REPORT

Valencia Road: Kolb Road to Houghton Road

Geotechnical and Pavement Design Report

Submitted to:

Mr. Kevin Thornton, PE
PSOMAS
333 E. Wetmore, Suite 450
Tucson, AZ 85705-5256

Registered Professional Engineer (Civil)
CERTIFICATE NO.
68108
JORGE
VELARDE
Date Signed: 8-17-20
ARIZONA, U.S.A.

Submitted by:

Golder Associates Inc.
7458 N. La Cholla Blvd., Tucson, Arizona, USA 85741

+1 520 888-8818

1660053 (Rev 0)

August 17, 2020

Distribution List

1 Electronic Copy - PSOMAS

1 Electronic Copy - Golder Associates Inc.

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the findings of a geotechnical study performed for the proposed improvements to Valencia Road from approximately Kolb Road to Houghton Road. Preliminary design work for the project is being performed by PSOMAS for the City of Tucson Department of Transportation (City) as Contract No. 161497.

The purpose of this report is to present the results of the field investigation and geotechnical laboratory testing, and to provide geotechnical recommendations for the pavement structural sections and factors affecting earthwork and other project features.

1.1 Project Background

The City plans to widen Valencia Road between Kolb Road and Houghton Road to a six-lane arterial with landscaped medians, bike lanes, sidewalks and street lighting using funding from the Regional Transportation Authority (RTA). The total project length is approximately 3.7 miles and will connect with two other recent improvement projects. The east project limit will be approximately 0.9 miles east of the Valencia Road and Kolb Road Intersection, which will be reconstructed as part of a separate project designed by EPS Group and for which Golder was the geotechnical engineer of record (Golder 2016). The west project limit will tie into the intersection of Valencia Road and Houghton Road, recently reconstructed as part of a separate Houghton Road improvement project designed by PSOMAS.

1.2 Scope of Services

Golder Associates Inc. (Golder) has provided the following services as part of the development of this report:

- A field investigation program that included 36 boreholes and four pavement cores along Valencia Road. The field investigation program is described in Section 3.1. The logs for the boreholes are included in Appendix A.
- Laboratory testing of representative materials samples. These samples were sent to Atek Engineering Consultants, LLC (ATEK) for testing to determine material classification and material geotechnical properties. Selected sample were also sent to GeoTesting Express Inc. (GeoTesting) for additional testing. Details of the laboratory testing program are discussed in Section 3.3. Summary tables and other laboratory test data are included in Appendix B.
- A total of nine borehole infiltration tests in hand-excavated boreholes. Infiltration test results are discussed in Section 3.4, and summary test results are included in Appendix C.
- A total of 19 Dynamic Cone Penetrometer tests (DCP) adjacent to every other borehole. Tests results are discussed in Section 3.5. Complete test data is included in Appendix D.
- Preparation of a pavement design in accordance with Pima County design methodology using data collected by Golder. Pavement structural section calculations are included in Appendix E.
- Preparation of this report summarizing the results and recommendations of the geotechnical study.

These services were performed in accordance with our proposal for professional services dated October 21, 2016.

1.3 Pavement Design Standards

The design of the flexible pavements presented in this report is in accordance with the 2013 Pima County Roadway Design Manual (PCDOT 2016) in place of the City's Active Practice Guideline 04 (TDOT 1987) based on direction from the City (Martin 2017). Pima County's procedures are generally consistent with the City and the Arizona Department of Transportation (ADOT 2017) with modifications for local adjustments to R-Value correlation procedures and coefficients used in the design process. Golder's designs assume the use of the PAG Standard Specifications (PAG 2014). Asphalt mixes should be the latest approved mixes by PAG or the City of Tucson Department of Transportation (TDOT) equivalent.

1.4 Organization of Report

This report is organized into 11 sections and six appendices as follows:

- **Section 1.0: Introduction** – Discusses the purpose of this report and the scope of work performed by Golder
- **Section 2.0: Regional Setting** – Provides a description of geographic setting, regional geology, and seismic setting for the project
- **Section 3.0: Site Investigation** – Summarizes the activities performed for the geotechnical field investigations and laboratory testing performed
- **Section 4.0: Site Conditions and Geotechnical Data** – Discusses surface and topographic conditions, subsurface soil conditions, geologic hazards, and groundwater at the project site. It also presents results of the subgrade R-value analysis
- **Section 5.0: Traffic Data** – Summarizes the available traffic data and presents the 18-kip equivalent single axle loadings needed for pavement analysis
- **Section 6.0: Pavement Structure Design** – Discusses the methods and parameters used to analyze pavement structural section
- **Section 7.0: Recommendations for Earthwork, and Slopes** – Summarizes factors needed for computing earthwork volumes, provides recommendations for mitigation of collapsible soil and poor R-value, provides recommendations for temporary and permanent slopes, and presents the results of soil electrochemical tests
- **Section 8.0: Summary of Geotechnical and Pavement Value Engineering** – Summarizes the results of the value engineering process engaged through the design phase
- **Section 9.0: Recommendations and Summary** – Summarizes the recommended pavement sections and other design and construction considerations for the project
- **Section 10.0: Limitations and Closing** – Presents the limitations of the geotechnical foundation recommendations developed
- **Section 11.0: References** – Provides the references that were used in preparation of this report
- **Appendix A: Geotechnical Field Investigation Information** – Provides descriptions of material encountered in the boreholes, including blow counts, dry density measurements, and other geotechnical sample data related to materials characterization or classification

- **Appendix B: Geotechnical Laboratory Testing** – Provides the results of the laboratory testing used in the development of the geotechnical recommendations
- **Appendix C: Borehole Infiltration Test Results** – Provides the results of the borehole infiltration testing discussed in Section 3.4
- **Appendix D: Dynamic Cone Penetrometer Test Results** – Discusses the results of the dynamic cone penetrometer testing described in Section 3.5
- **Appendix E**: **Pavement Unit Costs** – Calculations for the derivations of unit costs for pavement analysis
- **Appendix F: Pavement Design Calculations** – Calculations for the pavement section alternatives described in Section 6.0
- **Appendix G: Important Information About Your Geotechnical Report**

2.0 REGIONAL SETTING

The following discussion of regional and site geology is based on the work of McKittrick (1988) and Klawon et al. (1999).

2.1 Regional Geology

The project site is located on the southeastern portion of the Tucson basin. The surficial geology of the basin is dominated by a series of alluvial fan surfaces derived from the Santa Catalina, Tortolita, Tucson, and Rincon Mountains that filled in the valley after the Basin and Range extension began approximately 20 million years ago (Ma).

2.2 Site Geology

The two dominant surficial geologic units on the project site are mapped by McKittrick as QTbf and Qt5 (Terrace 5). McKittrick describes the QTbf unit as alluvium that does not exhibit a preserved geomorphic surface, meaning that erosion has occurred, and the alluvial fan surface is no longer visible and the deposit can be considered more as basin fill. The material is described as dominated by gravel with lenses of brown or reddish sand and silt. Deposits are typically weakly to moderately indurated with carbonate cementation. The QTbf unit is dated at early Pleistocene to Pliocene (1 to 5 Ma).

The Qt5 unit can be correlated to the University Terrace or Qor unit mapped by other authors (Dickinson 1999 and Klawon et al. 1999). The Qt5 or University Terrace unit is described as the oldest and highest terrace in the Tucson basin. These surfaces may represent a former level of maximum alluvial fill in the Tucson basin. The Qt5 unit is dated as middle to early Pleistocene (~500,000 years ago, ka to 2 Ma). These deposits are primarily sand and gravel and are described as generally coarser than younger terrace deposits. Surfaces typically contain strongly cemented calcic horizons with laminar caps.

3.0 SITE INVESTIGATION

3.1 Geotechnical Exploration Program

The field investigation for this project consisted of 36 boreholes and four pavement cores. Nine infiltration tests were performed on boreholes near natural drainages. Additionally, DCP tests were performed at every other hole. Investigation locations are shown on Figures 1 through 5. Golder's borehole and test pit logs are included in Appendix A. Borehole infiltration tests and DCP tests are discussed in Section 3.4 and 3.5, respectively.

Southlands Engineering, LLC (Southlands) drilled all borings between September 19 and September 26, 2017 using a truck-mounted CME-75 drill rig equipped with 8-inch outside diameter (OD) hollow stem augers. Standard Penetration Tests (SPT) were performed at intervals of 2.5 feet. A 2-inch OD, 18-inch long split spoon sampler or a 3-inch OD modified California sampler were used to perform the SPT in general accordance with ASTM D-1586. The split-spoon sampler was driven 18 inches (12 inches for modified California samples) into the soil with a 140-pound CME automatic hammer falling freely from a height of 30 inches. The number of blows required for each 6 inches of penetration is shown on the boring logs included in Appendix A. The number of blows required to advance the sampler the last 12 inches is the penetration resistance N value, or blow count, and provides a qualitative measure of the relative density of cohesionless soils or the consistency of cohesive soils. Traffic control services were provided by Border Traffic Safety, LLC.

All samples that were collected from the split-spoon sampler during the drilling program were placed and sealed in plastic bags or in ring sample tubes. Bulk samples of auger cuttings were collected as well. Selected samples were transported to ATEK in Tucson or GeoTesting in Acton, Massachusetts for geotechnical testing.

Golder geotechnical personnel were present throughout the field investigation program to observe the drilling operations, assist in sampling, and to prepare the descriptive logs of each boring.

Soils were classified in general accordance with ASTM D 2488, “Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)”. The boring logs present soil descriptions based on the field classifications that have been updated where necessary based on the results of the laboratory testing.

A summary of investigation locations is provided in Table 1. Boreholes and pavement cores were not surveyed but were field located using available mapping and imagery.

Table 1: Summary of Geotechnical Investigation

Investigation No.	Type	Northing[A]	Easting[A]	Station (ft)	Offset (ft)	Infiltration Test	DCP Test
BH-01	Borehole	412,024	1,036,888	114+90	34 L		
BH-02	Borehole	411,765	1,037,218	119+05	69 R		X
BH-03	Borehole	411,585	1,037,706	124+15	35 L	X	
BH-04	Borehole	411,286	1,038,135	129+40	7 L	X	X
BH-05	Borehole	410,990	1,038,542	134+40	22 R		
BH-06	Borehole	410,741	1,038,987	139+45	4 L		X
BH-07	Borehole	410,376	1,039,323	144+50	42 R	X	
BH-08	Borehole	409,990	1,039,659	149+55	48 L		X
BH-09	Borehole	409,466	1,039,891	155+30	12 R		
BH-10	Borehole	409,149	1,040,198	159+65	14 R		X
BH-11	Borehole	408,907	1,040,562	164+00	42 R		
BH-12	Borehole	408,847	1,041,064	168+95	12 L		X
BH-13	Borehole	408,708	1,041,428	172+60	128 R	X	

Investigation No.	Type	Northing[A]	Easting[A]	Station (ft)	Offset (ft)	Infiltration Test	DCP Test
BH-14	Borehole	408,884	1,042,016	178+50	41 L		X
BH-15	Borehole	408,851	1,042,651	184+85	1 R		
BH-16	Borehole	408,874	1,043,150	190+00	16 L		X
BH-17	Borehole	408,920	1,043,642	194+75	56 L	X	
BH-18	Borehole	408,860	1,044,152	199+85	5 R		X
BH-19	Borehole	408,910	1,044,653	204+90	43 L		
BH-20	Borehole	408,901	1,045,164	210+00	32 L		X
BH-21	Borehole	408,920	1,045,605	214+40	50 L		
BH-22	Borehole	408,884	1,046,140	219+75	12 L	X	X
BH-23	Borehole	408,883	1,046,533	223+70	10 L		
BH-24	Borehole	408,772	1,047,104	229+40	102 R		X
BH-25	Borehole	408,929	1,047,633	234+70	53 L		
BH-26	Borehole	408,890	1,048,138	239+75	12 L	X	X
BH-27	Borehole	408,861	1,048,625	244+60	18 R		
BH-28	Borehole	408,815	1,049,131	249+65	66 R		X
BH-29	Borehole	408,909	1,049,621	254+55	26 L	X	X
BH-30	Borehole	408,946	1,050,119	259+55	60 L		X
BH-31	Borehole	408,901	1,050,605	264+40	14 L		
BH-32	Borehole	408,928	1,051,144	269+80	39 L	X	X
BH-33	Borehole	408,935	1,051,660	274+95	33 L		
BH-34	Borehole	408,798	1,052,119	279+55	96 R		X
BH-35	Borehole	408,911	1,052,726	285+60	14 L		
BH-36	Borehole	408,966	1,053,163	289+95	67 L		X
PC-01	Pavement Core	408,815	1,042,738	185+70	38 R		
PC-02	Pavement Core	408,834	1,044,770	206+05	34 R		
PC-03	Pavement Core	408,813	1,046,676	225+10	61 R		
PC-04	Pavement Core	408,882	1,051,093	269+25	8 R		

Notes:
A = Grid Coordinates Arizona State Plane Central Zone NAD83 U.S. ft.
ft = feet

3.2 Pavement Coring Results

Cores through the existing pavement section were performed at four locations to evaluate the possibility of pavement rehabilitation and to obtain information to use in pavement removal quantities. Additionally, a total of three boreholes were drilled through the existing pavement section to supplement this information with additional measurements although no core was obtained. Golder noted the total thickness of asphaltic concrete (AC) and attempted to determine the thickness of aggregate base (AB) as well. The results of the pavement coring operation are summarized in Table 2.

Table 2: Summary of Existing Pavement Thickness

Investigation No.	Type	Station (ft)	Offset (ft)	AC Thickness (in)	AB Thickness (in)
BH-05	Borehole	134+40	22 R	4	8
BH-10	Borehole	159+65	14 R	4	8
BH-27	Borehole	244+60	18 R	4	8
PC-01	Pavement Core	185+70	38 R	4	N/A*
PC-02	Pavement Core	206+05	34 R	4	N/A*
PC-03	Pavement Core	225+10	61 R	5	N/A*
PC-04	Pavement Core	269+25	8 R	6	N/A*

Notes:
ft = feet
*Pavement Cores advanced only to bottom of AC

As-built drawings for a portion of the project indicate the presence of cement treated base. This layer either was not encountered in any of the locations investigated, or it had deteriorated to the extent that it could not be visually distinguished from aggregate base materials.

3.3 Laboratory Testing

Selected representative samples collected from the boreholes were tested for classification and material properties by ATEK for use in the evaluation of the subsurface conditions and to aid in engineering design for the proposed facilities. Two samples were shipped to GeoTesting in Acton, Massachusetts for Resilient Modulus testing.

The soils laboratory testing program included moisture content determination, grain-size analysis, Atterberg limit tests (plasticity), Resilient Modulus or R-Value, standard proctor, collapse potential, remolded swell potential, pH, and Resistivity. The laboratory tests were performed in accordance with the standard test procedures listed in Table 3. Summary tables of the results of all laboratory tests are included in Appendix B. The soils that were tested were checked against the field classifications, which were then updated where appropriate in accordance with ASTM D 2487.

Table 3: Geotechnical Test Methods Applied to Representative Soil Samples

Geotechnical Test	Test Procedure
In Situ Moisture Content	ASTM D 2216 / AASHTO T 265
Sieve (Grain Size) Analysis	ASTM C 136/C 117, ARIZ 201d
Atterberg Limits (Soil Plasticity)	ASTM D 4318, AASHTO T 89/T 90
R-Value	AASHTO T 190, ASTM D 2844
In-place Density	ASTM D 2937
Standard Proctor	ASTM D 698
Swell of Cohesive Soil	ASTM D 4546
Collapse Potential	ASTM D 5333
pH, Resistivity	ASTM D 4972, ARIZ 236
Soluble Chlorides	ASTM D 1411, ARIZ 736
Soluble Sulfates	ASTM C 1580, ARIZ 733
Resilient Modulus, Mr	AASHTO T 307

Notes:
ARIZ = Arizona Department of Transportation Test Method (ADOT 2016)

3.4 Borehole Infiltration Testing

Golder performed borehole infiltration testing at nine locations in general accordance with ASTM D 6391 – Standard Test Method for Field Measurement of Hydraulic Conductivity Using Borehole Infiltration, Method B (falling head test). The test procedure involved excavating a hole using a 5-inch diameter auger to a depth of 18 inches. A 4-inch diameter plastic pipe was seated into the hole, and a seal created around the outside of the pipe as indicated in the standard. A standpipe assembly with a clear pipe and measuring tape was attached to the 4-inch pipe, and the pipe filled with water to the starting level. A single trial involved recording the dropping level of the water in the standpipe at multiple time intervals. The number of points and time interval depends on the permeability of the material. A curve-fitting procedure is used in a spreadsheet to fit an equation to the observed data with the least error. The coefficients from the curve fitting are then used to compute the hydraulic conductivity for the soil according to that trial. Additional trials are performed by refilling the tube and collecting additional data points. Ideally, trials are performed until equilibrium is reached. Practically, trials are stopped when the last three hydraulic conductivity values derived from the trials show 25 percent or less deviation from the mean value of those points. Once the test was completed, the pipe was removed, and the hole backfilled. The results of the infiltration tests are included in Appendix C. The recommended hydraulic conductivity values at each location are presented in Table 4.

Table 4: Borehole Infiltration Test Results

Test Hole Number	Depth (in)	Stabilized Hydraulic Conductivity, K (cm/s)	Stabilized Hydraulic Conductivity, K (in/hr)	Station, Offset
BH-03	18	4.0×10^{-4}	0.6	124+15, 35L
BH-04	18	2.5×10^{-4}	0.4	129+40, 7L
BH-07	18	3.0×10^{-4}	0.4	144+50, 42R
BH-13	18	3.0×10^{-4}	0.4	172+60, 128R
BH-17	18	1.2×10^{-4}	0.2	194+75, 56L
BH-22	18	1.0×10^{-04}	0.1	219+75, 12L
BH-26	18	5.0×10^{-04}	0.7	239+75, 12L
BH-29	18	4.0×10^{-04}	0.6	254+55, 26L
BH-32	18	5.0×10^{-04}	0.7	269+80, 39L

Notes:
in = inch
in/hr = inch per hour
cm/s = centimeter per second

3.5 Dynamic Cone Penetrometer Testing

The field program included a total of four DCP tests, one adjacent to each test pit location. Golder measured the in-situ penetration rate of the DCP with an 8-kilogram (kg) hammer following ASTM D 6951: Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications. The rod includes a disposable cone-shaped tip 20 millimeters (mm) (0.79 inches) in diameter. The operator drove the DCP tip into the soil by lifting the sliding hammer to the handle then releasing it. The total penetration for a given number of blows is then measured in mm. The number of blows is recorded every 10 centimeters (cm) of penetration. The DCP equipment used in this project has a depth limitation of 1.70 m (5.6 feet).

The field investigation was conducted on September 28, 2017, sequentially with the drilling and coring. The weather was hot and dry, and there had not been any rain in the time preceding the investigation. The DCP soundings were conducted to a depth of 150 cm (4.92 feet) unless refusal was encountered. A refusal is defined here as when a total of 50 blows did not cause the rod to penetrate at least 7 cm (2.7 inches).

The correlated in-situ California Bearing Ratio (CBR) was computed for each 10 cm interval using the following equation recommended by the US Army Corps of Engineers (Webster et al. 1992) for non-clay soils and lean clay soils (when CBR is greater than 10 percent):

$$CBR = \frac{292}{DCP^{1.12}}$$

Where DCP represents the DCP Index value in mm/blow and CBR results are reported as a percentage. For DCP Index values less than 3 mm/blow, CBR equals 100 percent. CBR is a laboratory test that measures mechanical strength and stiffness of a native or compacted sample relative to a sample of standard crushed rock material and it is used by some Departments of Transportation to derive subgrade resilient modulus, just as PCDOT and ADOT use the R-Value test. DCP summary data sheets, calculations, and plots are included in Appendix D.

The graphical correlation between the cumulative blows and depth can be used to identify different layers where a change in slope occurs. Graphs on individual DCP sounding logs (Appendix D) depict the interpreted layers. Golder computed an average DCP index and CBR for each layer.

4.0 SITE CONDITIONS AND GEOTECHNICAL DATA

4.1 Subsurface Conditions

The boreholes encountered a relatively consistent layer of silty sand to clayey sand which agrees with the description of the geologic unit described in Section 2.2. Most of the samples obtained from the boreholes classified as Silty Sand (SM) while the samples obtained from boreholes BH-08, BH-11, BH-19, BH-22, BH-23, BH-26 and BH-29 classified as Clayey Sand (SC). Fines content generally ranged from 20 to 50 percent, and moisture contents ranged from 5 to 10 percent. Soil plasticity ranged from low to medium.

No groundwater was encountered in any of the boreholes. The regional groundwater table is reported as greater than 200 feet below the ground surface (ft-bgs) based on nearby groundwater measurements (ADWR 2015). Accordingly, it is not expected that regional groundwater will be encountered during construction of this project.

4.2 Geologic Hazards

Geologic hazards common in southern Arizona and relevant to this project include hydro-collapsible soils and expansive soils. These geologic hazards are discussed in the following sections.

4.2.1 Hydro-collapsible Soil

Hydro-compactive or collapsible soils are subject to significant volume reduction when wetted. This occurs primarily because of the breakdown of the soil structure as light calcium carbonate cementation or bonding between sand particles softens or weakens under increased moisture content. Wetting and loading history of the soil influence the collapse potential, and a soil may collapse under even relatively low loads, such as that imposed by pavement structures or small embankments, when the soil moisture content exceeds past levels. Often, the placement of a new structure changes the drainage or evapotranspiration regime of the soil, increasing the likelihood of a collapse event (Houston et al. 2002). The general criteria for field identification of soils with collapse potential are as follows (adapted from Beckwith 1979):

- Plasticity Index (PI) less than 10
- Dry density less than 95 pounds per cubic foot (pcf)
- Moisture content less than 8 percent
- SPT N-value less than 15 blows per foot

Several boreholes encountered potentially collapsible material based on the above criteria, particularly considering the SPT N-value. These include BH-04, BH-07, BH-13, BH-15, BH-25, BH-26, BH-30 and BH-31. ATEK performed collapsible potential tests on samples retrieved from these boreholes. The results of the collapse tests are provided in Table 5.

Table 5: Summary of Collapse Test Results

Borehole	Depth	In Situ Dry Density	SPT N60 Value [A]	In Situ Moisture Content	Collapse Index, I_e[B]	Degree of Collapse [C]
	(ft)	(pcf)	(blows/ft)	(%)	(%)	
BH-04	2.5	94.4	12	3.5	12	Severe
BH-07	5.0	96.1	50	8.5	10	Moderately Severe
BH-13	5.0	102.5	14	4.0	8	Moderately Severe
BH-15	2.5	103.0	40	8.6	8	Moderately Severe
BH-25	2.5	103.5	8	4.2	8	Moderately Severe
BH-26	5.0	103.1	5	5.4	7	Moderately Severe
BH-30	2.5	102.3	48	5.3	9	Moderately Severe
BH-31	2.5	112.9	31	5.0	8	Moderately Severe

Notes:
A = Corrected for sampler diameter and estimated hammer efficiency
B = Collapse index is the difference in height of the sample before and after inundation divided by the initial height of the specimen when the test is performed at an inundation stress of 4 ksf.
C = Based on Table 1 of ASTM D 5333-03.
ft = feet
pcf = pounds per cubic feet
% = percent

Recommendations related to mitigation of collapsible soil are presented in Section **7.1**.

4.2.2 Expansive Soils

The presence of potentially expansive soils was evaluated using the identification method presented as Table 10.4.6.3-1 of AASHTO (2014 with 2016 Interims), which is reproduced here as Table 6 for reference.

Table 6: Method for Identifying Potentially Expansive Soils (AASHTO 2012 with 2013 Interims)

Liquid Limit (%)	Plastic Limit (%)	Soil Suction (ksf)	Potential Swell (%)	Potential Swell Classification
> 60	> 35	> 8	> 1.5	High
50 - 60	25 - 35	3 – 8	0.5 – 1.5	Marginal
< 50	< 25	< 3	< 0.5	Low

Notes:
ksf = kips per square foot
% = percent

Atterberg limits for most of the samples indicated that soils would classify as a low swell potential according to Table 6. Golder performed four swell potential tests. Results for these tests are provided in Table 7 and indicate a marginal swell potential for three of the samples and a high swell potential for one sample.

Table 7: Summary of Swell Test Results

Borehole	Depth	Initial Moisture Content	Final Moisture Content	Swell	Potential Swell Classification
	(ft)	(%)	(%)	(%)	
BH-03	0-5	6.4	18.6	2.0	High
BH-19	0-5	7.7	19.6	1.1	Marginal
BH-26	0-5	7.9	17.8	1.2	Marginal
BH-31	0-5	6.8	16.1	0.8	Marginal

Notes:
ft = feet
% = percent

Maricopa County DOT (MCDOT 2017) recommends taking the average of three or more swell tests or in some instances, the worst-case swell result. If that percentage is between 2 and 5 percent, they recommend 6 inches of subgrade stabilization with lime or cement. Alternatively, the subgrade can be replaced to a depth of 24 inches below the base course with suitable material. Golder believes the 2 percent swell measured at BH-03 is borderline, and when factored in with the other swell test results and the index testing, we believe that treatment or overexcavation and replacement are not warranted in this case.

4.3 R-Value Analysis

Pima County adopted an update to the Pavement Design Section (3.13) of their Roadway Design Manual on April 29, 2016. The most significant change to this procedure is the addition of a correction equation that in most cases reduces correlated R-Values relative to the original ADOT correlation equation currently in use by the City. This in turn results in thicker and more costly pavement sections. The increase in initial construction cost is intended to result in better performance over the life of the pavement.

R-Value calculations in the draft report were based on current Pima County procedures. PSOMAS and the City asked Golder to use only the Pima County procedures for this city project. Table 8 provides the results of the R--Value testing with correlated R-Values reported for the current ADOT procedures (RCB) and the Pima County procedures (RPC).

Table 8: R-Value Analysis

Borehole ID	USCS	AASHTO	% Passing No. 200	Plasticity Index	R_{corr} (RCB)	R_{corr} (RPC)[A]	R_{tested}
BH-01	SM	A-2-6(0)	30	11	43	27	
BH-02	SM	A-2-4(0)	29	10	45	29	
BH-03	SM	A-2-4(0)	28	10	46	30	23
BH-04	SC-SM	A-1-b(0)	19	4	66	46	
BH-05	SM	A-1-b(0)	21	0	75	53	
BH-06	SM	A-4(1)	40	10	39	24	

Borehole ID	USCS	AASHTO	% Passing No. 200	Plasticity Index	R_{corr} (RCB)	R_{corr} (RPC)[A]	R_{tested}
BH-07	SM	A-4(1)	40	10	39	24	
BH-08	SC	A-6(2)	39	15	32	20	16
BH-09	SP-SM	A-1-b(0)	10	1	84	61	
BH-10	SM	A-1-b(0)	13	0	84	61	
BH-11	SC	A-2-4(0)	33	10	43	27	
BH-12	SM	A-2-4(0)	28	1	65	45	
BH-13	SM	A-1-b(0)	25	2	65	45	
BH-14	SM	A-2-6(0)	30	11	43	27	
BH-15	SC-SM	A-2-4(0)	29	7	51	34	
BH-16	SM	A-2-4(0)	33	10	43	27	23
BH-17	SM	A-2-4(0)	32	8	47	30	
BH-18	SM	A-4(0)	36	8	44	28	
BH-19	SC	A-4(1)	42	8	41	26	
BH-20	SM	A-4(0)	41	3	50	33	
BH-21	SM	A-2-4(0)	35	2	57	38	
BH-22	SC	A-2-4(0)	30	8	48	31	15
BH-23	SC	A-6(3)	47	13	31	19	
BH-24	SM	A-2-4(0)	30	2	61	42	
BH-25	SM	A-2-4(0)	20	7	58	39	
BH-26	SC	A-2-6(0)	29	11	44	28	
BH-27	SM	A-2-4(0)	27	0	69	48	
BH-28	SP-SM	A-1-b(1)	8	0	90	66	
BH-29	SC	A-2-4(0)	34	9	44	28	22
BH-30	SM	A-2-4(0)	28	0	68	47	
BH-31	SM	A-2-4(0)	22	7	56	38	
BH-32	SC-SM	A-2-4(0)	35	7	47	30	
BH-33	SC-SM	A-4(0)	36	5	50	33	
BH-34	SM	A-1-b(0)	22	2	68	48	67

Borehole ID	USCS	AASHTO	% Passing No. 200	Plasticity Index	R_{corr} (RCB)	R_{corr} (RPC)[A]	R_{tested}
BH-35	SC-SM	A-2-4(0)	29	6	53	35	
BH-36	SM	A-4(1)	40	10	39	24	

Notes:
% = percent
A – Using correction factor from April 2016 updates to Pima County Roadway Design Manual

4.3.1 Design R-Value

The primary pavement design input for addressing site-specific characteristics of the subgrade is the resilient modulus (Mr), or stiffness of the subgrade soil. Agencies in Arizona use the R-Value test as a proxy for the resilient modulus, and the design R-Value is used to compute M_R using an empirical equation. Golder evaluated several alternative methods of determining the subgrade strength to optimize the pavement sections while still ensuring adequate performance over the life of the pavement. The methods included DCP testing and laboratory resilient modulus tests.

4.3.1.1 Resilient Modulus Laboratory Test Results

Two resilient modulus laboratory tests were performed on samples from the boreholes BH-08 and BH-29. The resilient modulus test characterizes the subgrade stiffness response under repeated loading. Samples were compacted at optimum moisture content and 95 percent max dry density based on standard Proctor test results. Results are commonly presented in the form of an equation that is used to determine the material's modulus res onse ase on a lie ul an eviator stresses σ_d).

BH-08 Test Results $$Mr = 269.63\ x\ Pa\ x\ (\frac{\theta}{Pa})^{0.822} x\ (\frac{\sigma_d}{Pa})^{-0.828}$$

BH-29 Test Results $$Mr = 695.62\ x\ Pa\ x\ (\frac{\theta}{Pa})^{0.0137} x\ (\frac{\sigma_d}{Pa})^{-1.1}$$

Where:
Mr = Resilient Modulus
Pa = Atmospheric Pressure, psi
ul tress si
σ_d = Deviator Stress, psi

Golder selected stress values of 6 psi and 2 psi for deviator and confining stress (σ_3), respectively, to evaluate the subgrade based on guidance in Uz et al. (2015). The bulk stress or stress state was derived from the confining stress and applied to the modulus response equations. The analysis resulted in M_R Values of 7,045 psi and 27,325 psi for BH-08 and BH-29, respectively. These values were transformed back to equivalent R-Values using the ADOT equation and R-values of 15 and 57, respectively, were obtained. Tested M_R for BH-08 matched well with the tested R-value from the same borehole (R-value of 16), while the result from BH-29 is well over two times the tested R-Value of 22 at that location. The most likely explanation for the discrepancy is the inherent variability of the sample between what was sent to the ATEK for index and R-Value testing and what was sent to Geotesting for the Mr test. Golder attempted to homogenize the sample prior to testing, but this process may have been imperfect. The result is still in line with the upper range of tested and correlated R-values, so it is still consistent with the overall results.

4.3.1.2 Correlated Resilient Modulus from DCP Soundings

The field investigation also included 19 DCP tests conducted adjacent to every other borehole along the alignment. Most of the DCP tests were advanced to a depth ranging from 3 to 5 ft except for several shallow refusals. DCP results were reduced and layer changes were recognized by identifying the change in rate of blows/mm. The graphical output of the results is included in Appendix D. Golder estimated CBR values for every increment of penetration as explained in Section 3.4. We then calculated average CBR values for every Borehole excluding any outliers and values close to the depth of refusal due to their high influence in the average calculation. We converted average CBR values for each DCP sounding into correlated Mr according to the following equation (NCHRP 2001) where Mr is in psi:

$$Mr = 2555\ x\ CBR^{0.64}$$

The resulting correlated Mr values ranged between 20,000 psi and 65,000 psi (or R-Values between 26 and 160). The discrepancy between these high modulus values and those computed from other methods may be related to cementation in the soil, or gravel content affecting the DCP results. Accordingly, the DCP-derived modulus values were excluded from further analysis.

4.3.1.3 Conventional Resilient Modulus Analysis

The method for computing the R_{mean} or design R-Value is described in the ADOT PDM and factors in both the correlated R-Values and tested R-Values. The PCRDM Correlated R-Values using index properties and tested R-values yielded an average of 36 and 28, respectively. By using the ADOT PDM procedures, the R_{mean} was estimated at 35.4. Due to the high variance between consecutive correlated R-Values and the cyclical pattern observed along the corridor (Appendix E, Figure E-1), Golder selected a lower-bound R-Value for both the Design and the Construction Control.

To minimize the amount of overexcavation and replacement required, a Design and Construction Control R-Value of 27 was selected. The use of this R-Value as the Construction Control will only leave two sections (from STA 137+00 to 152+50 and from STA 221+50 to 226+50) which might require a type of subgrade improvement. This mitigation is explained further in Section 7.3.

4.4 Electrochemical Soil Properties

Bulk soil samples were collected from selected boreholes as listed in Table 9 and were subjected to laboratory tests to determine the electrochemical (corrosive) potential of the site soils. A summary of the laboratory corrosivity test results at these locations is presented in Table 9.

Table 9: Soil Chemical Properties

Location	Station	Depth (feet)	pH	Resistivity (ohm-cm)	Soluble Sulfates (ppm)	Chlorides (ppm)
BH-07	144+50	0-5	9.2	1,810	18	14
BH-13	172+60	0-5	8.9	2,750	95	40
BH-29	254+55	0-5	8.7	1,410	26	56

Location	Station	Depth (feet)	pH	Resistivity (ohm-cm)	Soluble Sulfates (ppm)	Chlorides (ppm)
BH-32	269+80	0-5	8.8	1,340	34	20
BH-35	285+60	0-5	8.9	1,950	47	28

Note:
ND = Not Detected at or above the Practical Quantitation Limit (PQL)
ohm-cm = ohm-centimeters
ppm = parts per million

Based on the guidelines for structural elements (American Concrete Institute 2011), the site soils are expected to have negligible potential with respect to sulfate attack on concrete. As a result, Type I/II cement may be used at the project site for concrete elements in contact with site soil. The chloride content suggests non-aggressive corrosion potential for exposed metal components; however, most of the resistivity results were below 2,000 ohm-cm which is considered aggressive. Generally, a pH between 6.5 and 7.5 is considered neutral with respect to corrosion. The site soils fall outside the neutral range on the basic side and should be considered mildly corrosive by this measure.

5.0 TRAFFIC DATA

PSOMAS provided Golder with traffic loading information based on PAG's 2045 model for Valencia Road, Nexus Road, and Old Vail Road (PSOMAS 2020). A summary of the ADT and 18-kip equivalent single axle loading (ESAL) values used is presented in Table 10.

Table 10: Summary of Traffic Data and Design ESALs

Roadway Segment	Design Year ADT (vpd)	Annual Growth Rate (%)	Design Lane ESALS
Valencia Rd, W of Old Vail Rd	40,544	3.0	5,348,198
Valencia Rd, Old Vail Rd to Nexus Rd	35,568	3.5	4,503,821
Valencia Rd, E of Nexus Rd	25,626	3.5	3,244,893
Nexus Road	13,620	1.0	2,398,779
Old Vail Road	6,470	1.0	1,141,959

Notes:
vpd = vehicles per day
% = percent
ESAL = Equivalent Single Axle Load

6.0 PAVEMENT STRUCTURE DESIGN

6.1 Pavement Rehabilitation

The project team was interested in the possibility of rehabilitating a portion of the existing pavement on Valencia Road in the vicinity of Rita Ranch as a cost-saving measure. This was particularly attractive when considering that as-built drawings show cement treated base underlying the pavement. However, Golder's field investigation did not encounter any cement treated base, or if it was encountered, it was so degraded as to be essentially indistinguishable from aggregate base materials. Additionally, most of pavement in the area is estimated to have been constructed prior to 2002, meaning that it has approximately five years or less of useful life remaining. Accordingly, Golder recommends total reconstruction of the pavement structural sections rather than utilizing a portion of the existing pavement along Valencia Road.

6.2 Subgrade Mitigation

The design and construction control R-Value of 27 is reasonable for the Tucson Metro area in Golder's experience and will not require extensive subgrade mitigation during construction. Localized areas of material having correlated or tested R-Values less than 27 are recommended to be treated by overexcavation and replacement with suitable material. Section 7.3 addresses the locations of recommended subgrade mitigation by overexcavation and replacement. The size of these areas is relatively small in relation to the overall project size. Accordingly, we do not consider it practical to recommend alternative methods of subgrade mitigation such as lime treatment or geogrid base reinforcement. If the overexcavation will severely impact utilities, drainage facilities, or constructability, Golder should be contacted to revisit this recommendation.

6.3 Basis for Comparison of Structural Section Alternatives

The following pavement sections were considered as potential pavement sections for this project:

- Asphaltic concrete (AC) over AB
- AC over Cement Treated AB (CTB)
- AC over Cement Treated Subgrade (CTS)

Asphalt rubber surface course was not used for this project. Initial estimates of construction unit prices that are used to compare the initial construction costs for structural section alternatives were obtained from previous City and Pima County projects and based on Golder's experience. These costs are meant only to compare the relative construction cost of the alternative pavement sections evaluated. PSOMAS and the City should independently develop costs for the purposes of compiling an overall construction cost estimate. Unit prices and cementitious material quantity calculations are presented in Appendix E. The unit prices selected for this evaluation are:

- AC (PAG Mix No. 1): \$4.08/square yard-inch (yd^2-in)
- AC (PAG Mix No. 2): \$4.89/ yd^2-in
- AB: \$1.06/yd^2-in
- CTB (4 percent cement): \$1.29/yd^2-in plus \$1.90/ yd^2 for treatment
- CTS (9 percent cement): \$0.50/ yd^2-in plus \$1.90/ yd^2 for treatment
- CTS (12 percent cement): \$0.66/ yd^2-in plus \$1.90/ yd^2 for treatment
- Pre-Cracking (micro-cracking of CTB or CTS): \$0.33/ yd^2

The AC costs are derived from similar City and Pima County projects include the following:

- AC (PAG No. 1): \$75.00/ton
- AC (PAG No. 2): 6\$90.00/ton

The cost for AB of \$1.06/yd^2-in is equivalent to approximately \$38.00 per cubic yard (yd^3).

Cement treated AB and Subgrade costs were derived using:

- Cement treated subgrade cost of \$1.90/yd^2 from a previous City of Tucson project
- Cementitious material for cement treated subgrade/base: \$112/ton
- Pre-cracking (micro-cracking) of \$120/hour with a coverage of approximately 365 yd^2 per hour

6.4 Flexible Pavement Design

6.4.1 Design Parameters

The flexible pavement design parameters used to develop the 20-year design life pavement sections for the project are shown in Table 11.

Table 11: Flexible Pavement Design Parameters

Location	Flexible Pavement Design Parameter					
	W_{18}	Z_R	S_0	P_O	P_T	ΔPSI
Valencia Rd, W of Old Vail Rd	5,348,198	-1.645	0.35	4.2	2.8	1.4
Valencia Rd, Old Vail Rd to Nexus Rd	4,503,821	-1.645	0.35	4.2	2.8	1.4
Valencia Rd, E of Nexus Rd	3,244,893	-1.645	0.35	4.2	2.8	1.4
Nexus Road	2,398,779	-1.645	0.35	4.2	2.8	1.4
Old Vail Road	1,141,959	-1.282	0.35	4.1	2.6	1.5

Notes:
W_{18} = 18-kip ESALs applied to the pavement during the design life in the design lane.
Z_R = Standard normal random variable corresponding to level of reliability values on page 3-43 of the PCRDM. A Level of Reliability of 95 percent is assigned to all arterial roadways, and 90 percent is assigned to Old Vail Road which classifies as a major collector based on traffic volumes.
S_0 = Standard error as given by the PCRDM.
P_O = The initial design serviceability index, computed from required P_T an P I values from PCRDM.
P_T = The design terminal serviceability index, from PCRDM.
P I P_O - P_T; this is the change from the present serviceability index over the 20-year design period, given on the PCRDM

In addition to these parameters, a resilient modulus (M_R) of 11,685 pounds per square inch (psi) was used throughout the project. This value is derived from the assumed design R-Value of 27 presented in Section 4.3.1.

The structural coefficients for AC, cement treated AB, and AB used for design are 0.44, 0.28 and 0.12, respectively, as given in Section 3.13 of the PCRDM (PCDOT 2016). The cement treated AB coefficient assumes that a mix design will be used that provides a minimum of 800 psi compressive strength at seven days. Cement treated subgrade coefficients assume that 9 and 12 percent cement provide a minimum of 500 psi and 800 psi in 7-day unconfined compressive strength, respectively. Figure 2-4 of the ADOT Materials Design Manual defines

CTS structural coefficients of 0.20 for 500 psi compressive strength and 0.23 for 800 psi compressive strength materials.

A drainage coefficient of 0.92 was assigned based on the PCRDM which corresponds to fair drainage conditions with the seasonal variation factor (SVF) for the Tucson area of 1.7 according to Table 2-7 and Table 2-4 of the ADOT Materials Design Manual.

6.4.2 Required Pavement Structural Number

The required pavement structural number computed are:

- Valencia Rd, W of Old Vail Rd: 4.04
- Valencia Rd, Old Vail Rd to Nexus Rd: 3.93
- Valencia Rd, E of Nexus Rd: 3.71
- Nexus Road: 3.52
- Old Vail Road: 2.90

The minimum required structural number for Arterials is 2.64 and for Collectors is 1.75 based on the PCRDM.

6.4.3 Alternative Pavement Structural Sections

Structural sections are provided for each roadway segment. Golder evaluated one conventional section (AC over AB), one CTB section, and two to three CTS sections with varying cement content for each roadway section. We attempted to ensure that the ratio of AB to AC for each alternative is between 1:1 and 1.75:1 as recommended in the PCRDM. Several of the alternatives listed here are marginally outside of this range, however Golder believes they should still be considered valid alternatives since the component lift thickness remain within the range that is practical and economical to compact with typical construction equipment.

Table 13 provides a summary of all alternative structural sections considered for each roadway segment. The recommended pavement sections for each scenario are highlighted in Table 12 and discussed in Section 6.4.4. Pavement design calculations sheets are included in Appendix F.

Table 12: Evaluation of Alternative Pavement Structural Sections

Roadway Segment	Section Number	PAG 1 AC (in)	PAG 2 AC (in)	Cement Treated AB (CTB, in)	Cement Treated Subgrade at 500 psi (CTS_{500}, in)	Cement Treated Subgrade at 800 psi (CTS_{800}, in)	AB (in)	Total Section Thickness (in)	Required Structural No.	Provided Structural No.	Initial Pavement Construction Costs ($/SY)
Valencia Rd, W of Old Vail Rd	1	3.5	3.0	0	0	0	11	17.5	4.04	4.07	$40.61
	2	3.0	3.0	6	0	0	0	12.0	4.04	4.32	$36.88
	3	3.0	3.0	0	8	0	0	14.0	4.04	4.24	$33.14
	4	3.0	3.0	0	0	7	0	13.0	4.04	4.25	$33.76
	5	3.0	2.0	0	0	10	0	15.0	4.04	4.50	$30.85
Valencia Rd, Old Vail Rd to Nexus Rd	1	3.5	3.0	0	0	0	10	16.5	3.93	3.96	$39.55
	2	3.0	3.0	5	0	0	0	11.0	3.93	4.04	$35.59
	3	3.0	3.0	0	7	0	0	13.0	3.93	4.04	$32.64
	4	3.0	3.0	0	0	6	0	12.0	3.93	4.02	$33.10
	5	3.0	2.0	0	0	10	0	15.0	3.93	4.50	30.85
Valencia Rd, E of Nexus Rd	1	3.0	3.0	0	0	0	10	16.0	3.71	3.74	$37.51
	2	3.0	2.5	5	0	0	0	10.5	3.71	3.82	$33.15
	3	3.0	3.0	0	6	0	0	12.0	3.71	3.84	$32.14
	4	3.0	3.0	0	0	5	0	11.0	3.71	3.79	$32.44
	5	3.0	2.0	0	0	10	0	15.0	3.71	4.50	$30.85
Nexus Road	1	3.0	3.0	0	0	0	8	14.0	3.52	3.52	$35.39

Roadway Segment	Section Number	PAG 1 AC (in)	PAG 2 AC (in)	Cement Treated AB (CTB, in)	Cement Treated Subgrade at 500 psi (CTS_{500}, in)	Cement Treated Subgrade at 800 psi (CTS_{800}, in)	AB (in)	Total Section Thickness (in)	Required Structural No.	Provided Structural No.	Initial Pavement Construction Costs ($/SY)
	2	3.0	2.0	5	0	0	0	10.0	3.52	3.60	$30.70
	3	3.0	2.0	0	7	0	0	12.0	3.52	3.60	$27.75
	4	3.0	2.0	0	0	6	0	11.0	3.52	3.58	$28.21
Old Vail Road	1	3.0	2.0	0	0	0	7	12.0	2.90	2.97	$29.44
	2	3.0	2.0	4	0	0	0	9.0	2.90	3.32	$29.41
	3	0.0	3.0	0	8	0	0	11.0	2.90	2.92	$20.90
	4	0.0	3.0	0	0	7	0	10.0	2.90	2.93	$21.52

6.4.4 Recommended Flexible Pavement Section

Golder recommends the following pavement sections for the project (components listed from the bottom to the top of the sections):

Valencia Road:

- 10 inches of CTS with 12 percent cement
- 3.0-inch lift of AC - PAG 1 (or TDOT equivalent)
- Tack coat
- 2.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $30.85 per square yard

Nexus Road:

- 6 inches of CTS with 12 percent cement
- 3.0-inch lift of AC - PAG 1 (or TDOT equivalent)
- Tack coat
- 2.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $28.21 per square yard

Old Vail Road:

- 7 inches of CTS with 12 percent cement
- 3.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $21.52 per square yard

Both Valencia Roadway segments east of Old Vail Road meet the required structural number with thinner CTS layers (between 6 and 8 inches). Golder recommends the proposed section for Valencia west of Old Vail Road be used along the full length of the project for constructability and because the potential cost savings is low.

Nexus Road and Old Vail Road meet the required structural number with the more economical option of 9 percent cement in the CTS. For consistency with the main roadway, Golder recommends using 12 percent cement as proposed for Valencia Road.

Fiber Reinforced Asphalt Concrete (FRAC) has been used on a number of recent City and County projects in the Tucson Metro area and has been well received by the agencies and contractors. The primary purpose of adding the fibers to the AC mix is to help control cracking which provides long-term performance benefits. Golder's analysis did not include any structural benefit to the fiber reinforcement.

6.5 Subgrade Acceptance

The 2016 modifications to the Pima County Roadway Design Manual suggest that with the use of Pima County correlated R-values, the design R-value is also the construction control R-value. Golder does not recommend equating the design and construction control R-values. The design R-value is based on a combination of average correlated and lab-tested R-values. By definition, use of the average R-value includes subgrade material that is above and below the average properties, defined in this case as the fines content and the plasticity index. If the mean R value is used to set the subgrade acceptance X value, then, by definition, a large percentage of the on-site subgrade soils would be rejected in the field. Use of the critical t-value approach per the ADOT Pavement Design Manual remains valid with the Pima County correlated R-values and allows for acceptance of the natural statistical variability of the material that was used to develop the design R-value (i.e., material around one-standard deviation below the mean value is acceptable subgrade when considering the overall average subgrade properties of the site).

Golder's R-value analysis handled statistical outliers by recommending overexcavation and replacement as select locations as described in Section 4.3. Accordingly, this project is a special case where a construction control R-value of 27 (same as design R-Value) is appropriate. The corresponding construction control X value is 61 for this project. The recommended subgrade acceptance chart is provided in Appendix D.

6.6 Use of Recycled Materials

The 2014 PAG Standard Specs (PAG 2014) contains additional language related to use of recycled asphalt pavement (RAP). The general approach in the Standard Specs is to allow the contractor to utilize RAP for several applications, but it is not required. Therefore, the construction bid prices for the items containing RAP will be lower for contractors using RAP than those using only "virgin" materials. Based on discussions with local contractors and materials experts, we believe contractors will maximize the use of RAP wherever possible.

6.6.1 RAP in Asphaltic Concrete

Section 406 of the 2019 PAG Standard Specs allows the contractor to utilize RAP in the AC mix where the RAP may not exceed 15 percent of total weight of aggregate in the mix. Previous projects have allowed the percentage of RAP be increased from 15 to 20 percent. This is consistent with ADOT's standard practice which allows 25 percent RAP in lower asphalt lifts, and 20 percent RAP in the top lifts. The total potential savings could be expressed as:

- Savings in new bitumen required + Savings in new aggregate required – Additional processing cost

Golder understands that plants that produce RAP have indicated that the additional processing cost and the savings in new aggregate essentially cancel each other out, leaving the savings in new bitumen required as the total savings. The potential savings for this project can be estimated by multiplying the total AC quantity for the project (in tons) by the percentage of RAP use, estimated 5 percent bitumen content of the millings, and the unit cost of bitumen (about $500 per ton). This savings is exclusive of any amount the plant may charge for the stockpiled RAP. The potential cost savings for this project associated with usage of RAP in AC is estimated to be $150,000 to $200,000.

6.7 Pavement Section Drainage

The proposed pavement sections do not include a drainage layer over the CTS. Golder recognizes that stabilizing subgrades with cement can affect the permeability of the material, limiting the drainage of the pavement system. Severe rainfall or ponding may increase the amount of infiltration into the pavement section, potentially entrapping water against the curb on the south side of the roadway. Roadway/drainage design for the project should include sufficient surface and subsurface drainage details to prevent this situation.

Golder reviewed several pavement design manuals and specification documents related to stabilized subbases, including the Maricopa Association of Governments Specifications for Public Works Construction (MAG 2020). MAG requires the use of a 4-inch drainage layer over cement treated bases. Additionally, the standard requires that cement treatment be held back a minimum of 1 foot from the curb line to permit drainage.

Following discussions with the City and PSOMAS, and based on the City's recent experience with a similar project in Tucson, the design team agreed that the AC layers will be constructed directly on CTS, but the drawings and specifications will account for a setback of the cement treatment equivalent to the width of the bike lane wherever curb is present. Golder does not anticipate impacts to service life resulting from the decreased structural number associated with this setback because of the low percentage of traffic loading actually applied to the shoulder or bike lane.

Golder will coordinate with the City and PSOMAS on the development of drainage details during final roadway design.

7.0 RECOMMENDATIONS FOR EARTHWORK AND SLOPES

7.1 Mitigation for Collapsible Soil

Collapsible soil deposits are present along the project corridor based on the data reported in Section 4.2.1. Mitigation of an identified collapsible soil deposit is warranted if: 1) a load is applied to the deposit, such as from a pavement or foundation; and 2) the soil is likely to become partially or fully saturated at some point in the design life of the facility. Golder performed infiltration tests at five locations as described in Section 3.4 to characterize the hydraulic conductivity of the native subgrade soil and evaluate the likelihood of partial or full saturation. We utilized an empirical relationship by Houston et al. (2002) along with our site-specific hydraulic conductivity results to estimate the depth of wetting front as a function of time.

The hydraulic conductivity of the native soils ranged from 0.1 inches per hour (in/hr) to 0.7 in/hr as reported in Table 4. The wetting front from a ponded water source could potentially infiltrate a depth of approximately 2.5 feet assuming the worst-case infiltration rate of 0.7 in/hr, and a ponding period of 1 week. However, this would require a ponding depth of over 12 inches to provide sufficient fluid volume to maintain the infiltration. This condition is unlikely to occur with standard roadway drainage design practice.

Based on the infiltration rate analysis, Golder does not believe comprehensive overexcavation and re-compaction along the roadway corridor is required. We recommend that project specifications include a special provision for use of a heavy vibratory roller to compact the full length of the roadway subgrade prior to placement of the pavement structural sections. The depth of influence of this type of compaction equipment is sufficient to mitigate the top 18 inches of potentially collapsible soil according to Christopher et al. (2006). The same specification should be referred to for subgrade preparation beneath the proposed drainage ditch on the north side of Valencia Road.

Other areas of potential concern occur where the probability of saturation is high or at significant permanent structures. We recommend over-excavation and recompaction near the following project elements:

- Near major drainage structures, such as box culverts
- Near retaining walls and sound walls

Other areas that the project team should carefully evaluate include:

- Near storm drains
- Close to wet utilities (water, reclaimed water, sanitary sewer)
- Any area where water could pond close to the roadway prism

7.1.1 Overexcavation and Recompaction at Major Drainage Structures

The overexcavation and recompaction limits should extend 3 feet below drainage structure invert elevation and a minimum of 2 feet in plan around the footprint of the structures, including drop inlets. The removed soil may be used to backfill the excavation and should be compacted to a minimum of 95 percent of the maximum dry density and ±2 percent of optimum moisture content as determined by ARIZ 225/226 and in accordance with the Standard Specifications. The limits of pipe bedding and shading or structural backfill from project plans and standard drawings shall still apply. The contractor may use pipe bedding or structure backfill in the overexcavation zone at no additional cost to PAG. The excavation and foundation preparation requirements of the relevant sections of the standard specifications shall apply.

Preliminary roadway designs propose segments of roadside channels on both sides of Valencia Road. Golder understands that channel design will include infiltration controls, hence overexcavation and recompaction recommendations do not apply for these structures. We do recommend subgrade preparation beneath the channels in accordance with the proposed special provision included in Section 7.1.3.

7.1.2 Water Harvesting Features

Water harvesting features may be planned for this project to capture on-site rainfall where practical and to allow it to infiltrate into the ground as opposed to running off the site. These project elements could increase the potential for water-induced soil collapse when located near pavements or structures. Accordingly, Golder provides the following recommendations for water harvesting features to minimize the potential for soil collapse because of water infiltrating beneath load-bearing structures:

- The plan limits of water harvesting basins should be at least 3 feet from any pavement, curb, wall, or other structure.
- Limit the depth of these features to a maximum of 12 inches, if possible, to limit the potential for lateral moisture migration as discussed in Section 7.1.
- Ensure compaction specifications are adequately enforced during construction beneath and near pavements and load bearing structures to reduce the hydraulic conductivity of the soil beneath these structures and limit the potential for lateral moisture migration.

7.1.3 Recommended Special Provision for Roadway Excavation

203-2 GENERAL of the Standard Specifications is revised to add:

The Contractor shall use a vibratory roller with a minimum drum weight of 12,500 pounds to compact the roadway subgrade prior to placement of the pavement structural sections.

Paragraph 7 of 203 3.03 (A) Construction Details – General of the Standard Specifications is revised as follows:

Prior to the placement of base material, the top 6 inches of the subgrade shall be scarified and compacted **using a minimum of 4 passes of a vibratory roller with a minimum drum weight of 12,500 pounds and** to a density of not less than 95 percent of the maximum density as determined in conformance with the requirements of the applicable test methods of the Arizona Department of Transportation Materials Testing Manual, as directed and approved by the Engineer, except that when asphaltic concrete or Portland cement concrete is to be placed directly on subgrade, the required density shall be 100 percent of the maximum density. When completed, the backfilled and compacted area shall remain firm and stable, as demonstrated by the lack of observable signs of deformation from wheel loading, even when subsequent courses of material are placed over the area.

7.2 Earthwork Factors

A ground compaction factor of 0.15 feet should be applied to compute required earthwork quantities. An earthwork factor of 10 percent shrink should be applied for native material excavated and placed as embankment fill compacted at 95 percent of standard proctor effort.

7.3 Unsuitable Soils

Table 14 provides Golder's recommended mitigation for unsuitable subgrade soil. Discussion of potentially collapsible soil deposits was presented in Sections 4.2.1 and 7.1, and discussion of poor-quality subgrade soil was discussed in Section 4.3.

Table 13: Recommended Mitigation for Unsuitable Soils

Station Limits	Depth of Overexcavation Below Top of Subgrade (feet)	Mitigation For	Recompact or Replace
137+00 – 152+50	2	Poor R-Value	Replace
221+50 – 226+50	2	Poor R-Value	Replace

Locations noted as "Replace" should be backfilled with borrow material meeting the subgrade acceptance chart shown in Appendix E. This material shall be placed in loose lifts not to exceed 8 inches following compaction and compacted to 95 percent of maximum dry density according to ARIZ 225 (standard proctor) and within 3 percent of optimum moisture content. The limits of overexcavation shall be from hinge to hinge with a vertical cut assumed for quantity calculation purposes.

7.4 Suitability of On-Site Soils for Backfill Applications

In general, the on-site materials will not meet the requirements of structure backfill or bedding/shading material based on the samples tested. The samples tested generally had fines content and PI outside acceptable limits and the resistivity most samples tested was below 2,000 ohm-cm.

7.5 Permanent Slopes

Permanent slopes on this project are anticipated to be less than 2 feet high; accordingly, slope stability analyses were not warranted for the project.

7.6 Temporary Excavations

Temporary cut slopes for construction that are less than 20 feet deep should be excavated in accordance with Occupational Safety and Health Administration (OSHA) Standards for Excavations, 29 CFR Part 1926, Subpart P. Native should be considered Type “B” soils in accordance with Subpart P, Appendix A. For excavations less than 20 feet deep, Subpart P, Appendix B indicates maximum allowable unshored slopes of 1H:1V for Type “B” soils. If steeper slopes are required due to the proximity of existing structures or utilities, the stability of the slope should be further evaluated by a geotechnical engineer, or shoring should be considered.

8.0 SUMMARY OF GEOTECHNICAL AND PAVEMENT VALUE ENGINEERING

Golder and the project team engaged in a value engineering process throughout the design phase. The purpose of this section is to document the project’s cost savings on geotechnical and pavement items because of these efforts. These estimated savings are computed using quantities from the approximate project area.

Table 14: Summary of Geotechnical and Pavement Value Engineering

Item	Estimated Project Savings	Comments
RAP used in AC	$175,000	Refer to Section 6.6.1.
Use of CTS relative to conventional AC over AB Pavement Section	$1,250,000	Refer to Section 6.3 and Table 12.
Total:	**$1,425,000**	

Notes:
yd^2 = square yard

9.0 RECOMMENDATIONS AND SUMMARY

All materials, methods, and procedures used in a pavement construction should comply with the relevant sections of the 2014 PAG Standard Specs and the project Special Provisions.

Results of collapse testing indicate the presence of potentially hydro-collapsible soil deposits along the corridor (Section 4.2.1). Golder performed infiltration tests, as described in Section 3.4, and utilized those results and published hydraulic conductivity coefficients for compacted material to analyze the potential for these deposits to become saturated. We concluded that the risk of saturation was low, and extensive overexcavation and recompaction is not warranted. We do recommend overexcavation and recompaction around major drainage structures and consideration should be given to areas near wet utilities. Refer to Section 7.1 for more discussion on mitigation of collapsible soil, including a discussion regarding water harvesting, and a proposed special provision for the project.

The project team initially considered re-using a portion of the existing pavement as a cost-saving measure. This is not considered feasible based on Golder's investigation, and a complete pavement reconstruction will be required.

We performed a comprehensive analysis to arrive at the design R-Value of 27 and construction control R-Value of 27. This analysis is discussed in Section 4.3. Considerations included the results of the correlated R-Values based on index test results for all boreholes, tested R-Values, the results of the DCP investigation, and the results of resilient modulus testing on two laboratory samples.

Pavement structure design included evaluating cost-saving/performance-enhancing alternatives consisting of cement treated base, and cement treated subgrade to compare with conventional AC over AB sections. Golder was asked to consider five different roadway sections based on traffic loading, three on Valencia Road, on for Nexus Road and one for Old Vail Road. Golder recommended the same pavement section for the three Valencia Roadway sections to simplify construction and because of minimal cost savings. The recommended pavement sections consist of:

Valencia Road:

- 10 inches of Cement Treated Subgrade (CTS) with 12 percent cement
- 3.0-inch lift of AC - PAG 1 (or TDOT equivalent)
- Tack coat
- 2.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $30.85 per square yard

Nexus Road:

- 6 inches of CTS with 12 percent cement
- 3.0-inch lift of AC - PAG 1 (or TDOT equivalent)
- Tack coat
- 2.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $28.21 per square yard

Old Vail Road:

- 7 inches of CTS with 12 percent cement
- 3.0-inch lift of AC – PAG 2 (or TDOT equivalent)
- Initial construction cost estimated at $21.52 per square yard

The design team should consider drainage details to prevent moisture from being trapped in the pavement section by the curb.

The design and construction-control R-Value is 27. Golder recommends overexcavation and replacement at the following locations that are anticipated to contain subgrade that will fall below the construction control R-value: from STA 137+00 to 152+50 and from STA 221+50 to 226+50.

Additional geotechnical recommendations related to permanent and temporary slopes, earthwork factors, and suitability of on-site soils for use as backfill are provided in Section 7.0.

The results of various geotechnical- and pavement-related value engineering performed throughout the design phase is summarized in Section 8.0. Golder estimates that the total savings for these items is approximately $1,425,000.

10.0 LIMITATIONS AND CLOSING

This report has been prepared exclusively for the use of PSOMAS and the City of Tucson for the specific application to the Roadway Improvement Project – Valencia Road: Kolb Road to Houghton Road. No third-party engineer or consultant shall be entitled to rely on any of the information, conclusions, or opinions contained in this report without the prior written approval from PSOMAS and Golder Associates Inc.

The conclusions and recommendations in this report have been prepared in a manner consistent with the level of care and skill ordinarily exercised by engineering professionals currently practicing under similar conditions, subject to the time limits and financial and physical constraints imposed on, or otherwise applicable to Golder’s analyses.

In preparing its conclusions and recommendations, Golder has relied upon information provided by the client, such as referenced reports and conceptual roadway sections. Golder is not responsible for errors or omissions in the information provided by the City of Tucson or PSOMAS.

Signature Page

Golder Associates Inc.

Jorge Velarde, PE
Project Geotechnical Engineer

Randy Post, PE
Senior Geotechnical Engineer

JV/RMP/rm

Golder and the G logo are trademarks of Golder Associates Corporation

https://golderassociates.sharepoint.com/sites/17220g/shared documents/6 deliverables/drafts/rev 0/1660053-r-001-rev0-20200817.docx

11.0 REFERENCES

AASHTO (American Association of State Highway and Transportation Officials). 2016. AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014 with 2015 and 2016 interims, Washington, D.C.

ADOT (Arizona Department of Transportation). 2016. Materials Testing Manual, Arizona Department of Transportation. Phoenix, AZ.

ADOT. 2017. Pavement Design Manual, September 29, 2017. Roadway Engineering Group, Pavement Design Section.

Arizona Department of Water Resources (ADWR). 2015. "GWSI – Groundwater Site Inventory." <https://gisweb.azwater.gov/waterresourcedata/GWSI.aspx>. May 27, 2015.

Beckwith, G.H. 1979. Experiences with Collapsing Soils in the Southwest" Spring Meeting, Arizona Section, American Society of Civil Engineers. March 1979.

City of Tucson Department of Transportation (TDOT). 1987. Active Practice Guideline 04: Design of Flexible Pavement. June 1, 1987.

Christopher, Barry R., C. Schwartz, R. Boudreau. 2006. Geotechnical Aspects of Pavements, NHI-05-037, National Highway Institute, US Department of Transportation, Washington D.C.

Dickinson, W.R. 1999. Geologic framework of the Catalina foothills, outskirts of Tucson (Pima County, Arizona): Arizona Geological Survey Contributed Map CM-99-B, 31 p., 1 sheet, scale 1:24000

Geosynthetic Materials Association (GMA). 2000. Geosynthetic Reinforcement of the Aggregate Base/Subbase Courses of Pavement Structures, GMA White Paper II, Roseville, MN. June 27, 2000.

Grasso, Benjamin. 2017. Personal communication (phone) between Benjamin Grasso (Sales Engineer, Alliance Geosynthetics) and Randy Post (Senior Engineer, Golder Associates Inc.) regarding FRAC structural coefficient and cost information.

Klawon, J.E., W.R. Dickinson, P.A. Pearthree. 1999. Surficial geology and geologic hazards of the Northern Tucson Basin, Pima County, Arizona. Arizona Geological Survey Open File Report, OFR-99-21, 1 map sheet, map scale 1:24,000, p. 28

Houston, S.L., W.N. Houston, and C.A. Lawrence. 2002. Collapsible Soil Engineering in Highway Infrastructure Development. Journal of Transportation Engineering, Vol. 128, No. 3. May 1, 2002.

Maricopa County Department of Transportation (MCDOT). 2017. *Roadway Design Manual*. February 2017 Update.

Maricopa Association of Governments (MAG). 2020. Uniform Standard Specifications and Details for Public Works Construction, 2020 Revision to the 2015 Edition, January 2020.

Martin, Sherry. 2017. Personal communication (email) between Sherry Martin (Project Manager, City of Tucson) and Randy Post (Senior Engineer, Golder Associates Inc.) regarding: pavement design standards for the project, September 11.

McKittrick, M.A. 1988. Surficial geologic maps of the Tucson Metropolitan Area. Arizona Geological Survey Open File Report, OFR-88-18, 12 map sheet, map scale 1:24,000, p 7.

National Cooperative Highway Research Program (NCHRP). 2001. Guide for mechanistic-empirical design of new and rehabilitated pavement structures. National Cooperative Highway Research Program, Transportation Research Board National Research Council, IL.

Pima Association of Governments (PAG). 2019. Standard Specifications for Public Improvements, 3 Volumes, 2019 Edition.

Pima County Department of Transportation (PCDOT). 2016. Pima County Roadway Design Manual, Fourth Edition, 2013 with October 2016 Updates.

Thornton, Kevin. 2017. Personal communication (email) between Kevin Thornton (Project Manager, PSOMAS) and Randy Post (Senior Engineer, Golder Associates Inc.) regarding: Valencia, Kolb to Houghton ESALs. 2023-2042, October 12.

Uz, V.E., M. Saltan, and . Gökalp. 2015. “Comparison of DCP, CBR, and RLT Test Results for Granular Pavement Materials and Subgrade with Structural Perspective”, International Symposium, Berlin, Germany. September, 2015.

Webster, S.L., R.H. Grau, and T.P. Williams. 1992. "Description and Application of Dual Mass Dynamic Cone Penetrometer," Report GL-92-3, Department of the Army, Washington, DC. May 1992. p. 19.

Figures- Geotechnical Investigation Plan

LEGEND

- BOREHOLES (5' DEPTH)
- PAVEMENT CORES
- PREVIOUS INVESTIGATIONS
- PRELIMINARY CULVERT LOCATIONS
- PRELIMINARY CHANNEL
- WASHES
- PROPOSED EDGE OF PAVEMENT
- PROPOSED VALENCIA ROAD
- EXISTING RIGHT OF WAY
- ADJACENT PROJECT INFORMATION
- MATCH LINES

400 200 0 400 Feet

1 in = 400 feet

NOTES

BOREHOLES ARE 5 FEET DEEP UNLESS NOTED

IN = INFILTRATION TEST
DCP = DYNAMIC CONE PENETRATION SOUNDING
PAV = DRILLED THROUGH EXISTING PAVEMENT

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE ARIZONA CENTRAL FIPS 0202 FEET
AERIAL IMAGERY: 0.3M RESOLUTION IMAGERY, DIGITAL GLOBE. DATE TAKEN 10/10/2016.

CLIENT
PSOMAS

PROJECT
VALENCIA ROAD, KOLB ROAD TO HOUGHTON ROAD

TITLE
GEOTECHNICAL INVESTIGATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	/1 /20
PREPARED	DZF
DESIGN	DZF
REVIEW	RP
APPROVED	P

PROJECT No.	CONTROL	Rev.	FIGURE
1660053	---		1

Path: L:\Site\Valencia_Houghton\Maps\SoilMap_201711.mxd

LEGEND

- BOREHOLES (5' DEPTH)
- PAVEMENT CORES
- PREVIOUS INVESTIGATIONS
- PRELIMINARY CULVERT LOCATIONS
- PRELIMINARY CHANNEL
- WASHES
- PROPOSED EDGE OF PAVEMENT
- PROPOSED VALENCIA ROAD
- EXISTING RIGHT OF WAY
- ADJACENT PROJECT INFORMATION
- MATCH LINES

400 200 0 400 Feet
1 in = 400 feet

NOTES

BOREHOLES ARE 5 FEET DEEP UNLESS NOTED

IN = INFILTRATION TEST
DCP = DYNAMIC CONE PENETRATION SOUNDING
PAV = DRILLED THROUGH EXISTING PAVEMENT

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE ARIZONA CENTRAL FIPS 0202 FEET
AERIAL IMAGERY: 0.3M RESOLUTION IMAGERY, DIGITAL GLOBE. DATE TAKEN 10/10/2016.

CLIENT
PSOMAS

PROJECT
VALENCIA ROAD, KOLB ROAD TO HOUGHTON ROAD

TITLE
GEOTECHNICAL INVESTIGATION PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	20
PREPARED	DZF
DESIGN	DZF
REVIEW	RP
APPROVED	P

PROJECT No.	CONTROL	Rev.	FIGURE
1660053	---		2

LEGEND

- BOREHOLES (5' DEPTH)
- PAVEMENT CORES
- PREVIOUS INVESTIGATIONS
- PRELIMINARY CULVERT LOCATIONS
- PRELIMINARY CHANNEL
- WASHES
- PROPOSED EDGE OF PAVEMENT
- PROPOSED VALENCIA ROAD
- EXISTING RIGHT OF WAY
- ADJACENT PROJECT INFORMATION
- MATCH LINES

400 200 0 400 Feet

1 in = 400 feet

NOTES

BOREHOLES ARE 5 FEET DEEP UNLESS NOTED

IN = INFILTRATION TEST
DCP = DYNAMIC CONE PENETRATION SOUNDING
PAV = DRILLED THROUGH EXISTING PAVEMENT

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE ARIZONA CENTRAL FIPS 0202 FEET
AERIAL IMAGERY: 0.3M RESOLUTION IMAGERY, DIGITAL GLOBE. DATE TAKEN 10/10/2016.

