Geotechnical and Pavement Engineering Report

Proposed Power Road Widening - Phase 3
Power Road from Riggs Road to Chandler Heights Road
Queen Creek, Arizona
August 8, 2022
Terracon Project No. 65215302

Prepared for:
Stantec
Chandler, Arizona

Prepared by:
Terracon Consultants, Inc.
Tempe, Arizona

EXPIRES 9/30/2023

August 8, 2022

Stantec
3133 West Frye Road, Suite 300
Chandler, Arizona 85266

Attn: Mr. Chris Eggers, P.E.
P: (480) 687-6063
E: Chris.eggers@stantec.com

Re: **Geotechnical and Pavement Engineering Report**
Proposed Power Road Widening - Phase 3
Power Road from Riggs Road to Chandler Heights Road
Queen Creek, Arizona
Terracon Project No. P65215302

Dear Mr. Eggers:

Terracon Consultants, Inc. (Terracon) has completed the Geotechnical and Pavement Engineering services for the above referenced project. This study was performed in general accordance with our Proposal Number P65215302 dated December 3, 2021. This geotechnical and pavement engineering report presents the findings of the results of the subsurface exploration and provides geotechnical and pavement engineering recommendations concerning the design of pavements for the project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
64485
EDDY F.
RAMIREZ
Date Signed 8/8/2022
ARIZONA, U.S.A.
EXPIRES 9/30/2023

Ramon Padilla

Eddy F. Ramirez, P.E.
Geotechnical Group Manager

Ramon Padilla, P.E.
Geotechnical Department Manager

Copies to: Addressee (1 via email)

REPORT TOPICS PAGE NO.

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

List of Abbreviations

AASHTO ..... American Association of State Highway and Transportation
ABC ..... Aggregate Base Course
AC ..... Asphalt Concrete
ACI ..... American Concrete Institute
ADOT ..... Arizona Department of Transportation
ADT ..... Average Daily Traffic
ADWR ..... Arizona Department of Water Resources
AR ..... Asphalt Rubber
ASTM ..... American Society for Testing and Materials
CMP ..... Corrugated Metal Pipe (culvert)
ESAL ..... Equivalent Single 18-kip Axle Load
GI ..... AASHTO Group Index
GF or OGF ..... Growth Factor or Overall Growth Factor
MAG ..... Maricopa Association of Governments
MCDOT ..... Maricopa County Department of Transportation
M_R ..... Resilient Modulus
MSL or AMSL ..... Mean Sea Level or Above Mean Sea Level
OSHA ..... Occupational Safety and Health Administration
PI ..... Plasticity Index
PCCP ..... Portland cement concrete pavement
pcf ..... Pounds per cubic foot
ppm ..... Parts per million
psf ..... Pounds per square foot
psi ..... Pounds per square inch
PSI ..... Present Serviceability Index
SN ..... Structural Number
SPT ..... Standard Penetration Test
TEF ..... Traffic Equivalency Factor

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INTRODUCTION

This report presents the results of our geotechnical and pavement engineering services performed for the Proposed Power Road Widening – Phase 3 Project in the Town of Queen Creek, Arizona. The proposed widening includes Power Road from Riggs Road to Chandler Heights Road. The purpose of our engineering services is to provide information and geotechnical and pavement engineering recommendations relative to the following:

- Subsurface soil conditions
- Earthwork
- Pavement design and construction
- Groundwater conditions
- Seismic considerations
- Pavement materials specifications

Our geotechnical engineering scope of work for this project included the following:

- Three (3) test borings advanced to a depth of approximately 5 feet below the existing ground surface;
- Pavement evaluation observations at three (3) boring locations;
- Two (2) double ring infiltration tests at selected locations of the planned storm drainage basin areas;
- Laboratory testing of soil samples;
- Geotechnical and pavement engineering analyses; and,
- Preparation of this report

Terracon previously completed geotechnical engineering services for Power Road Widening – Phase 2. Borings B-8 and B-9 completed in Phase 2 extend within the project limits for Phase 3. The boring logs and associated laboratory testing results from Borings B-8 and B-9 are included as part of this report.

A map showing the proposed project alignment is shown on the attached **Site Location** (Exhibit A-1). The **Exploration Plan** showing the approximate boring and infiltration test locations are included as Exhibit A-2 in Appendix A. A log of each boring is included in the **Exploration Results** section of this report (and are designated as Exhibits A-5 through A-9). The double ring infiltration test results are also presented in the **Exploration Results** section of this report (and are designated as Exhibits A-10 and A-11). The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are presented as Exhibits B-1 through B-10 in the **Exploration Results** section of this report, and laboratory test results are also summarized on the boring logs. Design worksheets for the pavement design are included as Exhibits C-1 through C-4 in the **Pavement Design** section of this report.

PROJECT DESCRIPTION

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Project Description and Proposed Construction</td><td>The planned roadway improvements for the Proposed Power Road Widening – Phase 3 will be along Power Road from Riggs Road to Chandler Heights Road. The project will include 1 mile of widening of the existing two-lane roadway to a five-lane roadway. The widening will be constructed on both sides of the existing asphalt paved roadway. We understand the project will be evaluated for a mill and overlay of the existing travel lanes. We understand the project will also include proposed storm-water retention basins and concrete lined channel on the east side of the roadway. We understand the depth of the concrete lined channel will be approximately 4 to 5 feet.</td></tr>
<tr><td>Proposed Structures</td><td>None are planned.</td></tr>
<tr><td>Traffic Data</td><td>Traffic data for the project was provided by the Town of Queen Creek including the Town of Queen Creek, Multimodal Transportation Master Plan, Final Report, dated December 2016. The following is a summary of the current traffic and roadway information for the project:
Roadway Classification and Number of Lanes:
■ Power Road is classified as a minor arterial roadway and is proposed to include 5 lanes (2 lanes in each direction and either an additional center turn lane or raised median).

Roadway Average Daily Traffic (ADT) two-way traffic volumes:
<table><tr><th>Roadway</th><th>2015</th></tr><tr><td>Power Road</td><td>10,400</td></tr></table>
Based on information provided by the Town of Queen Creek, we understand the growth rate from 2015 to 2025 is estimated at 5% and after 2025 is estimated at 2%. Based on information provided, we understand the percent truck traffic for the proposed roadway improvements is estimated at 5%. We understand the 20-year design period for the project is from 2023 to 2043. Based on the information provided, the design traffic volumes were extrapolated for the project design period.</td></tr>
<tr><td>Storm-water Retention</td><td>Storm-water retention basins are planned be located at selected locations along Power Road. We understand the depth of the bottom of the retention basin will be approximately 3 feet below grade.</td></tr>
</table>

Item	Description
Grading	We understand the proposed finished grades at the site are anticipated to remain about the same. Therefore, cuts and fills for the new pavement are anticipated to be minimal (of a few feet or less). We anticipate cuts on the order of 3 feet in planned retention basin areas, and cuts of 4 to 5 feet in the planned concrete lined channel areas.

SITE CONDITIONS

Item	Description
Parcel Information	The planned roadway improvements for the Proposed Power Road Widening – Phase 3 is located along Power Road from Riggs Road to Chandler Heights Road in Queen Creek, Arizona. See **Site Location** (Exhibit A-1) and **Exploration Plan** (Exhibit A-2) for additional site location information.
Existing Improvements	Power Road is oriented north-to-south with one lane of traffic in each direction. At the intersections of Power Road with Chandler Heights and Riggs Roads, Power Road gradually widens to accommodate left and right turn lanes.
Current ground cover	The existing ground cover at the site consists of asphalt paved roadways with graded shoulders generally followed by residential, commercial, and tree farm properties and vacant land.
Existing topography	Appears to be relatively flat with a gentle slope down towards the north. Aerial mapping indicates the ground surface elevation on the south end of the project to be roughly 1,394 feet above Mean Sea Level (MSL), and roughly 1,358 feet above MSL on the north end of the project.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

The field exploration for the project consisted of a total of 5 borings, with 3 borings were drilled at the project site on May 25, 2022 and 2 borings previously completed as part of the Phase 2 exploration were drilled on May 8, 2019. The approximate boring locations are shown on the **Exploration Plan** (Exhibit A-2) and are summarized in the following table:

Number of Explorations	Boring ID Nos.	Boring Depth (feet)	Planned Location
2	B-8 and B-9	5 and 5½	Power Road – Existing Pavement (from Phase 2)
3	B-301 through B-303	5	Power Road – Existing Pavement

Boring Layout and Elevations: Terracon personnel provided the proposed boring layout to Stantec prior to the field exploration. Coordinates for each boring were obtained with a handheld GPS unit (with estimated horizontal accuracy of about ±15 feet). If elevations and a more precise boring layout are desired, we recommend the borings be surveyed.

Subsurface Exploration Procedures: The borings were advanced with either a truck-mounted D-120 or CME-85 drill rig utilizing 8-inch outside diameter hollow-stem augers. At selected intervals, samples of the subsurface materials were taken at each boring location by driving split-spoon (SPT) or ring-lined barrel samplers in general accordance with ASTM Standards. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. A 3-inch O.D. and 2.5-inch I.D. ring lined sampler was used for sampling in the soil borings. Ring-lined, split-barrel sampling procedures are similar to standard split spoon sampling procedure; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. Bulk samples of subsurface materials were obtained from all the borings. Groundwater was not encountered during drilling and sampling. For safety purposes, Borings B-8 and B-9 were backfilled with auger cuttings, Borings B-301 through B-303 were backfilled with auger cuttings mixed with cement, and the pavement at all the boring locations were patched with cold patch asphalt concrete after their completion.

Our exploration team prepared field boring logs as part of the drilling operations. The sampling depths and other sampling information were recorded on the field boring logs. These field logs included visual classifications of the materials encountered during drilling, and our interpretation of the subsurface conditions between samples. The bulk samples were taken to our soil laboratory for testing and classification by a geotechnical engineer. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Exhibit A-4 in the **Exploration Results** section of this report. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory testing was performed on selected soil samples and the test results are presented in the **Exploration Results** (B-1 through B-10). These results were used for the geotechnical and pavement engineering analyses. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Atterberg Limits
- Moisture Content
- R-Value
- Remolded Swell
- Soluble Sulfate
- Soluble Chloride
- Sieve Analysis
- Dry Density
- Moisture Density Relationship
- pH
- Minimum Resistivity

SUBSURFACE CONDITIONS

Geology

The project area is located in the Basin and Range physiographic province ([1]Cooley, 1967) of the North American Cordillera ([2]Stern, et al, 1979) of the southwestern United States. The southern portion of the Basin and Range province is situated along the southwestern flank of the Colorado Plateau and is bounded by the Sierra Nevada Mountains to the west. Formed during middle and late Tertiary time (100 to 15 million years ago), the Basin and Range province is dominated by fault-controlled topography. These mountain ranges and valleys have evolved from generally complex movements and associated erosional and depositional processes.

Based on review of U.S. Geological Survey (USGS) geological maps, surficial geologic conditions mapped at the site consist of Holocene surficial deposits. These deposits consist of unconsolidated deposits associated with modern fluvial systems. This unit consists primarily of fine-grained, well-sorted sediment on alluvial plains, but also includes gravelly channel, terrace, and alluvial fan deposits on middle and upper piedmonts.

Land Subsidence and Earth Fissures

The site is located within the Eastern Metropolitan Phoenix area, portions of which have experienced historic and documented groundwater decline. The depletion of the groundwater table has resulted in compression of the aquifer material and the phenomenon known as areal subsidence. Earth fissures are fractures or cracks that form in alluvial basins due to substantial groundwater overdrafts that produce local subsidence. Based on a review of available Arizona Department of Water Resources (ADWR), the site is not within a mapped land subsidence area.

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[1] *Cooley, M.E., 1967,* ***Arizona Highway Geologic Map****, Arizona Geological Society.*
[2] *Stern, C.W., et al, 1979,* ***Geological Evolution of North America****, John Wiley & Sons, Santa Barbara, California.*

Earth fissures develop within land subsidence areas where a significant thickness of compressible alluvium overlies shallow irregular bedrock surfaces such as ridges and fault scarps or other subsurface features. Based on a review of the Earth Fissure Map of the Chandler Heights Study Area: Maricopa County, Arizona ([3]AZGS, 2019) prepared by the AZGS, there are no earth fissures mapped at the project site. The nearest mapped earth fissure is approximately 1¼ miles southeast of the project alignment.

Subsurface Profile

Specific conditions encountered at each of the boring logs presented in the attached **Exploration Results** (Exhibits A-5 through A-9). Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. The following table summarizes the pavement thicknesses observed and the subgrade soil conditions encountered.

Summary of Core Locations of Pavement Travel Lanes			
Location	**Approx. AC Thickness (inches)**	**Approx. ABC Thickness (inches)**	**Subgrade Soils Underlying the Existing Pavement Structure**
B-8	6.75	6.25	Fill: Silty Sand with Gravel (SM) followed by Native: Silty Sand with Gravel (SM)
B-9	7	7.5	Fill: Silty Sand with Gravel (SM) followed by Native: Clayey Sand (SC)
B-301	5.5	6	Silty Clayey Sand (SC-SM)
B-302	5.5	6	Clayey Sand (SC)
B-303	4.5	6.5	Silty Clayey Sand (SC-SM)

Based on conditions encountered in the borings, subsurface conditions on the project site can be generalized as follows:

[3] *Arizona Geological Survey (AZGS), 2019,* **Earth Fissure Map of the Chandler Heights Study Area: Pinal and Maricopa County Arizona,** *Digital Map Series – Earth Fissure Map 1, DM-EF-1 version 5.0.*

Description	Approximate Depth to Bottom of Stratum (feet)	Material Description	Relative Density / Consistency
Surface	0.9 to 1.1	Existing Pavement (AC & ABC)	---
Stratum 1[A]	2 to 3	Fill: Silty Sand with Gravel	Medium Dense
Stratum 2	5 to 5.5	Silty Clayey Sand, Clayey Sand, Silty Sand with Gravel	Loose to Medium Dense

A. Fill materials were encountered in Boring Nos. B-8 and B-9.

Laboratory Test Data

Laboratory tests were conducted on selected soil samples and the test results are presented as Exhibits B-1 through B-10 in the attached **Exploration Results** section of this report. Soil samples obtained from the borings were used for geotechnical and pavement engineering analysis for the proposed project. The following is a summary of laboratory testing performed on selected soils samples obtained from the borings:

The Atterberg limits test results of the near surface fill material and native soils encountered along the Power Road alignment generally exhibit non-plastic to low plasticity characteristics (with plasticity indices ranging from 0 to 8, with an average of 4). The gradation test results of these near surface soils indicate percent fines (percent passing the sieve No. 200) ranging from approximately 15 to 39 percent (with an average of 28).

