Geotechnical Evaluation

Mission Road Bicycle and Pedestrian Improvement Project
Colma, California

Town of Colma

1198 El Camino Real | Colma, California 94014

August 30, 2019 | Project No. 403573001

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

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

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

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Mr. Abdulkader Hashem
Town of Colma
1198 El Camino Real | Colma, California 94014

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1 INTRODUCTION

In accordance with your authorization, we have performed a geotechnical evaluation for the Mission Road Bicycle and Pedestrian Improvement Project located in Colma, California (Figure 1). The project limits along Mission Road extend between its intersections with El Camino Real to the north and Lawndale Boulevard to the south, about 4,500 linear feet. This report presents the findings and conclusions from our geologic hazards assessment, and our geotechnical recommendations for improvements at the site.

2 SCOPE OF SERVICES

Our scope of services included the following:

- Review of readily available background materials, including geologic maps, aerial photographs, topographic data, and hazard maps.
- Site reconnaissance to observe the general site conditions, and to mark the locations for our subsurface exploration.
- Coordination with Underground Service Alert (USA) to locate underground utilities in the vicinity of our subsurface exploration.
- Obtained an encroachment permit from the Town of Colma.
- Subsurface exploration consisting of two (2) borings to a depth of 5 feet below the existing ground surface. A representative of Ninyo & Moore logged the subsurface conditions exposed in the boring and collected bulk and relatively undisturbed soil samples for laboratory testing.
- Performance of percolation testing at two locations to evaluate the infiltration characteristics of the near-surface soil for design of stormwater treatment areas.
- Laboratory testing on selected samples to evaluate in-situ soil moisture content, grain size distribution, Atterberg limits, and corrosivity.
- Compilation and engineering analysis of the field and laboratory data, and the findings from our background review.
- Preparation of this report presenting our findings and conclusions regarding the potential geologic hazards and geotechnical conditions at the project site, and our geotechnical recommendations for proposed improvements.

3 SITE DESCRIPTION

The Mission Road project is located between the intersections of Mission Road and El Camino Real to the north and Mission Road and Lawndale Boulevard to the south in the Town of Colma, California (Figure 1). Various developments are located along this section of Mission Road including Holy Cross Cemetery, Mercy Housing Veteran's Village, and Verano HOA. Elevations along the roadway vary from approximately 80 feet above mean sea level (MSL) at the intersection with Lawndale Boulevard to about 100 feet MSL at the El Camino Real Intersection (Google Earth, 2019).

4 PROJECT DESCRIPTION

Based on our review of plans for the project (CGS Consultants, Inc., 2019) and the project description provided by the Town of Colma (2018), the proposed improvements will include new sidewalk, curb and gutter, curb ramps, new drainage inlets, curb extensions and bioretention facilities, and mid-block crosswalks with Rectangular Rapid Flashing Beacons (RRFB) systems. Our subsurface exploration was performed at the locations of the proposed bioretention facilities designated at Crosswalk Nos. 1 and 3 (see Figures 2 and 3). According to plans provided by the Town of Colma (2018), the bioretention facilities will be embedded approximately 30 inches below the adjoining roadway pavement.

5 FIELD EXPLORATION AND LABORATORY TESTING

Our field exploration included a site reconnaissance and subsurface exploration of the project site. The subsurface exploration was conducted on August 15, 2019, and consisted of two (2) hand auger borings drilled to depths of up to 5 feet below existing grade. The locations of Borings B-1 and B-2 are presented on Figures 2 and 3, respectively. A representative of Ninyo & Moore logged the subsurface conditions encountered and collected bulk soil samples for laboratory testing. The samples were then transported to our geotechnical laboratory for testing. Detailed logs of the borings are presented in Appendix A.

Laboratory testing was performed on soil samples recovered from the borings to evaluate in-place moisture content, soil gradation, Atterberg limits, and soil corrosivity. The results of the in-place moisture content tests are shown at the corresponding sample depth on the boring logs in Appendix A. The results of the other laboratory tests performed are presented in Appendix B.

Percolation tests were performed on August 15, 2019 at the locations shown on Figures 2 and 3 to depths of approximately 30 inches. The percolation test results and procedures utilized are presented in Appendix C. The test holes were backfilled with clean sand after testing.

6 GEOLOGIC AND GEOTECHNICAL CONDITIONS

Our findings regarding regional geologic setting, site geology, subsurface stratigraphy, and groundwater conditions at the subject site are provided in the following sections.

6.1 Regional Geologic Setting

The campus is located west of San Francisco Bay in the Coast Ranges geomorphic province of California. The Coast Ranges are comprised of several mountain ranges and structural valleys formed by tectonic processes commonly found around the Circum-Pacific belt. Basement rocks have been sheared, faulted, metamorphosed, and uplifted, and are separated by thick blankets of Cretaceous and Cenozoic sediments that fill structural valleys and line continental margins. The San Francisco Bay Area has several ranges that trend northwest, parallel to major strike-slip faults such as the San Andreas, Hayward, and Calaveras. Major tectonic activity associated with these and other faults within this regional tectonic framework consists primarily of right-lateral, strike-slip movement.