CLIENT
PSOMAS

PROJECT
VALENCIA ROAD, KOLB ROAD TO HOUGHTON ROAD

TITLE
GEOTECHNICAL INVESTIGATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	
PREPARED	DZF
DESIGN	DZF
REVIEW	RP
APPROVED	P

PROJECT No.	CONTROL	Rev.	FIGURE
1660053	---		3

LEGEND

- BOREHOLES (5' DEPTH)
- PAVEMENT CORES
- PREVIOUS INVESTIGATIONS
- PRELIMINARY CULVERT LOCATIONS
- PRELIMINARY CHANNEL
- WASHES
- PROPOSED EDGE OF PAVEMENT
- PROPOSED VALENCIA ROAD
- EXISTING RIGHT OF WAY
- ADJACENT PROJECT INFORMATION
- MATCH LINES

400 200 0 400 Feet

1 in = 400 feet

NOTES

BOREHOLES ARE 5 FEET DEEP UNLESS NOTED

IN = INFILTRATION TEST
DCP = DYNAMIC CONE PENETRATION SOUNDING
PAV = DRILLED THROUGH EXISTING PAVEMENT

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE ARIZONA CENTRAL FIPS 0202 FEET
AERIAL IMAGERY: 0.3M RESOLUTION IMAGERY, DIGITAL GLOBE. DATE TAKEN 10/10/2016.

CLIENT
PSOMAS

PROJECT
VALENCIA ROAD, KOLB ROAD TO HOUGHTON ROAD

TITLE
GEOTECHNICAL INVESTIGATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	
PREPARED	DZF
DESIGN	DZF
REVIEW	RP
APPROVED	P

PROJECT No.	CONTROL	Rev.	FIGURE
1660053	---		4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

- BOREHOLES (5' DEPTH)
- PAVEMENT CORES
- PREVIOUS INVESTIGATIONS
- PRELIMINARY CULVERT LOCATIONS
- PRELIMINARY CHANNEL
- WASHES
- PROPOSED EDGE OF PAVEMENT
- PROPOSED VALENCIA ROAD
- EXISTING RIGHT OF WAY
- ADJACENT PROJECT INFORMATION
- MATCH LINES

400 200 0 400 Feet

1 in = 400 feet

NOTES

BOREHOLES ARE 5 FEET DEEP UNLESS NOTED

IN = INFILTRATION TEST
DCP = DYNAMIC CONE PENETRATION SOUNDING
PAV = DRILLED THROUGH EXISTING PAVEMENT

REFERENCE

COORDINATE SYSTEM: NAD 1983 STATEPLANE ARIZONA CENTRAL FIPS 0202 FEET
AERIAL IMAGERY: 0.3M RESOLUTION IMAGERY, DIGITAL GLOBE. DATE TAKEN 10/10/2016.

CLIENT
PSOMAS

PROJECT
VALENCIA ROAD, KOLB ROAD TO HOUGHTON ROAD

TITLE
GEOTECHNICAL INVESTIGATION PLAN

CONSULTANT	YYYY-MM-DD	
GOLDER	PREPARED	DZF
	DESIGN	DZF
	REVIEW	RP
	APPROVED	P

PROJECT No.	CONTROL	Rev.	FIGURE
1660053	---		5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

APPENDIX A

Geotechnical Borehole Logs

RECORD OF BOREHOLE BH-01

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 09:00
DRILLING END : September 19, 2017 10:00
COORDINATES : N: 412023.6 ft E: 1036887.5 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to coarse, medium plasticity fines, fine to coarse gravel, light brown; strong HCL reaction; cohesive, w < PL	0.0	SM							
		2.5	(SW-SC), GRAVELLY SAND, fine to coarse, well graded, fine gravel, some medium plasticity fines, light brown; moderate cementation, strong HCL reaction; cohesive, w < PL	-2.5	SW -SC		SS 01	6-6-10 (16)	1.3 1.5	16 ■		G, A
5							MC 02	3-4	1.0 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-02

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 10:00
DRILLING END : September 19, 2017 11:00
COORDINATES : N: 41764.6 ft E: 1037218.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to coarse, medium plasticity fines, some fine gravel, dark brown; no HCL reaction; cohesive, w < PL	0.0	SM							
		2.5	(ML), SANDY CLAYEY SILT, medium plasticity, fine to medium sand, trace fine gravel, dark brown; strong HCL reaction; cohesive, very stiff, w < PL	-2.5	ML		MC 01	12-9	0.8 / 1.0		2.5 ft : Ring Sample	G, A
5							SS 02	16-25-24 (49)	1.5 / 1.5	49		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-03

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 11:00
DRILLING END : September 19, 2017 12:00
COORDINATES : N: 411585.2 ft E: 1037705.8 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SW), GRAVELLY SAND, fine to coarse, well graded, fine gravel, trace low plasticity fines, light brown; weak cementation, strong HCL reaction; non-cohesive, dense, w < PL	0.0	SW							
		2.5	(SM), SILTY SAND, fine to coarse, medium plasticity fines, some fine gravel, light brown; strong HCL reaction; cohesive, w < PL	-2.5	SM		SS 01	4-4-28 (32)	1.4 / 1.5	32		G, A, y, SPC, Swell, R
5							MC 02	15-50/0.25'	0.8 / 0.8		5.0 ft : Ring Sample	
			Bottom of borehole at 5.8 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

RECORD OF BOREHOLE BH-04

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 01:00
DRILLING END : September 19, 2017 02:00
COORDINATES : N: 411286.5 ft E: 1038135.3 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), GRAVELLY CLAYEY SAND, fine to coarse, medium plasticity fines, fine gravel, dark brown; strong HCL reaction; cohesive, w < PL	0.0	SC						
		2.5	(SC-SM), GRAVELLY CLAYEY SAND, fine to medium, fine to coarse gravel, low plasticity fines, light brown; weak cementation, strong HCL reaction; non-cohesive, compact, dry to moist	-2.5	SC-SM	MC 01	10-10	1.0 / 1.0	H	2.5 ft : Ring Sample	G, A, Collap
5						SS 02	3-5-6 (11)	2.0 / 1.5	11 ■		
			Bottom of borehole at 6.5 ft.								
10											
15											

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-05

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 02:00
DRILLING END : September 19, 2017 03:00
COORDINATES : N: 410990.2 ft E: 1038542.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Depth	Description	Elev	USCS	Sample Type & Number	Blows (per 6 inches, ASTM D 1586, 140-lb hammer, 30-in drop, Automatic Hammer)	REC / ATT (ft)	Penetration Resistance (blows/ft)	Notes / Water Levels	Additional Lab Testing
0.0	Asphaltic Concrete	0.0							
0.3	(SW-SM), SAND AND GRAVEL, well graded, and fine subrounded GRAVEL, some low plasticity fines	-0.3	SW-SM						
1.0	(SM), GRAVELLY SILTY SAND, fine to coarse, non plastic fines, fine to coarse subrounded gravel, light brown; weak HCL reaction; cohesive, w < PL	-1.0	SM						
2.5	(SC), CLAYEY SAND, fine to coarse, and medium plasticity fines, some fine gravel, dark brown; no HCL reaction; cohesive, w ~ PL	-2.5	SC	MC 01	14-23	0.7 / 1.0		2.5 ft : Ring Sample	G, A, y
5.5	(SC-SM), GRAVELLY CLAYEY SAND, fine to medium, low plasticity fines, fine subrounded gravel, very light white to yellow; weak cementation, strong HCL reaction; cohesive, w < PL	-5.5	SC-SM	SS 02	11-13-14 (27)	1.5 / 1.5	27		

Bottom of borehole at 6.5 ft.

Legend: ■ Penetration Resistance (blows/ft); H Liquid Limit & Plastic Limit (%); ○ Water Content (%). Scale: 20, 40, 60, 80. Depth scale (ft): 5, 10, 15.

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-06

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 03:00
DRILLING END : September 19, 2017 04:00
COORDINATES : N: 410740.9 ft E: 1038986.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine, and low plasticity fines, trace fine gravel, brown; strong HCL reaction; cohesive, w < PL	0.0	SM							
		1.0	Very light brown to white; strong HCL reaction	-1.0								
		2.5	(SC), CLAYEY SAND, fine to medium, medium plasticity fines, trace fine gravel, brown and light brown; strong HCL reaction; cohesive, w < PL	-2.5	SC		SS 01	13-17-21 (38)	1.5 / 1.5	38		G, A
5							MC 02	12-15	1.0 / 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-07

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 19, 2017 05:00
DRILLING END : September 19, 2017 06:00
COORDINATES : N: 410376.3 ft E: 1039322.7 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
	0.0	(SC), CLAYEY SAND, fine to coarse, and high plasticity fines, some fine gravel, dark brown; strong HCL reaction; cohesive, w < PL	0.0	SC						
	2.5	(SM), SILTY SAND, fine to medium, and medium plasticity fines, some fine gravel, light brown to very light brown; weak cementation, strong HCL reaction; cohesive, w < PL	-2.5	SM	SS 01	6-11-16 (27)	1.5 1.5	27		G, A, CHEM, Collap
5	5.0	(SW), GRAVELLY SAND, medium to coarse, well graded, fine gravel, trace low plasticity fines, light brown to very light brown; weak cementation, no HCL reaction; non-cohesive, compact, dry to moist	-5.0	SW	MC 02	21-50-0/-0.17'	0.8 0.8		5.0 ft : Ring Sample	
10					SS 03	11-8-8 (16)	1.5 1.5	16		
15					SS 04	10-10-9 (19)	1.5 1.5	19		
		Bottom of borehole at 16.5 ft.								

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-08

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 08:00
DRILLING END : September 20, 2017 09:00
COORDINATES : N: 409990.4 ft E: 1039658.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Depth	Description	Elev	USCS	Sample Type & Number	Blows (per 6 inches, ASTM D 1586, 140-lb hammer, 30-in drop, Automatic Hammer)	REC / ATT (ft)	Notes / Water Levels	Additional Lab Testing
0.0	(SW-SC), GRAVELLY SAND, medium to coarse, well graded, fine gravel, some high plasticity fines, dark brown; no HCL reaction; cohesive, w < PL	0.0	SW-SC					
1.5	(SC), CLAYEY SAND, fine to medium, and medium plasticity fines, some fine gravel, very light brown to white; moderate cementation, strong HCL reaction; cohesive, w < PL	-1.5	SC	MC 01	7-26	1.0 / 1.0	2.5 ft : Ring Sample	G, A, y, SPC, RM, R
				MC 02	12-22-24 (46)	1.2 / 1.5		

Bottom of borehole at 6.5 ft.

Chart legend: ■ Penetration Resistance (blows/ft); ├┤ Liquid Limit & Plastic Limit (%); ○ Water Content (%). Axis: 20, 40, 60, 80. Plotted: 46 ■ (at MC 02).

Depth scale (ft): 5, 10, 15

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-09

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 09:00
DRILLING END : September 20, 2017 10:00
COORDINATES : N: 409465.8 ft E: 1039891.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Depth	Description	Elev	USCS	Sample Type & Number	Blows (per 6 inches, ASTM D 1586, 140-lb hammer, 30-in drop, Automatic Hammer)	REC / ATT (ft)	Penetration Resistance (blows/ft)	Notes / Water Levels	Additional Lab Testing
0.0	(SC), GRAVELLY CLAYEY SAND, fine to medium, high plasticity fines, fine gravel, dark brown; moderate cementation, weak HCL reaction; cohesive, w < PL	0.0	SC						
2.0	(SW), GRAVELLY SAND, medium to coarse, well graded, fine gravel, trace low plasticity fines, very light brown; moderate cementation, no HCL reaction; non-cohesive, compact, dry to moist	-2.0	SW						
2.5	(SP-SM), SAND, medium to coarse, poorly graded, some fine to coarse subrounded gravel, some low plasticity fines, brown; strong HCL reaction; cohesive, w < PL	-2.5	SP-SM	SS 01	10-10-14 (24)	1.2 / 1.5	24		G, A
				MC 02	11-40	1.0 / 1.0		5.0 ft : Ring Sample	

Bottom of borehole at 6.0 ft.

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-10

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 10:00
DRILLING END : September 20, 2017 11:00
COORDINATES : N: 409149.0 ft E: 1040197.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Depth	Description	Elev	USCS	Sample Type & Number	Blows (per 6 inches, ASTM D 1586, 140-lb hammer, 30-in drop, Automatic Hammer)	REC ---- ATT (ft)	Notes / Water Levels	Additional Lab Testing
0.0	Asphaltic Concrete	0.0						
0.3	(SW-SM), SAND AND GRAVEL, well graded, and fine subrounded GRAVEL, some low plasticity fines	-0.3	SW-SM					
1.0	(SW), GRAVELLY SAND, medium to coarse, well graded, fine to coarse subrounded gravel, light brown; weak HCL reaction; non-cohesive, moist	-1.0	SW					
2.5	(SM), GRAVELLY SILTY SAND, medium to coarse, fine to coarse subrounded gravel, non plastic fines, light brown; no HCL reaction; non-cohesive, moist	-2.5	SM	MC 01	10-18	1.0 / 1.0	2.5 ft : Ring Sample	G, A, y
				SS 02	11-13-13 (26)	1.5 / 1.5		
6.5	Bottom of borehole at 6.5 ft.							

Penetration Resistance (blows/ft): 26 (at SS 02)

Legend: ■ Penetration Resistance (blows/ft); ⊢⊣ Liquid Limit & Plastic Limit (%); ○ Water Content (%)

Scale: 20 40 60 80

DEPTH (ft): 5, 10, 15

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-11

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 11:00
DRILLING END : September 20, 2017 12:00
COORDINATES : N: 408906.7 ft E: 1040562.1 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft); Liquid Limit & Plastic Limit (%); Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), CLAYEY SAND, fine to coarse, medium plasticity fines, some fine subrounded gravel, dark brown; no HCL reaction; cohesive, w < PL	0.0	SC							
							MC 01	13-25	1.0 1.0		2.5 ft : Ring Sample	G, A
		4.0	Very light brown to white; weak cementation, strong HCL reaction; cohesive	-4.0								
5							SS 02	20-20-23 (43)	1.5 1.5	43		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-12

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 01:00
DRILLING END : September 20, 2017 02:00
COORDINATES : N: 408847.1 ft E: 1041064.0 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) / ├┤ Liquid Limit & Plastic Limit (%) / ○ Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(CH), CLAY AND SAND, medium plasticity, and fine to medium SAND, some fine gravel, brown; moderate cementation, strong HCL reaction; cohesive, very stiff, w < PL	0.0	CH							
		2.5	(SM), GRAVELLY SILTY SAND, fine to medium, low plasticity fines, fine subrounded gravel, brown; weak cementation, strong HCL reaction; cohesive, w < PL	-2.5	SM		SS 01	6-9-12 (21)	1.1 / 1.5	21 ■		G, A
5							MC 02	12-35	1.0 / 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-13

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 02:00
DRILLING END : September 20, 2017 03:00
COORDINATES : N: 408707.8 ft E: 1041427.8 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), CLAYEY SAND, fine to medium, high plasticity fines, trace fine subrounded to subangular gravel, light brown to very light brown; moderate cementation, strong HCL reaction; cohesive, w < PL	0.0	SC							
		2.5	(SM), GRAVELLY SILTY SAND, fine to medium, medium plasticity fines, fine subrounded gravel, light brown; strong HCL reaction; cohesive, w < PL	-2.5	SM		SS 01	5-16-29 (45)	1.2 / 1.5	H 45 ■		G, A, CHEM, Collap
5		5.0	No HCL reaction	-5.0			MC 02	13-11	1.0 / 1.0		5.0 ft : Ring Sample	
10		10.0	(GM), SANDY SILTY GRAVEL, fine to coarse, subrounded, fine to medium sand, medium plasticity fines, light brown; strong HCL reaction; non-cohesive, loose, dry to moist	-10.0	GM		SS 03	19-20-23 (43)	1.5 / 1.5	43 ■		
15							SS 04	3-3-3 (6)	0.3 / 1.5	6 ■		
			Bottom of borehole at 16.5 ft.									

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-14

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 03:00
DRILLING END : September 20, 2017 04:00
COORDINATES : N: 408883.9 ft E: 1042015.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to medium, medium plasticity fines, fine subrounded gravel, dark brown red; no HCL reaction; cohesive, w < PL	0.0	SM							
		3.0	(SM), GRAVELLY SILTY SAND, fine to medium, fine subangular gravel, medium plasticity fines, very light brown to white; strong HCL reaction; non-cohesive, very dense, dry to moist	-3.0			SS 01	27-20-14 (34)	1.3 / 1.5	34		G, A
5							MC 02	15-50/0.25'	0.8 / 0.8		5.0 ft : Ring Sample	
			Bottom of borehole at 5.8 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-15

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 04:00
DRILLING END : September 20, 2017 05:00
COORDINATES : N: 408851.0 ft E: 1042650.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) ⊢ Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC-SM), GRAVELLY CLAYEY SAND, fine to medium, and low plasticity fines, fine subrounded to subangular gravel, red brown; no HCL reaction; cohesive, w < PL	0.0	SC-SM							
		1.5	(SC-SM), CLAYEY SAND, fine to medium, low plasticity fines, some fine subrounded gravel, very light brown; weak cementation, strong HCL reaction; cohesive, w < PL	-1.5								
							MC 01	32-36	1.0 / 1.0	⊢	2.5 ft : Ring Sample	G, A, Collap
5							SS 02	2-3-2 (5)	0.5 / 1.5	5 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-16

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 20, 2017 05:00
DRILLING END : September 20, 2017 06:00
COORDINATES : N: 408874.3 ft E: 1043149.8 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, medium plasticity fines, some coarse subangular gravel, red brown; strong HCL reaction; cohesive, w < PL	0.0	SM							
							SS 01	13-23-30 (53)	1.2 / 1.5	53		G, A, R
5							MC 02	17-8	1.0 / 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-17

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 08:00
DRILLING END : September 21, 2017 09:00
COORDINATES : N: 408919.9 ft E: 1043642.4 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to medium, medium plasticity fines, trace fine subangular gravel, dark brown; moderate cementation, strong HCL reaction; cohesive, w < PL	0.0	SM							
							MC 01	12-16	1.0 1.0	H	2.5 ft : Ring Sample	G, A
5							SS 02	16-18-32 (50)	1.1 1.5	50 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-18

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 09:00
DRILLING END : September 21, 2017 10:00
COORDINATES : N: 408860.3 ft E: 1044151.5 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), GRAVELLY CLAYEY SAND, fine to coarse, fine to coarse subrounded to subangular gravel, low plasticity fines, brown; strong HCL reaction; cohesive, w < PL	0.0	SC							
		2.5	(SM), SILTY SAND, fine to medium, and medium plasticity fines, some fine subangular gravel, very light brown; strong cementation, strong HCL reaction; cohesive, w < PL	-2.5	SM		MC 01	20-26	1.0 1.0		2.5 ft : Ring Sample	G, A
5							SS 02	11-14-16 (30)	1.2 1.5	30		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-19

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 10:00
DRILLING END : September 21, 2017 11:00
COORDINATES : N: 408910.0 ft E: 1044652.5 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), CLAYEY SAND, fine to medium, and medium plasticity fines, trace fine to coarse subrounded gravel, brown; strong HCL reaction; cohesive, w < PL	0.0	SC							
							SS 01	18-14-17 (31)	0.8 1.5	31		G, A, y, SPC, Swell
5							MC 02	32-50/0.42'	0.9 0.9		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-20

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 11:00
DRILLING END : September 21, 2017 12:00
COORDINATES : N: 408901.0 ft E: 1045164.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to medium, and low plasticity fines, trace fine gravel, brown; weak HCL reaction; cohesive, w < PL	0.0	SM							
							MC 01	15-26	1.0 1.0	H	2.5 ft : Ring Sample	G, A
5		5.0	(SM), GRAVELLY SILTY SAND, fine to medium, fine subangular gravel, medium plasticity fines, very light brown; strong HCL reaction; cohesive, w < PL	-5.0								
							SS 02	15-22-29 (51)	0.8 1.5	51 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-21

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 01:00
DRILLING END : September 21, 2017 02:00
COORDINATES : N: 408919.7 ft E: 1045604.9 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to medium, low plasticity fines, trace fine subangular gravel, brown; weak cementation, strong HCL reaction; cohesive, w < PL	0.0	SM						
						SS 01	8-9-8 (17)	1.0 / 1.5	17		G, A
5						MC 02	32-50/0.42'	0.9 / 0.9		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.								
10											
15											

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-22

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 02:00
DRILLING END : September 21, 2017 03:00
COORDINATES : N: 408883.8 ft E: 1046139.9 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC), CLAYEY SAND, fine to coarse, low plasticity fines, trace fine to coarse subrounded gravel, brown; strong HCL reaction; cohesive, dense, w < PL	0.0	SC							
							SS 01	11-9-12 (21)	1.0 / 1.5	21		G, A, R
5							MC 02	11-25	1.0 / 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-23

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 03:00
DRILLING END : September 21, 2017 04:00
COORDINATES : N: 408883.0 ft E: 1046533.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Depth	Description	Elev	USCS	Sample Type & Number	Blows (per 6 inches ASTM D 1586 140-lb hammer 30-in drop; Automatic Hammer)	REC / ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%)	Notes / Water Levels	Additional Lab Testing
0.0	(SM), GRAVELLY SILTY SAND, fine to medium, medium plasticity fines, fine subrounded gravel, dark brown; weak cementation, weak HCL reaction; cohesive, w < PL	0.0	SM						
2.5	(SC), CLAYEY SAND, fine to medium, and medium plasticity fines, some fine to coarse subrounded gravel, light brown; moderate cementation, strong HCL reaction; cohesive, w < PL	-2.5	SC	MC 01	11-33	1.0 / 1.0		2.5 ft : Ring Sample	G, A
				SS 02	11-12-14 (26)	1.0 / 1.5	26		
	Bottom of borehole at 6.5 ft.								

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-24

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 04:00
DRILLING END : September 21, 2017 05:00
COORDINATES : N: 408772.4 ft E: 1047103.6 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to medium, low plasticity fines, some fine subangular gravel, brown; weak cementation, strong HCL reaction; cohesive, w < PL	0.0	SM		SS 01	19-30-35 (65)	1.0 1.5	H 65 ■		M
5							MC 02	31-50/0.42'	0.9 0.9		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-25

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 05:00
DRILLING END : September 21, 2017 06:00
COORDINATES : N: 408928.8 ft E: 1047633.5 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) / ⊢ Liquid Limit & Plastic Limit (%) / ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to coarse, medium plasticity fines, some fine to coarse subrounded gravel, brown; strong HCL reaction; cohesive, w < PL	0.0	SM							
							MC 01	7-6	1.0 1.0	⊢	2.5 ft : Ring Sample	G, A, y, SPC, Swell, Collap
5		4.0	(GM), SANDY SILTY GRAVEL, fine, medium to coarse sand, low plasticity fines, very light brown; weak cementation, strong HCL reaction; non-cohesive, dense, dry to moist	-4.0	GM							
							SS 02	11-18-19 (37)	1.5 1.5	37 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-26

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 21, 2017 06:00
DRILLING END : November 28, 2017 07:00
COORDINATES : N: 408889.5 ft E: 1048138.4 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SW-SC), SAND AND GRAVEL, fine to coarse, well graded, and fine subrounded GRAVEL, some low plasticity fines, brown; weak HCL reaction; cohesive, w < PL	0.0	SW-SC							
		1.5	(SC), CLAYEY SAND, fine to medium, medium plasticity fines, some fine subangular gravel, very light brown to white; strong cementation, strong HCL reaction; cohesive, w < PL	-1.5	SC							
							SS 01	11-14-12 (26)	0.9 / 1.5	26		G, A, Collap
5							MC 02	5-4	1.0 / 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-27

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 07:00
DRILLING END : September 22, 2017 08:00
COORDINATES : N: 408861.2 ft E: 1048625.0 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	Asphaltic Concrete	0.0								
		0.3	(SW-SM), SAND AND GRAVEL, well graded, and fine subrounded GRAVEL, some low plasticity fines	-0.3	SW -SM							
		1.0	(SM), GRAVELLY SILTY SAND, fine to coarse, fine to coarse subrounded gravel, non plastic fines, light brown; weak HCL reaction; non-cohesive, dry to moist	-1.0	SM							
							MC 01	11-23	1.0 1.0		2.5 ft : Ring Sample	G, A, y
5							SS 02	7-12-29 (41)	1.5 1.5	41 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-28

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 08:00
DRILLING END : September 22, 2017 09:00
COORDINATES : N: 408815.0 ft E: 1049131.1 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) ⊢ Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SP), GRAVELLY SAND, medium to coarse, poorly graded, fine to coarse subrounded gravel, trace non plastic fines, very light brown; weak HCL reaction; non-cohesive, very dense, dry to moist	0.0	SP							
		2.0	(SP-SM), GRAVELLY SAND, medium to coarse, poorly graded, fine gravel, some non plastic fines, light brown; weak cementation, no HCL reaction; non-cohesive, dense, dry to moist	-2.0	SP-SM							
							SS 01	30-28-32 (60)	1.5 1.5	60 ■		G, A
5							MC 02	34-38	1.0 1.0		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-29

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 09:00
DRILLING END : September 22, 2017 10:00
COORDINATES : N: 408908.8 ft E: 1049621.2 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft) / Liquid Limit & Plastic Limit (%) / Water Content (%)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
	0.0	(SC), GRAVELLY CLAYEY SAND, fine to coarse, medium plasticity fines, fine subrounded gravel, brown; moderate cementation, strong HCL reaction; cohesive, w < PL	0.0	SC	SS 01	15-19-21 (40)	1.2 / 1.5	40		G, A, y, SPC, CHEM, RM, R
5					MC 02	30-50/0.42'	0.9 / 0.9		5.0 ft : Ring Sample	
10	10.0	(SC), CLAYEY SAND, fine to medium, medium plasticity fines, some fine to coarse subrounded gravel, very light brown; weak cementation, strong HCL reaction; cohesive, w < PL	-10.0		SS 03	22-50/0.42'	1.1 / 0.9			
15					SS 04	19-20-20 (40)	1.3 / 1.5	40		
		Bottom of borehole at 16.5 ft.								

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-30

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 10:00
DRILLING END : September 22, 2017 11:00
COORDINATES : N: 408945.7 ft E: 1050119.0 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to medium, low plasticity fines, fine subrounded to subangular gravel, brown; weak cementation, weak HCL reaction; cohesive, w < PL	0.0	SM							
		2.0	Very light brown to white; moderate cementation, strong HCL reaction	-2.0							2.5 ft : Ring Sample	
							MC 01	40-42	1.0 1.0	H		G, A, Collap
5							SS 02	11-17-20 (37)	1.5 1.5	37 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-31

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 11:00
DRILLING END : September 22, 2017 12:00
COORDINATES : N: 408901.3 ft E: 1050605.4 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) ⊢ Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to coarse, medium plasticity fines, fine to coarse subrounded to subangular gravel, brown; weak cementation, weak HCL reaction; cohesive, w < PL	0.0	SM							
											2.5 ft : Ring Sample	
							MC 01	15-38	1.0 1.0	⊢		G, A, y, SPC, Swell, Collap
		4.0	Very light brown; moderate cementation, strong HCL reaction	-4.0								
5												
							SS 02	11-11-10 (21)	1.2 1.5	21 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-32

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 01:00
DRILLING END : September 22, 2017 02:00
COORDINATES : N: 408928.4 ft E: 1051143.9 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

Legend: ■ Penetration Resistance (blows/ft); H Liquid Limit & Plastic Limit (%); ○ Water Content (%) — scale 20, 40, 60, 80

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to medium, fine to coarse subrounded gravel, medium plasticity fines, brown; weak cementation, strong HCL reaction; cohesive, w < PL	0.0	SM	SS 01	15-15-15 (30)	1.5 1.5	30		G, A, CHEM
5		5.0	(SC-SM), CLAYEY SAND, fine to medium, low plasticity fines, some fine subangular gravel, dark brown; strong HCL reaction; cohesive, w < PL	-5.0	SC-SM	MC 02	28-28	1.0 1.0		5.0 ft : Ring Sample	
10						SS 03	4-5-5 (10)	1.5 1.5	10		
		12.0	(SW-SM), GRAVELLY SAND, fine to medium, well graded, fine to coarse subrounded gravel, some non plastic fines, very light brown; moderate cementation, strong HCL reaction; non-cohesive, dense, dry to moist	-12.0	SW-SM						
15		15.0	(SP), SAND AND GRAVEL, fine to coarse, poorly graded, and fine to coarse subrounded GRAVEL, light brown; no HCL reaction; non-cohesive, dense, dry to moist	-15.0	SP	SS 04	19-16-16 (32)	1.5 1.5	32		
			Bottom of borehole at 16.5 ft.								

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-33

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 02:00
DRILLING END : September 22, 2017 03:00
COORDINATES : N: 408935.4 ft E: 1051660.4 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) ⊢ Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SC-SM), CLAYEY SAND, fine, and low plasticity fines, some fine subrounded gravel, dark brown; weak HCL reaction; cohesive, w < PL	0.0	SC-SM							
											2.5 ft : Ring Sample	
							MC 01	14-19	1.0 1.0	⊢		G, A
5												
							SS 02	14-16-19 (35)	1.0 1.5	35 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-34

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 03:00
DRILLING END : September 22, 2017 04:00
COORDINATES : N: 408798.0 ft E: 1052119.1 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), GRAVELLY SILTY SAND, fine to medium, low plasticity fines, fine to coarse subrounded gravel, very light brown; weak cementation, strong HCL reaction; cohesive, w < PL	0.0	SM							
							SS 01	23-30-30 (60)	1.5 1.5	H 60 ■		G, A, y, SPC, R
5							MC 02	15-50/0.42'	0.9 0.9		5.0 ft : Ring Sample	
			Bottom of borehole at 6.0 ft.									
10												
15												

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-35

PROJECT : Valencia Rd.: Kolb to Houghton
PROJECT NO. : 1660053
LOCATION : Tucson, AZ

DRILLING START : September 22, 2017 04:00
DRILLING END : September 22, 2017 05:00
COORDINATES : N: 408910.9 ft E: 1052726.1 ft

SHEET : 1 of 1
GS ELEV : 0.0
TOC ELEV :
DATUM : NAD83

DEPTH (ft)	Depth	DESCRIPTION	Elev	USCS	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	Penetration Resistance (blows/ft)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
	0.0	(SC-SM), GRAVELLY CLAYEY SAND, fine to medium, low plasticity fines, fine to coarse rounded to subrounded gravel, brown; moderate cementation, strong HCL reaction; cohesive, w < PL	0.0	SC-SM						
					SS 01	8-10-11 (21)	1.0 1.5	21		G, A, CHEM
5	5.0	(GM), SILTY GRAVEL AND SAND, fine to coarse, rounded, and fine to medium SAND, low plasticity fines, very light brown; weak cementation, strong HCL reaction; non-cohesive, very dense, dry to moist	-5.0	GM	MC 02	12-15	1.0 1.0		5.0 ft : Ring Sample	
10					SS 03	27-50/0.42'	0.8 0.9			
15					SS 04	50/0.42'	0.4 0.4			
		Bottom of borehole at 15.5 ft.								

Legend: ■ Penetration Resistance (blows/ft); ⊢ Liquid Limit & Plastic Limit (%); ○ Water Content (%). Scale: 20 40 60 80

DRILLING CO. : Southlands Engineering
DRILLER : Israel and Hami
DRILL RIG : CME 45

LOGGED : Jorge Velarde
CHECKED : Randy Post
REVIEWED : Randy Post

GOLDER

RECORD OF BOREHOLE BH-36

PROJECT : Valencia Rd.: Kolb to Houghton	DRILLING START : September 22, 2017 05:00	SHEET : 1 of 1
PROJECT NO. : 1660053	DRILLING END : September 22, 2017 06:00	GS ELEV : 0.0
LOCATION : Tucson, AZ	COORDINATES : N: 408966.0 ft E: 1053163.5 ft	TOC ELEV :
		DATUM : NAD83

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 inches ASTM D 1586 140-lb hammer 30-in drop Automatic Hammer	REC ---- ATT (ft)	■ Penetration Resistance (blows/ft) H Liquid Limit & Plastic Limit (%) ○ Water Content (%) 20 40 60 80	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
		0.0	(SM), SILTY SAND, fine to medium, and medium plasticity fines, some fine to coarse rounded gravel, brown; strong HCL reaction; cohesive, w < PL	0.0	SM							
		2.5	Very light brown; moderate cementation, strong HCL reaction	-2.5			MC 01	16-28	1.0 1.0		2.5 ft : Ring Sample	G, A
5							SS 02	17-17-26 (43)	1.5 1.5	43 ■		
			Bottom of borehole at 6.5 ft.									
10												
15												

DRILLING CO. : Southlands Engineering	LOGGED : Jorge Velarde	GOLDER
DRILLER : Israel and Hami	CHECKED : Randy Post	
DRILL RIG : CME 45	REVIEWED : Randy Post	

APPENDIX B

Geotechnical Laboratory Test Results

TABLE 1: GEOTECHNICAL LABORATORY TESTING SUMMARY SHEET

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

SAMPLING DATA						LAB TESTS AND CLASSIFICATION																		
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		STATION	OFFSET (FT)	WATER CONTENT (%)	DRY DENSITY (lb/ft^3)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	% GRAVEL	% SAND	% FINES (SILT & CLAY)	USCS SYMBOL	USCS SYMBOL (FINES ONLY)	AASHTO GROUP	MAXIMUM DRY DENSITY (lb/ft^3)	OPTIMUM MOISTURE CONTENT (%)	pH	RESISTIVITY (ohm-cm)	SULFATE (ppm)	CHLORIDE (%)	TESTED R-VALUE	OTHER TESTS
		TOP	BOTTOM																					
BH-01	1	0.0	5.0	114+90	34 L			36	25	11	12.9	57.6	29.5	SM		A-2-6								
BH-02	2	0.0	5.0	119+05	69 R			34	24	10	9.3	62.0	28.7	SM		A-2-4								
BH-03	3	0.0	5.0	124+15	35 L	9.1	99.8	36	26	10	11.3	60.8	27.8	SM		A-2-4							23	
BH-04	4	0.0	5.0	129+40	7 L			23	19	4	28.0	52.7	19.2	SC-SM		A-1-b								
BH-05	5	0.0	5.0	134+40	22 R						16.3	62.5	21.2	SM		A-1-b								
BH-06	6	0.0	5.0	139+45	4 L			35	25	10	5.1	54.6	40.3	SM		A-4								
BH-07	7	0.0	5.0	144+50	42 R			35	25	10	10.3	49.9	39.8	SM		A-4	121.7	10.4	9.2	1,810	18	14		
BH-08	8	0.0	5.0	149+55	48 L	8.5	95.1	38	23	15	5.6	55.7	38.6	SC		A-6	115.5	14.2					16	
BH-09	9	0.0	5.0	155+30	12 R			26	25	1	10.4	79.6	10.0	SW-SM		A-1-b								
BH-10	10	0.0	5.0	159+65	14 R	5.0	111.1	29	19	10	16.5	70.9	12.6	SC		A-2-4								
BH-11	11	0.0	5.0	164+00	42 R						7.7	59.5	32.8	SM		A-2-4								
BH-12	12	0.0	5.0	168+95	12 L			23	22	1	14.4	57.4	28.2	SM		A-2-4								
BH-13	13	0.0	5.0	172+60	128 R			27	25	2	15.1	59.8	25.1	SM		A-1-b			8.9	2,750	95	40		
BH-14	14	2.5	5.0	178+50	41 L			39	28	11	15.7	54.7	29.6	SM		A-2-6								
BH-15	15	2.5	5.0	184+85	1 R			28	21	7	6.7	64.0	29.3	SC-SM		A-2-4								
BH-16	16	0.0	5.0	190+00	16 L			36	26	10	7.3	59.9	32.8	SM		A-2-4							23	
BH-17	17	0.0	5.0	194+75	56 L			31	23	8	3.4	64.3	32.2	SM		A-2-4								
BH-18	18	0.0	5.0	199+85	5 R			33	25	8	8.8	55.4	35.7	SM		A-4								
BH-19	19	0.0	5.0	204+90	43 L	7.5	99.4	30	22	8	5.5	52.7	41.8	SC		A-4	120.0	11.2						

Golder Associates Inc.
7458 N. La Cholla Blvd., Tucson, AZ 85741 USA
Tel: (520) 888-8818 Fax: (520) 888-8818 www.golder.com

TABLE 1: GEOTECHNICAL LABORATORY TESTING SUMMARY SHEET

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

SAMPLING DATA						LAB TESTS AND CLASSIFICATION																		
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft) TOP	DEPTH (ft) BOTTOM	STATION	OFFSET (FT)	WATER CONTENT (%)	DRY DENSITY (lb/ft³)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	% GRAVEL	% SAND	% FINES (SILT & CLAY)	USCS SYMBOL	USCS SYMBOL (FINES ONLY)	AASHTO GROUP	MAXIMUM DRY DENSITY (lb/ft³)	OPTIMUM MOISTURE CONTENT (%)	pH	RESISTIVITY (ohm-cm)	SULFATE (ppm)	CHLORIDE (%)	TESTED R-VALUE	OTHER TESTS
BH-20	20	0.0	5.0	210+00	32 L			25	22	3	4.8	54.2	41.0	SM		A-4								
BH-21	21	0.0	5.0	214+40	50 L			24	22	2	3.2	62.1	34.6	SM		A-2-4								
BH-22	22	0.0	5.0	219+75	12 L			29	21	8	10.0	60.1	29.9	SC		A-2-4							15	
BH-23	23	0.0	5.0	223+70	10 L			37	24	13	7.4	45.8	46.8	SC		A-6								
BH-24	24	0.0	5.0	229+40	102 R			24	22	2	6.7	63.0	30.3	SM		A-2-4								
BH-25	25	2.5	5.0	234+70	53 L			31	24	7	11.9	67.9	20.1	SM		A-2-4								
BH-26	26	0.0	5.0	239+75	12 L			34	23	11	11.1	60.3	28.6	SC		A-2-6	121.4	11.4						
BH-27	27	0.0	5.0	244+60	18 R	9.5	118.0				15.0	58.4	26.6	SM		A-2-4								
BH-28	28	0.0	5.0	249+65	66 R						20.1	72.2	7.6	SW-SM		A-1-b								
BH-29	29	0.0	15.0	254+55	26 L	5.1	106.6	31	22	9	10.1	56.1	33.8	SC		A-2-4	119.7	12.0	8.7	1,410	26	56	22	
BH-30	30	0.0	5.0	259+55	60 L			36	31	5	6.1	65.6	28.3	SM		A-2-4								
BH-31	31	2.5	5.0	264+40	14 L			32	25	7	12.5	65.3	22.1	SM		A-2-4	124.5	9.6						
BH-32	32	5.0	10.0	269+80	39 L			27	20	7	7.1	57.7	35.1	SC-SM		A-2-4			8.8	1,340	34	20		
BH-33	33	0.0	5.0	274+95	33 L			26	21	5	6.1	57.9	36.0	SC-SM		A-4								
BH-34	34	0.0	5.0	279+55	96 R	3.3	109.9	28	26	2	16.5	61.9	21.6	SM		A-1-b	119.6	11.6					67	
BH-35	35	0.0	5.0	285+60	14 L			27	21	6	26.8	44.2	29.1	SC-SM		A-2-4			8.9	1,950	47	28		
BH-36	36	0.0	5.0	289+95	67 L			34	24	10	8.7	51.5	39.8	SM		A-4								

Golder Associates Inc.
7458 N. La Cholla Blvd., Tucson, AZ 85741 USA
Tel: (520) 888-8818 Fax: (520) 888-8818 www.golder.com

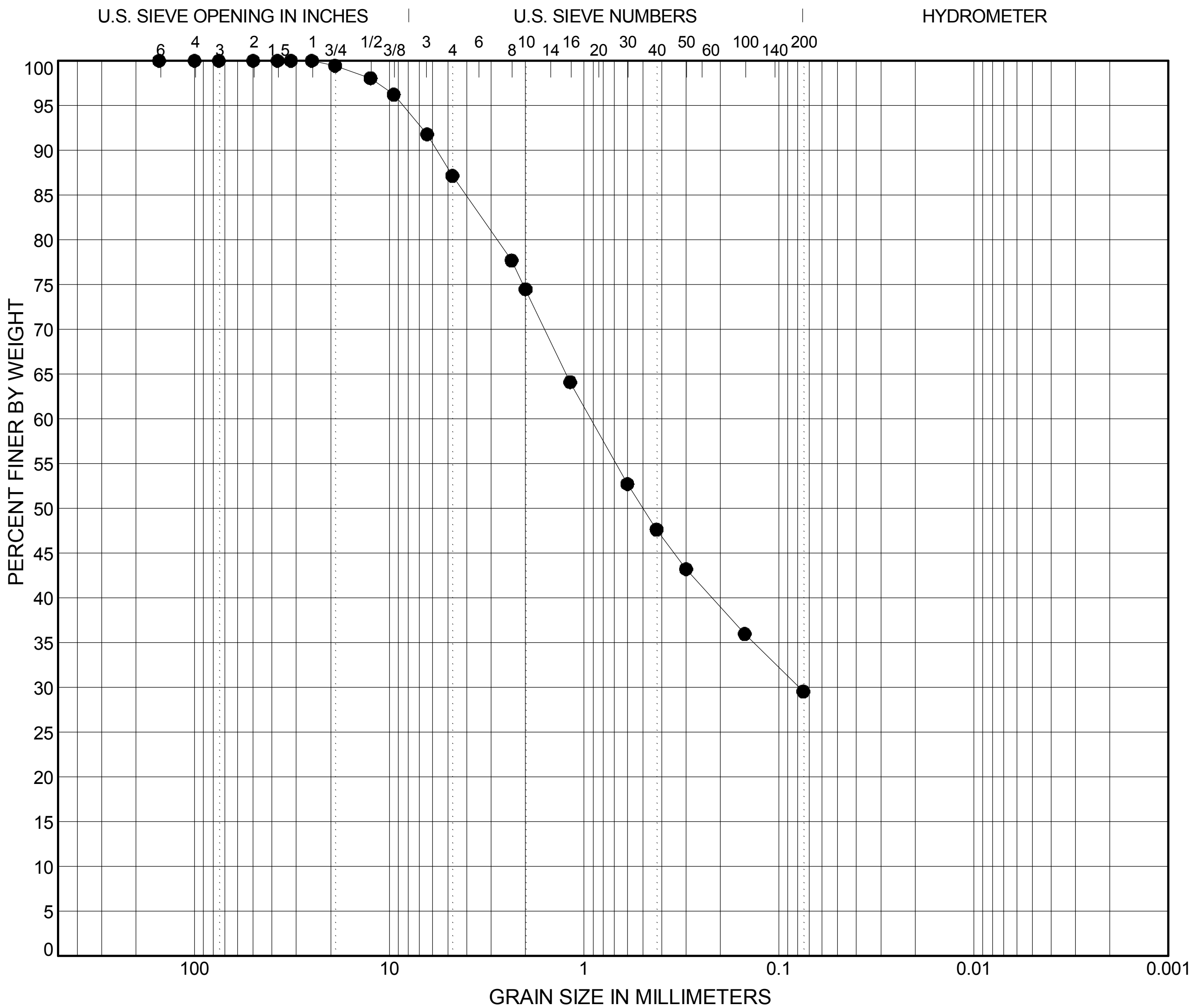
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
BH-01	1	0.0 - 5.0	SILTY SAND(SM)			12.9	57.6	29.5	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	96	92	87	78	74	64	53	48	43	36	29.5

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
36	25	11		0.98	4.054	0.925	0.499	0.079	0.016	0.009

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

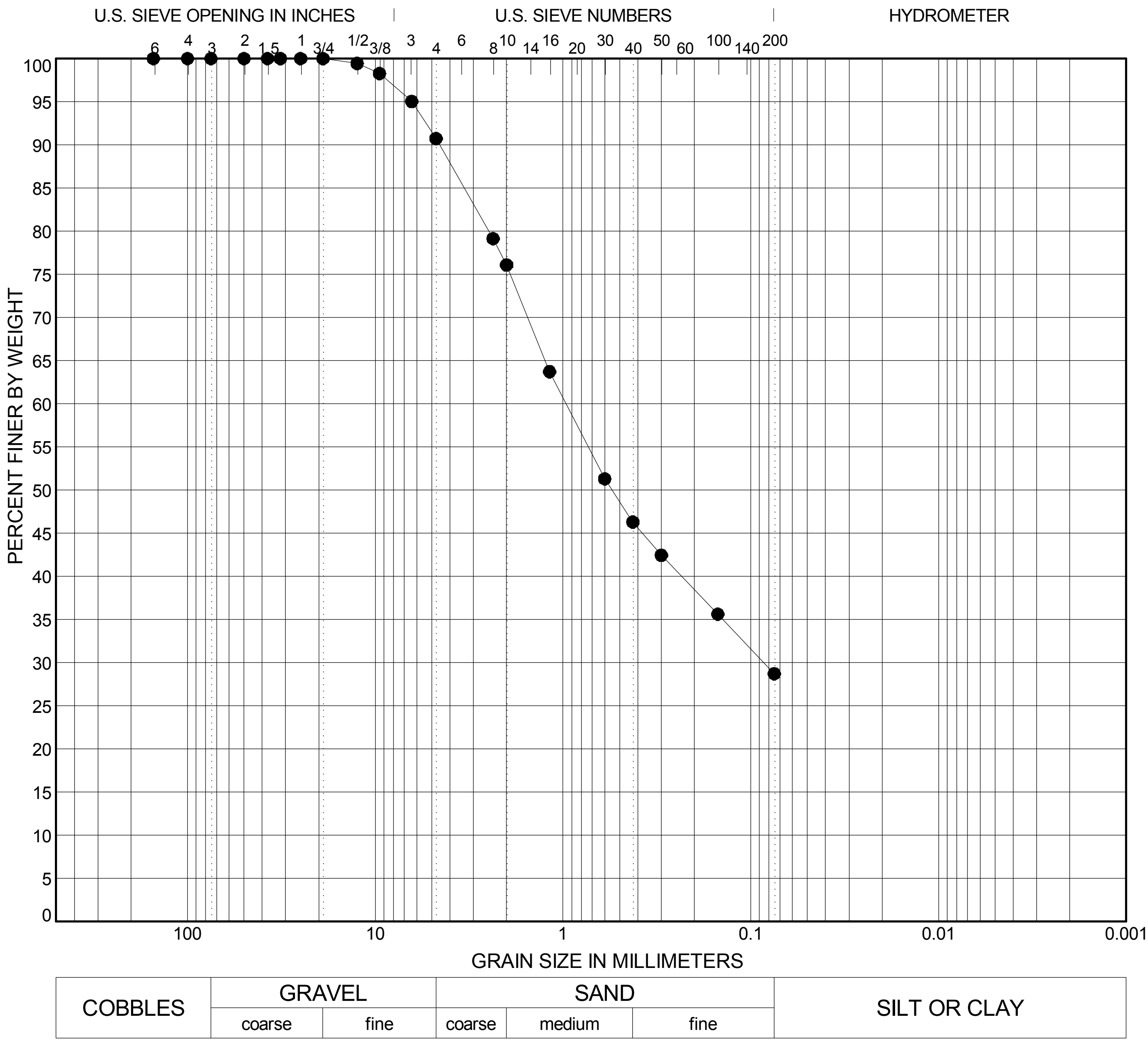
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines	
									%Silt	%Clay
●	BH-02	2	0.0 - 5.0	SILTY SAND(SM)			9.3	62.0	28.7	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	95	91	79	76	64	51	46	42	36	28.7

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes						
				D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
34	24	10		0.75	3.362	0.964	0.549	0.085	0.019	0.011

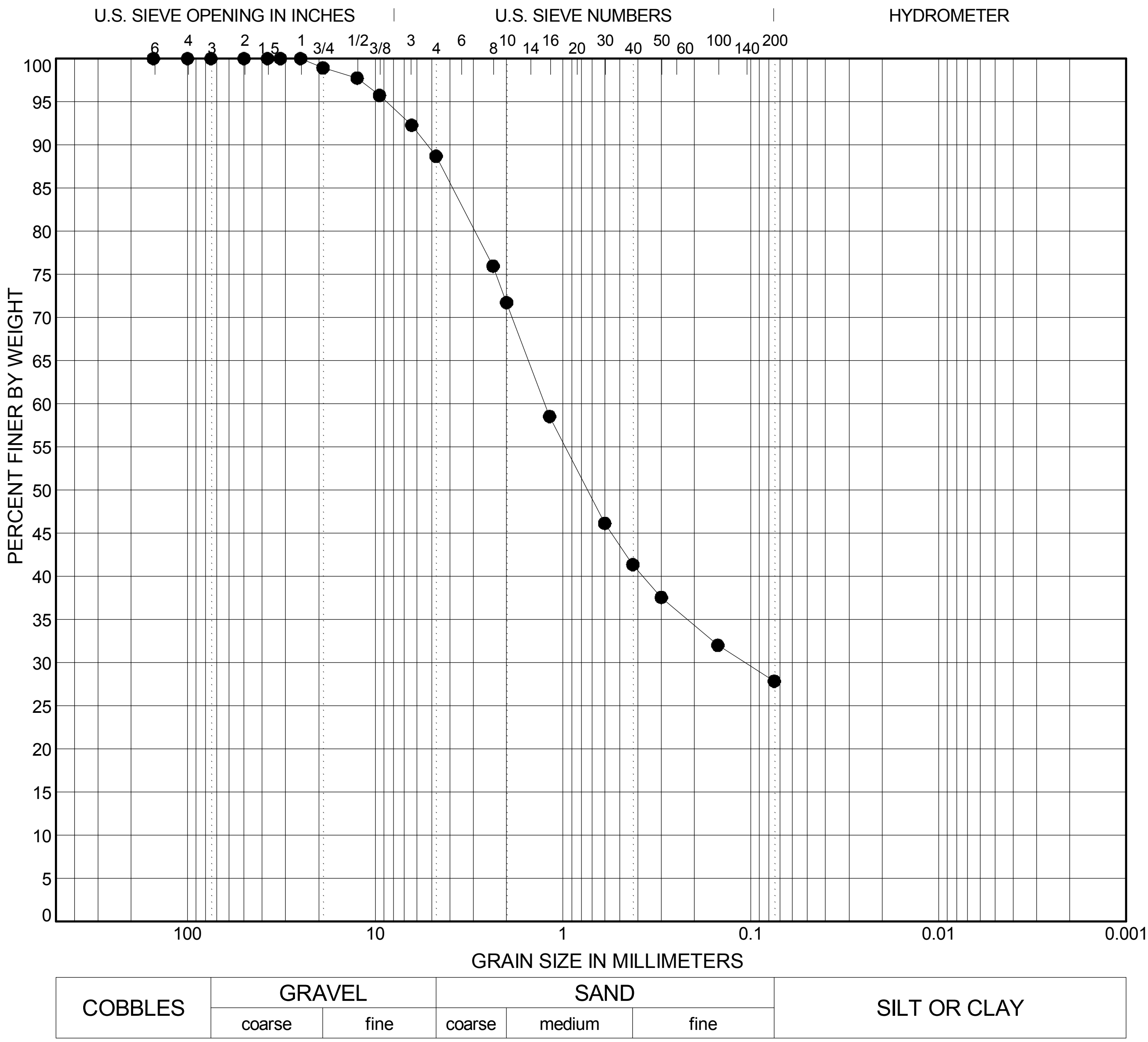
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines	
									%Silt	%Clay
●	BH-03	3	0.0 - 5.0	SILTY SAND(SM)			11.3	60.8	27.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	96	92	89	76	72	59	46	41	38	32	27.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes						
				D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
36	26	10	9.1	0.98	3.88	1.251	0.741	0.107	0.009	0.004

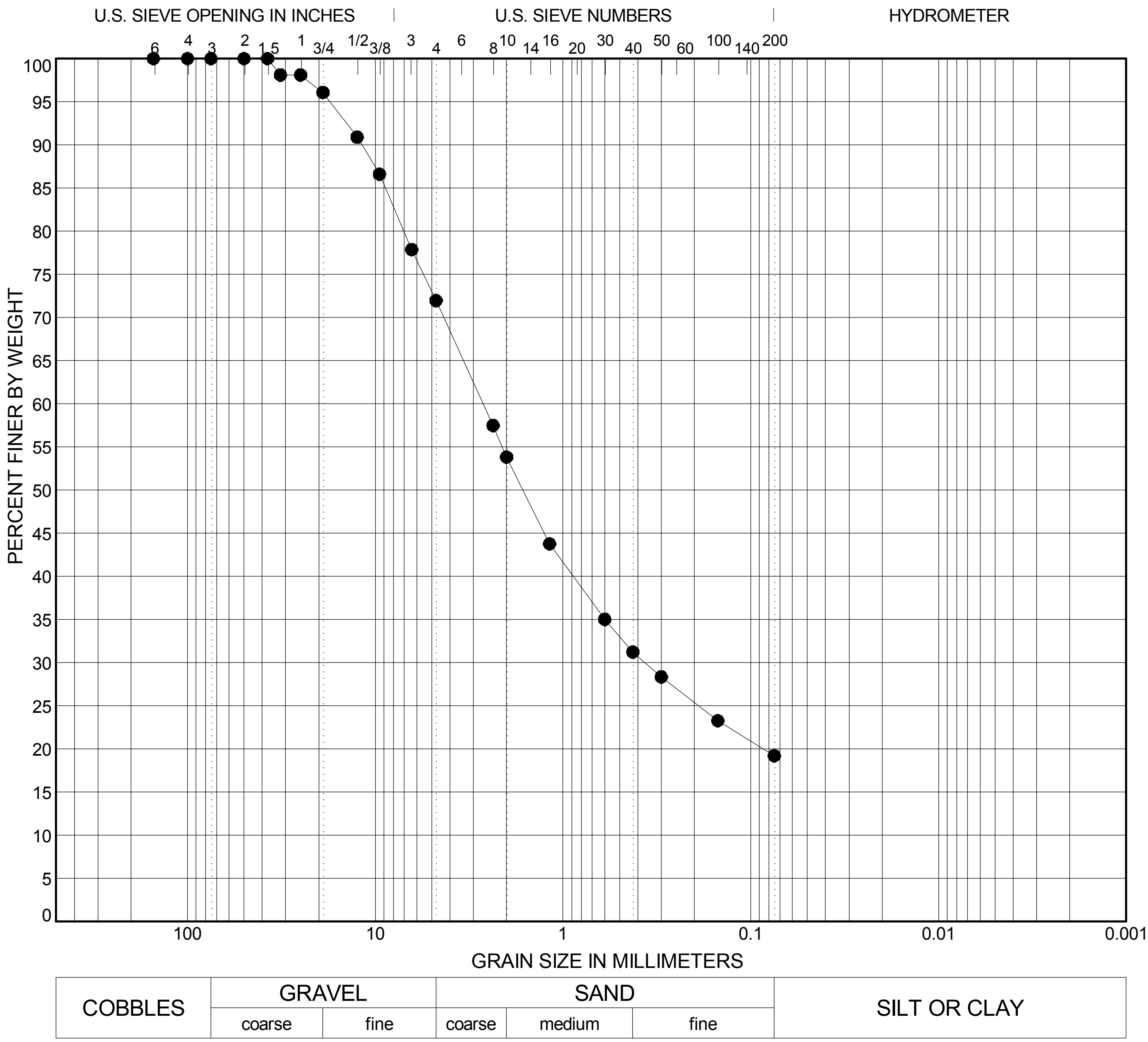
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-04	4	0.0 - 5.0	SILTY, CLAYEY SAND with GRAVEL(SC-SM)			28.0	52.7	19.2	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	98	98	96	91	87	78	72	57	54	44	35	31	28	23	19.2

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
23	19	4		1.48	8.837	2.665	1.637	0.366	0.037	0.016

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

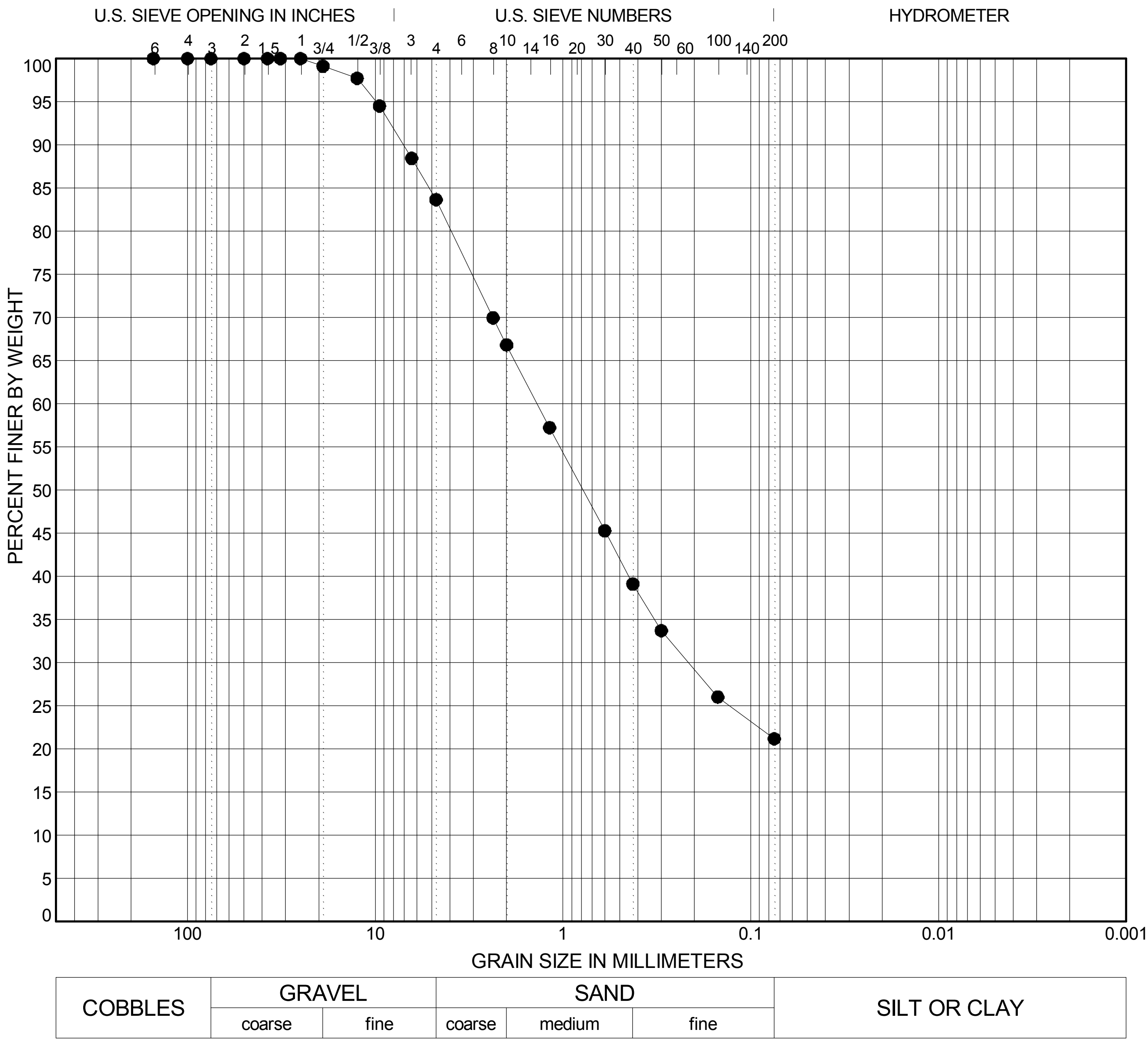
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-05	5	0.0 - 5.0				16.3	62.5	21.2	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	95	88	84	70	67	57	45	39	34	26	21.2

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
				0.98	5.166	1.374	0.784	0.215	0.031	0.015

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

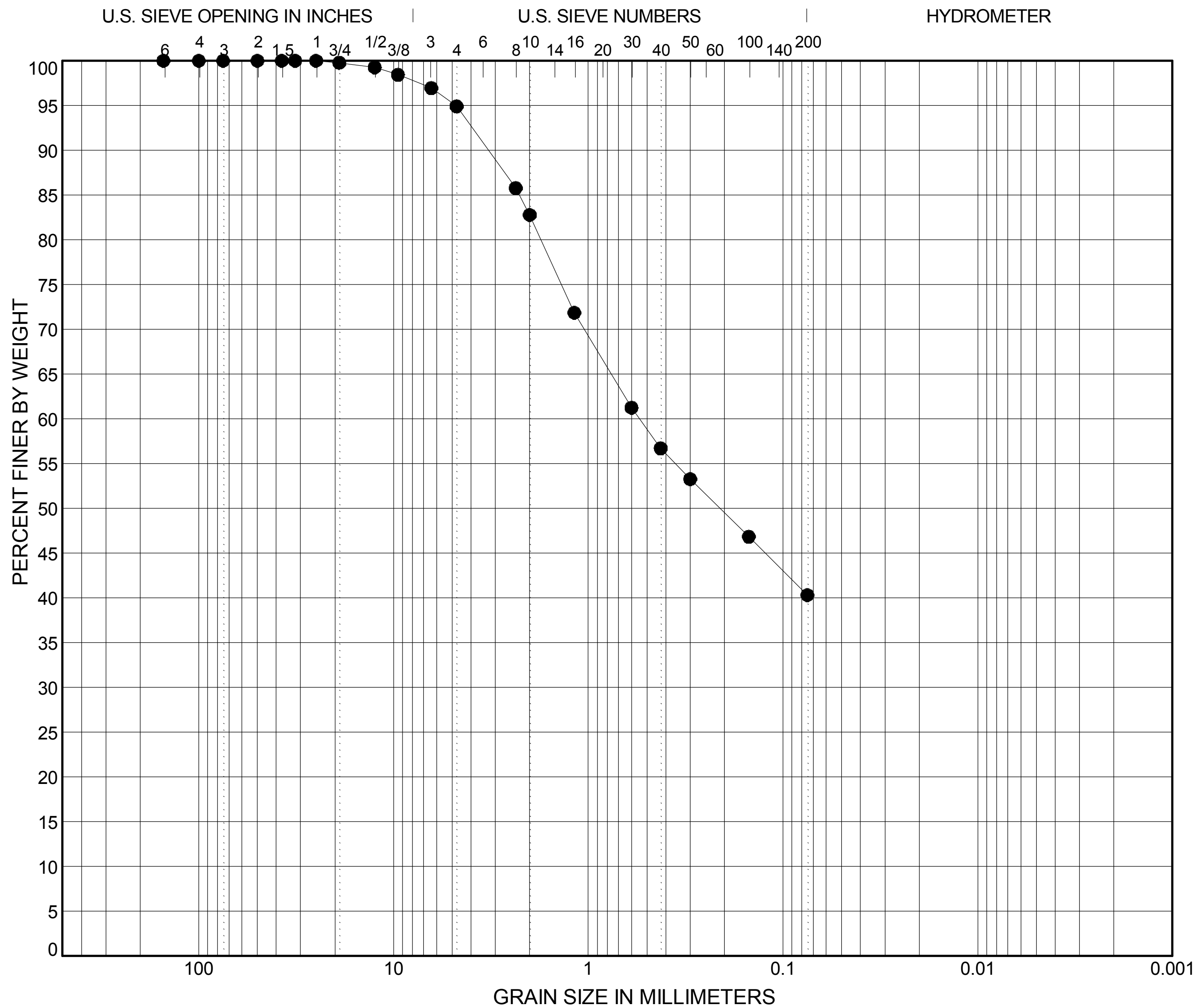
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines: %Silt	%Fines: %Clay
●	BH-06	6	0.0 - 5.0	SILTY SAND(SM)			5.1	54.6	40.3	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	97	95	86	83	72	61	57	53	47	40.3

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes: D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
35	25	10		0.98	2.261	0.546	0.211	0.025	0.005	0.003

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

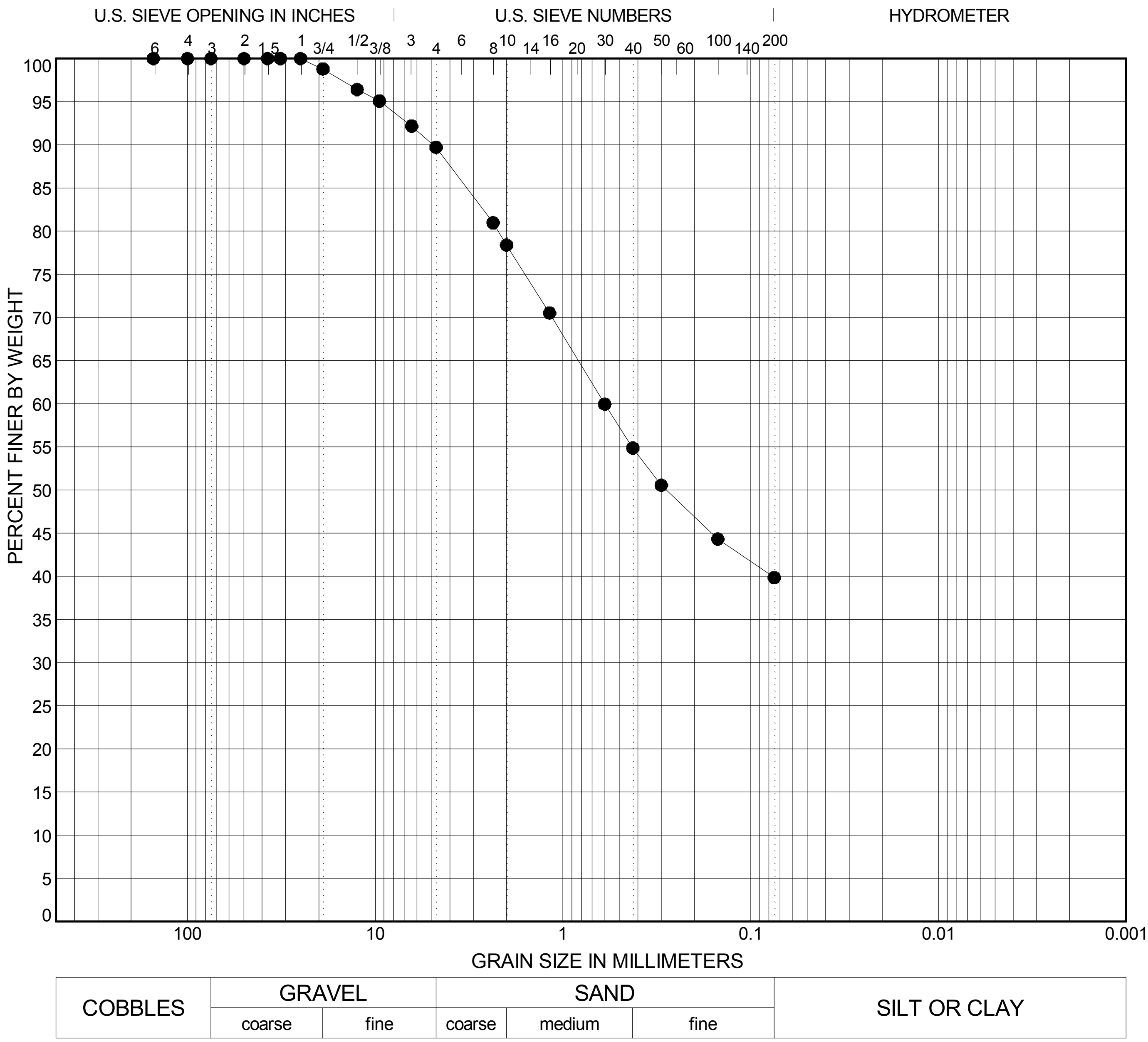
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-07	7	0.0 - 5.0	SILTY SAND(SM)			10.3	49.9	39.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	96	95	92	90	81	78	71	60	55	51	44	39.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
35	25	10		0.98	3.257	0.602	0.282	0.016	0.002	0.001

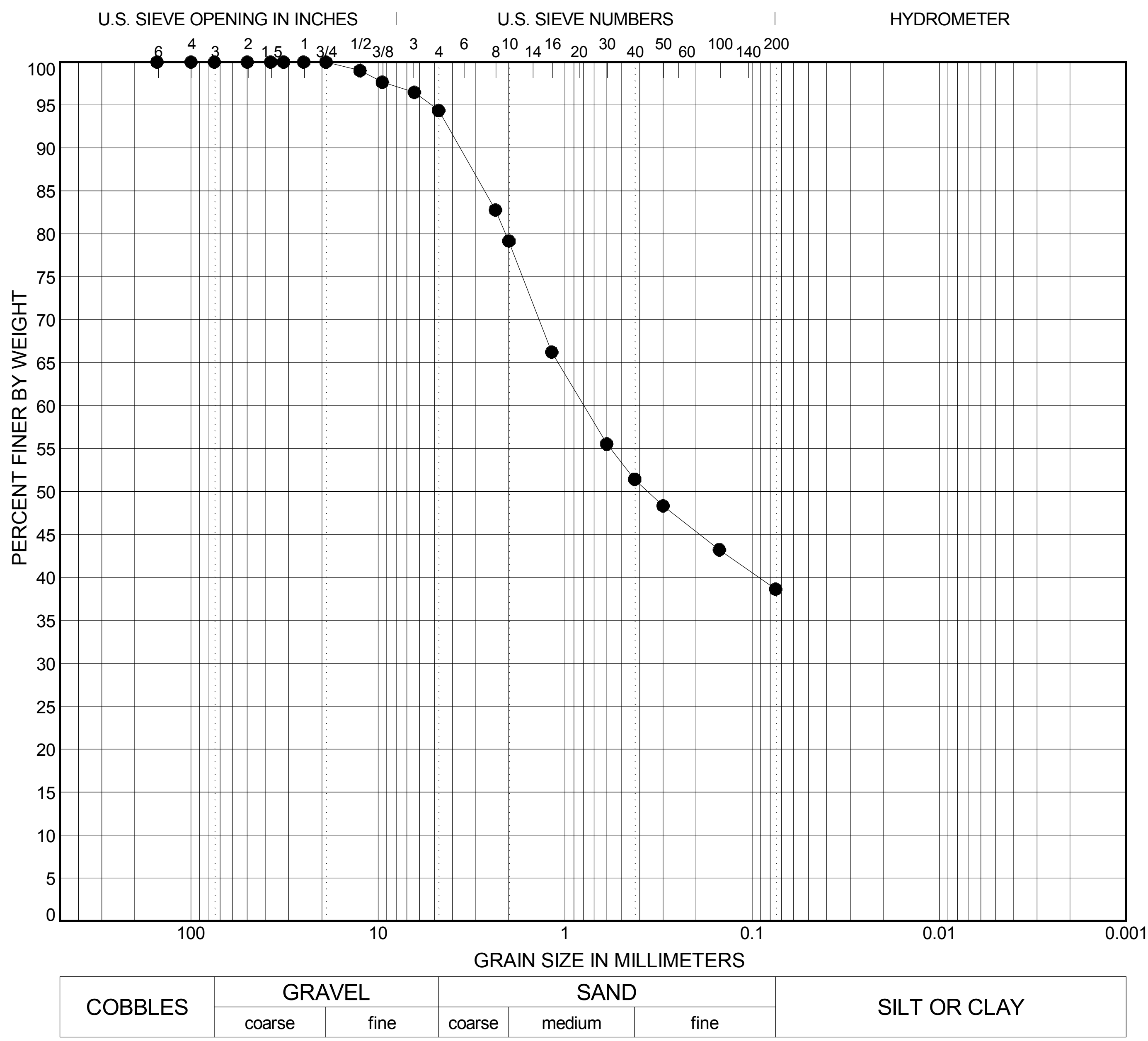
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