Standard Proctor (ASTM D698) test results indicated maximum dry densities of the site soils ranging from approximately 114.7 to 127.2 pounds per cubic foot (pcf) at optimum moisture contents ranging from approximately 9.2 to 14.7 percent.

R-value testing indicated R-values of the subgrade soils ranging from approximately 60 to 75 with an average of 70.

The following table indicates the roadway subgrade soils classification based on the American Association of State Highway and Transportation Officials (AASHTO) soil classification system. Based on this classification, the pavement subgrade materials underlying the proposed new and existing roadway are generally considered to have Excellent to Good support characteristics for pavements.

SUBGRADE SOIL CLASSIFCATION				
Boring No.	Approx. Depth	USCS Classification	AASHTO Classification	AASHTO Group Index
B-8	1 – 2.5	SM	A-1-b	0
B-8	2.5 – 5	SM	A-1-b	0
B-301	1 – 5	SC-SM	A-4	0
B-302	1 - 5	SC	A-4	0
B-303	1 – 5	SC-SM	A-2-4	0

Note: The AASHTO Classifications indicate the following general subgrade support characteristics:

(green)	Indicates Excellent to Good Subgrade Support Characteristics
(yellow)	Indicates Fair Subgrade Support Characteristics
(red)	Indicates Fair to Poor Subgrade Support Characteristics

The AASHTO classification method provides for the calculation of a Group Index, which is used as a scale for rating soil quality within a group. The Group Index (GI) values from the laboratory testing are summarized in the table above. Based on the Group Index values, the subgrade soils are considered generally uniform along the project alignment.

The results of the laboratory testing including the correlated R-Values and tested R-Value are summarized in the following table:

SUMMARY OF CORRELATED AND TESTED R-VALUES						
Boring	Depth (ft.)	LL	PI	-#200	R-Value Tested	R-Value Correlated
B-8	1 – 2.5	0	0	15	--	70
B-8	2.5 – 5	21	2	15	--	70
B-301	1 – 5	22	7	39	75	45
B-302	1 – 5	30	8	37	74	43
B-303	1 – 5	22	4	33	60	58

Groundwater Conditions

Groundwater was not observed in any of the test borings at the time of our field exploration, nor when checked upon completion of drilling. These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times, or at other locations. Groundwater conditions can change with varying seasonal and weather conditions, and other factors

Based on information obtained from the Arizona Department of Water Resources – Groundwater Data website (https://gisweb.azwater.gov/waterresourcedata/GWSI.aspx), the depth to regional groundwater was measured in February 2, 2009 to be approximately 300 feet below the ground surface (approximate elevation of 1,092 feet above mean sea level) at an Arizona Department of Water Resources (ADWR) monitored well site (Local I.D.: D-02-06 36AAB) located southwest of the project site along Riggs Road.

Double Ring Test Results

Infiltration testing was conducted at planned storm-water retention basins areas at the locations shown on the attached **Exploration Plan** (Exhibit A-2). The infiltration testing was performed in general accordance with the ASTM D3385 *Standard Test Method for Infiltration Rate of Soil in Field Using Double-Ring Infiltrometer* test method. A backhoe and operator were subcontracted to excavate to a depth of approximately 3 feet below the existing ground surface at the infiltration test locations. Detailed test results of field measurements for each of the 2 double ring infiltration tests are shown on the attached **Exploration Results** (Exhibits A-10 through A-11). The double ring infiltration test field measurements are provided to aid with the design of the planed storm-water retention basins. We understand the storm-water retention basins design will be performed by others.

The field infiltration rates measured are based on the soil conditions encountered at the particular locations of the infiltration tests, and the actual infiltration rate may vary from the values reported here. The following table summarizes the field measurements of the double ring infiltration testing performed at the site:

Double Ring Test Results			
Test Hole	Depth (feet)	Soil Classification	Field Measurement of Infiltration Rate (inches/hour)
DR-1	3	Silty Clayey Sand	1.2
DR-2	3	Silty Clayey Sand	2.1

It should be noted that siltation and vegetation growth along with other factors may affect the infiltration rates of the on-site retention basin areas. The infiltration rates presented in this report are unfactored field measurements, and a de-rating factor should be applied to these infiltration rates during the design of the proposed storm-water retention basins (performed by others). The de-rating factors should be in accordance with the Town of Queen Creek Standards and the Maricopa County Drainage Policies and Standards.

We recommend that excavations for the retention basins be excavated with light weight equipment to help reduce compaction of the basin bottom surface which will ultimately be used for infiltration of storm water. Once constructed, no traffic should be allowed to travel across the basin bottom. It should be noted that compaction of the basin bottom will result in reduced infiltration rates. If compaction of the basin bottom does occur, the exposed surface should be scarified to a minimum depth of 8 inches and left uncompacted.

Expansion Potential

The near surface soils encountered at the site along the proposed roadway improvements were generally comprised of silty sand, silty clayey sand, and clayey sand. The plasticity characteristics of the near surface site soils sampled along the Power Road alignment were generally non-plastic to low plasticity. Our laboratory testing included performing standard laboratory moisture-density relationships (i.e. standard Proctor ASTM D698) and remolded swell tests on the near surface soils sampled from our borings. The remolded swell test results indicated an expansion potential of ranging from approximately 0.1 to 1.1 percent when compacted to approximately 95 percent of their maximum dry density (ASTM D698) at a moisture content of approximately 2 percent below optimum with 144 pounds per square foot (psf) surcharge. Based on the results of our field and laboratory testing, we anticipate these site soils to generally have a low expansion potential.

Corrosion Considerations

Laboratory testing was performed on select samples obtained from the field exploration for the project. The results of the laboratory testing are summarized in the following table:

Summary of Chemical Laboratory Testing					
Boring	**Depth (feet)**	**pH**	**Minimum Resistivity (ohm-cm)**	**Sulfates (ppm)**	**Chlorides (ppm)**
B-301	1 – 5	9.0	3,221	6	< 3
B-302	1 – 5	10.6	2,483	133	< 3
B-303	1 – 5	8.6	4,160	8	< 3

Based on the American Concrete Institute (ACI) Design Manual, Section 318, Chapter 19 (ACI 318), concentrations of Sulfates of less than 0.1 percent are considered to result in a low sulfate exposure. The concentration of sulfate indicated by the laboratory testing is anticipated to result in a low sulfate exposure to concrete placed at the site. Therefore, American Society for Testing and Materials (ASTM) Type I/II portland cement is considered suitable for concrete at the site in contact with similar soluble sulfate concentrations. In addition, the laboratory test results indicate the site soils indicate a chloride content below the chloride limits outlined in Chapter 19 of the ACI 318 for new concrete construction. The minimum resistivity testing indicates the site soils are moderately corrosive toward ferrous metals, especially when soils have high moisture contents. The laboratory test results indicate the pH of the site soils is in the typical to slightly high range for soils in the Phoenix metropolitan area.

These values should be used to help determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction. Refer to corrosion results report and Summary of Laboratory Results contained in the attached **Exploration Results** for the complete results of the corrosivity testing performed on the site soils in conjunction with this geotechnical exploration. The corrosion information presented is specific to the samples tested. If the actual soils that will be in contact with the structures at the site are different than those tested, then additional corrosion testing should be performed. Terracon is not a corrosion engineer, and our scope of work was limited to performing corrosion laboratory tests on selected samples, presenting these results, and providing a brief comparison of the results to selected criteria. A qualified corrosion engineer should be consulted if corrosion of underground utilities and structures is a concern.

PAVEMENT CONDITION EVALUATION

Pavement Condition Survey

The condition of the existing pavement was evaluated at 5 sample unit locations along the project alignment, representing coverage of approximately 5 to 10 percent of the total pavement area for the project. These locations were typically in the vicinity of each boring location. Sample units ranged from approximately 2,600 to 6,400 square feet of existing roadway area. The general locations and size of these pavement sample units are summarized as follows:

Sample Unit Number	Approximate Location	Nearest Boring Location(s)	Sample Area (ft^2)
1	Power Road, South of Chandler Heights Road	B-8	3,900
2	Power Road, South of Chandler Heights Road	B-9	2,600
3	Power Road, South of Chandler Heights Road	B-301	3,900
4	Power Road, North of Riggs Road	B-302	6,400
5	Power Road, North of Riggs Road	B-303	2,600

This pavement condition evaluation was based on the procedures outlined in ASTM D6433-11, *Standard Practice for Roads and Parking Lots Pavement Condition Index Surv*eys. Engineering observations of the pavements were performed on July 19, 2022. The engineering observations were made to determine the types, amounts and severity of existing pavement distress in the sample units selected along the alignment.

Pavement Distress

Distress observed in the pavements on the roadway can be grouped into three broad categories which include:

Category I	Category II
Structural Distress	**Climate/Durability Distress**
■ Alligator ■ Edge Cracking ■ Potholes	■ Longitudinal and Transverse Cracking ■ Block Cracking ■ Weathering & Raveling

Structural distress is considered the most detrimental to pavement condition and when present, will shorten pavement life when preventative maintenance or rehabilitation measures are not undertaken on a timely basis. Climate/durability related distress usually contributes to deterioration in pavement serviceability. While less detrimental than structural distress, maintenance measures are usually employed for climate/durability distress to maintain safe pavement conditions.

The distresses observed in the asphalt pavements occur in varying degrees and locations in the pavement along the alignment. Descriptions of the distresses that have occurred in the pavement are as follows:

- **Alligator Cracking**: Alligator cracking was observed at the sample units near borings B-8, B-9, B-302, and B-303. The alligator cracking on the roadway was generally of low to medium severity. Alligator cracking, a structural distress, is usually the result of loss of support for the pavement through a reduction in the strength of the subgrade soils. However, alligator cracking can also be caused as a result of load related failure from traffic due to inadequate pavement thickness. Without proper maintenance or rehabilitation, alligator cracking usually increases in severity and propagates over larger areas of the pavement with infiltration of water to subgrade soils beneath the surface.

- **Edge Cracking**: Edge cracking was observed at the sample units near borings B-8, B-9, B-302 and B-303. Edge cracks are parallel to, and usually within 1 to 1.5 feet of the outer edge of the pavement. Edge cracks can be caused by weak base or subgrade conditions near the edge of the pavement. The edge cracks observed in the sample units was low to medium in severity.

- **Potholes**: Potholes were observed at the sample unit near boring B-9. The potholes on the roadway were generally of low severity. Potholes are small, bowl-shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole. **Longitudinal and Transverse Cracking**: Longitudinal and transverse cracking of low severity were observed at the sample units near borings B-8 and B-9. These types of cracks may or may not be load-related and are usually the result of climate, pavement durability or construction related factors including poorly constructed paving lane joints or shrinkage of the asphalt surface due to low temperatures, hardening of the asphalt and/or daily temperature cycling. Without proper maintenance or rehabilitation, this type of cracking can progress to more severe forms of pavement distress including block or alligator cracking, as can be seen along several areas of the alignment.

- **Block Cracking**: Block cracking was observed at sample units near boring B-8, B-9, B-302, and B-303. The block cracking was generally of low to medium severity. Block cracking is interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from 1-foot by 1-foot to 10-feet by 10-feet. Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling) and is not load-related. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in non-traffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles.

- **Weathering & Raveling:** Weathering was observed at the sample units near borings B-8, B-9, B-301, B-302, and B-303. Weathering and raveling are the wearing away of the pavement surface due to a loss of asphalt or tar binder and dislodged aggregate particles. These distresses indicate that either the asphalt binder has hardened appreciable or that a poor-quality mixture is present. In addition, raveling may be caused by certain types of traffic, e.g., tracked vehicles. Softening of the surface and dislodging of the aggregates due to oil spillage are also included under raveling.

Pavement Condition Rating

The Pavement Condition Index (PCI) as referenced by the ASTM D6433 standard is calculated on the basis of deducting certain values based on the type, amount and severity of distress within a pavement sample. Theoretically, a newly constructed pavement, or one which has been recently rehabilitated to restore structural integrity, has a Pavement Condition Index of 100. Pavements with some level of distress have a PCI less than 100. The numerical index of PCI provides for an indication of overall pavement condition. Based on our engineering evaluation of pavement distress and the numerical procedures for determination of the PCI as outlined in the ASTM standard, the Pavement Condition Index (PCI) for each pavement section is summarized as follows:

Sample Number	Nearest Boring Location	Sample Area (ft^2)	PCI for Section	Composite PCI Rating per ASTM D6433
1	B-8	3,900	56	Fair
2	B-9	2,600	41	Poor
3	B-301	3,900	94	Good
4	B-302	6,400	51	Poor
5	B-303	2,600	31	Very Poor

PCI Range	0-10	11-25	26-40	41-55	56-70	71-85	86-100
PCI Rating	Failed	Serious	Very Poor	Poor	Fair	Satisfactory	Good

Pavement Evaluation Summary

For most pavements, there is an approximate decrease of 40% in pavement condition over the first 75% of the life of the pavement, the point at which quality reaches a critical level. At that approximate age and at the critical PCI, predictions usually indicate a rapid increase in rate of deterioration and a significant decrease in the remaining life expectancy of the pavement unless planned maintenance and rehabilitation strategies are implemented. The current PCI for the pavement varies from 31 to 94, ranging from a composite rating of Very Poor to Good. The overall rating from the 5 sample units is generally Poor. The rating of the pavement is attributable to a combination of age (primarily evidenced by the climate/durability related distress observed in the pavement, block cracking, etc.) and the structural distress (i.e. alligator cracking, edge cracks, and potholes, etc.).

ROADWAY PAVEMENT THICKNESS DESIGN

General

Geotechnical and pavement engineering recommendations for the construction of the pavements associated with the proposed roadway improvements are presented in the following sections. These recommendations are based on our understanding of the project, our engineering analysis and design, and the results of our field exploration and laboratory testing for the site.

