drying or overexcavation of some materials may be appropriate.

On-site and imported soils (if needed) that exhibit relatively low plasticity indices and very low to low expansive potential are generally suitable for re-use as engineered fill. Relatively low plasticity indices are defined as a plasticity index ([PI] ASTM D4318) value of 15 or less. Very low to low expansive potential soils are defined as having an expansion index (per ASTM D4829) of 50 or less. The Atterberg limits tests performed on selected samples indicated that the samples tested ranged in PI values from 4 to 30. As such, it is our opinion that some of the on-site soils can be re-used as engineered fill during construction. However, please note that some oversized material was encountered in our borings. Additional field sampling and laboratory testing should be conducted by the contractor prior to construction to better evaluate the suitability of on-site soils for re-use as engineered fill.

Suitable fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 6 inches in dimension. Unsuitable fill material should be disposed of off-site or in non-structural areas.

Following the excavation of the trench and prior to the placement of any new fill, the resulting exposed surface should be carefully evaluated by the geotechnical consultant for the presence of soft, loose or wet native soils. Based on this evaluation, remediation may be needed. This remediation, if needed, should be addressed by the geotechnical consultant during the earthwork operations. An earthwork (shrinkage) factor of 10 to 20 percent for the on-site soils is estimated.

We recommend that the pipeline be supported on 6 inches, or more, (or 1/12 of the outside diameter of the pipe, whichever is more) of granular material that has particle sizes no more than 1-1/2 inches in diameter, and has 3 to 15 percent passing the No. 200 sieve. This bedding/pipe-zone backfill should extend 1 foot above the pipe crown. Care should be taken not to allow voids to form beneath the pipe (i.e., the pipe haunches should be supported) to avoid damaging the pipeline. This may involve fill placement by hand or small compaction equipment. The bedding/pipe zone should be placed in horizontal lifts no more than approximately 8 inches in loose thickness and compacted by appropriate mechanical methods, to a relative compaction of 95 percent (as evaluated by ASTM D698) and at a moisture content slightly above laboratory optimum. Pipe Bedding Guidelines are presented on Figure 4.

Trench and pit backfill zone, as discussed in this report, refers to the zone above the pipe zone/bedding backfill material in the trench. Backfill material in this zone should be moisture-conditioned to within 2 percent of its laboratory optimum and mechanically compacted to a relative compaction of 95 percent as evaluated by ASTM D698. Lift thickness for backfill will be dependent upon the type of compaction equipment utilized, but should generally be placed in lifts not exceeding 8 inches in loose thickness. Due to the clayey nature of the some of the site-soils, compaction may be difficult to achieve in some areas. Special care should be exercised to avoid damaging the pipe or other structures during the compaction of the backfill. Compaction should be accomplished in a manner that discourages surface water infiltration, as well as conveyance of subsurface moisture due to the intersection of natural drainages along the alignment.

The upper 2-foot zone, located below existing or proposed pavement/flatwork sections, should also be moisture-conditioned to slightly above its laboratory optimum; however, in this zone the material should be mechanically compacted to a relative compaction of 100 percent, for granular backfill, as evaluated by ASTM D698.

Backfilling should be accomplished by mechanical methods; compaction by flooding or jetting should not be permitted. In addition, particle sizes should not exceed 4 inches in diameter. Generated excavation materials that contain this oversize fraction shall not be used as backfill unless the material meets the criteria given above and/or the oversize fraction has been processed and removed from the material. Imported backfill material, if utilized, should meet the criteria for imported fill.

10.3 Trenchless Installation

As indicated earlier, trenchless technologies may be used to cross under the existing roadways. Based on the information from our borings, trenchless techniques may be appropriate. However, the presence of coarse gravel was observed near the pipe elevation in borings drilled for this project and could slow the rate of construction.

Following the installation of the utility inside the carrier casing, the annulus should be in-filled with fine gravel or sand that is blown in with air. A portion of the gravel or sand could be blown in first (so as to fill under the haunches of the utility) and minimize the potential for future movement of the pipe from uplift.

We understand that the excavations for the jacking and receiving pits will extend to 15 feet or less below the existing grade. Soils that are anticipated at, and below the pipe elevation consist predominantly of clayey or silty sands with gravel or silty gravel. Based upon the spacing of our borings, and the relative size of our samples compared to the planned excavations, variations from the boring logs should be anticipated.

We recommend that the contractor be responsible for the design of shaft shapes, dimensions and ground support systems for the jacking and receiving pit excavations so that such design can be compatible with his construction equipment and methods. Soldier piles with lagging or shored excavations may serve as a suitable system for rectangular shafts indicated on the plans. Driven sheeting may be difficult to install because of hard ground conditions and the possibility of encountering buried coarse gravel. In addition, driven sheeting may cause real and perceived damage by vibrations to nearby structures.

Jacking reaction force is developed by the action of the trenchless operation against the surface of the opposite wall of the jacking pit. The ultimate jacking force may be calculated using the lateral earth pressures presented on Figure 5. A factor of safety of 1.5 to 2.0 should be used to calculate allowable jacking resistance.

The contractor should implement a monitoring program during the jacking and boring operations to observe any ground movement above and adjacent to the pipe being installed. If signs of land subsidence or disturbance are noted, construction operations should be stopped to address the ground movement. The integrity of nearby utilities, and roadways will need to be protected during these operations.

Caving of the pipe shaft may occur, particularly where relatively loose surface soils are present. For stability and safety purposes, and to reduce ground movement, a perimeter shaft support system should be installed as the excavation progresses. Surface subsidence associated with these operations was not evaluated as part of our analysis.

10.4 Pipe Thrust Block Design

Figure 6 presents ultimate lateral earth pressures recommended for the design of thrust blocks to resist lateral forces on the pipes. A factor of safety of 1.5 to 2.0 should be used to calculate the allowable thrust block resistance.

10.5 Imported Fill Material

Imported fill, if utilized, should consist of granular material with a very low or low expansion potential as discussed in this report. Import material in contact with ferrous metals should preferably have low corrosion potential (minimum electrical resistivity more than 2,000 ohm-cm, chloride content less than 25 parts per million [ppm]). In lieu of this, corrosion protection techniques (e.g., cathodic protection, pipe wrapping, etc.), can be implemented. Imported material in contact with concrete should have a soluble sulfate content of less than 0.1 percent. The geotechnical consultant should evaluate such materials and details of their placement prior to importation. A corrosion specialist should be consulted for recommendations.

10.6 Modulus of Soil Reaction (E')

The modulus of soil reaction (E´) is used to characterize the stiffness of soil backfill placed on the sides of buried pipelines for the purpose of evaluating deflection caused by the weight of the backfill over the pipe. We anticipate that the invert depth of the waterline will generally be less than 20 feet bgs. For granular backfill bedding soils for pipes, we recommend using an E´ value of 1,500 pounds per square inch (psi).

10.7 Controlled Low Strength Material (CLSM)

It is our opinion that the backfill zone may be filled with either CLSM or acceptable on-site soils. CLSM consists of a fluid, workable mixture of aggregate, Portland cement, and water. The use of CLSM has some advantages:

- A narrower backfill zone can be used, thereby minimizing the quantity of soil to be excavated and possibly reducing disturbance to the near-by traffic.
- Relatively higher E' values may be used (E'= 3,000 psi).

- The support given to the connecting pipes is generally better.
- Because little compaction is needed to place CLSM, there is less risk of damaging the connecting pipes.
- CLSM can be batched to flow into irregularities in the trench bottom and walls.

The CLSM design mix should be in accordance with the MAG (2015) or Standard Specifications for Public Works Construction (Public Works Standard, Inc.). Additional mix design information can be provided upon request.

Buoyant or uplift forces on the piping should be considered when using CLSM and prudent construction techniques may result in multiple pours to avoid inducing excessive uplift forces. Sufficient time should be provided to allow the CLSM to cure before placing additional lifts of CLSM or trench backfill.

10.8 T-Top Pavement Replacement

In asphalt concrete (AC) paved areas over trench excavations, we recommend the use of MAG "T-Top" Type Trench Backfill (MAG detail 200-1) with respect to the asphalt and aggregate replacement at the surface of the trench excavations, in order to reduce the potential for distress due to differential settlement and water infiltration into the subsurface. This includes the removal of asphalt and aggregate base (AB) to 1 foot or more beyond the extent of each side of the installation trench, extending to 1 foot or more below the bottom of the asphalt layer. In the T-Top, the thickness of AB should be 12 inches or match either existing or design thickness, whichever is deeper. We recommend a seal be placed at the cold joint between the patch and the existing AC. Periodic maintenance of the pavement should be performed. The AC thickness should be in accordance with any City of Phoenix design requirements, or match the existing thickness, whichever is thicker.

10.9 Seismic Design Considerations

Design of the proposed improvements should be performed in accordance with the requirements of the governing jurisdictions and applicable building codes. Table 3 presents the seismic design parameters for the site in accordance with the 2012 International Building Code (IBC) guidelines and adjusted maximum considered earthquake spectral response acceleration parameters evaluated using the USGS, 2016 ground motion calculator (web-based):

Table 3 – 2012 IBC Seismic Design Criteria

Site Coefficients and Spectral Response Acceleration Parameters	Values
Class	D
Coefficient, F_a	1.6
Coefficient, F_v	2.4
Mapped Spectral Response Acceleration at 0.2-second Period, S_s	0.221 g
Mapped Spectral Response Acceleration at 1.0-second Period, S_1	0.068 g
Spectral Response Acceleration at 0.2-second Period Adjusted for Site Class, S_{MS}	0.353 g
Spectral Response Acceleration at 1.0-second Period Adjusted for Site Class, S_{M1}	0.163 g
Design Spectral Response Acceleration at 0.2-second Period, S_{DS}	0.236 g
Design Spectral Response Acceleration at 1.0-second Period, S_{D1}	0.108 g

10.10 Corrosion

The corrosion potential of the on-site materials was analyzed to evaluate its potential effect on the ferrous metals used for this project. Corrosion potential was evaluated using the results of laboratory testing on a sample obtained during our subsurface evaluation that was considered representative of soils along the project alignment.

Laboratory testing consisted of pH, minimum electrical resistivity, chloride and soluble sulfate contents, and redox and sulfide. The pH and minimum electrical resistivity tests were performed in general accordance with Arizona Test 236b, sulfate and chloride content tests were performed in accordance with Arizona Test Method 733 and 736, while redox and sulfide content tests were performed in accordance with ASTM G200-09 and HACH 8131 method, respectively. The results of the corrosivity tests are presented in Appendix B.

The soil pH values of the tested samples ranged from 7.9 to 8.4, which are considered to be alkaline. The minimum electrical resistivity ranged from 1,300 to 2,841 ohm-cm, which is considered to be corrosive to ferrous materials. The chloride content ranged from 10 to 47 ppm, which is also considered to be corrosive to ferrous metals. The soluble sulfate content of the soil samples ranged from 0.001 to 0.010 percent by weight, which is considered to represent negligible sulfate exposure for concrete.

The results of the laboratory testing indicate that the on-site materials are generally considered to be corrosive to ferrous metals; however, present a negligible sulfate exposure for concrete. Therefore, special consideration should be given to the use of heavy-gauge, corrosion-protected, underground steel pipe. As an alternative, plastic pipe or reinforced concrete pipe could be considered. We recommend that topsoil, organic soils, and mixtures of sand and clay not be placed adjacent to buried metallic utilities. Rather, we suggest a relatively clean sand and/or gravel, or CLSM, be placed around buried metal piping. Also, buried utilities of different metallic construction should be electrically isolated from each other to minimize galvanic corrosion problems. In addition, new piping should be electrically isolated from old piping so that the old metal will not increase the corrosion rate of the new metal. A corrosion specialist should be consulted for further recommendations.

10.11 Concrete

Laboratory chemical tests performed on selected samples of on-site soils indicated sulfate contents ranging from 0.001 to 0.010 percent by weight. Based on the following American Concrete Institute (ACI) table, the on-site soils should be considered to have a negligible sulfate exposure to concrete:

Table 4 – ACI Requirements for Concrete Exposed to Sulfate-Containing Soil

Sulfate Exposure	Water-Soluble Sulfate (SO_4) in Soil, Percentage by Weight	Cement Type	Water-Cementitious Materials Ratio, by Weight, Normal-Weight Aggregate Concrete[1]	*f'*$_c$, Normal-Weight and Lightweight Aggregate Concrete, psi
				x 0.00689 for MPa
Negligible	0.00 - 0.10	--	--	--
Moderate[2]	0.10 - 0.20	II, IP(MS), IS (MS)	0.50 or less	4,000 or more
Severe	0.20 - 2.00	V	0.45 or less	4,500 or more
Very severe	Over 2.00	V plus pozzolan[3]	0.45 or less	4,500 or more

Notes:

[1] A lower water-cementitious materials ratio or higher strength may be needed for low permeability or for protection against corrosion of embedded items or freezing and thawing (ACI Table 4.2.2).

[2] Seawater.

[3] Pozzolan that has been evaluated by test or service record to improve sulfate resistance when used in concrete containing Type V cement.

Notwithstanding the sulfate test results and due to the limited number of chemical tests performed, as well as our experience with similar soil conditions, we recommend the use of Type II cement for construction of concrete structures at this site. The concrete should have a water-cementitious materials ratio no more than 0.50 percent by weight for normal weight aggregate concrete. The structural engineer should ultimately select the concrete design strength based on the project specific loading conditions. Higher strength concrete may be selected for increased durability and resistance to shrinkage cracking.

10.12 Site Drainage

Positive surface drainage should be provided to divert water away from the trench zone and pavements. Surface water should not be permitted to pond over the trench zone or on pavement surfaces after construction. Water that is pumped out of the trench should be done so in an area that drains the water away from the trench.

10.13 Pre-Construction Conference

We recommend that a pre-construction conference be held. Representatives of the owner, civil engineer, the geotechnical consultant, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect, or if the project characteristics are significantly changed.

10.14 Construction Observation and Testing

During construction operations, we recommend that a qualified geotechnical consultant perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, to evaluate the suitability of proposed borrow materials for use as fill and to observe and test placement of compacted fill soils. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and that they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed foundations.

11 LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties’ sole risk.

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Aerial Photographs Reviewed

Source	Date(s)
Flood Control District of Maricopa County	1953, 1976, 1986, 1993 and 2013

FIGURES

Source: NAVTEQ, 03/15/15.

Note: Dimensions, directions and locations are approximate.

FIGURE 1

SITE LOCATION

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

604929001 | 10/17

bsm file no: 4929vmap1017

Source: NAVTEQ, 12/29/15.

Note: Dimensions, directions and locations are approximate.

FIGURE 2A

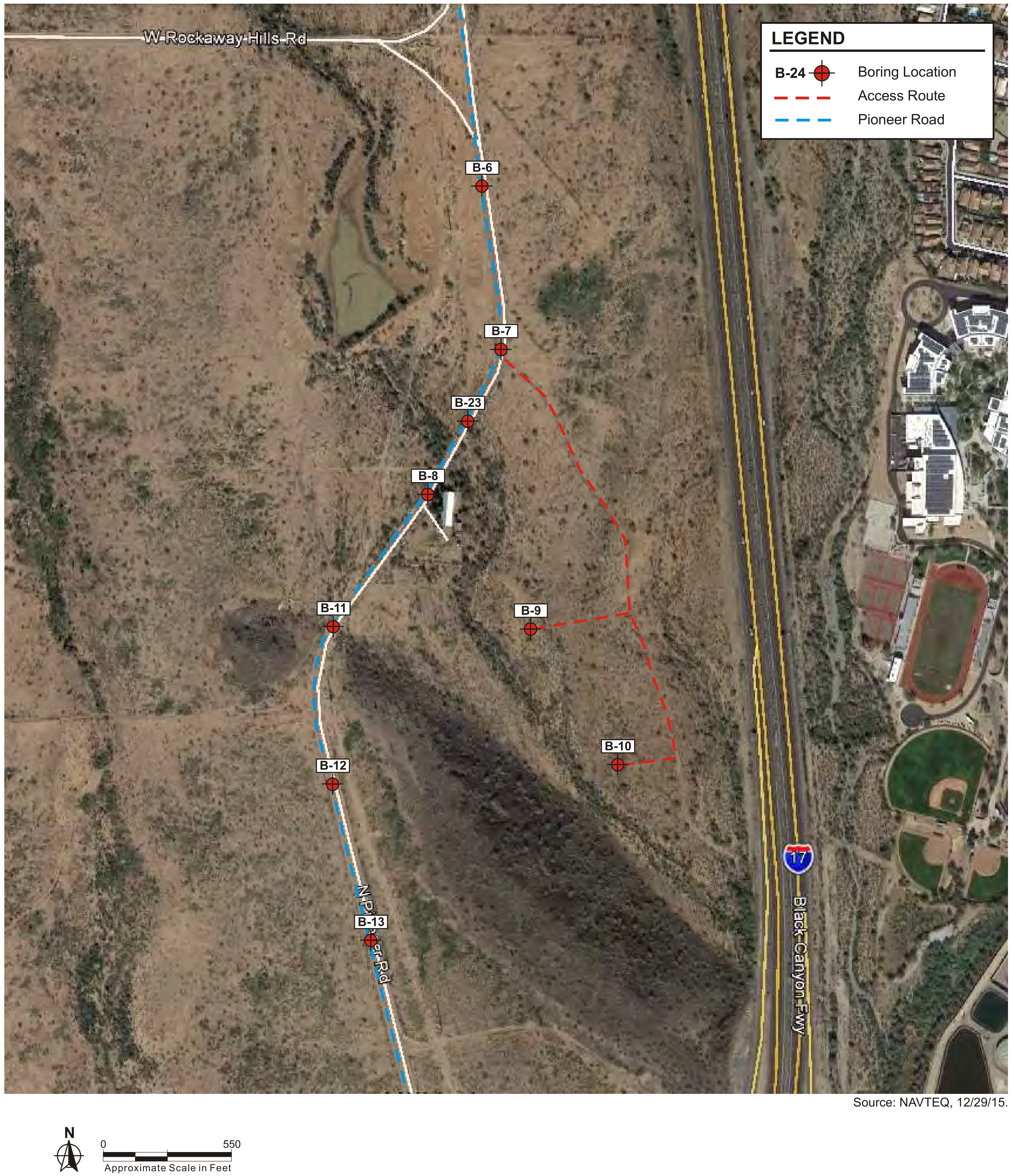
BORING LOCATIONS

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

604929001 | 10/17

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

bsm file no: 4929blm1017a



Source: NAVTEQ, 12/29/15.

Note: Dimensions, directions and locations are approximate.

FIGURE 2B

SITE LOCATIONS

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

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604929001 | 10/17

bsm file no: 4929blm1017b

Source: NAVTEQ, 12/29/15.

Note: Dimensions, directions and locations are approximate.