GOLDER

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-08	8	0.0 - 5.0	CLAYEY SAND(SC)			5.6	55.7	38.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	96	94	83	79	66	56	51	48	43	38.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
38	23	15	8.5	0.75	2.699	0.795	0.362	0.02	0.002	0.001

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

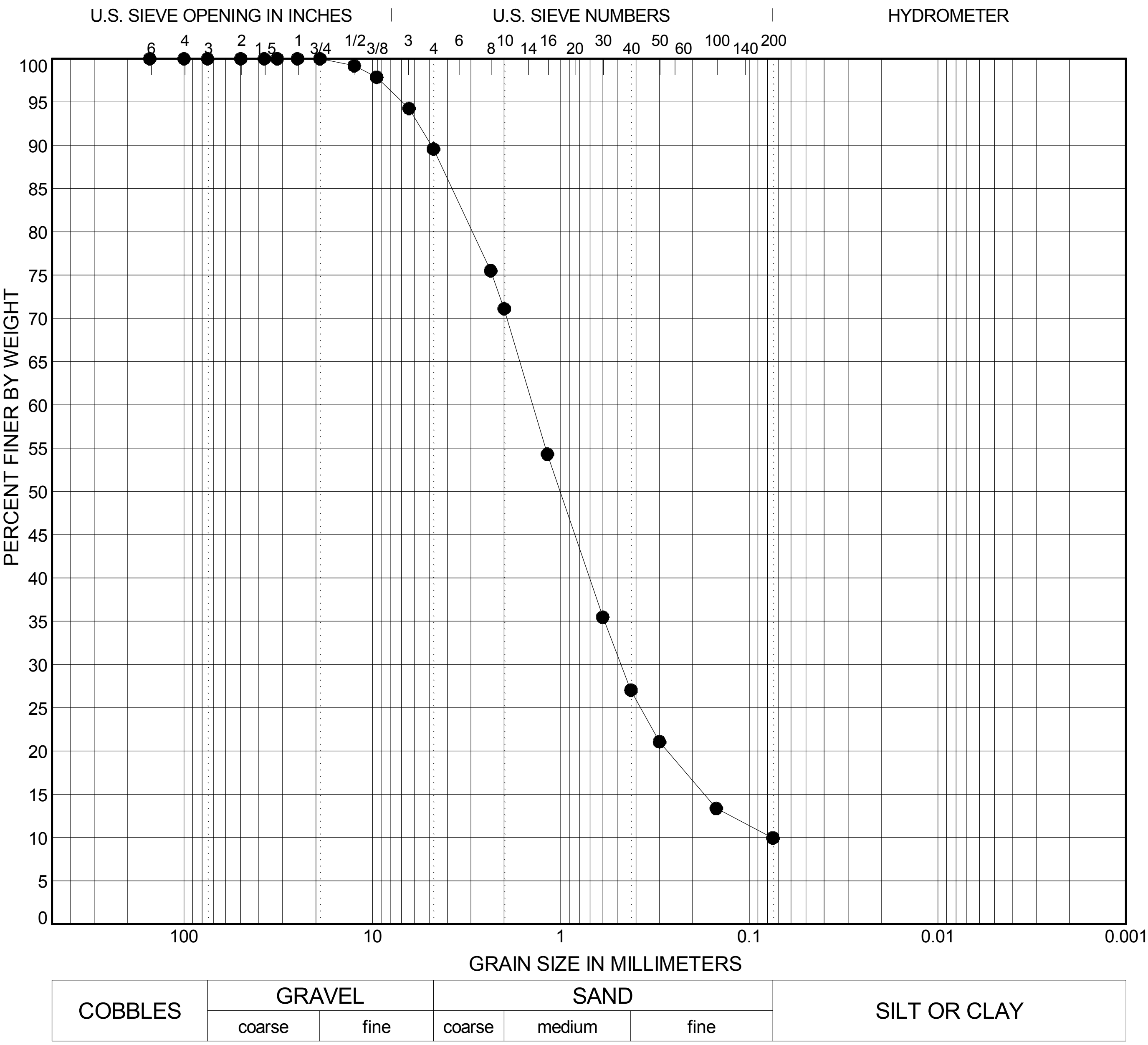
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-09	9	0.0 - 5.0	WELL-GRADED SAND with SILT(SW-SM)	2.16	18.65	10.4	79.6	10.0	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	94	90	76	71	54	35	27	21	13	10.0

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
26	25	1		0.75	3.784	1.411	1.011	0.48	0.174	0.076

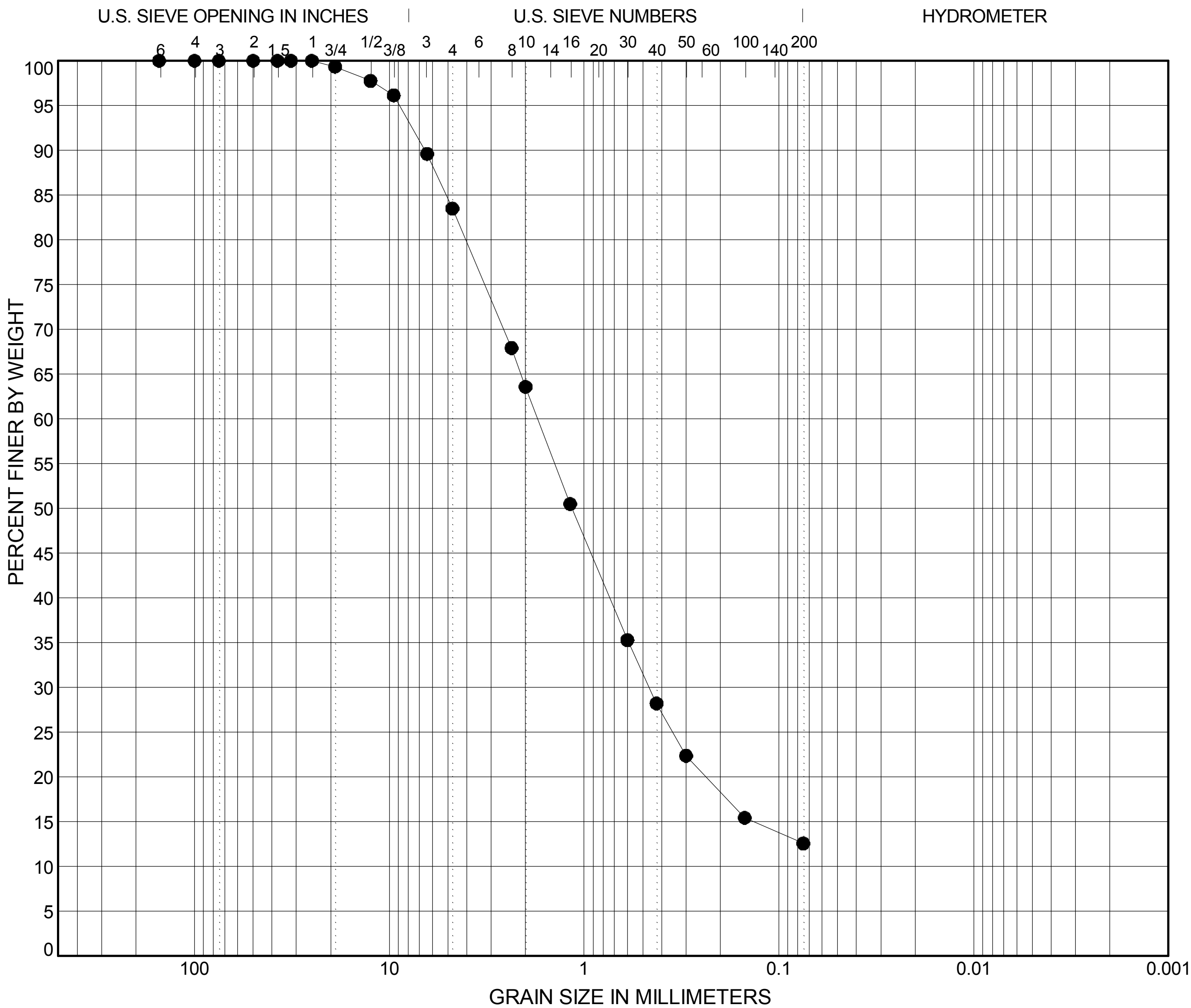
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-10	10	0.0 - 5.0	CLAYEY SAND with GRAVEL(SC)			16.5	70.9	12.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	96	90	83	68	64	50	35	28	22	15	12.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
29	19	10	5.0	0.98	5.113	1.732	1.155	0.464	0.135	0.04

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

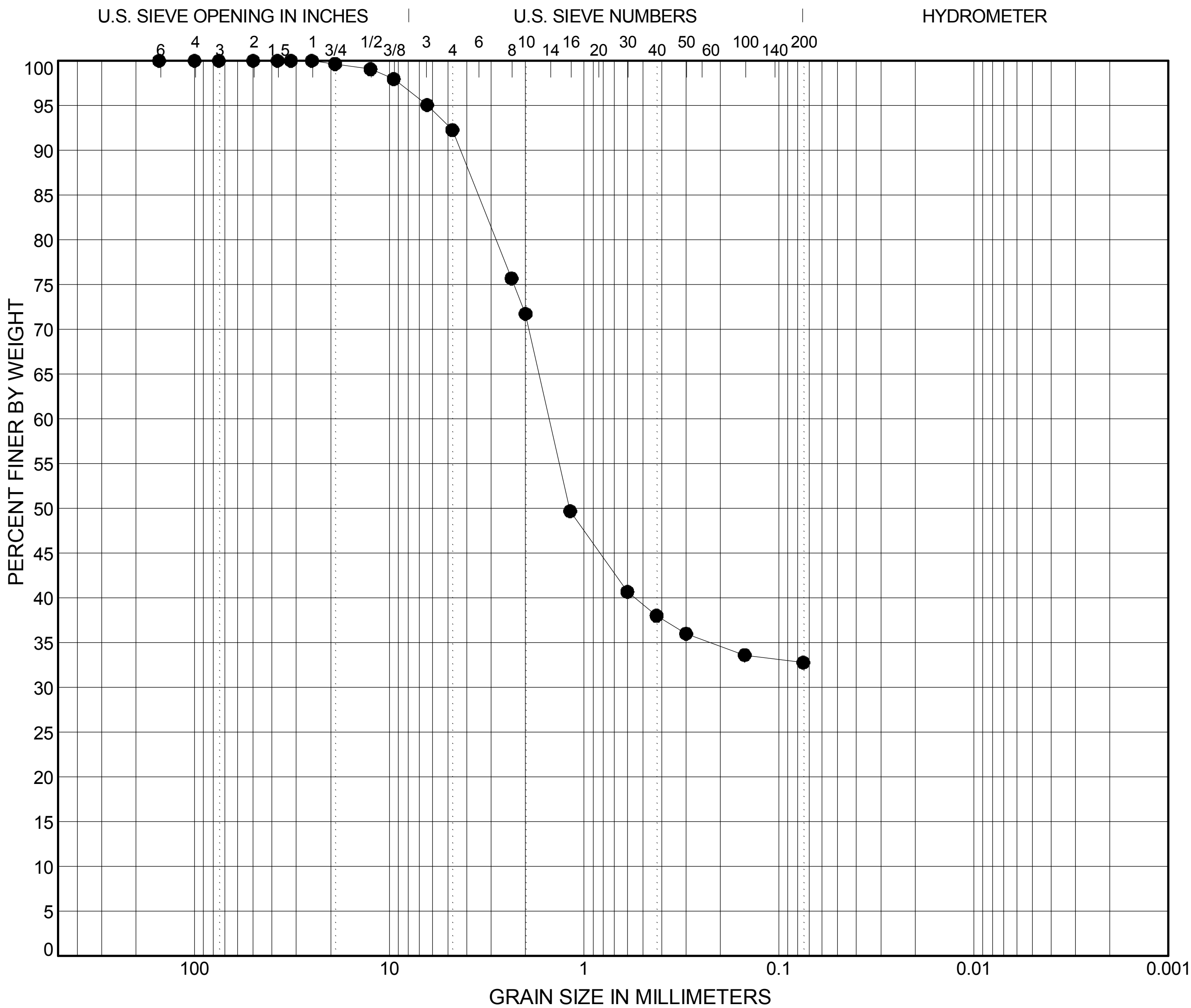
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-11	11	0.0 - 5.0				7.7	59.5	32.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	95	92	76	72	50	41	38	36	34	32.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
				0.98	3.496	1.51	1.189	0.008	0.0	0.0

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

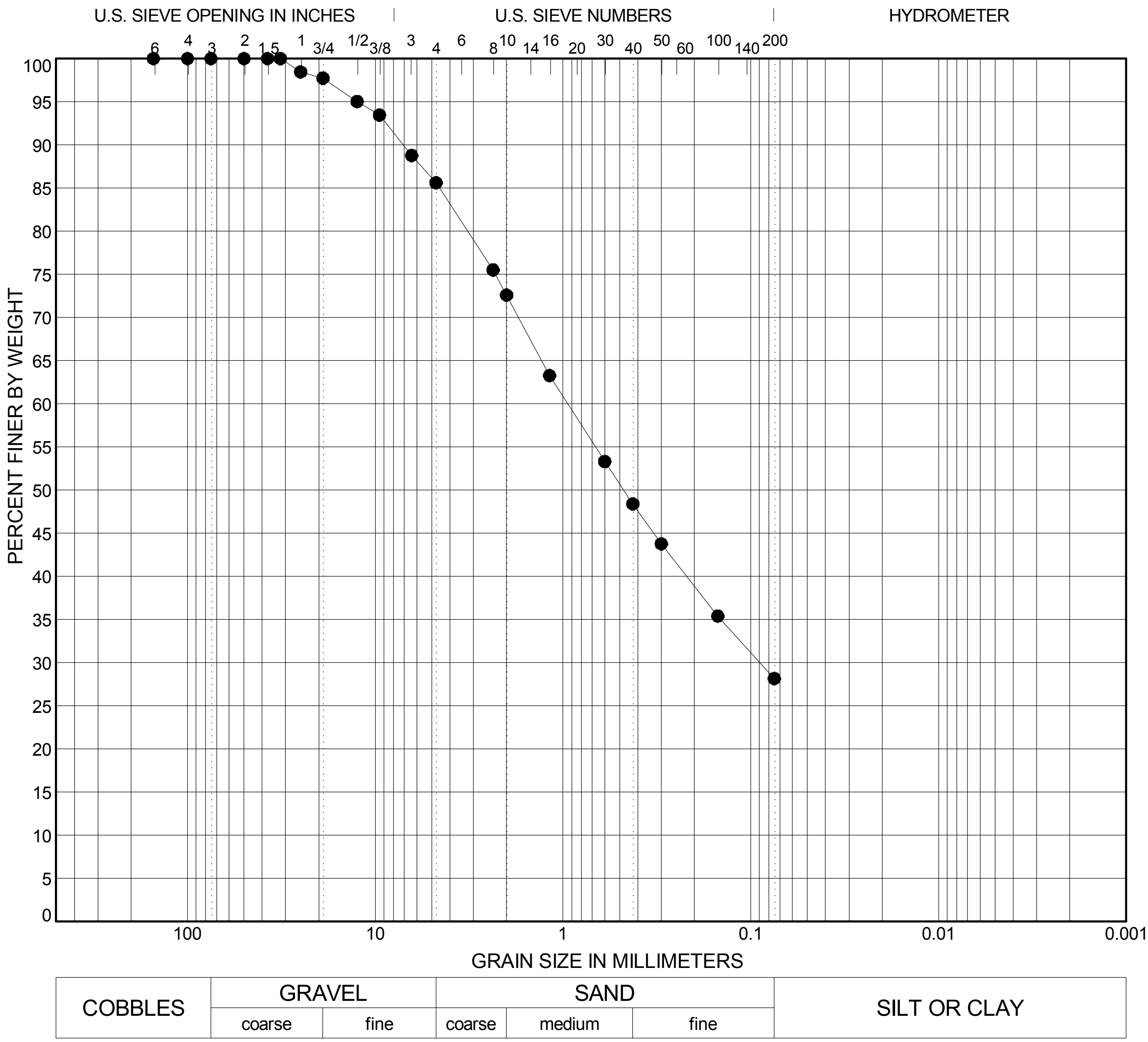
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-12	12	0.0 - 5.0	SILTY SAND(SM)			14.4	57.4	28.2	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	98	98	95	93	89	86	76	73	63	53	48	44	35	28.2

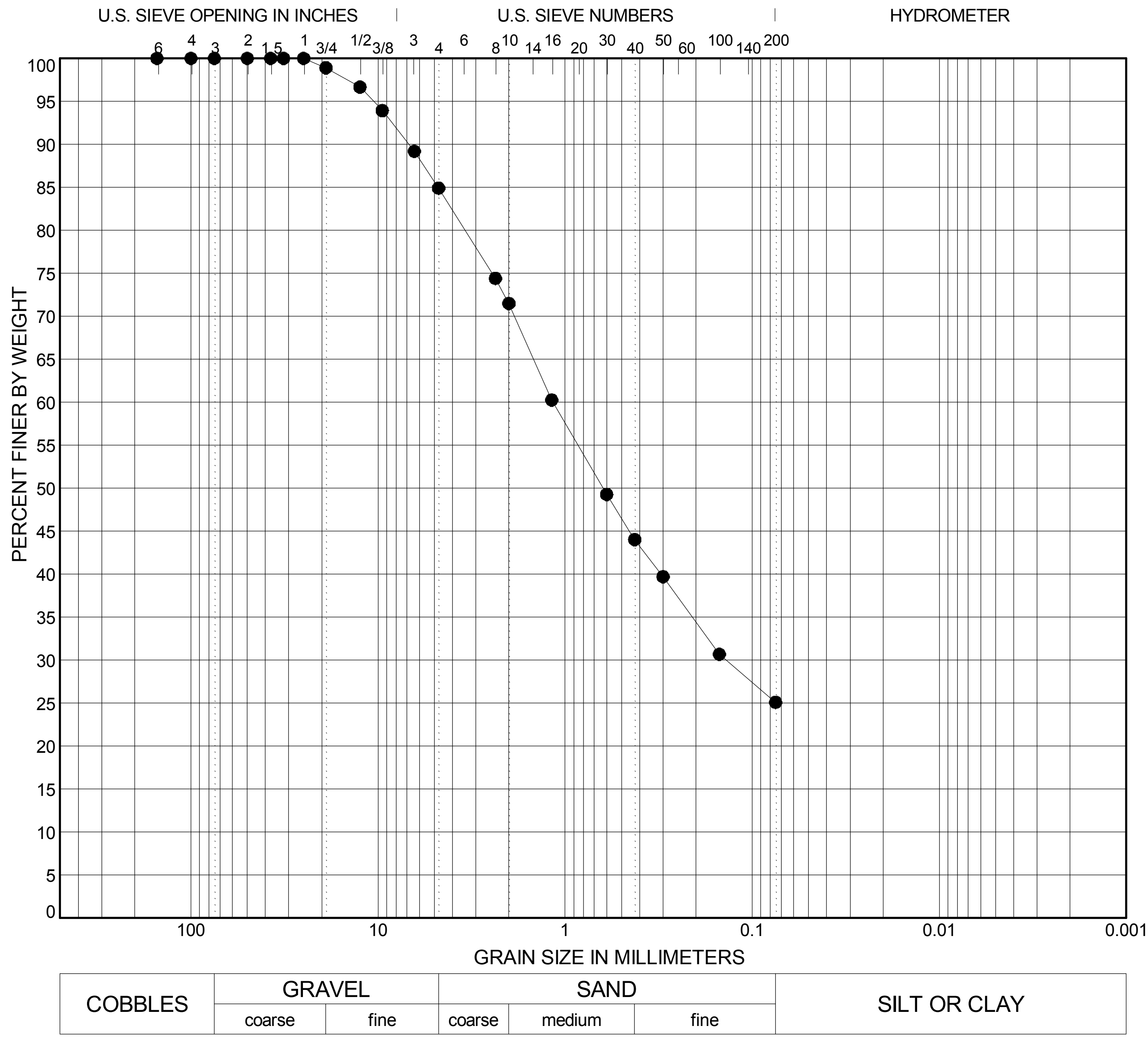
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
23	22	1		1.26	4.555	0.945	0.476	0.089	0.021	0.013

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-13	13	0.0 - 5.0	SILTY SAND with GRAVEL(SM)			15.1	59.8	25.1	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	97	94	89	85	74	71	60	49	44	40	31	25.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
27	25	2		0.98	4.782	1.161	0.628	0.138	0.022	0.012

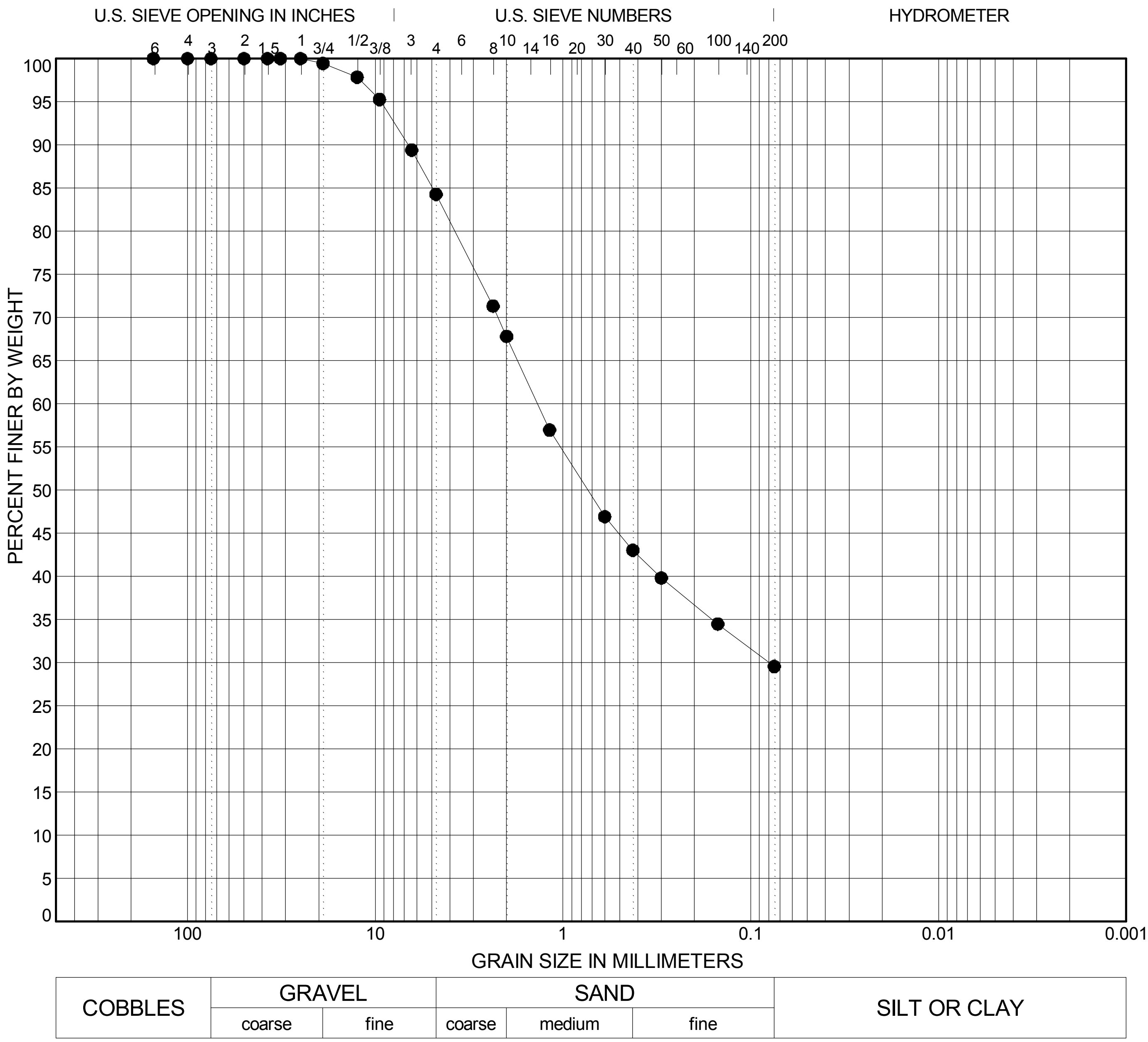
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

GOLDER

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-14	14	2.5 - 5.0	SILTY SAND with GRAVEL(SM)			15.7	54.7	29.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	95	89	84	71	68	57	47	43	40	34	29.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
39	28	11		0.98	4.955	1.368	0.739	0.08	0.01	0.005

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

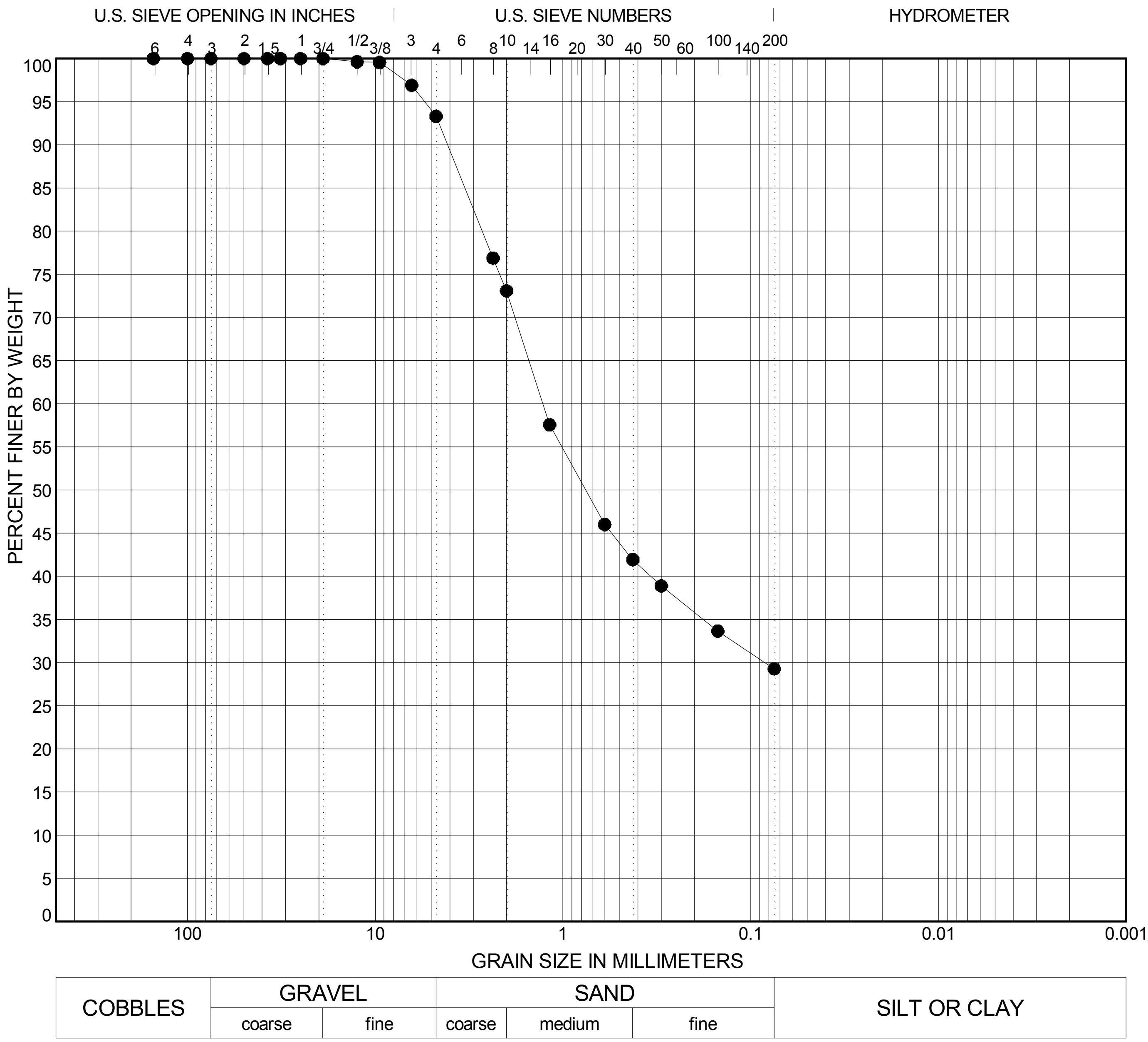
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-15	15	2.5 - 5.0	SILTY, CLAYEY SAND(SC-SM)			6.7	64.0	29.3	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	100	100	97	93	77	73	58	46	42	39	34	29.3

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
28	21	7		0.75	3.335	1.282	0.758	0.084	0.008	0.004

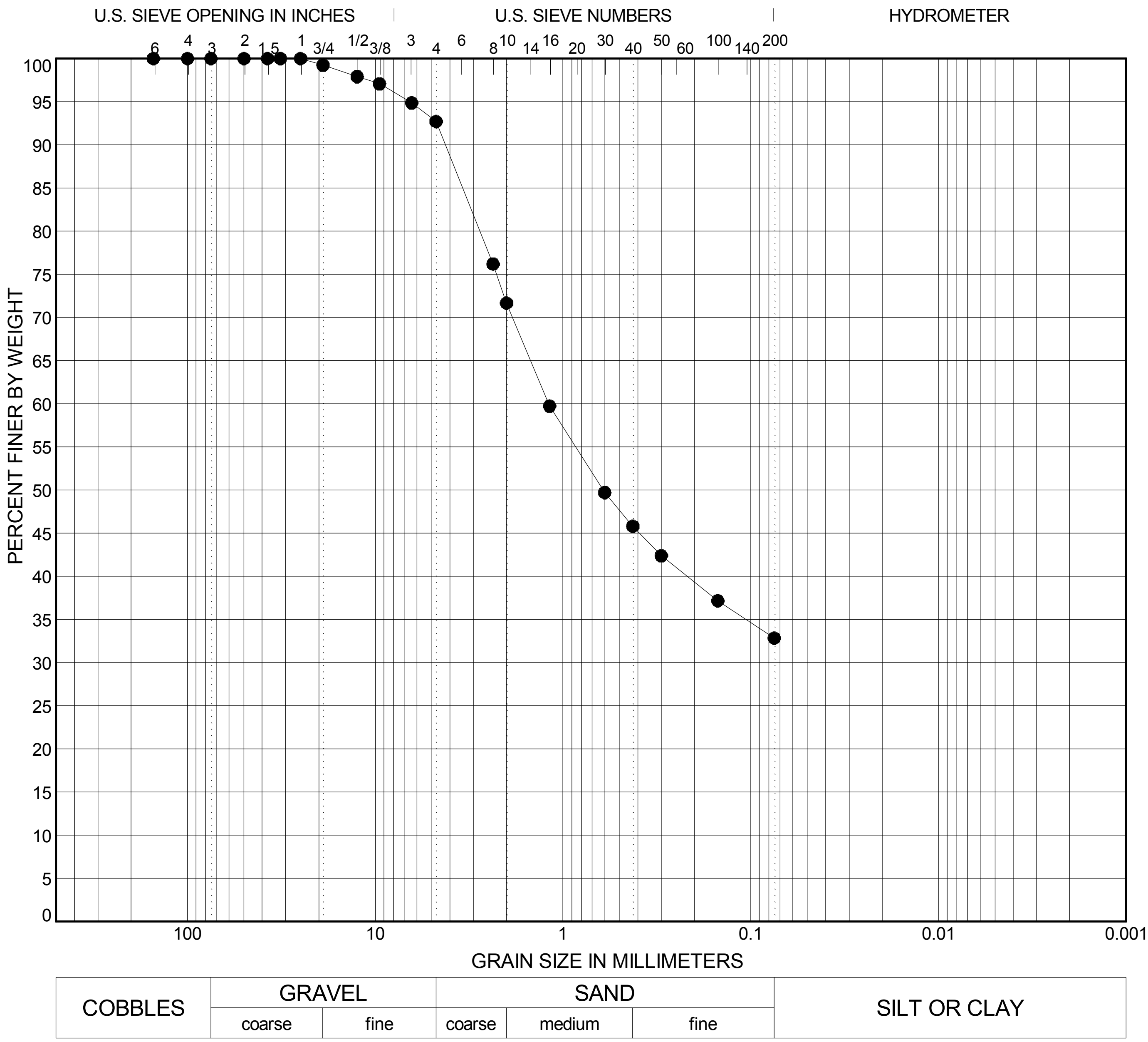
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-16	16	0.0 - 5.0	SILTY SAND(SM)			7.3	59.9	32.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	97	95	93	76	72	60	50	46	42	37	32.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
36	26	10		0.98	3.427	1.194	0.612	0.048	0.004	0.002

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

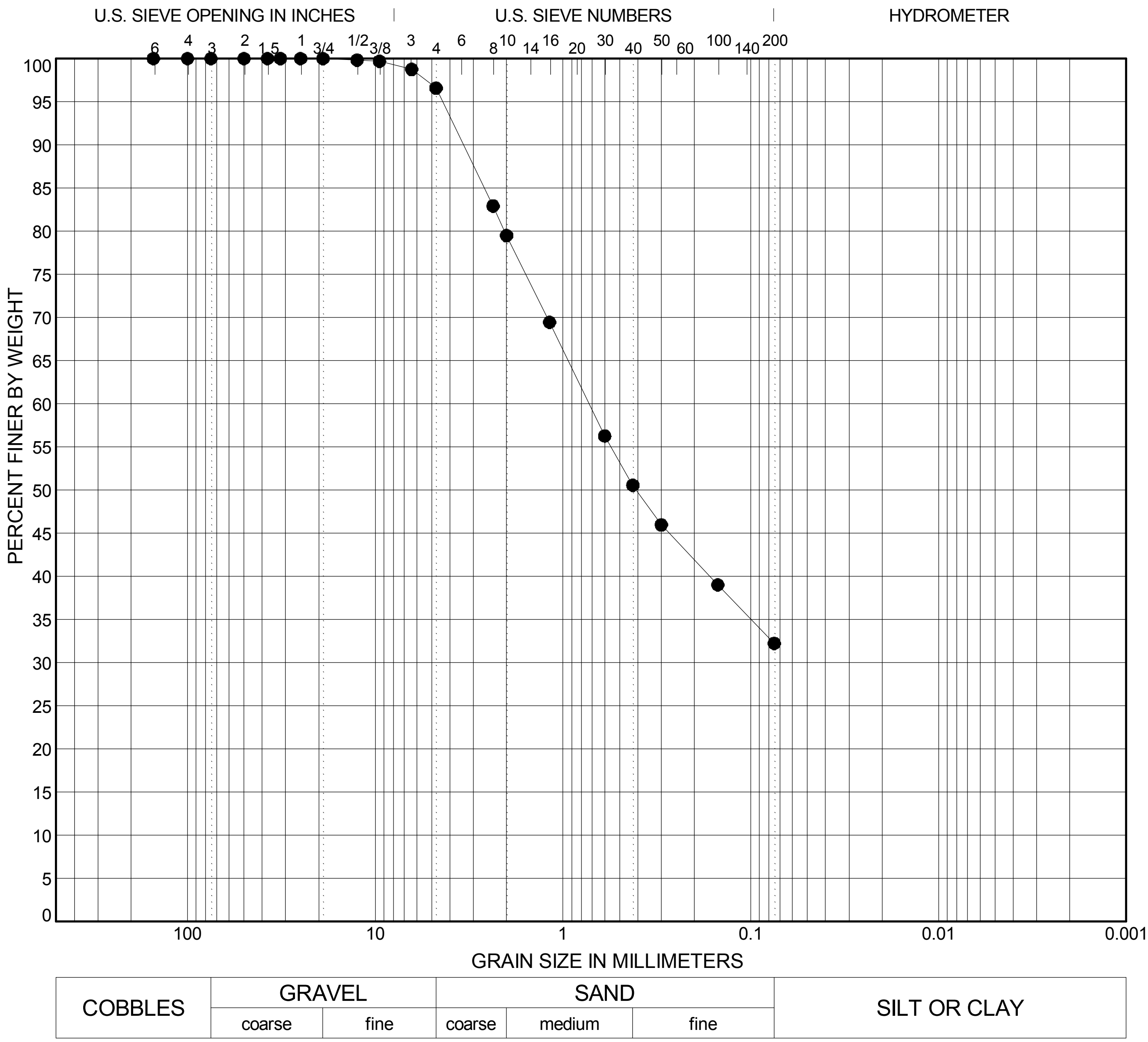
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines	
									%Silt	%Clay
●	BH-17	17	0.0 - 5.0	SILTY SAND(SM)			3.4	64.3	32.2	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	100	100	99	97	83	79	69	56	51	46	39	32.2

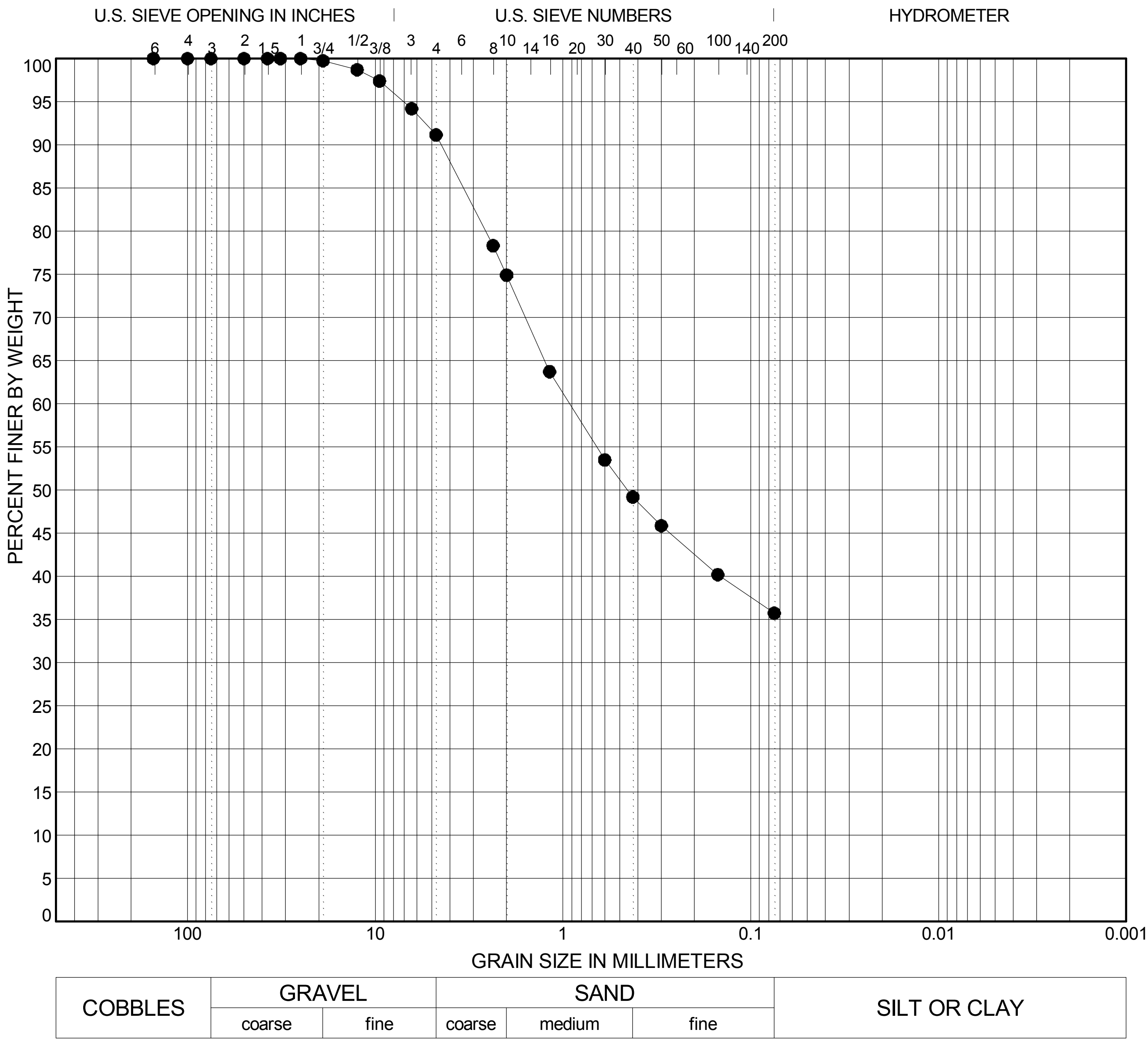
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes						
				D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
31	23	8		0.75	2.625	0.727	0.407	0.06	0.013	0.008

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-18	18	0.0 - 5.0	SILTY SAND(SM)			8.8	55.4	35.7	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	97	94	91	78	75	64	53	49	46	40	35.7

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
33	25	8		0.98	3.396	0.923	0.454	0.031	0.003	0.001

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

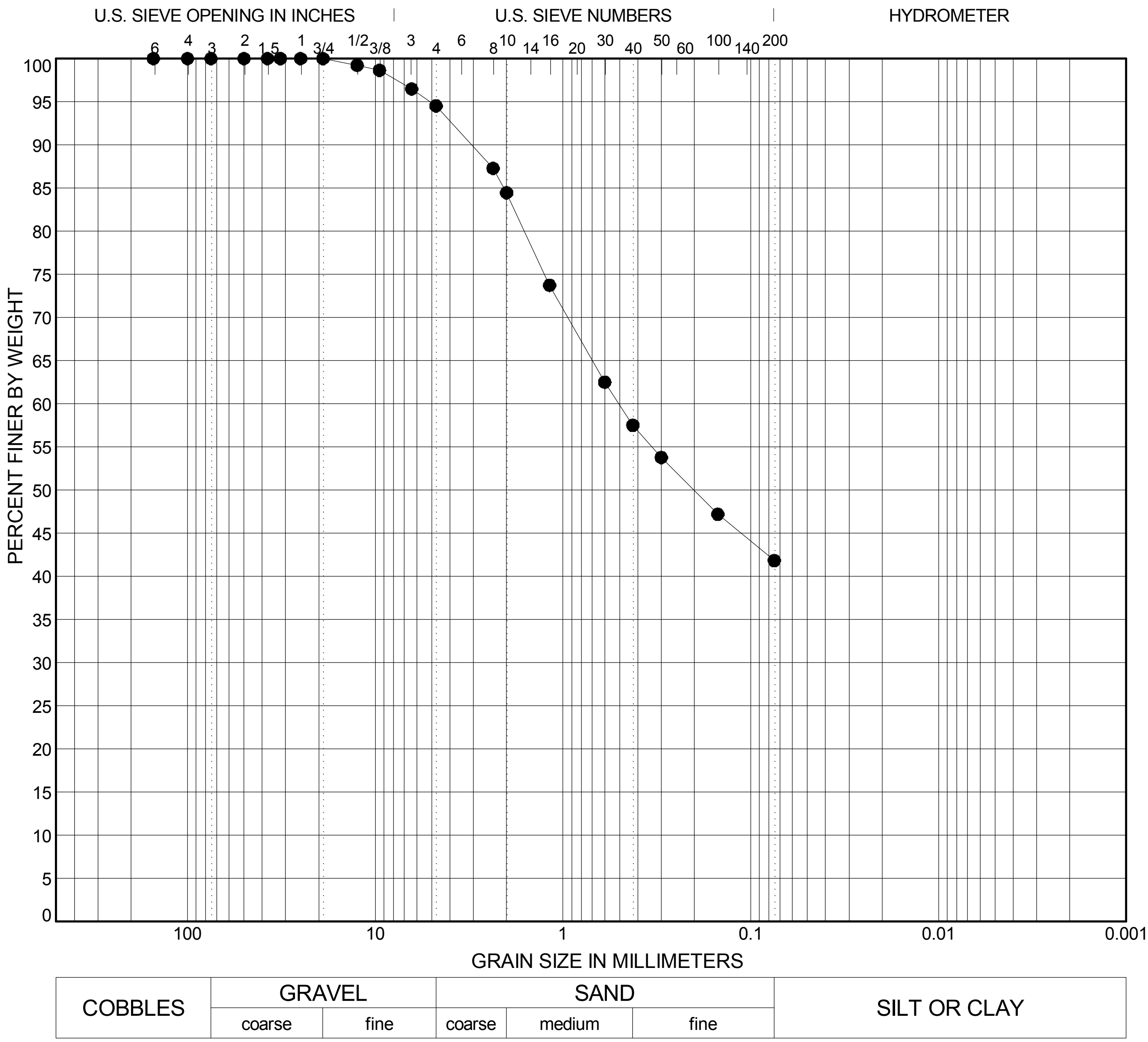
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-19	19	0.0 - 5.0	CLAYEY SAND(SC)			5.5	52.7	41.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	99	96	95	87	84	74	62	58	54	47	41.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
30	22	8	7.5	0.75	2.065	0.505	0.202	0.016	0.002	0.001

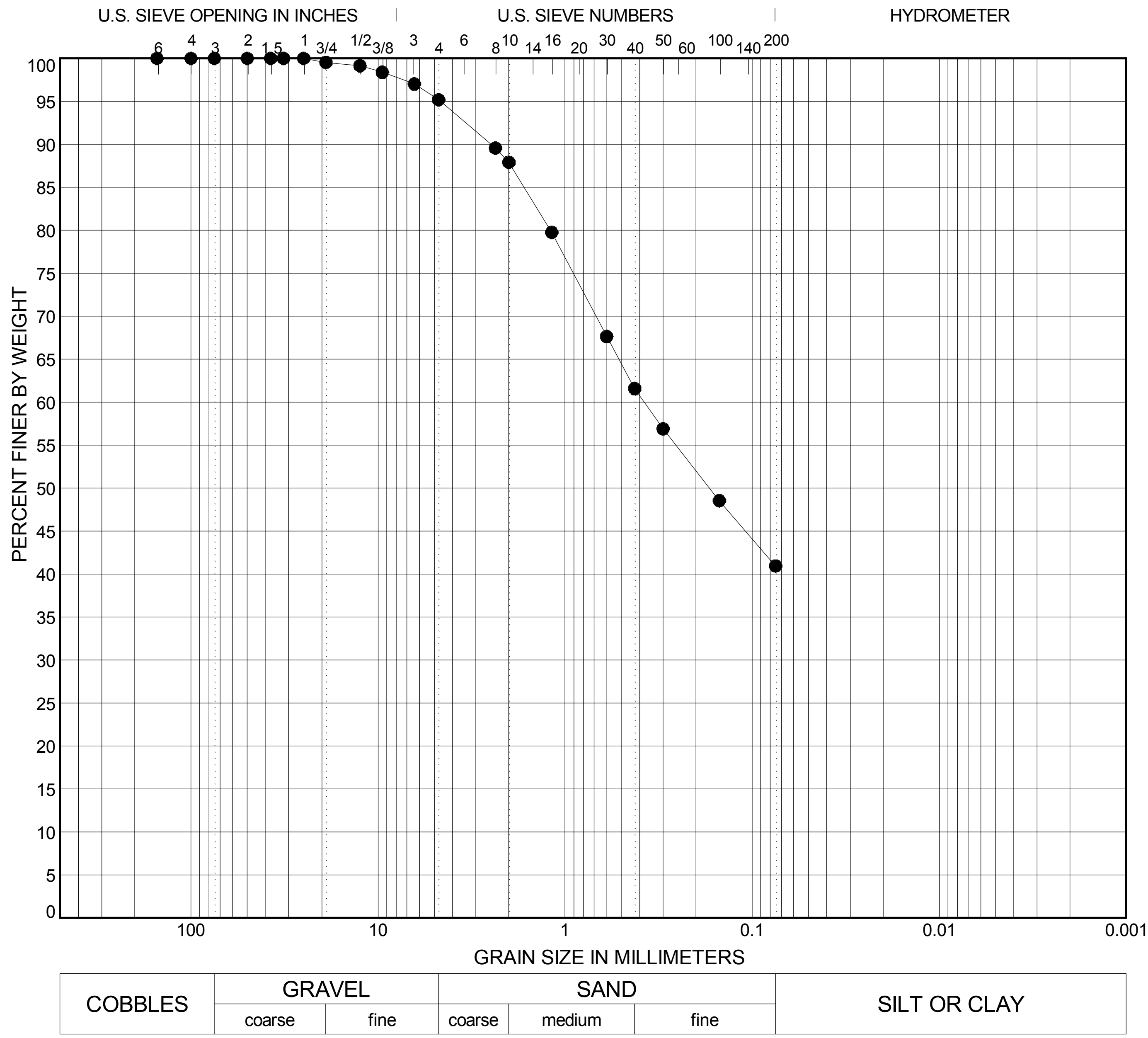
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-20	20	0.0 - 5.0	SILTY SAND(SM)			4.8	54.2	41.0	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	97	95	90	88	80	68	62	57	49	41.0

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
25	22	3		0.98	1.657	0.378	0.169	0.028	0.007	0.004

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

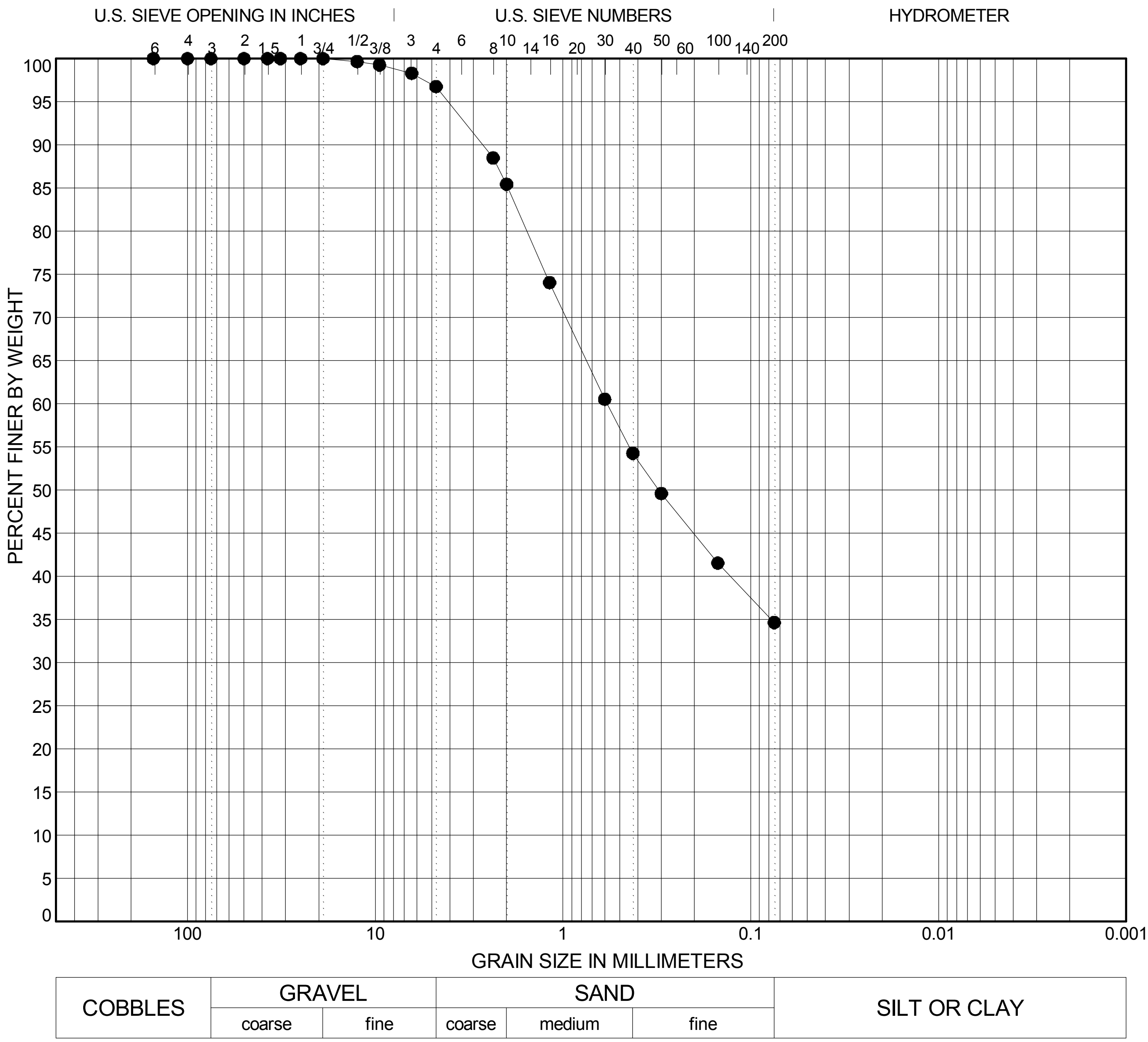
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines	
									%Silt	%Clay
●	BH-21	21	0.0 - 5.0	SILTY SAND(SM)			3.2	62.1	34.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	100	99	98	97	88	85	74	61	54	50	42	34.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes						
				D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
24	22	2		0.75	1.96	0.583	0.309	0.047	0.01	0.006

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

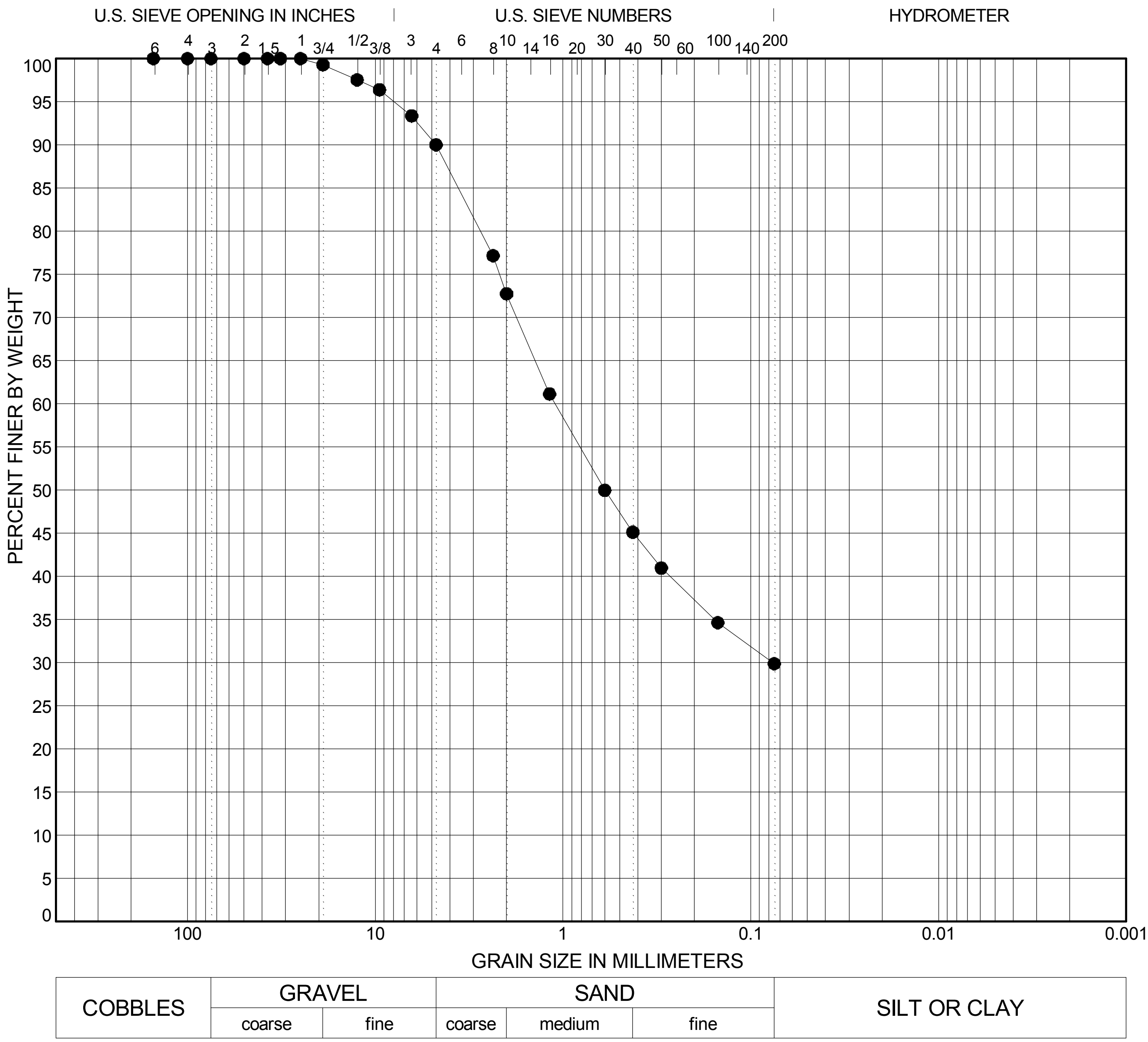
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines	
									%Silt	%Clay
●	BH-22	22	0.0 - 5.0	CLAYEY SAND(SC)			10.0	60.1	29.9	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	96	93	90	77	73	61	50	45	41	35	29.9

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes						
				D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
29	21	8		0.98	3.616	1.102	0.601	0.076	0.009	0.004

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

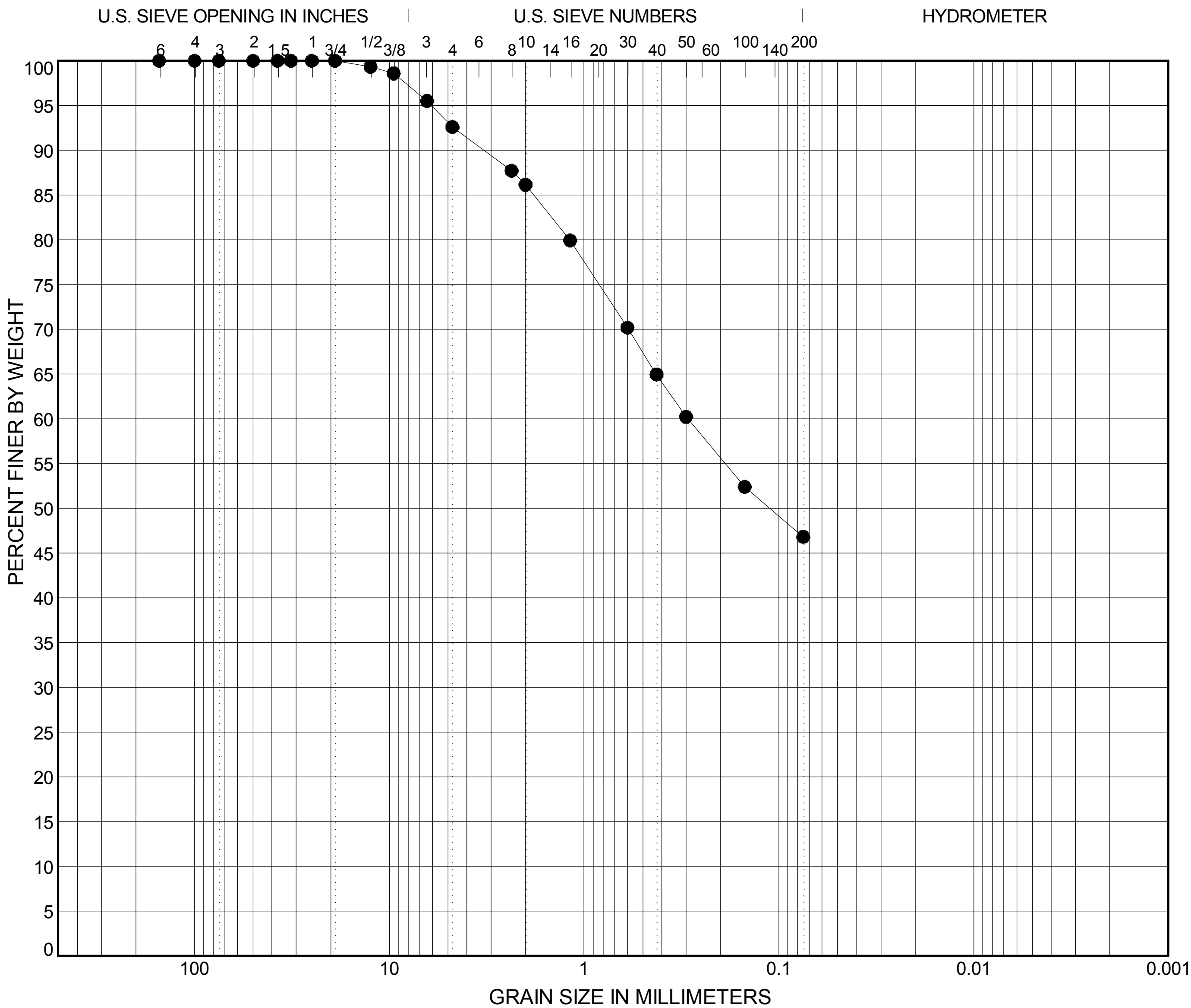
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-23	23	0.0 - 5.0	CLAYEY SAND(SC)			7.4	45.8	46.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	99	96	93	88	86	80	70	65	60	52	46.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
37	24	13		0.75	1.814	0.294	0.111	0.009	0.001	0.001

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

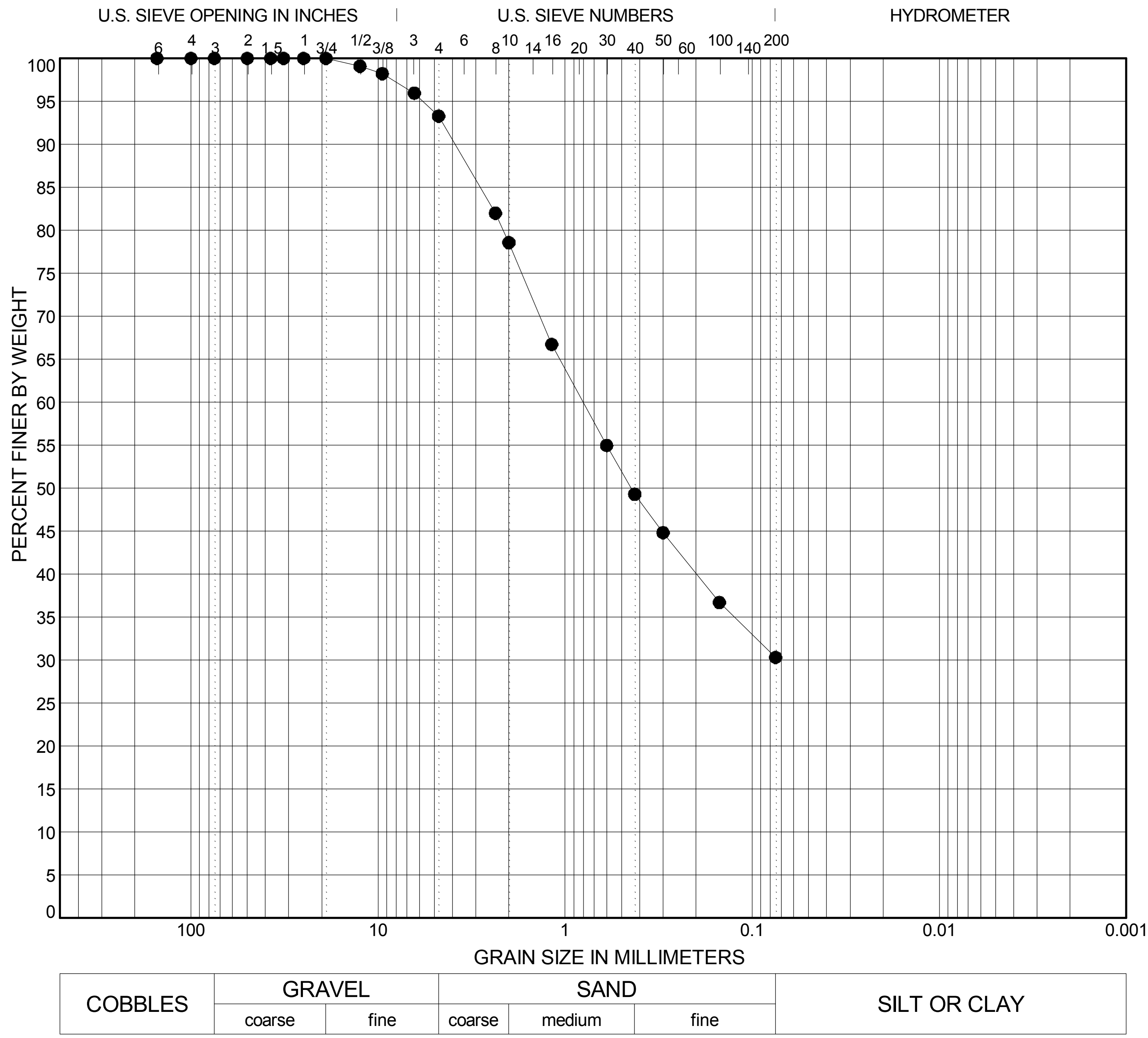
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-24	24	0.0 - 5.0	SILTY SAND(SM)			6.7	63.0	30.3	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	98	96	93	82	79	67	55	49	45	37	30.3

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
24	22	2		0.75	2.844	0.802	0.444	0.072	0.014	0.008

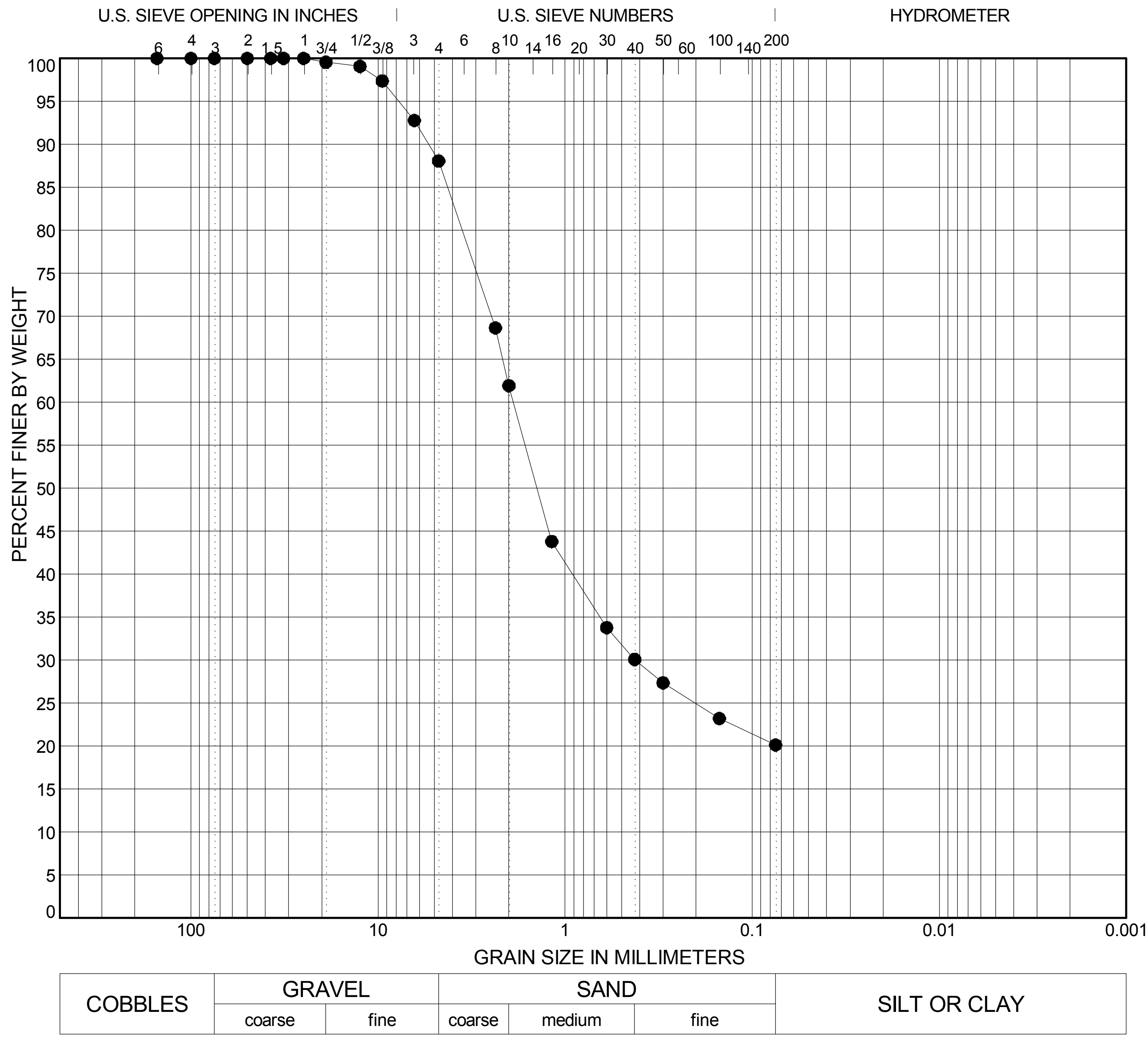
Effective Grain Sizes: D100 through D10 columns above.

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-25	25	2.5 - 5.0	SILTY SAND(SM)			11.9	67.9	20.1	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	99	97	93	88	69	62	44	34	30	27	23	20.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
31	24	7		0.98	4.254	1.891	1.414	0.421	0.024	0.008

Effective Grain Sizes: D100 through D10.