Traffic Analysis

The traffic data presented in this report such as roadway classification, Average Daily Traffic (ADT), predicted growth rates, and truck percentages were obtained from information provided by the Town of Queen Creek and Stanley Consultants, Inc. The traffic data information provided to Terracon included the Town of Queen Creek (TOQC) Multimodal Transportation Master Plan Final Report dated December 2016.

Detailed design calculations regarding conversion of the traffic data to 18-kip Equivalent Single Axle Loads (ESALs) are included in the **Pavement Design** (Exhibits C-1) section of this report. The following table summarizes the information provided to Terracon:

Roadway Section	Street Classification	2015 ADT	Provided 2015 to 2025 Growth Rate (%)	Provided After 2025 Growth Rate (%)
Power Road from Riggs Road to Chandler Heights Road	Arterial	10,400	5	2

ADT information for 2023 and 2043 design period was not provided in the TOQC Multimodal Transportation Master Plan Final Report. Based on information provided by the Town of Queen Creek, the ADT for 2023 and 2043 projections were estimated based on the information outlined above. In addition, an average growth rate for the overall design period (from 2023 to 2043) was then estimated for the roadway section. The following table outlines the design period traffic data:

Roadway Section	Design Period (years)	Estimated 2023 ADT	Estimated 2043 ADT	Estimated 2023 to 2043 Average Growth Rate (%)
Power Road from Riggs Road to Chandler Heights Road	20	15,370	24,200	2.3

Based on information provided by the Town of Queen Creek, we understand the following truck and car percentages are anticipated for the project roadway:

Roadway Section	Truck Percentage (TEP 1.2) [A]	Car Percentage (TEP 0.0008) [A]
Power Road from Riggs Road to Chandler Heights Road	5%	95%
Note [A]: Traffic Equivalency Factor (TEF).		

We understand the above ADT data is for two-way direction, resulting in a Directional Distribution Factor of 50 percent. The project roadway is planned to be 2-lanes in each direction; therefore, a Lane Distribution Factor of 90 percent was selected. Based on this information, the initial two-way daily traffic ($W_{0(2-18)}$), in terms of 18-kip equivalent single axle loads (ESALs), was determined by multiplying the number of cars and trucks by their TEF. Based on the data shown above, we also calculated the Overall Growth Factor (OGF) for a 20-year design period. The initial two-way daily traffic and OGF we calculated for the proposed roadway improvements are the following:

$W_{0(2-18)}$ and OGF		
Roadway Section	Initial Two-Way Daily 18-Kip ESAL ($W_{0(2-18)}$)	OGF
Power Road	933.9	25.04

The 18-kip ESAL for the design period (W_{2-18}) was calculated by multiplying the initial 2-way daily 18-kip ESAL by the OGF and by 365 days. The resulting values were then multiplied by the Directional Distribution Factor and by the Lane Distribution Factor in order to determine the design lane 18-kip ESALs (W_{18}). The 2-way 18-kip ESALs for the design period and the design lane 18-kip ESALs for the proposed roadway improvements are the following:

$W_{0(2\text{-}18)}$ and OGF		
Roadway Section	**Two-Way 18-Kip Design ESAL ($W_{2\text{-}18}$)**	**Design Lane 18-kip ESALs (W_{18})**
Power Road	8,534,145	3,840,365

Pavement Subgrade Parameters

The design resilient modulus (M_R) for the pavement analysis was determined in accordance with the procedures of the MCDOT Roadway Design Manual. The methodology uses data from actual R-value tests as well as R-value data correlated with sieve and plasticity test results. Based on the results of the laboratory testing and our analysis of the AASHTO Group Index data, the subgrade conditions along the alignment of the proposed new pavements were averaged and a single design R-value was used along the entire length of the project. Samples of subgrade materials were tested for sieve analysis, plasticity index, and R-value. Based on the laboratory test results and in general accordance with the MCDOT Roadway Design Manual, the calculated mean R-value (R_{MEAN}) and corresponding soil resilient modulus (M_R) are shown in **Pavement Design** (Exhibit C-3) and are summarized in the following table:

R_{MEAN} and M_R		
Roadway Section	**Mean R- Value (R_{MEAN})**	**Resilient Modulus (M_R)**
Power Road	65.6	26,000 [A]
Note [A]: Maximum allowed by design procedure.		

Pavement Design Parameters

Analysis for the pavement design of the project were based on the procedures of AASHTO as modified by the MCDOT Roadway Design Manual. For purposes of the pavement design for the project, the roadway has been classified as an “Arterial” road in accordance with the MCDOT Roadway Design Manual. Based on this classification and other data outlined in this report, the following design parameters were determined by the procedures outlined in the MCDOT Roadway Design Manual and were utilized for pavement engineering analyses for the project.

Design Parameter		Per MCDOT Design Method
Analysis Period		20 years
Level of Reliability		95%
Standard Normal Deviate, Z_R		-1.645
Overall Standard Deviation		0.45
Serviceability	Initial (P_0) PSI	4.5
	Terminal (Pt) PSI	2.5
Seasonal Variation Factor		1.0
Layer Structural Coefficients	Asphalt Concrete (AC)	0.42
	Aggregate Base (ABC)	0.12
	*Asphalt Rubber (AR)	0.61
*Applicable to AR used in the top 1.5 inches of the pavement surface.		

Pavement Thickness Design Recommendations

Design calculations for the project incorporating the parameters outlined above are shown in **Pavement Design** (Exhibit C-3). As outlined in the *TOQC Design Standards & Procedures Manual, Standard Detail No. R-120, Roadway Cross Section – Pavement Structural Sections*, the minimum pavement structure section for Arterial Roadways is a 2-inch surface course (of A-12.5 asphalt concrete) followed by a 3-inch base course (of A-19 asphalt concrete) followed by 12 inches aggregate base. The corresponding structural number for the TOQC minimum pavement structure section is 3.54. Based on the results of the design calculations, the minimum Structural Number (SN) required for the project is summarized in the following table:

Pavement Design Summary				
Roadway Section	**Design ESALs (20 years)**	**Design Resilient Modulus (M_R in psi)**	**Calculated Structural Number Required (SN)**	**TOQC Minimum SN Required**
Power Road	3,840,365	26,000	2.83	3.54

Based on the TOQC Design Standards, a minimum structural number (SN) of 3.54 is required for roadways classified as Arterials. Accordingly, this minimum SN of 3.54 requirement controlled the selection of design alternatives for the roadway section outlined above. The following pavement structure alternatives were developed for consideration by Stantec and the TOQC for this project:

AC Recommended Pavement Section Alternatives for: Power Road from Chandler Heights Road to Riggs Road (Borings B-8 through B-303)			
Pavement Construction Item	**Thicknesses (inches)**		
	Alt. A (w/ AR)	**Alt. B (AC & ABC)**	**Alt. C (Full depth AC)**
AR ARAC (½-inch mix) (MAG 325)	1.5 *	--	--
AC Pavement (½-inch mix) (MAG 321)	--	2.0	2.5
AC Pavement (¾-inch mix) (MAG 321)	3.0	3.0	6.0 **
Aggregate Base Course (MAG 310)	12.0	12.0	--
Total Pavement Thickness:	**16.5**	**17.0**	**8.5**
Required Structural Number (SN):	3.54	3.54	3.54
Actual Structural Number (SN):	3.62	3.54	3.57

Note 1: The asphalt concrete for this project should be based on a gyratory mix. Asphalt Rubber (AR); Asphalt Concrete (AC); Aggregate Base Course (ABC).
Note 2: Alternative C shown in the table above are included only for comparison purposes.
*Note 3: The TOQC Standard Detail No. R-120 notes 1 inch of AR ARAC. 1.5 inches of AR ARAC is recommended for this project.
**Note 4: Two layers required based on MAG maximum lift thickness.

Site grading within the new pavement areas should be accomplished as recommended in this report. A compacted subgrade of on-site soils or imported soils with equal or greater supporting properties is assumed. In an effort to reduce water infiltration and retard premature oxidation of the surfacing, the pavement surface should be sealed after the first summer of use, and routinely thereafter.

Preliminary Economic Evaluation Alternatives

The MCDOT Pavement Design Guide recommends an economic evaluation of the pavement design alternatives for this project. These preliminary cost estimates were prepared based on unit rates provided by MCDOT and their corresponding price factors presented in Section 10.3 of the MCDOT Roadway Design Manual. The following table summarizes the estimated costs of each alternative section determined from our analyses:

PRELIMINARY EVALUATION OF ALTERNATIVES							
Pavement Construction Item	Thickness (in)			Unit Price ($/sy/in)	Costs Per Square Yard		
	Alt. A	Alt. B	Alt. C		Alt. A	Alt. B	Alt. C
325 Asphalt Rubber ARAC	1.5	---	---	$4.37	$6.55	---	---
321 Asphalt Concrete Pavement	3	5	8.5	$4.08	$12.23	$20.39	$34.67
310 Aggregate Base Course	12	12	---	$0.76	$9.11	$9.11	---
Total Estimated Cost Per Square Yard					**$27.90**	**$29.51**	**$34.67**

The results of this economic evaluations favor Alternative A for initial cost considerations followed in cost order by Alternatives B and C. Alternative C, where provided, is included only for comparison purposes. However, this evaluation only represents potential estimated initial costs and does not account for life-cycle costs which would include costs for future maintenance and rehabilitation efforts.

Existing Pavement Rehabilitation

Based on our observations for the pavement evaluation survey, the overall rating of the existing pavement condition along the project alignment included ratings of Satisfactory, Fair, Poor and Very Poor with an overall rating of Poor. Rehabilitation of the existing pavement as part of the planned improvements is not anticipated to be suitable based on the following:

- The existing pavement condition indicates the existing pavement section has a reduced structural number and reduced thicknesses. In addition, the pavement condition of generally poor further reduces the effective structural number of the existing pavement section.

- A comparison of the recommended new pavement structure sections and the existing pavement thicknesses indicate potential difficulties integrating the existing pavements. Improving the existing pavement to meet the required structural number for the anticipated traffic would require various types of improvements including milling, placement of new asphalt concrete to replace the milled depth, and placement of a few additional inches of new asphalt concrete to compensate for structural number delta between the existing effective structural number and the required structural number. The placement of these additional few inches above the milled depth would elevate the finished pavement elevation above the existing pavement elevation. As a note, the performance of rehabilitated pavement may not perform the same as an adjacent new pavement section, and if rehabilitation is considered additional maintenance on rehabilitated areas of the project should be anticipated. If pavement rehabilitation becomes part of the planned improvements, then a pavement rehabilitation study should be performed to outline the details on integrating the existing pavements with the proposed new improvements.

MATERIALS DESIGN

Materials Specifications

The use of Maricopa Association of Governments (MAG) 2020 Uniform Standard Specifications and Details for Public Works Construction as an amended by the TOQC are recommended for work on the project. Based on the recommendations outlined in this report, the specifications, at a minimum, should include those listed in the following table.

MAG Specification	Specification Title	Comments/Recommendations
201	Clearing and Grubbing	--
205	Roadway Excavation	--
206	Structure Excavation and Backfill	--
210	Imported Borrow	--
211	Fill Construction	All fills placed on the project should be compacted to a minimum of 95% of the maximum density determined in accordance with ASTM D698. Moisture conditioning the fill materials to within 2% of optimum moisture content is recommended.
301	Subgrade Preparation	--
310	Placement and Construction of Aggregate Base Course	For areas of the site that may need a leveling course.
321	Placement and Construction of Asphalt Concrete Pavement	½-inch and/or ¾-inch Gyratory Asphalt Mix for High Traffic Conditions is recommended for the asphalt concrete on this project in accordance with Table 710-4.
325	Placement and Construction of Asphalt-Rubber Asphalt Concrete	--
329	Tack Coat	Tack coat between AC layers.
702	Base Materials	For areas of the site that may need a leveling course, Aggregate Base Course on the project should conform to the requirements of Section 702.2.
710	Asphalt Concrete	½-inch and/or ¾-inch Gyratory Asphalt Mix for High Traffic Conditions is recommended to the asphalt concrete on this project in accordance with Table 710-4.

MAG Specification	Specification Title	Comments/Recommendations
601	Trench Excavation, Backfilling and Compaction	--

Upon request, Terracon is available to assist in the review and development of the final specifications for the project.

Site Preparation and Earthwork

We recommend that all other site preparation and earthwork on the project be undertaken under the applicable portions of MAG Specifications as amended by the TOQC. Recommended changes to these specifications as outlined in the preceding table should be included in the specifications or special provisions for the project.

Excavation Characteristics

It is anticipated that excavations within the upper 5 feet for the construction along the project roadway alignment can be accomplished with conventional earthmoving equipment capable of handling sandy silt and silty sand soils with variable amounts of gravel and possible cobbles. The subgrade soils exposed during construction are expected to be relatively stable provided adequate slopes or shoring is implemented. In some areas of the site, some sloughing of the soils should be anticipated due to the granular characteristics of the site soils. The stability of the subgrade may also be affected by precipitation, repetitive construction traffic or other factors.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottoms. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

Permanent Slope Recommendations

The following recommendations are presented for construction of new permanent slopes for the project. We recommend permanent unprotected cut and fill slopes be constructed at a gradient no steeper than 3H:1V (horizontal to vertical). For cut and fill slopes protected with slope paving, slopes no steeper than 2.5H:1V are recommended.

Earthwork Factors

The earthwork factors are based on a comparison of the in-situ dry densities from ring samples to the density of bulk samples compacted to 95 percent of maximum dry density as determined by ASTM D698. The estimated earthwork factors of the upper 2 to 5 feet of the site soils when used as compacted fill is expected to be in the range of -1% (swell) to 18% (shrinkage) with an estimated average of about 9% (shrinkage). These percentages are based on compacting the materials to a minimum of 95 percent of the maximum dry density determined in accordance with ASTM D698. These earthwork factor estimates are included in **Pavement Design** (Exhibit C-4) section of this report.

These estimates are general in nature, and are based on our experience, limited data from our field exploration, and the soil conditions we encountered at the site. Earthwork factors may vary dependent upon the actual subsurface conditions, which may include variations in soil gradations and gravel contents. Earthwork values are also expected to be less in areas subjected to lower levels of compaction or where the existing natural soils are denser. Conversely, earthwork values are also expected to be more in areas subjected to higher levels of compaction or where the existing natural soils are less dense.