FIGURE 2C

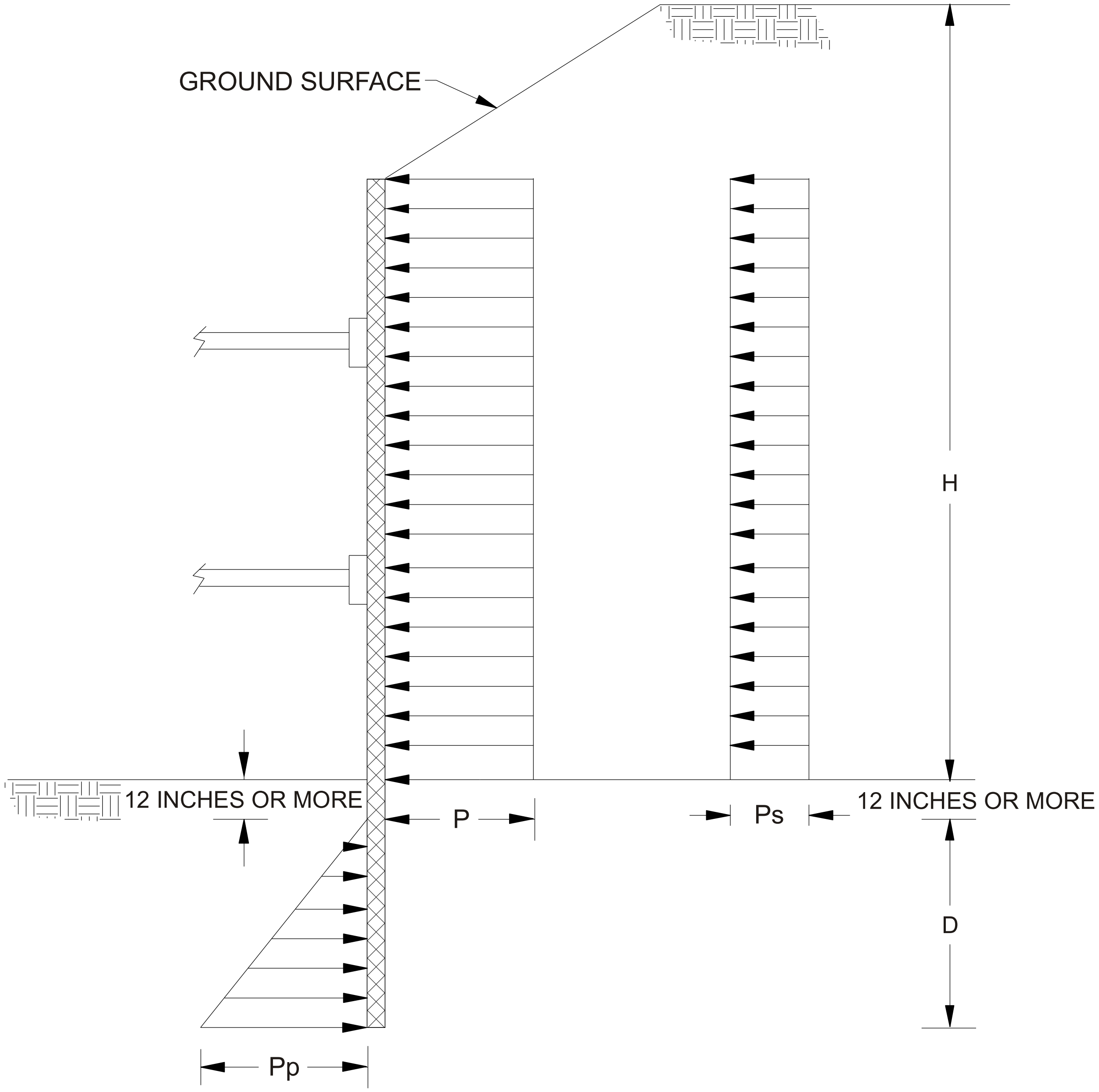
BORING LOCATIONS

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

604929001 | 10/17

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

bsm file no: 4929blm1017c



LATERAL EARTH PARAMETER	
APPARENT LATERAL EARTH PRESSURE, P	30H psf
CONSTRUCTION TRAFFIC INDUCED SURCHARGE PRESSURE, Ps	120 psf
PASSIVE LATERAL EARTH PRESSURE, Pp	340D psf

1. ASSUMES GROUNDWATER NOT PRESENT
2. SURCHARGES FROM EXCAVATED SOIL OR CONSTRUCTION MATERIALS ARE NOT INCLUDED
3. H AND D ARE IN FEET

NOT TO SCALE

FIGURE 3

LATERAL EARTH PRESSURES FOR BRACED EXCAVATION

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

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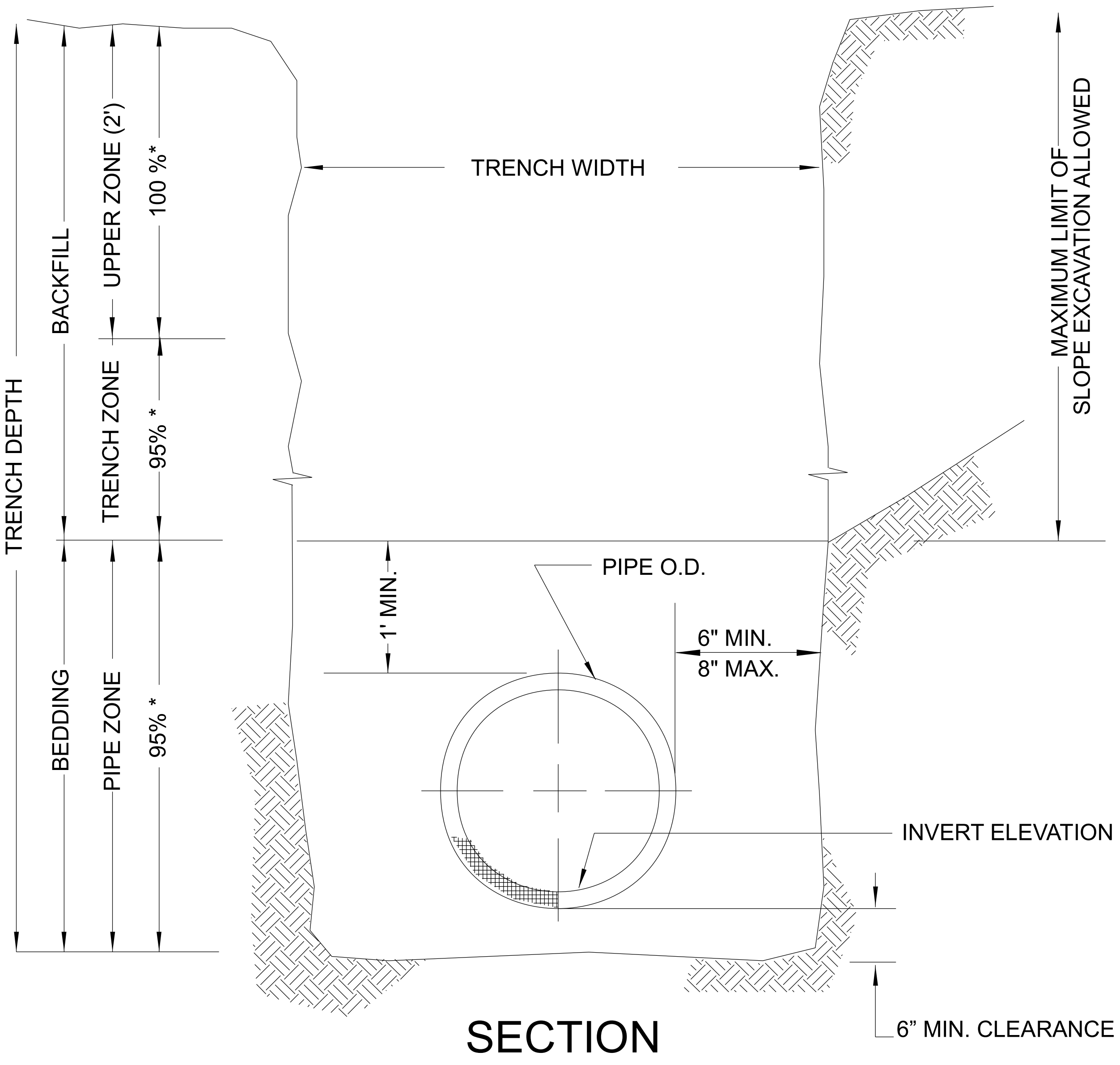

NOTE

* Indicates minimum relative compaction (see report for details).

Upper zone required for pavement areas only.

Diagram not drawn to scale.

NOT TO SCALE

FIGURE 4

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

PIPE BEDDING GUIDELINES

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

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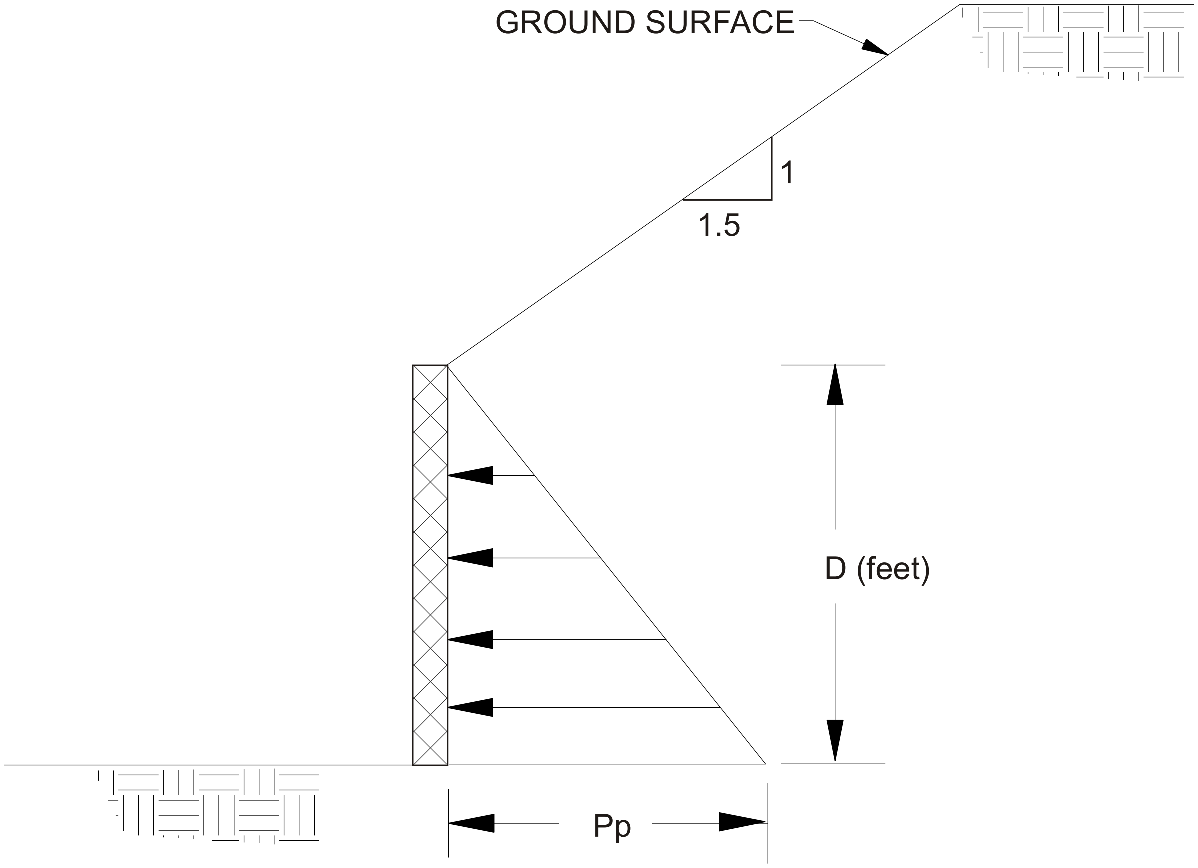
bsm file no: 4929pbg1017



ASSUMPTIONS AND NOTES:
1. NO GROUNDWATER
2. JACKING PIT GEOMETRY ASSUMED
3. Pp = 680 psf

NOT TO SCALE

FIGURE 5

JACKING PIT ULTIMATE PASSIVE JACKING RESISTANCE PRESSURES

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

604929001 | 10/17

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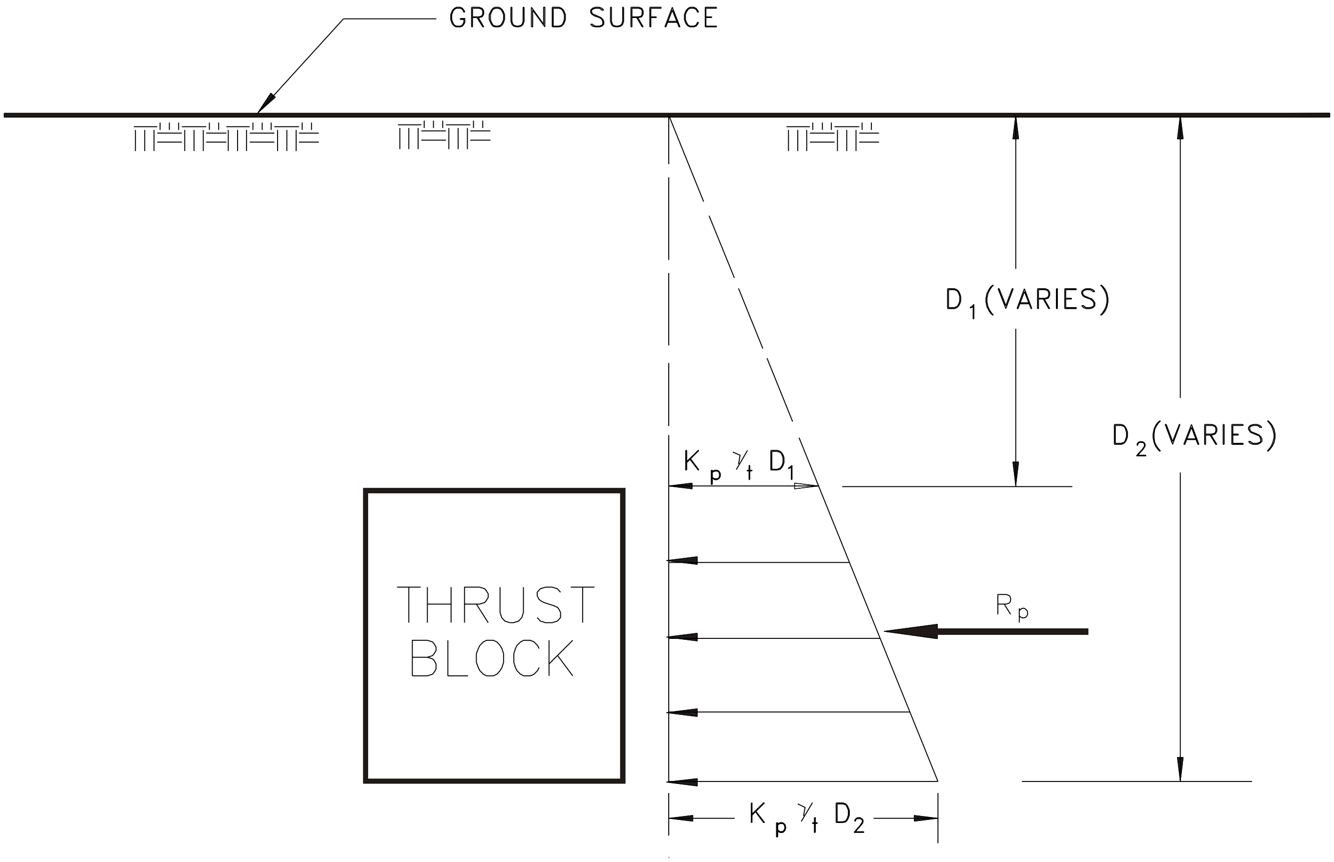
Geotechnical & Environmental Sciences Consultants



ASSUMPTIONS AND NOTES

1. $\Phi = 30^{\circ}$
2. $K_p = 3.0$
3. γ_t = 113 pcf
4. No groundwater
5. $R_p = (1/2)K_p \gamma_t (D_2^2 - D_1^2)$
   $R_p = 170\ (D_2^2 - D_1^2)$ plf

NOT TO SCALE

FIGURE 6

THRUST BLOCK LATERAL EARTH PRESSURE FOR PERMANENT PIPE INSTALLATION

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

604929001 | 10/17

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

bsm file no: 4929thr1017

APPENDIX A

Boring Logs

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples

Disturbed soil samples were obtained in the field using the following methods.

Bulk Samples

Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

The Standard Penetration Test Spoon

Disturbed drive samples of earth materials were obtained by means of a Standard Penetration Test spoon sampler. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 1-3/8 inches. The spoon was driven up to 18 inches into the ground with a 140-pound hammer free-falling from a height of 30 inches in general accordance with ASTM D1586. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the logs are those for the last 12 inches of penetration. Soil samples were observed and removed from the spoon, bagged, sealed, and transported to the laboratory for testing.

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following method.

The Modified Split-Barrel Drive Sampler

The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with a 140-pound hammer free-falling from a height of 30 inches in general accordance with ASTM D1586. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

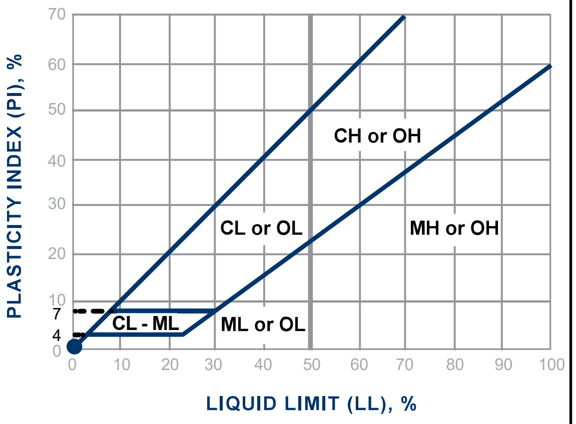
Soil Classification Chart Per ASTM D 2488

Primary Divisions			Secondary Divisions	
			Group Symbol	Group Name
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

Grain Size

Description		Sieve Size	Grain Size	Approximate Size
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

Plasticity Chart



Apparent Density - Coarse-Grained Soil

Apparent Density	Spooling Cable or Cathead		Automatic Trip Hammer	
	SPT (blows/foot)	Modified Split Barrel (blows/foot)	SPT (blows/foot)	Modified Split Barrel (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

Consistency - Fine-Grained Soil

Consistency	Spooling Cable or Cathead		Automatic Trip Hammer	
	SPT (blows/foot)	Modified Split Barrel (blows/foot)	SPT (blows/foot)	Modified Split Barrel (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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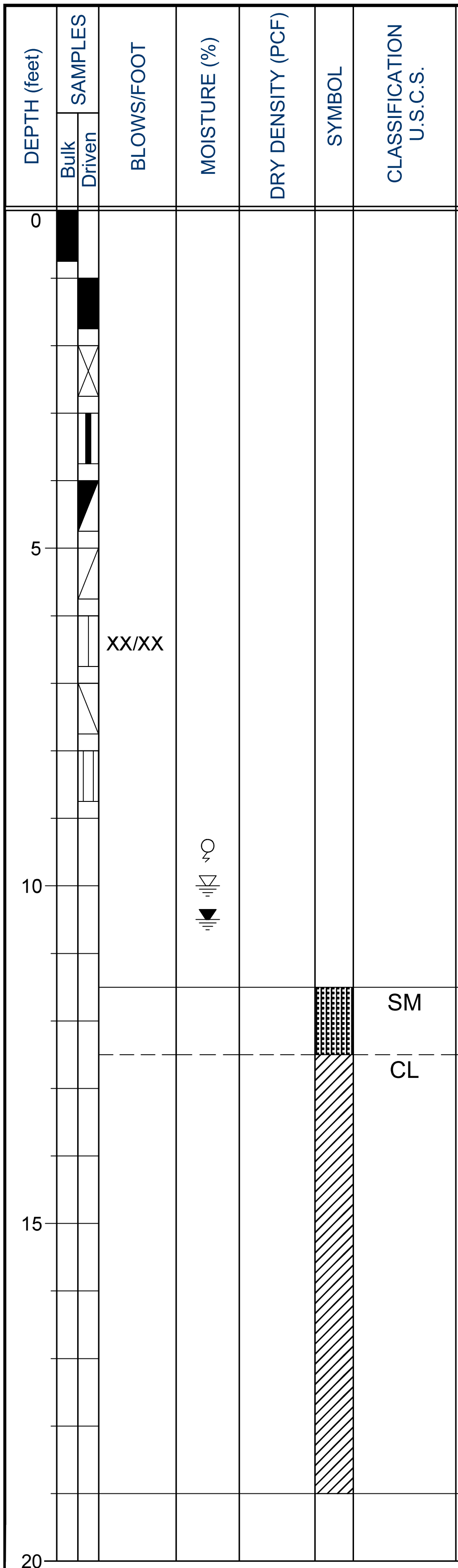
USCS METHOD OF SOIL CLASSIFICATION



BORING LOG EXPLANATION SHEET

Bulk sample.

Modified split-barrel drive sampler.

No recovery with modified split-barrel drive sampler.

Sample retained by others.

Standard Penetration Test (SPT).

No recovery with a SPT.

Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.

No recovery with Shelby tube sampler.

Continuous Push Sample.

Seepage.
Groundwater encountered during drilling.
Groundwater measured after drilling.

MAJOR MATERIAL TYPE (SOIL):
Solid line denotes unit change.
Dashed line denotes material change.

Attitudes: Strike/Dip
b: Bedding
c: Contact
j: Joint
f: Fracture
F: Fault
cs: Clay Seam
s: Shear
bss: Basal Slide Surface
sf: Shear Fracture
sz: Shear Zone
sbs: Shear Bedding Surface

The total depth line is a solid line that is drawn at the bottom of the boring.