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

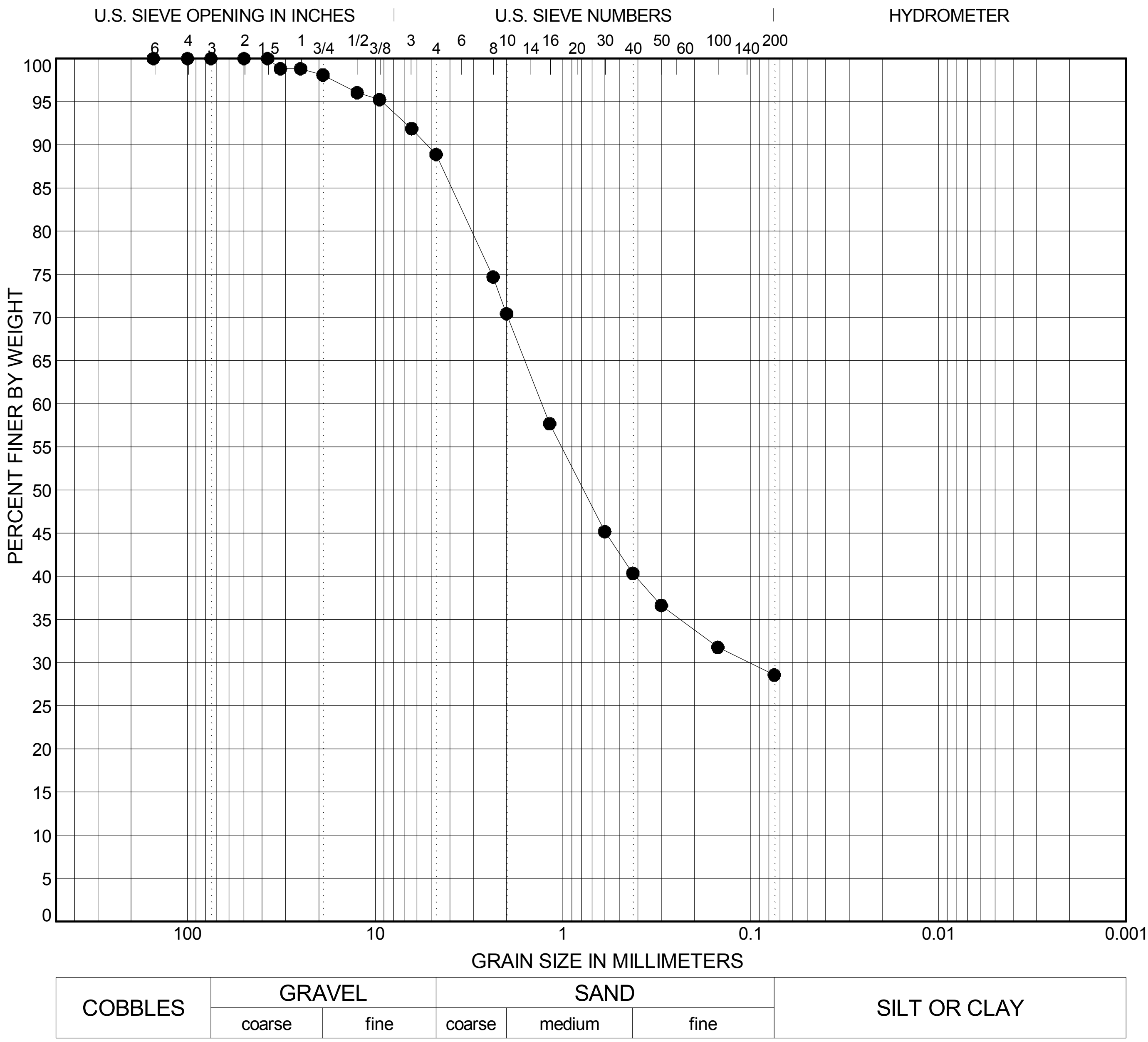
GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-26	26	0.0 - 5.0	CLAYEY SAND(SC)			11.1	60.3	28.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	99	99	98	96	95	92	89	75	70	58	45	40	37	32	28.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
34	23	11		1.48	3.921	1.298	0.779	0.102	0.004	0.001

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

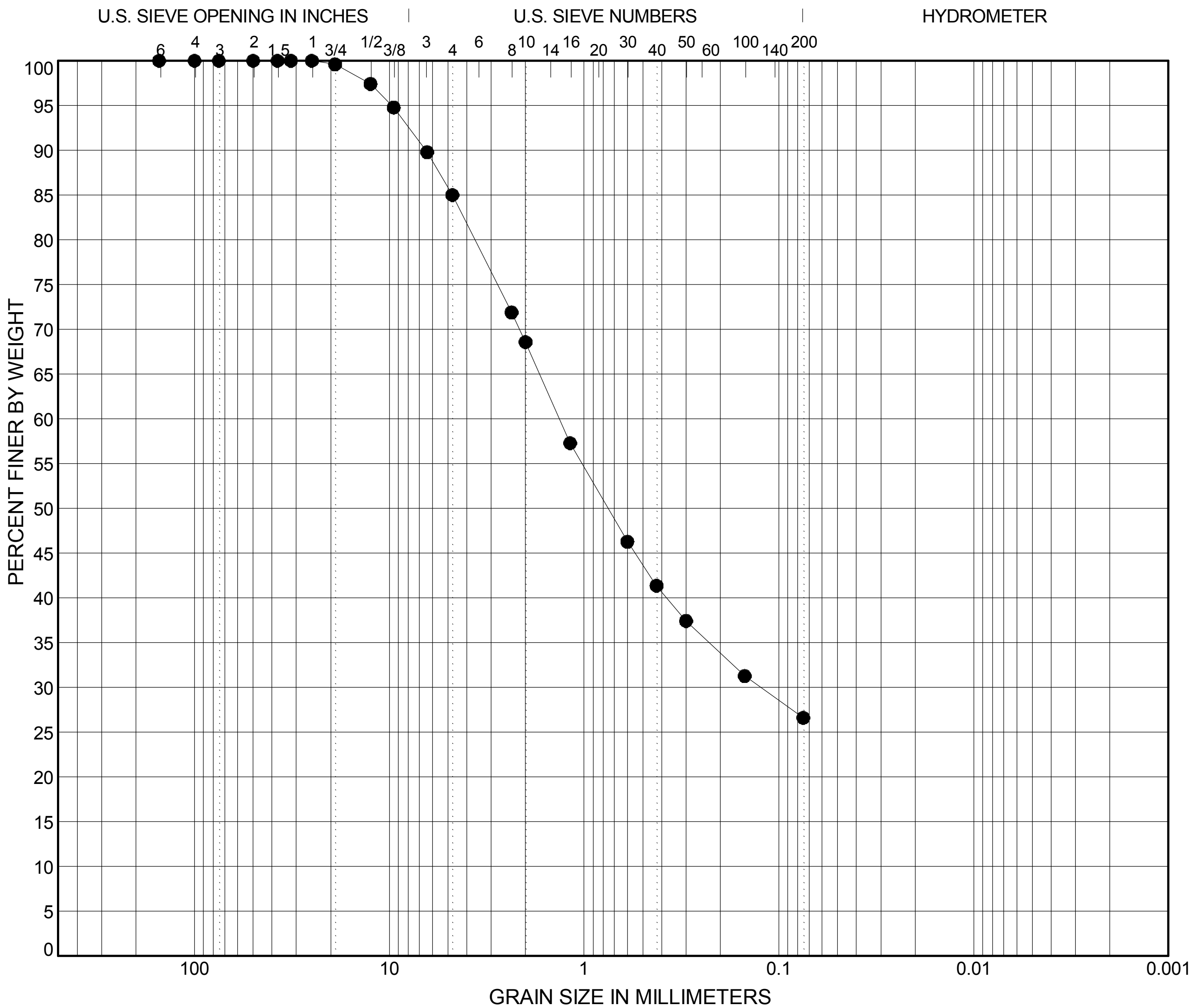
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-27	27	0.0 - 5.0				15.0	58.4	26.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	97	95	90	85	72	69	57	46	41	37	31	26.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
			9.5	0.98	4.749	1.34	0.754	0.124	0.013	0.006

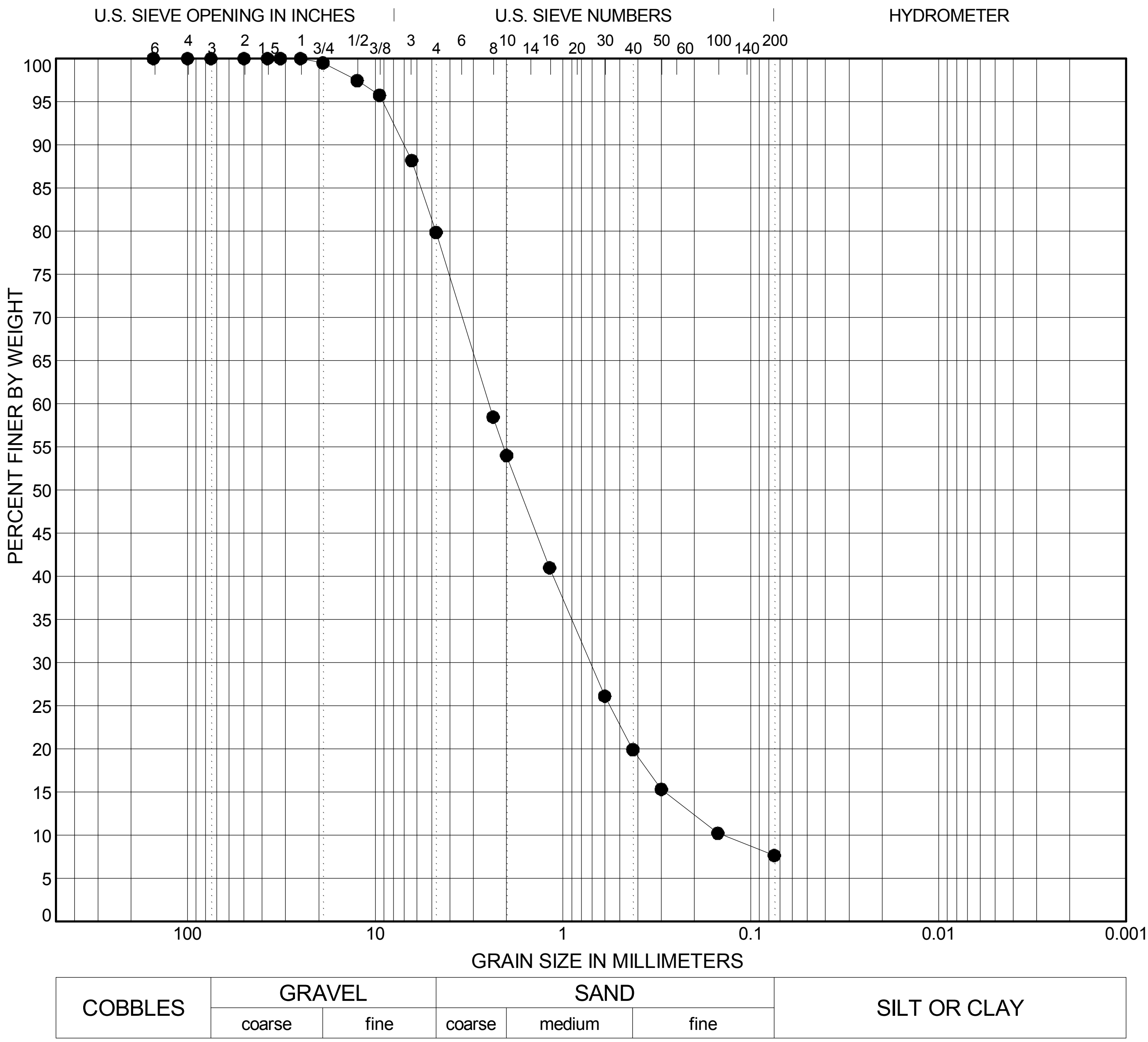
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson **PROJECT NAME** Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053 **PROJECT LOCATION** Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-28	28	0.0 - 5.0		1.46	17.58	20.1	72.2	7.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	97	96	88	80	58	54	41	26	20	15	10	7.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
				0.98	5.71	2.482	1.701	0.716	0.287	0.141

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053, VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

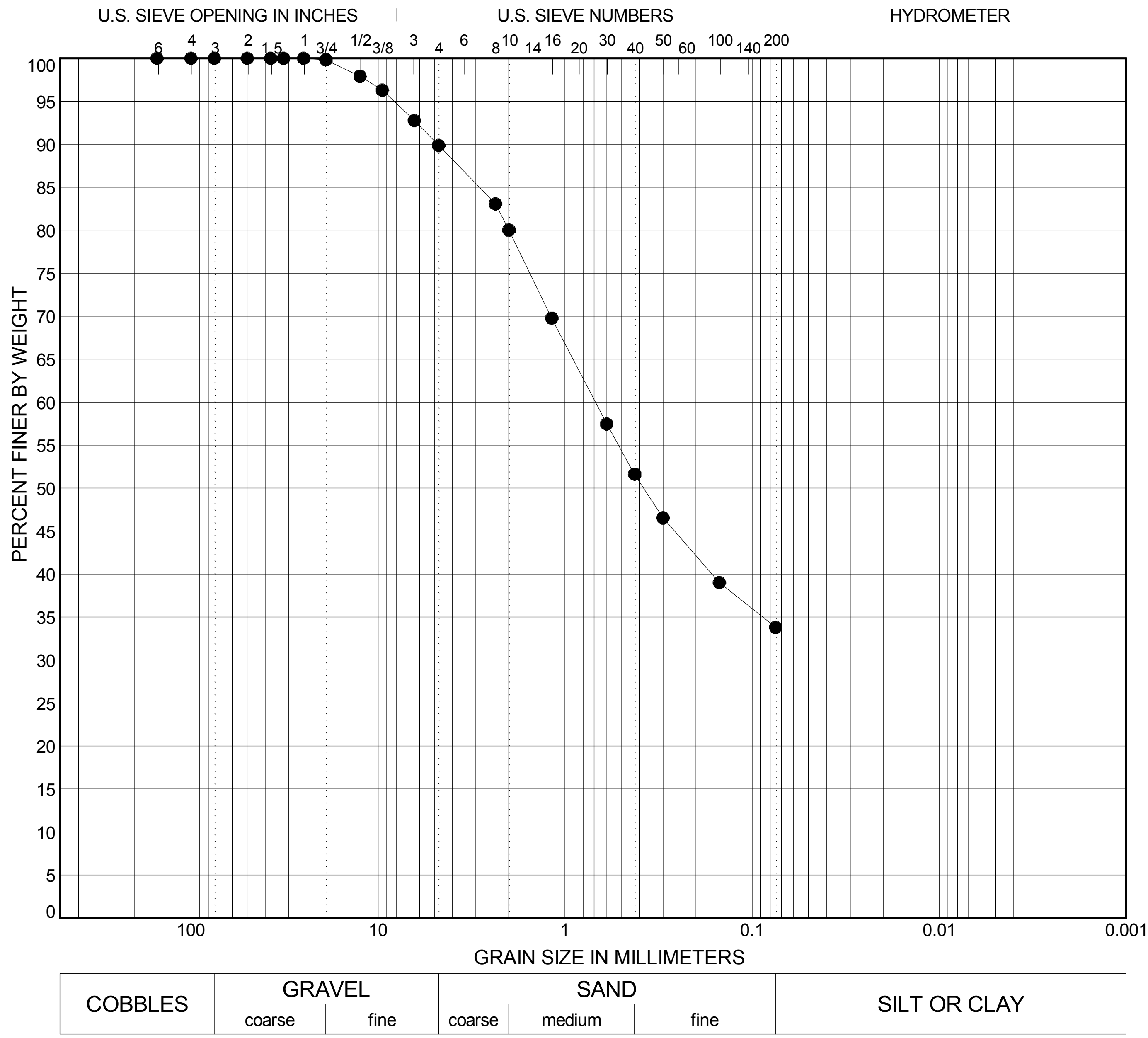
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-29	29	0.0 - 15.0	CLAYEY SAND(SC)			10.1	56.1	33.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	98	96	93	90	83	80	70	57	52	47	39	33.8

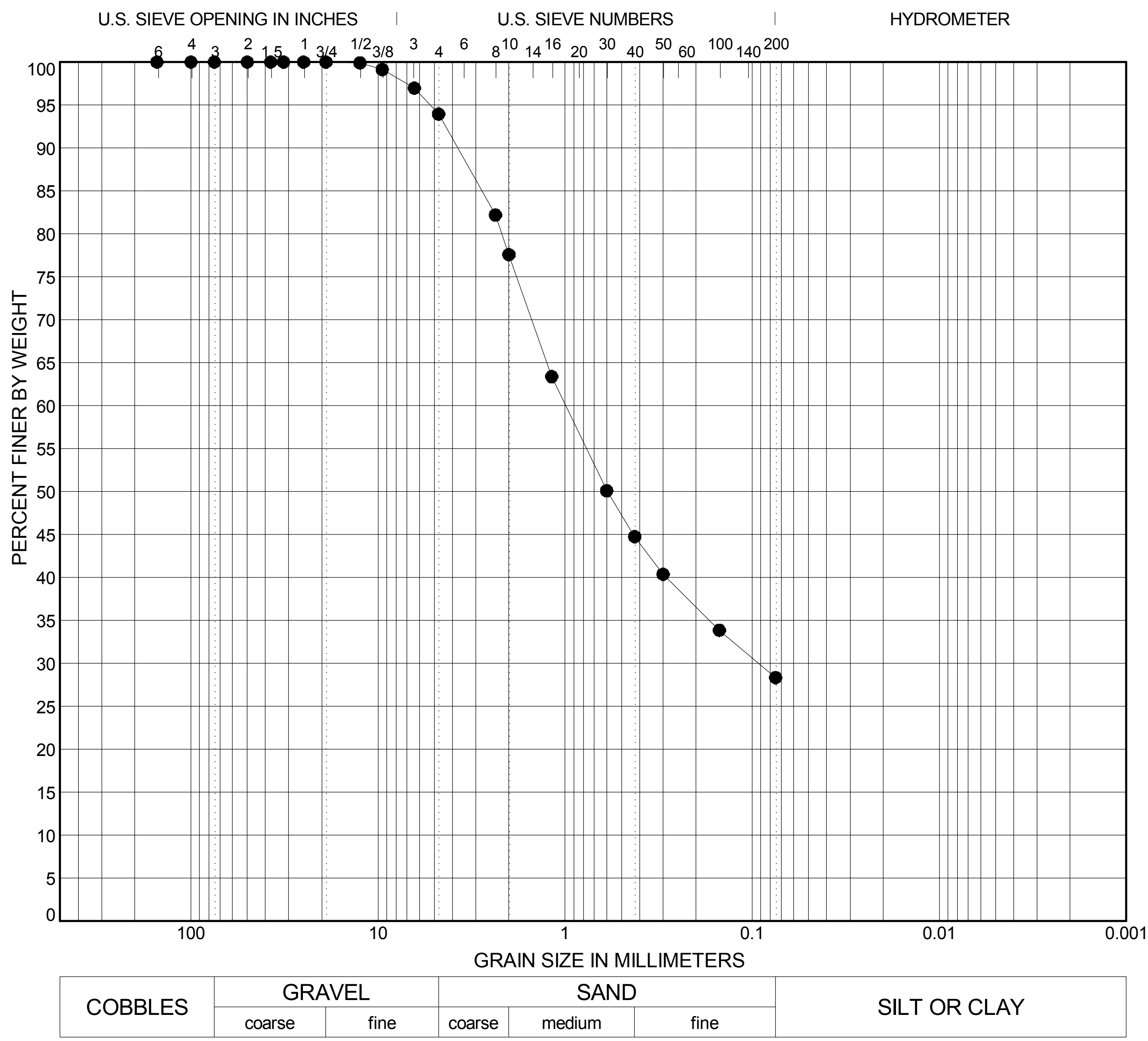
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
31	22	9	5.1	0.98	2.875	0.689	0.38	0.045	0.006	0.003

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:58 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-30	30	0.0 - 5.0	SILTY SAND(SM)			6.1	65.6	28.3	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	100	99	97	94	82	78	63	50	45	40	34	28.3

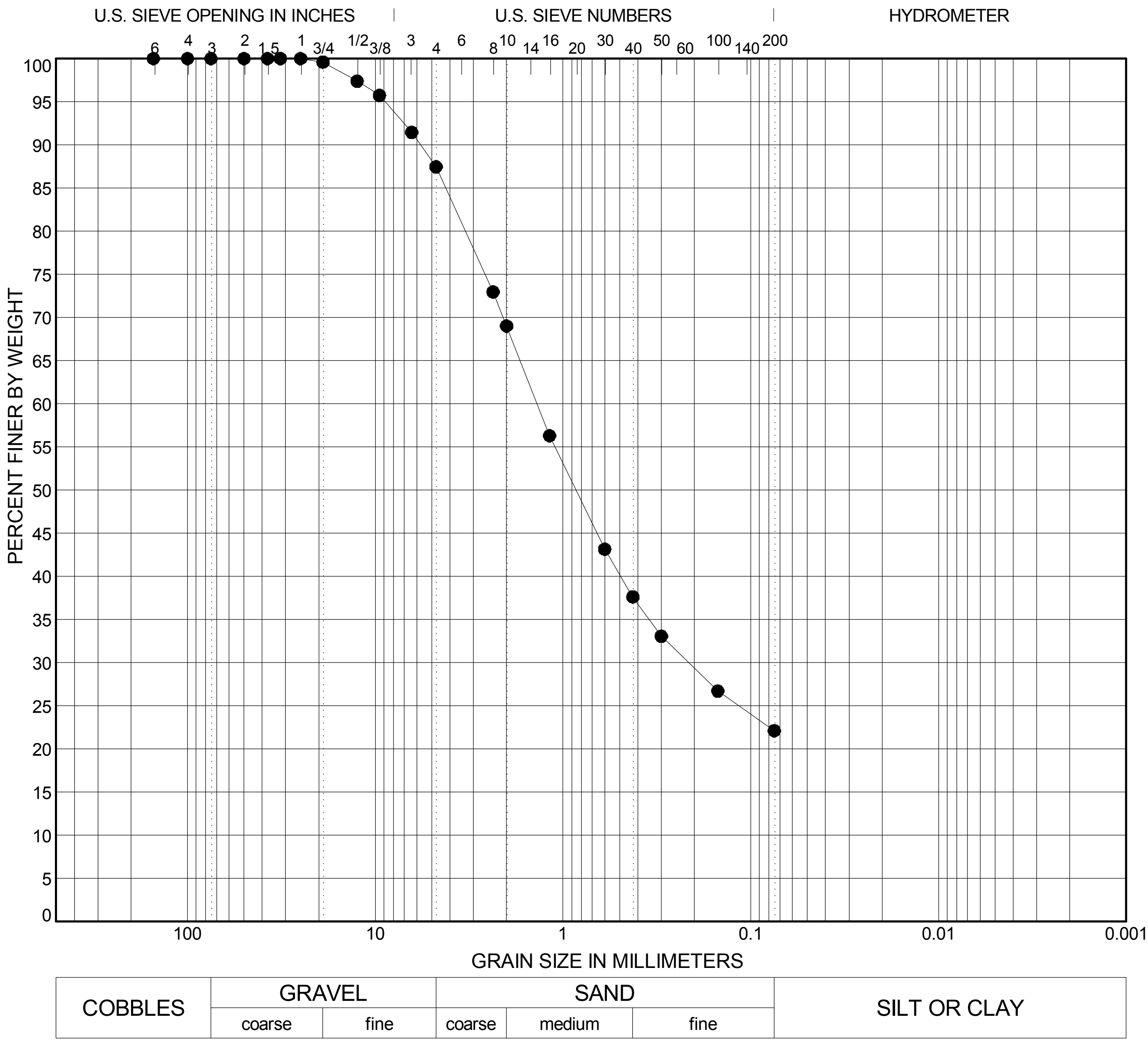
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
36	31	5		0.74	2.789	0.993	0.596	0.092	0.014	0.007

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-31	31	2.5 - 5.0	SILTY SAND(SM)			12.5	65.3	22.1	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	97	96	91	87	73	69	56	43	38	33	27	22.1

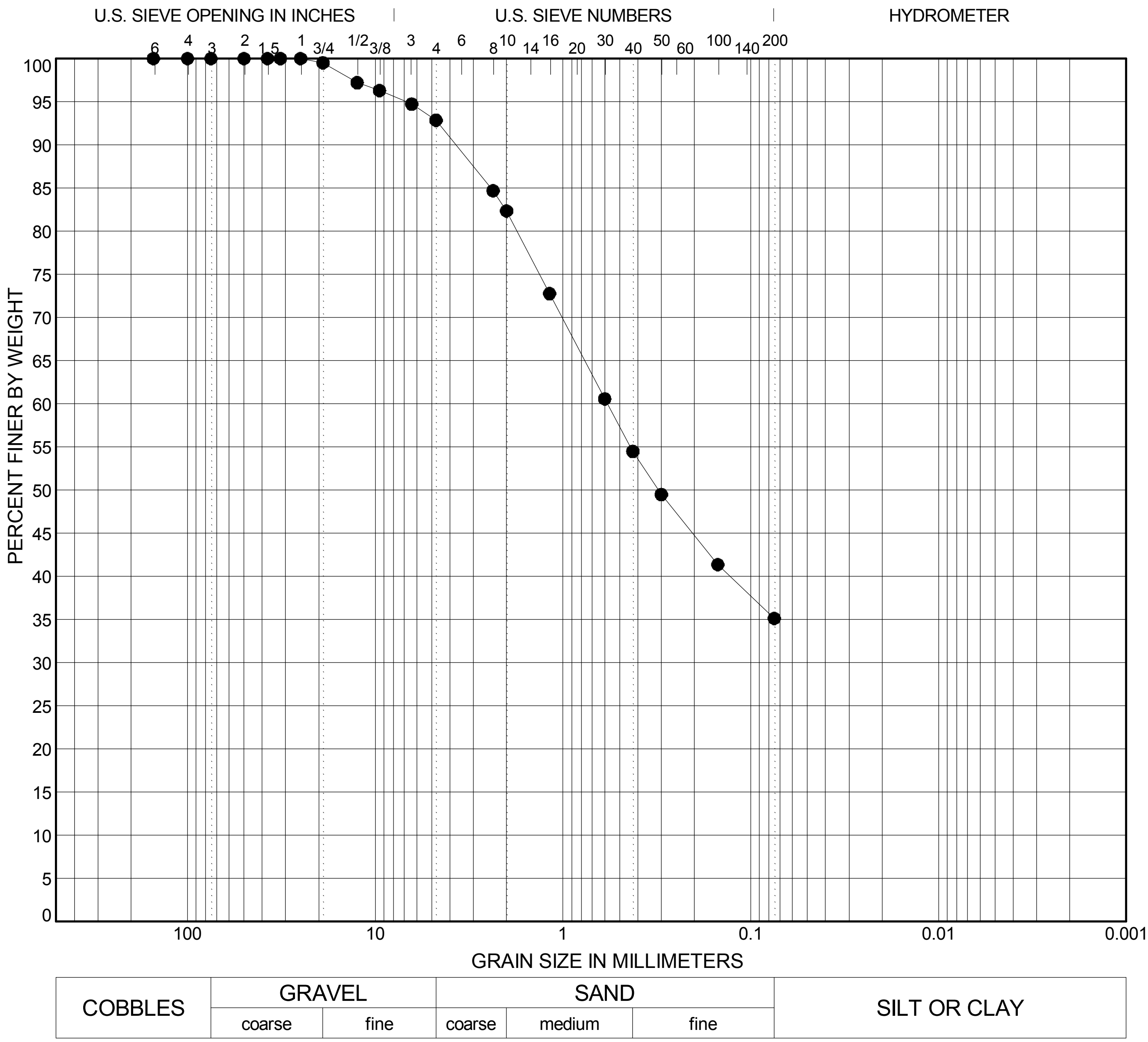
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
32	25	7		0.98	4.219	1.376	0.854	0.215	0.026	0.012

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-32	32	5.0 - 10.0	SILTY, CLAYEY SAND(SC-SM)			7.1	57.7	35.1	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	97	96	95	93	85	82	73	61	54	49	41	35.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
27	20	7		0.98	2.425	0.581	0.311	0.042	0.008	0.005

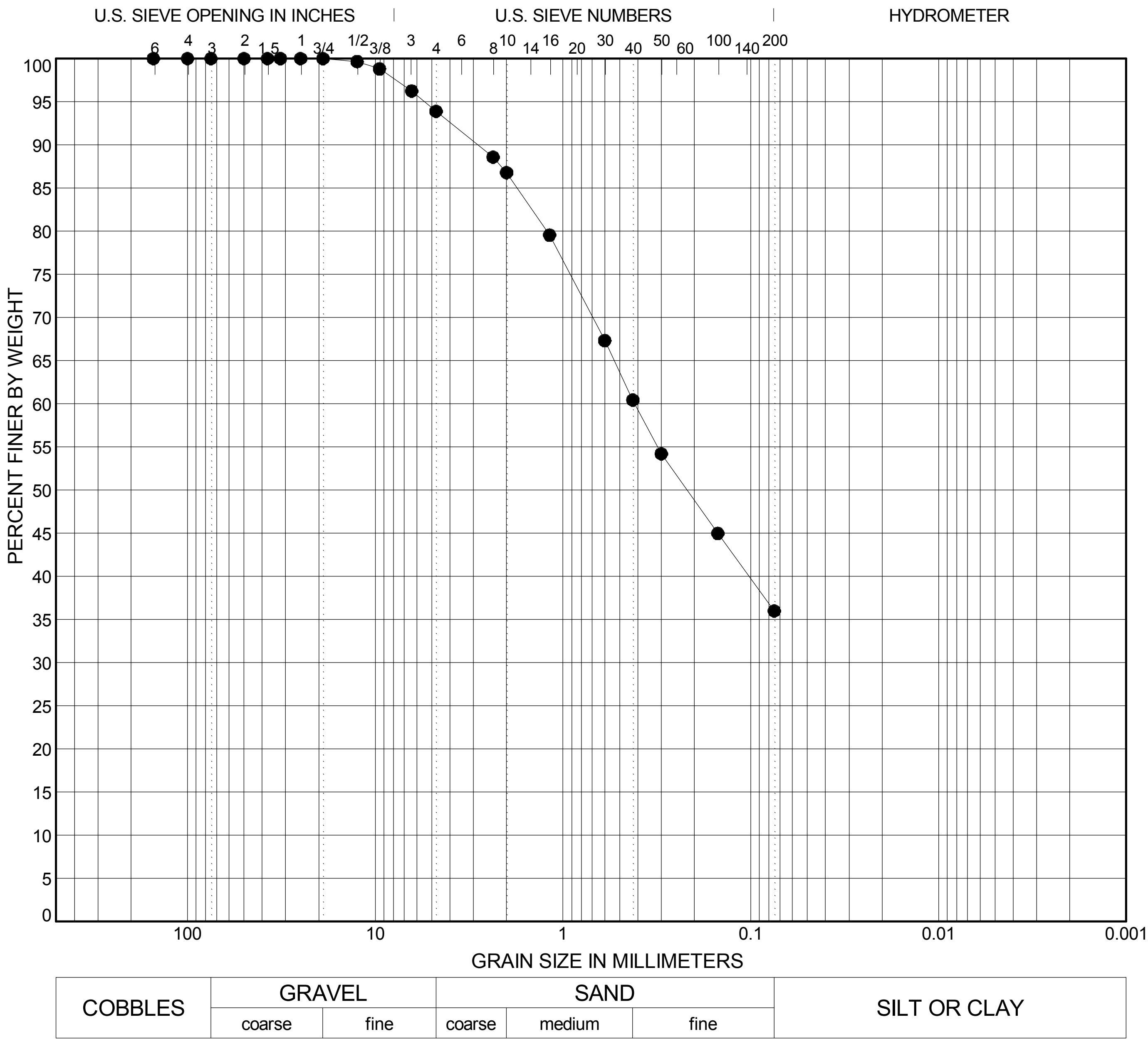
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-33	33	0.0 - 5.0	SILTY, CLAYEY SAND(SC-SM)			6.1	57.9	36.0	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	100	100	99	96	94	89	87	80	67	60	54	45	36.0

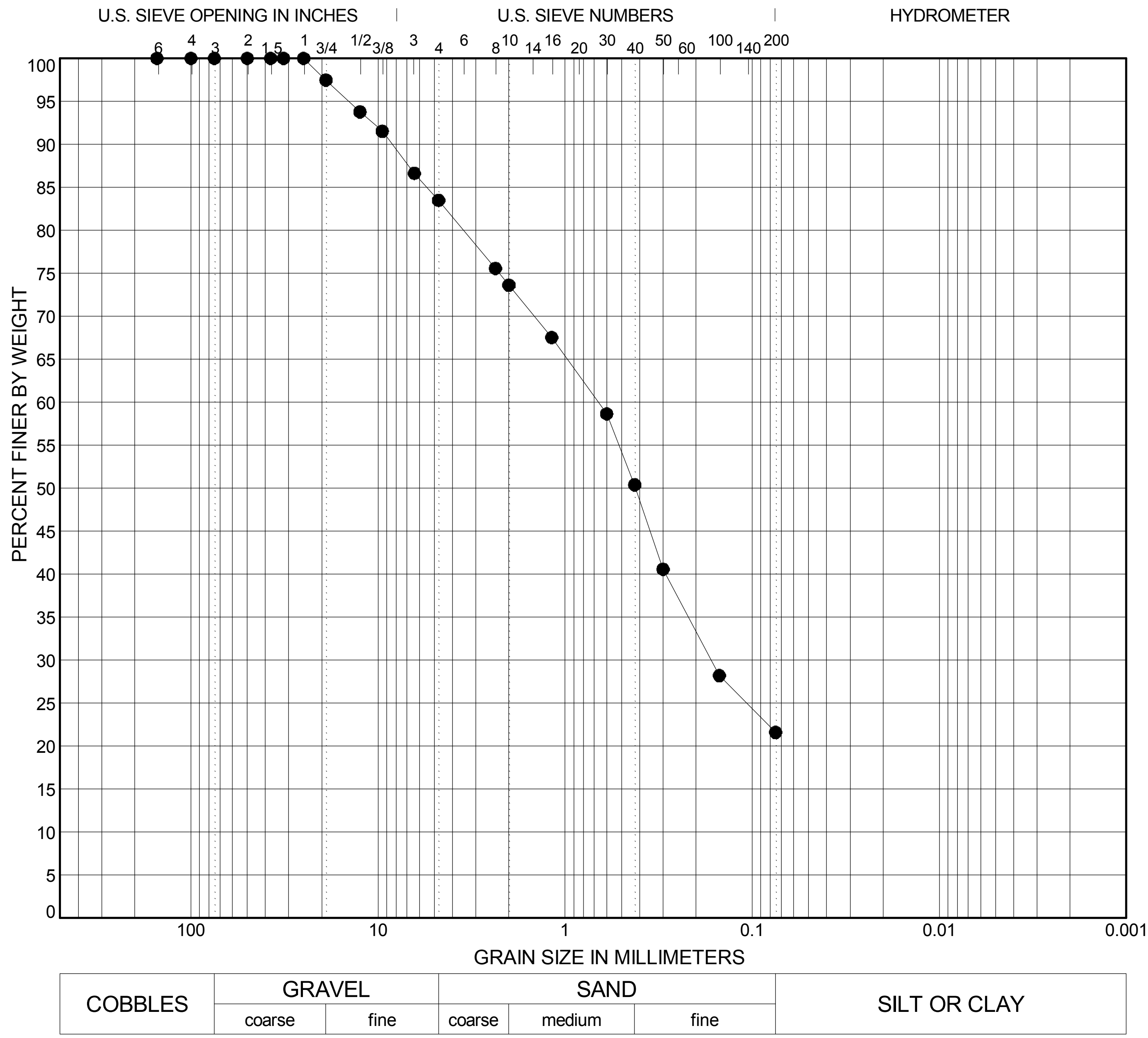
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
26	21	5		0.75	1.757	0.415	0.219	0.047	0.015	0.01

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-34	34	0.0 - 5.0	SILTY SAND with GRAVEL(SM)			16.5	61.9	21.6	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	97	94	92	87	83	76	74	68	59	50	41	28	21.6

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
28	26	2	3.3	0.98	5.484	0.665	0.419	0.166	0.038	0.022

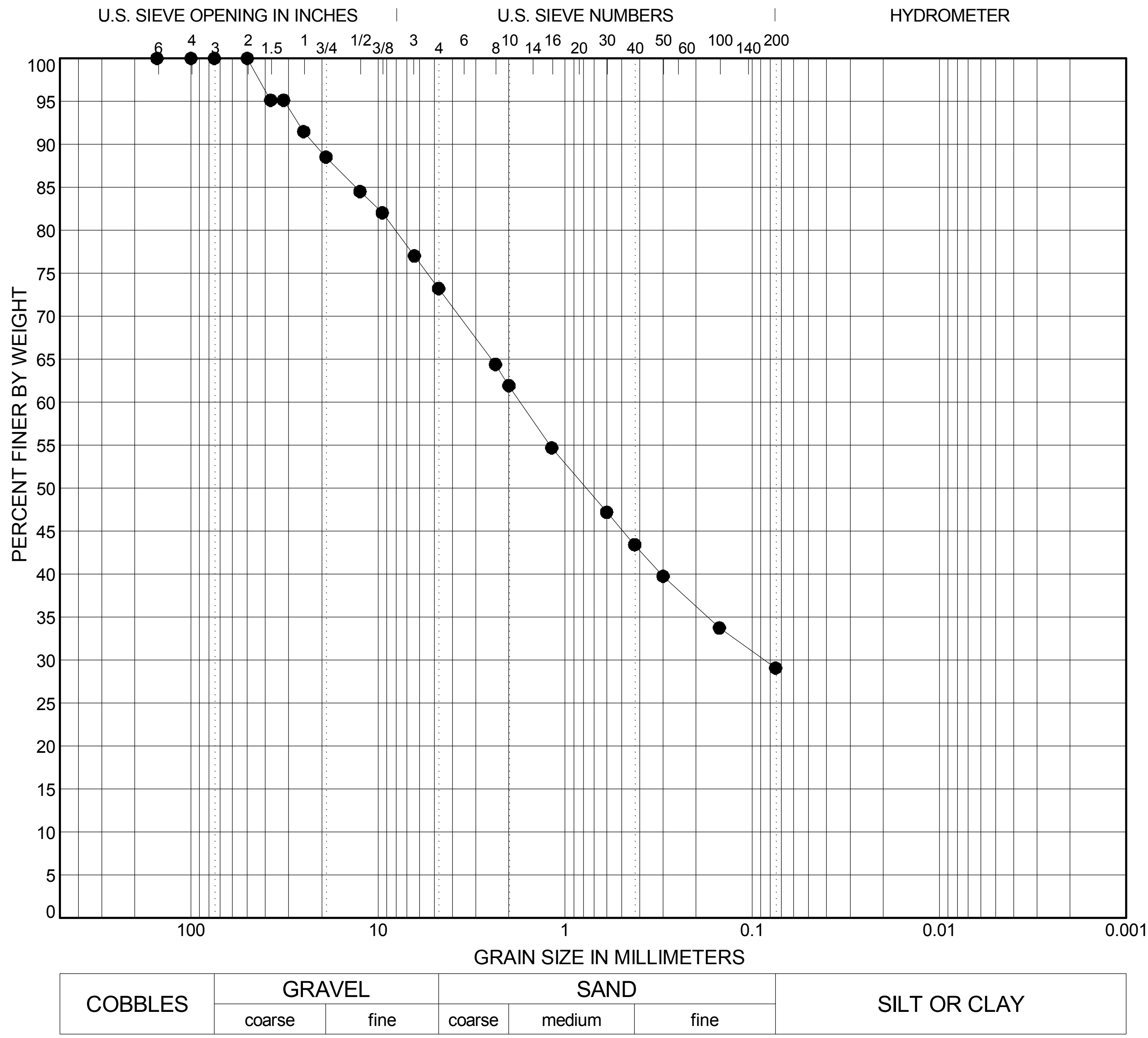
TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59 C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

GOLDER

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson
PROJECT NAME Valencia Rd: Kolb to Houghton
PROJECT NUMBER 1660053
PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-35	35	0.0 - 5.0	SILTY, CLAYEY SAND with GRAVEL(SC-SM)			26.8	44.2	29.1	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	95	95	91	89	85	82	77	73	64	62	55	47	43	40	34	29.1

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
27	21	6		1.97	13.158	1.737	0.773	0.086	0.009	0.004

SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

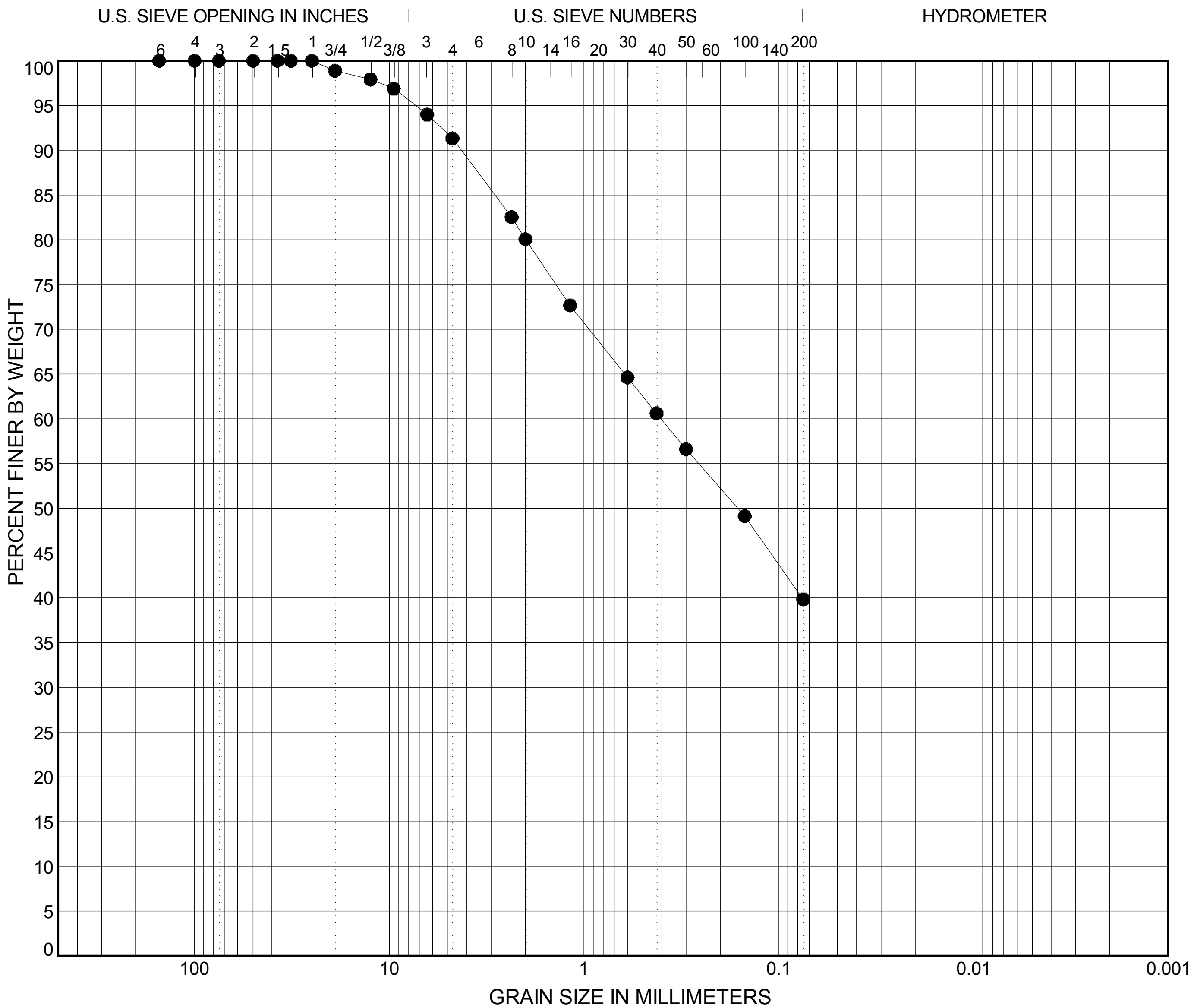
Reference(s): **ASTM C117, C136, D422, D4318**

CLIENT City of Tucson

PROJECT NAME Valencia Rd: Kolb to Houghton

PROJECT NUMBER 1660053

PROJECT LOCATION Kolb and Houghton, Tucson, Arizona



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	BH-36	36	0.0 - 5.0	SILTY SAND(SM)			8.7	51.5	39.8	

Percent Passing Data

6 in.	4 in.	3 in.	2 in.	1 1/2 in.	1 1/4 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	1/4 in.	#4	#8	#10	#16	#30	#40	#50	#100	#200
100	100	100	100	100	100	100	99	98	97	94	91	83	80	73	65	61	57	49	39.8

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	As-Received Moisture Content (%)	Effective Grain Sizes D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)
34	24	10		0.98	2.871	0.403	0.162	0.036	0.012	0.008

TUC GRAIN SIZE SINGLE - SWOPS_DTMPL_V1.4.GDT - 12/8/17 15:59
C:\USERS\ADRGARCIA\DESKTOP\GOLDER ASSOCIATES\1660053_VALENCIA K2H - GINT\1660053_VALENCIARD.GPJ

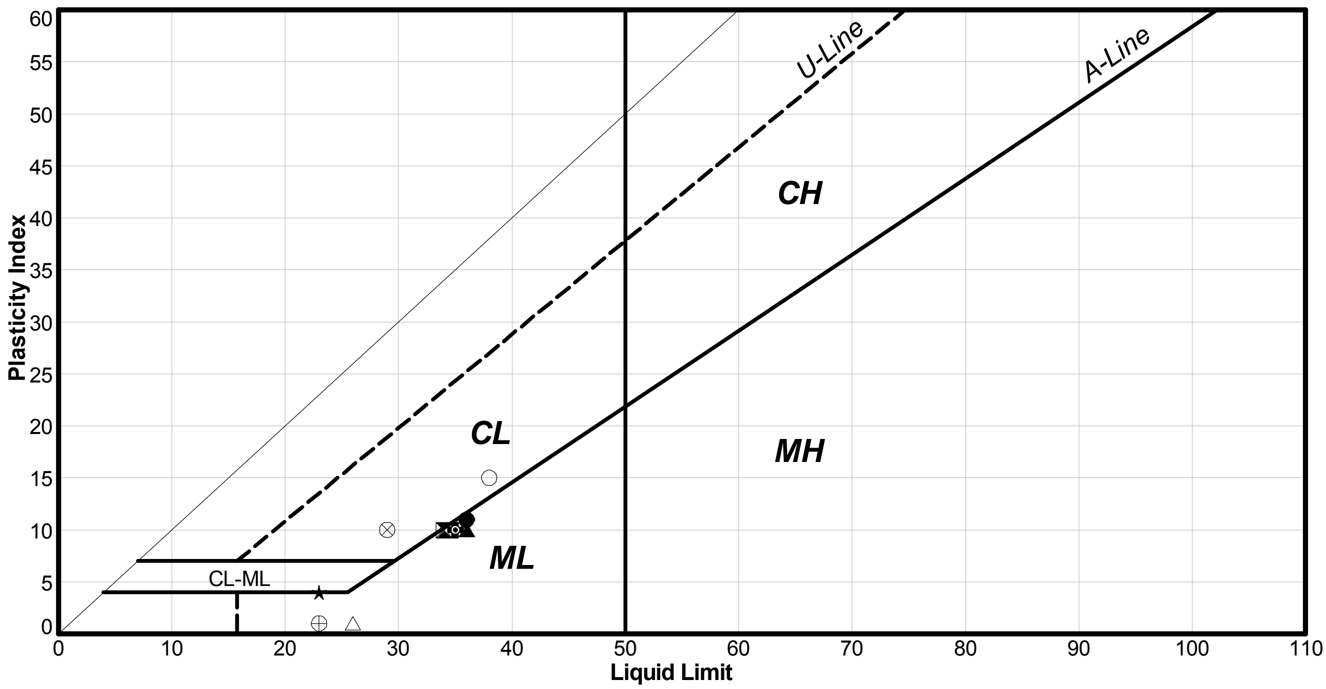
GOLDER

LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Percent Passing #200 Sieve (%)	LL (%)	PL (%)	PI (%)	Natural Water Content (%)	LI (%)	Fines USCS Symbol	USCS Classification of Entire Sample
●	BH-01	1	0	5.0	29.5	36	25	11			ML	Silty Sand (SM)
⧗	BH-02	2	0	5.0	28.7	34	24	10			ML	Silty Sand (SM)
▲	BH-03	3	0	5.0	27.8	36	26	10	9.1	-1.69	ML	Silty Sand (SM)
★	BH-04	4	0	5.0	19.2	23	19	4			CL-ML	Silty, Clayey Sand With Gravel (SC-SM)
⊙	BH-06	6	0	5.0	40.3	35	25	10			ML	Silty Sand (SM)
✿	BH-07	7	0	5.0	39.8	35	25	10			ML	Silty Sand (SM)
○	BH-08	8	0	5.0	38.6	38	23	15	8.5	-0.97	CL	Clayey Sand (SC)
△	BH-09	9	0	5.0	10.0	26	25	1			ML	Well-Graded Sand With Silt (SW-SM)
⊗	BH-10	10	0	5.0	12.6	29	19	10	5.0	-1.40	CL	Clayey Sand With Gravel (SC)
⊕	BH-12	12	0	5.0	28.2	23	22	1			ML	Silty Sand (SM)

NOTE: NP - NON-PLASTIC RESULT

TUC LAB ATTERBERG CASAGRANDE MULTI (10) - DF STD US LAB E-M.GDT - 12/6/17 13:58 C:\USERS\ADRGARCIA\DOCUMENTS\PROJECTS\1660053-VALENCIA RD\GINT\1660053_VALENCIARD.GPJ

Golder Associates Inc.

Tel: Fax: www.golder.com

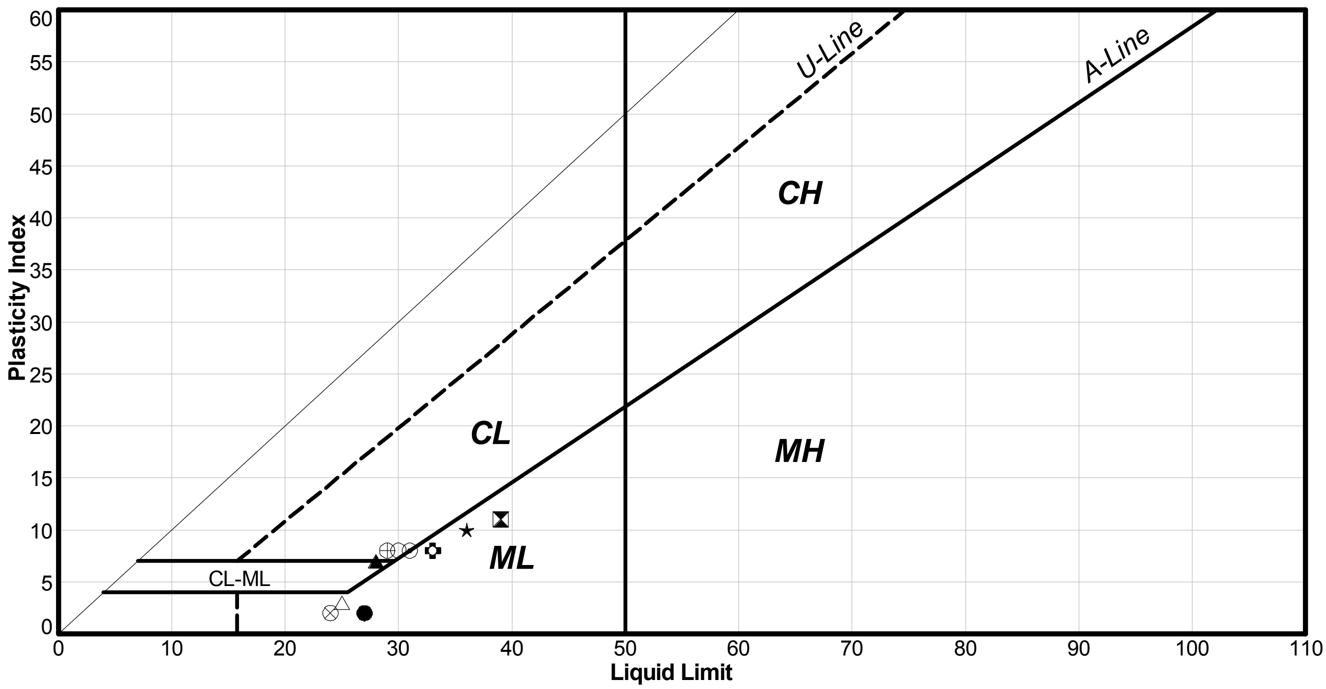
GOLDER

LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Percent Passing #200 Sieve (%)	LL (%)	PL (%)	PI (%)	Natural Water Content (%)	LI (%)	Fines USCS Symbol	USCS Classification of Entire Sample
●	BH-13	13	0	5.0	25.1	27	25	2			ML	Silty Sand With Gravel (SM)
⧗	BH-14	14	2.5	5.0	29.6	39	28	11			ML	Silty Sand With Gravel (SM)
▲	BH-15	15	2.5	5.0	29.3	28	21	7			CL	Silty, Clayey Sand (SC-SM)
★	BH-16	16	0	5.0	32.8	36	26	10			ML	Silty Sand (SM)
⊙	BH-17	17	0	5.0	32.2	31	23	8			ML	Silty Sand (SM)
✿	BH-18	18	0	5.0	35.7	33	25	8			ML	Silty Sand (SM)
○	BH-19	19	0	5.0	41.8	30	22	8	7.5	-1.81	CL	Clayey Sand (SC)
△	BH-20	20	0	5.0	41.0	25	22	3			ML	Silty Sand (SM)
⊗	BH-21	21	0	5.0	34.6	24	22	2			ML	Silty Sand (SM)
⊕	BH-22	22	0	5.0	29.9	29	21	8			CL	Clayey Sand (SC)

NOTE: NP - NON-PLASTIC RESULT

TUC LAB ATTERBERG CASAGRANDE MULTI (10) - DF STD US LAB E-M.GDT - 12/6/17 13:58
C:\USERS\ADRGARCIA\DOCUMENTS\PROJECTS\1660053-VALENCIA RD\GINT\1660053_VALENCIARD.GPJ

Golder Associates Inc.

Tel: Fax: www.golder.com

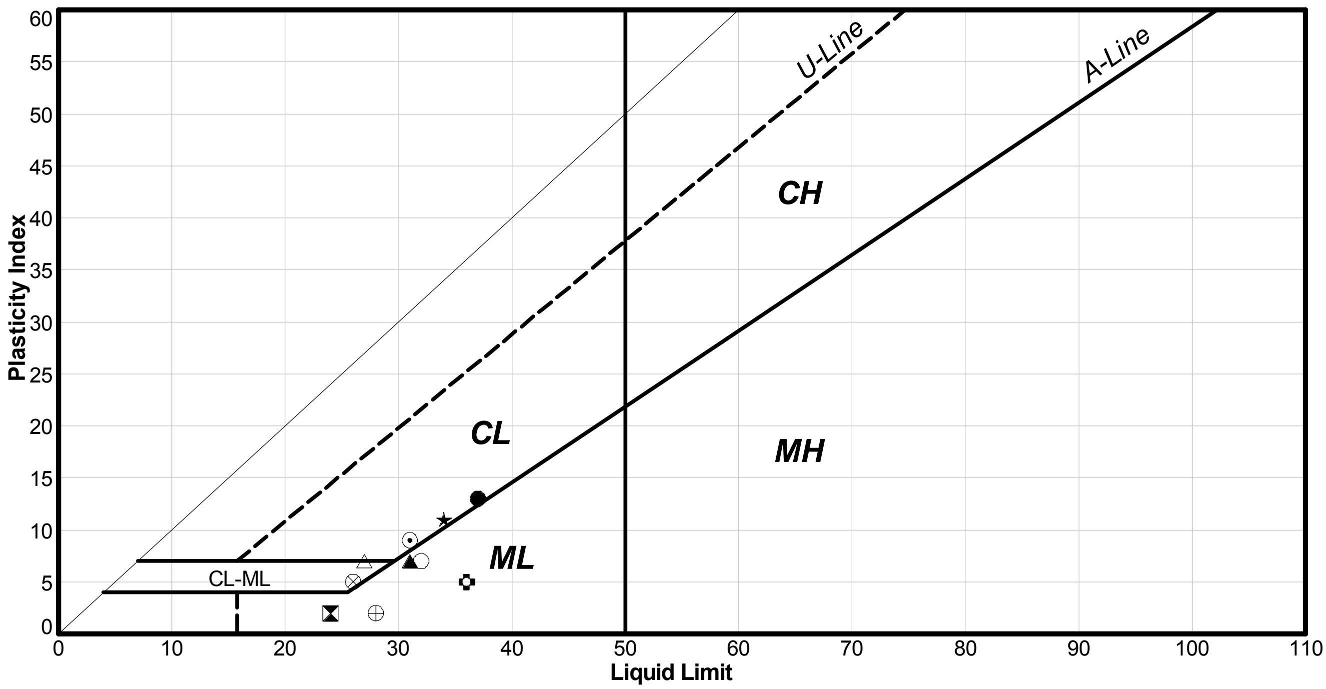
GOLDER

LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Percent Passing #200 Sieve (%)	LL (%)	PL (%)	PI (%)	Natural Water Content (%)	LI (%)	Fines USCS Symbol	USCS Classification of Entire Sample
●	BH-23	23	0	5.0	46.8	37	24	13			CL	Clayey Sand (SC)
⧗	BH-24	24	0	5.0	30.3	24	22	2			ML	Silty Sand (SM)
▲	BH-25	25	2.5	5.0	20.1	31	24	7			ML	Silty Sand (SM)
★	BH-26	26	0	5.0	28.6	34	23	11			CL	Clayey Sand (SC)
⊙	BH-29	29	0	15.0	33.8	31	22	9	5.1	-1.88	CL	Clayey Sand (SC)
✪	BH-30	30	0	5.0	28.3	36	31	5			ML	Silty Sand (SM)
○	BH-31	31	2.5	5.0	22.1	32	25	7			ML	Silty Sand (SM)
△	BH-32	32	5	10.0	35.1	27	20	7			CL	Silty, Clayey Sand (SC-SM)
⊗	BH-33	33	0	5.0	36.0	26	21	5			CL-ML	Silty, Clayey Sand (SC-SM)
⊕	BH-34	34	0	5.0	21.6	28	26	2	3.3	-11.35	ML	Silty Sand With Gravel (SM)

NOTE: NP - NON-PLASTIC RESULT

TUC LAB ATTERBERG CASAGRANDE MULTI (10) - DF STD US LAB E-M.GDT - 12/6/17 13:58
C:\USERS\ADRGARCIA\DOCUMENTS\PROJECTS\1660053-VALENCIA RD\GINT\1660053_VALENCIARD.GPJ

Golder Associates Inc.

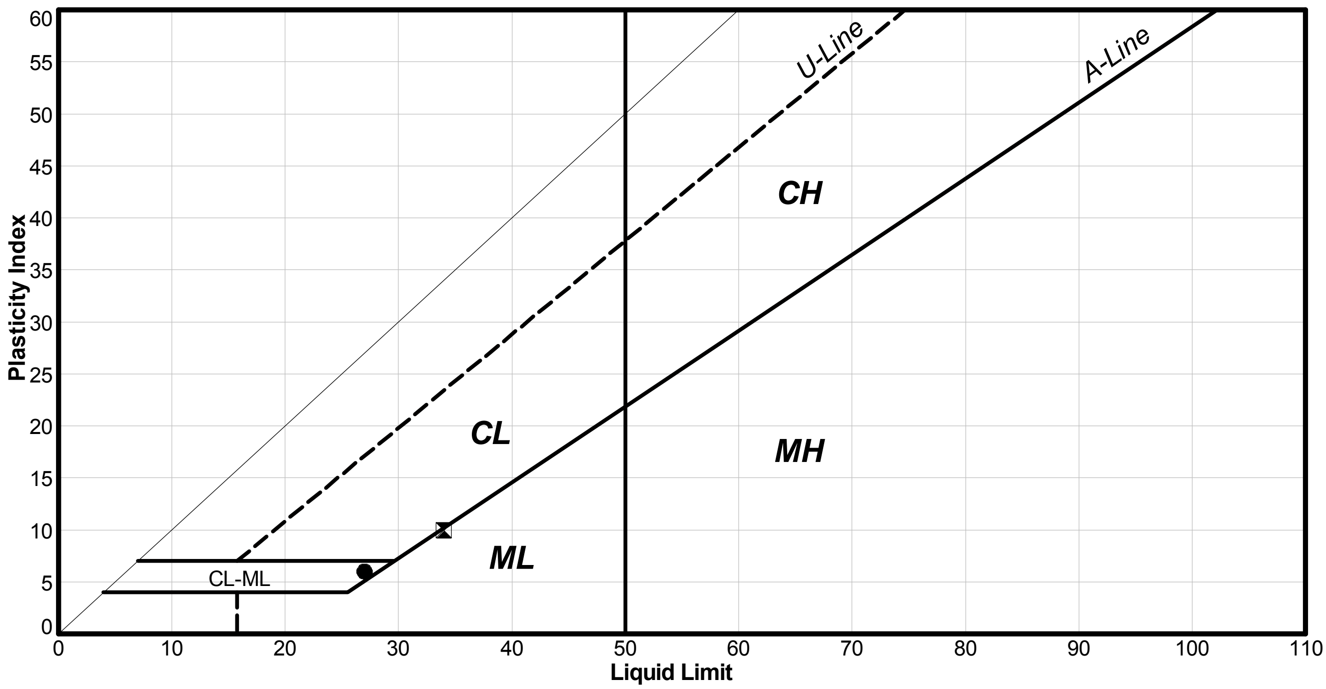
Tel: Fax: www.golder.com

LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s) **ASTM D 4318-05**

Client:	City of Tucson	**Project No.:**	1660053
Project:	Valencia Rd: Kolb to Houghton	**Lab Info:**	ATEK Engineering Consultants, Tucson, AZ
Location:	Kolb and Houghton, Tucson, Arizona		

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Percent Passing #200 Sieve (%)	LL (%)	PL (%)	PI (%)	Natural Water Content (%)	LI (%)	Fines USCS Symbol	USCS Classification of Entire Sample
●	BH-35	35	0	5.0	29.1	27	21	6			CL-ML	Silty, Clayey Sand With Gravel (SC-SM)
⧗	BH-36	36	0	5.0	39.8	34	24	10			ML	Silty Sand (SM)

NOTE: NP - NON-PLASTIC RESULT

TUC LAB ATTERBERG CASAGRANDE MULTI (10) - DF STD US LAB E-M.GDT - 12/6/17 13:58
C:\USERS\ADRGARCIA\DOCUMENTS\PROJECTS\1660053-VALENCIA RD\GINT\1660053_VALENCIARD.GPJ

Golder Associates Inc.