A ground compaction factor of approximately 0.1 feet is anticipated when estimating the change in elevation of the native soil surface due to scarification, moisture conditioning and re-compaction prior to fill placement.

Grading and Drainage

To the extent possible, grades should provide effective drainage away from the proposed structures during and after construction. Water permitted to pond next to the pavements can result in moisture content increases in subgrade soils and consequently in premature deterioration of the pavement structure and increased maintenance.

Positive drainage should be provided during construction and maintained throughout the life of the proposed improvements at the site. Infiltration of water into trenches should be prevented during construction. We recommend that protective slopes be provided with a minimum grade of approximately 5 percent for at least 10 feet from the pavement structures. Backfill placed at the site should be well compacted and free of all construction debris to reduce the moisture infiltration.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLAN

EXHIBIT A-1: SITE LOCATION

Proposed Power Road Widening - Phase 3 ■ Queen Creek, Arizona
August 8, 2022 ■ Terracon Project No. 65215302

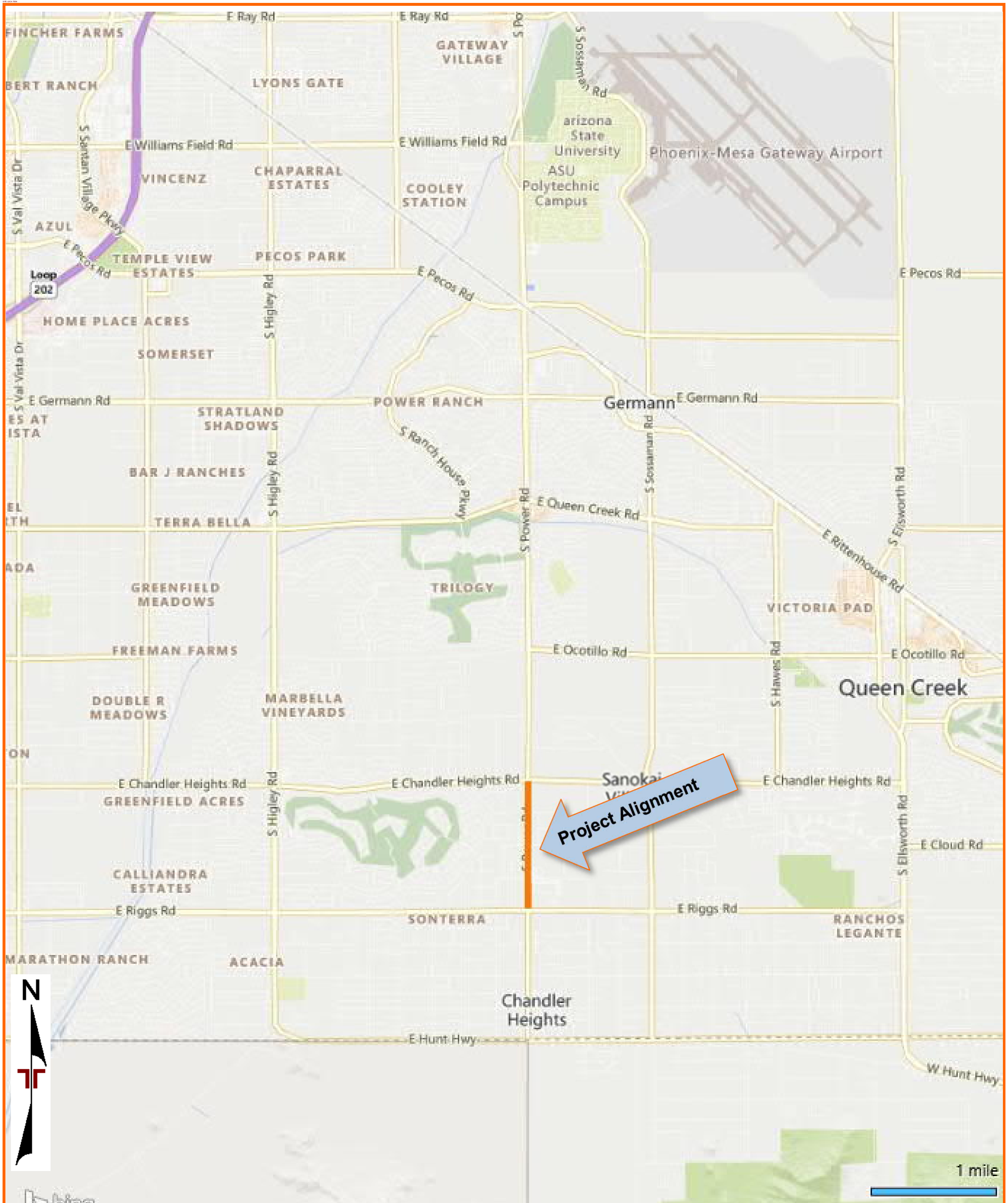


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXHIBIT A-2: EXPLORATION PLAN

Proposed Power Road Widening - Phase 3 ■ Queen Creek, Arizona
August 8, 2022 ■ Terracon Project No. 65215302

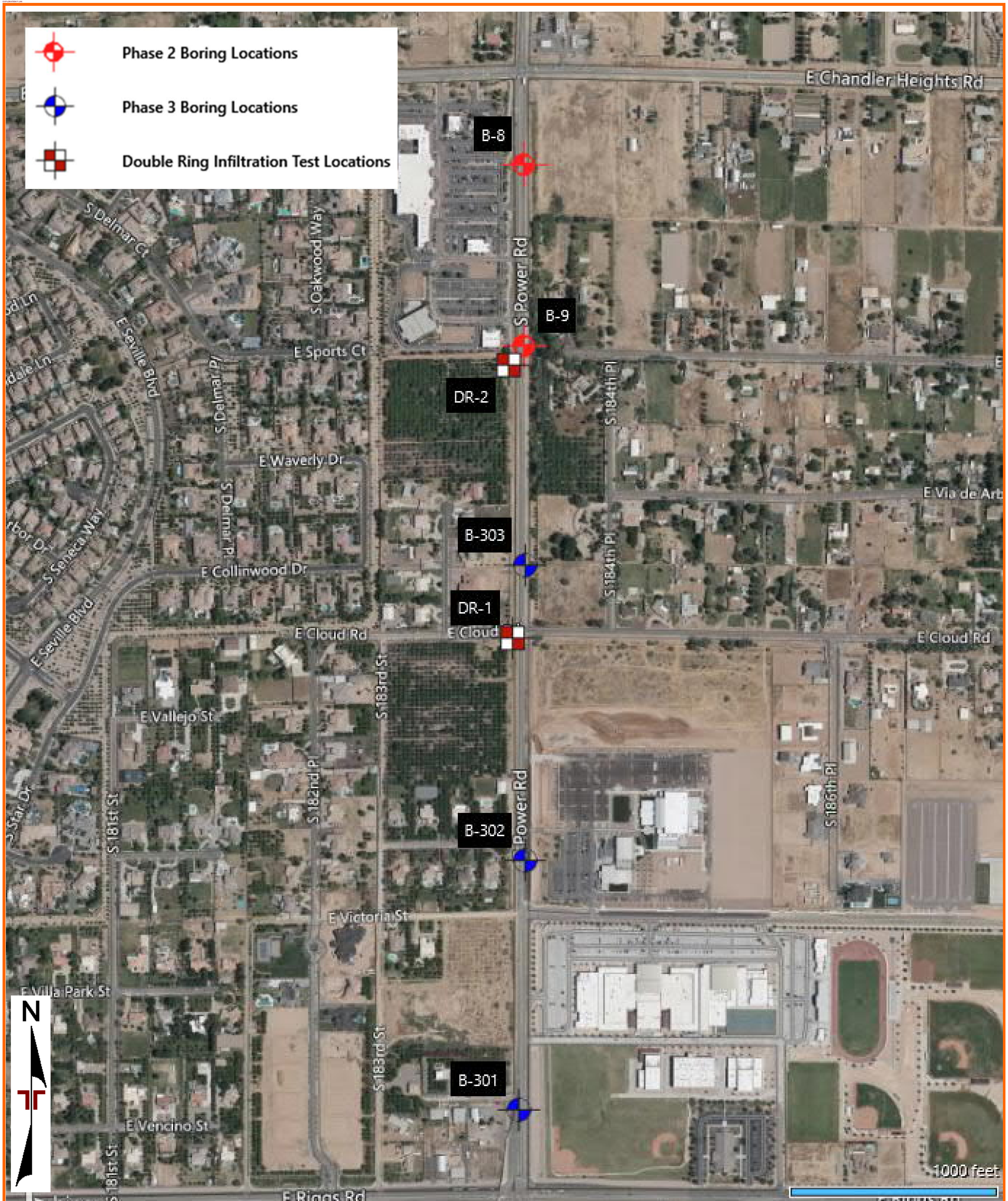


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Power Road Widening- Phase 3 ■ Queens Creek, Arizona

Terracon Project No. 65215302

SAMPLING	WATER LEVEL	FIELD TESTS
Auger Cuttings Ring Sampler Standard Penetration Test	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psi)**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 3.50	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	3.5 to 7.0	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium Stiff	7.0 to 14.0	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	14.0 to 28.0	8 - 15	10 - 18
Very Dense	> 50	> 99	Very Stiff	28.0 to 55.5	15 - 30	19 - 42
			Hard	> 55.5	> 30	> 42

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A” line [J]		CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

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

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

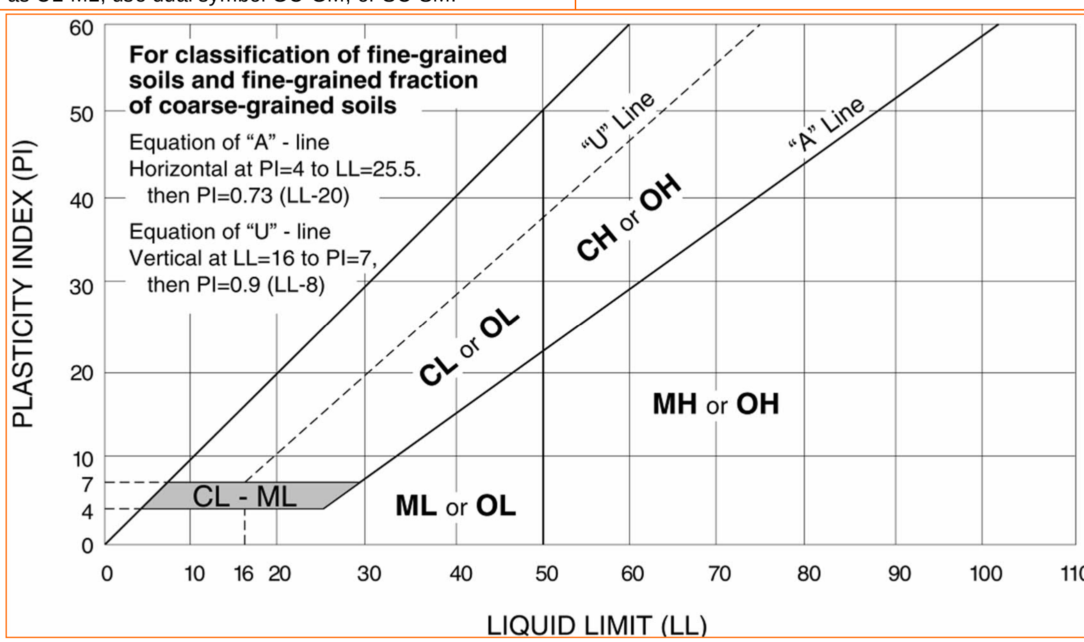
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



BORING LOG NO. B-8

PROJECT: Power Road Widening- Phase 3

CLIENT: Stantec Inc Chandler, AZ

SITE: Power Rd - Riggs Rd to Chandler Heights Rd Queens Creek, Arizona

LOCATION See Exploration Plan

Latitude: 33.2332° Longitude: -111.6858°

Approximate Surface Elev.: 1359 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.6	**ASPHALT CONCRETE**, Approximately 6.75 inches	1358.4+/-								
1.1	**AGGREGATE BASE COURSE**, Approximately 6.25 inches	1357.9+/-	1							
2.5	**FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse sand, fine gravel, nonplastic, medium dense	1356.5+/-	2			17-18	3.8	121	NP	15
5.5	**SILTY SAND WITH GRAVEL (SM)**, fine to coarse sand, fine gravel, low plasticity, medium dense loose	1353.5+/-	3 4 5			1-2-2 N=4			21-19-2	15

Boring Terminated at 5.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8" O.D. Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

Elevations were obtained from Google Earth Pro

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

Boring Started: 05-08-2019	Boring Completed: 05-08-2019
Drill Rig: D-120	Driller: D&S Drilling
Project No.: 65215302	Exhibit: A-5

BORING LOG NO. B-9

PROJECT: Power Road Widening- Phase 3

CLIENT: Stantec Inc
Chandler, AZ

SITE: Power Rd - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

LOCATION See Exploration Plan

Latitude: 33.2308° Longitude: -111.6858°

Approximate Surface Elev.: 1359 (Ft.) +/-

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.6	**ASPHALT CONCRETE**, Approximately 7 inches	1358.4+/-								
1.1	**AGGREGATE BASE COURSE**, Approximately 7.5 inches	1357.9+/-	1							
2.0	**FILL - SILTY SAND WITH GRAVEL (SM)**, fine to medium sand, fine gravel, low plasticity, brown	1357+/-	2							
			3			9-5-4 N=9				
5.0	**CLAYEY SAND (SC)**, trace gravel, low plasticity, brown, loose	1354+/-	4–5			3-5	6.8	98		

Boring Terminated at 5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8" O.D. Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

Elevations were obtained from Google Earth Pro

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

Boring Started: 05-08-2019	Boring Completed: 05-08-2019
Drill Rig: D-120	Driller: D&S Drilling
Project No.: 65215302	Exhibit: A-6