DATE DRILLED 6/05/17 BORING NO. B-1

GROUND ELEVATION 1,847' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	SC	ALLUVIUM: Brown, dry, very dense, clayey SAND with gravel.
	■	■	50/3"	4.9	89.5	▨		
	■	■	50/4"			▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 3.3 feet (Refusal). Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 1

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA
604929001 | 10/17

DATE DRILLED 6/05/17 BORING NO. B-2

GROUND ELEVATION 1,839' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■						SC	<u>ALLUVIUM</u>: Brown, dry, very dense, clayey SAND.
	■	■	50/5"				GC	Brown, dry, very dense, clayey GRAVEL with sand; numerous caliche nodules.
		☒	50/2"					3.5 ft; no recovery; coarse gravel; cobbles.
5								Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 5.8 feet (Refusal). Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling.
								<u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
10								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 2

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA
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DATE DRILLED 6/05/17 BORING NO. B-3

GROUND ELEVATION 1,833' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GC	<u>ALLUVIUM</u>: Brown, dry, very dense, clayey GRAVEL with sand; numerous caliche nodules; moderately to strongly cemented.
			50/3"	4.0	97.9			
			60					
5								
		☒	50/5"					No recovery; refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 6.4 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling.
								<u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
10								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 3

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/05/17 BORING NO. B-4

GROUND ELEVATION 1,825' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	ALLUVIUM: Brown, dry, very dense, silty SAND; few gravel; numerous caliche nodules weakly to moderately cemented.
			75					
			60	8.4	91.5			
5								
			50/2"				GC	Brown, dry, very dense, clayey GRAVEL with sand; numerous caliche nodules; moderately cemented. Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 6.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling.
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Notes:

Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

FIGURE A- 4

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/05/17 BORING NO. B-5

GROUND ELEVATION 1,818' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GC	ALLUVIUM: Brown, dry, very dense, clayey GRAVEL with sand; numerous caliche nodules; moderately cemented.
			50/4"	6.3	90.2			
			50/5"					
5								Refusal on gravel; cobbles and/or boulders or bedrock or bedrock.
								Total Depth = 5.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 5

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/05/17 BORING NO. B-6

GROUND ELEVATION 1,809' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	GC	ALLUVIUM: Brown, dry, very dense, clayey GRAVEL with sand; few cobbles.
	■	▶	50/2"			▨		
	■					▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 2 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling.
								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
5								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 6

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

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DATE DRILLED 6/05/17 BORING NO. B-7

GROUND ELEVATION 1,801' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	SC	ALLUVIUM: Brown, dry, very dense, clayey SAND.
	■	■	50/3"	11.1	101.7	▨		
						▨	GC	Brown, dry, very dense, clayey GRAVEL with sand; numerous caliche nodules; moderately cemented.
		◣	50/3"			▨		
						▨		Refusal on gravel; cobbles and/or boulders or bedrock.
5								Total Depth = 5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 7

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA
604929001 | 10/17

DATE DRILLED 6/05/17 BORING NO. B-8

GROUND ELEVATION 1,787' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES		BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	Bulk	Driven						
0	■		50/0"				GP	ALLUVIUM: No spoon sample - due to coarse gravel; cobbles; possible boulders. Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 1.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 8

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA
604929001 | 10/17

DATE DRILLED 6/05/17 BORING NO. B-9

GROUND ELEVATION 1,779' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	GC	<u>ALLUVIUM</u>: No ring recovery; bagged shoed; clayey GRAVEL; cobbles; possible boulders.
	■	☒	50/4"			▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 2 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling. <u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 9

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/05/17 BORING NO. B-10

GROUND ELEVATION 1,773' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	GC	<u>ALLUVIUM</u>: Brown/gray, dry, very dense, clayey GRAVEL with sand.
	■	■	50/2"			▨		
	■					▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 2.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/05/17 shortly after completion of drilling. <u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 10

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WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/06/17 BORING NO. B-11

GROUND ELEVATION 1,791' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	SC	<u>ALLUVIUM</u>: Brown, dry, medium dense, clayey SAND; scattered caliche nodules; moderate cemented.
	■	■	36	11.2	103.0	▨		
	■	■	50/2"			▨		Very dense.
5	■		50/0"			▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 5.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. <u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 11

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

DATE DRILLED 6/06/17 BORING NO. B-12
GROUND ELEVATION 1,787' ± (MSL) SHEET 1 OF 1
METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)
DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"
SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	CL	ALLUVIUM: Brown, dry, hard, lean CLAY; scattered caliche nodules.
	■	■	25			▨		
	■					▨	CH	Brown, moist, hard, fat CLAY.
	■	■	39	9.1	112.5	▨		
5						▨		
		■	50/1			▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 7 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling.
10								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 6/06/17 BORING NO. B-13

GROUND ELEVATION 1,778' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						▨	SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; scattered caliche nodules.
			66	11.2	109.7	▨		
			22			▨		Trace fine to coarse gravel.
5						▨		
			50/0"			▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 6 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 13

DATE DRILLED 6/06/17 BORING NO. B-14

GROUND ELEVATION 1,768' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; scattered caliche nodules.
			45					
			50/5"	12.2	112.7			
							CH	Brown, dry, hard, fat CLAY.
5								
							SC	Brown, dry, very dense, clayey SAND; numerous caliche nodules; moderately to strongly cemented.
			74					
			50/3"					No ring recovery; bagged shoe; coarse gravel; possible cobbles. Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 9 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling.
10								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 6/06/17 BORING NO. B-15

GROUND ELEVATION 1,757' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	CL	ALLUVIUM: Brown, dry, hard, lean CLAY.
	■	■	50/5"	7.4	107.4	▨		
	■	■	80/7"			▩	SC	Brown, dry, very dense, clayey SAND; trace gravel; numerous caliche nodules; strongly cemented.
5						▩		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 5.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 6/06/17 BORING NO. B-16
GROUND ELEVATION 1,746' ± (MSL) SHEET 1 OF 1
METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)
DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"
SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; trace gravel; scattered caliche nodules.
			64/9"					
			50/3"	4.5	98.2			Numerous caliche nodules; few coarse gravel; cobbles.
								Refusal on gravel; cobbles and/or boulders or bedrock.
5								Total Depth = 5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 16

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DATE DRILLED 6/06/17 BORING NO. B-17

GROUND ELEVATION 1,730' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	SC	ALLUVIUM: Brown, dry, very dense, clayey SAND; few gravel; scattered caliche nodules.
	■	■	50/3"	3.0	118.2	▨		
		■	50/1"				GP	Brown/gray, dry, very dense, poorly graded GRAVEL with sand; trace clay; cobbles. Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 3.1 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 6/06/17 BORING NO. B-18

GROUND ELEVATION 1,725' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	GP-GC	<u>ALLUVIUM</u>: Brown, dry, hard, poorly graded GRAVEL with clay.
	■	■	31			▨		
	■					▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 3 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling.
5								<u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 18

DATE DRILLED 6/06/17 BORING NO. B-19

GROUND ELEVATION 1,724' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■					▨	GC	<u>ALLUVIUM</u>: Brown, dry, very dense, clayey GRAVEL with sand; cobbles; numerous caliche nodules.
	■	◣	50/5"			▨		
						▨		Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 2.5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling.
								<u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
5								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 19

DATE DRILLED 6/06/17 BORING NO. B-20

GROUND ELEVATION 1,718' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SC	<u>ALLUVIUM</u>: Brown, dry, very dense, clayey SAND; scattered caliche nodules.
			72	5.2	115.7			
			50/3"				GM	Dark brown, dry, very dense, silty GRAVEL with sand.
								Refusal on gravel; cobbles and/or boulders or bedrock.
5								Total Depth = 5 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. <u>Notes</u>: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 6/06/17 BORING NO. B-21

GROUND ELEVATION 1,713' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES		BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
	Bulk	Driven						
0	■		50/0"			▨	SC	ALLUVIUM: Brown, dry, very dense, clayey SAND with sand and gravel; cobbles; possible boulders. No recovery - due to coarse gravel; cobbles; possible boulders. Refusal on gravel; cobbles and/or boulders or bedrock.
								Total Depth = 2 feet. (Refusal) Groundwater not encountered during drilling. Backfilled on 6/06/17 shortly after completion of drilling. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 21

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DATE DRILLED 9/21/17 BORING NO. B-22
GROUND ELEVATION 1,835' ± (MSL) SHEET 1 OF 2
METHOD OF DRILLING CME-75, ODEX (D&S Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GC	ALLUVIUM: Light gray, dry, dense, clayey GRAVEL with sand; weakly to strongly cemented; numerous caliche nodules.
			50/4"					
			50/5"					
5								
			50/2"					No recovery; hard material.
			50/4"				GP	Light bluish gray, dry, very dense, poorly graded GRAVEL; weakly to strongly cemented; cobbles and boulders.
10								
			50/0"					No recovery.
15								
			50/1"					No recovery. Total Depth = 18.6 feet. Groundwater not encountered during drilling. Backfilled on 9/21/17 shortly after completion of drilling.
20								

DATE DRILLED 9/21/17 BORING NO. B-22

GROUND ELEVATION 1,835' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING CME-75, ODEX (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
20								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 9/21/17 BORING NO. B-23
GROUND ELEVATION 1,790' ± (MSL) SHEET 1 OF 2
METHOD OF DRILLING CME-75, ODEX (D&S Drilling)
DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"
SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GC	ALLUVIUM: Brown, dry, very dense, clayey GRAVEL with sand; weakly to strongly cemneted; scattered caliche nodules.
			50/2"					
			50/3"					
5								
			59					
		☒	50/3"					No recovery; coarse gravel; cobbles and boulders.
10								
			50/4"				GP	Brown, dry, very dense, poorly graded GRAVEL with sand; weakly to strongly cemneted.
15								
		☒	50/3"					No recovery; grab sample.
								Total Depth = 18.8 feet. Groundwater not encountered during drilling. Backfilled on 9/21/17 shortly after completion of drilling.
20								

FIGURE A- 23

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DATE DRILLED 9/21/17 BORING NO. B-23

GROUND ELEVATION 1,790' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING CME-75, ODEX (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
20								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 23

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DATE DRILLED 9/21/17 BORING NO. B-24

GROUND ELEVATION 1,720' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING CME-75, ODEX (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GC	ALLUVIUM: Brown, dry, very dense, clayey GRAVEL with sand.
			77/11"					
							SC	Brown, dry, very dense, clayey SAND; few gravel.
			51					
5								
			51					Dense.
			50/5"				GC	Brown, dry, very dense, clayey GRAVEL with sand; weakly to strongly cemented.
10								
			50/4"				GP	Brown, dry, very dense, poorly graded GRAVEL with sand; weakly to strongly cemented; trace clay.
15								
							SC	Brown, dry, very dense, clayey SAND.
			50/4"					
								Total Depth = 18.8 feet. Groundwater not encountered during drilling. Backfilled on 9/21/17 shortly after completion of drilling.
20								

DATE DRILLED 9/21/17 BORING NO. B-24

GROUND ELEVATION 1,720' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING CME-75, ODEX (D&S Drilling)

DRIVE WEIGHT 140 lbs. (Auto. Trip Hammer) DROP 30"

SAMPLED BY DM LOGGED BY DM REVIEWED BY SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
20								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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FIGURE A- 24

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APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D2488. Soil classifications are indicated on the logs of the exploratory excavations in Appendix A.

In-Place Moisture and Density Tests

The moisture content and dry density of relatively undisturbed samples obtained from the exploratory excavations were evaluated in general accordance with ASTM D2937. The test results are presented on the logs of the exploratory excavations in Appendix A.

Gradation Analysis

Gradation analysis tests were performed on selected representative soil samples in general accordance with ASTM D422. The grain-size distribution curves are shown on Figures B-1 through B-8. These test results were utilized in evaluating the soil classifications in accordance with the Unified Soil Classification System.

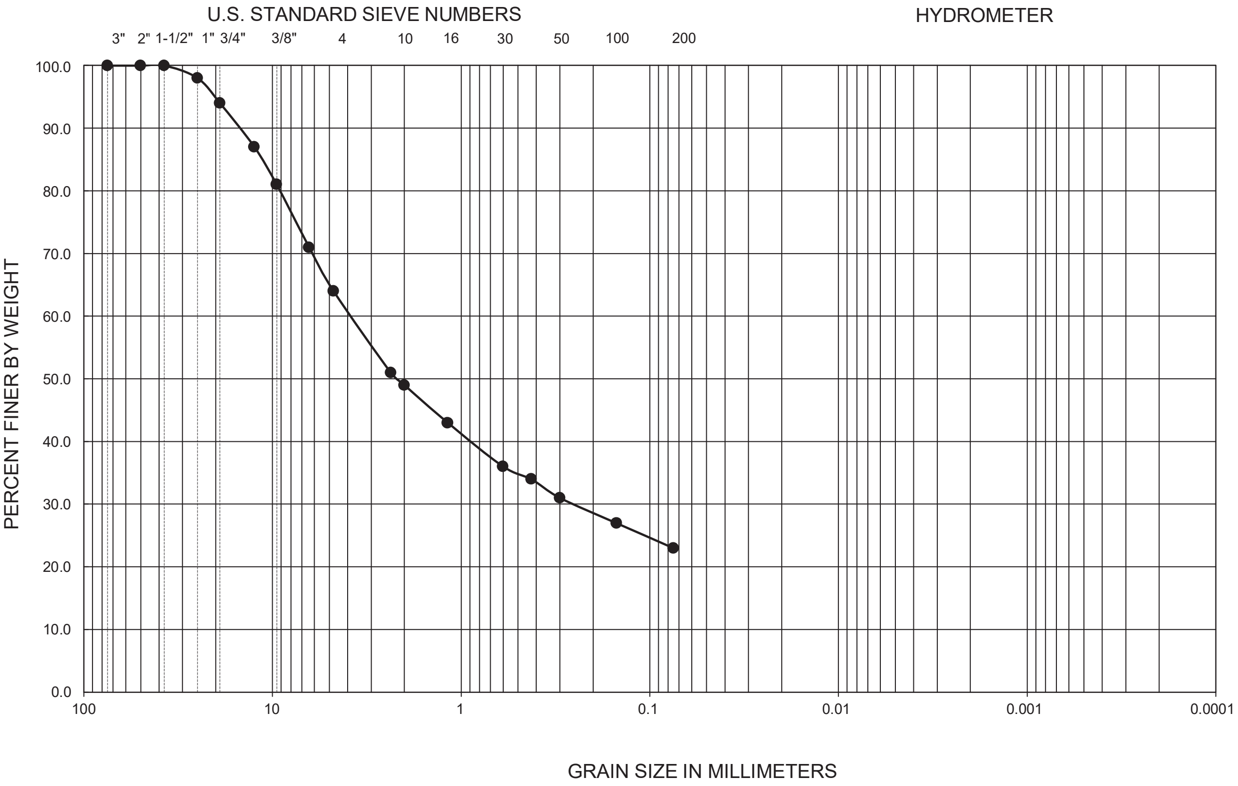
Atterberg Limits

Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D4318. These test results were utilized to evaluate the soil classification in accordance with the Unified Soil Classification System. The test results and classifications are shown on Figure B-9.

Soil Corrosivity Tests

Soil pH and minimum resistivity tests were performed on representative samples in general accordance with Arizona Test 236b. The chloride content of selected samples was evaluated in general accordance with Arizona Test 736. The sulfate content of selected samples was evaluated in general accordance with Arizona Test 733. Redox content was performed in accordance with ASTM G200-09. Sulfide content was performed in accordance with HACH 8131. The test results are presented on Figure B-10.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-1	0.0-3.3	32	22	10	--	0.255	3.89	--	--	23.0	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-1

GRADATION TEST RESULTS

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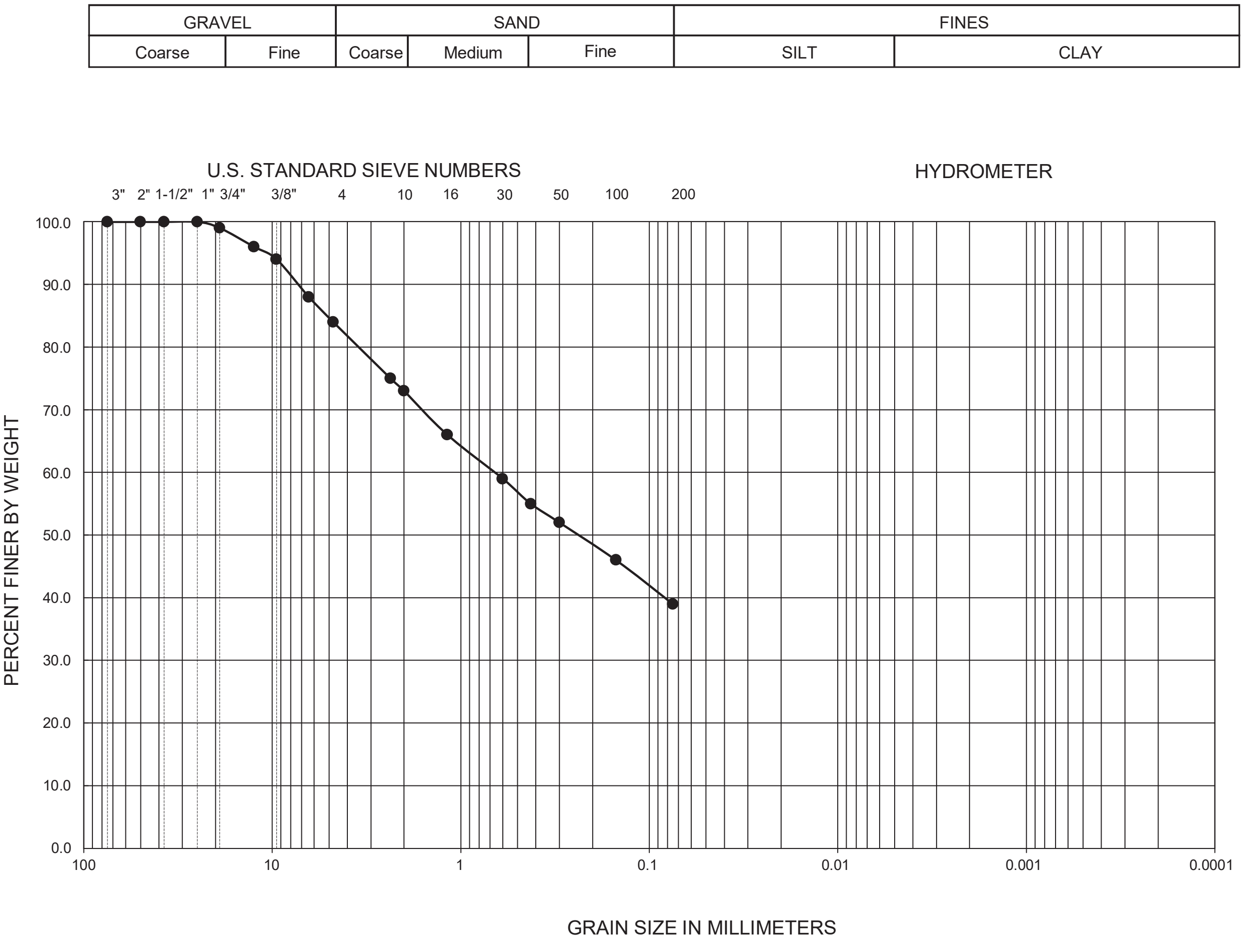
PHOENIX, ARIZONA



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-4	0.0-5.0	29	23	6	--	--	0.66	--	--	39.0	SM

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FIGURE B-2

GRADATION TEST RESULTS

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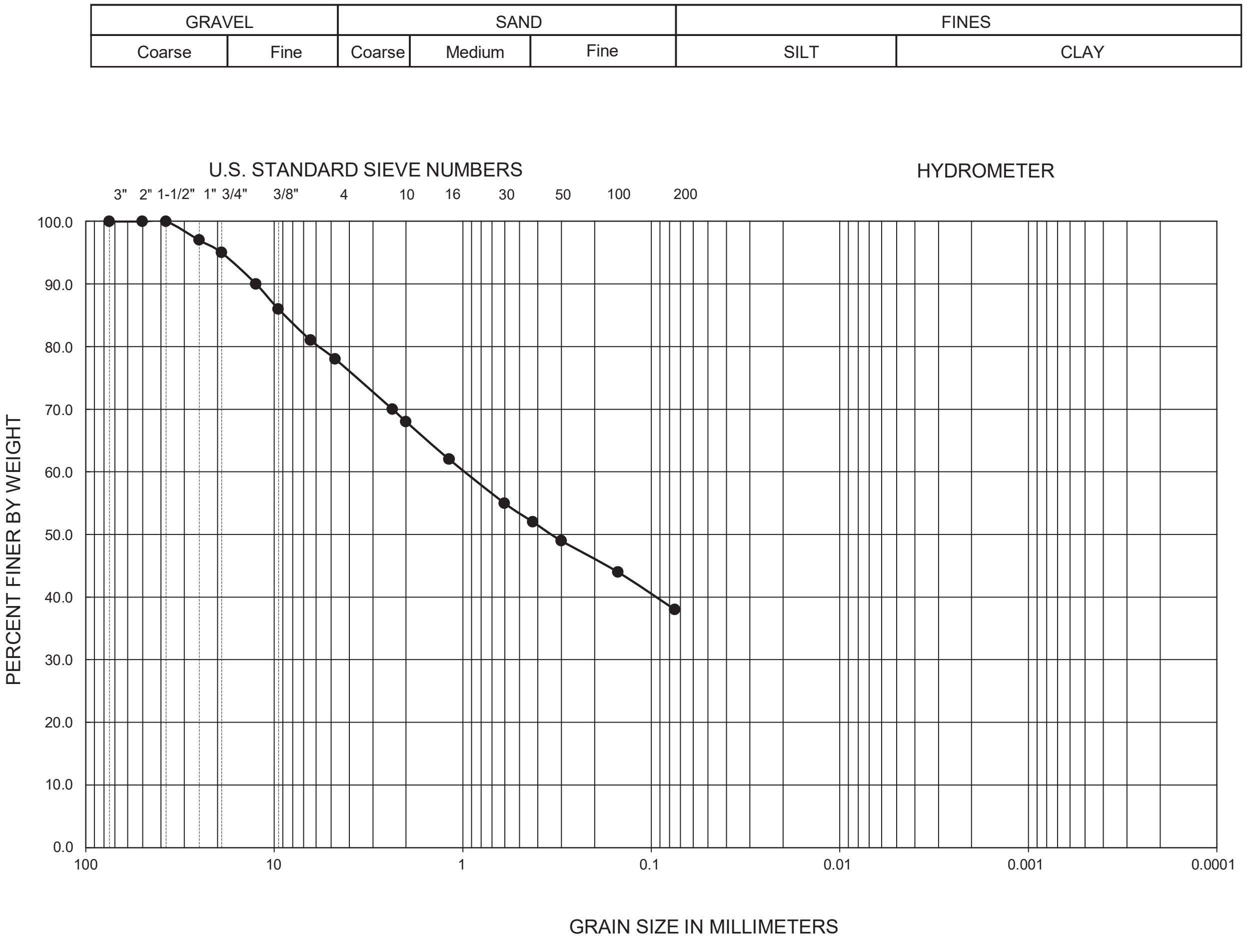

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-7	0.0-2.0	32	16	16	--	--	0.98	--	--	38.0	SC