Tel: Fax: www.golder.com

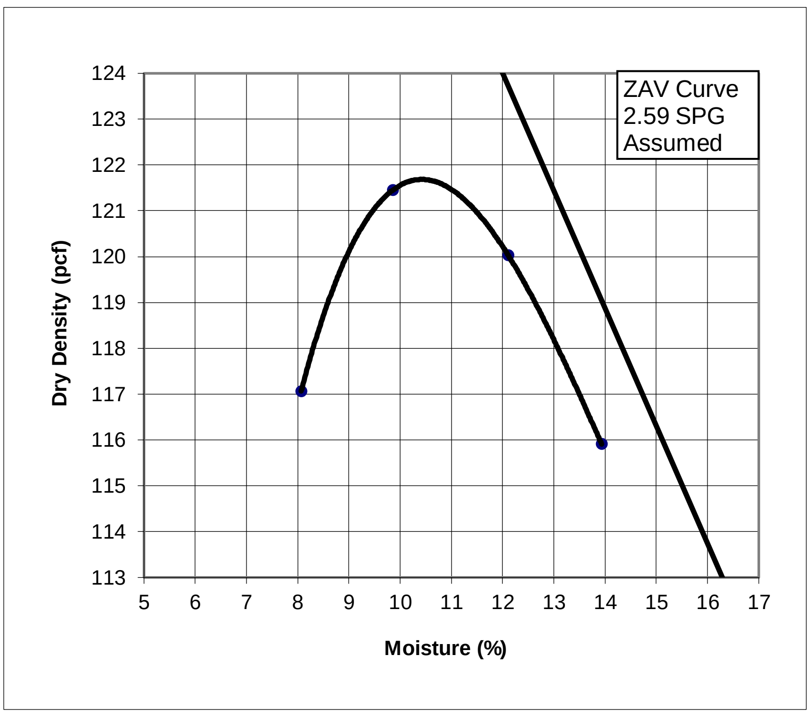
Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd. - Golder Project #1660053	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	3
SAMPLE SOURCE:	BH-03	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)
Maximum dry density:	121.7	1949
Optimum moisture (%):	10.4	10.4



SIEVE SIZE	PERCENT PASSING	SPECS
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	100	
1 in / 25 mm	100	
3/4 in / 19 mm	99	
1/2 in / 12.5 mm	98	
3/8 in / 9.5 mm	96	
1/4 in / 6.4 mm	92	
#4, 4.75mm	89	
#8, 2.36mm	76	
#10, 2.00mm	72	
#16, 1.18mm	59	
#30, 0.60mm	46	
#40, .425mm	41	
#50, .300mm	38	
#100, .150mm	32	
#200, .075mm	28	

LL: 36
PL: 26
PI: 10

USCS: SM
AASHTO: A-2-4(0)

AASHTO Description: Silty gravel and sand

NOTES:

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

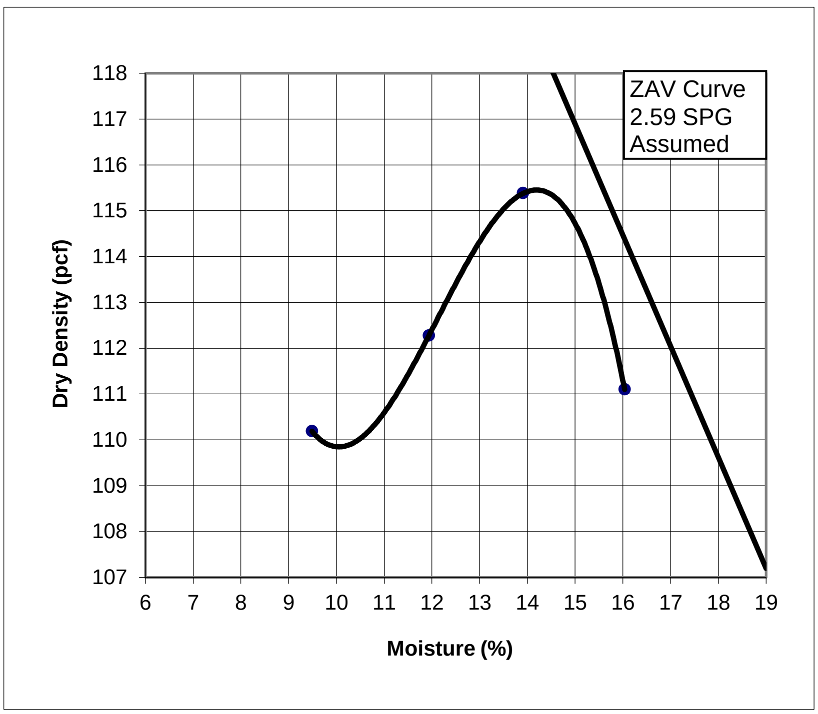
Reviewed by: Rafael Hernandez, PE

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd.	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	8
SAMPLE SOURCE:	BH-08	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)
Maximum dry density:	115.5	1849
Optimum moisture (%):	14.2	14.2



SIEVE SIZE	PERCENT PASSING	SPECS
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	100	
1 in / 25 mm	100	
3/4 in / 19 mm	100	
1/2 in / 12.5 mm	99	
3/8 in / 9.5 mm	98	
1/4 in / 6.4 mm	96	
#4, 4.75mm	94	
#8, 2.36mm	83	
#10, 2.00mm	79	
#16, 1.18mm	66	
#30, 0.60mm	56	
#40, .425mm	51	
#50, .300mm	48	
#100, .150mm	43	
#200, .075mm	38.6	

LL:	38
PL:	23
PI:	15
USCS:	SC
AASHTO:	A-6(2)

NOTES:

AASHTO Description: Clayey soils

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

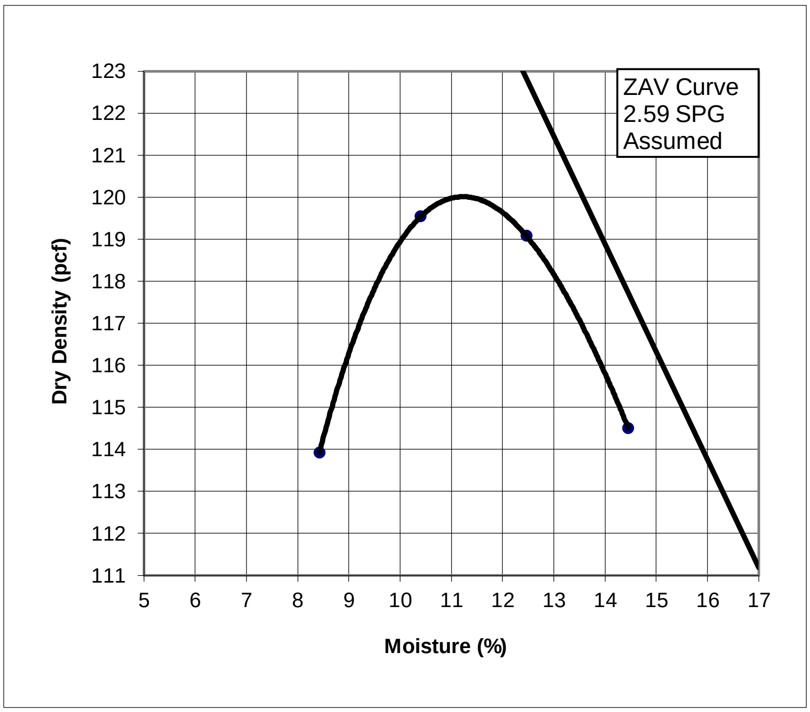
Reviewed by: Brian Lasham

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd. - Golder Project #1660053	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	19
SAMPLE SOURCE:	BH-19	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)
Maximum dry density:	120.0	1922
Optimum moisture (%):	11.2	11.2



SIEVE SIZE	**PERCENT PASSING**	**SPECS**
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	100	
1 in / 25 mm	100	
3/4 in / 19 mm	100	
1/2 in / 12.5 mm	99	
3/8 in / 9.5 mm	99	
1/4 in / 6.4 mm	96	
#4, 4.75mm	95	
#8, 2.36mm	87	
#10, 2.00mm	84	
#16, 1.18mm	74	
#30, 0.60mm	62	
#40, .425mm	58	
#50, .300mm	54	
#100, .150mm	47	
#200, .075mm	42	

LL:	30
PL:	22
PI:	8
USCS:	SC
AASHTO:	A-4(1)
AASHTO Description:	Silty soils

NOTES:

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

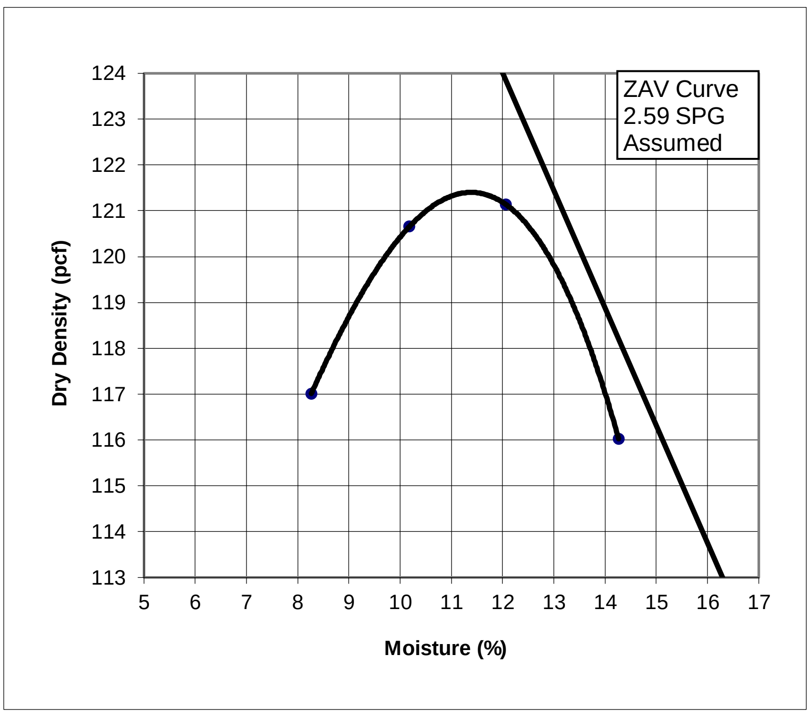
Reviewed by: Rafael Hernandez, PE

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd. - Golder Project #1660053	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	26
SAMPLE SOURCE:	BH-26	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)
Maximum dry density:	121.4	1945
Optimum moisture (%):	11.4	11.4



SIEVE SIZE	PERCENT PASSING	SPECS
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	99	
1 in / 25 mm	99	
3/4 in / 19 mm	98	
1/2 in / 12.5 mm	96	
3/8 in / 9.5 mm	95	
1/4 in / 6.4 mm	92	
#4, 4.75mm	89	
#8, 2.36mm	75	
#10, 2.00mm	70	
#16, 1.18mm	58	
#30, 0.60mm	45	
#40, .425mm	40	
#50, .300mm	37	
#100, .150mm	32	
#200, .075mm	29	

LL:	34
PL:	23
PI:	11
USCS:	SC
AASHTO:	A-2-6(0)

AASHTO Description: Clayey gravel and sand

NOTES:

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

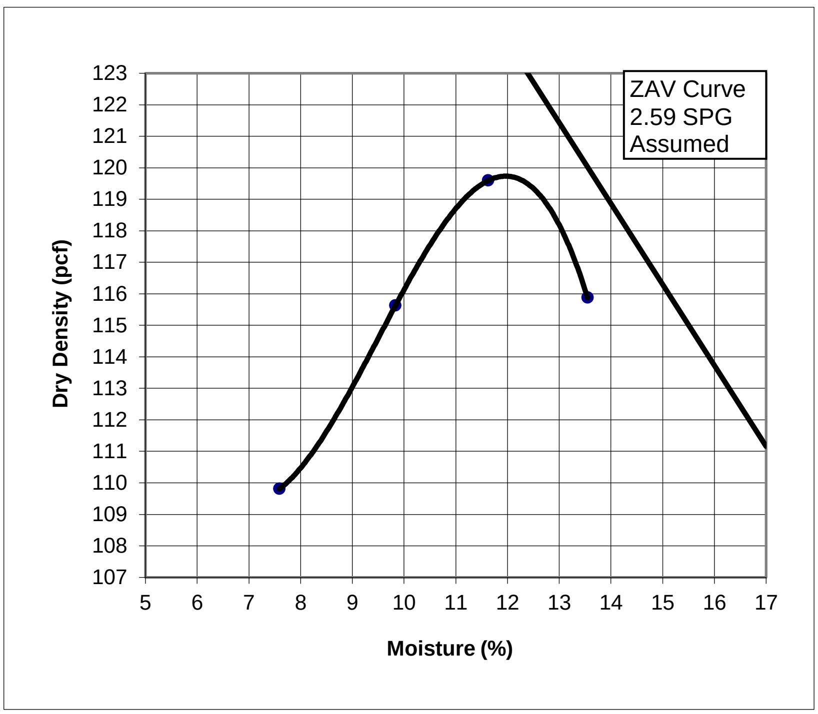
Reviewed by: Rafael Hernandez, PE

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd.	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	29
SAMPLE SOURCE:	BH-29	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)	Rock Correction
Maximum dry density:	119.7	1918	122.3
Optimum moisture (%):	12.0	12.0	10.9



SIEVE SIZE	**PERCENT PASSING**	**SPECS**
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	100	
1 in / 25 mm	100	
3/4 in / 19 mm	100	
1/2 in / 12.5 mm	98	
3/8 in / 9.5 mm	96	
1/4 in / 6.4 mm	93	
#4, 4.75mm	90	
#8, 2.36mm	83	
#10, 2.00mm	80	
#16, 1.18mm	70	
#30, 0.60mm	57	
#40, .425mm	52	
#50, .300mm	47	
#100, .150mm	39	
#200, .075mm	33.8	

LL:	31
PL:	22
PI:	9
USCS:	SC
AASHTO:	A-2-4(0)

NOTES:

AASHTO Description: Silty gravel and sand

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

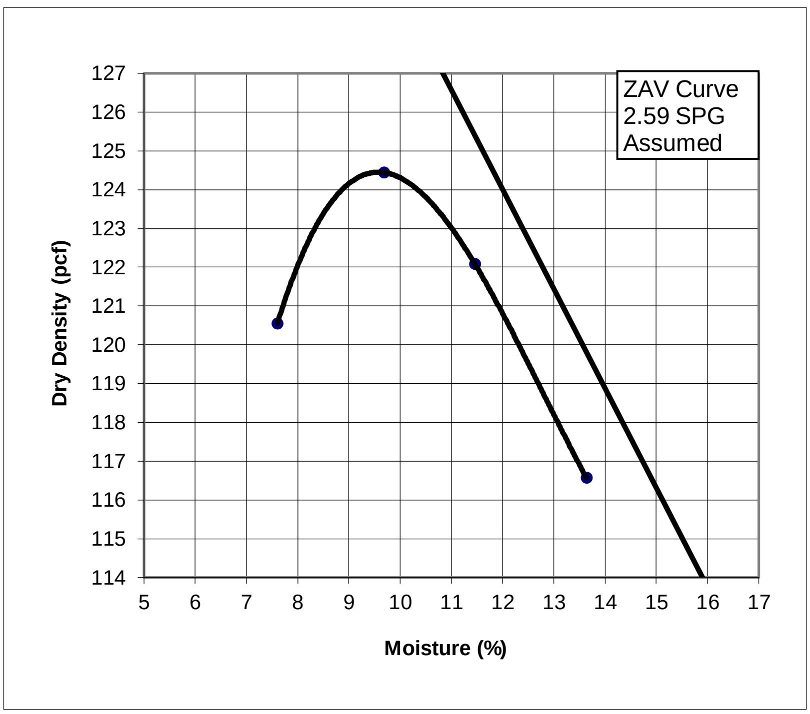
Reviewed by: Brian Lasham

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT NO:**	170111
LOCATION:	Valencia Rd. - Golder Project #1660053	**WORK ORDER NO:**	1720218
MATERIAL:	Native	**LAB NO:**	31
SAMPLE SOURCE:	BH-31	**SAMPLE DATE:**	9/26/2017

LABORATORY COMPACTION CHARACTERISTICS OF SOILS USING
STANDARD EFFORT (12,400ft-lb-ft/cu.ft) (ASTM D698A)
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES (ASTM C136/C117)
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318) (DRY PREP)

	English (pcf)	Metric (kg / cu.m.)
Maximum dry density:	124.5	1993
Optimum moisture (%):	9.6	9.6



SIEVE SIZE	**PERCENT PASSING**	**SPECS**
6 in / 152mm	100	
4 in / 100mm	100	
3 in / 75mm	100	
2 in / 50mm	100	
1 1/2 in / 37.5mm	100	
1 1/4 in / 32 mm	100	
1 in / 25 mm	100	
3/4 in / 19 mm	100	
1/2 in / 12.5 mm	97	
3/8 in / 9.5 mm	96	
1/4 in / 6.4 mm	91	
#4, 4.75mm	87	
#8, 2.36mm	73	
#10, 2.00mm	69	
#16, 1.18mm	56	
#30, 0.60mm	43	
#40, .425mm	38	
#50, .300mm	33	
#100, .150mm	27	
#200, .075mm	22	

LL: 32
PL: 25
PI: 7

USCS: SM
AASHTO: A-2-4(0)

AASHTO Description: Silty gravel and sand

NOTES:

- The zero air void curve represents a specific gravity of: 2.59 assumed, (also used in the 'Rock Correction Calculation)
- This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at clients request.
- The "Rock Correction" is based on the sieve performed for this sample

Reviewed by: Rafael Hernandez, PE

ENGINEERING CONSULTANTS

PROJECT:	Golder Associates	**PROJECT:**	170111
LOCATION:	Valencia Rd	**WORK ORDER:**	1720218
SAMPLE DATE:	9/26/2017	**REVIEWED BY:**	R. Hernandez, PE

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD -- ASTM D 2937

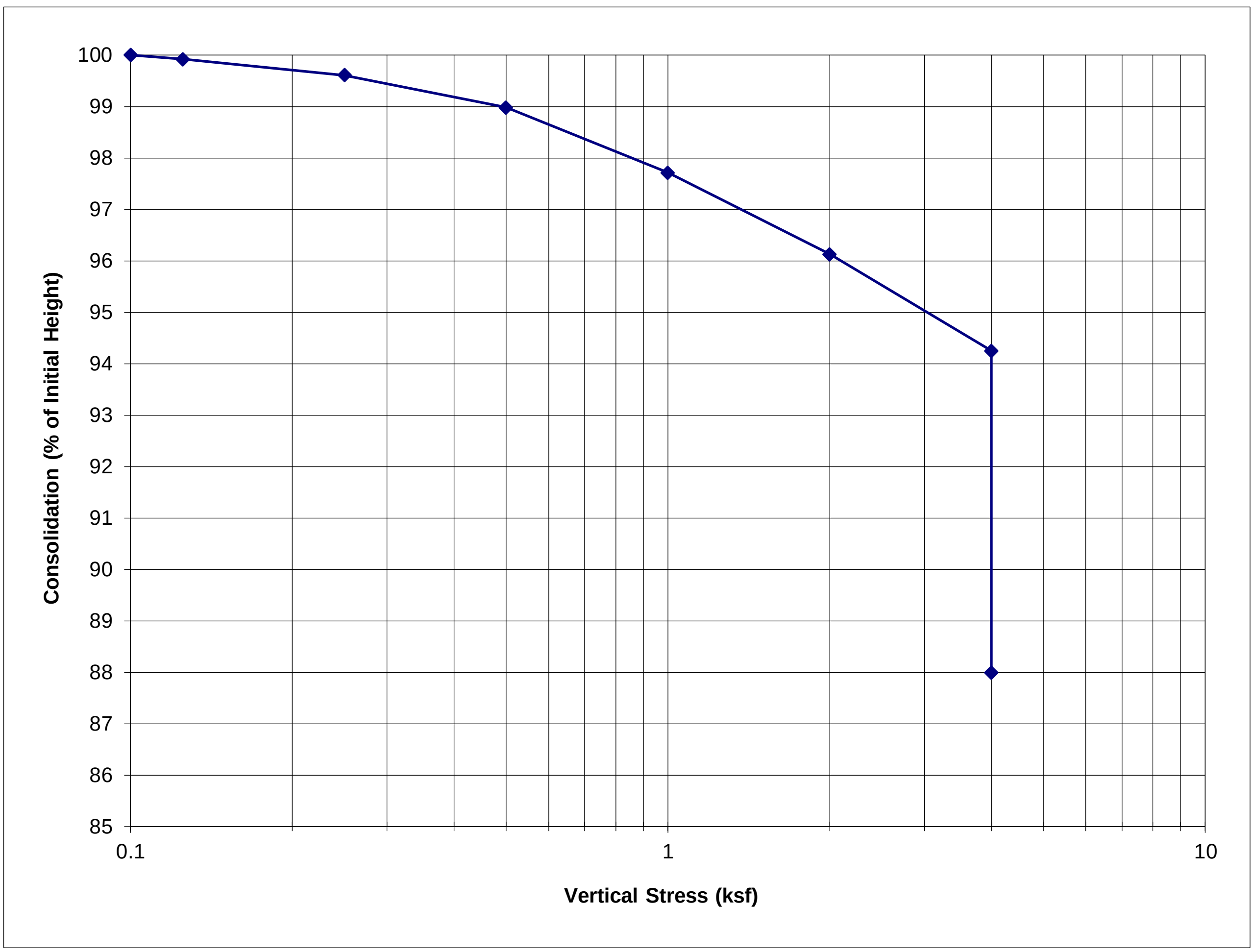
LAB #	SAMPLE SOURCE	MOISTURE WET WEIGHT (g)	 DRY WEIGHT (g)	 MOISTURE CONTENT	# OF RINGS	WET WEIGHT + RINGS (g)	WEIGHT OF RINGS (g)	DRY DENSITY (pcf)
3	BH-03	394.6	361.7	9.1%	3	525.5	130.9	99.8
5	BH-05				*No Ring Sample Available*			
8	BH-08	372.5	343.3	8.5%	3	500.4	126.6	95.1
10	BH-10	704.3	671.0	5.0%	5	933.3	229.0	111.1
19	BH-19	645.3	600.3	7.5%	5	859.4	214.1	99.4
26	BH-26	640.1	611.6	4.7%	5	853.3	213.2	101.3
27	BH-27	779.8	712.3	9.5%	5	1000.4	220.6	118.0
29	BH-29	540.3	514.1	5.1%	4	713.4	172.3	106.6
31	BH-31	566.6	538.0	5.3%	4	737.3	170.7	111.4
34	BH-34	548.4	531.0	3.3%	4	731.3	182.9	109.9

ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	4
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-04	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.05
Initial Moisture Content	3.5%	Final Moisture Content	15.9%
Initial Dry Density(pcf)	94.4	Final Dry Density(pcf)	107.2
Initial Degree of Saturation	15%	Final Degree of Saturation	96%
Initial Void Ratio	0.6	Final Void Ratio	0.4
Estimated Specific Gravity	2.40	Saturated at	4 ksf

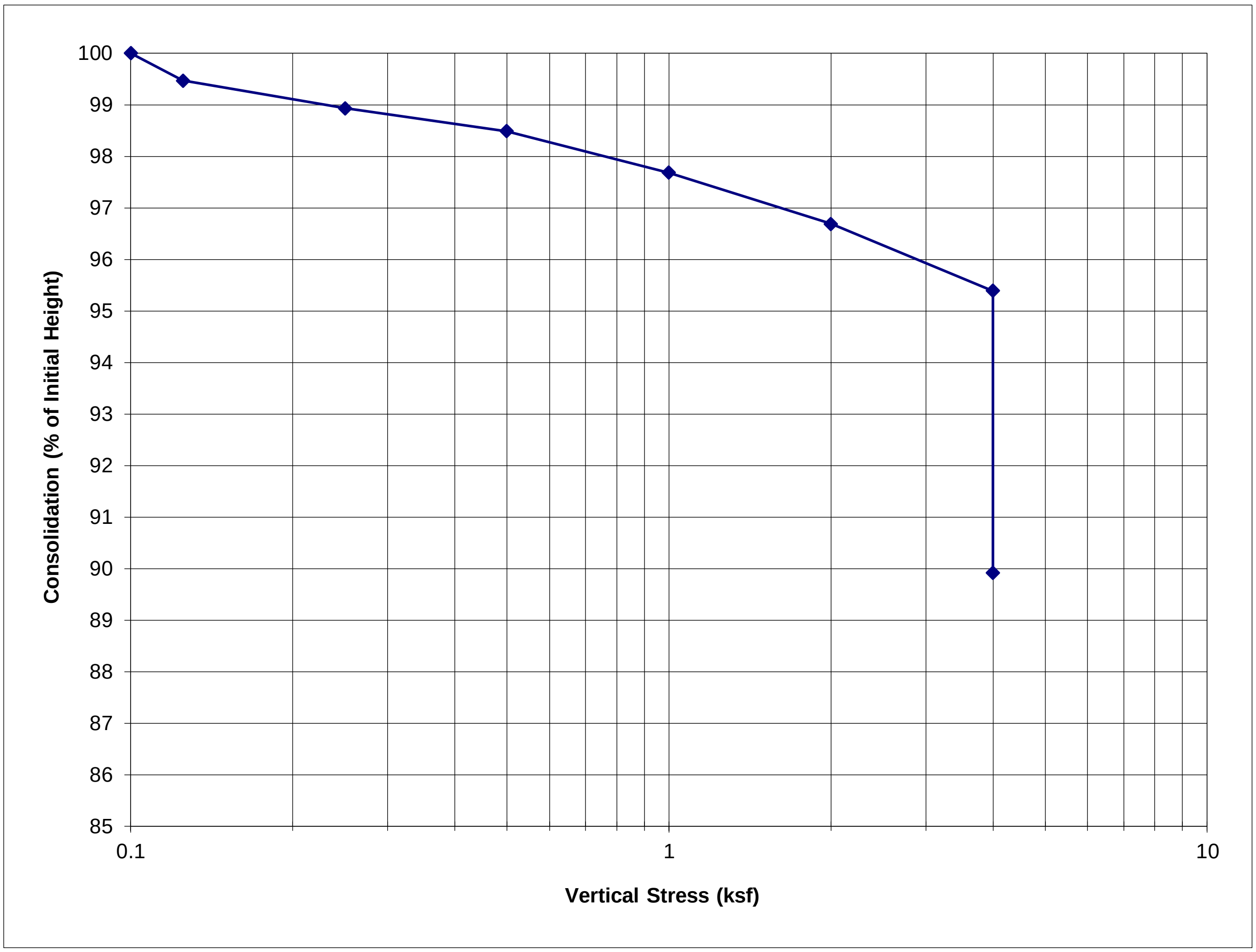


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	7
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-07	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.14
Initial Moisture Content	8.5%	Final Moisture Content	21.4%
Initial Dry Density(pcf)	96.1	Final Dry Density(pcf)	106.8
Initial Degree of Saturation	31%	Final Degree of Saturation	100%
Initial Void Ratio	0.8	Final Void Ratio	0.6
Estimated Specific Gravity	2.70	Saturated at	4 ksf

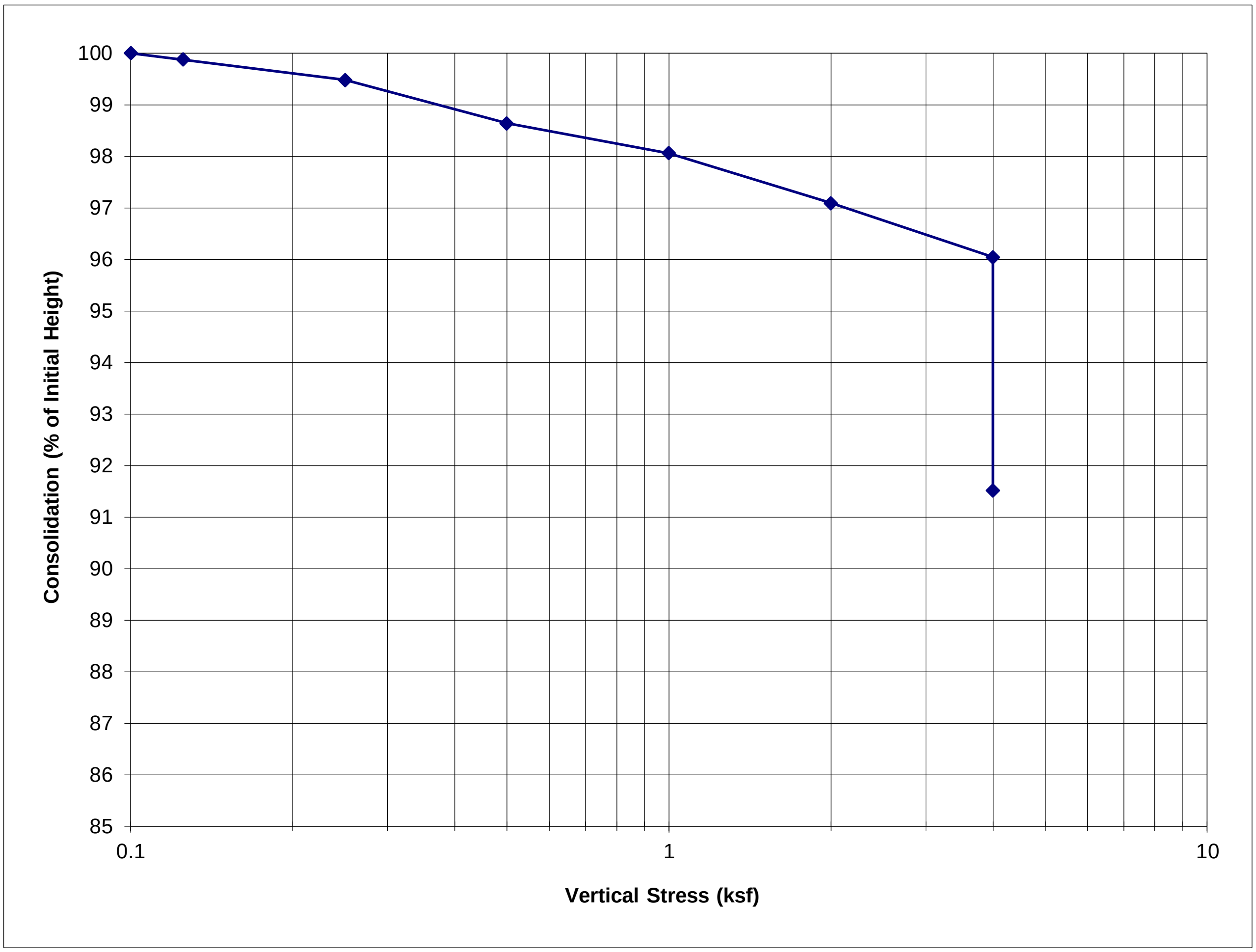


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	13
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-13	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.21
Initial Moisture Content	4.0%	Final Moisture Content	17.7%
Initial Dry Density(pcf)	102.5	Final Dry Density(pcf)	112.0
Initial Degree of Saturation	18%	Final Degree of Saturation	100%
Initial Void Ratio	0.6	Final Void Ratio	0.5
Estimated Specific Gravity	2.63	Saturated at	4 ksf

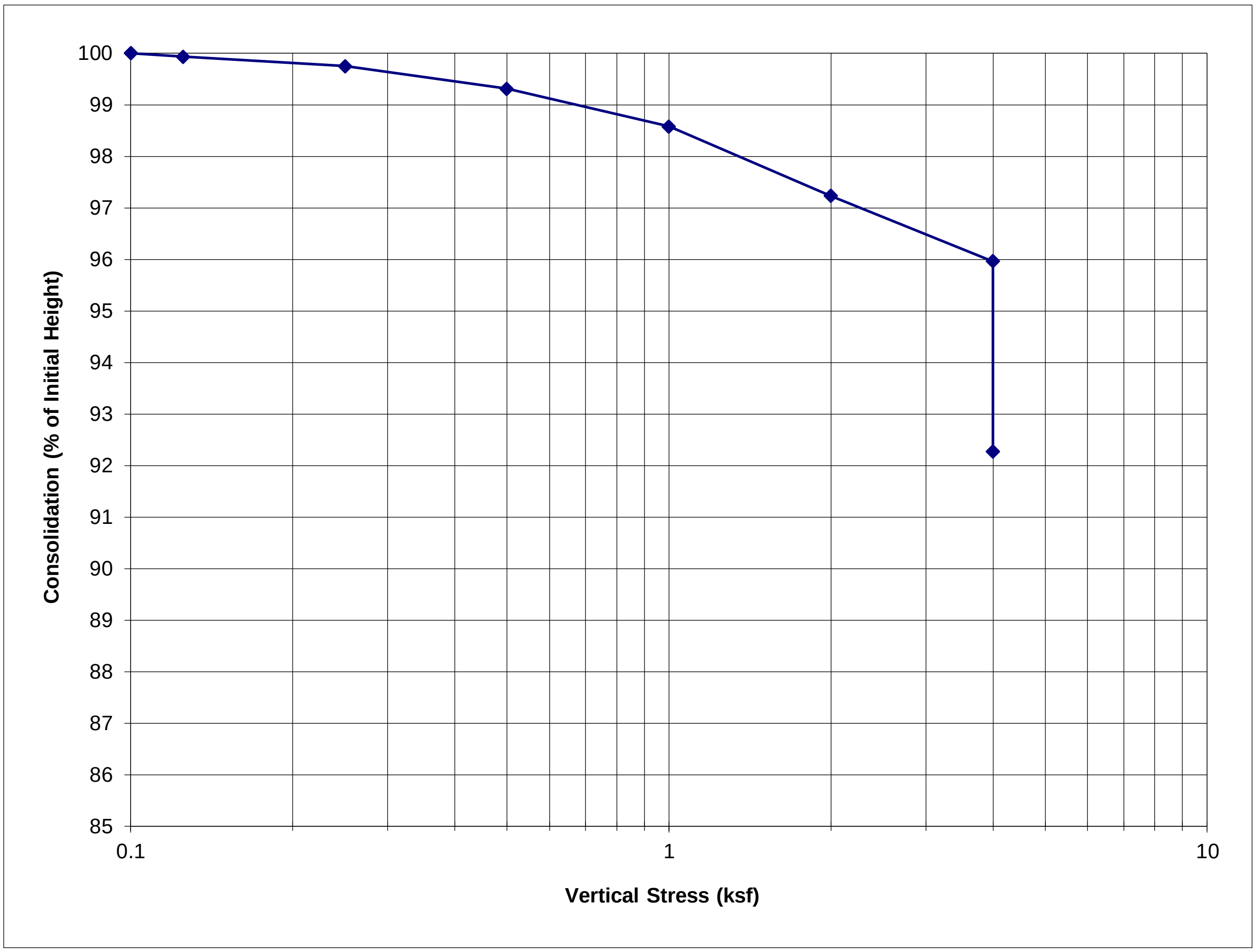


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	15
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-15	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.25
Initial Moisture Content	8.6%	Final Moisture Content	20.2%
Initial Dry Density(pcf)	103.0	Final Dry Density(pcf)	111.6
Initial Degree of Saturation	35%	Final Degree of Saturation	103%
Initial Void Ratio	0.7	Final Void Ratio	0.5
Estimated Specific Gravity	2.75	Saturated at	4 ksf

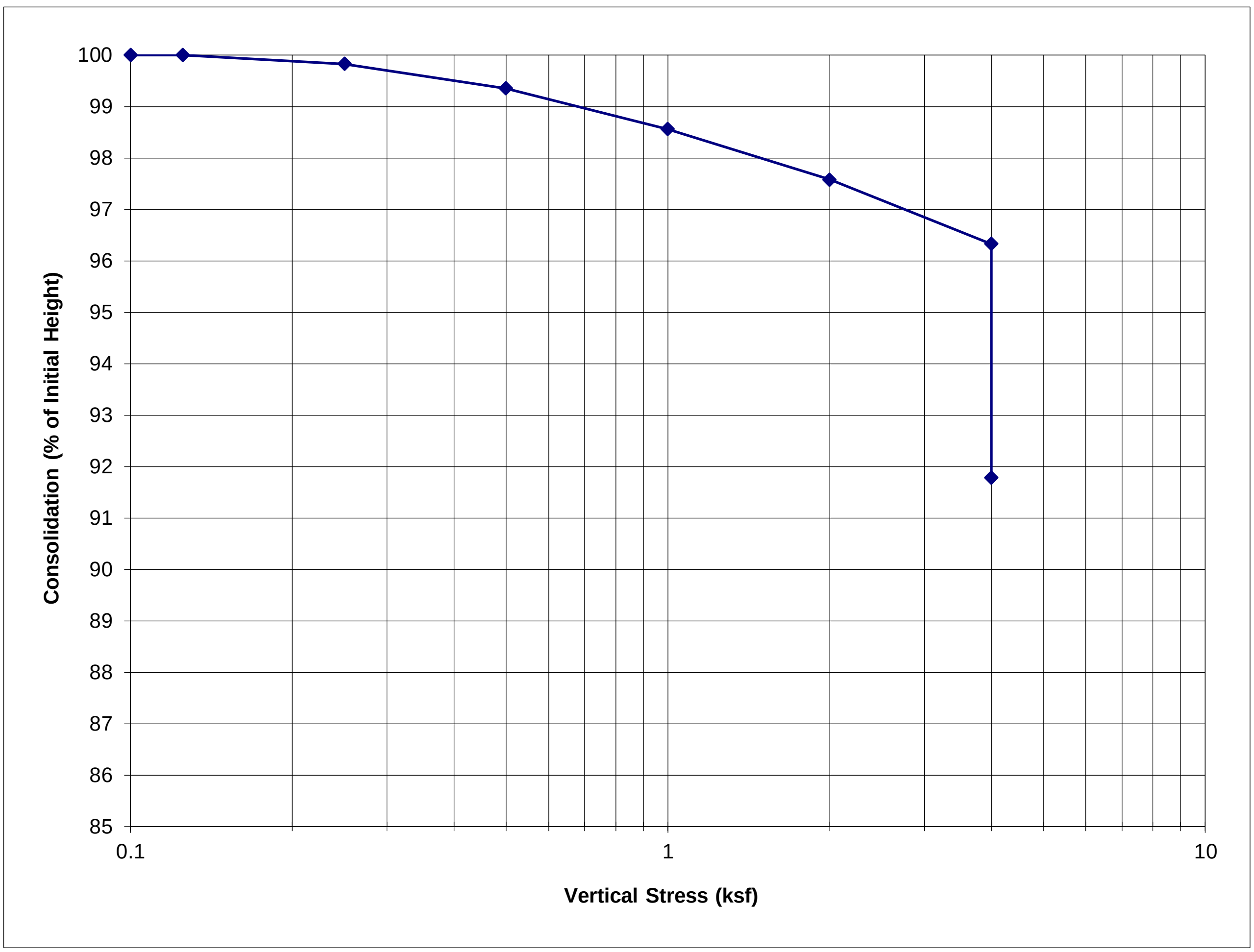


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	25
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-25	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.23
Initial Moisture Content	4.2%	Final Moisture Content	18.4%
Initial Dry Density(pcf)	103.5	Final Dry Density(pcf)	112.7
Initial Degree of Saturation	18%	Final Degree of Saturation	101%
Initial Void Ratio	0.6	Final Void Ratio	0.5
Estimated Specific Gravity	2.70	Saturated at	4 ksf

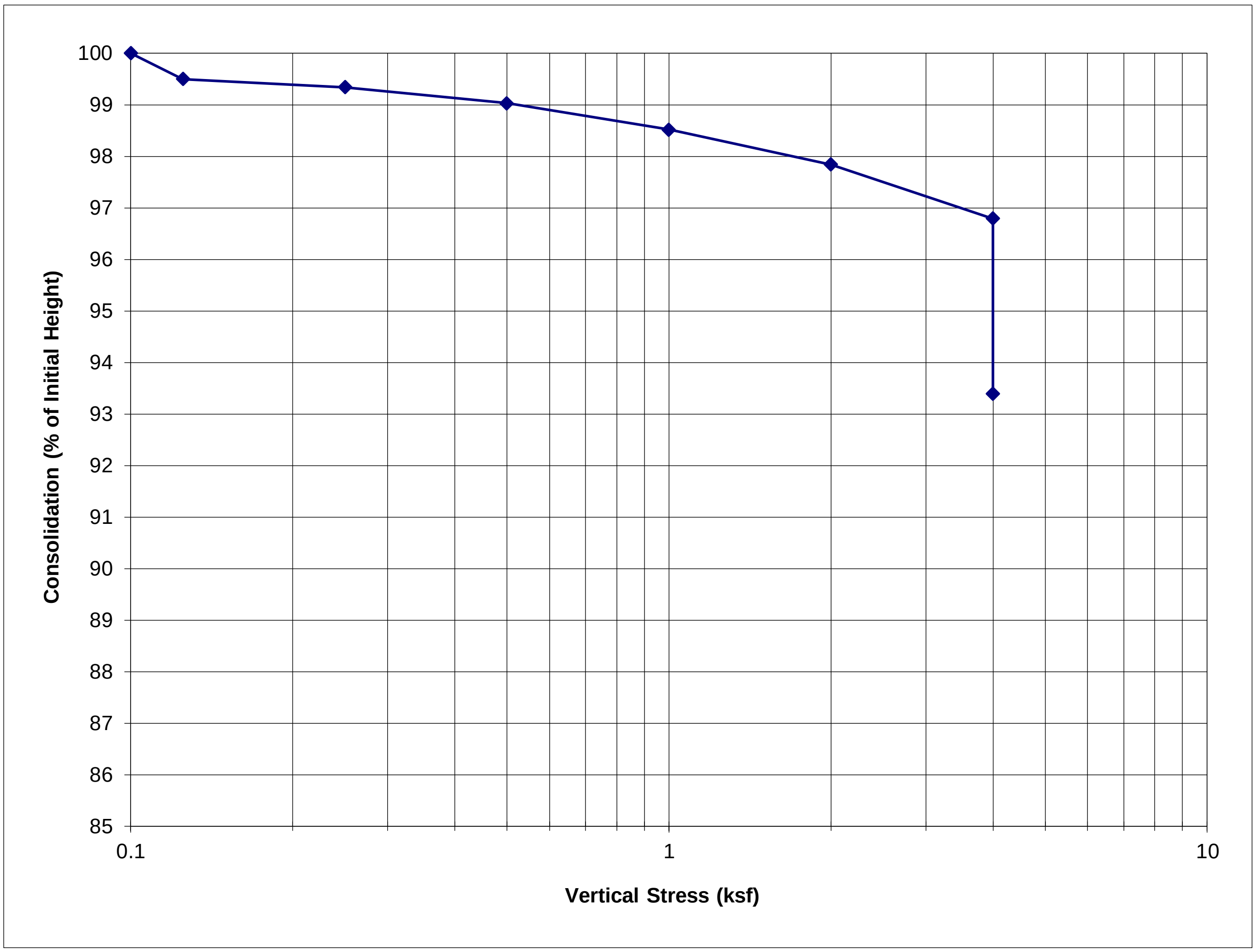


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	26
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-26	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.30
Initial Moisture Content	5.4%	Final Moisture Content	18.7%
Initial Dry Density(pcf)	103.1	Final Dry Density(pcf)	110.3
Initial Degree of Saturation	24%	Final Degree of Saturation	99%
Initial Void Ratio	0.6	Final Void Ratio	0.5
Estimated Specific Gravity	2.65	Saturated at	4 ksf

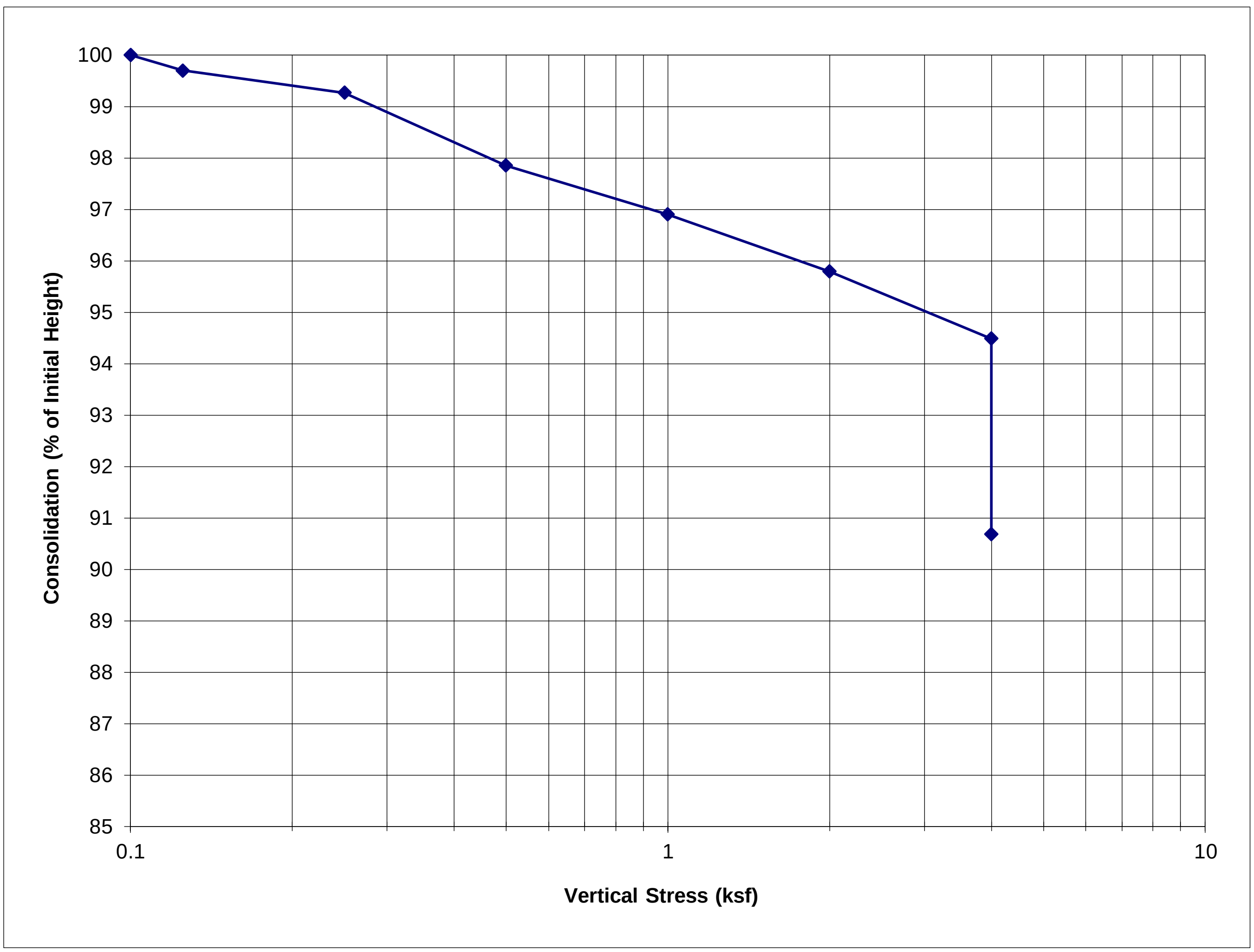


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	30
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-30	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.18
Initial Moisture Content	5.3%	Final Moisture Content	13.0%
Initial Dry Density(pcf)	102.3	Final Dry Density(pcf)	112.8
Initial Degree of Saturation	29%	Final Degree of Saturation	102%
Initial Void Ratio	0.4	Final Void Ratio	0.3
Estimated Specific Gravity	2.35	Saturated at	4 ksf

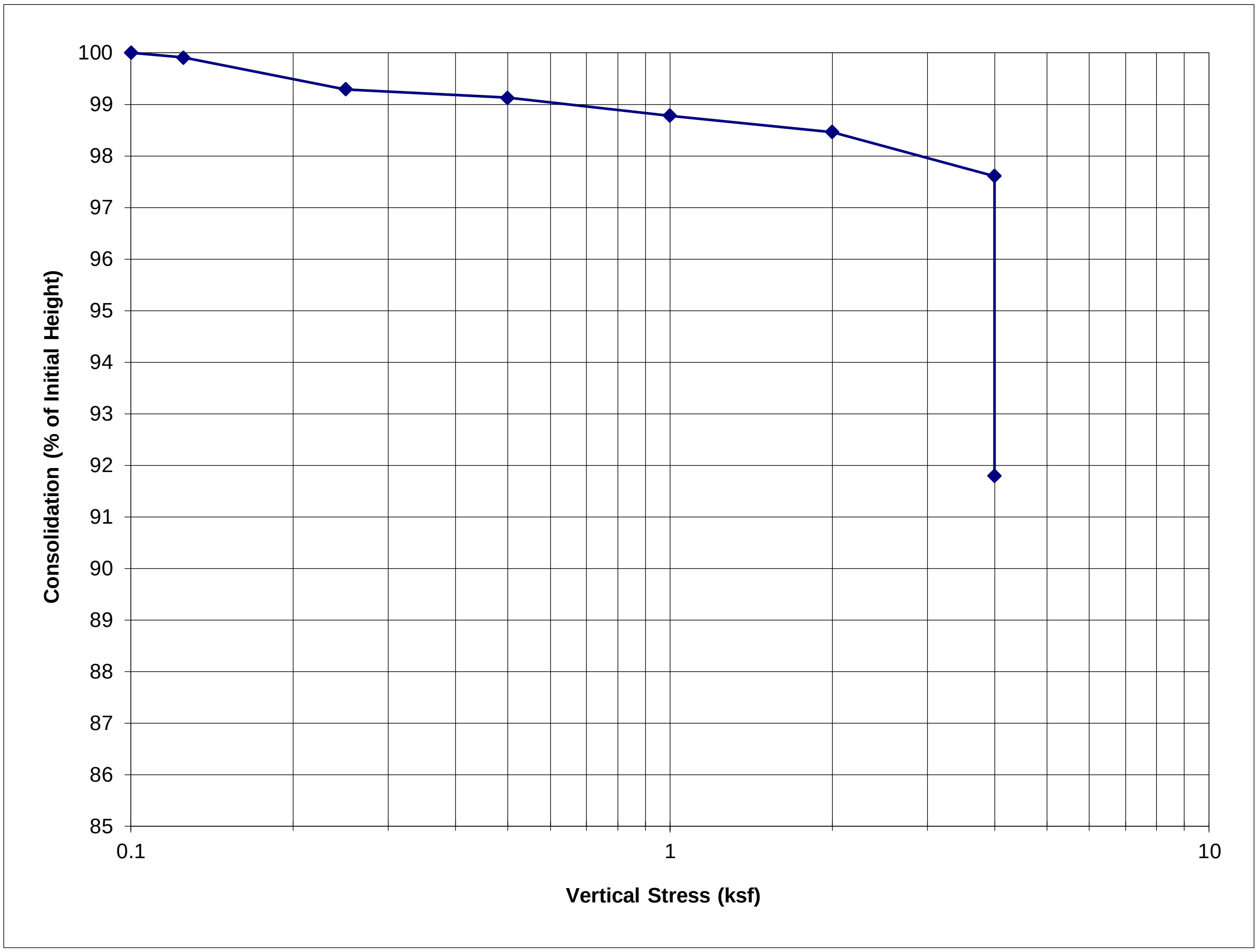


ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Project Location:	Valencia Rd.	**Work Order Number:**	1720218
Client:	Golder Associates	**Lab Number:**	31
Material:	Native	**Date Sampled:**	09/26/17
Sample Source:	BH-31	**Reviewed By:**	A. Ortega, PE
Sample Prep:	In-Situ		

One-Dimensional Swell or Collapse of Soils (ASTM D4546)

Initial Volume (cu.in)	4.60	Final Volume (cu.in)	4.23
Initial Moisture Content	5.0%	Final Moisture Content	14.1%
Initial Dry Density(pcf)	112.9	Final Dry Density(pcf)	123.0
Initial Degree of Saturation	30%	Final Degree of Saturation	116%
Initial Void Ratio	0.4	Final Void Ratio	0.3
Estimated Specific Gravity	2.59	Saturated at	4 ksf



atek ENGINEERING CONSULTANTS

Project:	Golder Associates	**Project Number:**	170111
Location:	Valencia Rd.	**Work Order Number:**	1710181
Client:	Native	**Lab Number:**	See Below
Material:	See Below	**Date Sampled:**	09/26/17
Sample Source:	See Below	**Reveiwed By:**	R. Hernandez, PE

Swell Potential of Soil ASTM D4546

Sample Number	Sample Source	Swell (%)	Initial Moisture Content (%)	Final Moisture Content (%)
3	BH-03	2.0	6.4	18.6
19	BH-19	1.1	7.7	19.6
26	BH-26	1.2	7.9	17.8
31	BH-31	0.8	6.8	16.1

Note: Ring Samples were subjected to a 125 psf surcharge.

111 South Weber Drive, Suite 1
Chandler, AZ 85226

www.atekec.com

p 480.659.8065
f 480.656.9658

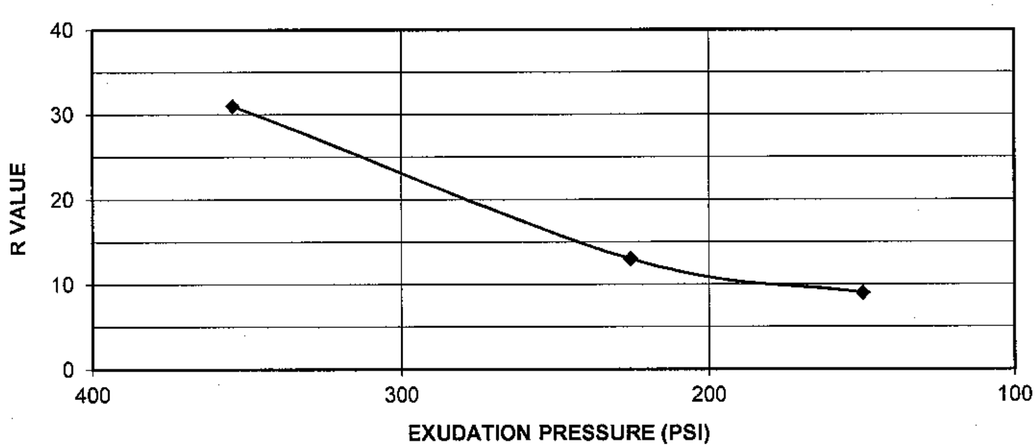
SPEEDIE AND ASSOCIATES
Geotechnical ▪ Environmental ▪ Materials Engineers
3331 EAST WOOD STREET • PHOENIX, ARIZONA 85040

Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT:	Valencia Road- 170111	**JOB NO:**	172022LA
LOCATION:	Tucson, Arizona	**LAB NO:**	510699
SAMPLE SOURCE:	BH-03		

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	10.1%	11.5%	12.4%
Compaction Pressure (psi)	250	100	75
Specimen Height (inches)	2.45	2.50	2.56
Dry Density (pcf)	127.8	125.1	122.0
Ph @ 1000 (lb)	37.0	50.0	57.0
Ph @ 2000 (lb)	100.0	131.0	140.0
Displacement	3.37	3.68	3.69
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	355	225	150
R Value	31	13	9
Corrected R Value	31	13	9



R VALUE AT 300 PSI = 23

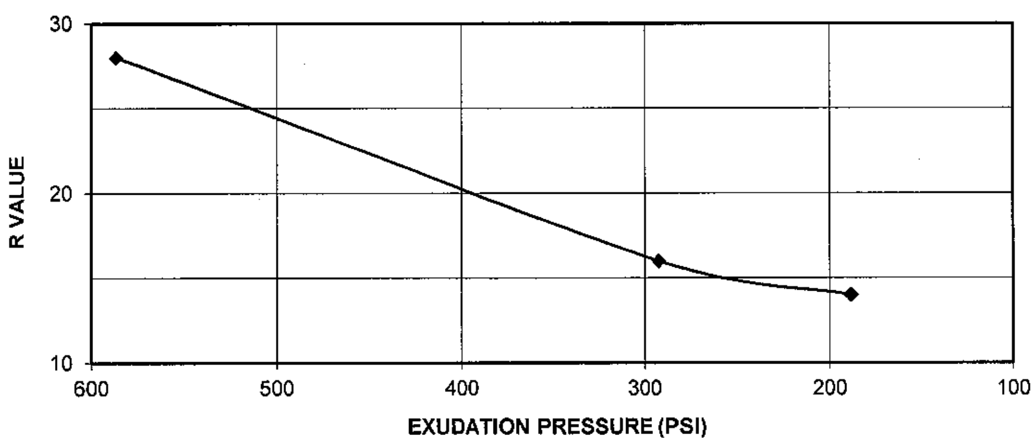
SPEEDIE AND ASSOCIATES
Geotechnical ▪ Environmental ▪ Materials Engineers
3331 EAST WOOD STREET • PHOENIX, ARIZONA 85040

Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT:	Valencia Road- 170111	**JOB NO:**	172022LA
LOCATION:	Tucson, Arizona	**LAB NO:**	510700
SAMPLE SOURCE:	BH-08		

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	12.0%	13.3%	14.9%
Compaction Pressure (psi)	205	100	55
Specimen Height (inches)	2.47	2.54	2.63
Dry Density (pcf)	124.1	120.8	116.5
Ph @ 1000 (lb)	39.0	51.0	58.0
Ph @ 2000 (lb)	109.0	126.0	132.0
Displacement	3.07	3.55	3.62
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	586	292	188
R Value	28	16	13
Corrected R Value	28	16	14



R VALUE AT 300 PSI = 16

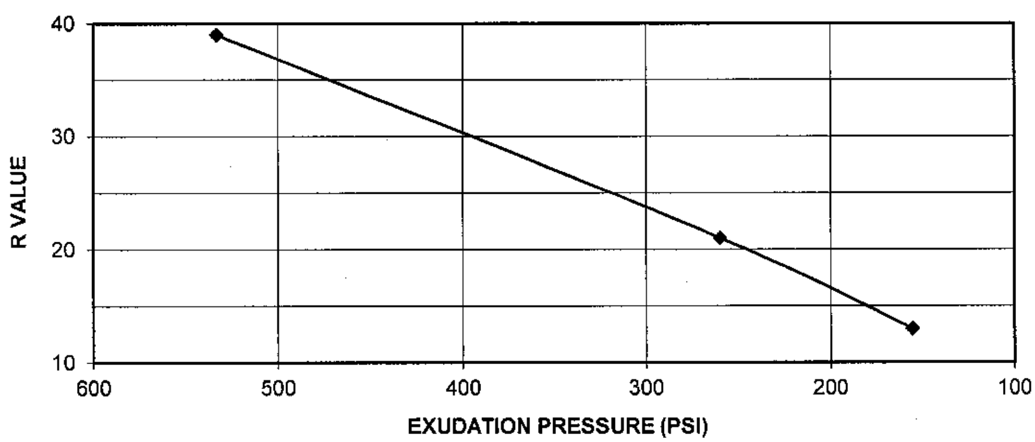
SPEEDIE AND ASSOCIATES
Geotechnical ▪ Environmental ▪ Materials Engineers
3331 EAST WOOD STREET • PHOENIX, ARIZONA 85040

Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT:	Valencia Road- 170111	**JOB NO:**	172022LA
LOCATION:	Tucson, Arizona	**LAB NO:**	510701
SAMPLE SOURCE:	BH-16		

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	9.3%	10.0%	10.9%
Compaction Pressure (psi)	250	165	60
Specimen Height (inches)	2.38	2.47	2.53
Dry Density (pcf)	131.2	129.6	125.9
Ph @ 1000 (lb)	31.0	45.0	52.0
Ph @ 2000 (lb)	84.0	116.0	129.0
Displacement	3.08	3.58	4.11
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	533	259	155
R Value	42	21	13
Corrected R Value	39	21	13



R VALUE AT 300 PSI = 23

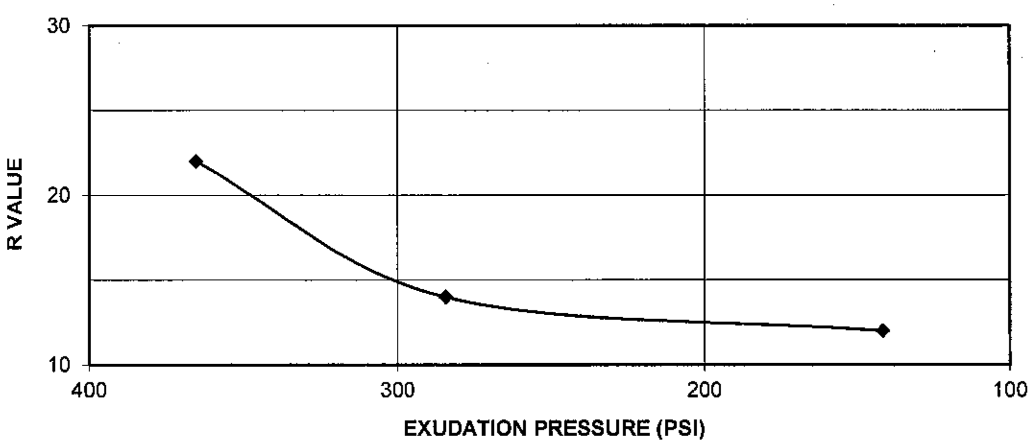
SPEEDIE AND ASSOCIATES
Geotechnical ▪ Environmental ▪ Materials Engineers
3331 EAST WOOD STREET • PHOENIX, ARIZONA 85040

Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT:	Valencia Road- 170111	**JOB NO:**	172022LA
LOCATION:	Tucson, Arizona	**LAB NO:**	510702
SAMPLE SOURCE:	BH-22		

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	9.8%	10.3%	12.0%
Compaction Pressure (psi)	200	125	70
Specimen Height (inches)	2.43	2.43	2.53
Dry Density (pcf)	129.2	128.4	124.6
Ph @ 1000 (lb)	44.0	50.0	53.0
Ph @ 2000 (lb)	113.0	126.0	131.0
Displacement	3.42	3.68	3.99
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	365	284	142
R Value	23	15	12
Corrected R Value	22	14	12



R VALUE AT 300 PSI = 15

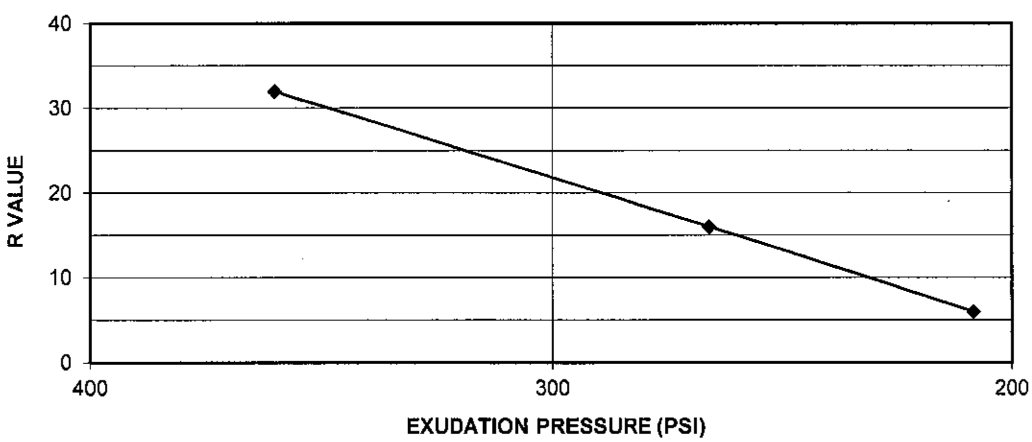
Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT: Valencia Road- 170111
LOCATION: Tucson, Arizona
SAMPLE SOURCE: BH-29

JOB NO: 172022LA
LAB NO: 510703

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	11.0%	12.0%	13.0%
Compaction Pressure (psi)	200	130	70
Specimen Height (inches)	2.47	2.50	2.56
Dry Density (pcf)	126.4	124.9	122.1
Ph @ 1000 (lb)	37.0	50.0	57.0
Ph @ 2000 (lb)	99.0	127.0	145.0
Displacement	3.25	3.44	3.89
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	360	266	209
R Value	32	16	6
Corrected R Value	32	16	6



R VALUE AT 300 PSI = 22

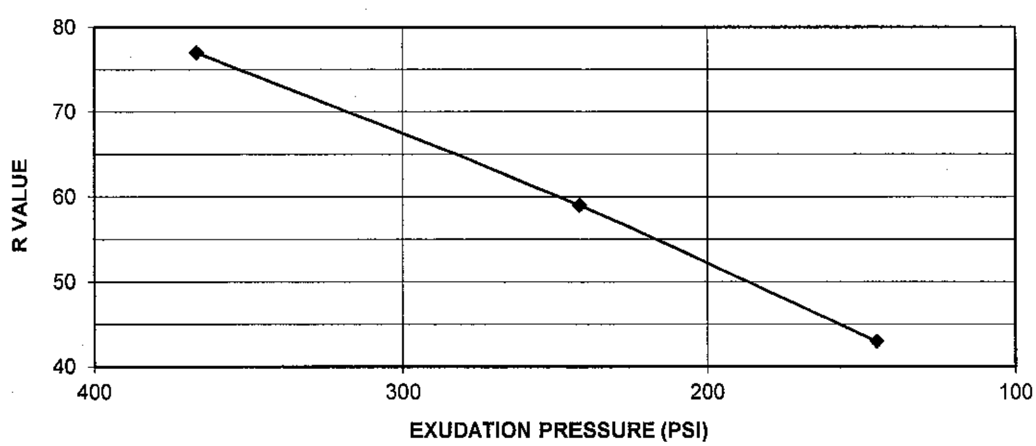
SPEEDIE
AND ASSOCIATES
Geotechnical ▪ Environmental ▪ Materials Engineers
3331 EAST WOOD STREET • PHOENIX, ARIZONA 85040

Resistance R-Value and Expansion Pressure of Compacted Soils

PROJECT:	Valencia Road- 170111	**JOB NO:**	172022LA
LOCATION:	Tucson, Arizona	**LAB NO:**	510704
SAMPLE SOURCE:	BH-34		

R VALUE CALCULATION - AASHTO T190

SPECIMEN I.D.	**A**	**B**	**C**
Moisture content	10.0%	11.0%	11.1%
Compaction Pressure (psi)	350	350	350
Specimen Height (inches)	2.53	2.54	2.55
Dry Density (pcf)	126.8	126.4	126.0
Ph @ 1000 (lb)	14.0	21.0	30.0
Ph @ 2000 (lb)	26.0	48.0	73.0
Displacement	3.80	3.99	3.91
Expansion Pressure (psi)	0.0	0.0	0.0
Exudation Pressure (psi)	367	242	145
R Value	77	59	43
Corrected R Value	77	59	43



R VALUE AT 300 PSI = 67

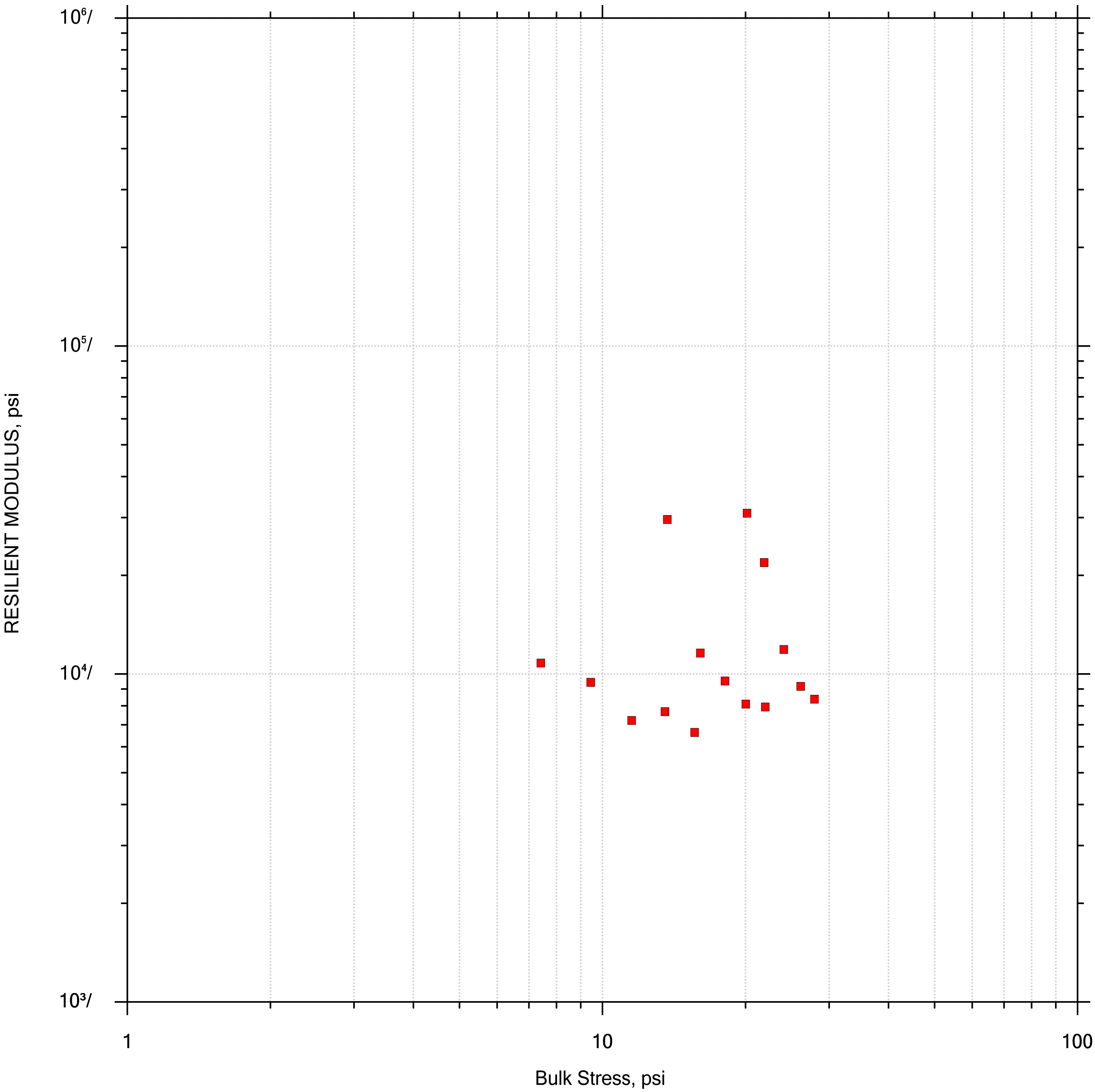
GeoTesting EXPRESS

Client:	Golder Associates	Test Date:	10/18/17
Project Name:	Valencia Rd. Geotech	Tested By:	md
Project Location:	Tucson, AZ	Checked By:	njh
GTX #:	307158		
Boring ID:	BH-08		
Sample ID:	1		
Depth, ft.	0-5		
Soil Description:	Moist, reddish brown clayey sand with gravel		
Sample Preparation:	Target Compaction: 95% of Maximum Dry Density (115.5 pcf) at Optimum Moisture Content (14.2%)		
Material Type:	Type 2		
Test No.:	RM-1		
Test Comments:	Proctor values provided by client.		

Resilient Modulus of Soil by AASHTO T 307

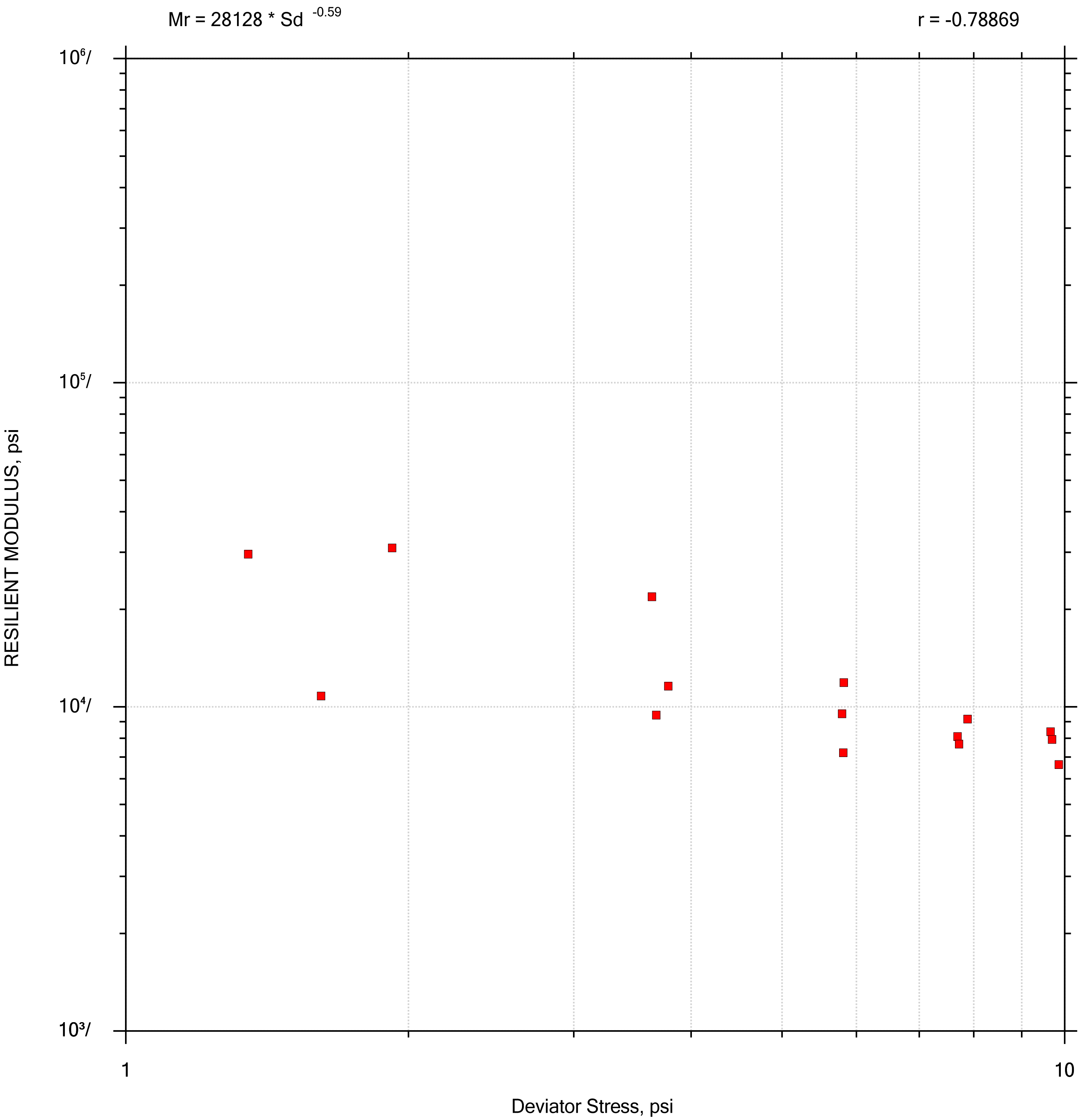
Test Information:		
	Preconditioning-Greater than 5% perm. strain? (Y=yes or N=no)	N
	Testing-greater than 5% perm. Strain? (Y=yes or N=no)	N
	Testing-Number of Load Sequences Completed (0-15)	15
Specimen Information:		
	Diameter @ top of compacted specimen (in.)	2.86
	Diameter @ middle of compacted specimen (in.)	2.86
	Diameter @ bottom of compacted specimen (in.)	2.86
	Average Diameter of specimen (in.)	2.86
	Membrane Thickness {1} (in.)	0.01
	Membrane Thickness {2} (in.)	0
	Net Diameter (in.)	2.85
	Height of Specimen, Cap and Base, (in.)	8.0
	Height Cap and Base, (in.)	2.3
	Initial Length of Specimen, Lo, (in.)	5.70
	Initial Area Cross Section of Specimen, Ao, (in^2)	6.38
	Initial Volume of Specimen, (Ao)(Lo), (in^3)	36.3
	Soil Specimen Weight	---
	Initial Weight of Container and Wet Soil, (grams)	---
	Final Weight of Container and Wet Soil, (grams)	---
	Weight of Wet Soil Used (grams)	1196
Soil Properties:		
	In Situ Moisture Content(Nuclear), %	N/A
	In Situ Wet Density (Nuclear), (pcf)	N/A
	Specific Gravity	---
	Liquid Limit	---
	Plastic Limit	---
	Plasticity Index	---
Test Specimen Properties:		
	Compaction Moisture Content, %	13.1
	Moisture Content after Resilient Modulus Testing, %	14.0
	Compaction Dry Density r_d, pcf	110.8
	Permanent Strain, %	1.8
	Quick Shear Test	N/A
	Stress-Strain Plot Attached (Y=yes, N=no)	N
	Triaxial Shear Maximum Strength (Max Load/X-Section Area), psi	N/A
	Specimen Fail During Triaxial Shear? (Y=yes, N=no)	N/A

Mr = 8441.9 * B $^{0.0974}$ r = 0.074898



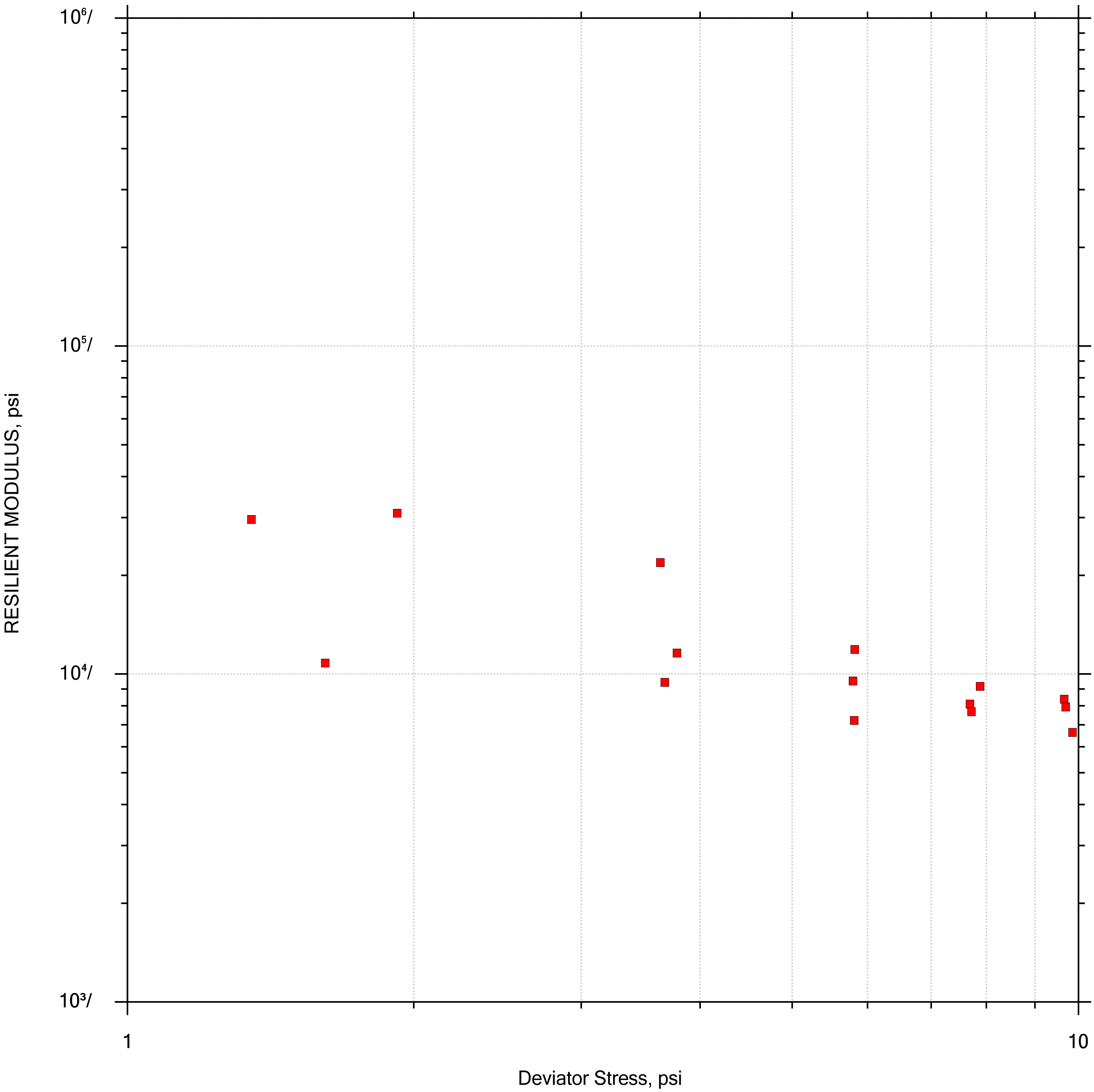
Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-08	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-1	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (115.5 pcf) at Optimum Moisture Content (14.2%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-1.dat		

GeoTesting EXPRESS



Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-08	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-1	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (115.5 pcf) at Optimum Moisture Content (14.2%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-1.dat		

$Mr = 269.63 * Pa * (B/Pa)^{0.822} * (Sd/Pa)^{-0.828}$ r = 0.95927



Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-08	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-1	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (115.5 pcf) at Optimum Moisture Content (14.2%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-1.dat		

GeoTesting EXPRESS

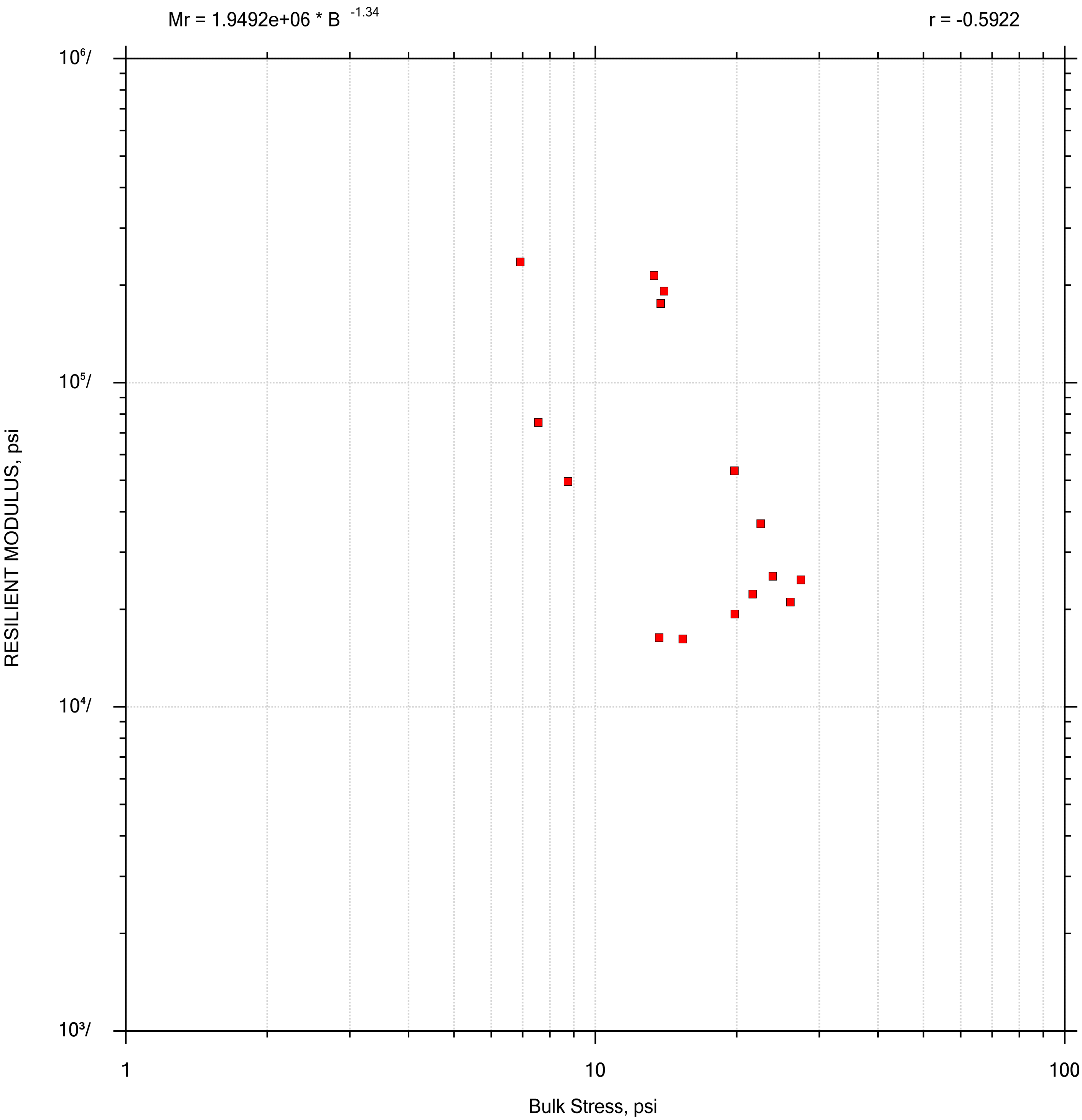
Confining Stress S3 (psi)	Nom. Max. Deviator Stress (psi)	Mean Deviator Stress (psi)	Std. Dev. Deviator Stress (psi)	Mean Bulk Stress (psi)	Mean Resilient Strain (%)	Std. Dev. Resilient Strain (%)	Mean Resilient Modulus (psi)	Std. Dev. Resilient Modulus (psi)
6.075	2	1.922	0.0221	20.15	0.01	0.00	30926	910.9
6.089	4	3.633	0.1032	21.9	0.01	0.00	21865	659.31
6.085	6	5.816	0.0411	24.07	0.04	0.00	11879	234.71
6.086	8	7.88	0.2058	26.14	0.08	0.00	9166.7	211.82
6.093	10	9.659	0.1352	27.94	0.10	0.00	8379.9	337.7
4.113	2	1.35	0.0238	13.69	0.00	0.00	29593	3612.7
4.096	4	3.782	0.0571	16.07	0.03	0.00	11586	363.92
4.107	6	5.793	0.0531	18.11	0.05	0.00	9517.7	346.92
4.111	8	7.689	0.1437	20.02	0.09	0.00	8103.5	233.99
4.105	10	9.694	0.1474	22.01	0.11	0.00	7935.1	235.5
1.934	2	1.614	0.0066	7.417	0.01	0.00	10800	1564
1.925	4	3.672	0.0597	9.447	0.03	0.00	9432.1	404.28
1.903	6	5.809	0.0255	11.52	0.07	0.00	7219.6	100.32
1.939	8	7.718	0.0788	13.53	0.09	0.00	7672.4	190.33
1.924	10	9.856	0.1153	15.63	0.13	0.00	6639	145.62

Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-08	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-1	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (115.5 pcf) at Optimum Moisture Content (14.2%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-1.dat		

Client:	Golder Associates	Test Date:	10/18/17
Project Name:	Valencia Rd. Geotech	Tested By:	md
Project Location:	Tucson, AZ	Checked By:	njh
GTX #:	307158		
Boring ID:	BH-29		
Sample ID:	1		
Depth, ft.	0-5		
Soil Description:	Moist, reddish brown clayey sand with gravel		
Sample Preparation:	Target Compaction: 95% of Maximum Dry Density (119.7 pcf) at Optimum Moisture Content (12%)		
Material Type:	Type 2		
Test No.:	RM-2		
Test Comments:	Proctor values provided by client.		