BORING LOG NO. B-301

PROJECT: Power Road Widening- Phase 3

CLIENT: Stantec Inc Chandler, AZ

SITE: Power Rd - Riggs Rd to Chandler Heights Rd Queens Creek, Arizona

LOCATION See Exploration Plan

Latitude: 33.2207° Longitude: -111.6859°

Approximate Surface Elev.: 1388 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**ASPHALT CONCRETE**, Approximately 5.5 inches	1387.5+/-								
1.0	**AGGREGATE BASE COURSE**, Approximately 6 inches	1387+/-	1							
	SILTY CLAYEY SAND (SC-SM), trace gravel, fine to coarse sand, fine gravel, low plasticity, brown, loose		2			5-5	7.5	111	22-15-7	39
			3							
5.0		1383+/-	4			4-4	8.7	106		
	Boring Terminated at 5 Feet		5							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8" O.D. Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings mixed with cement
Surface Capped with Asphalt

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

Elevations were obtained from Google Earth Pro

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

Boring Started: 05-25-2022	Boring Completed: 05-25-2022
Drill Rig: CME-85	Driller: Southlands Engineering
Project No.: 65215302	Exhibit: A-7

BORING LOG NO. B-302

PROJECT: Power Road Widening- Phase 3

**CLIENT: Stantec Inc
Chandler, AZ**

**SITE: Power Rd - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona**

LOCATION See Exploration Plan

Latitude: 33.2240° Longitude: -111.6858°

Approximate Surface Elev.: 1376 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**ASPHALT CONCRETE**, Approximately 5.5 inches	1375.5+/-								
1.0	**AGGREGATE BASE COURSE**, Approximately 6 inches	1375+/-	1							
	CLAYEY SAND (SC), trace gravel, fine to coarse sand, fine gravel, low plasticity, brown, loose		2			3-6	8.2	108	30-22-8	37
			3							
	medium dense		4			7-14	11.9	90		
5.0		1371+/-	5							
	Boring Terminated at 5 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8" O.D. Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings mixed with cement
Surface Capped with Asphalt

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

Elevations were obtained from Google Earth Pro

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

Boring Started: 05-25-2022	Boring Completed: 05-25-2022
Drill Rig: CME-85	Driller: Southlands Engineering
Project No.: 65215302	Exhibit: A-8

BORING LOG NO. B-303

PROJECT: Power Road Widening- Phase 3

CLIENT: Stantec Inc Chandler, AZ

SITE: Power Rd - Riggs Rd to Chandler Heights Rd Queens Creek, Arizona

LOCATION See Exploration Plan

Latitude: 33.2279° Longitude: -111.6858°

Approximate Surface Elev.: 1365 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.4	**ASPHALT CONCRETE**, Approximately 4.5 inches	1364.6+/-								
0.9	**AGGREGATE BASE COURSE**, Approximately 6.5 inches	1364.1+/-	1							
	SILTY CLAYEY SAND (SC-SM), trace gravel, fine to coarse sand, fine gravel, low plasticity, brown, medium dense		2			19-16	6.5	119	22-18-4	33
			3							
5.0		1360+/-	4			8-21	12.2	107		
	Boring Terminated at 5 Feet		5							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
8" O.D. Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings mixed with cement
Surface Capped with Asphalt

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

Elevations were obtained from Google Earth Pro

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

Boring Started: 05-25-2022	Boring Completed: 05-25-2022
Drill Rig: CME-85	Driller: Southlands Engineering
Project No.: 65215302	Exhibit: A-9

DOUBLE RING INFILTRATION TEST SUMMARY

Project

Project Name:	Power Road Phase 3
Project Location:	Queen Creek, Arizona
Project Number:	65215302
Lat/Long	33.22694, -111.68600

Test Details

Test No.:	DR-1
Depth (Elev.):	3 feet
Technician:	MB
Date:	5/25/2022
Weather:	Sunny
Liquid Type:	Water

Test Setup

Inner Ring Area:	113.1	in^2
Inner Ring Diameter:	12.0	in
Annular space between Outer and Inner rings:	339	in^2
Outer Ring Diameter:	24.0	in
Depth of Liquid Inner Ring:	10.00	in
Depth of Liquid Annular Space:	10.00	in

Soil Description

Depth:	0' - 3'
Description:	Silty Clayey Sand

Trial No.	Time		Elapsed Time (hr:min:sec)	Volume Measurements				Infiltration Rate, in/hr	
				Start		Finish			
	Start	Finish		Inner Ring Volume, in^3	Annular Space Volume, in^3	Inner Ring Volume, in^3	Annular Space Volume, in^3	Inner Ring	Annular Space
1	8:16:00 AM	8:31:00 AM	0:15:00	1131	3393	1188	3520	2.0	1.5
2	8:33:00 AM	8:48:00 AM	0:15:00	1117	3372	1166	3499	1.8	1.5
3	8:49:00 AM	9:04:00 AM	0:15:00	1124	3351	1159	3457	1.3	1.3
4	9:05:00 AM	9:20:00 AM	0:15:00	1159	3457	1188	3541	1.0	1.0
5	9:22:00 AM	9:52:00 AM	0:30:00	1188	3541	1265	3775	1.4	1.4
6	9:56:00 AM	10:24:00 AM	0:30:00	1103	3266	1180	3478	1.4	1.3
7	10:26:00 AM	11:26:00 AM	1:00:00	1180	3478	1272	3753	0.8	0.8
8	11:27:00 AM	12:27:00 PM	1:00:00	1103	3308	1230	3647	1.1	1.0
9	12:28:00 PM	1:28:00 PM	1:00:00	1173	3520	1301	3902	1.1	1.1
10	1:30:00 PM	2:30:00 PM	1:00:00	1159	3435	1294	3817	1.2	1.1

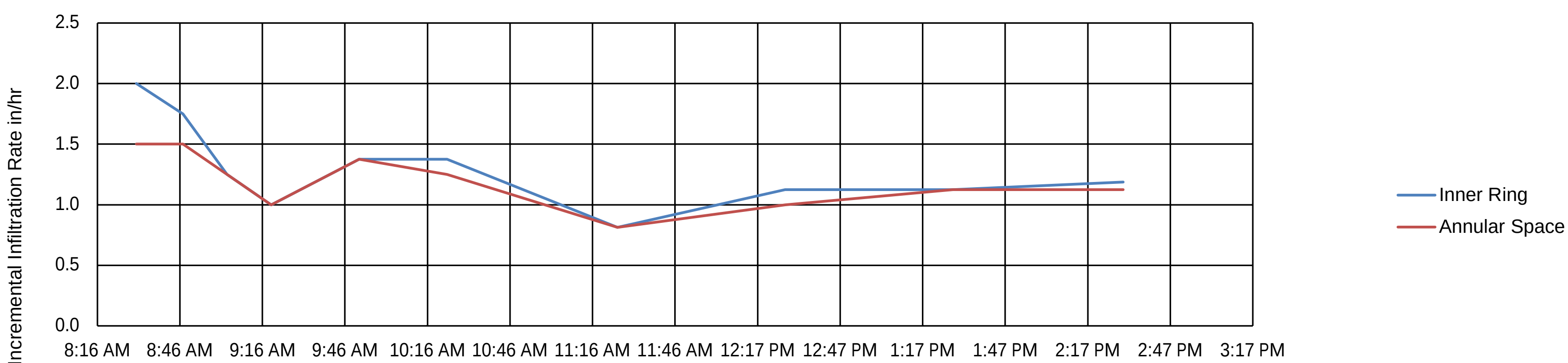


Exhibit: A-10

DOUBLE RING INFILTRATION TEST SUMMARY

Project

Project Name:	Power Road Phase 3
Project Location:	Queen Creek, Arizona
Project Number:	65215302
Lat/Long	33.23055, -111.68606

Test Details

Test No.:	DR-2
Depth (Elev.):	3 feet
Technician:	MB
Date:	5/25/2022
Weather:	Sunny
Liquid Type:	Water

Test Setup

Inner Ring Area:	113.1	in^2
Inner Ring Diameter:	12.0	in
Annular space between Outer and Inner rings:	339	in^2
Outer Ring Diameter:	24.0	in
Depth of Liquid Inner Ring:	8.50	in
Depth of Liquid Annular Space:	9.00	in

Soil Description

Depth:	0' - 3'
Description:	Silty Clayey Sand

Trial No.	Time		Elapsed Time (hr:min:sec)	Volume Measurements				Infiltration Rate, in/hr	
				Start		Finish			
	Start	Finish		Inner Ring Volume, in^3	Annular Space Volume, in^3	Inner Ring Volume, in^3	Annular Space Volume, in^3	Inner Ring	Annular Space
1	7:56:00 AM	8:11:00 AM	0:15:00	961	3054	1018	3223	2.0	2.0
2	8:16:00 AM	8:31:00 AM	0:15:00	961	3054	1018	3223	2.0	2.0
3	8:37:00 AM	8:52:00 AM	0:15:00	961	2884	1018	3054	2.0	2.0
4	8:58:00 AM	9:13:00 AM	0:15:00	961	2884	1018	3138	2.0	1.5
5	9:20:00 AM	9:50:00 AM	0:30:00	848	2545	961	2799	2.0	1.5
6	9:55:00 AM	10:25:00 AM	0:30:00	961	2884	1103	3223	2.5	1.0
7	10:30:00 AM	11:30:00 AM	1:00:00	990	2884	1188	3478	1.8	1.8
8	11:34:00 AM	12:34:00 PM	1:00:00	1060	3138	1286	3817	2.0	2.0
9	12:38:00 PM	1:38:00 PM	1:00:00	1074	3181	1301	3859	2.0	2.0
9	1:41:00 PM	2:41:00 PM	1:00:00	1074	3138	1315	3859	2.1	2.1

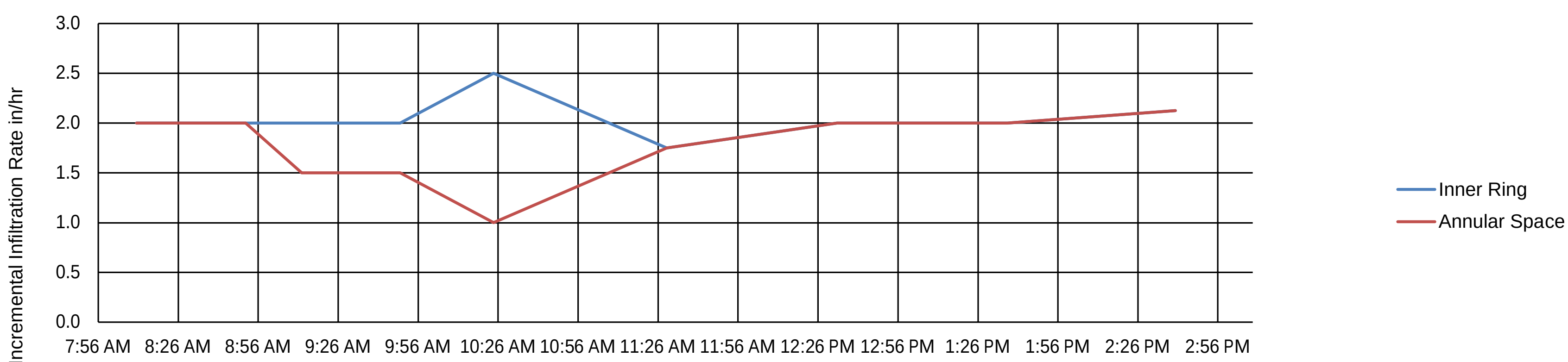
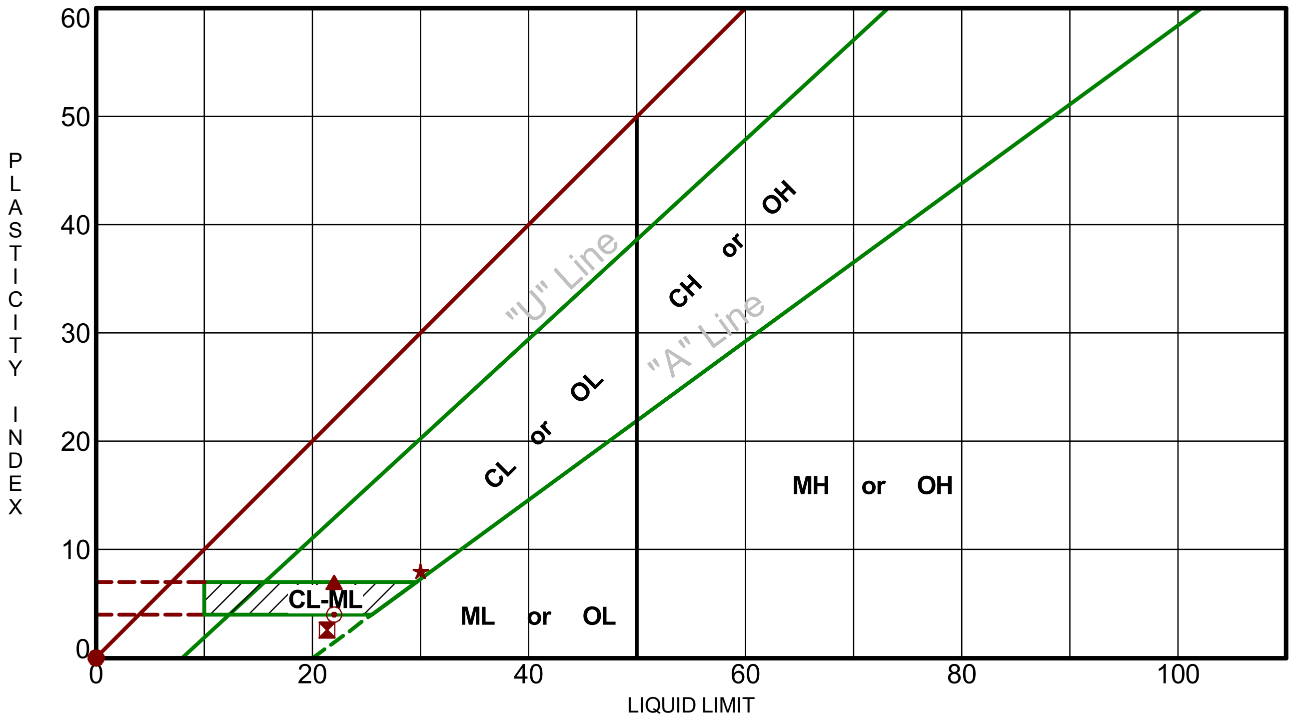