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FIGURE B-3

GRADATION TEST RESULTS

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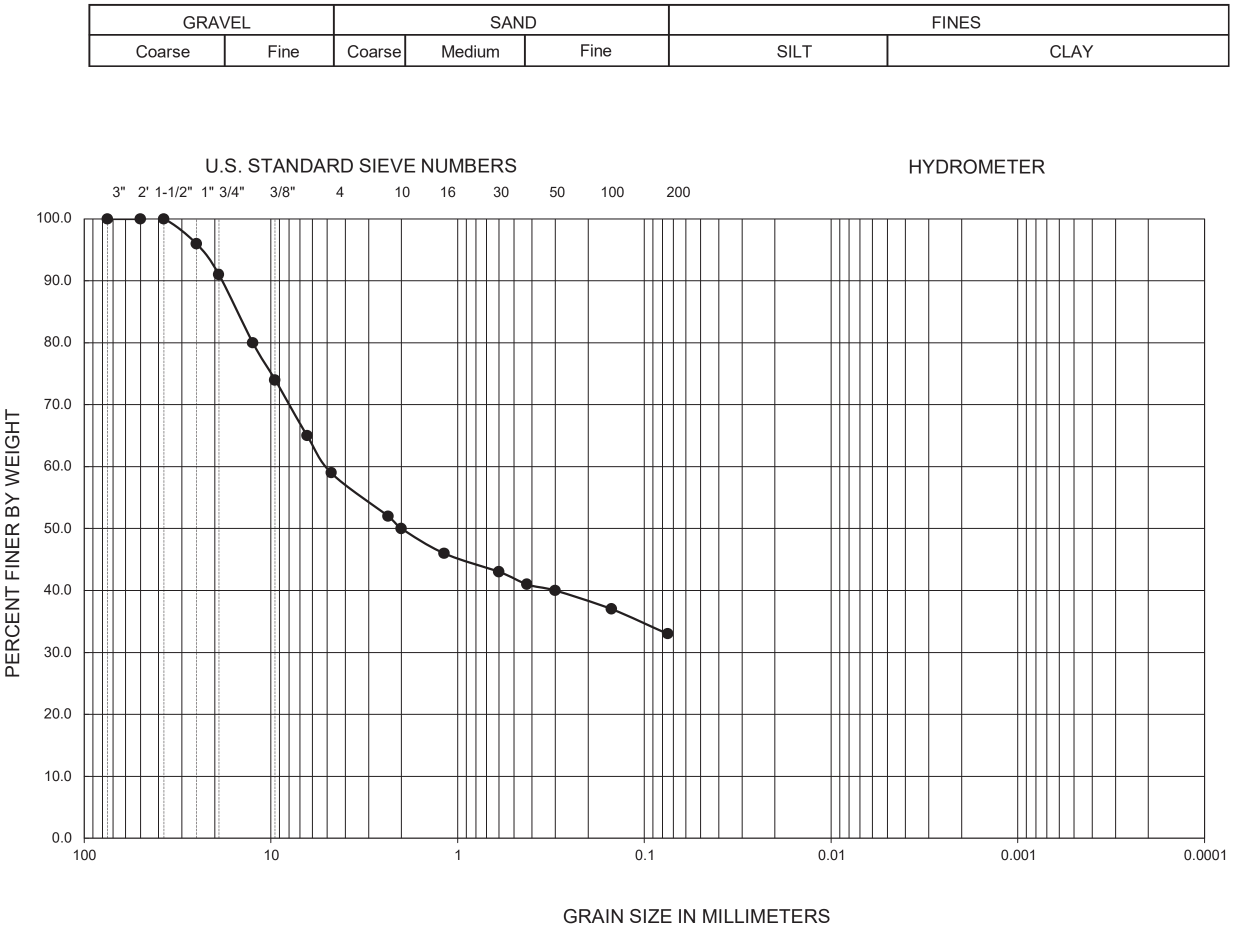

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-10	0.0-2.5	35	16	19	--	--	5.00	--	--	33.0	GC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-4

GRADATION TEST RESULTS

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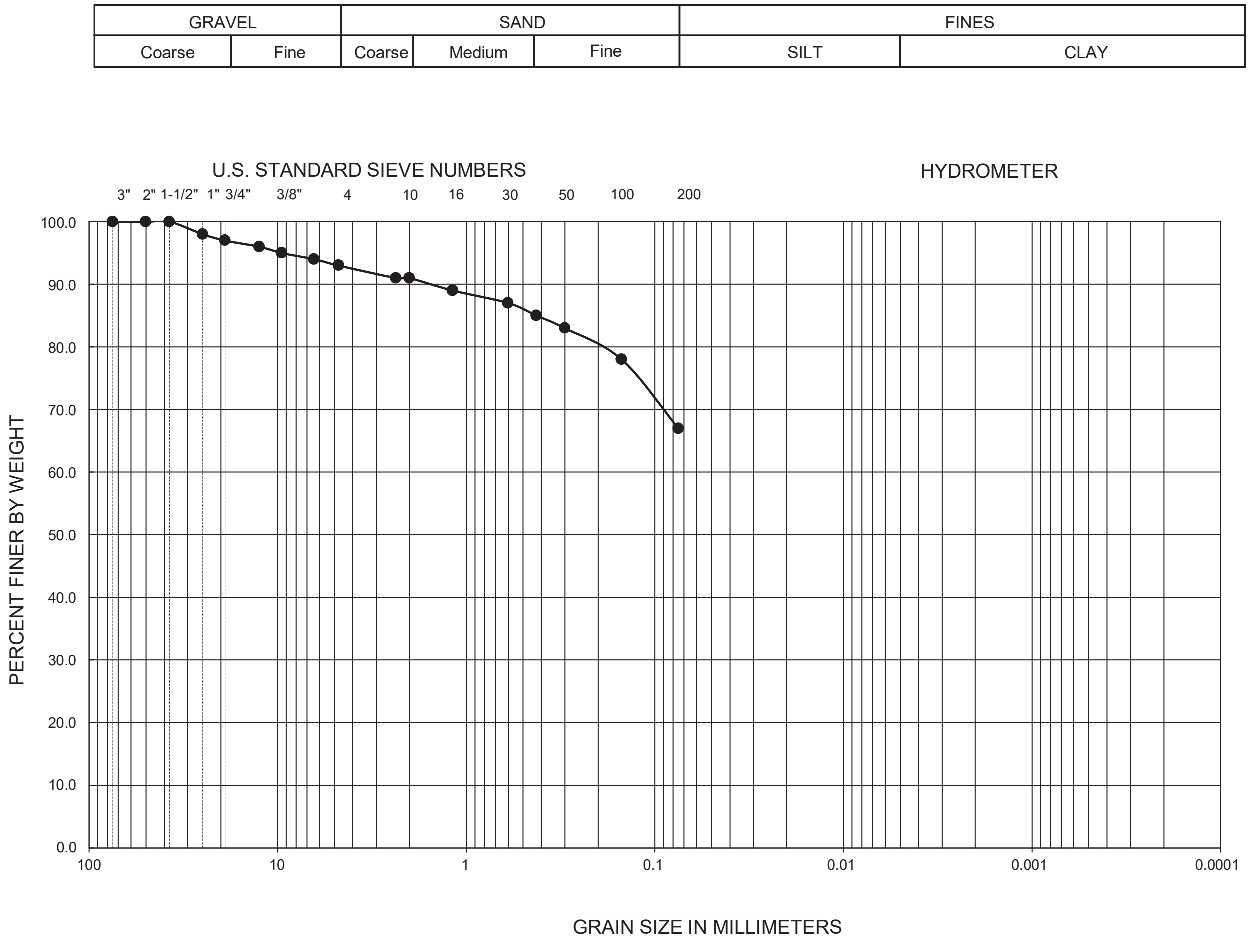

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-12	0.0-3.0	39	14	25	--	--	--	--	--	67.0	CL

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FIGURE B-5

GRADATION TEST RESULTS

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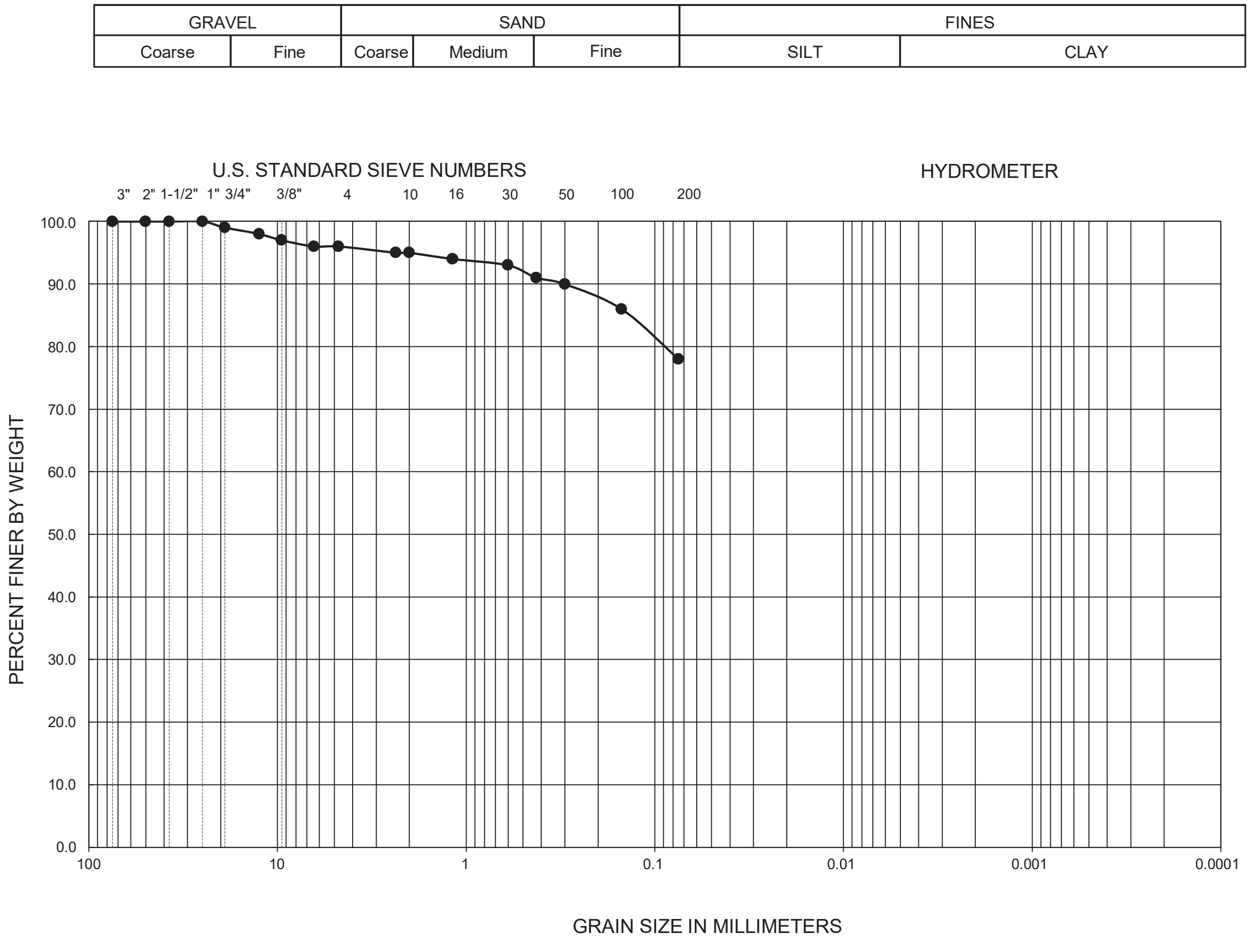

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-15	0.0-5.0	45	15	30	--	--	--	--	--	78.0	CL

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FIGURE B-6

GRADATION TEST RESULTS

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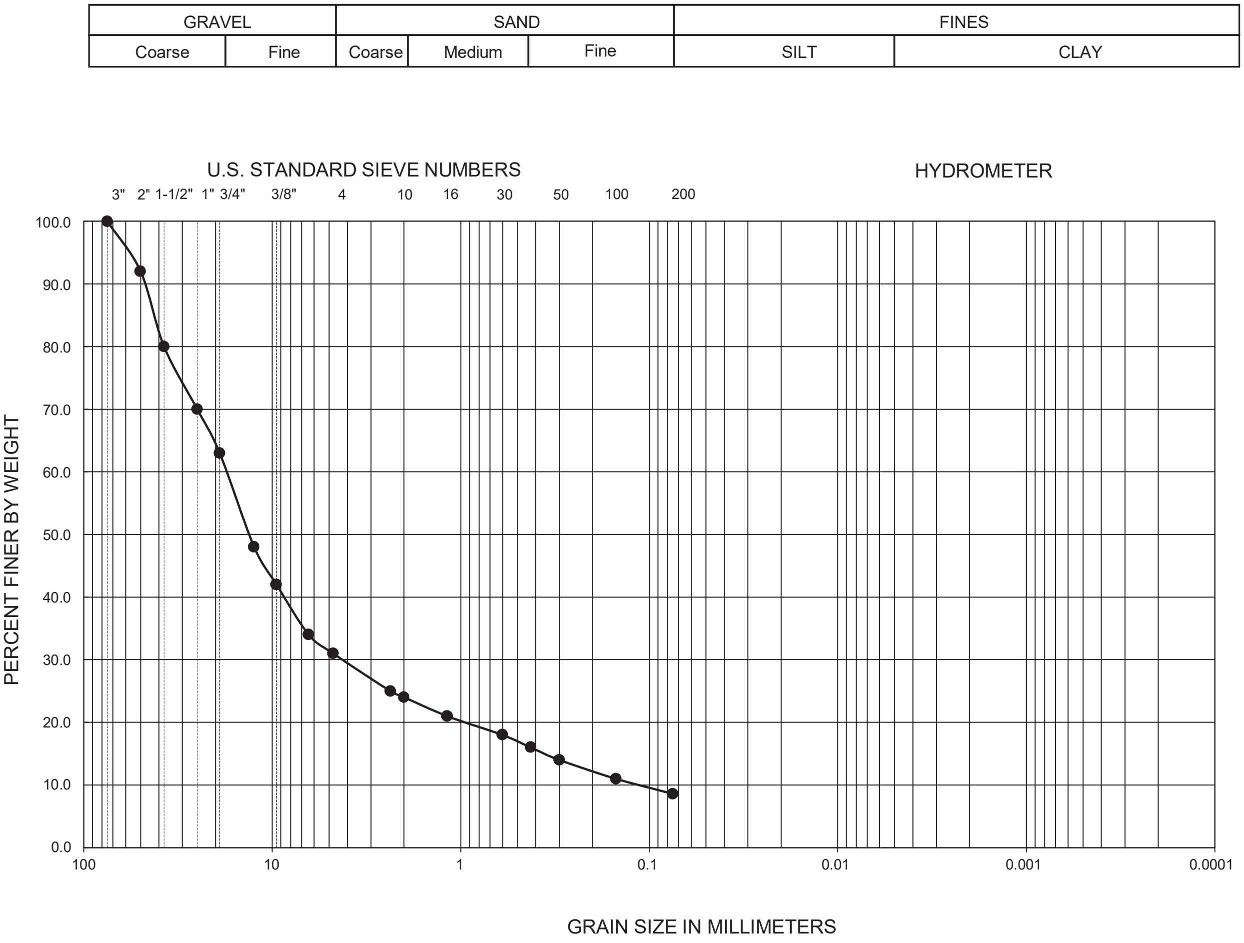
PHOENIX, ARIZONA



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-18	0.0-3.0	21	17	4	0.111	4.292	17.57	158.3	9.4	8.6	GP-GC

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FIGURE B-7

GRADATION TEST RESULTS

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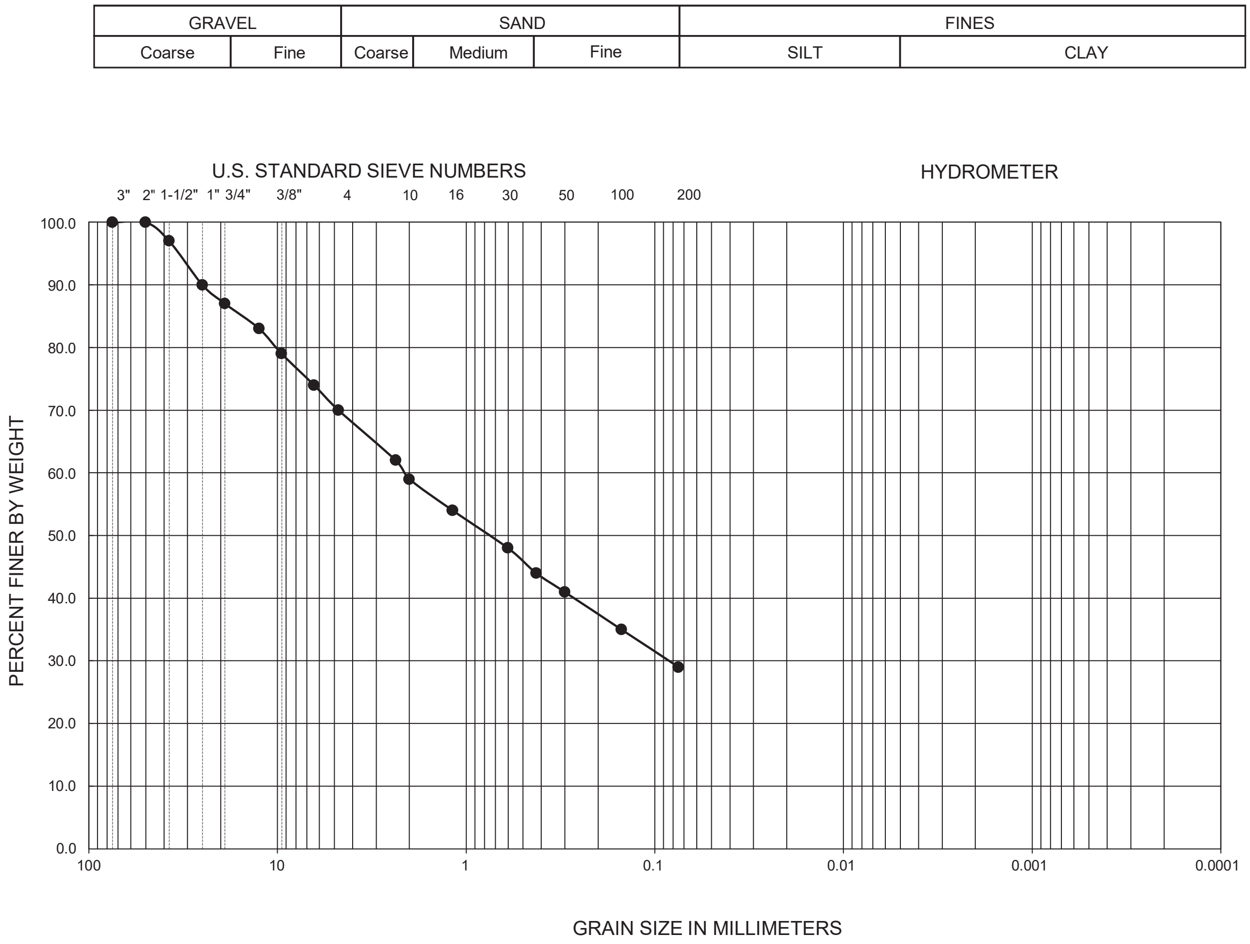
WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-21	0.0-2.0	32	18	14	--	0.083	2.13	--	--	29.0	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

FIGURE B-8

GRADATION TEST RESULTS

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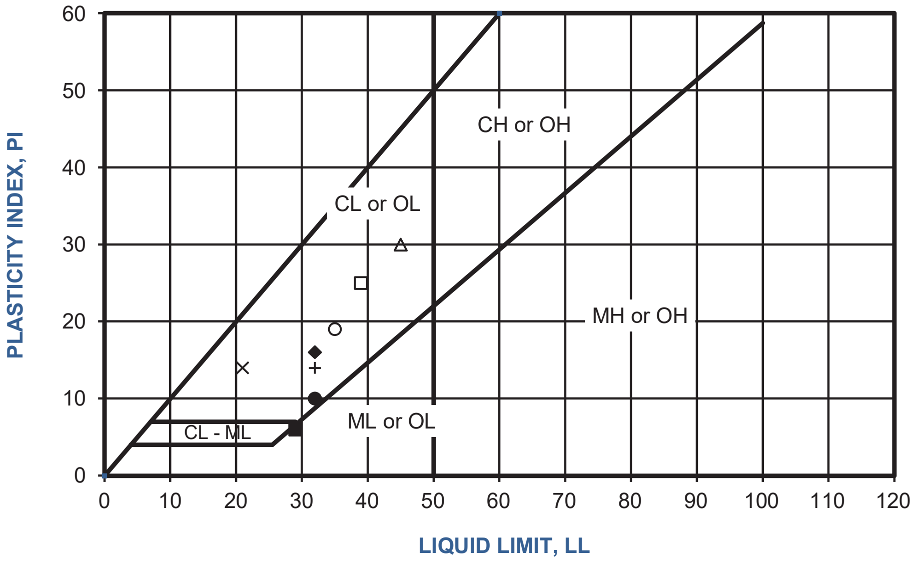
WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	B-1	0.0-3.3	32	22	10	CL	SC
■	B-4	0.0-5.0	29	23	6	ML	SM
◆	B-7	0.0-2.0	32	16	16	CL	SC
○	B-10	0.0-2.5	35	16	19	CL	GC
□	B-12	0.0-3.0	39	14	25	CL	CL
△	B-15	0.0-5.0	45	15	30	CL	CL
X	B-18	0.0-3.0	21	17	4	SC	GP-GC
+	B-21	0.0-2.0	32	18	14	CL	SC

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-9

ATTERBERG LIMITS TEST RESULTS

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604929001 | 10/17

SAMPLE LOCATION	SAMPLE DEPTH (ft)	pH[1]	RESISTIVITY[1] (Ohm-cm)	REDOX POTENTIAL[2] ((Eo) mV)	SULFATE CONTENT[3]		CHLORIDE CONTENT[4] (ppm)	SULFIDE CONTENT[5] (PPM)
					(ppm)	(%)		
B-1	0.0-3.3	8.4	2,841	235	50	0.005	14	<1.0
B-3	0.0-5.0	8.2	2,240	--	--	--	--	--
B-6	0.0-2.0	8.3	2,080	--	--	--	--	--
B-9	0.0-2.0	7.9	1,270	--	--	--	--	--
B-10	0.0-2.5	8.0	1,300	222	13	0.001	10	<1.0
B-21	0.0-2.0	7.9	1,333	--	100	0.010	47	--

[1] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 236c

[2] PERFORMED IN GENERAL ACCORDANCE WITH ASTM G200-09

[3] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 733

[4] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 736

[5] PERFORMED IN GENERAL ACCORDANCE WITH HACH 8131

FIGURE B-10

CORROSIVITY TEST RESULTS

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

WEST ANTHEM WATER AND WASTEWATER INFRASTRUCTURE
PHOENIX, ARIZONA

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14388
GREGG ALAN CREASER
DATE SIGNED 5/17/17
Expires 06/30/2017

REPORT ON GEOTECHNICAL INVESTIGATION

DESIGNATION:	West Anthem Wastewater Improvements Index No. WS90500276, WS90400067, WS90501005
LOCATION:	Pioneer Road to Carefree Highway Maricopa County, AZ
CLIENT:	Stanley Consultants, Inc.
PROJECT NO:	161708SA
DATE:	May 17, 2017

3331 East Wood Street ▪ Phoenix, AZ 85040 ▪ Phone (602) 997-6391 ▪ Fax (602) 943-5508
4025 East Huntington Drive, Suite 140 ▪ Flagstaff, AZ 86004 ▪ Phone (928) 526-6681 ▪ Fax (928) 526-6685
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TABLE OF CONTENTS

Registered Professional Engineer (Civil)
CERTIFICATE NO.
14388
GREGG ALAN
CREASER
DATE SIGNED 5/17/17
ARIZONA, U.S.A.
Expires 06/30/2017

1.0 INTRODUCTION

This report presents the results of a subsoil investigation carried out along the route of the proposed West Anthem Wastewater Improvements to be located between Sheriffs Pistol Range Road at Pioneer Road and North Valley Parkway at Carefree Highway in Phoenix and Maricopa, Arizona.