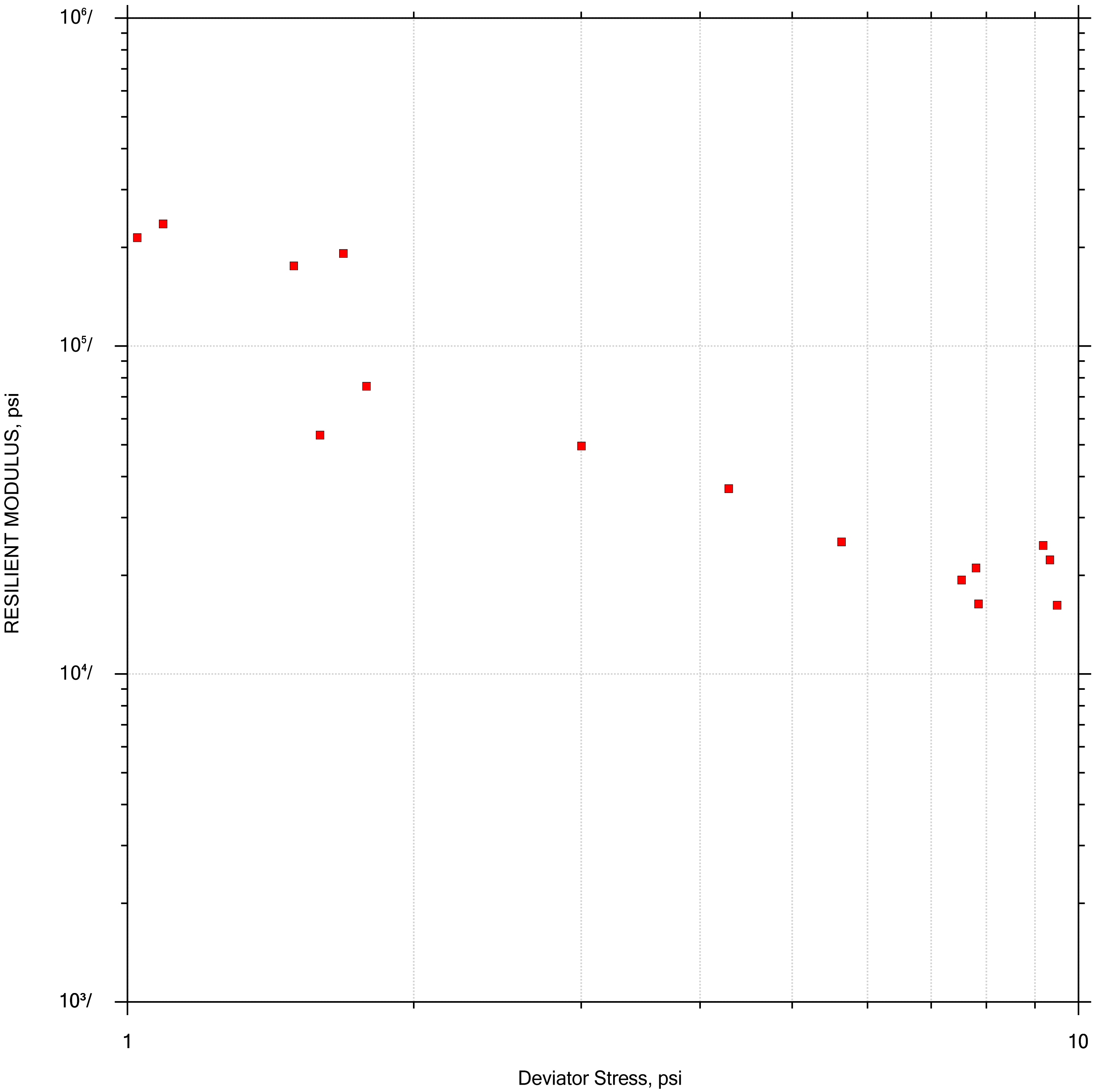
Resilient Modulus of Soil by AASHTO T 307

Test Information:		
	Preconditioning-Greater than 5% perm. strain? (Y=yes or N=no)	N
	Testing-greater than 5% perm. Strain? (Y=yes or N=no)	N
	Testing-Number of Load Sequences Completed (0-15)	15
Specimen Information:		
	Diameter @ top of compacted specimen (in.)	2.86
	Diameter @ middle of compacted specimen (in.)	2.86
	Diameter @ bottom of compacted specimen (in.)	2.86
	Average Diameter of specimen (in.)	2.86
	Membrane Thickness {1} (in.)	0.01
	Membrane Thickness {2} (in.)	0
	Net Diameter (in.)	2.85
	Height of Specimen, Cap and Base, (in.)	8.0
	Height Cap and Base, (in.)	2.3
	Initial Length of Specimen, Lo, (in.)	5.70
	Initial Area Cross Section of Specimen, Ao, (in^2)	6.38
	Initial Volume of Specimen, (Ao)(Lo), (in^3)	36.3
	Soil Specimen Weight	---
	Initial Weight of Container and Wet Soil, (grams)	---
	Final Weight of Container and Wet Soil, (grams)	---
	Weight of Wet Soil Used (grams)	1216
Soil Properties:		
	In Situ Moisture Content(Nuclear), %	N/A
	In Situ Wet Density (Nuclear), (pcf)	N/A
	Specific Gravity	---
	Liquid Limit	---
	Plastic Limit	---
	Plasticity Index	---
Test Specimen Properties:		
	Compaction Moisture Content, %	12.6
	Moisture Content after Resilient Modulus Testing, %	12.1
	Compaction Dry Density r_d, pcf	113.2
	Permanent Strain, %	0.5
	Quick Shear Test	N/A
	Stress-Strain Plot Attached (Y=yes, N=no)	N
	Triaxial Shear Maximum Strength (Max Load/X-Section Area), psi	N/A
	Specimen Fail During Triaxial Shear? (Y=yes, N=no)	N/A



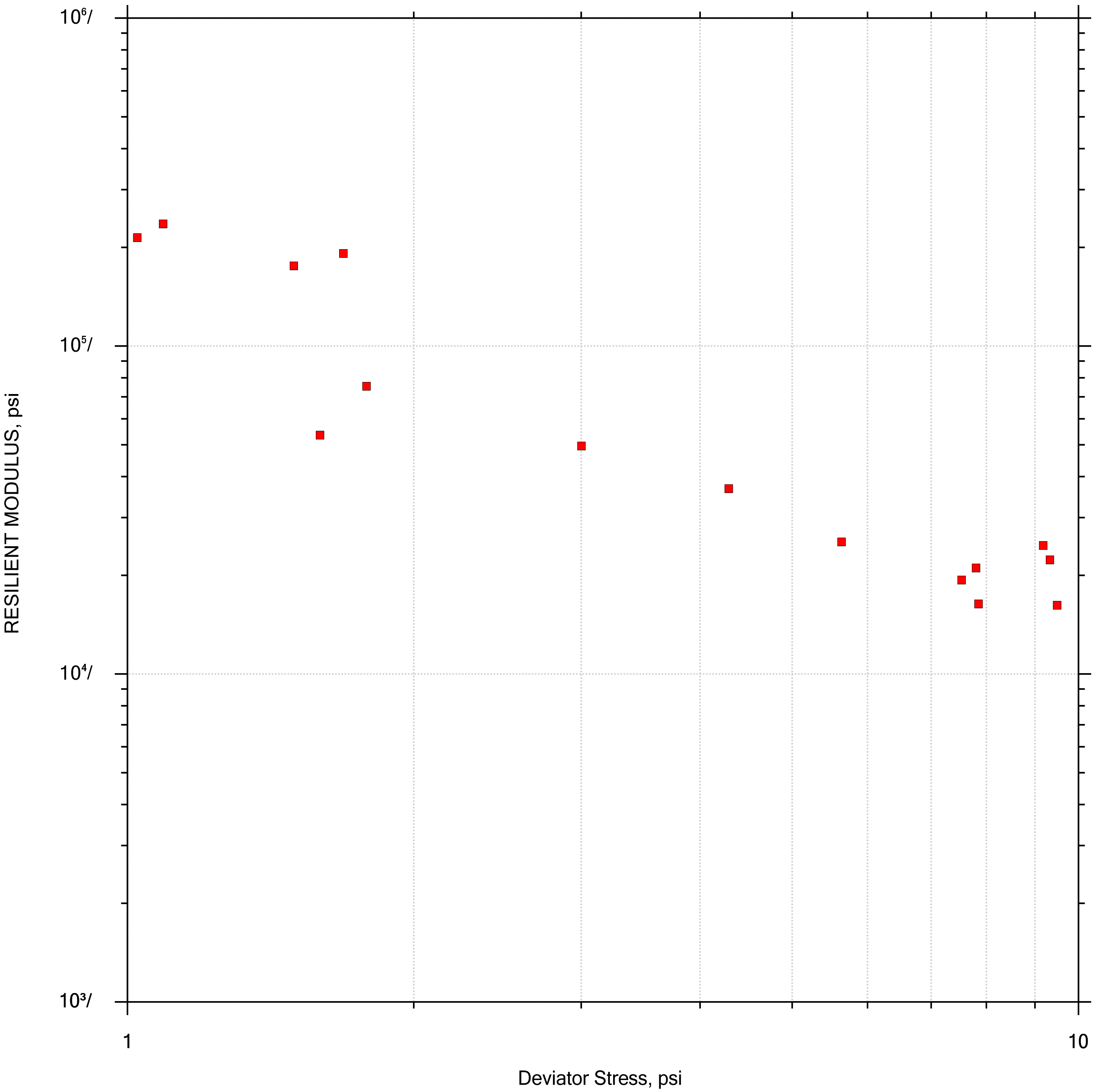
Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-29	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-2	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (119.7 pcf) at Optimum Moisture Content (12%) (provided by client)		Page 2 of 5
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-2.dat		

$Mr = 1.9771e{+}05 * Sd^{-1.1}$ r = -0.94283



Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-29	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-2	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (119.7 pcf) at Optimum Moisture Content (12%) (provided by client)		Page 3 of 5
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-2.dat		

$M_r = 695.62 * P_a * (B/P_a)^{0.0137} * (S_d/P_a)^{-1.1}$ r = 0.94284



Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-29	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-2	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (119.7 pcf) at Optimum Moisture Content (12%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-2.dat		

RM SUMMARY REPORT

Confining Stress S3 (psi)	Nom. Max. Deviator Stress (psi)	Mean Deviator Stress (psi)	Std. Dev. Deviator Stress (psi)	Mean Bulk Stress (psi)	Mean Resilient Strain (%)	Std. Dev. Resilient Strain (%)	Mean Resilient Modulus (psi)	Std. Dev. Resilient Modulus (psi)
6.064	2	1.594	0.2980	19.79	0.00	0.00	53519	6151.3
6.07	4	4.288	0.1138	22.5	0.01	0.00	36763	2643
6.079	6	5.634	0.0904	23.87	0.02	0.00	25281	953.63
6.08	8	7.802	0.1386	26.04	0.03	0.00	21046	552.11
6.075	10	9.181	0.0332	27.4	0.03	0.00	24657	589.53
4.102	2	1.024	0.0365	13.33	0.00	0.00	2.1398e+05	59085
4.093	4	1.496	0.0161	13.78	0.00	0.00	1.7558e+05	94373
4.108	6	1.687	0.0095	14.01	0.00	0.00	1.916e+05	94033
4.094	8	7.535	0.2415	19.82	0.04	0.00	19337	1222.2
4.099	10	9.332	0.0417	21.63	0.04	0.00	22274	525.68
1.944	2	1.09	0.0140	6.923	0.00	0.00	2.3577e+05	93038
1.927	4	1.784	0.0604	7.564	0.00	0.00	75428	8615.5
1.914	6	3.002	0.0175	8.743	0.00	0.00	49576	4037.3
1.941	8	7.85	0.2208	13.67	0.04	0.00	16355	618.14
1.954	10	9.496	0.1077	15.36	0.05	0.00	16206	318.84

Project: Valencia Rd. Geotech	Location: Tucson, AZ	Project No.: GTX-307158
Boring No.: BH-29	Tested By: md	Checked By: njh
Sample No.: 1	Test Date: 10/19/17	Depth: 0-5 ft
Test No.: RM-2	Sample Type: reconstituted	Elevation: ---
Description: Moist, reddish brown clayey sand with gravel		
Remarks: Target Compaction: 95% of Maximum Dry Density (119.7 pcf) at Optimum Moisture Content (12%) (provided by client)		
File: \\hal1\Projects\GTX307158\6 Lab Testing\Soil\RM\307158-RM-2.dat		

APPENDIX C

Borehole Infiltration Test Results

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-03 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

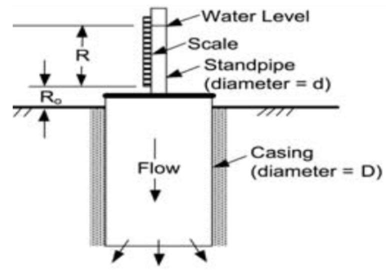
d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 2.5 minutes

Fitted Variables

a = 0.00601 s^{-1}
Z* = -0.39748 m
Z_0 = 1.07818 m
MSE = 2.88E-05 m
R_T = 0.7591
K = 5.21E-04 cm/s
K = 0.7 in/hr



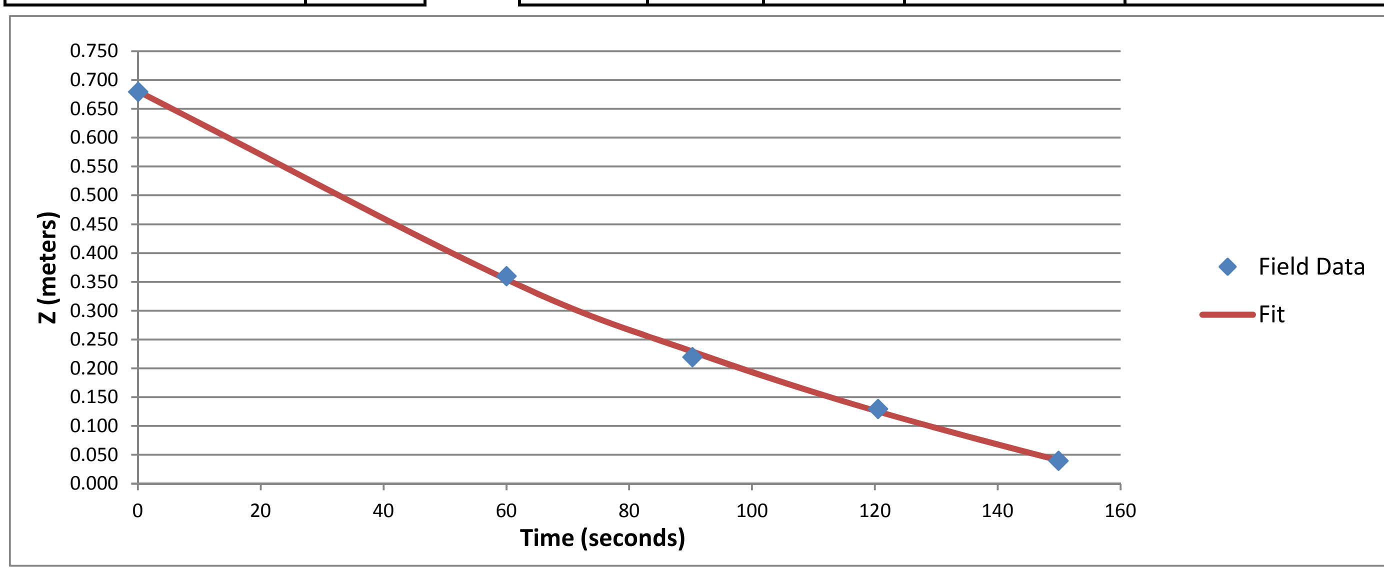
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/19/17 9:05:00 AM	68.0
9/19/17 9:06:00 AM	36.0
9/19/17 9:06:30 AM	22.0
9/19/17 9:07:00 AM	13.0
9/19/17 9:07:30 AM	4.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.680	0	0.681	7.02E-04	4.93E-07
0.360	60	0.354	-5.74E-03	3.29E-05
0.220	90	0.229	9.32E-03	8.70E-05
0.130	120	0.125	-4.85E-03	2.35E-05
0.040	150	0.041	5.59E-04	3.12E-07



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-03 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

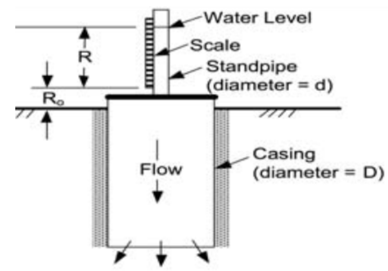
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 3 minutes

Fitted Variables

a = 0.00458 s^{-1}
Z* = -0.41240 m
Z_0 = 1.08624 m
MSE = 2.06E-05 m

R_T = 0.7591
K = 3.97E-04 cm/s
K = 0.6 in/hr



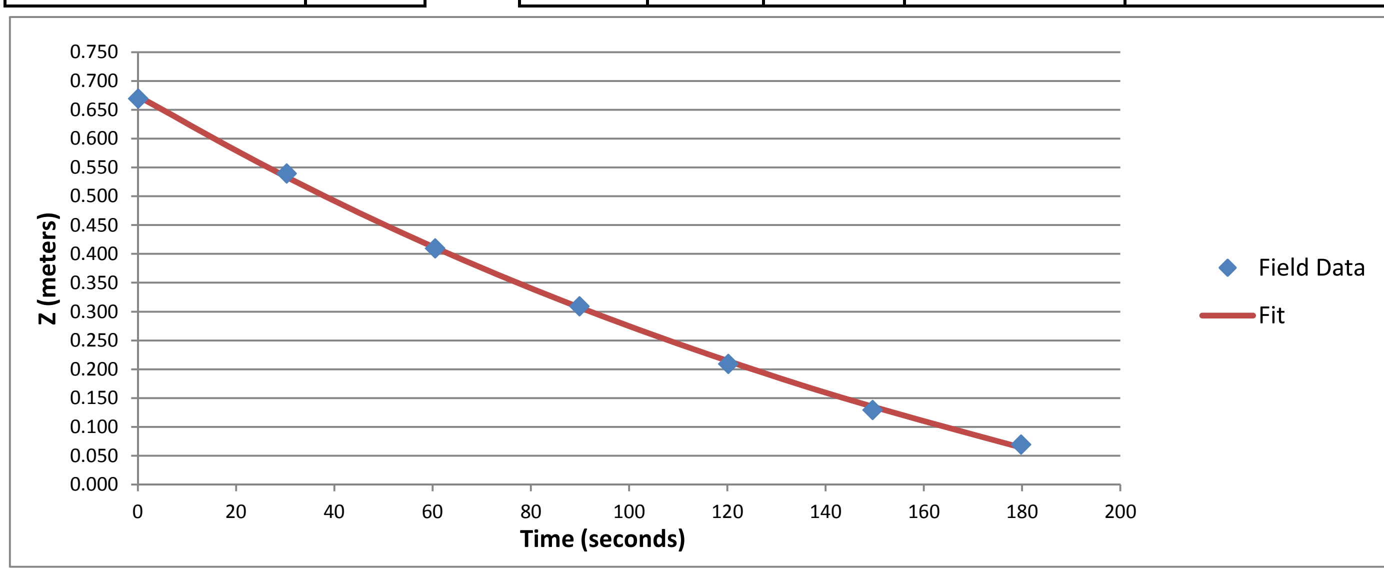
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/19/17 9:10:00 AM	67.0
9/19/17 9:10:30 AM	54.0
9/19/17 9:11:00 AM	41.0
9/19/17 9:11:30 AM	31.0
9/19/17 9:12:00 AM	21.0
9/19/17 9:12:29 AM	13.0
9/19/17 9:13:00 AM	7.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.670	0	0.674	3.84E-03	1.48E-05
0.540	30	0.533	-6.63E-03	4.40E-05
0.410	60	0.411	1.05E-03	1.11E-06
0.310	90	0.307	-2.60E-03	6.74E-06
0.210	120	0.214	4.32E-03	1.86E-05
0.130	149	0.135	5.43E-03	2.95E-05
0.070	180	0.065	-5.42E-03	2.94E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

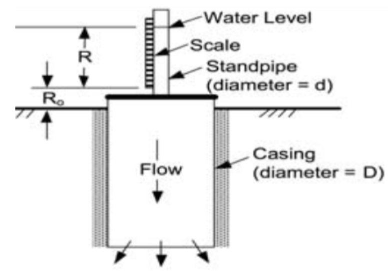
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-03 **Performed By:** JAV
Trial No: 3 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Fitted Variables

a = 0.00348 s^{-1}
Z* = -0.55006 m
Z_0 = 1.17983 m
MSE = 5.45E-06 m



Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 3.5 minutes

R_T = 0.7591
K = 3.01E-04 cm/s
K = 0.4 in/hr

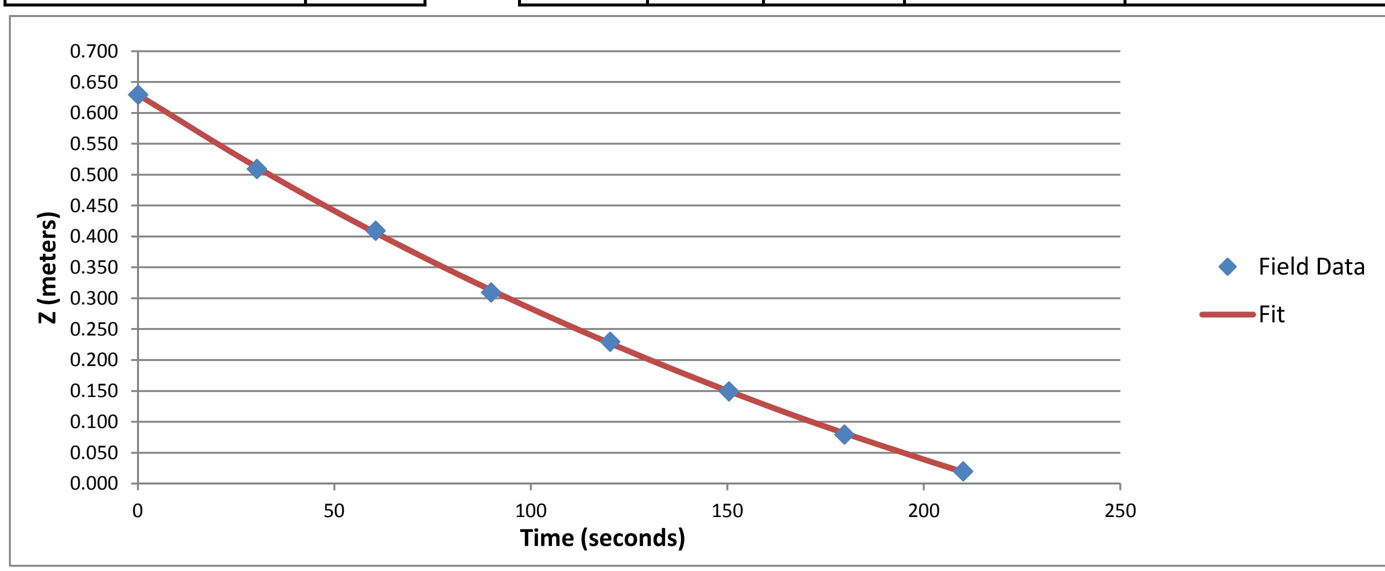
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	R (cm)
9/19/17 9:15:00 AM	63.0
9/19/17 9:15:30 AM	51.0
9/19/17 9:16:00 AM	41.0
9/19/17 9:16:30 AM	31.0
9/19/17 9:17:00 AM	23.0
9/19/17 9:17:30 AM	15.0
9/19/17 9:18:00 AM	8.0
9/19/17 9:18:30 AM	2.0

Z-t computations

Z (m)	t (s)	Fit Z (m)	Error (m)	$Error^2$ (m2)
0.630	0	0.630	-2.29E-04	5.23E-08
0.510	30	0.512	2.04E-03	4.15E-06
0.410	60	0.406	-3.95E-03	1.56E-05
0.310	90	0.313	3.23E-03	1.04E-05
0.230	120	0.227	-2.92E-03	8.51E-06
0.150	150	0.150	-4.68E-04	2.19E-07
0.080	180	0.082	1.61E-03	2.61E-06
0.020	210	0.019	-1.42E-03	2.02E-06



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-03

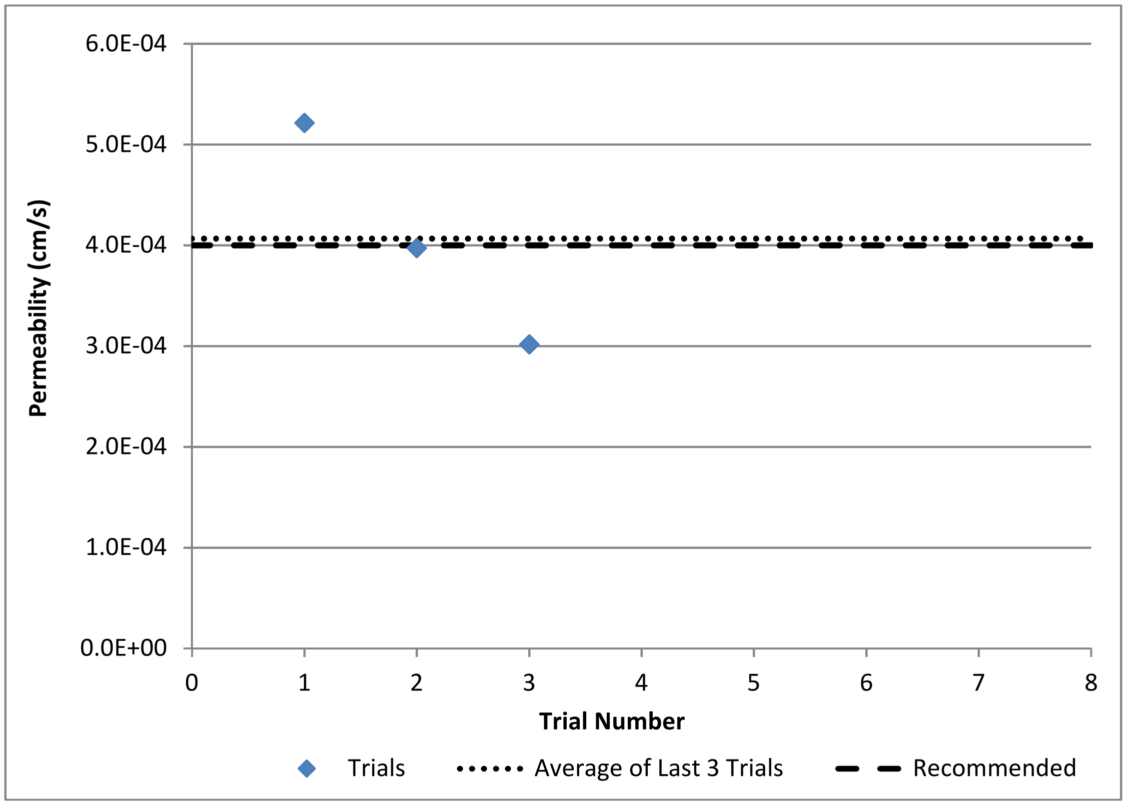
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 4.07E-04 cm/s = 0.6 in/hr

Recommended Hydraulic Conductivity: 4.00E-04 cm/s = 0.6 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	5.21E-04	28%
2	3.97E-04	2%
3	3.01E-04	26%

Notes:



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

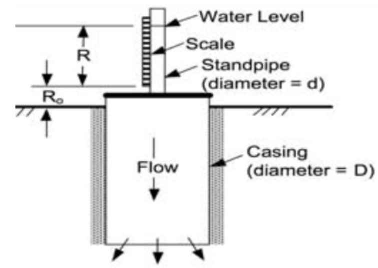
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-04 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d =	2	cm
D =	10	cm
R_0 =	0	cm
Air Temp =	90	degrees F

Fitted Variables

a =	0.00304	s^{-1}
Z* =	-0.28346	m
Z_0 =	0.96591	m
MSE =	8.42E-05	m



Calculations / Result

T =	32	degrees C
Total Time of Test:	0 hours 6.5 minutes	
R_T =	0.7591	
K =	**2.64E-04**	**cm/s**
K =	**0.4**	**in/hr**

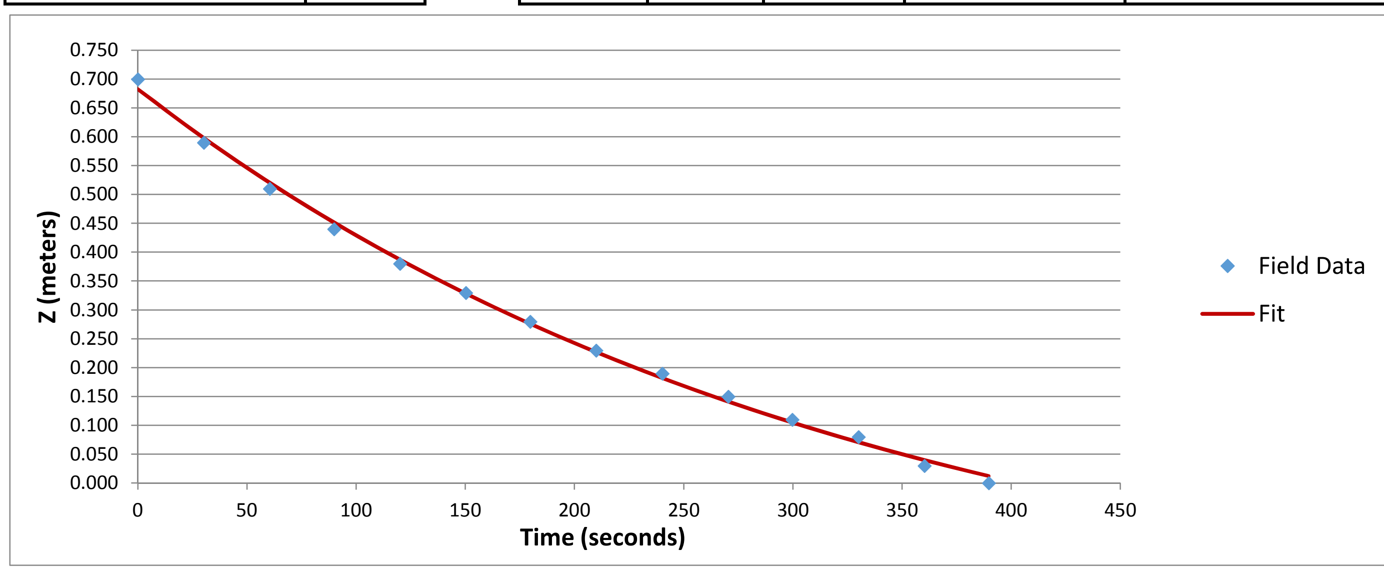
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/19/17 9:40:00 AM	70.0
9/19/17 9:40:30 AM	59.0
9/19/17 9:41:00 AM	51.0
9/19/17 9:41:30 AM	44.0
9/19/17 9:42:00 AM	38.0
9/19/17 9:42:30 AM	33.0
9/19/17 9:43:00 AM	28.0
9/19/17 9:43:30 AM	23.0
9/19/17 9:44:00 AM	19.0
9/19/17 9:44:30 AM	15.0
9/19/17 9:45:00 AM	11.0
9/19/17 9:45:30 AM	8.0
9/19/17 9:46:00 AM	3.0
9/19/17 9:46:30 AM	0.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.700	0	0.682	-1.75E-02	3.08E-04
0.590	30	0.598	7.63E-03	5.81E-05
0.510	60	0.520	1.02E-02	1.05E-04
0.440	90	0.452	1.16E-02	1.34E-04
0.380	120	0.387	7.03E-03	4.95E-05
0.330	150	0.328	-1.85E-03	3.43E-06
0.280	180	0.276	-4.10E-03	1.68E-05
0.230	210	0.227	-3.22E-03	1.04E-05
0.190	240	0.182	-8.03E-03	6.45E-05
0.150	270	0.141	-8.91E-03	7.94E-05
0.110	300	0.105	-5.18E-03	2.68E-05
0.080	330	0.071	-9.28E-03	8.61E-05
0.030	360	0.040	9.62E-03	9.25E-05
0.000	390	0.012	1.20E-02	1.44E-04



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-04

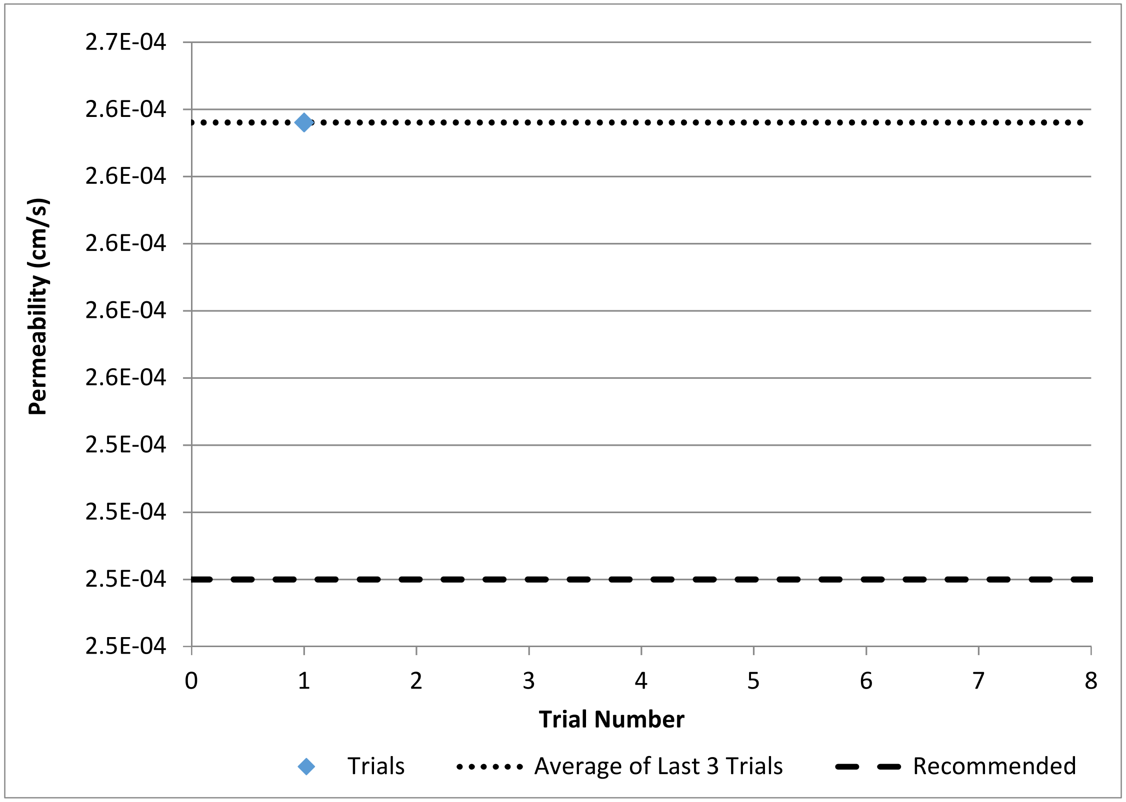
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 2.64E-04 cm/s = 0.4 in/hr

Recommended Hydraulic Conductivity: 2.50E-04 cm/s = 0.4 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	2.64E-04	✓ 0%

Notes:



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

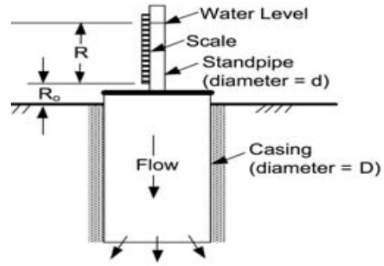
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-07 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Fitted Variables

a = 0.00619 s^{-1}
Z* = -0.36965 m
Z_0 = 1.06771 m
MSE = 1.30E-05 m



Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 2.5 minutes

R_T = 0.7591
K = 5.37E-04 cm/s
K = 0.8 in/hr

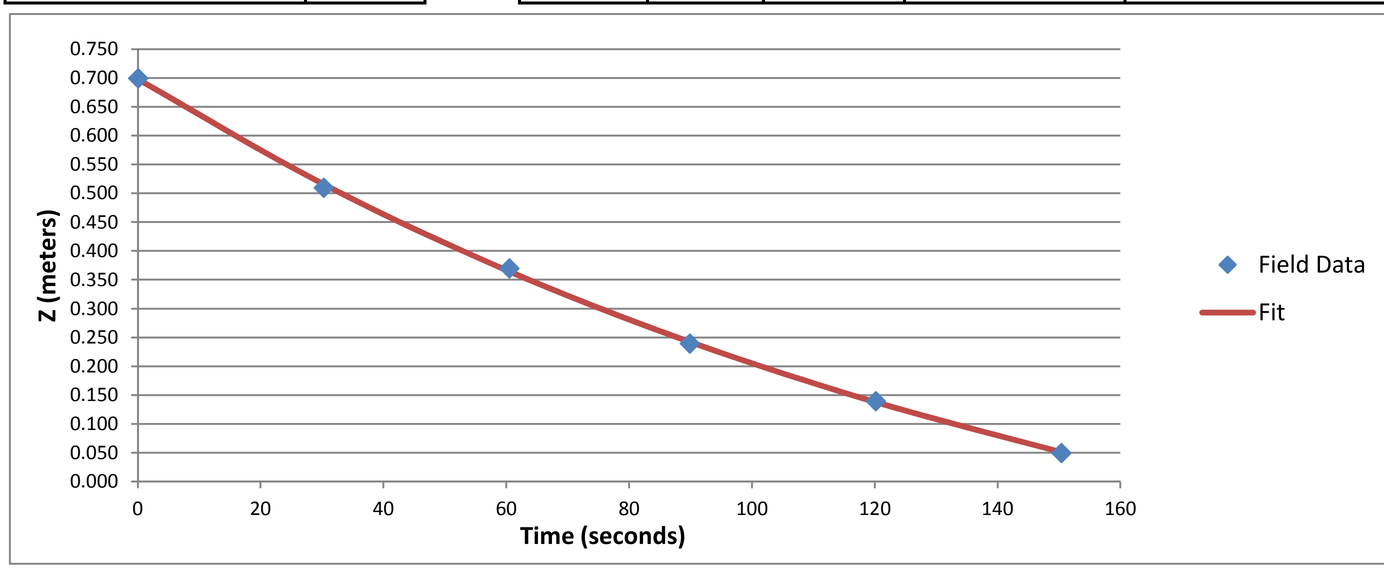
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	R (cm)
9/19/17 10:00:00 AM	70.0
9/19/17 10:00:30 AM	51.0
9/19/17 10:01:00 AM	37.0
9/19/17 10:01:30 AM	24.0
9/19/17 10:02:00 AM	14.0
9/19/17 10:02:30 AM	5.0

Z-t computations

Z (m)	t (s)	Fit Z (m)	Error (m)	Error² (m2)
0.700	0	0.698	-1.94E-03	3.75E-06
0.510	30	0.516	5.74E-03	3.30E-05
0.370	60	0.365	-5.44E-03	2.96E-05
0.240	90	0.242	2.45E-03	6.01E-06
0.140	120	0.138	-2.07E-03	4.29E-06
0.050	150	0.051	1.26E-03	1.58E-06



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-07 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

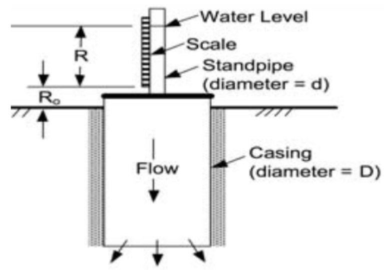
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 3 minutes

Fitted Variables

a = 0.00347 s^{-1}
Z* = -0.67676 m
Z_0 = 1.37596 m
MSE = 1.06E-06 m

R_T = 0.7591
K = 3.01E-04 cm/s
K = 0.4 in/hr



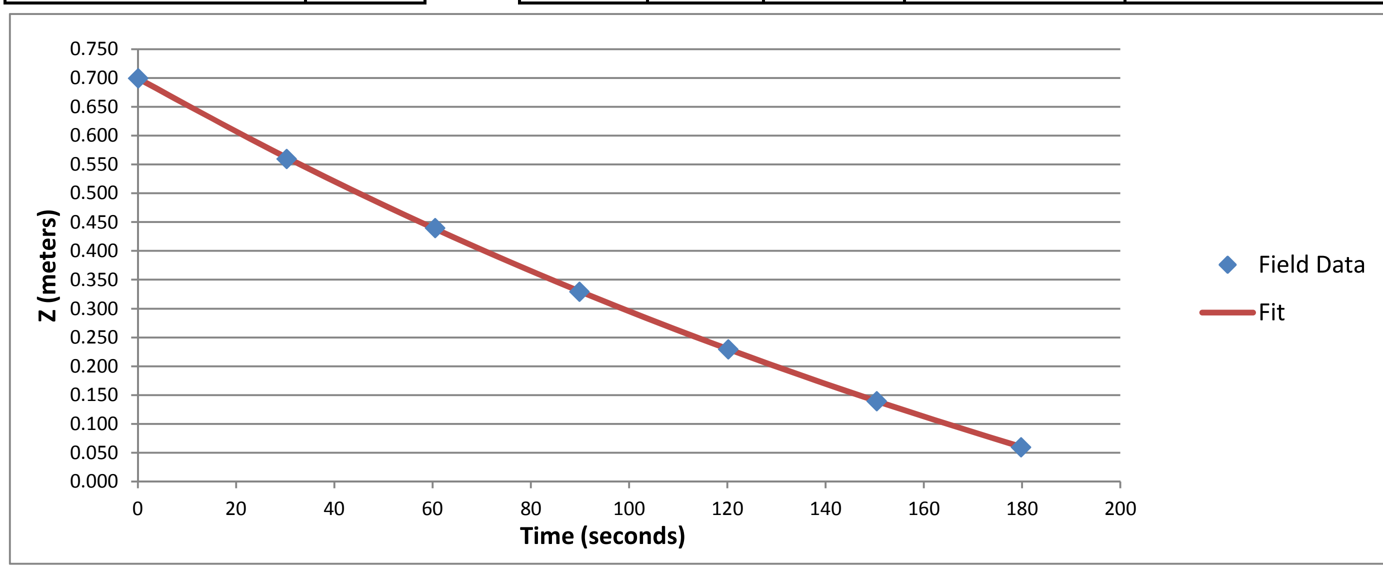
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/19/17 10:05:00 AM	70.0
9/19/17 10:05:30 AM	56.0
9/19/17 10:06:00 AM	44.0
9/19/17 10:06:30 AM	33.0
9/19/17 10:07:00 AM	23.0
9/19/17 10:07:30 AM	14.0
9/19/17 10:08:00 AM	6.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.700	0	0.699	-8.01E-04	6.42E-07
0.560	30	0.562	2.02E-03	4.10E-06
0.440	60	0.439	-1.47E-03	2.17E-06
0.330	90	0.330	3.57E-04	1.27E-07
0.230	120	0.230	-4.63E-05	2.15E-09
0.140	150	0.140	-4.40E-04	1.93E-07
0.060	180	0.060	3.87E-04	1.50E-07



GOLDER

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-07

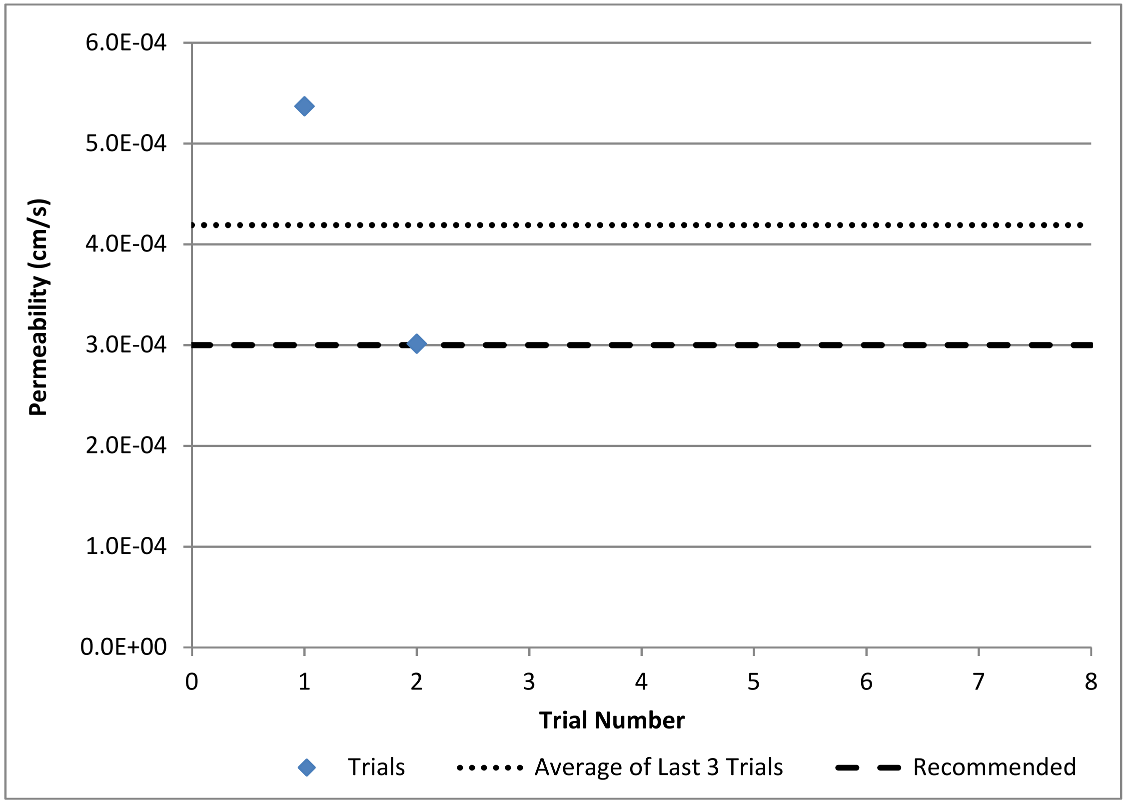
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 4.19E-04 cm/s = 0.6 in/hr

Recommended Hydraulic Conductivity: 3.00E-04 cm/s = 0.4 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	5.37E-04	28%
2	3.01E-04	28%

Notes:



GOLDER

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-13 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

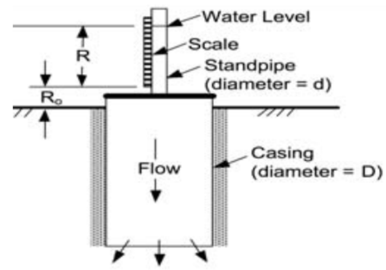
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 3 minutes

Fitted Variables

a = 0.00531 s^{-1}
Z* = -0.44094 m
Z_0 = 1.14087 m
MSE = 3.20E-06 m

R_T = 0.7591
K = 4.61E-04 cm/s
K = 0.7 in/hr



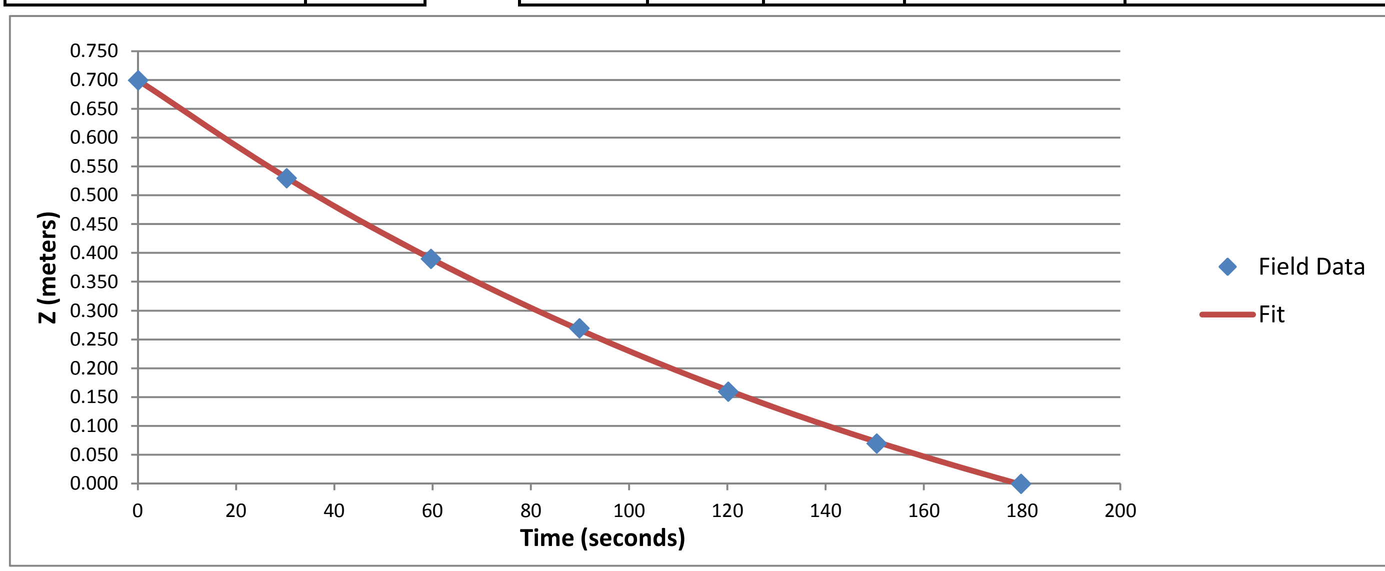
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/20/17 9:05:00 AM	70.0
9/20/17 9:05:30 AM	53.0
9/20/17 9:06:00 AM	39.0
9/20/17 9:06:30 AM	27.0
9/20/17 9:07:00 AM	16.0
9/20/17 9:07:30 AM	7.0
9/20/17 9:08:00 AM	0.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*$Error^2$ (m2)*
0.700	0	0.700	-6.47E-05	4.18E-09
0.530	30	0.531	6.12E-04	3.74E-07
0.390	60	0.390	2.25E-04	5.05E-08
0.270	90	0.267	-3.13E-03	9.82E-06
0.160	120	0.162	1.82E-03	3.30E-06
0.070	150	0.072	2.36E-03	5.56E-06
0.000	180	-0.002	-1.81E-03	3.28E-06



GOLDER

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

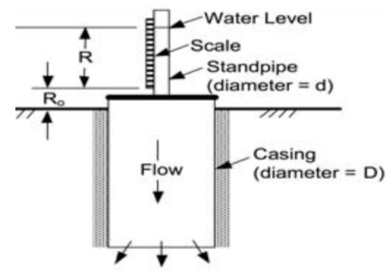
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-13 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP

Inputs

d =	2	cm
D =	10	cm
R_0 =	0	cm
Air Temp =	90	degrees F

Fitted Variables

a =	0.00340	s^{-1}
Z* =	-0.80307	m
Z_0 =	1.50159	m
MSE =	6.94E-06	m



Calculations / Result

T =	32	degrees C
Total Time of Test:	0 hours 3 minutes	

R_T =	0.7591	
K =	**2.95E-04**	**cm/s**
K =	**0.4**	**in/hr**

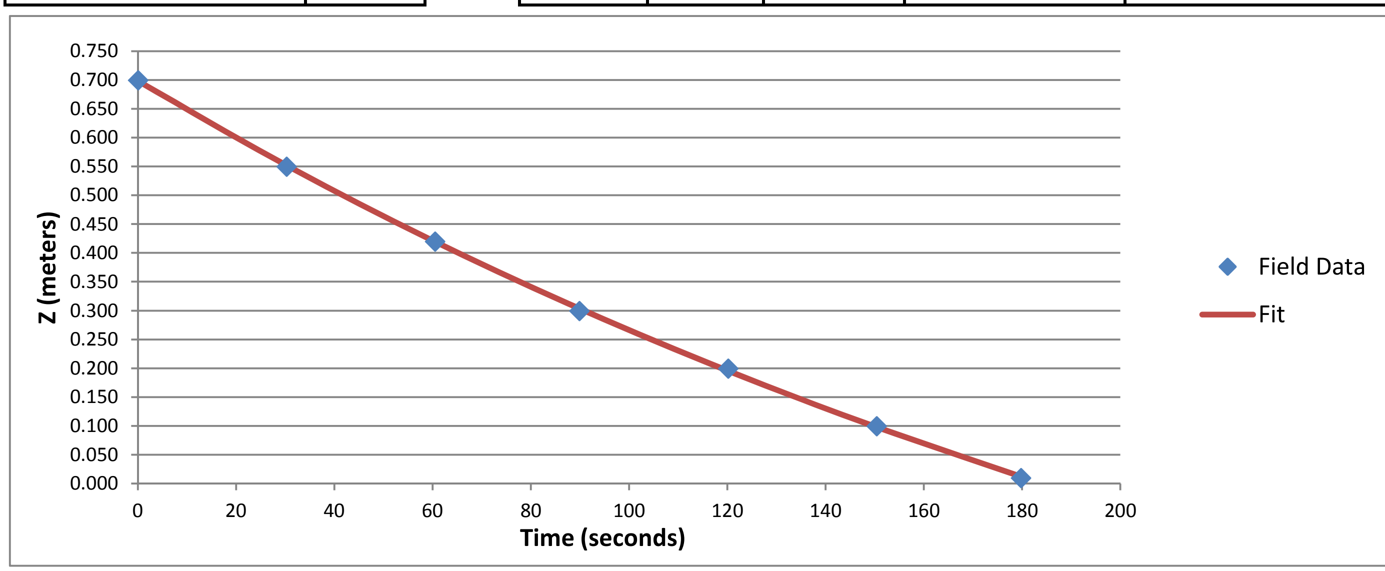
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/20/17 9:10:00 AM	70.0
9/20/17 9:10:30 AM	55.0
9/20/17 9:11:00 AM	42.0
9/20/17 9:11:30 AM	30.0
9/20/17 9:12:00 AM	20.0
9/20/17 9:12:30 AM	10.0
9/20/17 9:13:00 AM	1.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.700	0	0.699	-1.47E-03	2.18E-06
0.550	30	0.552	1.96E-03	3.84E-06
0.420	60	0.420	-2.98E-04	8.89E-08
0.300	90	0.304	3.59E-03	1.29E-05
0.200	120	0.196	-4.42E-03	1.96E-05
0.100	150	0.098	-1.90E-03	3.59E-06
0.010	180	0.013	2.53E-03	6.42E-06



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-13 **Performed By:** JAV
Trial No: 3 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

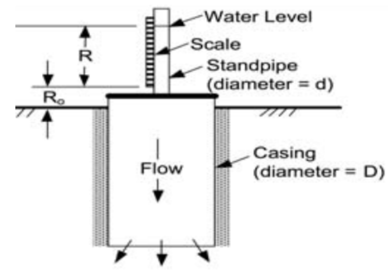
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 2.5 minutes

Fitted Variables

a = 0.00318 s^{-1}
Z* = -0.84436 m
Z_0 = 1.44223 m
MSE = 9.34E-06 m

R_T = 0.7591
K = 2.75E-04 cm/s
K = 0.4 in/hr



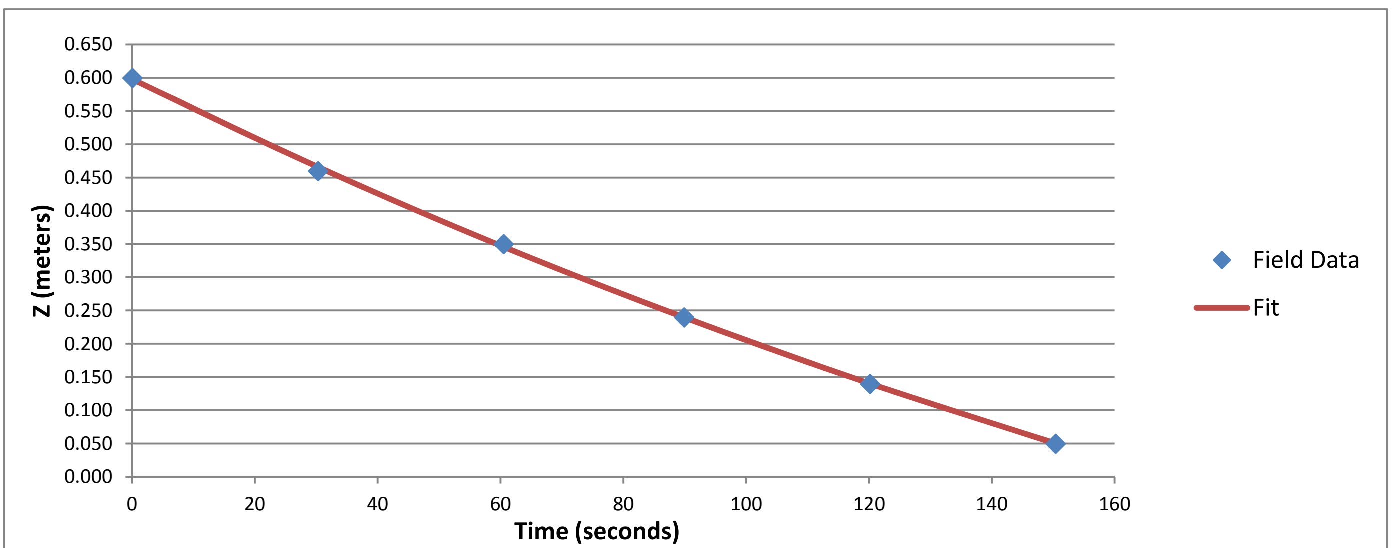
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/20/17 9:15:00 AM	60.0
9/20/17 9:15:30 AM	46.0
9/20/17 9:16:00 AM	35.0
9/20/17 9:16:30 AM	24.0
9/20/17 9:17:00 AM	14.0
9/20/17 9:17:30 AM	5.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.600	0	0.598	-2.13E-03	4.53E-06
0.460	30	0.466	5.79E-03	3.35E-05
0.350	60	0.346	-4.19E-03	1.76E-05
0.240	90	0.240	-2.17E-04	4.70E-08
0.140	120	0.140	4.97E-04	2.47E-07
0.050	150	0.050	3.04E-04	9.24E-08



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

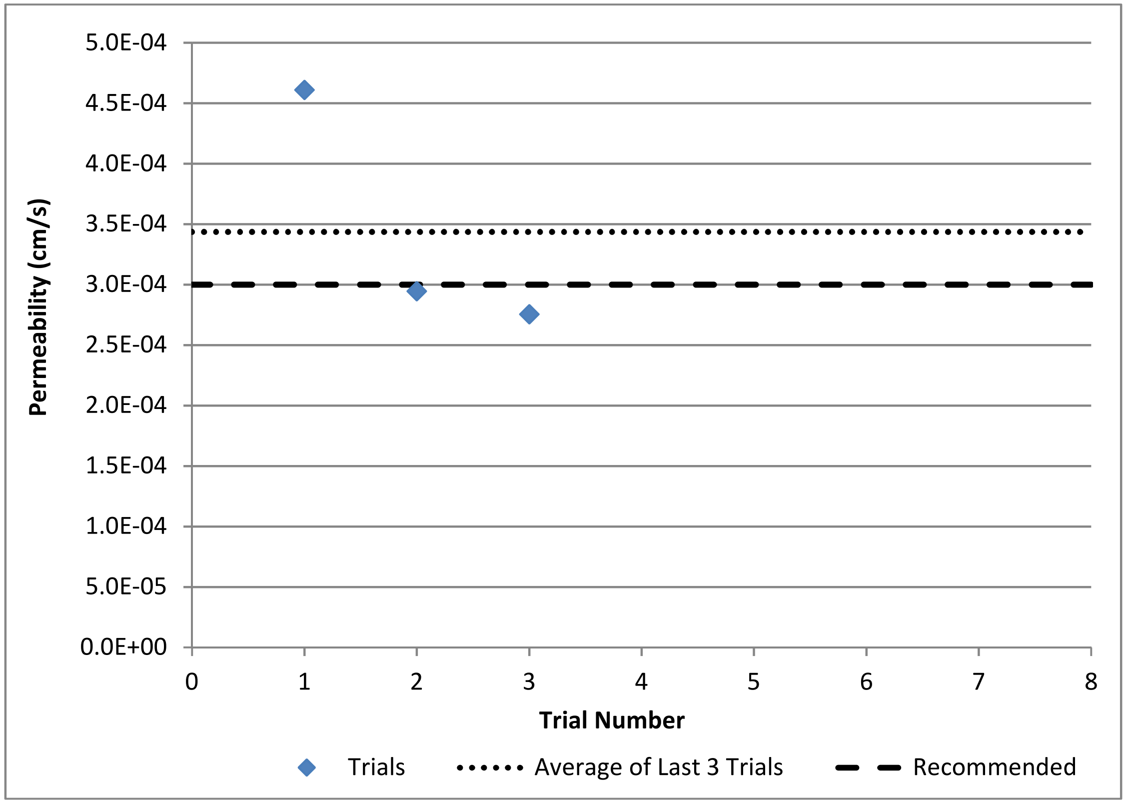
Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-13

Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 3.44E-04 cm/s = 0.5 in/hr

Recommended Hydraulic Conductivity: 3.00E-04 cm/s = 0.4 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	4.61E-04	34%
2	2.95E-04	14%
3	2.75E-04	20%



Notes:

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

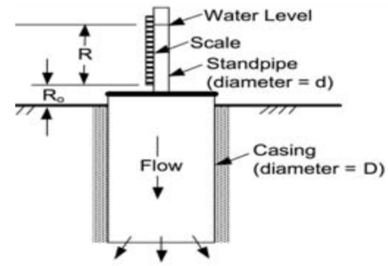
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-17 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Fitted Variables

a = 0.00136 s^{-1}
Z* = 0.00504 m
Z_0 = 0.67945 m
MSE = 4.12E-05 m



$$K = R_T \frac{a \pi d^2}{11D}$$

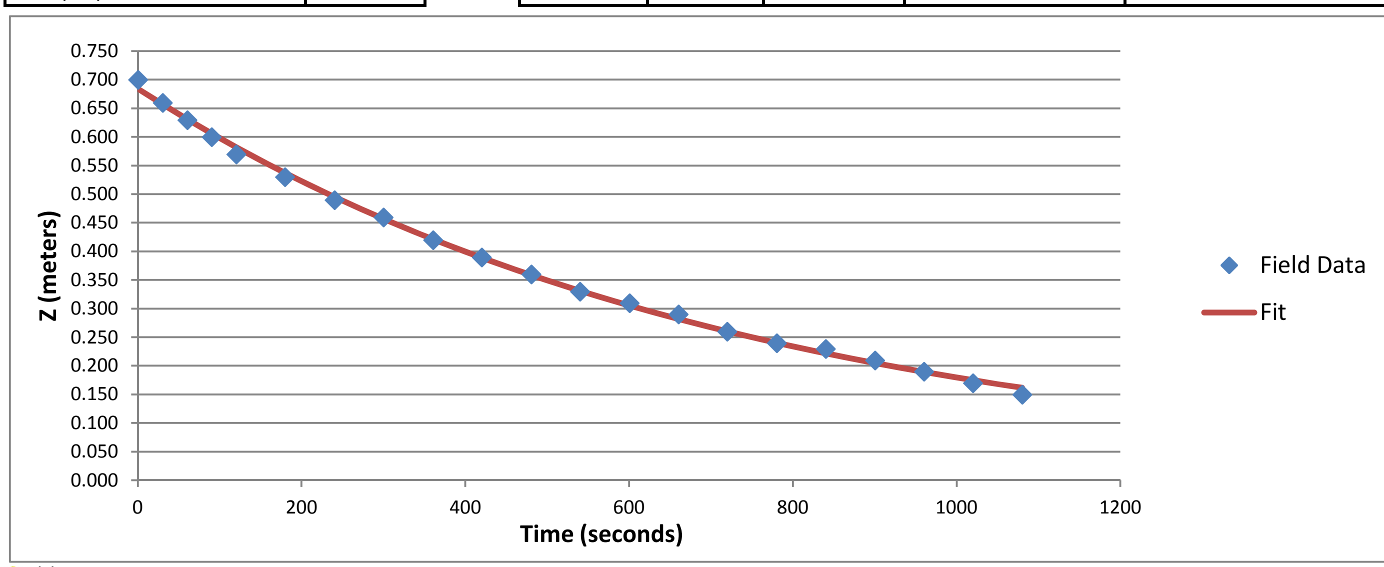
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 18 minutes