Exhibit: A-11

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-8	1 - 2.5	NP	NP	NP	15.2	SM	SILTY SAND with GRAVEL
⊠	B-8	2.5 - 5	21	19	2	14.9	SM	SILTY SAND with GRAVEL
▲	B-301	1 - 5	22	15	7	39.2	SC-SM	SILTY, CLAYEY SAND
★	B-302	1 - 5	30	22	8	37.2	SC	CLAYEY SAND
⊙	B-303	1 - 5	22	18	4	33.0	SC-SM	SILTY, CLAYEY SAND

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

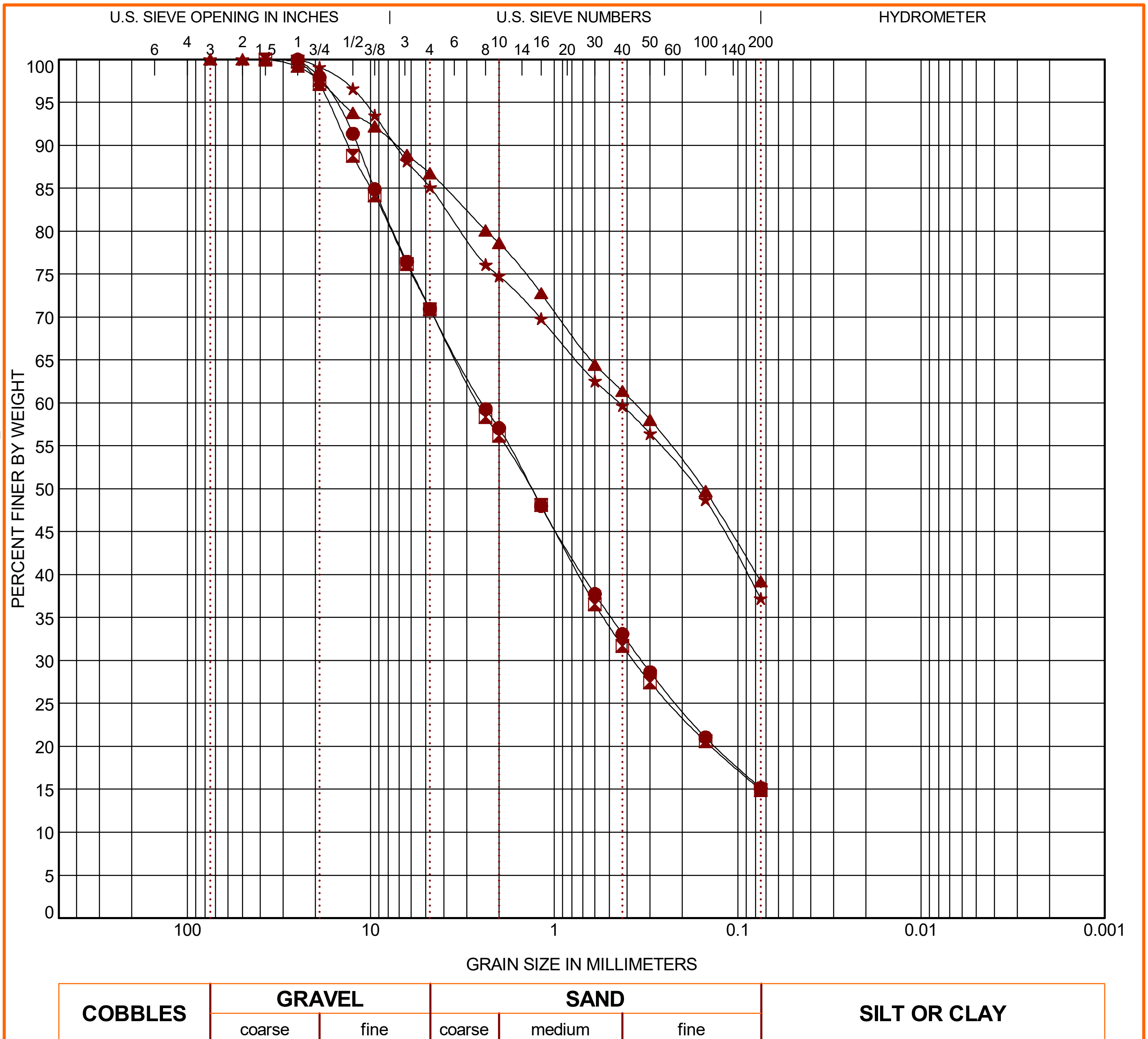
PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
● B-8	1 - 2.5	SILTY SAND with GRAVEL (SM)	A-1-b (0)		NP	NP	NP		
⊠ B-8	2.5 - 5	SILTY SAND with GRAVEL (SM)	A-1-b (0)		21	19	2		
▲ B-301	1 - 5	SILTY, CLAYEY SAND (SC-SM)	A-4 (0)		22	15	7		
★ B-302	1 - 5	CLAYEY SAND (SC)	A-4 (0)		30	22	8		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
● B-8	1 - 2.5	25	2.464	0.334		29.1	55.8		15.2	
⊠ B-8	2.5 - 5	37.5	2.585	0.369		29.1	56.0		14.9	
▲ B-301	1 - 5	75	0.368			13.2	47.6		39.2	
★ B-302	1 - 5	75	0.441			14.9	47.9		37.2	

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

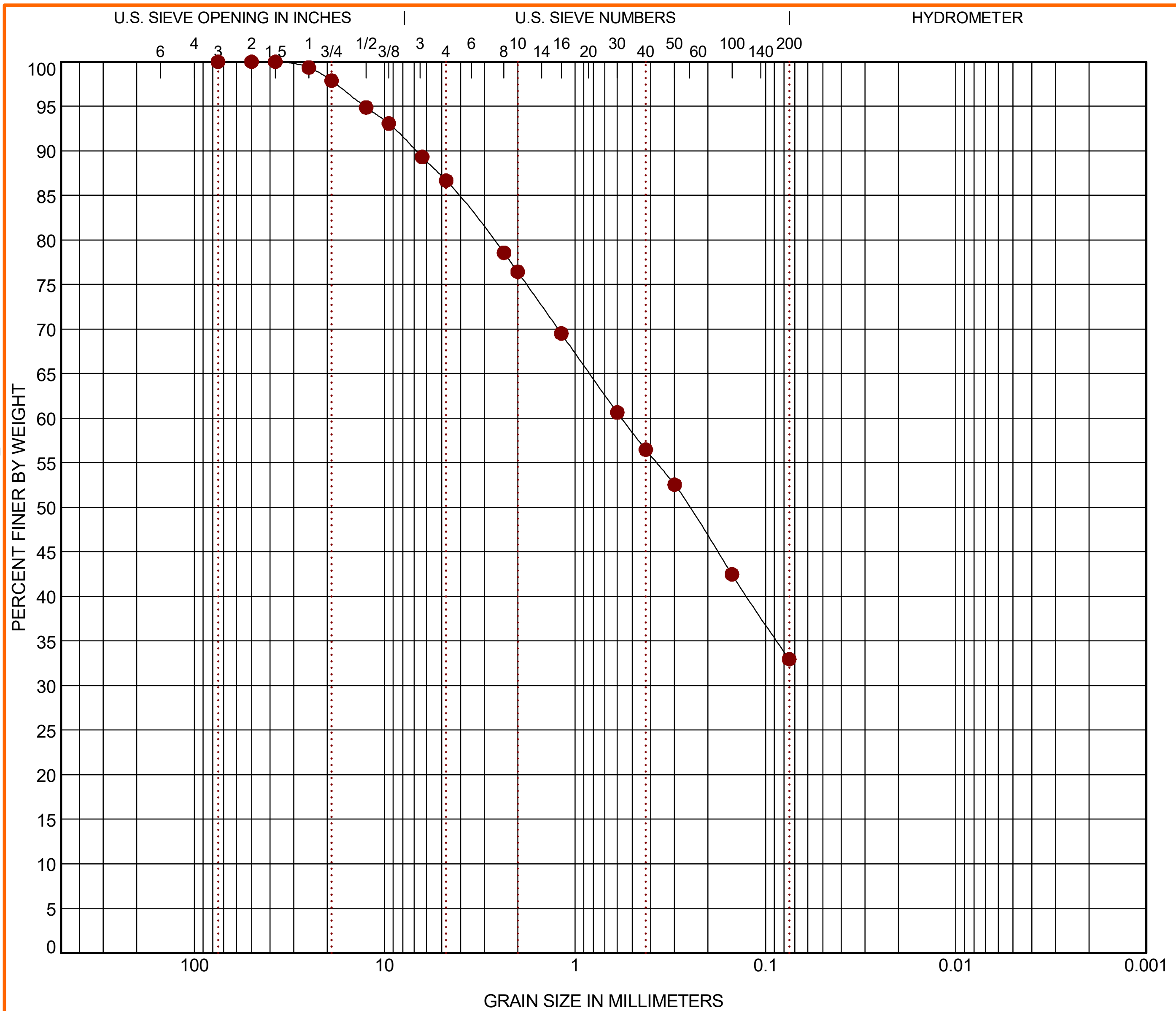
PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-303	1 - 5	SILTY, CLAYEY SAND (SC-SM)	A-2-4 (0)		22	18	4		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-303	1 - 5	75	0.569			13.3	53.7		33.0	

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

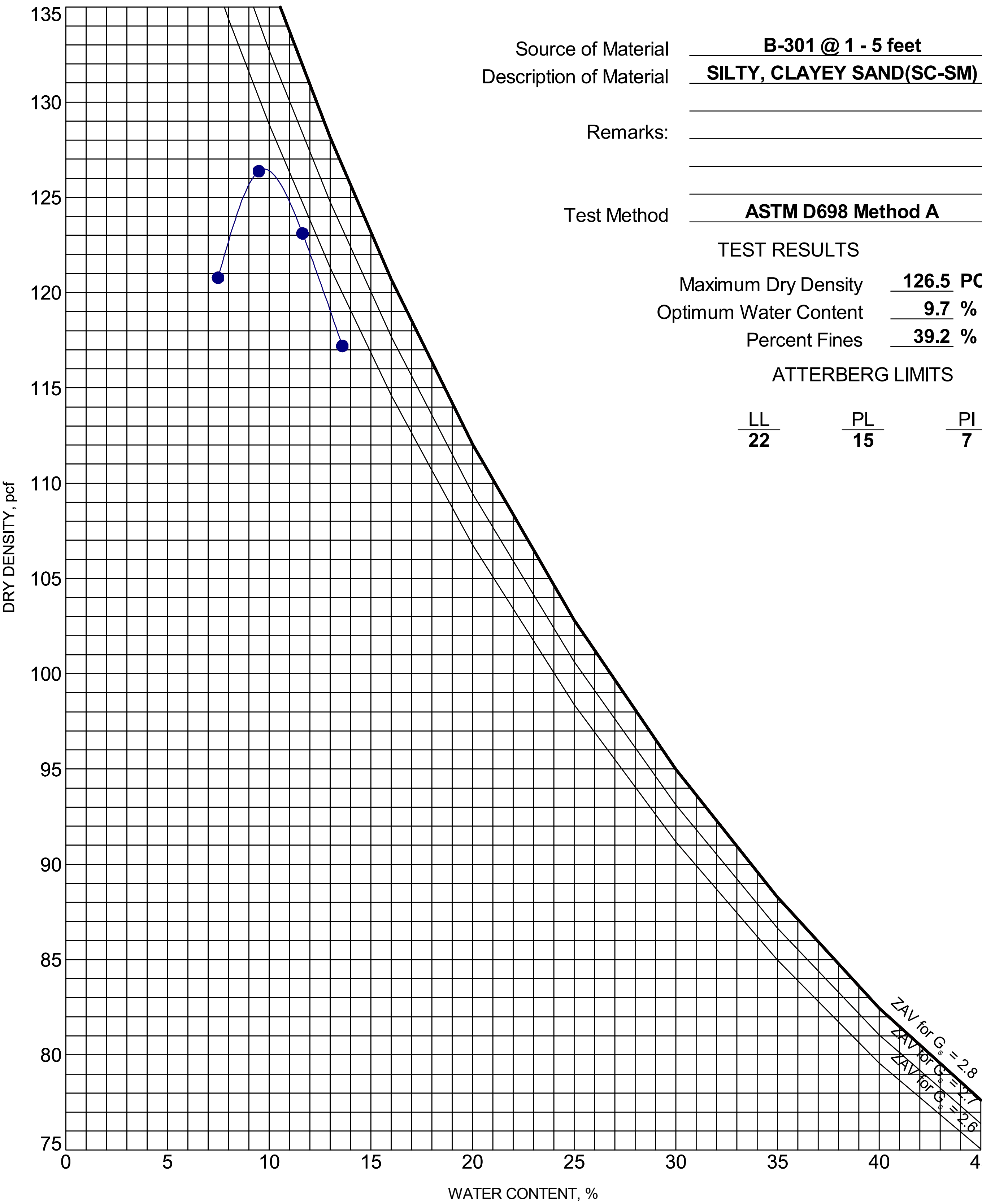
PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-3

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material	**B-301 @ 1 - 5 feet**
Description of Material	**SILTY, CLAYEY SAND(SC-SM)**
Remarks:	
Test Method	**ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**126.5**	**PCF**
Optimum Water Content	**9.7**	**%**
Percent Fines	**39.2**	**%**