Preliminary information calls for the design and construction of a 0.5 MGD lift station located 1,100+/- feet north of Sheriffs Pistol Range Road and Pioneer Road. The lift station discharges into three (two 14-inch and one 6-inch diameter) parallel force mains running south for about 5,000 lf and ends in a discharge structure at the southwest corner of I-17 and Pioneer Road. From the discharge structure, wastewater flows in an approximately 10,000 lf gravity sewer crossing under Interstate I-17 using jack-and-bore/tunnel technology and then south along North Valley Parkway and connecting to an existing 24-inch gravity sewer at North Valley Parkway and the Carefree Highway. The gravity sewer is 18-inch to 21-inch in diameter and expected to be installed at minimum cover depth on the order of 5 to 18 feet; closer to 18 feet deep near Carefree Highway. Sections passing under drainage features may be deeper.

2.0 GENERAL SITE AND SOIL CONDITIONS

2.1 Site Conditions

The pipeline will be located mainly within the right of way for North Valley Parkway starting on the south side of Carefree Highway north to approximately 1,200 feet north of Cloud Road where it will turn to the west to go under I-17 and turn north where it will follow I-17 then Pioneer Road for approximately 6,800lf. I-17 is a 4 lane divided interstate highway and Carefree Highway a 4 lane roadway, with turn lanes at the intersection. Some major and minor washes cross the road. The roadway is bounded by commercial, retail and residential development on the south end up to about 1000 feet north of 33rd Lane with vacant desert terrain to the north. The west side of I-17 consists of vacant desert terrain, the Pioneer Living History Village and a mobile home park. A brief look at historical photos indicated that the site has never been previously developed before current conditions or farmed. The old I-17 roadway was located on the west side of the current alignment. The roadway is asphalt paved with the adjacent ground surface is generally gently sloped with sparse desert trees and bushes on the surface. There are a number of underground and overhead utilities along the alignment.

2.2 Geologic Conditions

The site is **located outside known areas** that have undergone considerable subsidence due to groundwater removal. Areas of subsidence are known to produce earth fissuring, which has affected areas within several miles of the site. Subsidence is a basin wide phenomenon that would result in differential elevation changes over long distances, which would not affect the type of buildings proposed for this site. No evidence of earth fissures was observed on the site. Fissure gullies form over subsurface irregularities such as bedrock highs, which cause tensional stresses and differential subsidence. Where such anomalies are not present, subsidence tends to be uniform over a wide area, this having minimal effect on surficial structures. The closest known earth fissures are located at 40th street and Lupine, many miles south from the site. These fissures were discovered in the 70's and are considered inactive at this time. Based on local experience, subsidence and earth fissures historically have **not** been a problem in this area.

2.3 Seismic Design Parameters

The project area is located in a seismic zone that is considered to have low historical seismicity. The Phoenix area has had only two magnitude 3.0 events in over 100 years. Liquefaction is not considered a concern as groundwater exceeds 15 meters below ground surface.

Although borings were not advanced to 100 feet, based on the nature of the subsoils encountered in the borings and geology in the area, Site Class Definition, Class C may be used for design of the structures.

2.4 General Subsurface Conditions

The geological materials are divided into three basic soil/rock types that were identified along the alignment as follows

Alluvial Soil – This unit consists of unconsolidated to semi-consolidated alluvial/flood plain sediment. The soils consist of clayey sands, silty sands with gravel, cobbles and small to medium sized boulders. The USCS refers to these as the Ebon-Pinamt-Tremant Association. These soils typically have a cobbly gravel loam surface underlain with very gravelly sandy clay loam subsoil. The surface is non-calcareous, with variable concentrations of lime with depth.

Alluvial Soil/Cemented Alluvium – This unit is a transitional area between the Alluvial Soil and Cemented Alluvium/Conglomerate. This unit includes alluvial soil, recent alluvial deposits from the active washes, and heavily cemented alluvium. The alluvial soil and recent alluvial deposits are anticipated to be relatively shallow overlying shallow cemented alluvium/conglomerate.

Cemented Alluvium/Conglomerate – This unit consists of consolidated old alluvial and valley plains sediment. The soils are heavily cemented calcareous sandy silts and clays containing gravel and cobble size rock fragments. Cementation is generally moderate to heavy, exhibiting rock-like characteristics of a conglomerate at several locations. USCS refers to these soils as part of the Rillito-Gunsight-Pinal Association. The soils typically have a strongly calcareous gravelly loam surface underlain with strongly to very strongly calcareous gravelly sandy loam.

Where drilled, the existing pavement consists of 4 to 6 inches of asphalt over 6 to 12 inches of aggregate base. Subsoil conditions consist of clayey gravel, well graded gravel, silty gravel, silty sand, clayey sand, and sandy lean clay to the termination depths of borings at 15.4 to 60.3 feet below grade. Subordinate amounts of gravel and cobble were also noted in the soil profile along with various degrees of calcareous cementation. Soil conditions at the time of investigation were classified as ‘dry’ to ‘moist’**.** Standard Penetration Test values generally ranged from 10 to 50+ blows per foot (bpf) in the upper 5+ feet increasing to 50+ bpf in the deeper soils. It should be noted that loose soils were encountered in borings B-2, B-5, B-6, B-7 and B-8 at a depth of 5 feet below existing grades. Fill material was also encountered in borings B-5 through B-11 at depths of 3 to 12 feet below existing grades. No groundwater was encountered during this investigation.

Due to the very dense gravelly nature of the soils, in-situ dry densities were not obtainable. Laboratory testing indicated liquid limits in the range of non-plastic to 41 with a plasticity index of non-plastic to 13.

3.0 ANALYSIS AND RECOMMENDATIONS

3.1 Analysis

Analysis of the field and laboratory data indicates that subsoils at the site are generally favorable for the support of the proposed pipeline on typical bedding required for the piping and trench loading conditions. However, if the pipeline profile lies within a potential loose/soft soil segment, some additional pipe bedding or increased manhole bases may be warranted. It is likely to encounter near saturated soils near drainage features or in areas where depressed unpaved shoulder areas have been subjected to flooding after recent heavy rains. This may require increasing pipe bedding depending on depth. It is also recommended to increase the manhole base sizes due to lower bearing capacity and increasing the size of thrust blocks due to low lateral bearing (passive pressure) capacity. Any structures required can be supported on shallow spread foundations**.**

Loose surficial soils and some wash fills may be encountered and will likely be disturbed due to various construction activities. However, the hard/dense nature of the soils at the founding level should make them suitable for support of the minor structures without the need for over-excavation and re-compaction provided they remain dry.

Groundwater is not expected to be a factor in the design or construction of shallow foundations and underground utilities. **Excavation operations may be difficult due to very dense, rocklike conditions.** It should be noted that the fact that a boring was advanced to a particular depth should not lead to the assumption that it is necessarily excavatable by conventional means. **Very dense and/or rocky conditions may require more aggressive rock removal techniques.** The contractor should be responsible for determining what equipment will be required to make excavations.

3.2 Site Preparation

The entire area to be occupied by the proposed construction should be stripped of all vegetation, debris, rubble, and obviously loose surface soils. It is recommended that for any section where loose/soft soils are expected in the upper 5 to 10 feet and/or encountered at the bottom of the trenches or manhole bases, the loose/soft soils be over-excavated down to at least 12 inches below the pipe, manhole base or at-grade equipment base. The over-excavated zone should then be replaced with compacted bedding material. This process will require close inspection during trenching to locate the loose soils and over-excavate while the trench is being excavated to avoid having to go back on the trench to remove loose soil. **A representative of the geotechnical engineer shall examine the exposed subgrade** once sub-excavation is complete and prior to backfilling to ensure removal of deleterious materials. Fill placement and quality should be as defined in the "Fill and Backfill" section of this report.

Removal and replacement of existing asphalt surfacing will likely disturb the underlying aggregate base course (ABC) and possibly subgrade. After removal of the surface, the exposed base will require fine grading and re-compaction. The exposed subgrade under the new pavement, curb, gutter and sidewalks shoulder areas should be prepared in accordance with M.A.G. Standard Specification 301. This includes proof rolling to detect unstable subgrade areas. **If stable,** it is recommended to increase the thickness of the scarification, moisture conditioning and compaction to 12 inches. The grade should be re-compacted to at least 95 percent dry density as determined by ASTM D698.

While no obvious signs of wet or unstable soils were found in the limited boring locations, it is not uncommon to find overly moist soils (above optimum) under old pavements, low shoulder areas that collect water and leaking irrigation pipes and canals. These conditions can result in pumping issues and will impact obtaining compaction of the subgrade. If isolated zones of unstable or soft subgrade are found during site grading, there are several options available to help stabilize these conditions. The first option would be to remove the unstable soils to a depth on the order of 2 feet below the finished subgrade; deeper excavations may be required if the loose areas extend deeper. The soils may be set aside to dry (if necessary) and be re-compacted once they have dried sufficiently, or other local soils or asphalt millings from the existing roadway may be used.

As an alternate to complete removal of the soils, the soils can be mixed with dry cement. Since using cement is only to dry and stabilize the soils, not part of the structural design, it is recommended to generally follow M.A.G. 311, Soil Cement. It is recommended that a minimum of 12 inches of cement stabilized soils be used below the pavement structural section. If very soft soils are encountered, increase this depth as needed to stabilize. Another option is to use a high quality geogrid such as Tensar TX7 or equal installed per manufacture recommendations and M.A.G. Standard Specifications 306 and 796 for geogrid.

Prior to placing structural fill below footing bottom elevation (if required), the exposed grade should be scarified to a depth of 8 inches, moisture-conditioned to optimum (±2 percent) and compacted to at least 95 percent of maximum dry density as determined by ASTM D-698. Pavement areas should be scarified, moisture-conditioned and compacted in a similar manner.

Prior to placing sidewalks, the exposed grade should be scarified 8 inches, moisture conditioned to at least optimum to 3 percent above optimum and lightly but uniformly compacted to 90 but not more than 95 percent of maximum dry density as determined by ASTM D-698.

3.3 Foundation Design

It is recommended that any vault/manhole structures be founded on a mat type foundation bearing on medium dense native soils (or 12 inches of compacted bedding material (or Aggregate Base, crushed stone or 1½ sack MAG Spec 728 CLSM) as indicated above in loose/soft zones) at an invert depth on the order of 10 feet below grade. If site preparation is carried out as set forth herein, a recommended allowable bearing capacity of **4,000 psf** can be utilized for design. This bearing capacity refers to the total of all loads, dead and live, and is a net pressure. It may be increased one-third for wind, seismic or other loads of short duration. All footing excavations should be level and cleaned of all loose or disturbed materials. Positive drainage away from any proposed structure must be maintained at all times.

Estimated settlements under design loads are on the order of less than 1-inch, virtually all of which will occur during construction. Post-construction differential settlements will be negligible, under existing and compacted moisture contents. Additional localized settlements of the same magnitude could occur if native supporting soils were to experience a significant increase in moisture content.

3.4 Lateral Pressures

The following lateral pressure values may be utilized for the proposed construction:

Active Pressures	
Unrestrained Walls	35 pcf
Restrained Walls	60 pcf
Passive Pressures	
Continuous Footings	300 pcf
Spread Footings or Drilled Piers	350 pcf
Coefficient of Friction (w/ passive pressure)	0.35
Coefficient of Friction (w/out passive pressure)	0.45

All backfill must be compacted to not less than 95 percent (ASTM D-698) to mobilize these passive values at low strain. **If/where *softer stiff/loose soil conditions are encountered in the upper 5 to 10 feet, over-sized thrust blocks are recommended where needed or use mechanically restrained joints as specified by the pipeline engineer. For thrust block design by the pipeline engineer, it is recommended to use a lateral bearing capacity of 1,500 psf for thrust block calculations in the upper 10 feet, not the 3000 psf noted in MAG Detail 380. The higher value is suitable in dense to very dense soils zones.***

3.5 Excavations

Care should be taken during excavation not to endanger nearby elements such as roadways, utilities, etc. **Depending on proximity**, existing elements may require shoring, bracing or underpinning to provide structural stability and protect personnel working in the excavation. The need for shoring or bracing is a means and methods decision by the contractor. They may elect to layback the excavations to a safe condition if there is room or to reduce the amount of excavation and backfill required.

The extent of how easily a material is excavated is largely affected by the effort applied by the contractor. Although a specific material maybe rippable with concentrated effort being applied, such operations may not be viewed as cost effective. Large fragments produced from ripping operations may require secondary fragmentation to reduce the rock to sizes suitable for fill placement.

Excavations to the levels expected will likely terminate within differing soil types. All excavations must comply with current governmental regulations including the current OSHA Excavation and Trench Safety Standards. Based on this limited soil data, the upper soils would be classified as Type C. This would require side slopes for open-cut excavation to 20+ feet depth be cut back at 1½:1 (horizontal to vertical). It is recommended that a representative of the Geotechnical Engineer or the Contractor Qualified party examine the cut slope during excavation to reduce the risks posed by unstable conditions. The slopes should be protected from erosion due to run-off or long-term surcharge at the slope crest. Construction equipment, building materials, excavated soil and vehicular traffic should not be allowed within 10 feet or one-third the slope height, whichever is greater, from the top of slope. Adjustments to the recommended slopes may be necessary due to wet zones, loose strata and other conditions not observed in the borings. Shotcrete or soil stabilizer on the slope face may be useful in preventing erosion due to run-off and/or drying of the slope. **Due to the existing infrastructure, open trench layback may not be possible as discussed above. Therefore shoring (trench boxes) will be required in those circumstances.**

3.6 Bedding, Backfill and Fill

The native soils are suitable for trench backfill (above any required bedding) and roadway fill provided oversize rock (plus 6 inches) is removed. The trench backfill should be moisture conditioned, placed in suitable lifts and mechanically compacted as specified. **Water settling is not recommended.** Pipe bedding should meet the project specifications as specified by the governing municipality. Special granular pipe bedding or cementitious slurry meeting MAG Standard Specifications Section 728 for Controlled Low Strength Material (CLSM) may be required depending on the pipe materials and trench loading conditions. As noted above, it is recommended that for any section where loose/soft soils are encountered at the bottom of the trench, the loose/soft soils be over-excavated down to at least 12 inches below the pipe. The over-excavated zone should then be replaced with compacted bedding material. This process will require close inspection during trenching to identify any loose soils and to permit any necessary over-excavation to be performed during the initial excavation process.

The silty fine sand soils may be sensitive to excessive moisture content and will become unstable at elevated moisture content. Accordingly, it may be necessary to compact soils on the dry side of optimum, especially in asphalt pavement areas.

If imported common fill for use in site grading is required, it should be examined by a Soils Engineer to ensure that it is of low swell potential and free of organic or otherwise deleterious material. In general, the fill should have 100 percent passing the 3-inch sieve and no more than 60 percent passing the 200 sieve. For the fine fraction (passing the 40 sieve), the liquid limit and plasticity index should not exceed 30 percent and 10 percent, respectively. It should exhibit less than 1.5 percent swell potential when compacted to 95 percent of maximum dry density (ASTM D-698) at a moisture content of 2 percent below optimum, confined under a 100 psf surcharge, and inundated.

Fill should be placed on subgrade which has been properly prepared and approved by a Soils Engineer. Fill must be wetted and thoroughly mixed to achieve optimum moisture content, ±2 percent. Fill should be placed in horizontal lifts of 8-inch thickness (or as dictated by compaction equipment) and compacted to the percent of maximum dry density per ASTM D-698 set forth as follows:

A.	Manhole and Minor Structures		
	1.	Below footing level	95
B.	Pavement/Sidewalk Subgrade or Fill		95
C.	Utility Trench Backfill		95 (full depth)
D.	Aggregate Base Course		
	1.	Below Equipment Slabs	95
	2.	Below asphalt paving	100
E.	Landscape Areas		90

Under any roadways, the backfill above the top of any pipe shall meet the requirements of MAG Standard Specification Section 601, Type I backfill using a MAG specified aggregate base or concrete slurry. **In order to reduce trench settlement potential, all fill under roadways should be compacted to 95 percent full depth.**

Accurate prediction of the amount of construction water necessary for compaction is not possible due to the varying factors. These include variable natural soil moisture, seasonal changes in moisture content, air temperature and wind speed that impact evaporation. The optimum moisture contents reported on the moisture-density relations data is based on the minus #4 materials. It will be corrected downward depending on the percentage of rock (plus #4 fraction) in the matrix. For ADOT highway projects, a range of 80 to 100 gallons per cubic yard, for winter to summer months respectively, is typically recommended.

The value for the Modulus of Soil Reaction Value (E’) is dependent on the pipe backfill material utilized, the laying conditions and pipe backfill compaction. Based on the soil test data and field observations, the following Modulus of Soil Reaction Value (E’) values may be used.

Table 3.6.1 Modulus of Soil Reaction (E')

Pipe Backfill Material	Compaction (%)	E' (psi)	Comments
Native Fill	95	2,000	1,2
Granular Fill	95	3,000	1,3
Undisturbed Loose Native Soils	N/A	500	4

Note:

1. Standard Proctor maximum dry density (ASTM D-698).
2. Must meet Fill and Backfill specifications. Assumes well mixed 3-inch minus native soils obtained from pipe trench/excavation. Must meet the following Unified Soil classification: (1) fine-grained soils with Liquid limit<50% and medium to no plasticity (CL,ML,ML-CL) and more than 25% retained on #200 sieve; or (2) coarse-grained soils with fines (GM,GC,SM,SC) containing more than 12% fines.
3. Must meet fill and backfill specifications. Assumes 3-inch minus coarse-grained soils with little or no fines (GW,GP,SW,SP) containing less than 12% fines or soils meeting the requirements of M.A.G. section 702 Table 702-1Type A or Type B select.
4. Assumes firm/loose to very stiff/medium dense native soils.

3.7 Corrosion

Laboratory pH values ranged from 7.5 to 8.3. Sulfate concentrations ranged from 3 to 47 ppm with chloride concentrations from 7 to 660 ppm. Resistivity tests conducted indicate that values measured from 570 to 9700 ohm-cm. Depending on areas, this reflects a mild to severe degree of corrosiveness to buried metal. Accordingly, suitable pipe wall thickness and/or corrosion protection should be selected by the designer per the trench/traffic loading and lifetime requirements of the project. A recommendation for corrosion protection is beyond the scope of work for this investigation.

3.8 Roadways

If earthwork in paved areas is carried out to finish subgrade elevation as set forth herein, the subgrade will provide adequate support for pavements. The location designation is for reference only. **The designer/owner should choose the appropriate sections to meet the anticipated traffic volume and life expectancy.** The section capacity is reported as daily ESALs, Equivalent 18 kip Single Axle Loads. Typical heavy trucks impart 1.0 to 2.5 ESALs per truck depending on load. It takes approximately 1,200 passenger cars to impart 1 ESAL.

As an alternative to a traditional asphalt or concrete pavement section, we anticipate that it will be more likely that there will be unpaved access road, typically consisting of a gravel surface to provide all-weather access. There are several methods to accomplish this depending on construction budget, anticipated traffic and willingness to provide maintenance. A thicker section of aggregate base is provided as an option. Alternative options could also include a soil cement roadway which could have a surface treatment of decomposed granite or gravel applied.

Table 3.8.1 Pavement Sections

Area of Placement	Flexible (AC Pavement)		
	Thickness		Daily 18-kip ESALs
	AC (0.39)	ABC (0.12)	
North Valley Parkway (Arterial Street)	4.0"	6.0"	98
	5.0”	6.0”	285
	6.0"$^{(2)}$	**6.0"**$^{(2)}$	738
Unpaved Access Roads	-	8.0”	1.5

Notes:

1. Designs are based on AASHTO design equations and ADOT correlated R-Values.
2. **Minimum section per City of Phoenix standard details for Arterial Streets.**
3. Full depth asphalt or increased asphalt thickness can be increased by adding 1.0-inch asphalt for each 3 inches of base course replaced.

Pavement Design Parameters:

Assume:	One 18 kip Equivalent Single Axle Load(ESAL)/Truck
Life:	20 years
Subgrade Soil Profile:	
% Passing #200 sieve:	29%
Plasticity Index:	7%
k:	125 pci (assumed)
R value:	29 (per AASHTO Formula)
M_R:	17,100 (per AASHTO design)

These designs assume that all subgrades are prepared in accordance with the recommendations contained in the "Site Preparation" and "Fill and Backfill" sections of this report, and paving operations are carried out in a proper manner. If pavement subgrade preparation is not carried out immediately prior to paving, the entire area should be proof-rolled at that time with a heavy pneumatic-tired roller to identify locally unstable areas for repair.

Pavement base course material should be aggregate base per M.A.G. Section 702 Specifications. Asphalt concrete materials and mix design should conform to M.A.G. 710 for heavy traffic. It is recommended that a ½ inch or ¾ inch mix designation be used for the pavements. While a ¾ inch mix may have a somewhat rougher texture, it offers more stability and resistance to scuffing, particularly in truck turning areas. Pavement installation should be carried out under applicable portions of M.A.G. Section 321 and municipality standards. The asphalt supplier should be informed of the pavement use and be required to provide a mix that will provide stability and be aesthetically acceptable. Some of the newer M.A.G. mixes are very coarse and could cause placing and finish problems. A mix design should be submitted for review to determine if it will be acceptable for the intended use.