R_T = 0.7591
K = 1.18E-04 cm/s
K = 0.2 in/hr

Field Data / **Z-t computations**

Time	R (cm)	Z (m)	t (s)	Fit Z (m)	Error (m)	Error^2 (m2)
9/22/17 10:00:00 AM	70.0	0.700	0	0.684	-1.55E-02	2.41E-04
9/22/17 10:00:30 AM	66.0	0.660	30	0.657	-2.89E-03	8.33E-06
9/22/17 10:01:00 AM	63.0	0.630	60	0.631	8.41E-04	7.07E-07
9/22/17 10:01:30 AM	60.0	0.600	90	0.606	6.33E-03	4.01E-05
9/22/17 10:02:00 AM	57.0	0.570	120	0.582	1.21E-02	1.47E-04
9/22/17 10:03:00 AM	53.0	0.530	180	0.537	7.17E-03	5.14E-05
9/22/17 10:04:00 AM	49.0	0.490	240	0.495	5.15E-03	2.66E-05
9/22/17 10:05:00 AM	46.0	0.460	300	0.457	-3.01E-03	9.08E-06
9/22/17 10:06:00 AM	42.0	0.420	360	0.421	1.30E-03	1.70E-06
9/22/17 10:07:00 AM	39.0	0.390	420	0.389	-1.11E-03	1.24E-06
9/22/17 10:08:00 AM	36.0	0.360	480	0.359	-1.42E-03	2.02E-06
9/22/17 10:09:00 AM	33.0	0.330	540	0.331	1.05E-03	1.10E-06
9/22/17 10:10:00 AM	31.0	0.310	600	0.305	-4.69E-03	2.20E-05
9/22/17 10:11:00 AM	29.0	0.290	660	0.282	-8.08E-03	6.52E-05
9/22/17 10:12:00 AM	26.0	0.260	720	0.260	3.62E-04	1.31E-07
9/22/17 10:13:00 AM	24.0	0.240	780	0.240	2.02E-04	4.09E-08
9/22/17 10:14:00 AM	23.0	0.230	840	0.222	-8.11E-03	6.58E-05
9/22/17 10:15:00 AM	21.0	0.210	900	0.205	-5.23E-03	2.74E-05
9/22/17 10:16:00 AM	19.0	0.190	960	0.189	-7.87E-04	6.19E-07
9/22/17 10:17:00 AM	17.0	0.170	1020	0.175	4.87E-03	2.37E-05
9/22/17 10:18:00 AM	15.0	0.150	1080	0.161	1.15E-02	1.31E-04



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

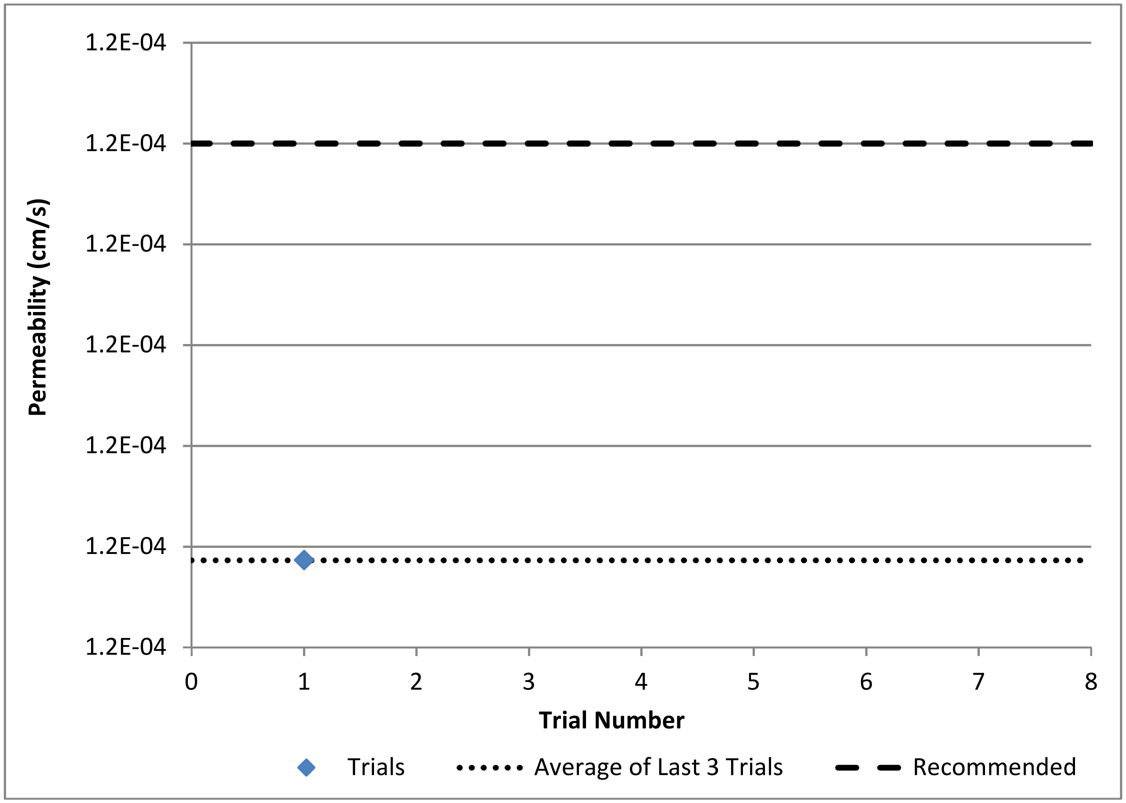
Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-17
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 1.18E-04 cm/s = 0.2 in/hr

Recommended Hydraulic Conductivity: 1.20E-04 cm/s = 0.2 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	1.18E-04	✓ 0%

Notes:



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-22 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

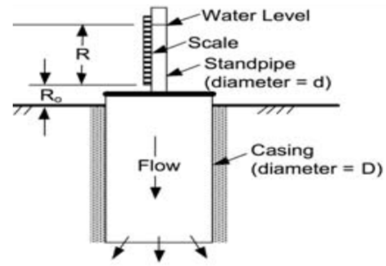
d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 20 minutes

Fitted Variables

a = 0.00115 s^{-1}
Z* = -0.01044 m
Z_0 = 0.69518 m
MSE = 6.62E-05 m
R_T = 0.7591
K = 9.95E-05 cm/s
K = 0.1 in/hr



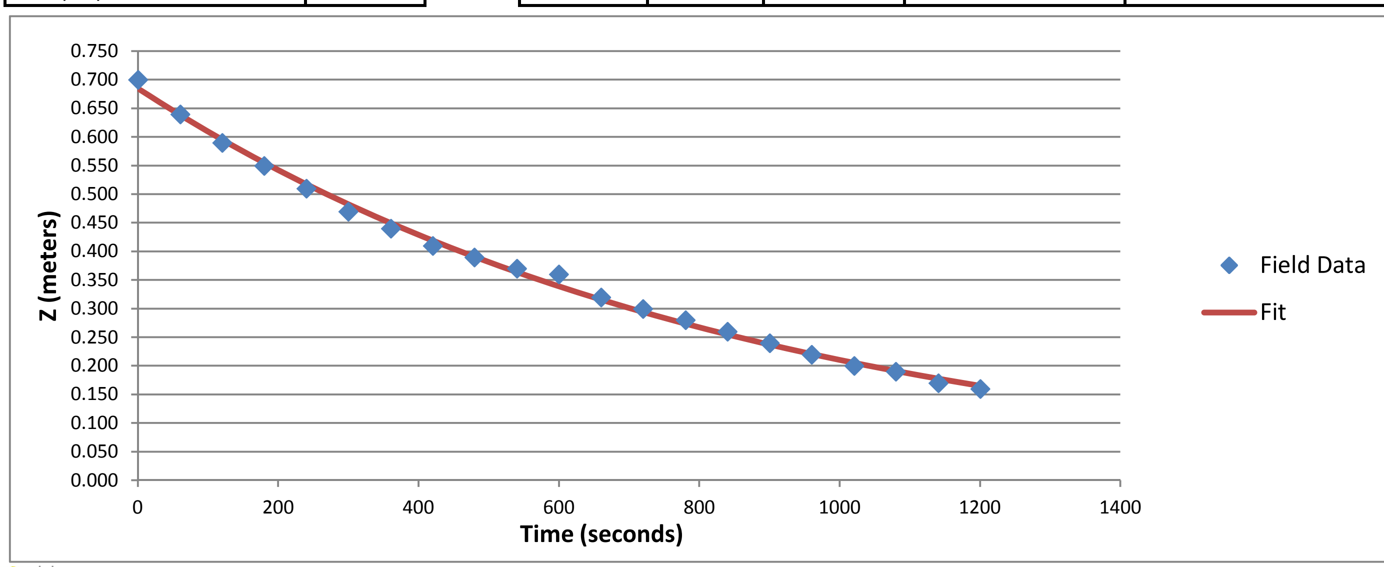
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	R (cm)
9/20/17 10:00:00 AM	70.0
9/20/17 10:01:00 AM	64.0
9/20/17 10:02:00 AM	59.0
9/20/17 10:03:00 AM	55.0
9/20/17 10:04:00 AM	51.0
9/20/17 10:05:00 AM	47.0
9/20/17 10:06:00 AM	44.0
9/20/17 10:07:00 AM	41.0
9/20/17 10:08:00 AM	39.0
9/20/17 10:09:00 AM	37.0
9/20/17 10:10:00 AM	36.0
9/20/17 10:11:00 AM	32.0
9/20/17 10:12:00 AM	30.0
9/20/17 10:13:00 AM	28.0
9/20/17 10:14:00 AM	26.0
9/20/17 10:15:00 AM	24.0
9/20/17 10:16:00 AM	22.0
9/20/17 10:17:00 AM	20.0
9/20/17 10:18:00 AM	19.0
9/20/17 10:19:00 AM	17.0
9/20/17 10:20:00 AM	16.0

Z-t computations

Z (m)	t (s)	Fit Z (m)	Error (m)	$Error^2$ (m2)
0.700	0	0.685	-1.53E-02	2.33E-04
0.640	60	0.638	-1.85E-03	3.43E-06
0.590	120	0.595	5.28E-03	2.78E-05
0.550	180	0.555	5.24E-03	2.75E-05
0.510	240	0.517	7.33E-03	5.37E-05
0.470	300	0.482	1.24E-02	1.55E-04
0.440	360	0.449	9.41E-03	8.85E-05
0.410	420	0.419	9.01E-03	8.12E-05
0.390	480	0.391	6.25E-04	3.90E-07
0.370	540	0.364	-6.26E-03	3.91E-05
0.360	600	0.339	-2.10E-02	4.41E-04
0.320	660	0.316	-4.41E-03	1.95E-05
0.300	720	0.294	-5.96E-03	3.55E-05
0.280	780	0.274	-6.37E-03	4.06E-05
0.260	840	0.255	-5.15E-03	2.65E-05
0.240	900	0.237	-2.93E-03	8.56E-06
0.220	960	0.221	7.13E-04	5.09E-07
0.200	1020	0.205	5.22E-03	2.73E-05
0.190	1080	0.191	9.66E-04	9.33E-07
0.170	1140	0.177	7.47E-03	5.58E-05
0.160	1200	0.165	5.05E-03	2.55E-05



GOLDER

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-22

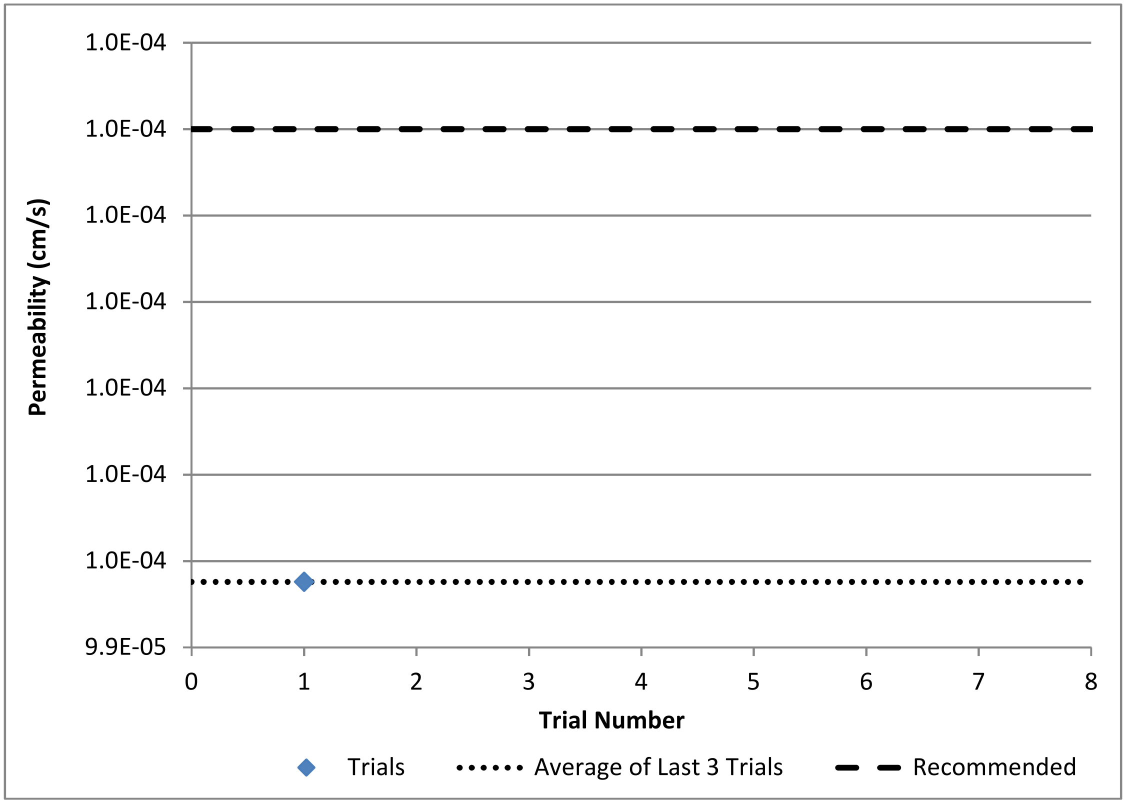
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 9.95E-05 cm/s = 0.1 in/hr

Recommended Hydraulic Conductivity: 1.00E-04 cm/s = 0.1 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	9.95E-05	✓ 0%

Notes:



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-26 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

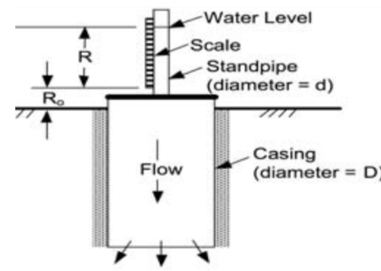
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 3 minutes

Fitted Variables

a = 0.00738 s^{-1}
Z* = -0.19941 m
Z_0 = 0.89497 m
MSE = 3.90E-05 m

R_T = 0.7591
K = 6.40E-04 cm/s
K = 0.9 in/hr



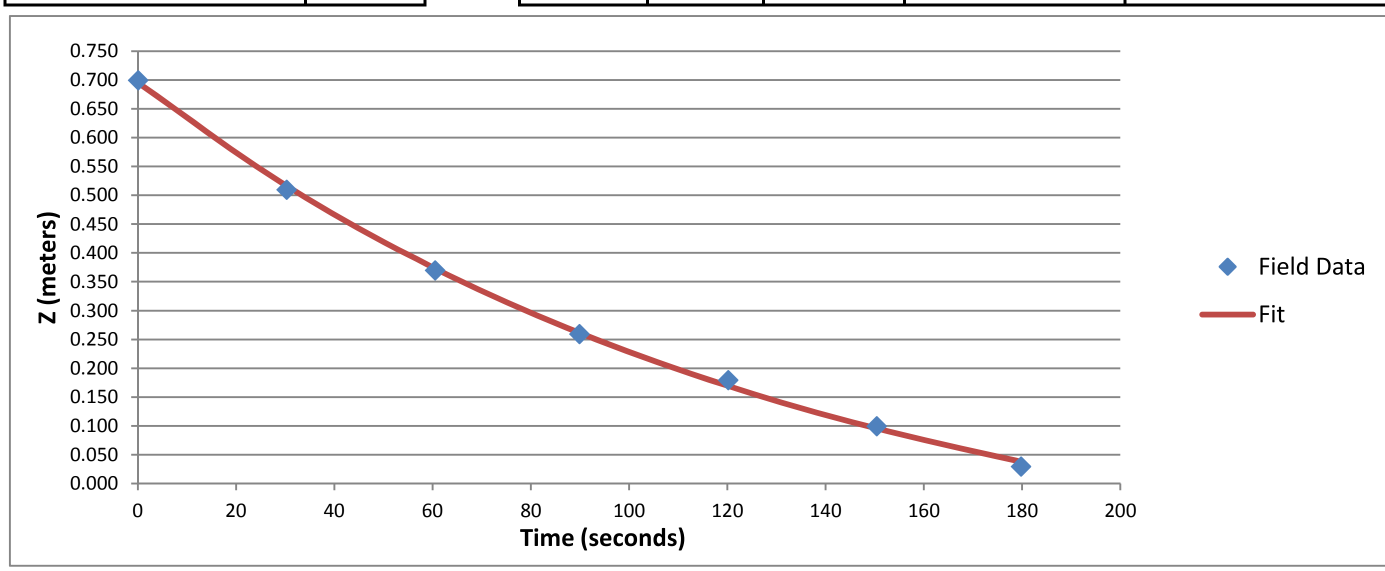
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/21/17 9:05:00 AM	70.0
9/21/17 9:05:30 AM	51.0
9/21/17 9:06:00 AM	37.0
9/21/17 9:06:30 AM	26.0
9/21/17 9:07:00 AM	18.0
9/21/17 9:07:30 AM	10.0
9/21/17 9:08:00 AM	3.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.700	0	0.696	-4.44E-03	1.97E-05
0.510	30	0.517	6.50E-03	4.23E-05
0.370	60	0.373	3.27E-03	1.07E-05
0.260	90	0.262	1.62E-03	2.62E-06
0.180	120	0.169	-1.06E-02	1.13E-04
0.100	150	0.096	-4.41E-03	1.94E-05
0.030	180	0.038	8.08E-03	6.53E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-26 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

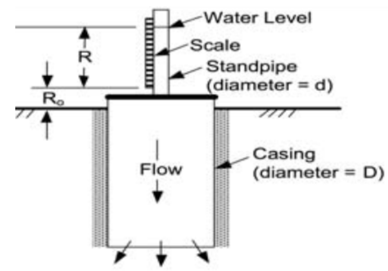
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 4.5 minutes

Fitted Variables

a = 0.00376 s^{-1}
Z* = -0.35771 m
Z_0 = 1.05398 m
MSE = 1.47E-05 m

R_T = 0.7591
K = 3.26E-04 cm/s
K = 0.5 in/hr



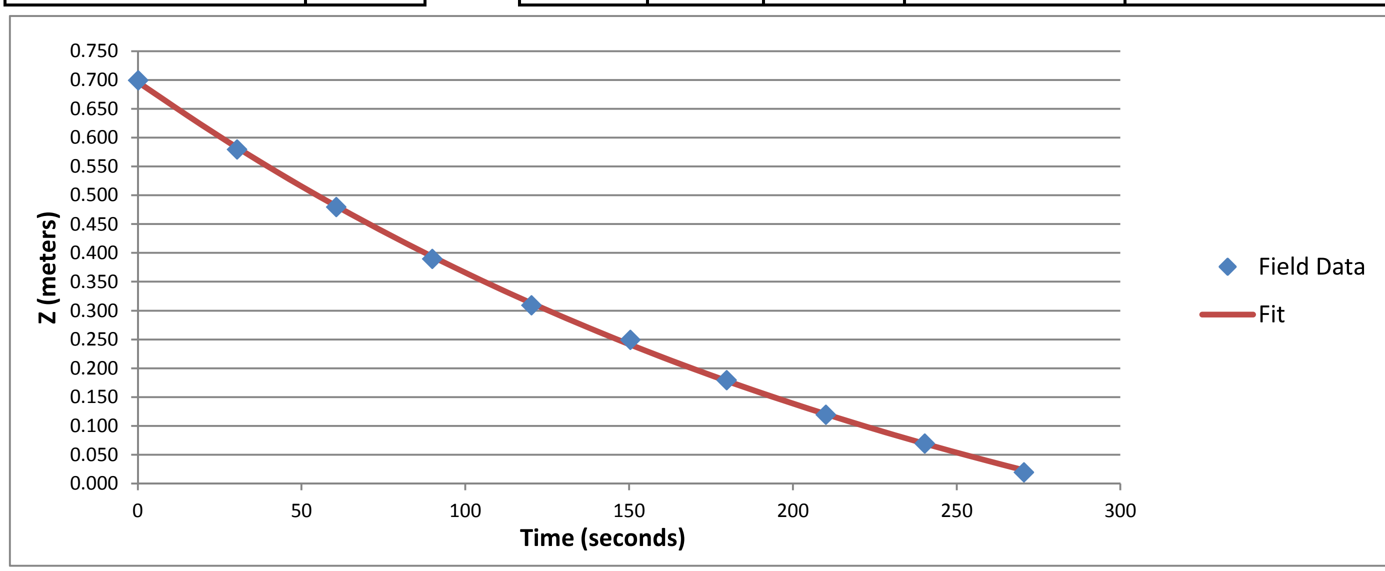
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/19/17 9:10:00 AM	70.0
9/19/17 9:10:30 AM	58.0
9/19/17 9:11:00 AM	48.0
9/19/17 9:11:30 AM	39.0
9/19/17 9:12:00 AM	31.0
9/19/17 9:12:30 AM	25.0
9/19/17 9:13:00 AM	18.0
9/19/17 9:13:30 AM	12.0
9/19/17 9:14:00 AM	7.0
9/19/17 9:14:30 AM	2.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.700	0	0.696	-3.74E-03	1.40E-05
0.580	30	0.583	2.90E-03	8.42E-06
0.480	60	0.482	1.73E-03	3.00E-06
0.390	90	0.394	3.88E-03	1.51E-05
0.310	120	0.313	3.04E-03	9.26E-06
0.250	150	0.241	-9.10E-03	8.28E-05
0.180	180	0.178	-1.75E-03	3.05E-06
0.120	210	0.121	6.06E-04	3.67E-07
0.070	240	0.069	-8.40E-04	7.06E-07
0.020	270	0.023	3.25E-03	1.05E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-26

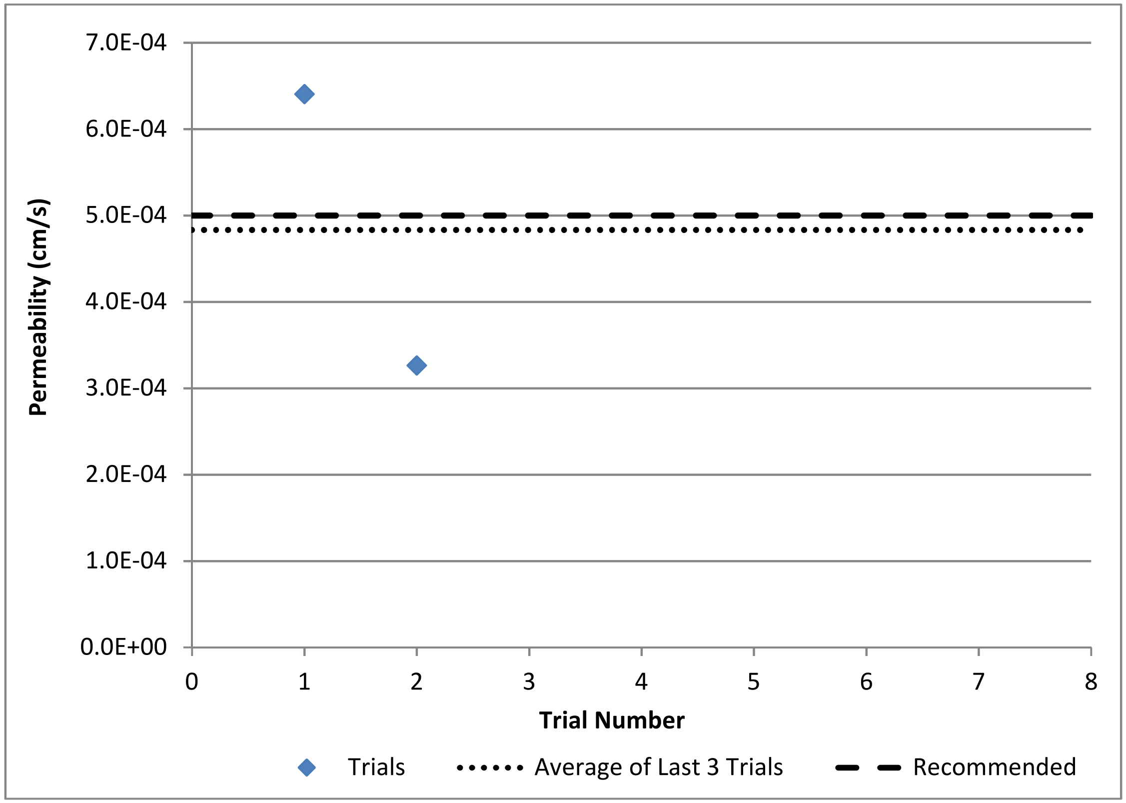
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 4.83E-04 cm/s = 0.7 in/hr

Recommended Hydraulic Conductivity: 5.00E-04 cm/s = 0.7 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	6.40E-04	32%
2	3.26E-04	32%

Notes:



GOLDER

Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

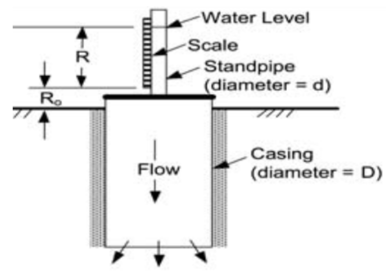
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-29 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

Fitted Variables

a = 0.00775 s^{-1}
Z* = -0.33162 m
Z_0 = 1.03000 m
MSE = 2.20E-05 m



Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 2 minutes

R_T = 0.7591
K = 6.72E-04 cm/s
K = 1.0 in/hr

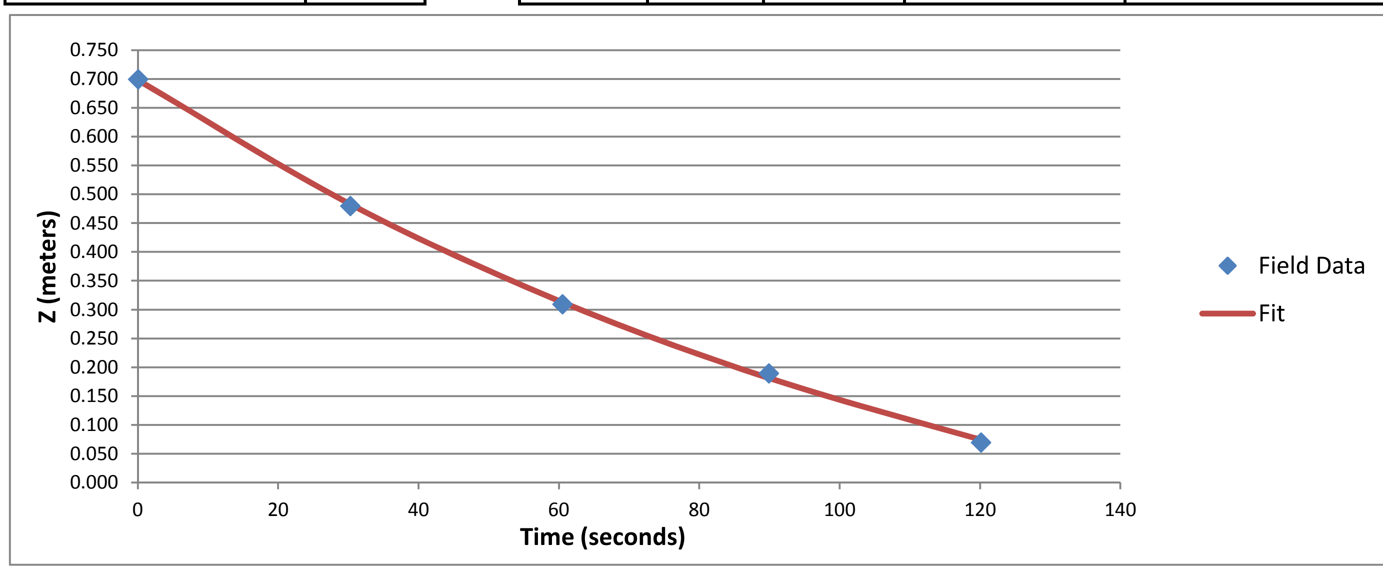
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/21/17 10:05:00 AM	70.0
9/21/17 10:05:30 AM	48.0
9/21/17 10:06:00 AM	31.0
9/21/17 10:06:30 AM	19.0
9/21/17 10:07:00 AM	7.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error² (m2)*
0.700	0	0.698	-1.62E-03	2.63E-06
0.480	30	0.483	3.08E-03	9.47E-06
0.310	60	0.313	2.78E-03	7.74E-06
0.190	90	0.182	-8.49E-03	7.21E-05
0.070	120	0.074	4.25E-03	1.81E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-29 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP

Inputs

d = 2 cm
D = 10 cm
R_0 = 0 cm
Air Temp = 90 degrees F

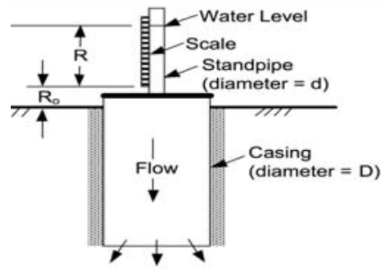
Calculations / Result

T = 32 degrees C
Total Time of Test: 0 hours 2.5 minutes

Fitted Variables

a = 0.00484 s^{-1}
Z* = -0.51272 m
Z_0 = 1.21529 m
MSE = 2.40E-05 m

R_T = 0.7591
K = 4.19E-04 cm/s
K = 0.6 in/hr



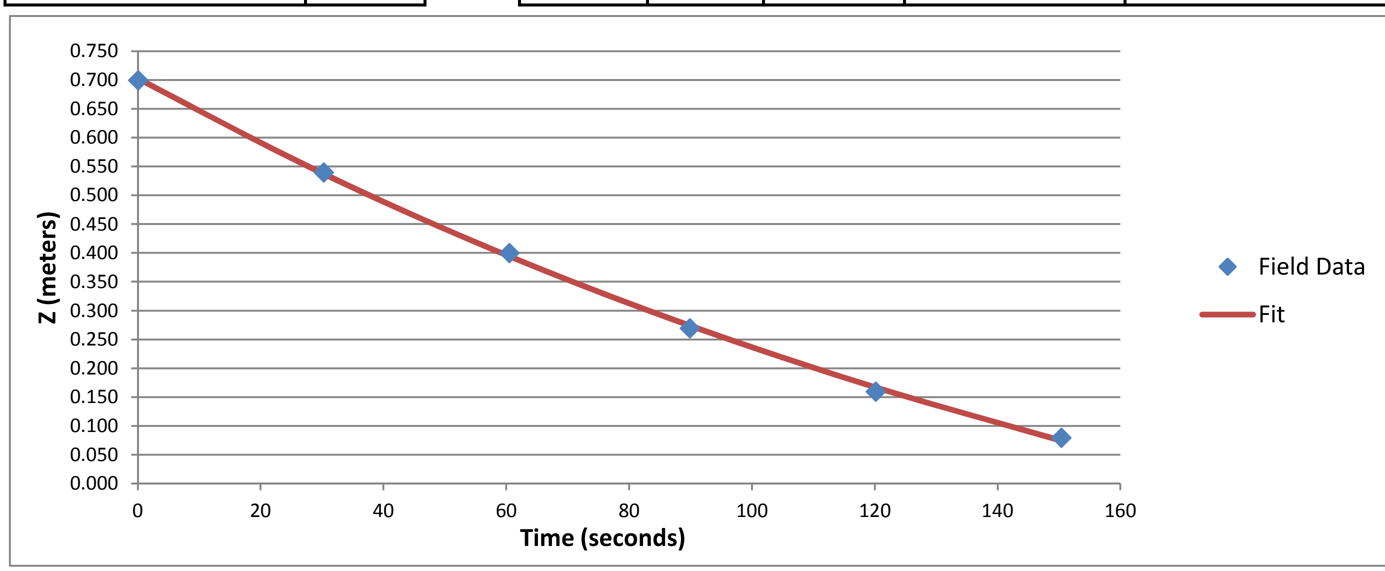
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	R (cm)
9/21/17 10:10:00 AM	70.0
9/21/17 10:10:30 AM	54.0
9/21/17 10:11:00 AM	40.0
9/21/17 10:11:30 AM	27.0
9/21/17 10:12:00 AM	16.0
9/21/17 10:12:30 AM	8.0

Z-t computations

Z (m)	t (s)	Fit Z (m)	Error (m)	$Error^2$ (m2)
0.700	0	0.703	2.57E-03	6.61E-06
0.540	30	0.537	-2.80E-03	7.84E-06
0.400	60	0.394	-5.67E-03	3.21E-05
0.270	90	0.274	4.19E-03	1.75E-05
0.160	120	0.167	7.11E-03	5.05E-05
0.080	150	0.075	-5.40E-03	2.91E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053

Hole ID / Location: BH-29 **Performed By:** JAV

Trial No: 3 **Checked By:** RMP

Inputs

d = 2 cm

D = 10 cm

R_0 = 0 cm

Air Temp = 90 degrees F

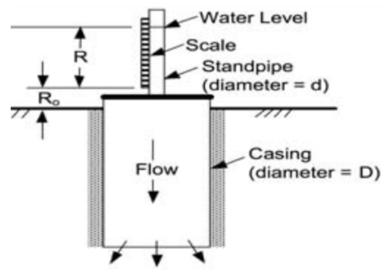
Fitted Variables

a = 0.00404 s^{-1}

Z* = -0.60413 m

Z_0 = 1.20369 m

MSE = 4.26E-06 m



$$K = R_T \frac{a\pi d^2}{11D}$$

Calculations / Result

T = 32 degrees C

Total Time of Test: 0 hours 2.5 minutes

R_T = 0.7591

K = 3.51E-04 cm/s

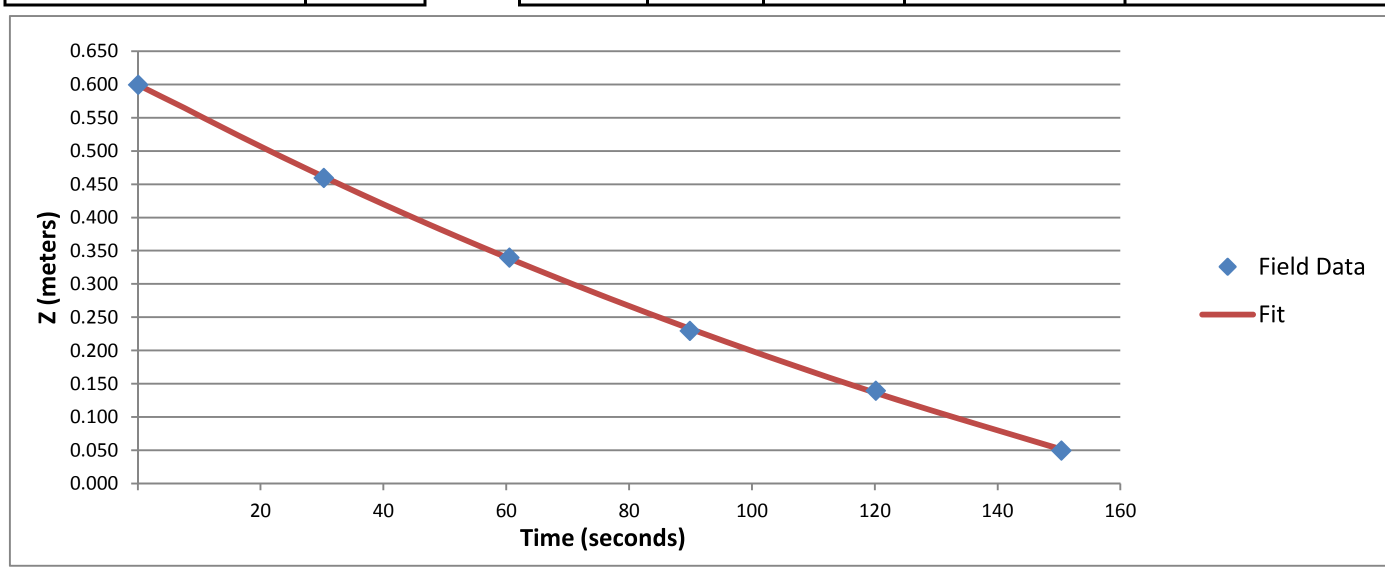
K = 0.5 in/hr

Field Data

Time	*R (cm)*
9/21/17 10:15:00 AM	60.0
9/21/17 10:15:30 AM	46.0
9/21/17 10:16:00 AM	34.0
9/21/17 10:16:30 AM	23.0
9/21/17 10:17:00 AM	14.0
9/21/17 10:17:30 AM	5.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.600	0	0.600	-4.44E-04	1.97E-07
0.460	30	0.461	1.05E-03	1.10E-06
0.340	60	0.338	-1.52E-03	2.32E-06
0.230	90	0.233	2.93E-03	8.58E-06
0.140	120	0.137	-3.39E-03	1.15E-05
0.050	150	0.051	1.37E-03	1.88E-06



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

Project: Valencia Rd. Improvements Geotech Inv.
Hole ID / Location: BH-29

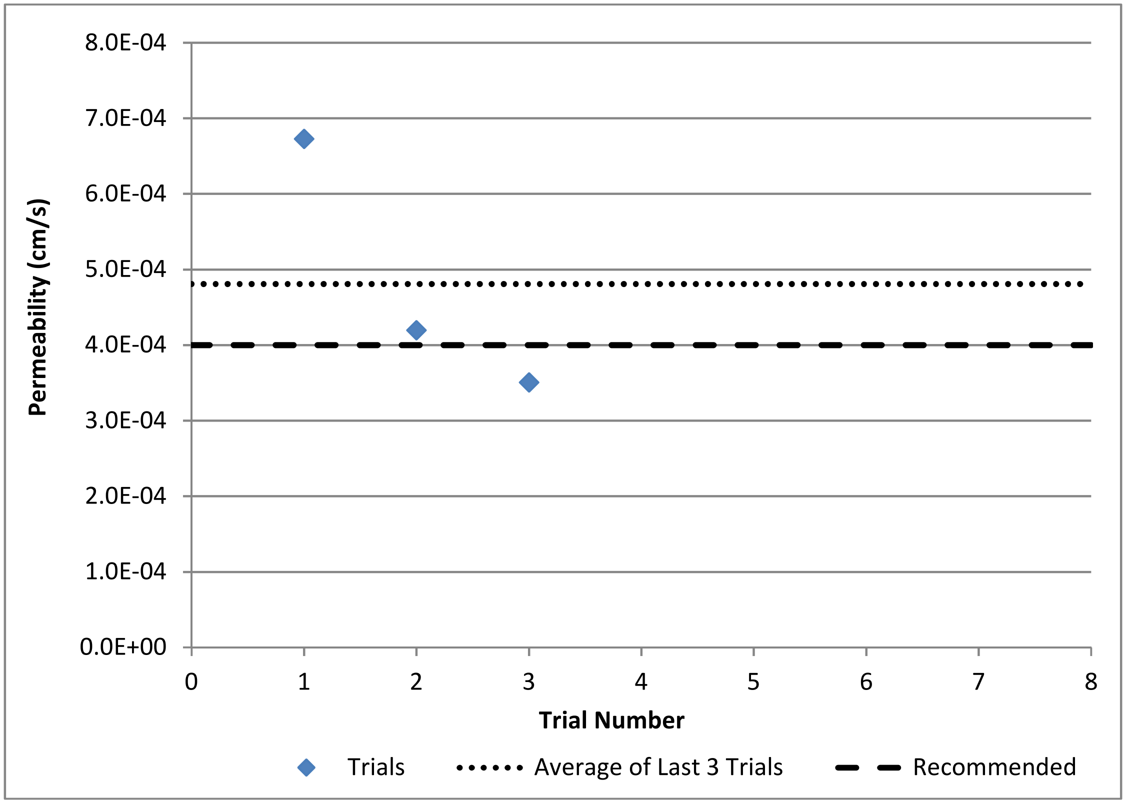
Project No. 1660053
Analyzed By: JAV
Checked By: RMP

Average of Last 3 Trials: 4.81E-04 cm/s = 0.7 in/hr

Recommended Hydraulic Conductivity: 4.00E-04 cm/s = 0.6 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	6.72E-04	40%
2	4.19E-04	13%
3	3.51E-04	27%

Notes:



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-32 **Performed By:** JAV
Trial No: 1 **Checked By:** RMP

Inputs

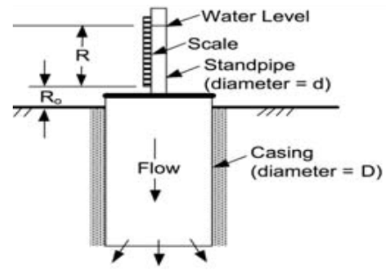
d =	2	cm
D =	10	cm
R_0 =	0	cm
Air Temp =	90	degrees F

Calculations / Result

T =	32	degrees C
Total Time of Test:	0 hours 2.5 minutes	

Fitted Variables

a =	0.00632	s^{-1}
Z* =	-0.40939	m
Z_0 =	1.10616	m
MSE =	4.46E-05	m
R_T =	0.7591	
K =	**5.48E-04**	**cm/s**
K =	**0.8**	**in/hr**



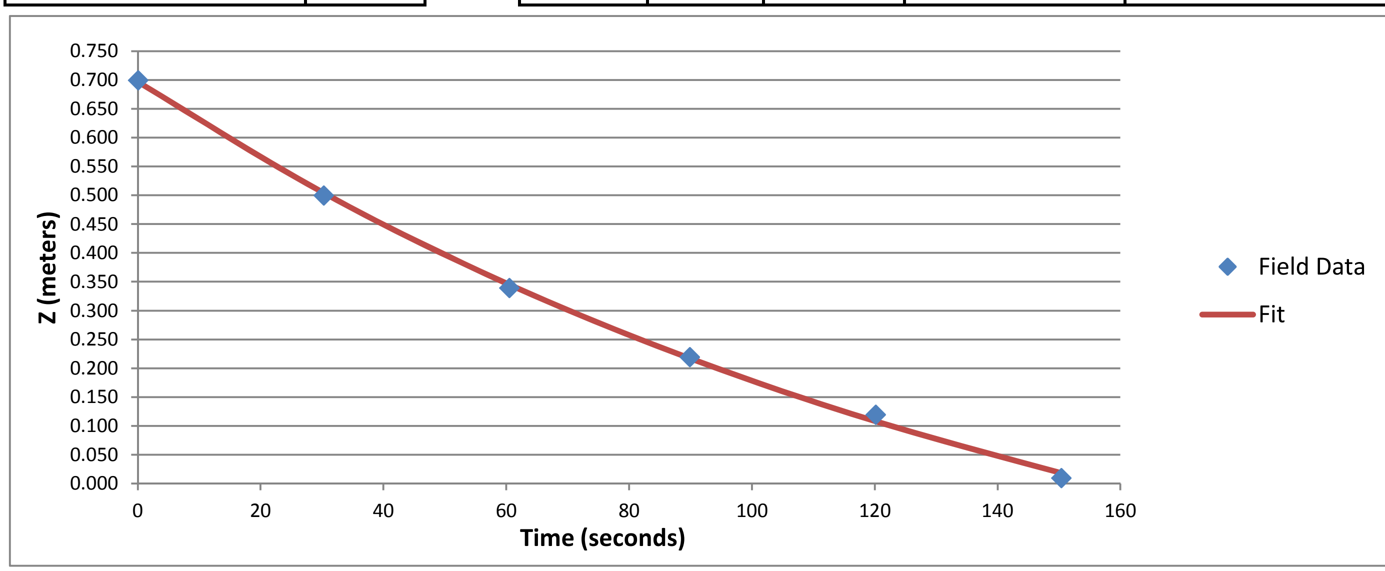
$$K = R_T \frac{a\pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/22/17 9:05:00 AM	70.0
9/22/17 9:05:30 AM	50.0
9/22/17 9:06:00 AM	34.0
9/22/17 9:06:30 AM	22.0
9/22/17 9:07:00 AM	12.0
9/22/17 9:07:30 AM	1.0

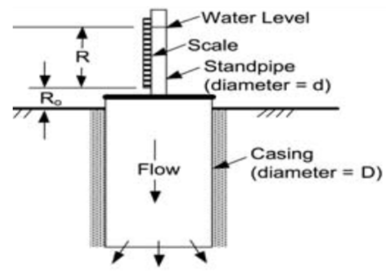
Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.700	0	0.697	-3.23E-03	1.04E-05
0.500	30	0.504	4.25E-03	1.81E-05
0.340	60	0.345	5.24E-03	2.75E-05
0.220	90	0.217	-2.68E-03	7.17E-06
0.120	120	0.108	-1.18E-02	1.38E-04
0.010	150	0.018	8.16E-03	6.66E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B (Single Trial)

Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-32 **Performed By:** JAV
Trial No: 2 **Checked By:** RMP



Inputs

d =	2	cm
D =	10	cm
R_0 =	0	cm
Air Temp =	90	degrees F

Calculations / Result

T =	32	degrees C
Total Time of Test:	0 hours 2.5 minutes	

Fitted Variables

a =	0.00507	s^{-1}
Z* =	-0.44653	m
Z_0 =	1.03484	m
MSE =	1.58E-05	m
R_T =	0.7591	
K =	**4.40E-04**	**cm/s**
K =	**0.6**	**in/hr**

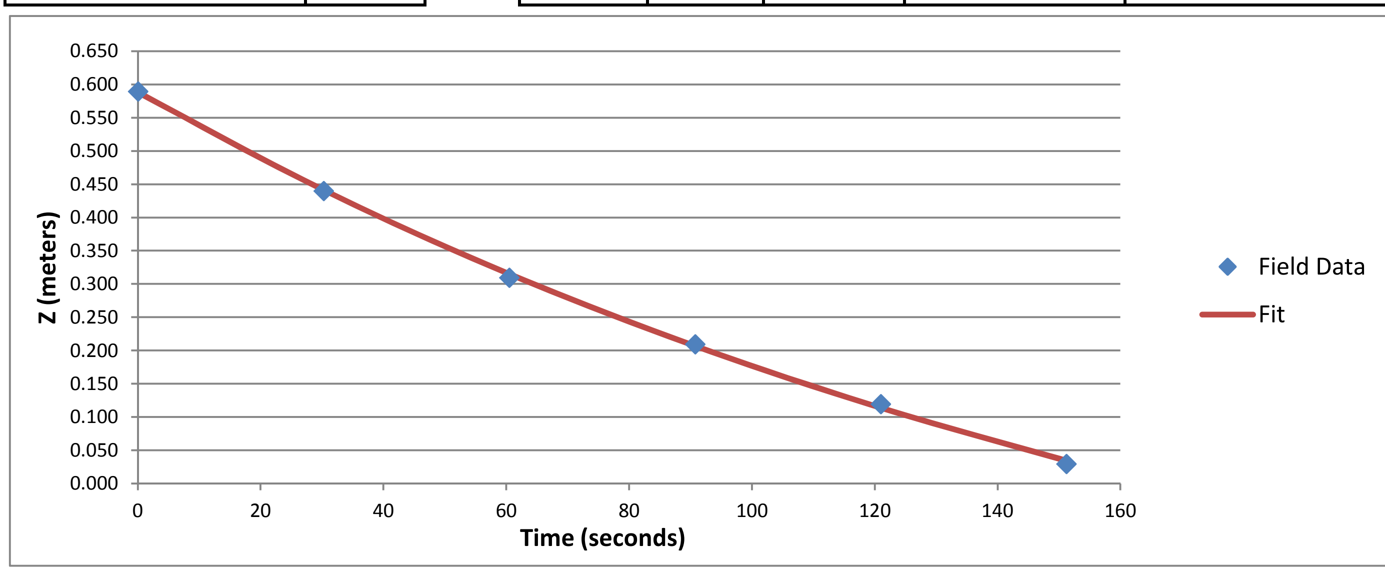
$$K = R_T \frac{a \pi d^2}{11D}$$

Field Data

Time	*R (cm)*
9/22/17 9:10:00 AM	59.0
9/22/17 9:10:30 AM	44.0
9/22/17 9:11:00 AM	31.0
9/22/17 9:11:31 AM	21.0
9/22/17 9:12:01 AM	12.0
9/22/17 9:12:31 AM	3.0

Z-t computations

Z (m)	*t (s)*	*Fit Z (m)*	*Error (m)*	*Error^2 (m2)*
0.590	0	0.588	-1.69E-03	2.87E-06
0.440	30	0.441	1.26E-03	1.59E-06
0.310	60	0.315	5.11E-03	2.61E-05
0.210	91	0.207	-3.11E-03	9.69E-06
0.120	121	0.114	-5.96E-03	3.55E-05
0.030	151	0.034	4.39E-03	1.93E-05



Borehole Hydraulic Conductivity Test - ASTM D 6391 Method B

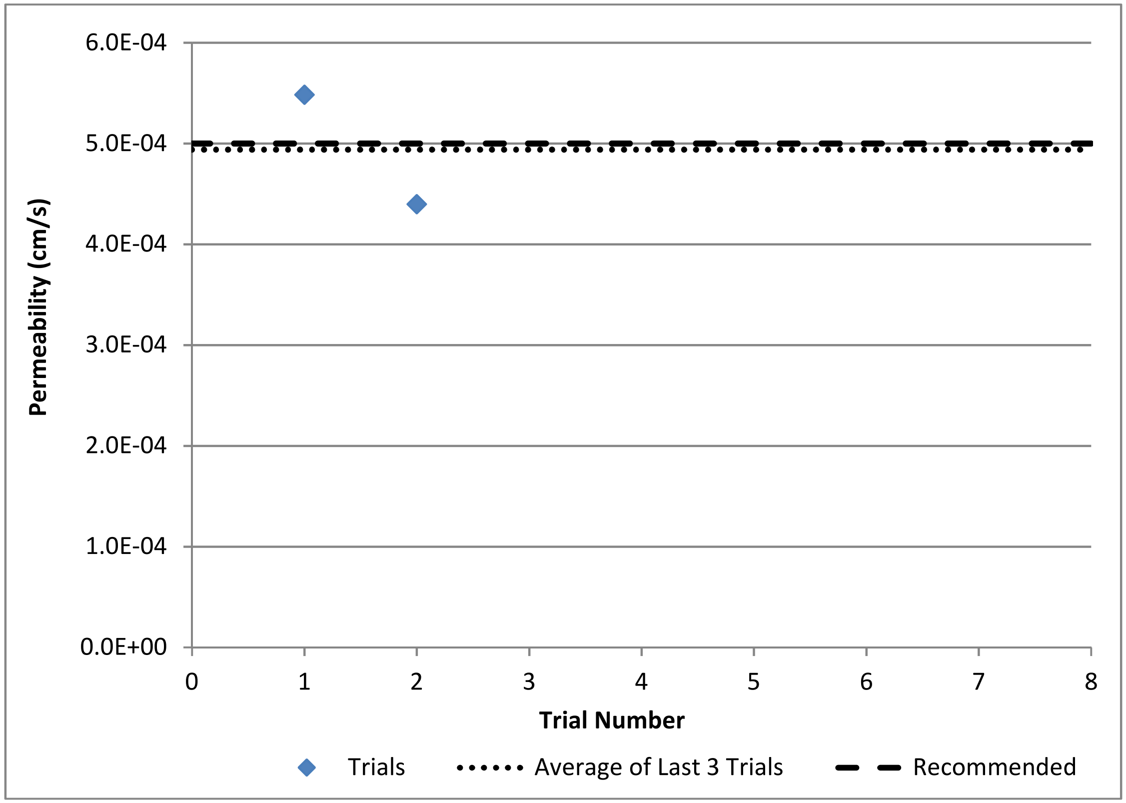
Project: Valencia Rd. Improvements Geotech Inv. **Project No.** 1660053
Hole ID / Location: BH-32 **Analyzed By:** JAV
Checked By: RMP

Average of Last 3 Trials: 4.94E-04 cm/s = 0.7 in/hr

Recommended Hydraulic Conductivity: 5.00E-04 cm/s = 0.7 in/hr

Trial	*K (cm/s)*	*Diff Vs. Avg (%)*
1	5.48E-04	✓ 11%
2	4.40E-04	✓ 11%

Notes:



APPENDIX D

Dynamic Cone Penetrometer Test Results

GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-02

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
6	75	75	12.5	1	12.5	17.3	16
6	126	51	8.5	1	8.5	26.6	21
6	189	63	10.5	1	10.5	21.0	18
6	215	26	4.3	1	4.3	56.5	34
6	270	55	9.2	1	9.2	24.4	20
6	323	53	8.8	1	8.8	25.5	20
6	376	53	8.8	1	8.8	25.5	20
6	445	69	11.5	1	11.5	18.9	17
6	515	70	11.7	1	11.7	18.6	17
6	580	65	10.8	1	10.8	20.3	18
6	633	53	8.8	1	8.8	25.5	20
6	672	39	6.5	1	6.5	35.9	25
6	702	30	5.0	1	5.0	48.1	30
6	729	27	4.5	1	4.5	54.2	33
6	750	21	3.5	1	3.5	71.8	39
6	769	19	3.2	1	3.2	80.3	42
6	788	19	3.2	1	3.2	80.3	42
6	806	18	3.0	1	3.0	85.3	44
6	824	18	3.0	1	3.0	85.3	44
6	839	15	2.5	1	2.5	104.6	50
6	854	15	2.5	1	2.5	104.6	50
6	869	15	2.5	1	2.5	104.6	50
6	882	13	2.2	1	2.2	122.8	56
6	895	13	2.2	1	2.2	122.8	56
6	909	14	2.3	1	2.3	113.0	53
3	915	6	2.0	1	2.0	134.3	59

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layers exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	2.4	8.7	29.9	0.45	17.3	56.5
Layer 2	2.4	3.0	2.8	97.2	0.24	54.2	134.3
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

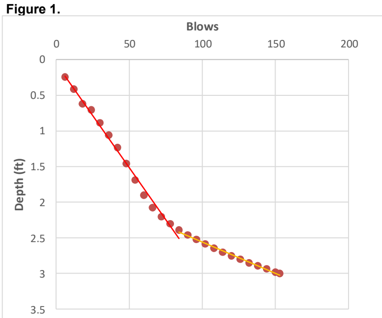


Figure 2.

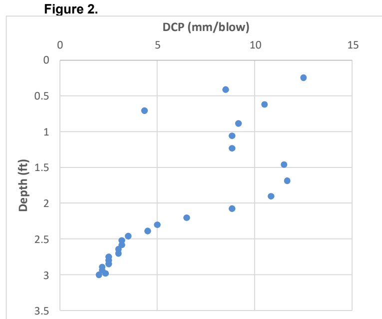


Figure 3.

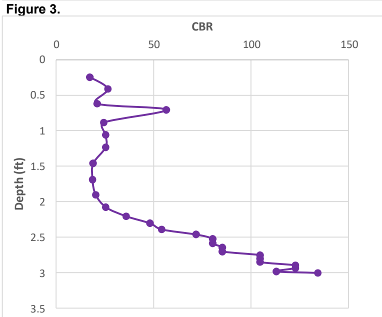
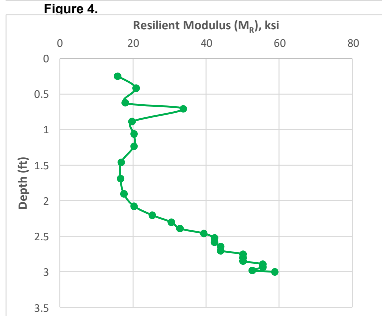


Figure 4.



CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-04

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	54	54	5.4	1	5.4	44.2	29
10	72	18	1.8	1	1.8	151.2	63
10	80	8	0.8	1	0.8	374.9	113

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0	0.3	2.7	190.1	0.89	44.2	374.9
Layer 2							
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

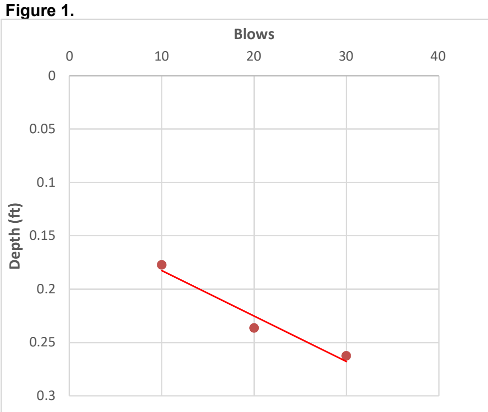


Figure 2.

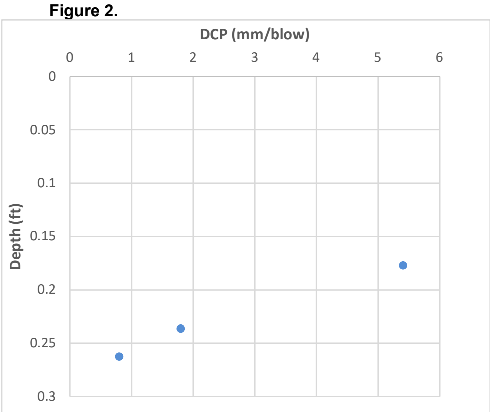


Figure 3.

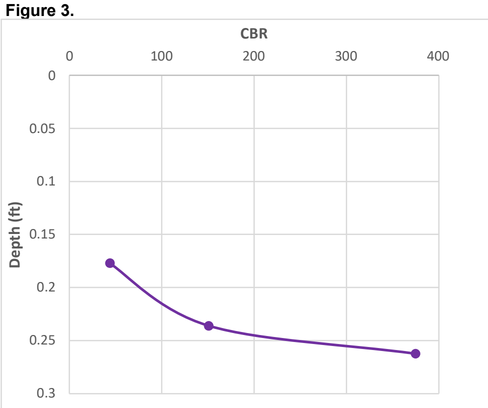
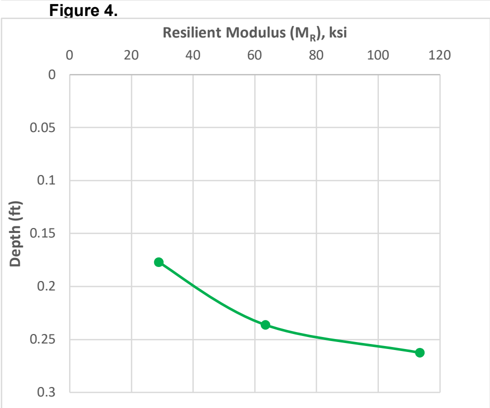


Figure 4.



CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-06

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0		--	--	--			
10	160	160	16.0	1	16.0	13.1	13
10	280	120	12.0	1	12.0	18.1	16
10	358	78	7.8	1	7.8	29.3	22
10	433	75	7.5	1	7.5	30.6	23
10	508	75	7.5	1	7.5	30.6	23
10	586	78	7.8	1	7.8	29.3	22
10	658	72	7.2	1	7.2	32.0	23
10	693	35	3.5	1	3.5	71.8	39
10	718	25	2.5	1	2.5	104.6	50
10	744	26	2.6	1	2.6	100.1	49
10	767	23	2.3	1	2.3	114.9	53
10	793	26	2.6	1	2.6	100.1	49
10	813	20	2.0	1	2.0	134.3	59
10	838	25	2.5	1	2.5	104.6	50
10	863	25	2.5	1	2.5	104.6	50
10	891	28	2.8	1	2.8	92.2	46
10	923	32	3.2	1	3.2	79.4	42
10	948	25	2.5	1	2.5	104.6	50
10	975	27	2.7	1	2.7	96.0	47
10	1008	33	3.3	1	3.3	76.7	41
10	1058	50	5.0	1	5.0	48.1	30
10	1238	180	18.0	1	18.0	11.5	12
10	1418	180	18.0	1	18.0	11.5	12

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	2.2	9.4	26.1	0.28	13.1	32.0
Layer 2	2.3	3.3	2.7	98.8	0.17	71.8	134.3
Layer 3	3.5	4.7	13.7	23.7	0.89	11.5	48.1
Layer 4							

1.1 Graphical Output

Figure 1.

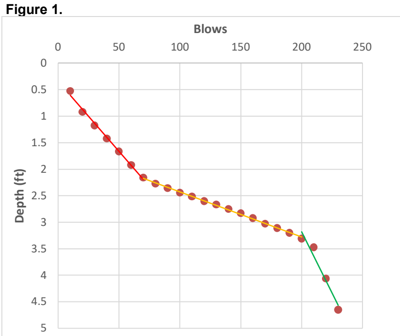


Figure 2.

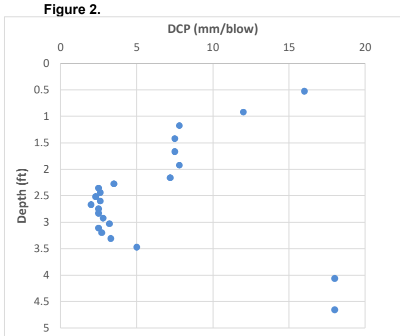


Figure 3.

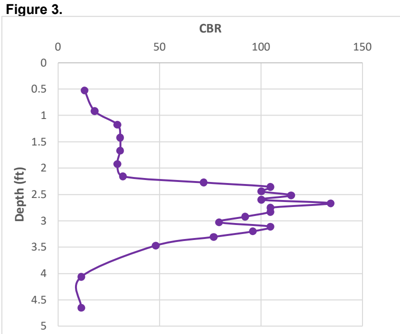


Figure 4.

GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-08

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R \text{ (psi)} = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	75	75	7.5	1	7.5	30.6	23
10	100	25	2.5	1	2.5	104.6	50
10	152	52	5.2	1	5.2	46.1	30
10	199	47	4.7	1	4.7	51.6	32
10	243	44	4.4	1	4.4	55.6	33
10	288	45	4.5	1	4.5	54.2	33
10	330	42	4.2	1	4.2	58.5	35
10	366	36	3.6	1	3.6	69.6	39
10	396	30	3.0	1	3.0	85.3	44
10	425	29	2.9	1	2.9	88.6	45
10	457	32	3.2	1	3.2	79.4	42
10	495	38	3.8	1	3.8	65.5	37
10	535	40	4.0	1	4.0	61.8	36
10	582	47	4.7	1	4.7	51.6	32
10	627	45	4.5	1	4.5	54.2	33
10	669	42	4.2	1	4.2	58.5	35
10	708	39	3.9	1	3.9	63.6	36
10	750	42	4.2	1	4.2	58.5	35
10	792	42	4.2	1	4.2	58.5	35
10	846	54	5.4	1	5.4	44.2	29
10	886	40	4.0	1	4.0	61.8	36
10	924	38	3.8	1	3.8	65.5	37
10	973	49	4.9	1	4.9	49.2	31
10	993	20	2.0	1	2.0	134.3	59
10	1020	27	2.7	1	2.7	96.0	47
10	1045	25	2.5	1	2.5	104.6	50

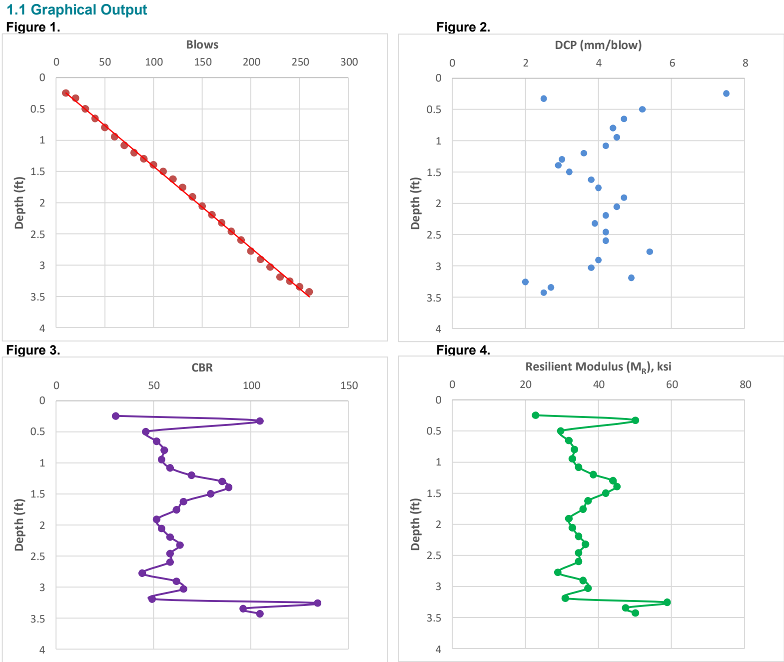
*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0	3.4	4.0	67.4	0.34	30.6	134.3
Layer 2							
Layer 3							
Layer 4							

1.1 Graphical Output



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-10

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R \text{ (psi)} = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	65	65	6.5	1	6.5	35.9	25
10	124	59	5.9	1	5.9	40.0	27
10	176	52	5.2	1	5.2	46.1	30
10	223	47	4.7	1	4.7	51.6	32
10	269	46	4.6	1	4.6	52.9	32
10	313	44	4.4	1	4.4	55.6	33
10	342	29	2.9	1	2.9	88.6	45
10	365	23	2.3	1	2.3	114.9	53
10	395	30	3.0	1	3.0	85.3	44
10	425	30	3.0	1	3.0	85.3	44
10	465	40	4.0	1	4.0	61.8	36
10	510	45	4.5	1	4.5	54.2	33
10	565	55	5.5	1	5.5	43.3	28
10	623	58	5.8	1	5.8	40.8	27
10	670	47	4.7	1	4.7	51.6	32
10	705	35	3.5	1	3.5	71.8	39
10	740	35	3.5	1	3.5	71.8	39
10	771	31	3.1	1	3.1	82.2	43
10	800	29	2.9	1	2.9	88.6	45
10	817	17	1.7	1	1.7	161.2	66
10	835	18	1.8	1	1.8	151.2	63
10	845	10	1.0	1	1.0	292.0	97
10	857	12	1.2	1	1.2	238.1	85

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	1.0	5.2	47.0	0.17	35.9	55.6
Layer 2	1.1	1.4	2.8	93.5	0.15	85.3	114.9
Layer 3	1.5	2.2	4.9	50.3	0.17	40.8	61.8
Layer 4	2.3	2.8	2.3	144.6	0.58	71.8	292.0

1.1 Graphical Output

Figure 1.

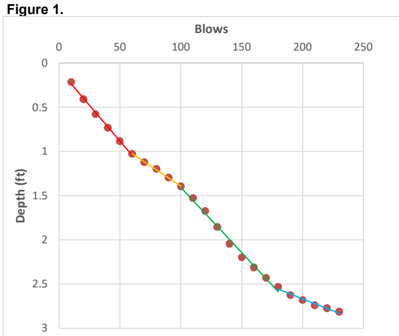


Figure 2.

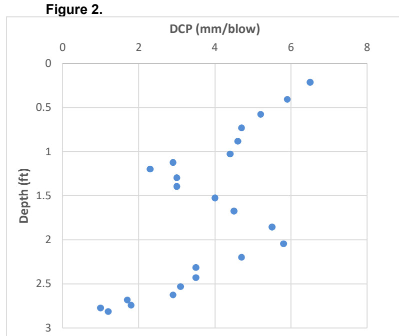


Figure 3.

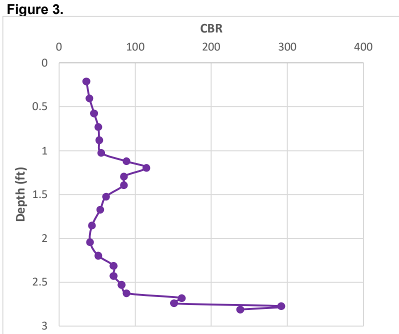


Figure 4.

GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-12

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	60	60	6.0	1	6.0	39.3	27
10	75	15	1.5	1	1.5	185.4	72
10	90	15	1.5	1	1.5	185.4	72
10	98	8	0.8	1	0.8	374.9	113
10	109	11	1.1	1	1.1	262.4	90
10	118	9	0.9	1	0.9	328.6	104
10	160	42	4.2	1	4.2	58.5	35
10	204	44	4.4	1	4.4	55.6	33
10	227	23	2.3	1	2.3	114.9	53
10	250	23	2.3	1	2.3	114.9	53
10	267	17	1.7	1	1.7	161.2	66
10	280	13	1.3	1	1.3	217.7	80
10	297	17	1.7	1	1.7	161.2	66
10	309	12	1.2	1	1.2	238.1	85
10	329	20	2.0	1	2.0	134.3	59
10	342	13	1.3	1	1.3	217.7	80
10	355	13	1.3	1	1.3	217.7	80
10	368	13	1.3	1	1.3	217.7	80
10	383	15	1.5	1	1.5	185.4	72
10	396	13	1.3	1	1.3	217.7	80
10	414	18	1.8	1	1.8	151.2	63
10	427	13	1.3	1	1.3	217.7	80
10	444	17	1.7	1	1.7	161.2	66
10	461	17	1.7	1	1.7	161.2	66
10	479	18	1.8	1	1.8	151.2	63
10	496	17	1.7	1	1.7	161.2	66
10	510	14	1.4	2	2.8	92.2	46
5	516	6	1.2	3	3.6	69.6	39

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.4	2.0	229.3	0.52	39.3	374.9
Layer 2	0.4	0.7	4.3	57.0	0.04	55.6	58.5
Layer 3	0.7	1.7	1.8	168.2	0.28	69.6	238.1
Layer 4							

1.1 Graphical Output

Figure 1.

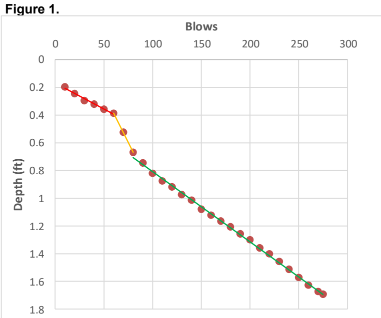


Figure 2.