ATTERBERG LIMITS

LL	PL	PI
22	**15**	**7**

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

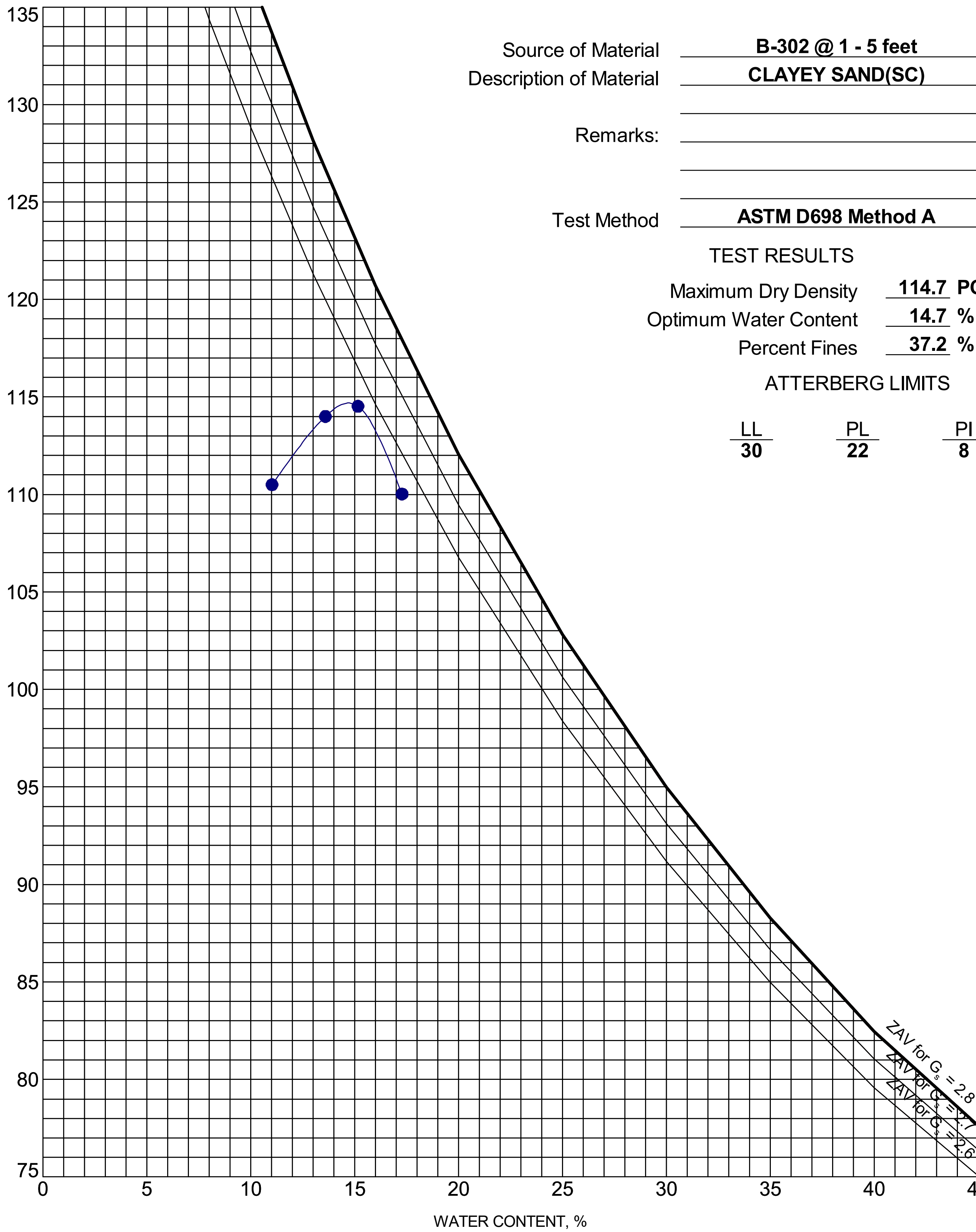
PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-4

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-302 @ 1 - 5 feet**

Description of Material: **CLAYEY SAND(SC)**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density **114.7 PCF**

Optimum Water Content **14.7 %**

Percent Fines **37.2 %**

ATTERBERG LIMITS

LL	PL	PI
30	**22**	**8**

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 65215302 POWER ROAD WIDENI.GPJ TERRACON_DATATEMPLATE.GDT 7/26/22

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

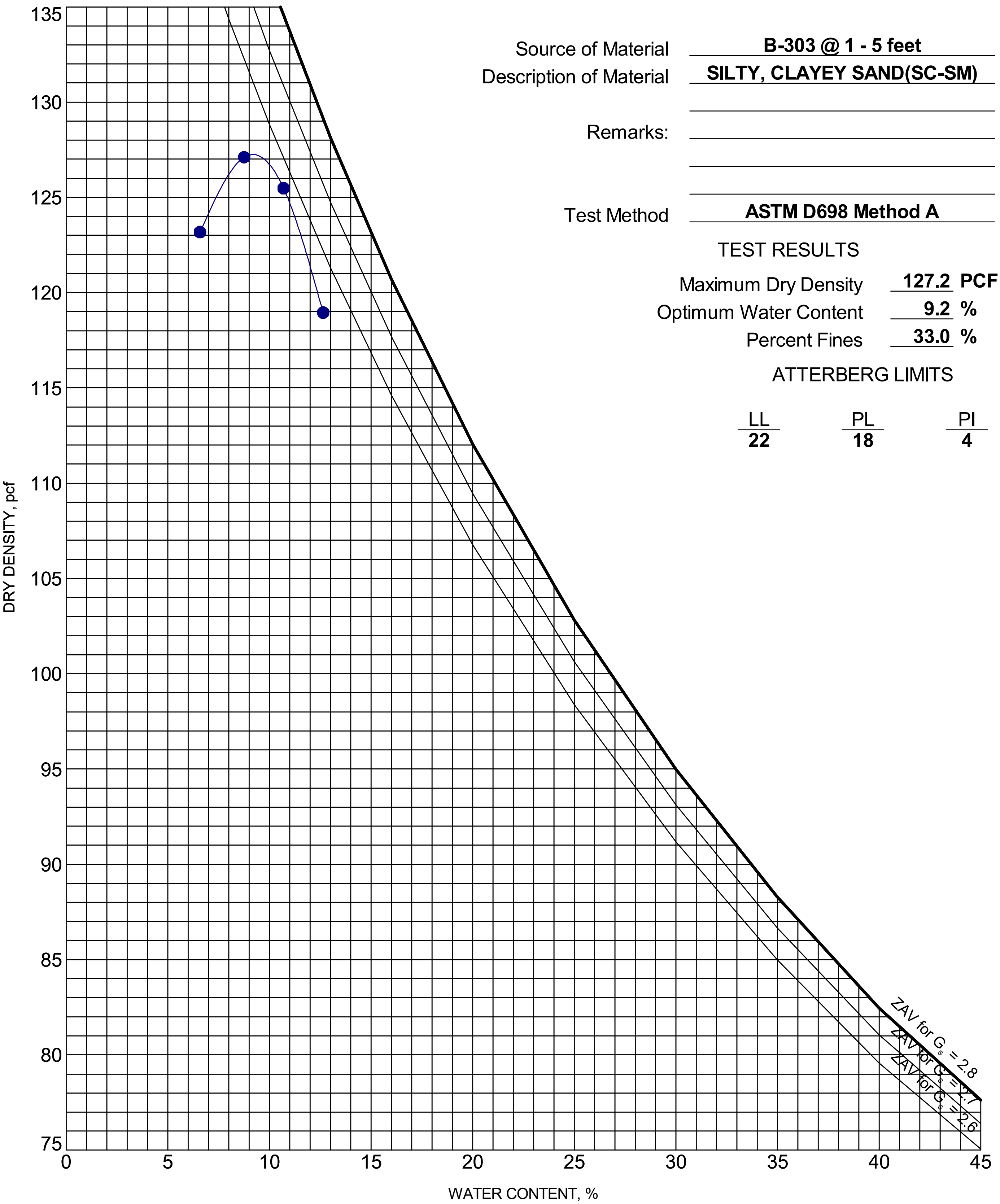
PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-5

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **B-303 @ 1 - 5 feet**

Description of Material **SILTY, CLAYEY SAND(SC-SM)**

Remarks:

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density **127.2 PCF**

Optimum Water Content **9.2 %**

Percent Fines **33.0 %**

ATTERBERG LIMITS

LL	PL	PI
22	**18**	**4**

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Rd to Chandler Heights Rd
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ

PROJECT NUMBER: 65215302

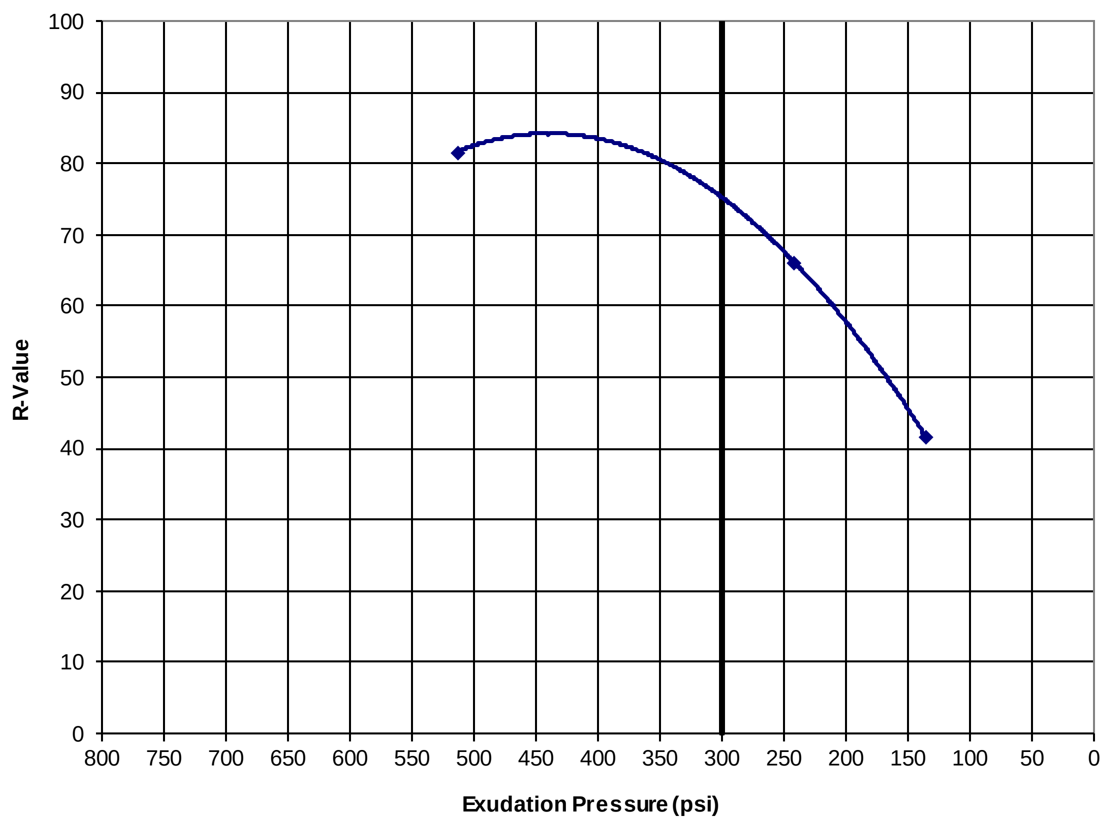
CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-6

PROJECT:	Pow er Road Widening - Phase 3	**JOB NO:**	65215302
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	
MATERIAL:	Silty, Clayey Sand	**LAB NO:**	B-301@1-5'
SAMPLE SOURCE:	B-301@1-5'	**DATE RECEIVED:**	05/27/22

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (ASTM D2844)

SPECIMEN I. D.	**A**	**B**	**C**
Moisture Content	9.9%	9.0%	8.1%
Compaction Pressure (psi)	150	300	350
Specimen Height (inches)	2.52	2.56	2.60
Dry Density (pcf)	127.5	127.7	128.3
Horiz. Pres. @ 1000lbs (psi)	33.0	19.0	11.0
Horiz. Pres. @ 2000lbs (psi)	70.0	38.0	21.0
Displacement	4.51	4.34	4.11
Expansion Pressure (psi)	0.0	0.0	0.1
Exudation Pressure (psi)	136	242	514
R Value	42	66	82

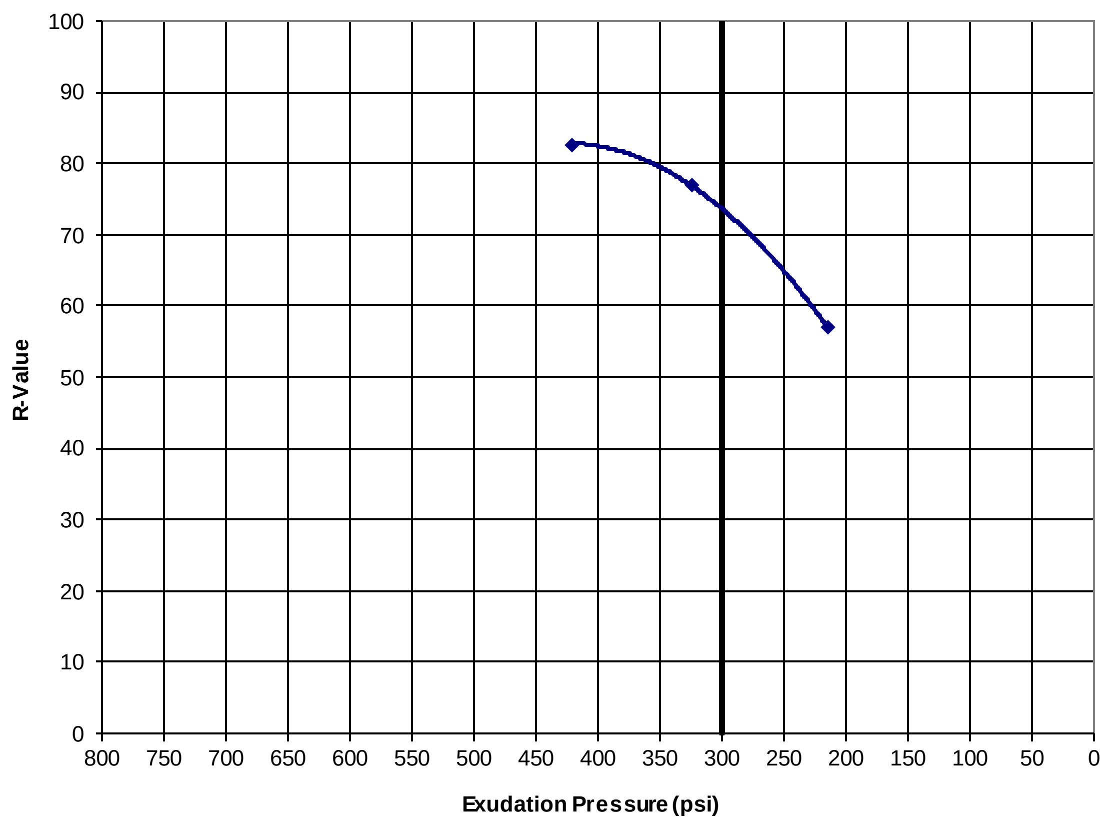


R Value at 300 PSI = 75

PROJECT:	Power Road Widening - Phase 3	**JOB NO:**	65215302
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	
MATERIAL:	Clayey Sand	**LAB NO:**	B-302@1-5'
SAMPLE SOURCE:	B-302@1-5'	**DATE RECEIVED:**	05/27/22