For sidewalks and other areas not subjective to vehicular traffic a 4-inch section of concrete will be sufficient. For areas subject to heavier traffic, such as the entrance apron, a thicker section of 6 inches of concrete is recommended.

Portland Cement Concrete Pavement must have a minimum 28-day flexural strength 550 psi (compressive strength of approximately 3,700 psi). It may be cast directly on the prepared subgrade with proper compaction (reduced) and the elevated moisture content as recommended in the report. Lacking an aggregate base course, attention must be paid to using low slump concrete and proper curing, especially on the thinner sections. No reinforcing is necessary. Joint design and spacing should be in accordance with ACI recommendations. Construction joints should contain dowels or be tongue-and-grooved to provide load transfer. Tie bars are recommended on the joints adjacent to unsupported edges. Maximum joint spacing in feet should not exceed 2 to 3 times the thickness in inches. Joint sealing with a quality silicone sealer is recommended to prevent water from entering the subgrade allowing pumping and loss of support.

Proper subgrade preparation and joint sealing will reduce (but not eliminate) the potential for slab movements (thus cracking) on the expansive native soils. Frequent jointing will reduce uncontrolled cracking and increase the efficiency of aggregate interlock joint transfer.

In order to support the anticipated service vehicle traffic or any other heavy type trucks on an unpaved surface, it is recommended that the base consist of at least **8.0 inches** of compacted aggregate base (MAG Spec. Section 702 crushed rock AB) on **8 inches** of prepared and compacted subgrade. The subgrade should be compacted to at least 95 percent to the full depth. The AB shall be compacted to 100 percent per ASTM D 698. Depending on equipment used, more than one lift may be required to gain the density required. If desired, the surface can consist of 2 to 4 inches of decomposed granite (D.G.). A D.G. stabilizer should be considered to reduce the amount of maintenance required to maintain the surface.

Adequate drainage will be critical for long-term performance of the roadway. Special attention must be paid to proper crowning (crossfall) and/or longitudinal slope to prevent ponding on the roadway and adequate drainage provisions for the subgrade. A minimum cross slope of 5 percent is recommended for unpaved areas.

4.0 GENERAL

The scope of this investigation and report includes only regional published considerations for seismic activity and ground fissures resulting from subsidence due to groundwater withdrawal, not any site specific studies. The scope does not include any considerations of hazardous releases or toxic contamination of any type.

Our analysis of data and the recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific sample locations. Our work has been performed in accordance with generally accepted engineering principles and practice for a preliminary investigation; this warranty is in lieu of all other warranties expressed or implied.

We recommend that a representative of the Geotechnical Engineer observe and test the earthwork and foundation portions of this project to ensure compliance to project specifications and the field applicability of subsurface conditions which are the basis of the recommendations presented in this report. If any significant changes are made in the scope of work or type of construction that was assumed in this report, we must review such revised conditions to confirm our findings if the conclusions and recommendations presented herein are to apply.

Respectfully submitted,
SPEEDIE & ASSOCIATES, INC.

Ray C. Markley Jr., E.I.T.

Registered Professional Engineer (Civil)
Certificate No.
37292
KEITH R.
GRAVEL
Date Signed 5/17/17
Arizona, U.S.A.
Expires 03/31/2020

Keith R. Gravel, P.E.

Registered Professional Engineer (Civil)
Certificate No.
14388
GREGG ALAN
CREASER
Date Signed 5/17/17
Arizona, U.S.A.
Expires 06/30/2017

Gregg A. Creaser, P.E.

APPENDIX

FIELD AND LABORATORY INVESTIGATION

SOIL BORING LOCATION PLANS

SOIL LEGEND

LOG OF TEST BORINGS

TABULATION OF TEST DATA

CORROSIVE TEST DATA

FIELD AND LABORATORY INVESTIGATION

On October 5, 6, 7, 12, 13 & 14, November 30 and December 1, 2016, soil test borings were drilled at the approximate locations shown on the attached Soil Boring Location Plan. All exploration work was carried out under the full-time supervision of our geologist, who recorded subsurface conditions and obtained samples for laboratory testing. The soil borings were advanced with a truck-mounted CME-75 drill rig utilizing TubeX rock hammer. Detailed information regarding the borings and samples obtained can be found on an individual Log of Test Boring prepared for each drilling location.

Laboratory testing consisted of grain-size distribution and plasticity (Atterberg Limits) tests for classification purposes. Laboratory resistivity, pH, sulfate and chloride concentration were also conducted for corrosivity analysis. All field and laboratory data are presented in this appendix.

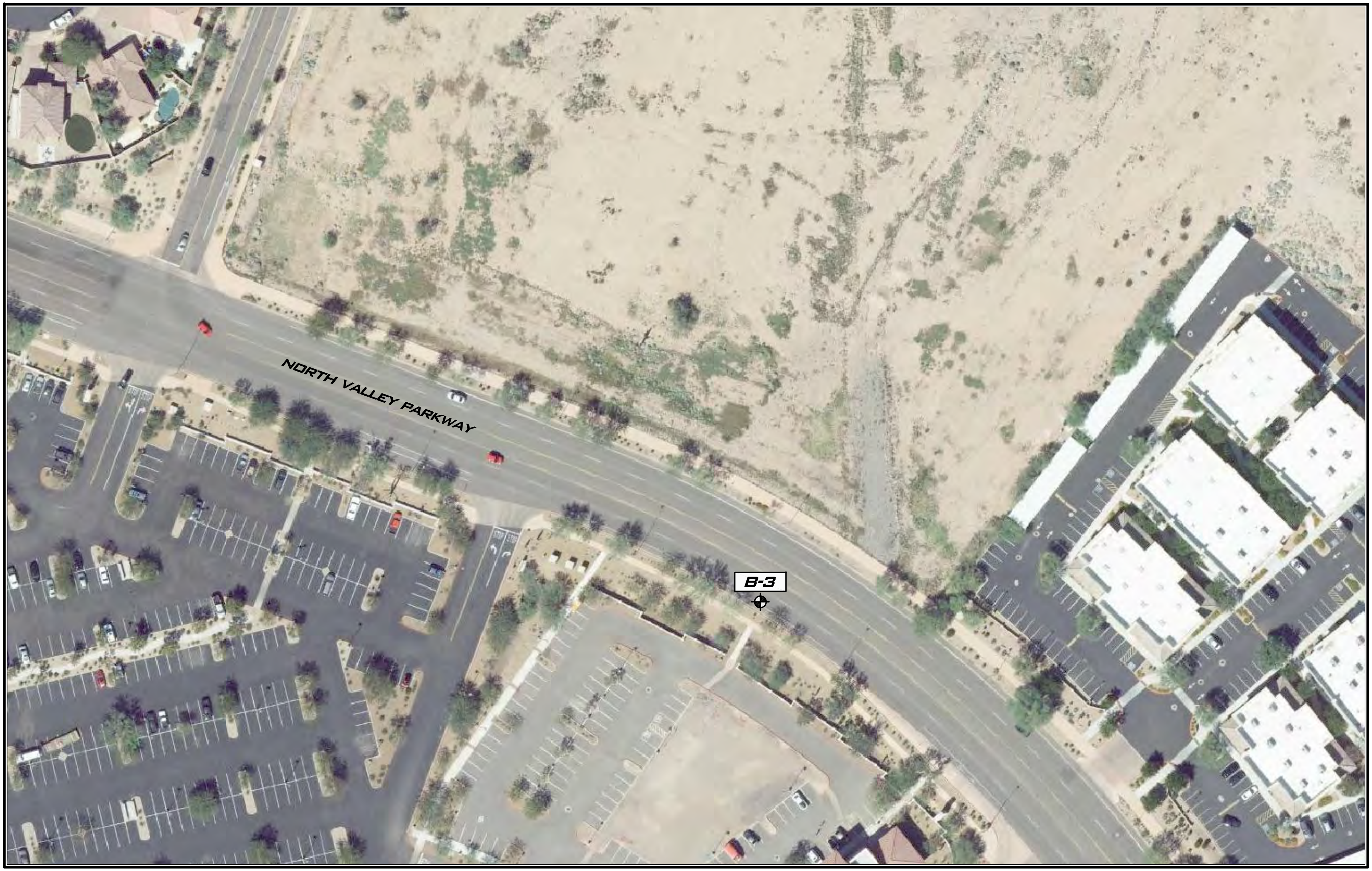
⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

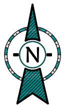
SHEET: 1 of 8 DR: TSW REV: DATE: 09/27/16 PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL • ENVIROMENTAL • MATERIALS ENGINEERS



⌖ - APPROXIMATE SOIL BORING LOCATIONS



SOIL BORING LOCATION PLAN

SHEET: 2 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL• ENVIROMENTAL• MATERIALS ENGINEERS

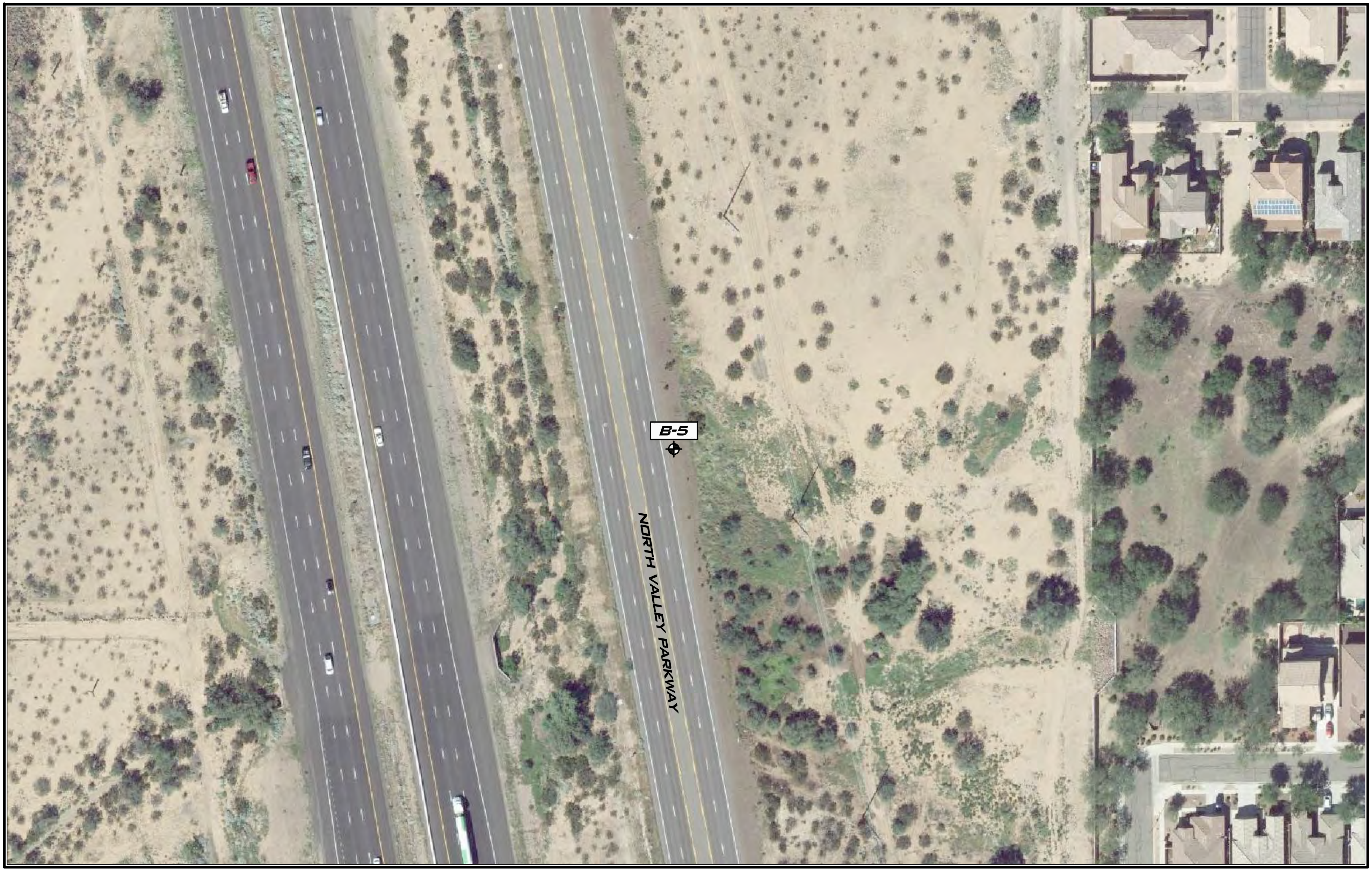
⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

SHEET: 3 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL• ENVIROMENTAL• MATERIALS ENGINEERS



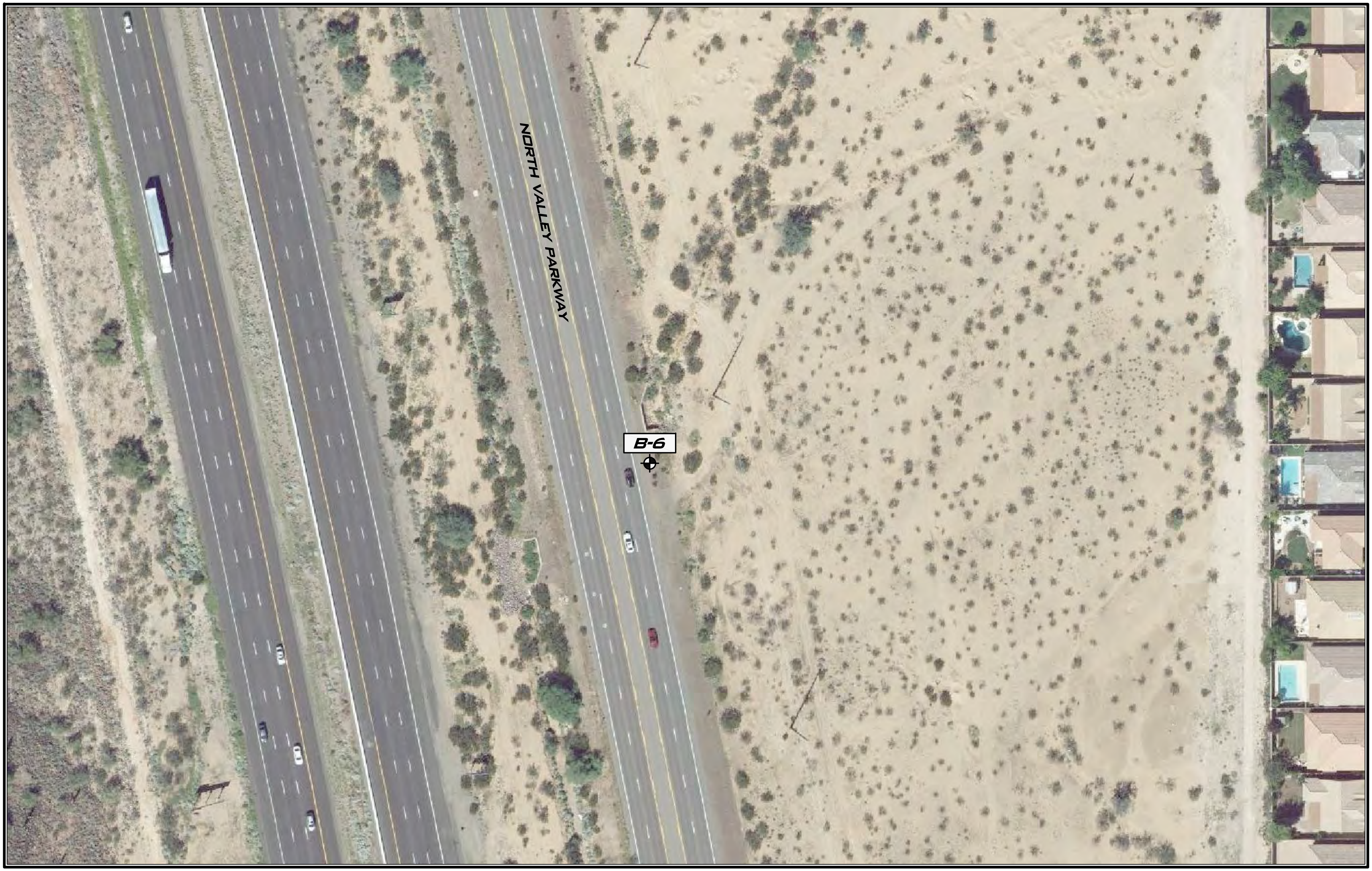
⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

SHEET: 4 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL • ENVIROMENTAL • MATERIALS ENGINEERS



⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

SHEET: 5 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL ■ ENVIROMENTAL ■ MATERIALS ENGINEERS

⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

SHEET: 6 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL • ENVIROMENTAL • MATERIALS ENGINEERS

⌖ - APPROXIMATE SOIL BORING LOCATIONS

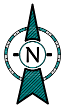
SOIL BORING LOCATION PLAN

SHEET: 7 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL ▪ ENVIROMENTAL ▪ MATERIALS ENGINEERS

⌖ - APPROXIMATE SOIL BORING LOCATIONS



SOIL BORING LOCATION PLAN

SHEET: 8 of 8 | DR: TSW | REV: | DATE: 09/27/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
PIONEER ROAD TO CAREFREE HIGHWAY
MARICOPA COUNTY, ARIZONA

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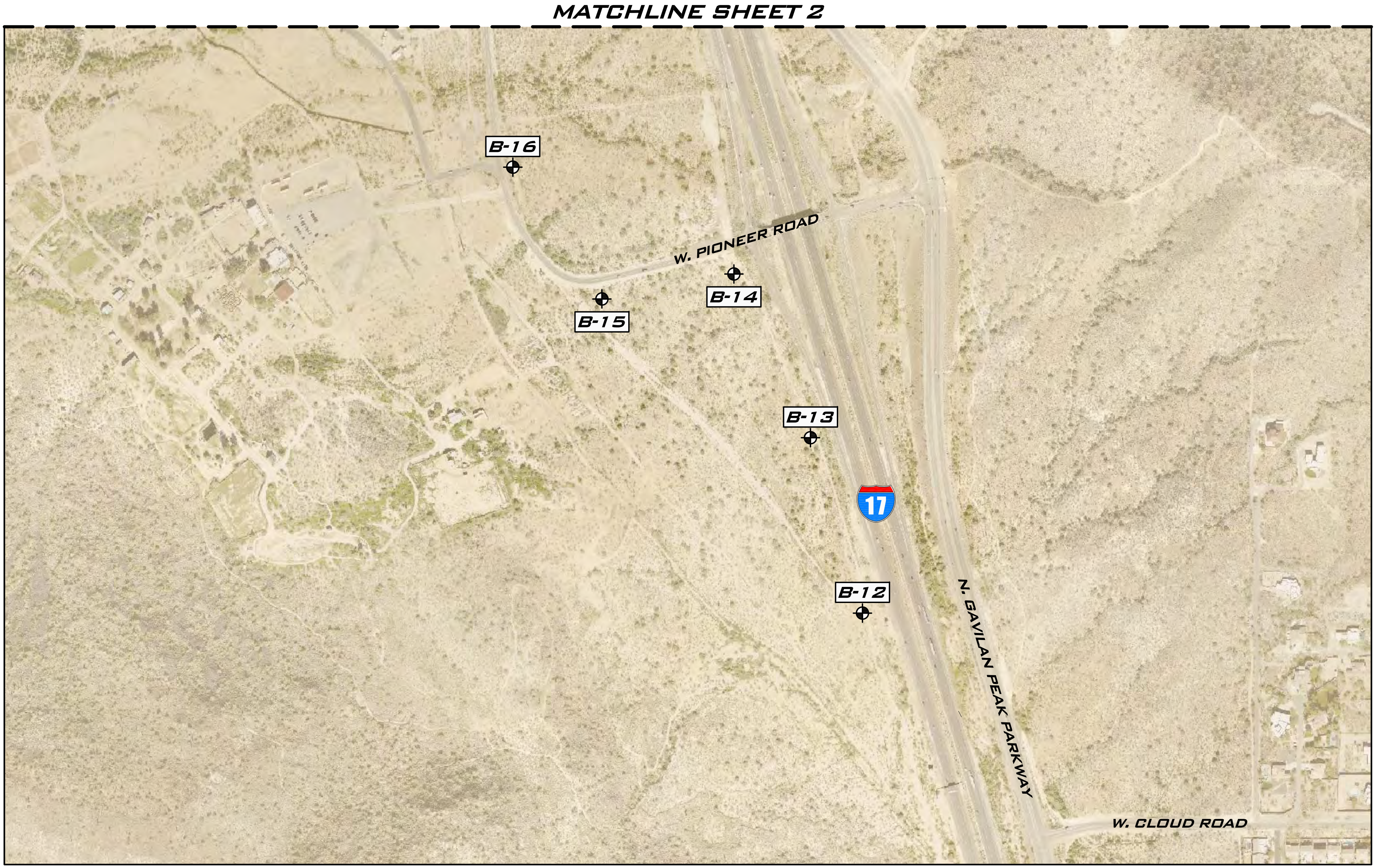


⌖ - APPROXIMATE SOIL BORING LOCATIONS

N

SOIL BORING LOCATION PLAN

SHEET: 1 of 2 | DR: TSW | REV: | DATE: 11/18/16 | PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
CLOUD ROAD TO LIFT STATION SITE (WEST I-17)
PHOENIX, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL ▪ ENVIROMENTAL ▪ MATERIALS ENGINEERS

⌖ - APPROXIMATE SOIL BORING LOCATIONS

SOIL BORING LOCATION PLAN

SHEET: 2 of 2
DR: TSW
REV:
DATE: 11/18/16
PROJECT NO. 161708SA

WEST ANTHEM WASTEWATER IMPROVEMENTS
CLOUD ROAD TO LIFT STATION SITE (WEST I-17)
PHOENIX, ARIZONA

SPEEDIE AND ASSOCIATES
GEOTECHNICAL▪ ENVIROMENTAL▪ MATERIALS ENGINEERS

SOIL LEGEND

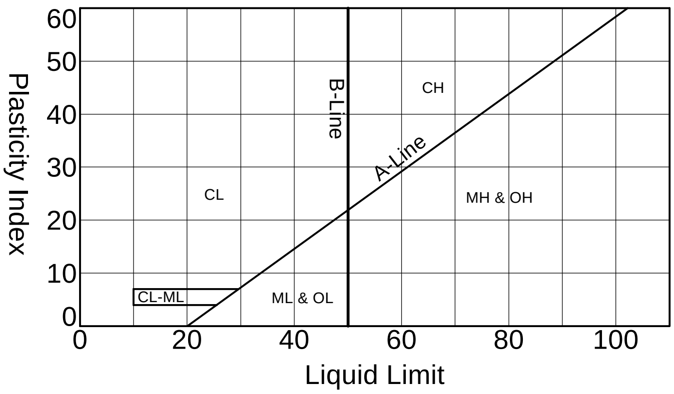
SAMPLE DESIGNATION	DESCRIPTION	
AS	**Auger Sample**	A grab sample taken directly from auger flights.
BS	**Large Bulk Sample**	A grab sample taken from auger spoils or from bucket of backhoe.
S	**Spoon Sample**	Standard Penetration Test (ASTM D-1586) Driving a 2.0 inch outside diameter split spoon sampler into undisturbed soil for three successive 6-inch increments by means of a 140 lb. weight free falling through a distance of 30 inches. The cumulative number of blows for the final 12 inches of penetration is the Standard Penetration Resistance.
RS	**Ring Sample**	Driving a 3.0 inch outside diameter spoon equipped with a series of 2.42-inch inside diameter, 1-inch long brass rings, into undisturbed soil for one 12-inch increment by the same means of the Spoon Sample. The blows required for the 12 inches of penetration are recorded.
LS	**Liner Sample**	Standard Penetration Test driving a 2.0-inch outside diameter split spoon equipped with two 3-inch long, 3/8-inch inside diameter brass liners, separated by a 1-inch long spacer, into undisturbed soil by the same means of the Spoon Sample.
ST	**Shelby Tube**	A 3.0-inch outside diameter thin-walled tube continuously pushed into the undisturbed soil by a rapid motion, without impact or twisting (ASTM D-1587).
--	**Continuous Penetration Resistance**	Driving a 2.0-inch outside diameter "Bullnose Penetrometer" continuously into undisturbed soil by the same means of the spoon sample. The blows for each successive 12-inch increment are recorded.