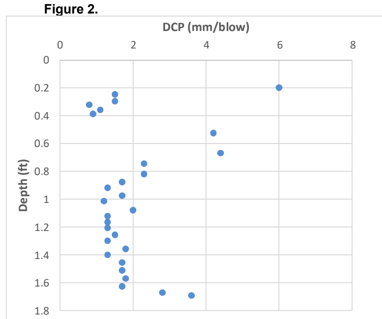


Figure 3.

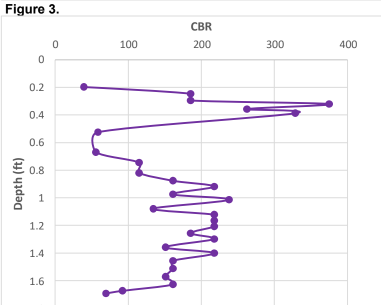
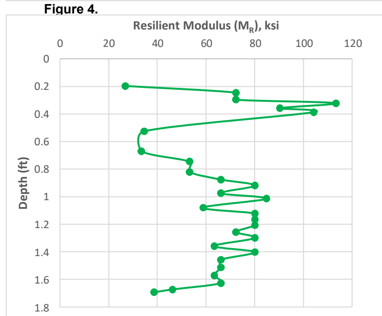


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-14

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	60	60	6.0	1	6.0	39.3	27
10	100	40	4.0	1	4.0	61.8	36
10	125	25	2.5	1	2.5	104.6	50
10	170	45	4.5	1	4.5	54.2	33
10	225	55	5.5	1	5.5	43.3	28
10	275	50	5.0	1	5.0	48.1	30
10	305	30	3.0	1	3.0	85.3	44
10	363	58	5.8	1	5.8	40.8	27
10	407	44	4.4	1	4.4	55.6	33
10	445	38	3.8	1	3.8	65.5	37
10	485	40	4.0	1	4.0	61.8	36
10	525	40	4.0	1	4.0	61.8	36
10	557	32	3.2	1	3.2	79.4	42
10	592	35	3.5	1	3.5	71.8	39
10	625	33	3.3	1	3.3	76.7	41
10	662	37	3.7	1	3.7	67.5	38
10	700	38	3.8	1	3.8	65.5	37
10	732	32	3.2	1	3.2	79.4	42
10	762	30	3.0	1	3.0	85.3	44
10	797	35	3.5	1	3.5	71.8	39
10	835	38	3.8	1	3.8	65.5	37
10	880	45	4.5	1	4.5	54.2	33
10	930	50	5.0	1	5.0	48.1	30
10	965	35	3.5	1	3.5	71.8	39
10	980	15	1.5	1	1.5	185.4	72
10	990	10	1.0	1	1.0	292.0	97

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	3.2	4.0	64.9	0.24	39.3	104.6
Layer 2	3.2	3.2	2.0	183.1	0.60	71.8	292.0
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

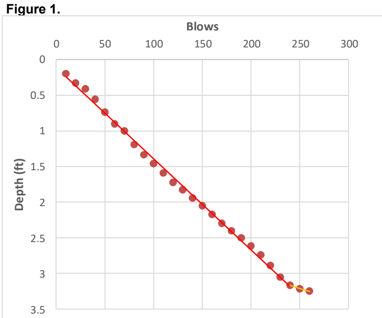


Figure 2.

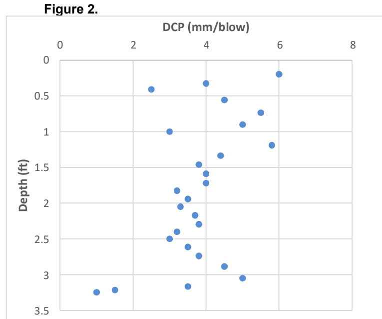


Figure 3.

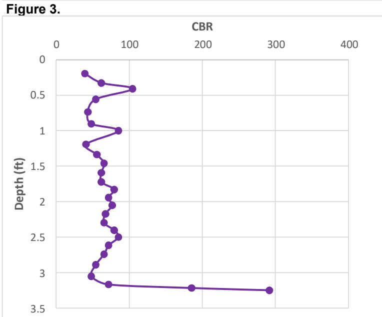
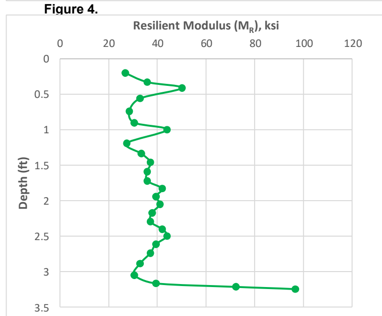


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-16

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	95	95	9.5	1	9.5	23.5	19
10	151	56	5.6	1	5.6	42.4	28
10	216	65	6.5	1	6.5	35.9	25
10	279	63	6.3	1	6.3	37.2	26
10	334	55	5.5	1	5.5	43.3	28
10	369	35	3.5	1	3.5	71.8	39
10	402	33	3.3	1	3.3	76.7	41
10	437	35	3.5	1	3.5	71.8	39
10	475	38	3.8	1	3.8	65.5	37
10	516	41	4.1	1	4.1	60.1	35
10	558	42	4.2	1	4.2	58.5	35
10	600	42	4.2	1	4.2	58.5	35
10	654	54	5.4	1	5.4	44.2	29
10	718	64	6.4	1	6.4	36.5	26
10	793	75	7.5	1	7.5	30.6	23
10	842	49	4.9	1	4.9	49.2	31
10	870	28	2.8	1	2.8	92.2	46
10	895	25	2.5	1	2.5	104.6	50
10	923	28	2.8	1	2.8	92.2	46
10	950	27	2.7	1	2.7	96.0	47
10	981	31	3.1	1	3.1	82.2	43
10	1019	38	3.8	1	3.8	65.5	37
10	1065	46	4.6	1	4.6	52.9	32
10	1093	28	2.8	1	2.8	92.2	46

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	1.1	6.7	36.4	0.22	23.5	43.3
Layer 2	1.2	1.6	3.5	71.4	0.06	65.5	76.7
Layer 3	1.7	2.8	5.2	48.2	0.24	30.6	60.1
Layer 4	2.8	3.6	3.1	84.7	0.20	52.9	104.6

1.1 Graphical Output

Figure 1.

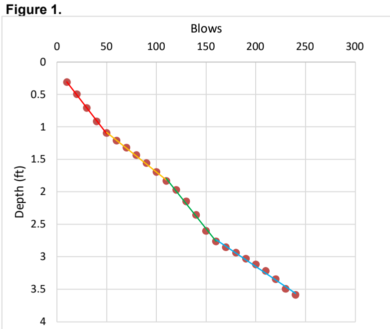


Figure 2.

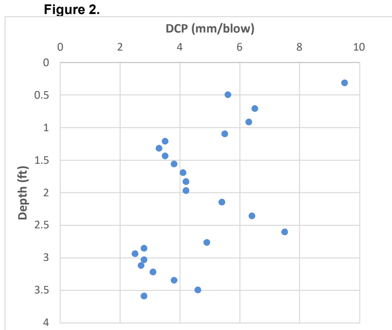


Figure 3.

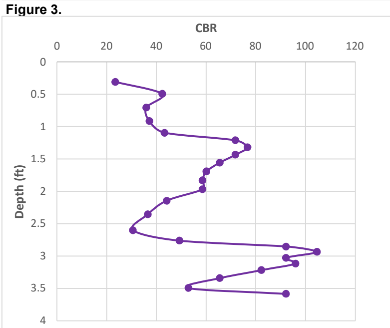
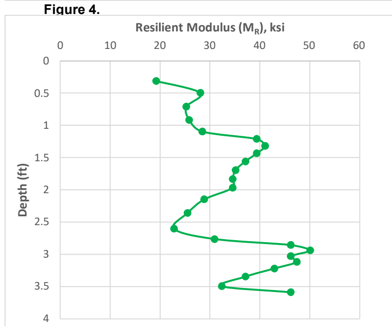


Figure 4.



CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-18

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	45	45	4.5	1	4.5	54.2	33
10	70	25	2.5	1	2.5	104.6	50
10	94	24	2.4	1	2.4	109.5	52
10	105	11	1.1	1	1.1	262.4	90
10	115	10	1.0	1	1.0	292.0	97
5	115	0	0.0	1	0.0		

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.3	3.1	89.4	0.34	54.2	109.5
Layer 2	0.3	0.4	1.1	277.2	0.08	262.4	292.0
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

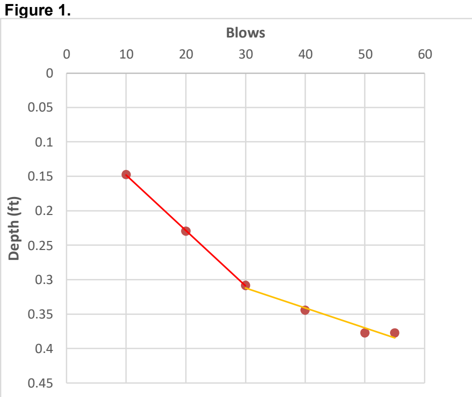


Figure 2.

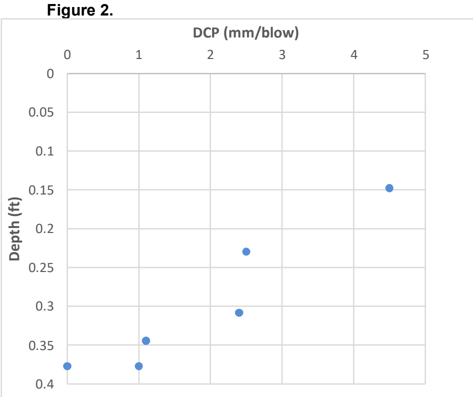


Figure 3.

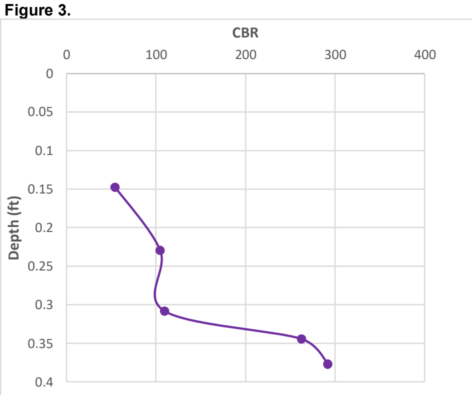


Figure 4.

GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-20

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	124	124	12.4	1	12.4	17.4	16
10	183	59	5.9	1	5.9	40.0	27
10	230	47	4.7	1	4.7	51.6	32
10	265	35	3.5	1	3.5	71.8	39
10	297	32	3.2	1	3.2	79.4	42
10	321	24	2.4	1	2.4	109.5	52
10	335	14	1.4	1	1.4	200.3	76
10	347	12	1.2	1	1.2	238.1	85
10	358	11	1.1	1	1.1	262.4	90
10	374	16	1.6	1	1.6	172.5	69
10	398	24	2.4	1	2.4	109.5	52
10	425	27	2.7	1	2.7	96.0	47
10	462	37	3.7	1	3.7	67.5	38
10	506	44	4.4	1	4.4	55.6	33
10	553	47	4.7	1	4.7	51.6	32
10	605	52	5.2	1	5.2	46.1	30
10	659	54	5.4	1	5.4	44.2	29
10	727	68	6.8	1	6.8	34.1	24
10	797	70	7.0	1	7.0	33.0	24
10	854	57	5.7	1	5.7	41.6	28
10	909	55	5.5	1	5.5	43.3	28
10	961	52	5.2	1	5.2	46.1	30
10	1011	50	5.0	1	5.0	48.1	30
10	1061	50	5.0	1	5.0	48.1	30
10	1109	48	4.8	1	4.8	50.4	31
10	1157	48	4.8	1	4.8	50.4	31

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	1.0	5.9	52.0	0.48	17.4	79.4
Layer 2	1.1	1.4	1.8	169.8	0.39	96.0	262.4
Layer 3	1.5	3.8	5.2	47.1	0.18	33.0	67.5
Layer 4							

1.1 Graphical Output

Figure 1.

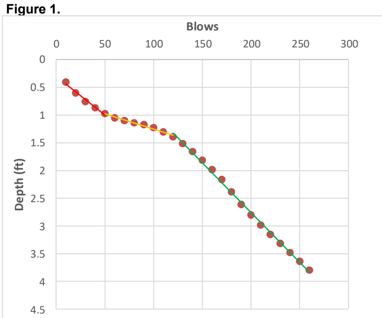


Figure 2.

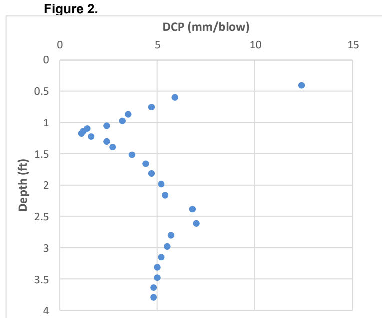


Figure 3.

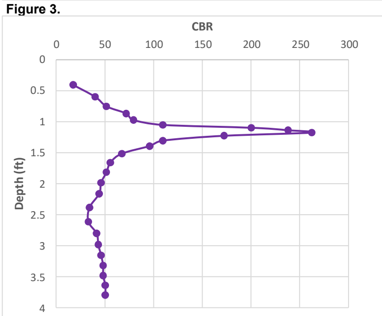


Figure 4.

GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-22

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	30	30	3.0	1	3.0	85.3	44
10	45	15	1.5	1	1.5	185.4	72
10	55	10	1.0	1	1.0	292.0	97
10	70	15	1.5	1	1.5	185.4	72
10	79	9	0.9	1	0.9	328.6	104
10	85	6	0.6	1	0.6	517.4	139
10	96	11	1.1	1	1.1	262.4	90
10	117	21	2.1	1	2.1	127.2	57
10	138	21	2.1	1	2.1	127.2	57
10	165	27	2.7	1	2.7	96.0	47
10	205	40	4.0	1	4.0	61.8	36
10	260	55	5.5	1	5.5	43.3	28
10	339	79	7.9	1	7.9	28.8	22
10	440	101	10.1	1	10.1	21.9	18
10	508	68	6.8	1	6.8	34.1	24
10	555	47	4.7	1	4.7	51.6	32
10	577	22	2.2	1	2.2	120.7	55
10	590	13	1.3	1	1.3	217.7	80
10	595	5	0.5	1	0.5	634.7	159
5	595	0	0.0	1	0.0		

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.5	1.7	220.7	0.60	85.3	517.4
Layer 2	0.7	1.8	6.5	40.3	0.37	21.9	61.8
Layer 3	1.8	2.0	1.3	324.4	0.84	120.7	634.7
Layer 4							

1.1 Graphical Output

Figure 1.

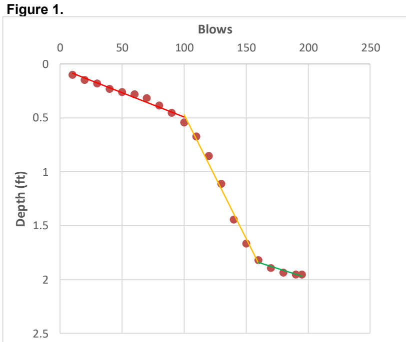


Figure 2.

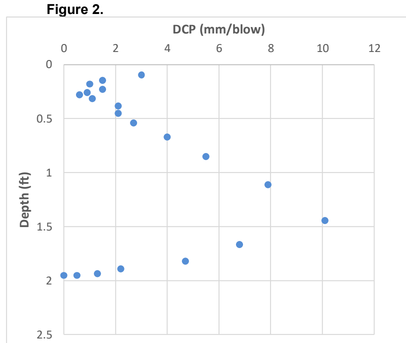


Figure 3.

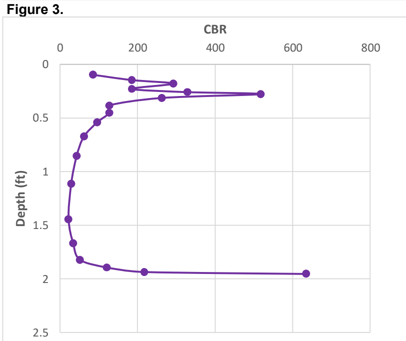
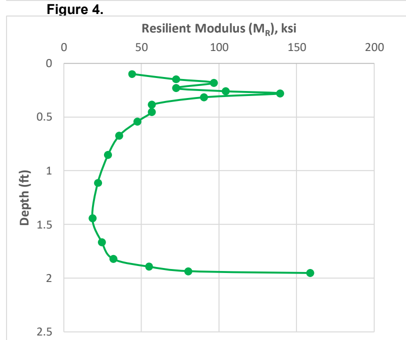


Figure 4.



CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-24

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	17	17	1.7	1	1.7	161.2	66
10	41	24	2.4	1	2.4	109.5	52
10	54	13	1.3	1	1.3	217.7	80
10	60	6	0.6	1	0.6	517.4	139
10	67	7	0.7	1	0.7	435.4	125
5	68	1	0.2	1	0.2	1771.0	306

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.2	1.8	162.8	0.33	109.5	217.7
Layer 2	0.2	0.2	0.5	908.0	0.82	435.4	1771.0
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

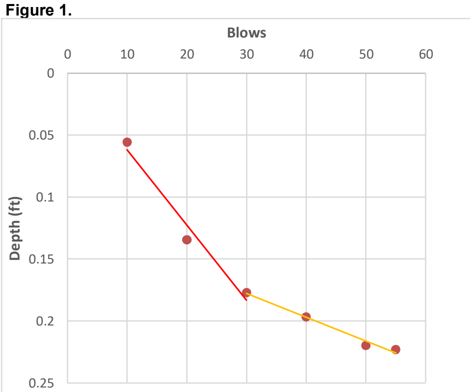


Figure 2.

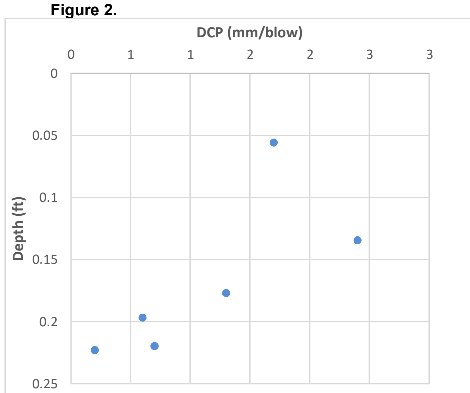


Figure 3.

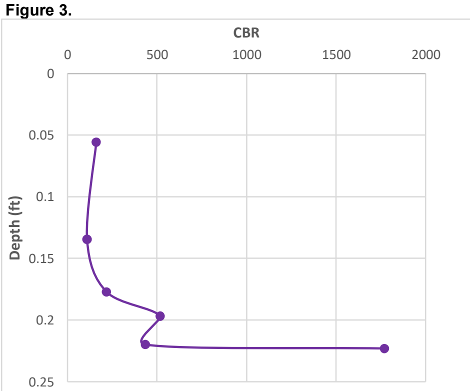
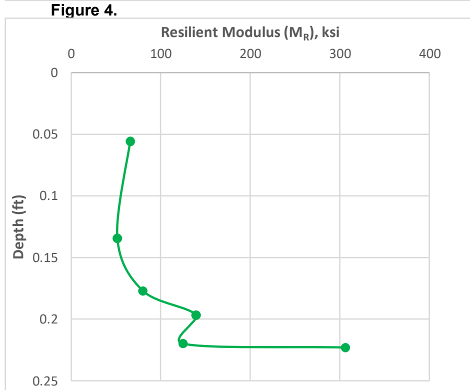


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-26

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	22	22	2.2	1	2.2	120.7	55
10	27	5	0.5	1	0.5	634.7	159
10	42	15	1.5	1	1.5	185.4	72
10	60	18	1.8	1	1.8	151.2	63
10	75	15	1.5	1	1.5	185.4	72
10	90	15	1.5	1	1.5	185.4	72
10	110	20	2.0	1	2.0	134.3	59
10	115	5	0.5	1	0.5	634.7	159
10	165	50	5.0	1	5.0	48.1	30
10	175	10	1.0	1	1.0	292.0	97
10	187	12	1.2	1	1.2	238.1	85
10	200	13	1.3	1	1.3	217.7	80
10	206	6	0.6	1	0.6	517.4	139

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.1	0.1	0.5	634.7		134.3	634.7
Layer 2	0.1	0.4	1.7	168.4	0.14	134.3	185.4
Layer 3	0.4	0.4	0.5	634.7		634.7	634.7
Layer 4	0.4	0.5	5.0	48.1		48.1	48.1
Layer 4	0.5	0.7	1.0	316.3	0.44	217.7	517.4

1.1 Graphical Output

Figure 1.

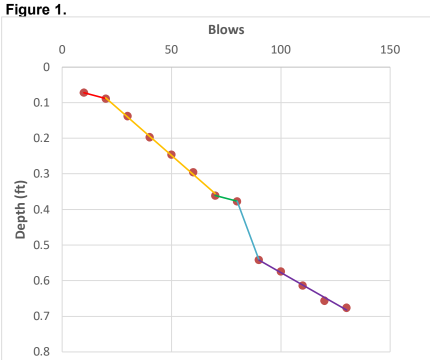


Figure 2.

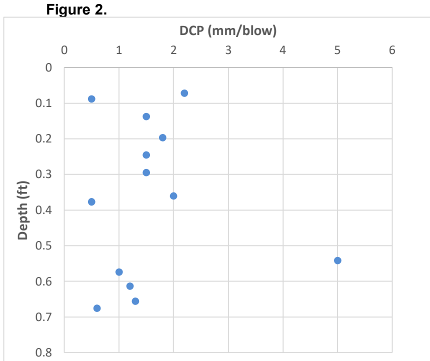


Figure 3.

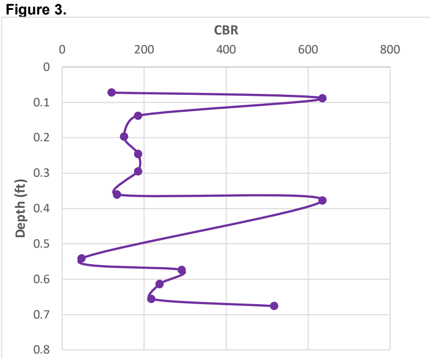
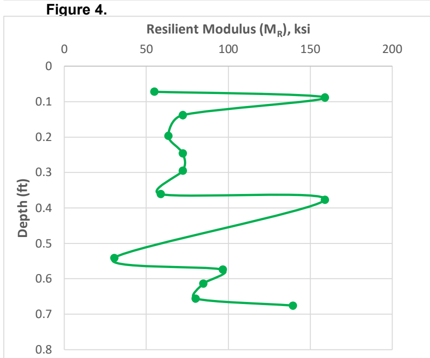


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-28

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	96	96	9.6	1	9.6	23.2	19
10	177	81	8.1	1	8.1	28.0	22
10	236	59	5.9	1	5.9	40.0	27
10	305	69	6.9	1	6.9	33.6	24
10	367	62	6.2	1	6.2	37.8	26
10	420	53	5.3	1	5.3	45.1	29
10	475	55	5.5	1	5.5	43.3	28
10	535	60	6.0	1	6.0	39.3	27
10	581	46	4.6	1	4.6	52.9	32
10	615	34	3.4	1	3.4	74.2	40
10	630	15	1.5	1	1.5	185.4	72
10	637	7	0.7	1	0.7	435.4	125
10	641	4	0.4	1	0.4	814.8	186

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	2.0	6.2	41.7	0.34	23.2	74.2
Layer 2	2.1	2.1	0.9	478.6	0.66	185.4	814.8
Layer 3							
Layer 4							

1.1 Graphical Output

Figure 1.

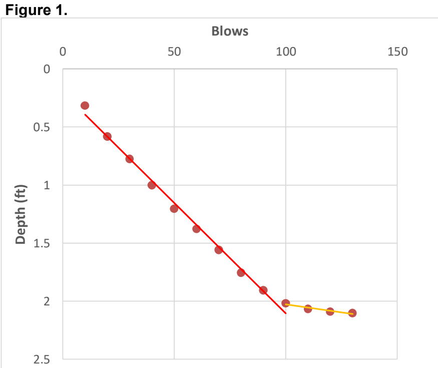


Figure 2.

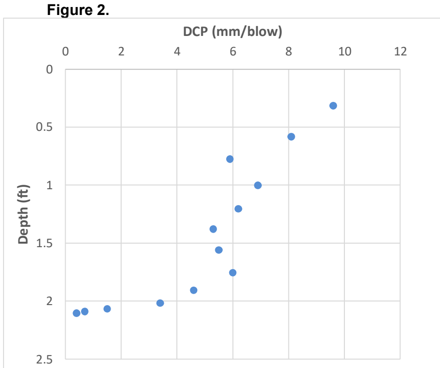


Figure 3.

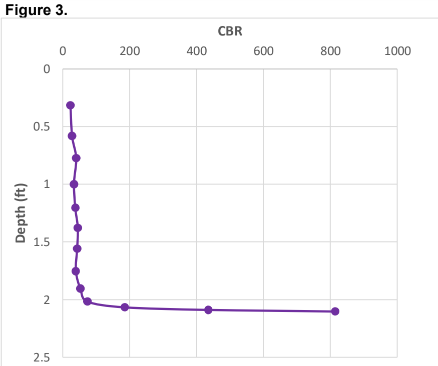
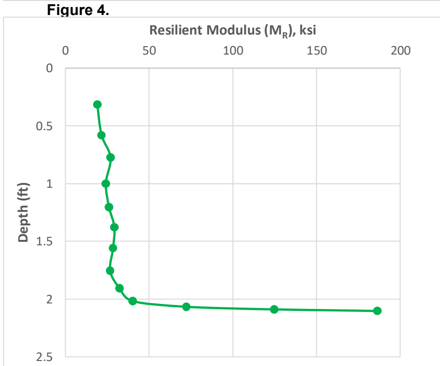


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-29

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	65	65	6.5	1	6.5	35.9	25
10	90	25	2.5	1	2.5	104.6	50
10	112	22	2.2	1	2.2	120.7	55
10	130	18	1.8	1	1.8	151.2	63
10	152	22	2.2	1	2.2	120.7	55
10	170	18	1.8	1	1.8	151.2	63
10	190	20	2.0	1	2.0	134.3	59
10	212	22	2.2	1	2.2	120.7	55
10	245	33	3.3	1	3.3	76.7	41
10	275	30	3.0	1	3.0	85.3	44
10	315	40	4.0	1	4.0	61.8	36
10	365	50	5.0	1	5.0	48.1	30
10	436	71	7.1	1	7.1	32.5	24
10	512	76	7.6	1	7.6	30.1	23
10	577	65	6.5	1	6.5	35.9	25
10	642	65	6.5	1	6.5	35.9	25
10	707	65	6.5	1	6.5	35.9	25
10	767	60	6.0	1	6.0	39.3	27
10	817	50	5.0	1	5.0	48.1	30
10	872	55	5.5	1	5.5	43.3	28
10	897	25	2.5	1	2.5	104.6	50
10	927	30	3.0	1	3.0	85.3	44
10	952	25	2.5	1	2.5	104.6	50
5	967	15	3.0	1	3.0	85.3	44

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	1.0	2.9	105.8	0.35	35.9	151.2
Layer 2	1.2	2.9	6.2	38.8	0.17	30.1	48.1
Layer 3	2.9	3.2	2.8	95.0	0.12	85.3	104.6
Layer 4							

1.1 Graphical Output

Figure 1.

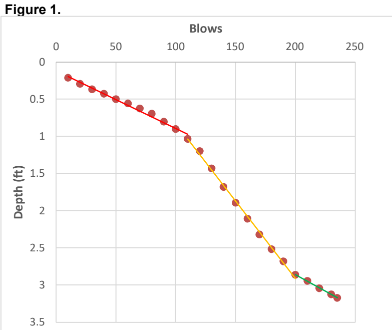


Figure 2.

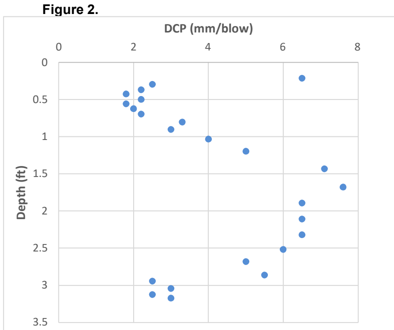


Figure 3.

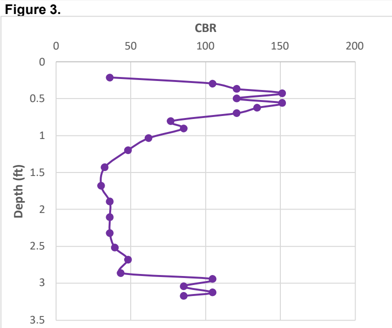
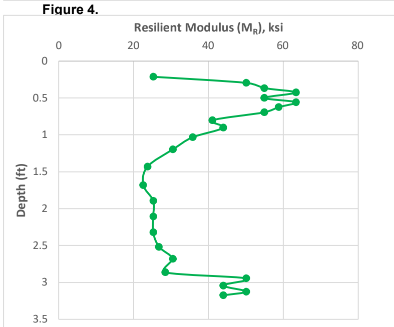


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-30

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \textit{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \textit{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	82	82	8.2	1	8.2	27.7	21
10	130	48	4.8	1	4.8	50.4	31
10	172	42	4.2	1	4.2	58.5	35
10	213	41	4.1	1	4.1	60.1	35
10	240	27	2.7	1	2.7	96.0	47
10	261	21	2.1	1	2.1	127.2	57
10	287	26	2.6	1	2.6	100.1	49
10	320	33	3.3	1	3.3	76.7	41
10	360	40	4.0	1	4.0	61.8	36
10	401	41	4.1	1	4.1	60.1	35
10	446	45	4.5	1	4.5	54.2	33
10	497	51	5.1	1	5.1	47.1	30
10	528	31	3.1	1	3.1	82.2	43
10	562	34	3.4	1	3.4	74.2	40
10	595	33	3.3	1	3.3	76.7	41
10	610	15	1.5	1	1.5	185.4	72
10	619	9	0.9	1	0.9	328.6	104
10	633	14	1.4	1	1.4	200.3	76
10	647	14	1.4	1	1.4	200.3	76
10	660	13	1.3	1	1.3	217.7	80
10	672	12	1.2	1	1.2	238.1	85
10	685	13	1.3	1	1.3	217.7	80
10	694	9	0.9	1	0.9	328.6	104
10	705	11	1.1	1	1.1	262.4	90
10	715	10	1.0	2	2.0	134.3	59
10	724	9	0.9	3	2.7	96.0	47
10	730	6	0.6	4	2.4	109.5	52
5	731	1	0.2	5	1.0	292.0	97

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.7	5.3	49.2	0.30	27.7	60.1
Layer 2	0.8	0.9	2.5	107.8	0.16	96.0	127.2
Layer 3	1.0	2.0	3.9	66.6	0.19	47.1	82.2
Layer 4	2.0	2.4	1.5	216.2	0.35	96.0	328.6

1.1 Graphical Output

Figure 1.

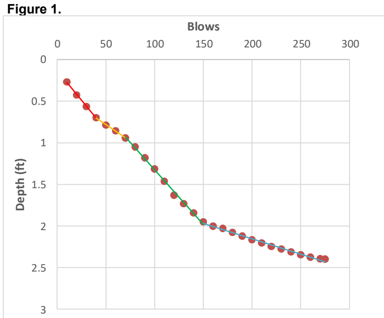


Figure 2.

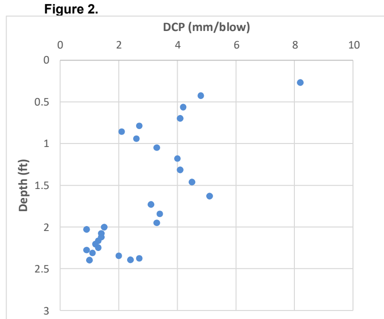


Figure 3.

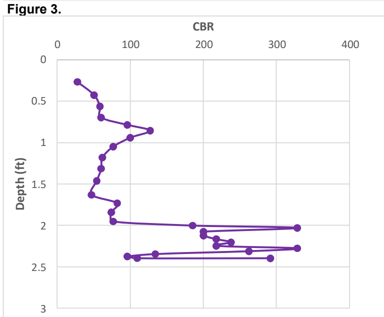
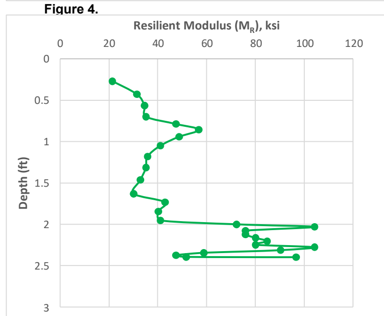


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-32

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	35	35	3.5	1	3.5	71.8	39
10	47	12	1.2	1	1.2	238.1	85
10	60	13	1.3	1	1.3	217.7	80
10	77	17	1.7	1	1.7	161.2	66
10	97	20	2.0	1	2.0	134.3	59
10	110	13	1.3	1	1.3	217.7	80
10	125	15	1.5	1	1.5	185.4	72
10	145	20	2.0	1	2.0	134.3	59
10	160	15	1.5	1	1.5	185.4	72
10	185	25	2.5	1	2.5	104.6	50
10	205	20	2.0	1	2.0	134.3	59
10	230	25	2.5	1	2.5	104.6	50
10	250	20	2.0	1	2.0	134.3	59
10	275	25	2.5	1	2.5	104.6	50
10	300	25	2.5	1	2.5	104.6	50
10	310	10	1.0	1	1.0	292.0	97

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.5	1.8	171.8	0.30	71.8	238.1
Layer 2	0.6	1.0	2.3	114.5	0.13	104.6	134.3
Layer 3	1.0	1.0	1.0	292.0		292.0	292.0
Layer 4							

1.1 Graphical Output

Figure 1.

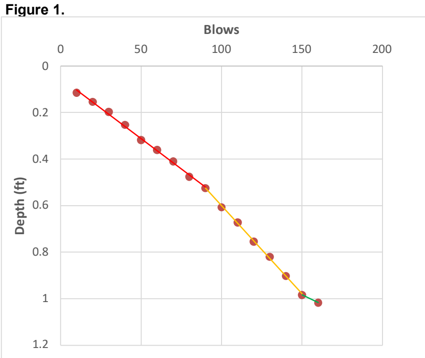


Figure 2.

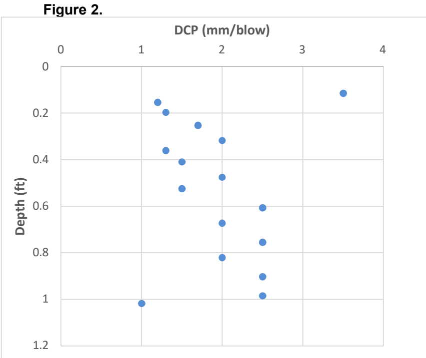


Figure 3.

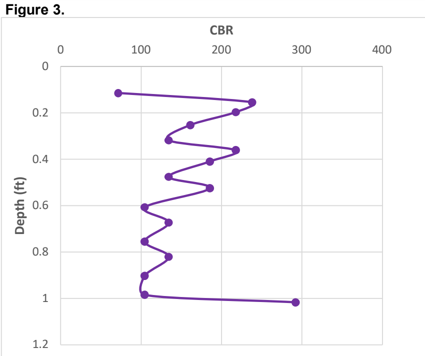
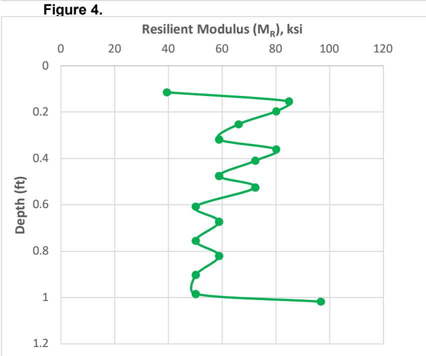


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-34

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \text{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \text{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	100	100	10.0	1	10.0	22.2	19
10	160	60	6.0	1	6.0	39.3	27
10	205	45	4.5	1	4.5	54.2	33
10	261	56	5.6	1	5.6	42.4	28
10	331	70	7.0	1	7.0	33.0	24
10	381	50	5.0	1	5.0	48.1	30
10	420	39	3.9	1	3.9	63.6	36
10	527	107	10.7	1	10.7	20.5	18
10	622	95	9.5	1	9.5	23.5	19
10	672	50	5.0	1	5.0	48.1	30
10	740	68	6.8	1	6.8	34.1	24
10	828	88	8.8	1	8.8	25.6	20
10	941	113	11.3	1	11.3	19.3	17
10	1069	128	12.8	1	12.8	16.8	16
10	1204	135	13.5	1	13.5	15.8	15
5	1298	94	18.8	1	18.8	10.9	12

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	1.4	6.0	43.2	0.32	22.2	63.6
Layer 2	1.7	2.0	10.1	22.0	0.09	20.5	23.5
Layer 3	2.2	2.7	6.9	35.9	0.32	25.6	48.1
Layer 4	3.1	4.3	14.1	15.7	0.22	10.9	19.3

1.1 Graphical Output

Figure 1.

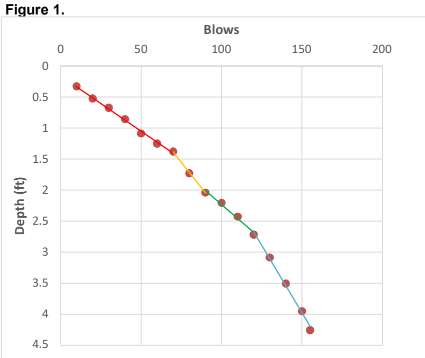


Figure 2.

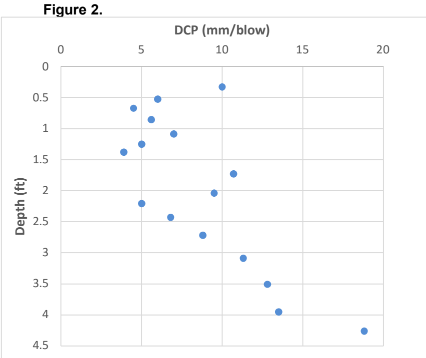


Figure 3.

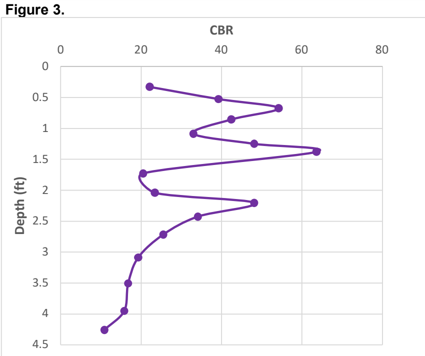
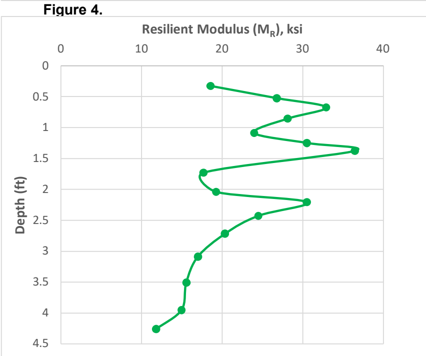


Figure 4.



GOLDER

CALCULATIONS

Date:	11/30/2017	**Made by:**	JAV
Project No.:	1660053	**Checked by:**	RMP
Subject:	DCP Calculations		
Project Short Title:	Valencia Rd.		

DCP BH-36

1.0 DCP Calculations

To estimate the in situ California Bearing Ratio (CBR), the DCP index in mm/blow is calculated by dividing the penetration per the number of blows measured in the field. The CBR value is estimated using the correlation for non-clayey materials in the ASTM D6951 (Equation 01). The Resilient Modulus (M_R) is calculated based on the Mechanistic-Empirical Pavement Design Guide (MEPDG) correlation for CBR (Equation 02).

$$CBR = 292/DCP^{1.12} \quad \textit{(Equation 01)}$$

$$M_R\ (psi) = 2555(CBR)^{0.64} \quad \textit{(Equation 02)}$$

Table 1. DCP Calculations

# of Blows	Cummulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Blow Factor	DCP (mm/blow)	CBR (%)	M_R (ksi)
0	0	--	--	--			
10	160	160	16.0	1	16.0	13.1	13
10	280	120	12.0	1	12.0	18.1	16
10	360	80	8.0	1	8.0	28.4	22
10	425	65	6.5	1	6.5	35.9	25
10	525	100	10.0	1	10.0	22.2	19
10	660	135	13.5	1	13.5	15.8	15
10	775	115	11.5	1	11.5	18.9	17
10	870	95	9.5	1	9.5	23.5	19
10	955	85	8.5	1	8.5	26.6	21
10	1035	80	8.0	1	8.0	28.4	22
10	1115	80	8.0	1	8.0	28.4	22
5	1140	25	5.0	1	5.0	48.1	30

*Rounded Penetration Per Blow to nearest 0.5 to correlate to CBR%.
**Hammer blow factor equals 1 for 8 kg hammer. This hammer was used in the field.

If a distinct layer exist, a change in slope in the cummulative penetration blows versus depth will be observed for each layer (Figure 1). An average DCP and CBR is then estimated for each layer

Table 2. Average DCP and CBR per Layer

Layer	From (mm)	To (mm)	Average DCP (mm/blow)	Average CBR	CBR COV %	Min CBR	Max CBR
Layer 1	0.0	0.9	14.0	15.6	0.23	13.1	18.1
Layer 2	1.2	1.7	7.3	32.2	0.16	28.4	35.9
Layer 3	2.2	2.9	11.1	20.1	0.17	15.8	23.5
Layer 4	3.1	3.7	7.4	32.9	0.31	26.6	48.1

1.1 Graphical Output

Figure 1.

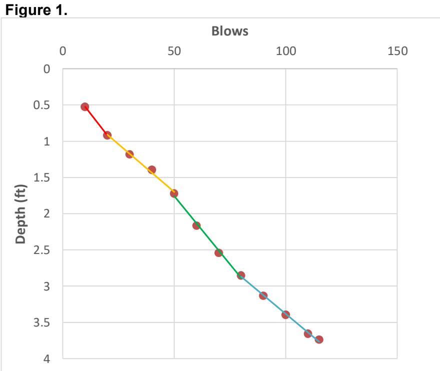


Figure 2.

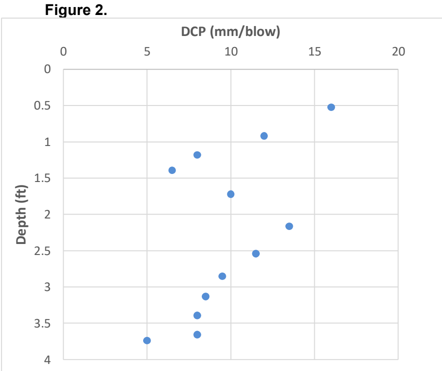


Figure 3.

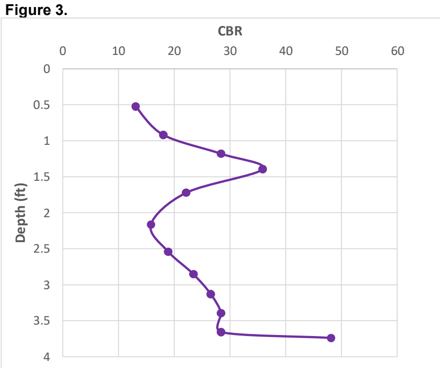


Figure 4.

APPENDIX E

Pavement Design Calculations

Pavement Unit Costs Calculations

Date:	6/4/2020	**Rev:**	1	**Made by:**	RMP
Project No.:	1660053			**Checked by:**	JAV
Roadway:	Valencia Road			**Reviewed by:**	MP
Project Short Title:	Kolb Road to Houghton Road				

Spreadsheet Version 1.0

1.0 PURPOSE
Confirm pavement item unit costs for use in comparing alternative sections on initial construction cost basis.

2.0 REFERENCES
1. Thornton, Kevin. 2020. Personal communication (email) between Kevin Thornton (Principal Director of Sustainability) and Randy Post (Senior Engineer, Golder Associates Inc.) regarding pavement unit costs, May 28.

2. Pima County Procurement Department. 2016. Bid Tabulation for Wilmot road: Sahuarita road to Interstate 10. Solicitation No. 217216, Project 4RTWNS, May 31, 2016.

3. ADOT. 2017. Pavement Design Manual.

4. Hveem and Zube. 1963. California mix design for cement treated base.

5. Maricopa County. 2020. Roadway Design Manual.

3.0 ASSUMPTIONS
1. As noted in calcs.

4.0 CALCULATIONS
Unit Costs provided by PSOMAS (Reference 1):

PAG No. 1 AC:	\$75/Ton	
PAG No. 2 (Terminal Mix) AC:	\$90/Ton	
Aggregate Base (AB):	\$38/Ton	

From Reference 2:

Cement Treated Subgrade (CTS):	\$1.90/yd²	
Cementitious Materials for CTS:	\$112/Ton	
Pre-Cracking of CTS:	\$120/Hr	(400 hrs for 146,255 yd²)

For CTS, assume 9% cement (by weight) gets you ~500 psi and 12% gets you 800 psi - Those are 7-Day UCS values.

For Cement Treated Base (CTB), MAG indicates that ~3% cement is fairly standard. Assume we can meet 800 psi at 7 days with 4% cement for this project.
Per PAG, max lift thickness is 8 in for CTS. So if we want 12" of CTS, should actually do 8" CTS and 4" CTB.

PAG spect list 500 psi as the min comp. strength. If you use the standard coefficients in the ADOT or PCRDM (0.28 CTB, 0.23 CTS), those are for 800 psi per Figure 2-4 of Reference 3.

No max lift thickness for CTB in PAG specs, but presume that 8" is a reasonable max. Probably more like 6". 4" min per MAG.

Pavement Unit Costs Calculations

Date:	6/4/2020	**Rev:**	1	**Made by:**	RMP
Project No.:	1660053			**Checked by:**	JAV
Roadway:	Valencia Road			**Reviewed by:**	MP
Project Short Title:	Kolb Road to Houghton Road				

5.0 RESULTS

5.1 Aggregate Base

$$\$38.00/yd^3 x \frac{1\ yd^3}{27\ ft^3}\ x \frac{1}{135\frac{lb}{ft^3}}\ x \frac{2000\ lb}{ton} = \$20.85/\ ton$$

Per Reference 5, yd²/in/ton factor = 19.75

AB cost =

$$\frac{20.85\ /ton}{19.75} = \$1.06\ /yd^2 - in$$

5.2 Asphalt Concrete

Per Reference 5, yd²/in/ton factor = 18.39

PAG 1:

$$\$75.00/ton\ x\ \frac{1}{18.39} = \$4.08/yd^2 - in$$

PAG 2:

$$\$90.00/ton\ x\ \frac{1}{18.39} = \$4.89/yd^2 - in$$

5.3 Cement Treated Base (Assume 4% Cement)

AB costs: $1.06/sq. yd. - in

For cement cost, figure out tons of AB in 1 yd² - in:

$$\frac{135\frac{lb}{ft^3}}{1}\ x\ \frac{27\ ft^3}{1\ yd^3}\ x\ \frac{1\ ton}{2000\ lb}\ x\ \frac{1\ yd}{3\ ft}\ x \frac{1\ ft}{12\ in} = 0.051\ ton\ /\ yd^2 - in$$

$$\frac{0.051\ ton}{yd^2\ - in}\ x\ 0.04\ x\ \$112.0\ /ton = \$0.23/yd^2 - in\quad for\ cement$$

Total cost: $\$1.29/yd^2 - in + \$1.90yd^2\ to\ mix\ in - situ$

Pavement Unit Costs Calculations

Date:	6/4/2020	**Rev:** 1		**Made by:**	RMP
Project No.:	1660053			**Checked by:**	JAV
Roadway:	Valencia Road			**Reviewed by:**	MP
Project Short Title:	Kolb Road to Houghton Road				

5.4 Cement Treated Subgrade (Assume 9% Cement and 12% Cement)

Asume 130 pcf subgrade (conservative)
Calculate tons of subgrade soil in one yd²-in:

$$\frac{130\frac{lb}{ft^3}}{1}\ x\ \frac{27\ ft^3}{1\ yd^3}\ x\ \frac{1\ ton}{2000\ lb}\ x\ \frac{1\ yd}{3\ ft}\ x\ \frac{1\ ft}{12\ in} = 0.049\ ton\ /\ yd^2 - in$$

For 9% cement:

$$\frac{0.049\ ton}{yd^2\ - in}\ x\ 0.09\ x\ \$112.0\ /ton = \$0.50/yd^2 - in \qquad +\$1.90/yd^2\ to\ mix$$

For 12% cement:

$$\frac{0.049\ ton}{yd^2\ - in}\ x\ 0.12\ x\ \$112.0\ /ton = \$0.66/yd^2 - in \qquad +\$1.90/yd^2\ to\ mix$$

5.5 Pre-cracking or Micro-cracking

From Reference 2:

$$\$120\ /\ hr\ x\ 400\ hr = \frac{\$48{,}000}{146{,}255\ yd^2} = \$0.33\ /\ yd^2$$

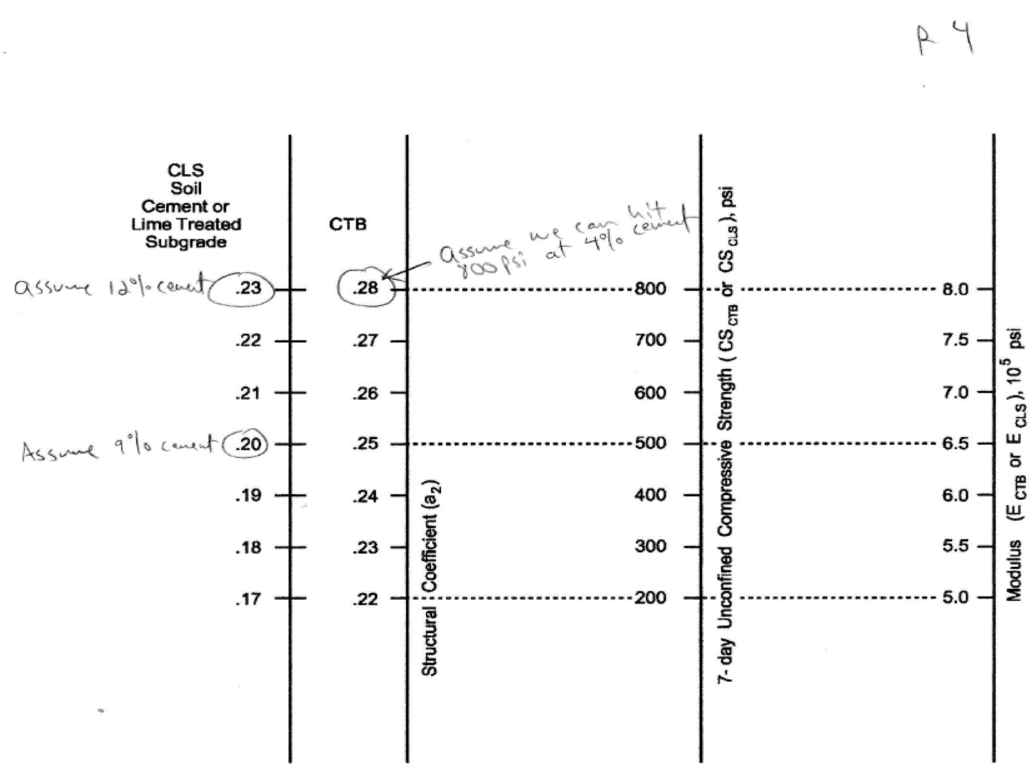
Apply this cost to CTB and CTS

Pavement Unit Costs Calculations

Date: 6/4/2020 **Rev:** 1 **Made by:** RMP
Project No.: 1660053 **Checked by:** JAV
Roadway: Valencia Road **Reviewed by:** MP
Project Short Title: Kolb Road to Houghton Road

6.0 REFERENCE INFORMATION

R 4



$a_2 = 0.20 + 0.0001\,(CS_{CTB})$ $a_2 = 0.12 + 2\times10^{-7}(E_{CTB})$

$a_2 = 0.15 + 0.0001\,(CS_{CLS})$ $a_2 = 0.07 + 2\times10^{-7}(E_{CLS})$

Figure 2-4 Structural Layer Coefficient of Chemically Stabilized Base and Subgrade (Chart for estimating structural layer coefficient of cement treated base (CTB) and stabilized soil subgrade based on unconfined compressive strength or elastic modulus)

ATTACHMENT F

Pavement Design Calculations

Table E-1: R-Value Analysis

Borehole ID	% Passing No. 200	Plasticity Index	R_{corr} (RCB)	R_{corr} (RPC)[A]	R_{tested}
BH-01	30	11	43	27	
BH-02	29	10	45	29	
BH-03	28	10	46	30	23
BH-04	19	4	66	46	
BH-05	21	0	75	53	
BH-06	40	10	39	24	
BH-07	40	10	39	24	
BH-08	39	15	32	20	16
BH-09	10	1	84	61	
BH-10	13	0	84	61	
BH-11	33	10	43	27	
BH-12	28	1	65	45	
BH-13	25	2	65	45	
BH-14	30	11	43	27	
BH-15	29	7	51	34	
BH-16	33	10	43	27	23
BH-17	32	8	47	30	
BH-18	36	8	44	28	
BH-19	42	8	41	26	
BH-20	41	3	50	33	
BH-21	35	2	57	38	
BH-22	30	8	48	31	15
BH-23	47	13	31	19	
BH-24	30	2	61	42	
BH-25	20	7	58	39	
BH-26	29	11	44	28	
BH-27	27	0	69	48	
BH-28	8	0	90	66	
BH-29	34	9	44	28	22
BH-30	28	0	68	47	
BH-31	22	7	56	38	
BH-32	35	7	47	30	
BH-33	36	5	50	33	
BH-34	22	2	68	48	67
BH-35	29	6	53	35	
BH-36	40	10	39	24	
	No.		**36**	**36**	**6**
	Average		**54**	**36**	**28**
	Std. Dev.		**14**	**12**	**18**

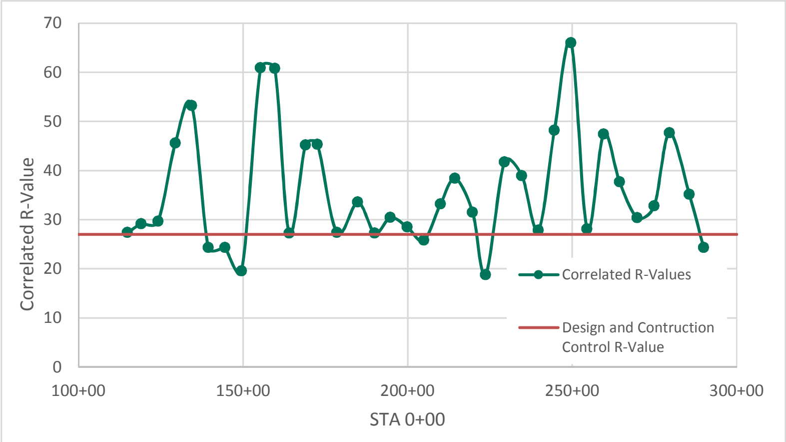


Fig. E-1. Pima County Roadway Design Correlated R-Values

ADOT Equation (PDM, 2017) R_{mean} = **35.4**

Design and Construction Control R-Value = 27.0

Valencia Road: Kolb Road to Houghton Road
Valencia Rd. W of Old Vail - Section 1 (Conventional AC over AB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)		**5,348,198**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)		**95.00 %**	
	Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)		**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index:	**Po =**	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
	Pt =	**2.8**	
	Delta-PSI =	1.4	
Resilient Modulus (Mr)		**11,685**	psi with R value of: **27**
Seasonal Variation Factor		**1.7**	(pages 89-92)
Quality of Base Drainage Number		**3**	<=
	Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **4.04**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.50	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=11.00	inches	a7 = 0.12
Total Section Thickness =	17.5	inches	

Structural Number Provided, SN = **4.07**

PAVEMENT SECTION IS SUFFICIENT
100.74% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY)
$40.61
Life-Cycle ($/SY)
-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd. W of Old Vail - Section 2 (With CTB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)		**5,348,198**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)		**95.00 %**	
	Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)		**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index:	**Po =**	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
	Pt =	**2.8**	
	Delta-PSI =	1.4	
Resilient Modulus (Mr)		**11,685**	psi with R value of: **27**
Seasonal Variation Factor		**1.7**	(pages 89-92)
Quality of Base Drainage Number		**3**	<=
	Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **4.04**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=6.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	12.0	inches	

Structural Number Provided, SN = **4.32**

PAVEMENT SECTION IS SUFFICIENT
106.81% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY)
$36.88
Life-Cycle ($/SY)
-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd. W of Old Vail - Section 3 (With CTS - 500 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **5,348,198** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **4.04**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=8.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 14.0 inches

Structural Number Provided, SN = **4.24**

PAVEMENT SECTION IS SUFFICIENT
104.83% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY) **$33.14**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Valencia Rd. W of Old Vail - Section 4 (With CTS - 800 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)	**5,348,198**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)	**95.00 %**	
Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)	**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index: Po =	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt =	**2.8**	
Delta-PSI =	1.4	
Resilient Modulus (Mr)	**11,685**	psi with R value of: **27**
Seasonal Variation Factor	**1.7**	(pages 89-92)
Quality of Base Drainage Number	**3**	<=
Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **4.04**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=7.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	13.0	inches	

Structural Number Provided, SN = **4.25**

PAVEMENT SECTION IS SUFFICIENT
105.08% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial (\$/SY)
$33.76
Life-Cycle ($/SY)
-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd. W of Old Vail - Section 5 (With CTS - 800 psi, Minimize AC)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **5,348,198** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**

Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)

Pt = **2.8**

Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)

Quality of Base Drainage Number **3** <=

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **4.04**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=10.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 15.0 inches

Structural Number Provided, SN = **4.50**

PAVEMENT SECTION IS SUFFICIENT
111.26% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs

Initial ($/SY)	**$30.85**
Life-Cycle ($/SY)	-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, Old Vail Rd to Nexus Rd - Section 1 (Conventional AC over AB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **4,503,821** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.93**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.50	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=10.00	inches	a7 = 0.12

Total Section Thickness = 16.5 inches

Structural Number Provided, SN = **3.96**

PAVEMENT SECTION IS SUFFICIENT
100.93% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY) **$39.55**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, Old Vail Rd to Nexus Rd - Section 2 (CTB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **4,503,821** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index:
Po = **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.93**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=5.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 11.0 inches

Structural Number Provided, SN = **4.04**

PAVEMENT SECTION IS SUFFICIENT
102.86% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY) **$35.59**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, Old Vail Rd to Nexus Rd - Section 3 (With CTS 500 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) 4,503,821 Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) 95.00 %
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** 4.2 Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = 2.8
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor 1.7 (pages 89-92)
Quality of Base Drainage Number 3 <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.93**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=7.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 13.0 inches

Structural Number Provided, SN = **4.04**

PAVEMENT SECTION IS SUFFICIENT
102.86% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00 /Sq.Yd.	
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00 /Sq.Yd.	
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23 /Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23 /Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23 /Sq.Yd.	
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23 /Sq.Yd.	
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00 /Sq.Yd.	

Pavement Section Costs
Initial ($/SY)
$32.64
Life-Cycle ($/SY)
-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, Old Vail Rd to Nexus Rd - Section 4 (With CTS 800 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) — **4,503,821** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) — **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) — **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index:
Po = **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) — **11,685** psi with R value of: **27**

Seasonal Variation Factor — **1.7** (pages 89-92)
Quality of Base Drainage Number — **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.93**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=6.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 12.0 inches

Structural Number Provided, SN = **4.02**

PAVEMENT SECTION IS SUFFICIENT
102.35% of that required

Pavement Unit Costs

Item	Unit Cost		Fixed Cost
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial (\$/SY) **$33.10**
Life-Cycle (\$/SY) -

GOLDER

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, Old Vail Rd to Nexus Rd - Section 4 (With CTS 800 psi, minimize AC)

AASHTO Flexible Pavement Design Process	15-Jun-20	Made By:	R. Post
		Chkd By:	J. Velarde

ESAL's (W-18)	**4,503,821**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)	**95.00 %**	
Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)	**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index: Po =	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt =	**2.8**	
Delta-PSI =	1.4	
Resilient Modulus (Mr)	**11,685**	psi with R value of: **27**
Seasonal Variation Factor	**1.7**	(pages 89-92)
Quality of Base Drainage Number	**3**	<=
Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.93**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=10.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	15.0	inches	

Structural Number Provided, SN = **4.50**

PAVEMENT SECTION IS SUFFICIENT
114.58% of that required

Pavement Unit Costs

				Pavement Section Costs
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	Initial ($/SY)
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	**$30.85**
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	Life-Cycle
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	($/SY)
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, E of Nexus Rd - Section 1 (Conventional AC over AB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post	
	Chkd By:	J. Velarde	

ESAL's (W-18)		**3,244,893**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)		**95.00 %**	
	Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)		**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index:	**Po =**	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
	Pt =	**2.8**	
	Delta-PSI =	1.4	
Resilient Modulus (Mr)		**11,685**	psi with R value of: **27**
Seasonal Variation Factor		**1.7**	(pages 89-92)
Quality of Base Drainage Number		**3**	<=
	Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.71**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=10.00	inches	a7 = 0.12
Total Section Thickness =	16.0	inches	

Structural Number Provided, SN = **3.74**

PAVEMENT SECTION IS SUFFICIENT
100.91% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs

Initial ($/SY)	**$37.51**
Life-Cycle ($/SY)	**-**

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, E of Nexus Rd - Section 2 (CTB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **3,244,893** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.71**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.50	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=5.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 10.5 inches

Structural Number Provided, SN = **3.82**

PAVEMENT SECTION IS SUFFICIENT
102.96% of that required

Pavement Unit Costs

				Pavement Section Costs
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	Initial
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	($/SY)
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	**$33.15**
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	Life-Cycle
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	($/SY)
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, E of Nexus Rd - Section 3 (With CTS - 500 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) 3,244,893 Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) 95.00 %
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** 4.2 Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = 2.8
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor 1.7 (pages 89-92)
Quality of Base Drainage Number 3 <=

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.71**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=6.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 12.0 inches

Structural Number Provided, SN = **3.84**

PAVEMENT SECTION IS SUFFICIENT
103.50% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY)
$32.14
Life-Cycle ($/SY)
-

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, E of Nexus Rd - Section 4 (With CTS - 800 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)	**3,244,893**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)	**95.00 %**	
Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)	**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index: Po =	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt =	**2.8**	
Delta-PSI =	1.4	
Resilient Modulus (Mr)	**11,685**	psi with R value of: **27**
Seasonal Variation Factor	**1.7**	(pages 89-92)
Quality of Base Drainage Number	**3**	<=
Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Drainage	
Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.71**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=5.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	11.0	inches	

Structural Number Provided, SN = **3.79**

PAVEMENT SECTION IS SUFFICIENT
102.15% of that required

Pavement Unit Costs

Layer	Cost			
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	

Pavement Section Costs
Initial ($/SY)
$32.44
Life-Cycle ($/SY)
-

GOLDER

Valencia Road: Kolb Road to Houghton Road
Valencia Rd, E of Nexus Rd - Section 5 (With CTS - 800 psi, minimize AC)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)		**3,244,893**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)		**95.00 %**	
	Zr =	-1.645	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)		**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index:	**Po =**	**4.2**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
	Pt =	**2.8**	
	Delta-PSI =	1.4	
Resilient Modulus (Mr)		**11,685**	psi with R value of: **27**
Seasonal Variation Factor		**1.7**	(pages 89-92)
Quality of Base Drainage Number		**3**	<=
	Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Drainage	No.
Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **3.71**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=10.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	15.0	inches	

Structural Number Provided, SN = **4.50**

PAVEMENT SECTION IS SUFFICIENT
121.29% of that required

Pavement Unit Costs

Layer	Cost		Fixed	
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	

Pavement Section Costs
Initial ($/SY)
$30.85
Life-Cycle ($/SY)
-

GOLDER

Valencia Road: Kolb Road to Houghton Road
Nexus Road - Section 1 (Conventional AC over AB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **2,398,779** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**

Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)

Pt = **2.8**

Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)

Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.52**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=8.00	inches	a7 = 0.12

Total Section Thickness = 14.0 inches

Structural Number Provided, SN = **3.52**

PAVEMENT SECTION IS SUFFICIENT
100.17% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY) **$35.39**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Nexus Road - Section 2 (CTB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **2,398,779** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.52**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=5.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 10.0 inches

Structural Number Provided, SN = **3.60**

PAVEMENT SECTION IS SUFFICIENT
102.35% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY) **$30.70**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Nexus Road - Section 3 (With CTS - 500 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **2,398,779** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.52**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=7.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 12.0 inches

Structural Number Provided, SN = **3.60**

PAVEMENT SECTION IS SUFFICIENT
102.35% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs
Initial ($/SY)
$27.75
Life-Cycle ($/SY)
-

GOLDER

Valencia Road: Kolb Road to Houghton Road
Nexus Road - Section 4 (With CTS - 800 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) — **2,398,779** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) — **95.00 %**
Zr = -1.645 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) — **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index:
Po = **4.2** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.8**
Delta-PSI = 1.4

Resilient Modulus (Mr) — **11,685** psi with R value of: **27**

Seasonal Variation Factor — **1.7** (pages 89-92)
Quality of Base Drainage Number — **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **3.52**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness	Units	Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=6.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 11.0 inches

Structural Number Provided, SN = **3.58**

PAVEMENT SECTION IS SUFFICIENT
101.78% of that required

Pavement Unit Costs

Layer	Cost		Fixed	
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	

Pavement Section Costs
Initial ($/SY) **$28.21**
Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Old Vail Road - Section 1 (Conventional AC over AB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **1,141,959** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **90.00 %**
Zr = -1.282 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index:
Po = **4.1** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.6**
Delta-PSI = 1.5

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **2.90**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=7.00	inches	a7 = 0.12

Total Section Thickness = 12.0 inches

Structural Number Provided, SN = **2.97**

PAVEMENT SECTION IS SUFFICIENT
102.59% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Pavement Section Costs

Initial ($/SY)	**$29.44**
Life-Cycle ($/SY)	-

Valencia Road: Kolb Road to Houghton Road
Old Vail Road - Section 1 (CTB)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **1,141,959** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **90.00 %**
Zr = -1.282 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.1** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.6**
Delta-PSI = 1.5

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Structural Number Required, SN_{reqd} = **2.90**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=3.00	inches	a1 = 0.44
PAG 2 AC =	D2=2.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=4.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 9.0 inches

Structural Number Provided, SN = **3.32**

PAVEMENT SECTION IS SUFFICIENT
114.57% of that required

Pavement Section Costs

Initial ($/SY) **$29.41**

Pavement Unit Costs

Layer	Unit Cost		Fixed Cost
PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Life-Cycle ($/SY) -

Valencia Road: Kolb Road to Houghton Road
Old Vail Road - Section 3 (With CTS - 500 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18) **1,141,959** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) **90.00 %**
Zr = -1.282 Table in Section 3.13 PCRDM (page 3-43, 2016)

Standard Error (So) **0.35** Pima C. Standard Number (3.13 page 3-1, 2016)

Serviceability Index: **Po =** **4.1** Table on Chapter 3.13 PCRDM (page 3-1, 2016)
Pt = **2.6**
Delta-PSI = 1.5

Resilient Modulus (Mr) **11,685** psi with R value of: **27**

Seasonal Variation Factor **1.7** (pages 89-92)
Quality of Base Drainage Number **3** <=

Base Drainage Coefficient, m2 = 0.92 Per PCRDM (p. 3-44)

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **2.90**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=0.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=0.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=8.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12

Total Section Thickness = 11.0 inches

Structural Number Provided, SN = **2.92**

PAVEMENT SECTION IS SUFFICIENT
100.77% of that required

Pavement Section Costs

Initial ($/SY) **$20.90**

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.

Life-Cycle ($/SY) **-**

Valencia Road: Kolb Road to Houghton Road
Old Vail Road - Section 4 (With CTS - 800 psi)

AASHTO Flexible Pavement Design Process

15-Jun-20	Made By:	R. Post
	Chkd By:	J. Velarde

ESAL's (W-18)		**1,141,959**	Flexible 18-kip Equivalent Single Axle Loads
Level of Reliability (R)		**90.00 %**	
	Zr =	-1.282	Table in Section 3.13 PCRDM (page 3-43, 2016)
Standard Error (So)		**0.35**	Pima C. Standard Number (3.13 page 3-1, 2016)
Serviceability Index:	**Po =**	**4.1**	Table on Chapter 3.13 PCRDM (page 3-1, 2016)
	Pt =	**2.6**	
	Delta-PSI =	1.5	
Resilient Modulus (Mr)		**11,685**	psi with R value of: **27**
Seasonal Variation Factor		**1.7**	(pages 89-92)
Quality of Base Drainage Number		**3**	<=
	Base Drainage Coefficient, m2 =	0.92	Per PCRDM (p. 3-44)

Drainage	Number
Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Structural Number Required, SN_{reqd} = **2.90**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coefficients
PAG 1 AC =	D1=0.00	inches	a1 = 0.44
PAG 2 AC =	D2=3.00	inches	a2 = 0.44
Cement Treated Base (CTB, 800 psi) =	D3=0.00	inches	a3 = 0.28
Cement Treated Base (CTB, 500 psi) =	D4=0.00	inches	a4 = 0.25
Cement Treated Subgrade (CTS, 800 psi) =	D5=7.00	inches	a5 = 0.23
Cement Treated Subgrade (CTS, 500 psi) =	D6=0.00	inches	a6 = 0.20
Aggregate Base =	D7=0.00	inches	a7 = 0.12
Total Section Thickness =	10.0	inches	

Structural Number Provided, SN = **2.93**

PAVEMENT SECTION IS SUFFICIENT
101.11% of that required

Pavement Unit Costs

PAG 1 AC =	$4.08	/Sq. Yd./in. +	$0.00/Sq.Yd.	
PAG 2 AC =	$4.89	/Sq. Yd./in. +	$0.00/Sq.Yd.	
Cement Treated Base (CTB, 800 psi) =	$1.29	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Base (CTB, 500 psi) =	-	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 800 psi) =	$0.66	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Cement Treated Subgrade (CTS, 500 psi) =	$0.50	/Sq. Yd./in. +	$2.23/Sq.Yd.	
Aggregate Base =	$1.06	/Sq. Yd./in. +	$0.00/Sq.Yd.	

Pavement Section Costs
Initial ($/SY)
$21.52
Life-Cycle ($/SY)
-

GOLDER

APPENDIX G

Important Information About Your Geotechnical Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GBA GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org   www.geoprofessional.org

GOLDER

golder.com