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (ASTM D2844)

SPECIMEN I. D.	A	B	C
Moisture Content	13.3%	12.4%	11.5%
Compaction Pressure (psi)	200	350	350
Specimen Height (inches)	2.60	2.59	2.56
Dry Density (pcf)	117.7	118.8	120.5
Horiz. Pres. @ 1000lbs (psi)	22.0	12.0	10.0
Horiz. Pres. @ 2000lbs (psi)	54.0	27.0	21.0
Displacement	4.06	4.04	3.64
Expansion Pressure (psi)	0.0	0.0	0.1
Exudation Pressure (psi)	216	325	422
R Value	57	77	83

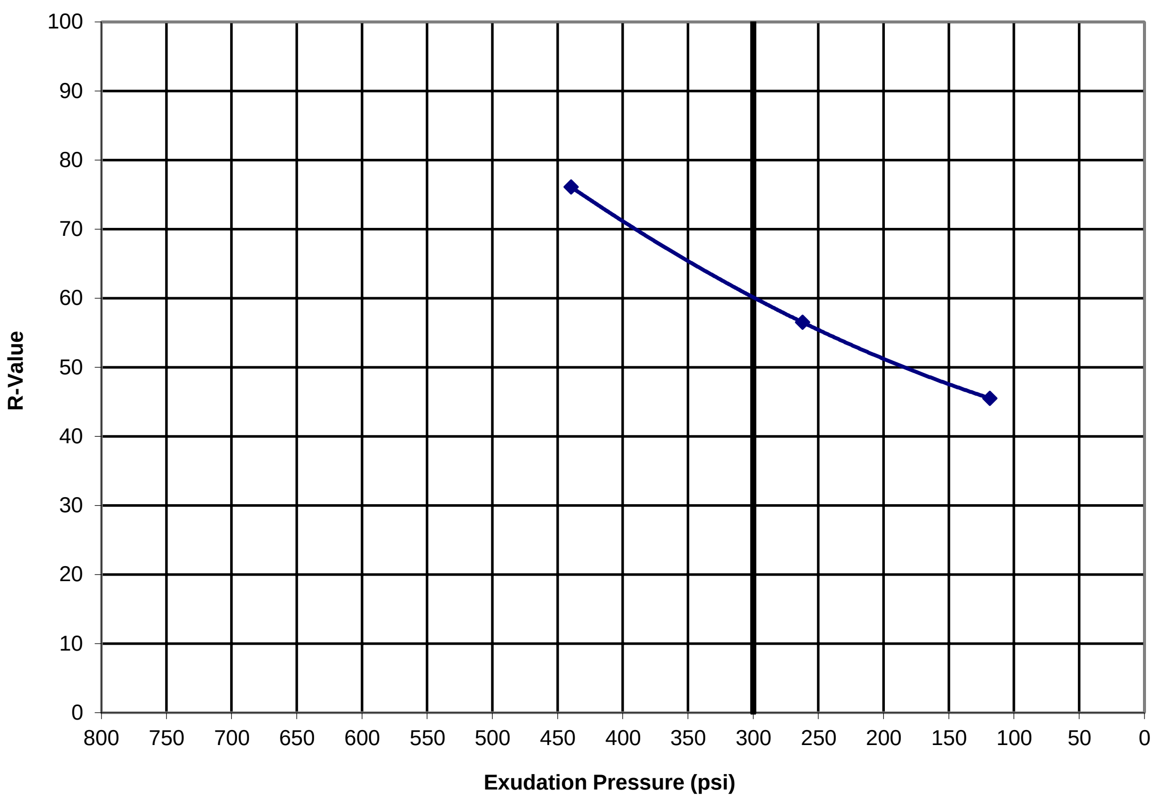


R Value at 300 PSI = 74

PROJECT:	Power Road Widening - Phase 3	**JOB NO:**	65215302
LOCATION:	Phoenix, AZ	**WORK ORDER NO:**	
MATERIAL:	Clayey Silt	**LAB NO:**	B-303@1-5'
SAMPLE SOURCE:	B-303@1-5'	**DATE RECEIVED:**	05/27/22

RESISTANCE R-VALUE AND EXPANSION PRESSURE OF COMPACTED SOILS (ASTM D2844)

SPECIMEN I. D.	**A**	**B**	**C**
Moisture Content	9.8%	8.9%	8.1%
Compaction Pressure (psi)	75	200	350
Specimen Height (inches)	2.50	2.48	2.53
Dry Density (pcf)	125.4	127.9	129.6
Horiz. Pres. @ 1000lbs (psi)	29.0	23.0	15.0
Horiz. Pres. @ 2000lbs (psi)	64.0	48.0	26.0
Displacement	4.49	4.49	4.05
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	119	262	440
R Value	46	57	76



R Value at 300 PSI = 60

MOTZZ LABORATORY, INC.

Laboratory Analysis Report

Terracon
Eddy Ramirez
4685 S. Ash Ave
Suite H4
Tempe, AZ 85282

Project: 65215302
Date Received: 6/1/2022
Date Reported: 6/7/2022

PO Number: 65215302

Lab Number: 942180-1 **B-301 (0-5)**

Test Parameter	Method	Result	Units	Levels
pH (ARIZ 236e)	ARIZ 236e	9.0	SU	
Minimum Resistivity	ARIZ 236e	3221	ohm-cm	
Sulfate	ARIZ 733b	6	ppm	
Chloride	ARIZ 736b	< 3	ppm	

Lab Number: 942180-2 **B-302 (0-4)**

Test Parameter	Method	Result	Units	Levels
pH (ARIZ 236e)	ARIZ 236e	10.6	SU	
Minimum Resistivity	ARIZ 236e	2483	ohm-cm	
Sulfate	ARIZ 733b	133	ppm	
Chloride	ARIZ 736b	3	ppm	

Lab Number: 942180-3 **B-303 (0-4)**

Test Parameter	Method	Result	Units	Levels
pH (ARIZ 236e)	ARIZ 236e	8.6	SU	
Minimum Resistivity	ARIZ 236e	4160	ohm-cm	
Sulfate	ARIZ 733b	8	ppm	
Chloride	ARIZ 736b	< 3	ppm	

SUMMARY OF LABORATORY RESULTS

Borehole No.	Depth (ft.)	USCS Soil Class.	In-Situ Properties		Classification				Expansion Testing					Corrosivity				Remarks
			Dry Density (pcf)	Water Content (%)	Passing #200 Sieve (%)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Dry Density (pcf)	Water Content (%)	Surcharge (psf)	Expansion (%)	Expansion Index EI_{50}	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)	
B-8	1.0 - 2.5	SM			15	NP	NP	NP										
B-8	2.0 - 3.0	SM	121	4														1, 2
B-8	2.5 - 5.0	SM			15	21	19	2										
B-9	4.0 - 5.0	SC	98	7														1, 2
B-301	1.0 - 5.0	SC-SM			39	22	15	7	120	7.7	144	0.2		9.0	3221	6	< 3	
B-301	2.0 - 3.0	SC-SM	111	7														1, 2
B-301	4.0 - 5.0	SC-SM	106	9														1, 2
B-302	1.0 - 5.0	SC			37	30	22	8	109	12.7	144	0.1		10.6	2483	133	3	
B-302	2.0 - 3.0	SC	108	8														1, 2
B-302	4.0 - 5.0	SC	90	12														1, 2
B-303	1.0 - 5.0	SC-SM			33	22	18	4	121	7.2	144	1.1		8.6	4160	8	< 3	
B-303	2.0 - 3.0	SC-SM	119	6														1, 2
B-303	4.0 - 5.0	SC-SM	107	12														1, 2

REMARKS

1. Dry Density and/or moisture determined from one or more rings of a multi-ring sample.
2. Visual Classification.
3. Submerged to approximate saturation.
4. Expansion Index in accordance with ASTM D4829-95.
5. Air-Dried Sample

PROJECT: Power Road Widening- Phase 3

SITE: Power Road - Riggs Road to Chandler Heights Road
Queens Creek, Arizona

Terracon
4685 S Ash Ave, Ste H-4
Tempe, AZ
PH. 480-897-8200 FAX. 480-897-1133

PROJECT NUMBER: 65215302

CLIENT: Stantec Inc
Chandler, AZ

EXHIBIT: B-11

PAVEMENT DESIGN

Design Traffic Analysis

Spreadsheet To Calculate Traffic for Pavement Design

- Traffic Analysis is based upon procedures by the Asphalt Institute, MS-1 (2008)
- Average Daily Traffic (ADT) is required along with annual growth rate
- Lane factor adjusts design lane traffic for 2, 4 or 6 lanes
- Truck quantities are based on Rural, Urban or Interstate statistics
- All Truck Factors are 18-kip equivalents per vehicle

Initial Data

PROJECT DATA

Project name:	Power Road Widening - Phase 3
Location:	Power Rd from Riggs Rd to Chandler Heights Rd
Terracon Project No.	65215302

STREET DATA

Street Name	Power Road
Current Average Daily Traffic (ADT)	15,370
Design Period (years)	20
Annual Growth Rate (%)	2.30%
Number of Traffic Lanes (2, 4 or 6)	4
Percentage of Trucks (%)	5.0%

STREET CLASSIFICATIONS

Rural Systems	Urban Systems
Interstate	Interstate
Principal	Freeway
Minor Arterial	Principal
Major Collector	Minor Arterial
Minor Collector	Collector

Equivalent 18-kip Axle Load Analysis

Vehicle Type	% Traffic	No. of Vehicles	Truck Factor	Growth Factor	Equivalent Axle Loads
Chandler Heights Road					
Passenger Cars	95%	5,329,548	0.0008	25.04	106,747
Trucks	5%	280,503	1.2000	25.04	8,427,398
All Single Units and Automobiles	100%	5,610,050			8,534,145
All Vehicles	100%	5,610,050			8,534,145

Traffic Summary

TOTALS

Equivalent Axle Loads (EAL's)	**8,534,145**
Lane Factor	**0.45**
Design Equivalent Axle Loads	**3,840,365**
Design Traffic Number (DTN)	**526.1**

Design Resilient Modulus Analysis

Project Data

PROJECT NAME, LOCATION and SEASONAL VARIATION FACTOR

Project Name:	Power Road Widening - Phase 3
Location:	Maricopa County
Seasonal Variation Factor:	1.0

Laboratory Test Data

Boring No. Point ID	Boring Location	Depth (ft)	LL	PI	-#200	Laboratory R-Value	Correlated R-Value
B-8		1 – 2.5	0	0	15		70
B-8		2.5 - 5	21	2	15		70
B-301		1 – 5	22	7	39	75	45
B-302		1 - 5	30	8	37	73	43
B-303		1 – 5	22	4	33	60	58

Mean R-Value and Modulus Calculations

Number of Laboratory Tested R-Values:	3	(Nt)
Average of Laboratory Tested R-Value Results:	69.33	(Rt)
Standard Deviation of Laboratory Tested R-Values:	8.14	(SDt)
Number of Correlated R-Value:	5	(Nc)
Average of Correlated R-Value Results:	57.11	(Rc)
Standard Deviation of Correlated R-Values:	13.17	(SDc)
Adjusted Average of Tested R-Values:	69.3	
Adjusted Average of Correlated R-Values:	53.9	(Rc)

Calculation for Mean R-Value:

$$R_{mean} = \frac{2xN_t \times R_t \times SD_c^2 + N_c \times R_c \times SD_t^2}{2xN_t \times SD_c^2 + N_c \times SD_t^2}$$

R_{mean} = **65.6**

Seasonal Variation Factor for Project Location= **1.0**

Design Resilient Modulus M_r (adjusted for SVF)= **26,000** psi

Flexible Pavement Design Analysis

Design Criteria

PROJECT DATA

Pavement Designation	Power Road
Design Life (years)	20
Equivalent Axle Loads/Day	526
Total ESALs	3,840,365
Seasonal Variation Factor	1.0
Reliability	95%
Overall Standard Deviation	0.45

SUBGRADE CONDITIONS

Mean R-Value, R_{Mean}	65.6
Resilient Modulus MR (psi)	44,838
Design Modulus (psi)	26,000

SERVICEABILITY

Initial Design Serviceability Index	4.5
Terminal Design Serviceability Index	2.5

LAYER COEFFICIENTS	**Structural**	**Drainage**
Asphalt Rubber	0.61	N/A
Asphalt Concrete	0.42	N/A
Aggregate Base Course	0.12	1.00
Cement Treated Subgrade	0.16	1.00

Design Calculations

Required Structural Number SN: **2.83** **(TOQC Min. 3.54 for Arterial)**

Alternative	Recommended Pavement Section Thickness Inches				Total Structural Number	Δ Structural Number
	Asphalt Rubber	Asphalt Concrete Surface	Aggregate Base Course	Lime Treated Subgrade		
A	1.5	3.0	12		3.62	0.79
B		5.0	12		3.54	0.71
C		8.5			3.57	0.74

EARTHWORK SHRINKAGE ESTIMATES

Terracon Project No.: 65215302

Project Name: Power Road Widening - Phase 3

NG = Nuclear Gauge

R = Ring Sample

Under Shrinkage / Bulking column, positive numbers indicate Shrinkage and negative numbers indicate Bulking.

Boring	Test	Depth bgs (in)	Maximum Dry Density (pcf)	95% of Max Dry Density (pcf)	Optimum Moisture (%)	(In-situ) Dry Density (pcf)	(In-situ) Moisture Content (%)	Compaction (%)	Shrinkage / Bulking (%)
B-8	R	2	126.5	120.2	9.7	121	4	96	-1
B-9	R	4	126.5	120.2	9.7	98	7	77	18
B-301	R	2	126.5	120.2	9.7	111	7	88	8
B-301	R	4	126.5	120.2	9.7	106	9	84	12
B-302	R	2	114.7	109.0	14.7	108	8	94	1
B-302	R	4	114.7	109.0	14.7	90	12	78	17
B-303	R	2	127.2	120.8	9.2	119	6	94	2
B-303	R	4	127.2	120.8	9.2	107	12	84	11

ESTIMATED AVERAGE PERCENT SHRINKAGE:	**9**