CONSISTENCY			RELATIVE DENSITY	
Clays & Silts	Blows/Foot	Strength (tons/sq ft)	Sands & Gravels	Blows/Foot
Very Soft	0 - 2	0 - 0.25	Very Loose	0 - 4
Soft	2 - 4	0.25 - 0.5	Loose	5 - 10
Firm	5 - 8	0.5 - 1.0	Medium Dense	11 - 30
Stiff	9 - 15	1 - 2	Dense	31 - 50
Very Stiff	16 - 30	2 - 4	Very Dense	> 50
Hard	> 30	> 4		

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	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
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, 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 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND 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
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL OR MODIFIED SYMBOLS MAY BE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS OR TO PROVIDE A BETTER GRAPHICAL PRESENTATION OF THE SOIL

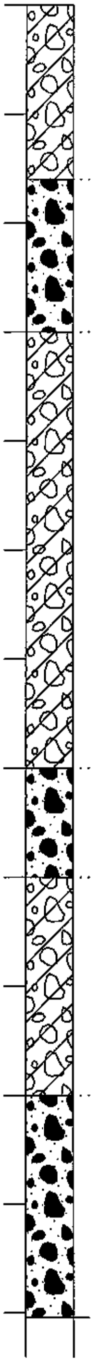
MATERIAL SIZE	PARTICLE SIZE			
	Lower Limit		Upper Limit	
	mm	Sieve Size ◆	mm	Sieve Size ◆
SANDS				
Fine	0.075	#200	0.42	#40
Medium	0.420	#40	2.00	#10
Coarse	2.000	#10	4.75	#4
GRAVELS				
Fine	4.75	#4	19	0.75" ×
Coarse	19	0.75" ×	75	3" ×
COBBLES	75	3" ×	300	12" ×
BOULDERS	300	12" ×	900	36" ×
◆U.S. Standard		×Clear Square Openings		



Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)

Graphic Log



Visual Classification

Depth (feet)	Visual Classification
0	Loose Brown <u>CLAYEY GRAVEL</u> (GC-Dry to Moist) with 1-5% Cobble
5	Very Dense, 5-15% Cobble
8.0	Very Dense Light Brown <u>WELL GRADED GRAVEL</u> (GW-Dry) with 10-20% Cobble
15.0	Very Dense Brown <u>CLAYEY GRAVEL</u> (GC-Dry to Moist) with 10-20% Cobble
25	5-15% Cobble
35.0	Very Dense Brown <u>WELL GRADED GRAVEL</u> (GW-Dry) with 5-15% Cobble
40.0	Very Dense Brown <u>CLAYEY GRAVEL</u> (GC-Dry) with 5-15% Cobble
50.0	Very Dense Brown <u>WELL GRADED GRAVEL</u> (GW-Dry) with 5-15% Cobble
60.2	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 – 25 – 50)
S-1	2.5	NT	NT	
S-2	6.3	NT	NT	77/9"
S-3	11.0	NT	NT	77/12"
S-4	15.8	NT	NT	97/9"
S-5	20.3	NT	NT	50/3"
S-6	25.5	NT	NT	50/6"
S-7	31.5	NT	NT	82/12"
S-8	35.3	NT	NT	50/4"
S-9	40.5	NT	NT	50/6"
S-10	45.4	NT	NT	50/5"
S-11	50.3	NT	NT	50/4"
S-12	55.8	NT	NT	97/9"
S-13	60.3	NT	NT	50/3"

Boring Date: **10-5-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 1**

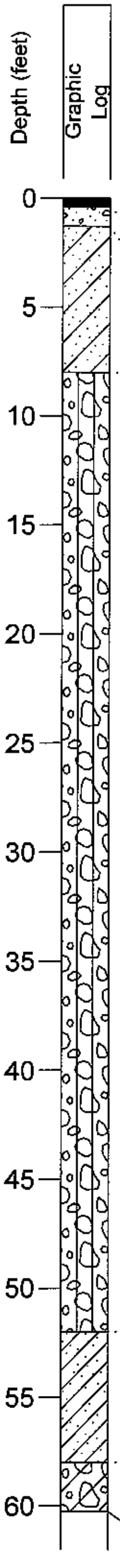
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

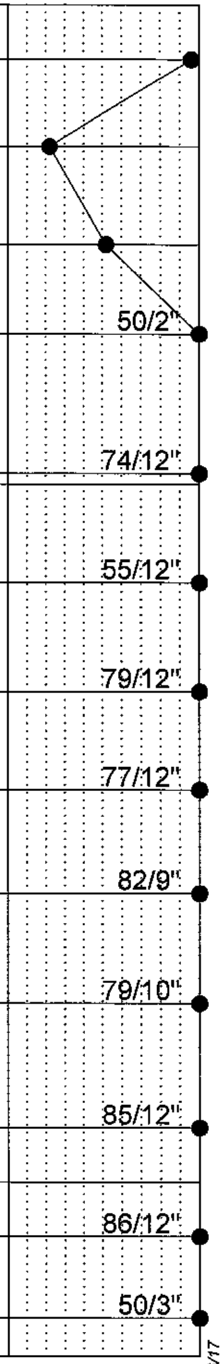
Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Visual Classification

Visual Classification	Depth
5" Asphalt Concrete	0.4
10" Aggregate Base	1.3
Dense Brown CLAYEY SAND (SC-Dry to Moist) with Some Gravel Medium Dense	8.0
Medium Dense Brown SILTY GRAVEL (GM-Dry to Moist) 1-5% Cobble Very Dense, 5-15% Cobble 1-5% Cobble Dry 5-15% Cobble Reddish Brown, 1-5% Cobble	52.0
Hard Brown SANDY LEAN CLAY (CL-Moist) with Little Gravel	58.0
Very Dense Brown CLAYEY GRAVEL (GC-Moist) with 5-15% Cobble	60.3
End of Boring	

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
RS-3	11.0	NT	NT	
S-4	15.1	NT	NT	50/2"
S-6	21.5	NT	NT	74/12"
~~BS-5~~	~~22.0~~	~~NT~~	~~NT~~	
S-7	26.5	NT	NT	55/12"
S-8	31.5	NT	NT	79/12"
S-9	36.0	NT	NT	77/12"
S-10	40.8	NT	NT	82/9"
S-11	45.8	NT	NT	79/10"
S-12	51.5	NT	NT	85/12"
AS-13	54.0	NT	NT	
S-14	56.5	NT	NT	86/12"
S-15	60.3	NT	NT	50/3"



Boring Date: **10-12-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 2**

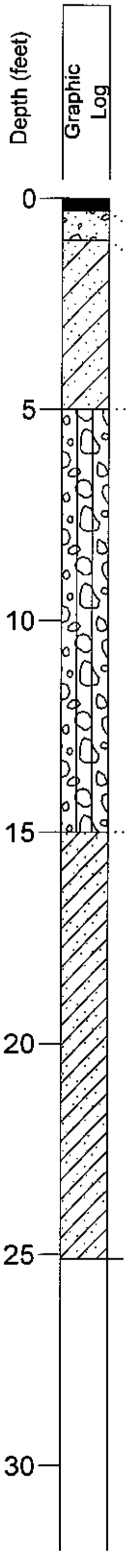
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

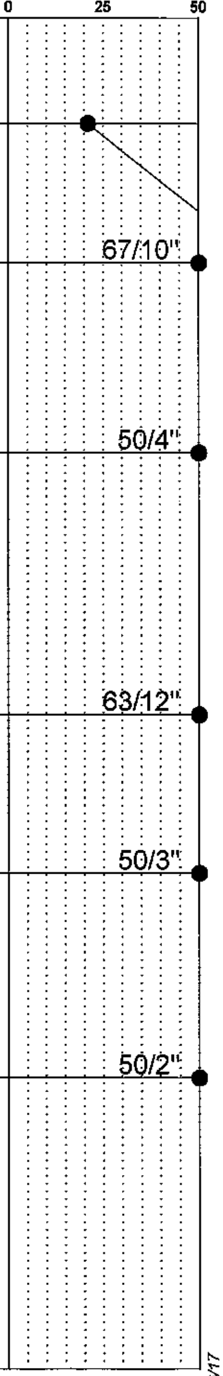


Visual Classification

Depth (feet)	Visual Classification
0.3	4" Asphalt Concrete
1.0	8" Aggregate Base
5.0	Medium Dense Brown CLAYEY SAND (SC-Dry to Moist) with Some Gravel
15.0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with Moderate Calcareous Cementation and 1-5% Cobble 5-15% Cobble
25.1	Hard Brown SANDY LEAN CLAY (CL-Dry) with Little Gravel and 1-5% Cobble

End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	5.8	NT	NT	67/10"
S-3	10.3	NT	NT	50/4"
S-4	16.5	NT	NT	63/12"
S-5	20.3	NT	NT	50/3"
S-6	25.1	NT	NT	50/2"



Boring Date: **10-14-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 3**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 – 25 – 50)
0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 1-5% Cobble					
		S-1	1.8	NT	NT	80/9"
3.0	Very Dense Light Brown CLAYEY GRAVEL (GC-Dry) with 1-5% Cobble					
		S-2	6.5	NT	NT	90/12"
8.0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble					
		S-4	10.8	NT	NT	67/10"
		BS-3	13.0	NT	NT	
15.8	End of Boring	S-5	15.8	NT	NT	72/9"

Boring Date: **10-7-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 4**

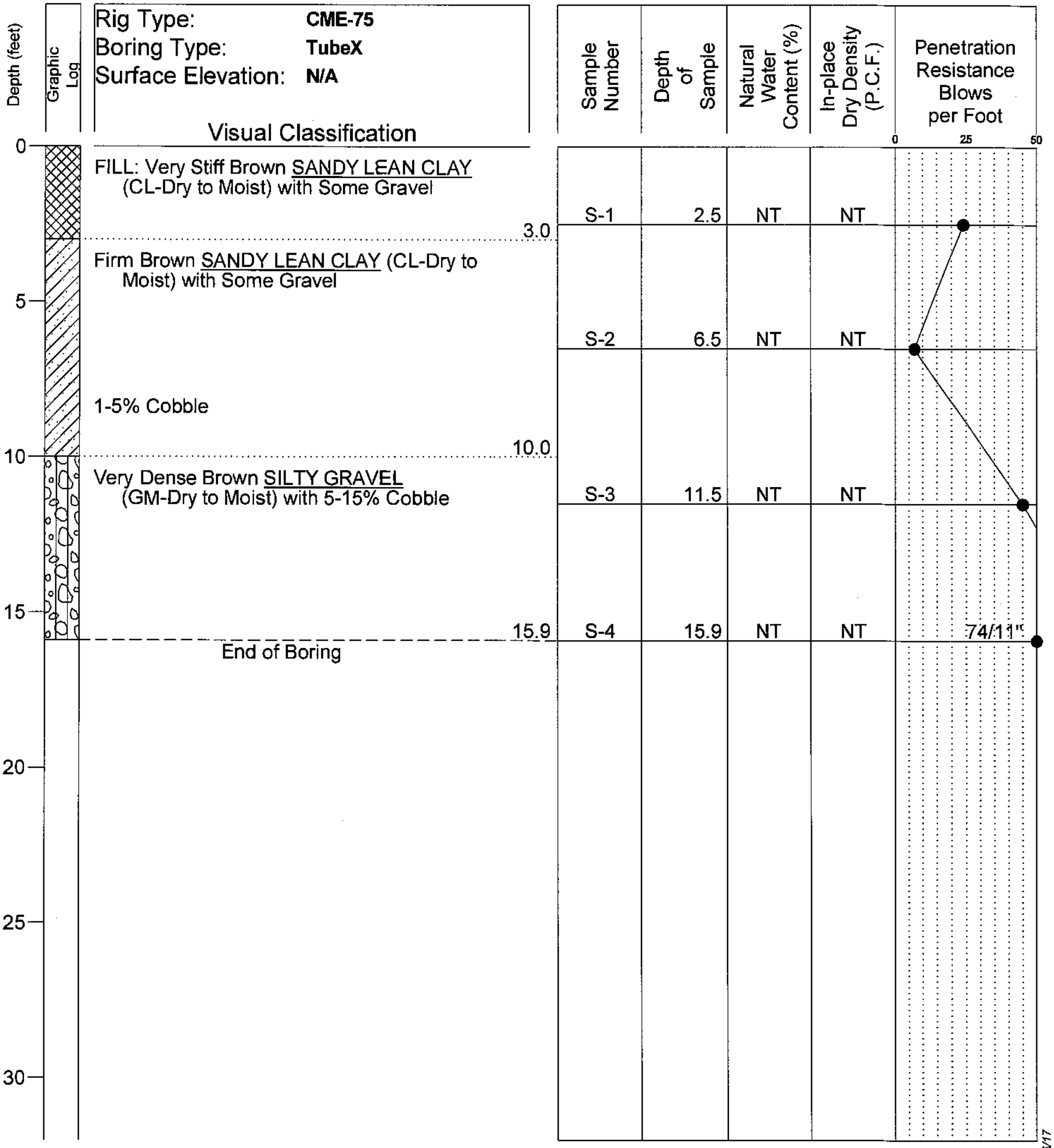
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Visual Classification

Depth (feet)	Visual Classification
0	FILL: Very Stiff Brown <u>SANDY LEAN CLAY</u> (CL-Dry to Moist) with Some Gravel
3.0	Firm Brown <u>SANDY LEAN CLAY</u> (CL-Dry to Moist) with Some Gravel 1-5% Cobble
10.0	Very Dense Brown <u>SILTY GRAVEL</u> (GM-Dry to Moist) with 5-15% Cobble
15.9	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
S-3	11.5	NT	NT	
S-4	15.9	NT	NT	74/11"

Boring Date: **10-7-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

▽
▼

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 5**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

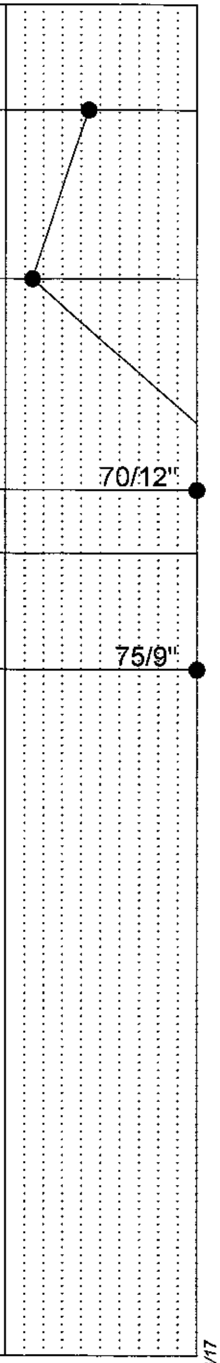
Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification
0	FILL: Very Stiff Brown SANDY LEAN CLAY (CL-Dry to Moist) with Some Gravel
3.0	Loose Light Brown SILTY SAND (SM-Dry to Moist) with Some Gravel
	1-5% Cobble
	Very Dense, Weak Calcareous Cementation
15.8	Moderate Calcareous Cementation
	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
S-4	11.5	NT	NT	70/12"
BS-3	13.0	NT	NT	
S-5	15.8	NT	NT	75/9"



Boring Date: **10-7-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 6**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

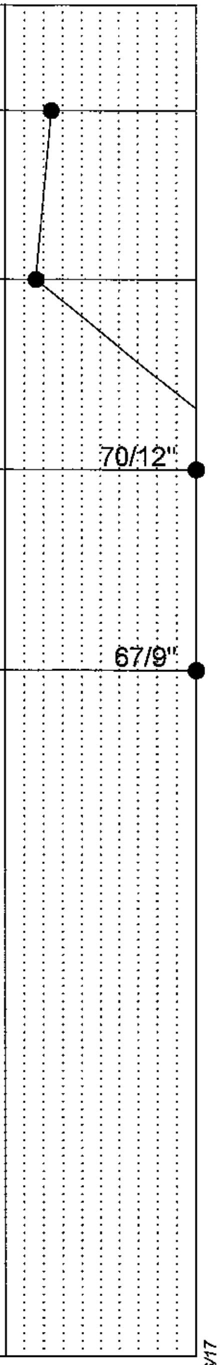
Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification
0	FILL: Stiff Brown SANDY LEAN CLAY (CL-Dry to Moist) with Some Gravel
3.0	Loose Brown SILTY SAND (SM-Dry to Moist) with some Gravel
	1-5% Cobble
	Very Dense, Weak Calcareous Cementation
13.0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 1-5% Cobble
15.8	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
S-3	11.0	NT	NT	70/12"
S-4	15.8	NT	NT	67/9"



Boring Date: **10-7-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 7**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

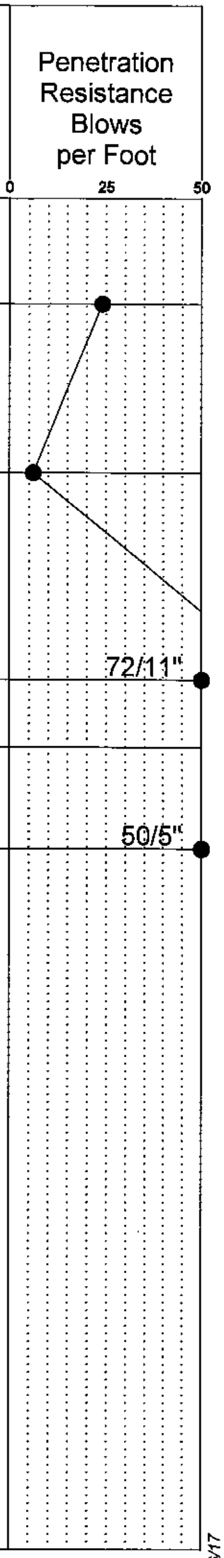
Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification
0 – 4.0	FILL: Very Stiff Brown SANDY LEAN CLAY (CL-Dry to Moist) with Little Gravel
4.0 – 8.0	Firm Brown SANDY LEAN CLAY (CL-Moist) with Little Gravel
8.0 – 15.4	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with Weak Calcareous Cementation and 1-5% Cobble
15.4	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
S-4	11.4	NT	NT	72/11"
BS-3	13.0	NT	NT	
S-5	15.4	NT	NT	50/5"



Boring Date: **10-7-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 8**

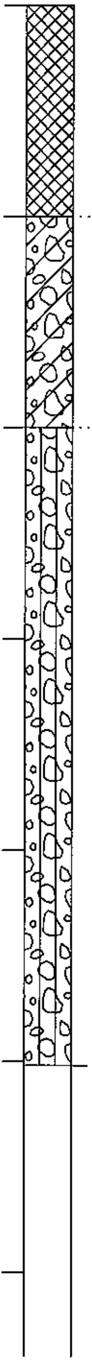
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

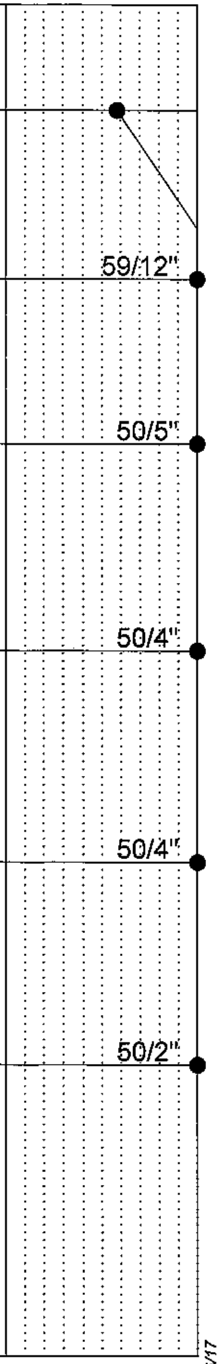
Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
0	FILL: Very Stiff Brown SANDY LEAN CLAY (CL-Dry to Moist) with Some Gravel	S-1	2.5	NT	NT	
5.0	Very Dense Brown CLAYEY GRAVEL (GC-Dry to Moist) with 1-5% Cobble	S-2	6.5	NT	NT	59/12"
10.0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble	S-3	10.4	NT	NT	50/5"
		S-4	15.3	NT	NT	50/4"
		S-5	20.3	NT	NT	50/4"
25.1	End of Boring	S-6	25.1	NT	NT	50/2"



Boring Date: **10-14-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B- 9**

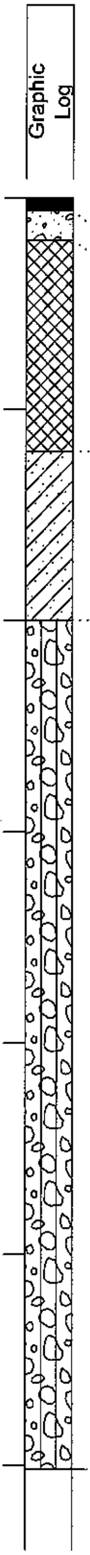
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

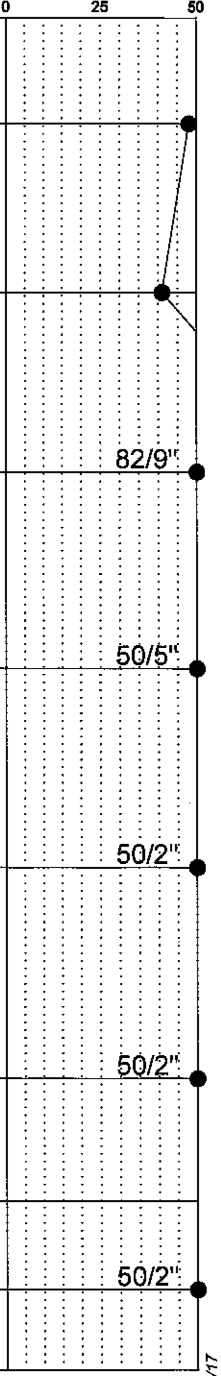
Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Visual Classification	Depth (feet)
4" Asphalt Concrete	0.3
8" Aggregate Base	1.0
FILL: Hard Brown SANDY LEAN CLAY (CL-Dry to Moist) with Some Gravel	6.0
Hard Brown SANDY LEAN CLAY (CL-Dry to Moist) with Some Gravel	10.0
Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 1-5% Cobble 5-15% Cobble	30.1
End of Boring	

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	
S-3	10.8	NT	NT	82/9"
S-4	15.4	NT	NT	50/5"
S-5	20.1	NT	NT	50/2"
S-7	25.1	NT	NT	50/2"
BS-6	28.0	NT	NT	
S-8	30.1	NT	NT	50/2"



Boring Date: **10-14-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-10**

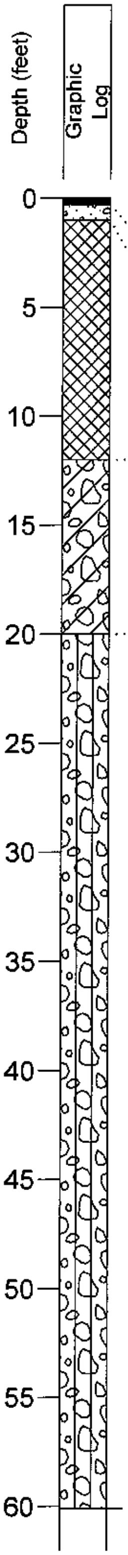
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

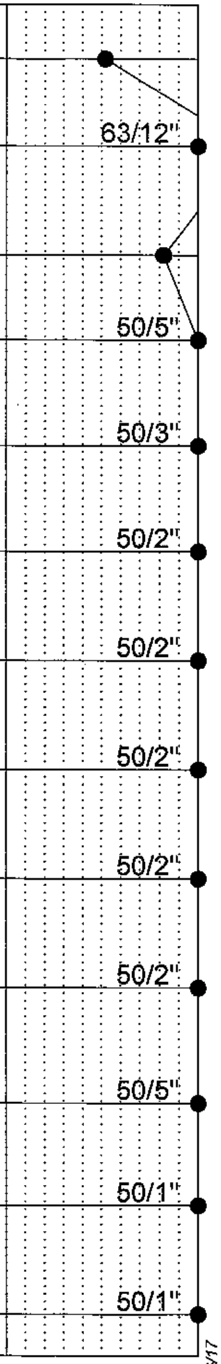
Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Visual Classification

4" Asphalt Concrete	0.3
8" Aggregate Base	1.0
FILL: Very Stiff Brown SANDY LEAN CLAY (CL-Moist) with Some Gravel Hard, Dry to Moist Dry	12.0
Very Dense Light Brown CLAYEY GRAVEL (GC-Dry) with Weak Calcareous Cementation and 1-5% Cobble	20.0
Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble Possible Bedrock	60.1
End of Boring	

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	63/12"
S-3	11.5	NT	NT	
S-4	15.4	NT	NT	50/5"
S-5	20.3	NT	NT	50/3"
S-6	25.1	NT	NT	50/2"
S-7	30.1	NT	NT	50/2"
S-8	35.1	NT	NT	50/2"
S-9	40.1	NT	NT	50/2"
S-10	45.1	NT	NT	50/2"
S-11	50.4	NT	NT	50/5"
S-12	55.1	NT	NT	50/1"
S-13	60.1	NT	NT	50/1"



Boring Date: **10-13-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

∇ ▼

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-11**

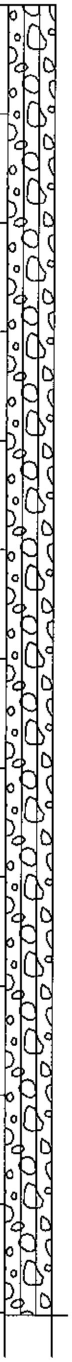
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Depth (feet)	Visual Classification
0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble
25	Possible Bedrock
60.1	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 / 25 / 50)
S-1	1.3	NT	NT	50/4"
S-2	5.3	NT	NT	50/6"
S-3	10.3	NT	NT	50/3"
S-4	15.3	NT	NT	50/3"
S-6	20.1	NT	NT	50/2"
~~BS-5~~	~~21.0~~	~~NT~~	~~NT~~	
S-7	25.1	NT	NT	50/1"
S-8	30.1	NT	NT	50/2"
S-9	35.1	NT	NT	50/2"
S-10	40.1	NT	NT	50/1"
S-11	45.1	NT	NT	50/1"
S-12	50.1	NT	NT	50/2"
S-13	55.1	NT	NT	50/1"
S-14	60.1	NT	NT	50/1"

Boring Date: **10-6-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

▽
▼

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-12**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 – 25 – 50)
0	Very Dense Light Brown SITLY GRAVEL (GM-Dry) with 5-15% Cobble					
		S-1	2.0	NT	NT	71/12"
5		S-2	5.5	NT	NT	50/6"
10		S-3	10.1	NT	NT	50/2"
15		S-4	15.1	NT	NT	50/2"
20	20.1 End of Boring	S-5	20.1	NT	NT	50/2"
25						
30						

Boring Date: **12-1-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-13**

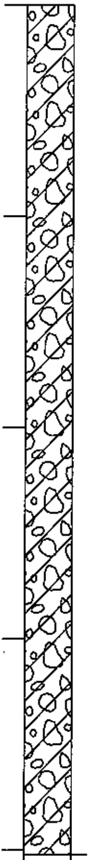
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 25 50)
0	Very Dense Light Brown CLAYEY GRAVEL (GC-Dry) with 5-15% Cobble	S-1	1.8	NT	NT	77/10"
5		S-2	5.1	NT	NT	50/2"
10	Reddish Brown	S-3	10.4	NT	NT	50/2"
15	Light Brown	BS-4	15.0	NT	NT	
		S-5	15.3	NT	NT	50/4"
20	20.1 End of Boring	S-6	20.1	NT	NT	50/2"
25						
30						

Boring Date: **12-1-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-14**

West Anthem Wastewater Improvements

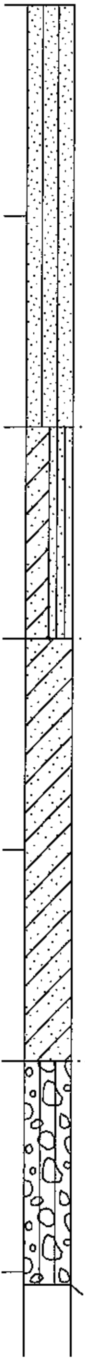
Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Visual Classification



0.0 – 10.0: Dense Light Brown SILTY GRAVEL (SM-Dry) with Some Gravel and Weak Calcareous Cementation

1-5% Cobble

Very Dense, White

10.0 – 15.0: Very Dense Reddish Brown SILTY, CLAYEY SAND (SC/SM-Dry) with Some Gravel and 1-5% Cobble

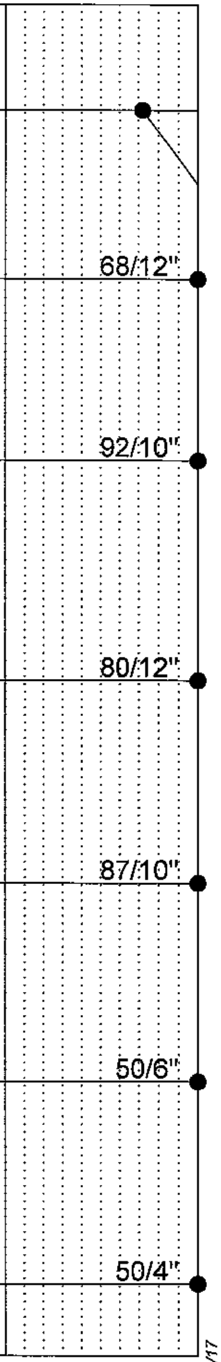
15.0 – 25.0: Very Dense Dark Brown CLAYEY SAND (SC-Dry) with Some Gravel and 1-5% Cobble

25.0 – 30.3: Very Dense Reddish Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble

Brown

30.3: End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
S-2	6.5	NT	NT	68/12"
S-3	10.8	NT	NT	92/10"
S-4	16.0	NT	NT	80/12"
S-5	20.8	NT	NT	87/10"
S-6	25.5	NT	NT	50/6"
S-7	30.3	NT	NT	50/4"



Boring Date: **11-30-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date	
Free Water was Not Encountered			∇
			▼

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-15**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot (0 / 25 / 50)
0	Very Dense Light Brown <u>SILTY GRAVEL</u> (GM-Dry) with 5-15% Cobble and Moderate Calcareous Cementation					
		S-1	2.0	NT	NT	66/12"
5		S-2	5.5	NT	NT	50/6"
10		S-4	10.4	NT	NT	50/5"
		BS-3	12.0	NT	NT	
15		S-5	15.4	NT	NT	50/5"
17.3	End of Boring	S-6	17.3	NT	NT	50/4"
20						
25						
30						

Boring Date: **12-1-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

▽ ▼

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-16**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**

Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
0	Very Dense Light Brown SILTY, CLAYEY SAND (SC/SM-Dry) with Some Gravel, 1-5% Cobble and Moderate Calcareous Cementation	S-1	2.3	NT	NT	50/3"
3.0	Very Dense Light Brown SILTY GRAVEL (GM-Dry) with 5-15% Cobble and Weak Calcareous Cementation	S-2	5.3	NT	NT	50/4"
10	Gray	S-3	10.3	NT	NT	50/4"
15		S-4	15.4	NT	NT	50/5"
18.3	End of Boring	S-5	18.3	NT	NT	50/4"

Boring Date: **12-1-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-17**

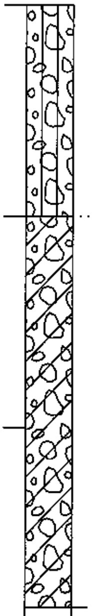
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

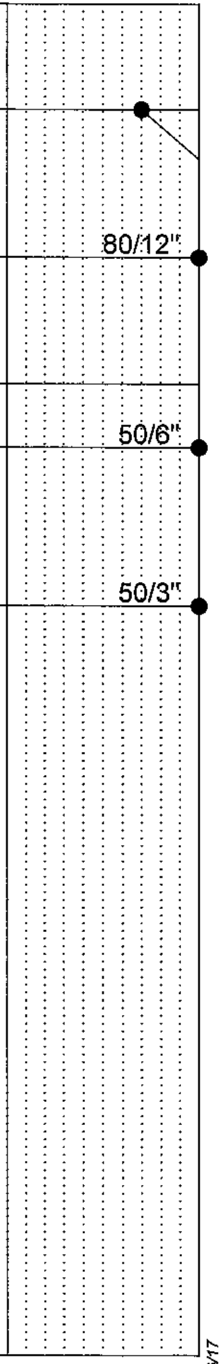
Anthem, Arizona

Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Depth (feet)	Visual Classification	Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
0	Dense Light Brown <u>SILTY GRAVEL</u> (GM-Dry) with 1-5% Cobble and Moderate Calcareous Cementation	S-1	2.5	NT	NT	
5.0	Very Dense Reddish Brown <u>CLAYEY GRAVEL</u> (GC-Dry) with 5-15% Cobble and Weak Calcareous Cementation	S-2	6.0	NT	NT	80/12"
		BS-3	9.0	NT	NT	
		S-4	10.5	NT	NT	50/6"
14.3	End of Boring	S-5	14.3	NT	NT	50/3"



Depth (feet): 0, 5, 10, 15, 20, 25, 30

Boring Date: **12-1-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-18**

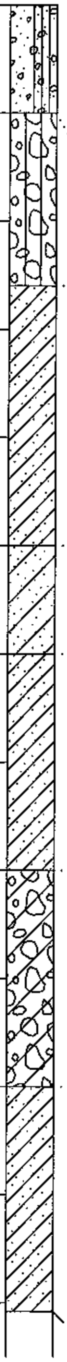
West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

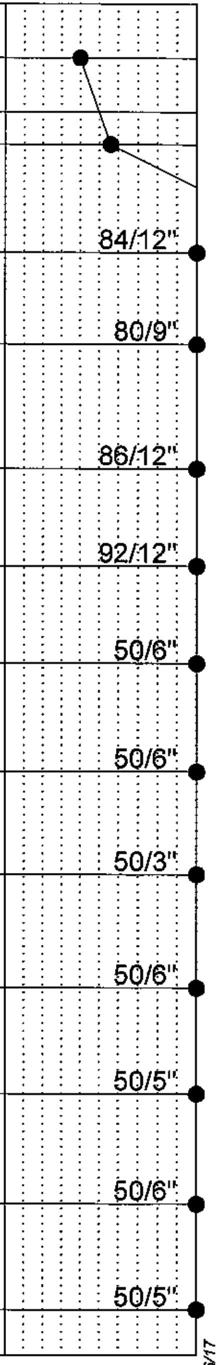
Project No.: **161708SA**

Rig Type: **CME-75**
Boring Type: **TubeX**
Surface Elevation: **N/A**



Depth (feet)	Visual Classification
0 – 5.0	Medium Dense Light Brown <u>WELL GRADED SAND with SILT</u> (SW/SM-Dry) with Some Gravel and Moderate Calcareous Cementation 1-5% Cobble
5.0 – 13.0	Medium Dense Light Brown <u>SILTY GRAVEL</u> (GM-Dry) with 1-5% Cobble and Moderate Calcareous Cementation Very Dense, 5-15% Cobble
13.0 – 25.0	Hard Reddish Brown <u>SANDY LEAN CLAY</u> (CL-Dry) with Little Gravel
25.0 – 30.0	Very Dense Brown <u>CLAYEY SAND</u> (SC-Dry) with Little Gravel
30.0 – 40.0	Hard Brown <u>SANDY LEAN CLAY</u> (CL-Dry) with Little Gravel
40.0 – 50.0	Very Dense Brown <u>CLAYEY GRAVEL</u> (GC-Dry) with 1-5% Cobble
50.0 – 60.4	Hard Brown <u>SANDY LEAN CLAY</u> (CL-Dry) with Little Gravel and Trace Limestone No Limestone Dark Brown
60.4	End of Boring

Sample Number	Depth of Sample	Natural Water Content (%)	In-place Dry Density (P.C.F.)	Penetration Resistance Blows per Foot
S-1	2.5	NT	NT	
BS-2	5.0	NT	NT	
S-3	6.5	NT	NT	
S-4	11.5	NT	NT	84/12"
S-5	15.8	NT	NT	80/9"
S-6	21.5	NT	NT	86/12"
S-7	26.0	NT	NT	92/12"
S-8	30.5	NT	NT	50/6"
S-9	35.5	NT	NT	50/6"
S-10	40.3	NT	NT	50/3"
S-11	45.5	NT	NT	50/6"
S-12	50.4	NT	NT	50/5"
S-13	55.5	NT	NT	50/6"
S-14	60.4	NT	NT	50/5"



Boring Date: **11-30-16**
Field Engineer/Technician: **R. Markley**
Driller: **Gabe**
Contractor: **Geomechanics SW**

Water Level

Depth	Hour	Date
Free Water was Not Encountered		

NT = Not Tested

SPEEDIE AND ASSOCIATES

Log of Test Boring Number: **B-19**

West Anthem Wastewater Improvements

Pioneer Road to Carefree Highway

Anthem, Arizona

Project No.: **161708SA**

TABULATION OF TEST DATA

SOIL BORING or TEST PIT NUMBER	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE INTERVAL (ft)	NATURAL WATER CONTENT (Percent of Dry Weight)	IN-PLACE DRY DENSITY (Pounds Per Cubic Foot)	PARTICLE SIZE DISTRIBUTION (Percent Finer)					ATTERBERG LIMITS			UNIFIED SOIL CLASSIFICATION	SPECIMEN DESCRIPTION
						#200 SIEVE	#40 SIEVE	#10 SIEVE	#4 SIEVE	3" SIEVE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX		
B- 2	BS-5	BULK	17.0 - 22.0	NT	NT	12	27	59	76	100	39	26	13	SW-SM	WELL-GRADED SAND with SILT and GRAVEL
B- 4	BS-3	BULK	8.0 - 13.0	NT	NT	2	15	52	64	100	NP	NP	NP	SP	POORLY GRADED SAND with GRAVEL
B- 6	BS-3	BULK	8.0 - 13.0	NT	NT	32	58	85	94	100	41	30	11	SM	SILTY SAND
B- 8	BS-3	BULK	8.0 - 13.0	NT	NT	24	46	71	83	100	27	24	3	SM	SILTY SAND with GRAVEL
B-10	BS-6	BULK	23.0 - 28.0	NT	NT	5	26	75	95	100	NP	NP	NP	SW-SM	WELL-GRADED SAND with SILT
B-12	BS-5	BULK	16.0 - 21.0	NT	NT	8	38	83	94	100	NP	NP	NP	SP-SM	POORLY GRADED SAND with SILT
B-14	BS-4	BULK	11.0 - 15.0	NT	NT	19	38	68	86	100	26	21	5	SC-SM	SILTY, CLAYEY SAND
B-16	BS-3	BULK	7.0 - 12.0	NT	NT	16	35	64	79	100	24	21	3	SM	SILTY SAND with GRAVEL
B-18	BS-3	BULK	4.0 - 9.0	NT	NT	11	34	69	82	100	NP	NP	NP	SW-SM	WELL-GRADED SAND with SILT and GRAVEL
B-19	BS-2	BULK	0.0 - 5.0	NT	NT	11	26	54	78	100	NP	NP	NP	SW-SM	WELL-GRADED SAND with SILT and GRAVEL

Sieve analysis results do not include material greater than 3". Refer to the actual boring logs for the possibility of cobble and boulder sized materials.

NT=Not Tested

Sheet 1 of 1

West Anthem Wastewater Improvements
Pioneer Road to Carefree Highway
Anthem, Arizona
Project No. 161708SA

SPEEDIE AND ASSOCIATES

CORROSIVE TEST DATA

SOIL BORING or TEST PIT NUMBER	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE INTERVAL (ft)	PERCENT FINER #200 SIEVE	pH	RESISTIVITY (Ohm-Centimeters)	PPM SULFATE (SO4)	PPM CHLORIDE (CL)	SULFIDE (+ or -)	REDOX (millivolts)	UNIFIED SOIL CLASSIFICATION	SPECIMEN DESCRIPTION
B- 2	BS-5	BULK	17.0 - 22.0	12	7.56	1176	3	17	NT	NT	SW-SM	WELL-GRADED SAND with SILT and GRAVEL
B- 4	BS-3	BULK	8.0 - 13.0	2	8.15	3668	3	41	NT	NT	SP	POORLY GRADED SAND with GRAVEL
B- 6	BS-3	BULK	8.0 - 13.0	32	7.54	567	18	160	NT	NT	SM	SILTY SAND
B- 8	BS-3	BULK	8.0 - 13.0	24	7.96	692	47	660	NT	NT	SM	SILTY SAND with GRAVEL
B-10	BS-6	BULK	23.0 - 28.0	5	7.96	8304	3	27	NT	NT	SW-SM	WELL-GRADED SAND with SILT
B-12	BS-5	BULK	16.0 - 21.0	8	8.22	9688	22	24	NT	NT	SP-SM	POORLY GRADED SAND with SILT
B-14	BS-4	BULK	11.0 - 15.0	19	8.26	3813	6	10	NT	NT	SC-SM	SILTY, CLAYEY SAND
B-16	BS-3	BULK	7.0 - 12.0	16	8.35	3075	3	7	NT	NT	SM	SILTY SAND with GRAVEL
B-18	BS-3	BULK	4.0 - 9.0	11	8.3	1799	15	36	NT	NT	SW-SM	WELL-GRADED SAND with SILT and GRAVEL

Sheet 1 of 1

West Anthem Wastewater Improvements
Pioneer Road to Carefree Highway
Anthem, Arizona
Project No. 161708SA

SPEEDIE
AND ASSOCIATES