6.2 Site Geology

A regional geologic map prepared by Bonilla (1998) indicates that this portion of Mission Road is underlain by Holocene age alluvial deposits and Pleistocene age sedimentary deposits of the Colma Formation. Both deposits generally consist of sand, silt and clay with variable amounts of gravel and cobbles.

6.3 Subsurface Conditions

The following sections provide a generalized description of the geologic units encountered during our subsurface evaluation. More detailed descriptions are presented on the logs in Appendix A.

6.3.1 Fill

Fill was encountered in Borings B-2 and P-2 to a depth of about 1½ feet. The fill generally consisted of a layer of well graded gravel overlying a layer of asphalt concrete (AC), which was about 5 inches thick.

6.3.2 Alluvium

Alluvium was encountered in Boring B-1 to the depth explored of 5 feet and in B-2 from beneath the fill to the depth of about 3 feet. The alluvium, as encountered, generally consisted of brown, dry to moist, medium dense, silty sand with gravel.

6.4 Groundwater

Groundwater was not encountered during our subsurface exploration. Previous geotechnical evaluations performed for projects along this portion of Mission Road indicate that groundwater is at a depth of about 30 feet below the ground surface (Rockridge Geotechnical, 2015; Stevens, Ferrone & Bailey, 2002).

Fluctuations in the groundwater level across the site and over time may occur due to seasonal precipitation, variations in topography or subsurface hydrogeologic conditions, or as a result of changes to nearby irrigation practices or groundwater pumping. In addition, seeps may be encountered at elevations above the observed groundwater levels due to perched groundwater conditions, leaking pipes, preferential drainage, or other factors not evident at the time of our exploration.

6.5 Static Settlement

We understand that the proposed improvements will be relatively light and that significant changes to the site grade are not proposed. We anticipate, therefore, that settlement due to sustained loading by the proposed improvements will be tolerable, provided that those improvements are designed in accordance with the recommendations in this report.

6.6 Unsuitable Materials

Fill materials that were not placed and compacted under the observation of a geotechnical engineer, or fill materials lacking documentation of such observation, are considered undocumented fill. Undocumented fill is unsuitable as a bearing material below foundations, due to the potential for differential settlement resulting from variable support characteristics or the potential inclusion of deleterious materials. Undocumented fill was encountered up to depths of 1½ feet below the ground surface during our subsurface exploration. Recommendations for subgrade preparation and foundation embedment are provided to mitigate the undocumented fill concerns.

Soil containing roots or other organic matter are not suitable as fill or subgrade material below foundations, pavements, or engineered fill. Recommendations for clearing and grubbing to remove vegetative matter in soil during site preparation are provided.

6.7 Excavation Characteristics

We anticipate that the project will involve excavations for foundations and utilities. We anticipate that heavy earthmoving equipment in good working condition should be able to make the proposed excavations.

Excavations in the fill may encounter obstructions consisting of debris, rubble, abandoned structures, or over-sized materials that may require special handling or demolition equipment for removal.

Near-vertical temporary cuts in the near surface deposits up to 4 feet in depth should remain stable for a limited period of time. However, sloughing of the materials exposed on the excavation sidewall may occur, particularly if the excavation extends near the groundwater level, encounters granular soil, is exposed to water, or if the sidewall is disturbed during construction operations. Excavation subgrade may become unstable if exposed to wet conditions. Recommendations for excavation stabilization are presented. Excavated materials may also be wet and need to be dried out before reuse as fill.

6.8 Corrosive/Deleterious Soil

An evaluation of the corrosivity of the on-site material was conducted to assess the impact to concrete and metals. The corrosion impact was evaluated using the results of limited laboratory testing on samples obtained during our subsurface study. Laboratory testing to quantify pH, resistivity, chloride, and soluble sulfate contents was performed on a sample of the near-surface soil. The results of the corrosivity tests are presented in Appendix B. California Department of Transportation (Caltrans) defines a corrosive environment as an area within 1,000 feet of brackish water or where the soil contains more than 500 parts per million (ppm) of chlorides, sulfates of 0.2 (2,000 ppm) percent or more, or pH of 5.5 or less (Caltrans, 2018). Based on these criteria, the site does not meet the definition of a corrosive environment. Ferrous metal will still undergo corrosion on site, but special mitigation measures are not needed. Based on the criteria used to evaluate the deleterious nature of soil on concrete and recommendations from the American Concrete Institute (ACI, 2014) for sulfate exposure classes, the soil on site is defined as Exposure Class S0.

6.9 Infiltration Characteristics

Ninyo & Moore performed percolation testing to evaluate the rate of infiltration on site for design of bioretention systems. The percolation test procedures utilized are presented in Appendix C. The test results, presented in Appendix C and summarized in Table 1, indicate that the infiltration rate of the near surface soil on site is relatively fast and consistent with Hydrologic Soil Group A. Due to the variability of subsurface materials encountered during our exploration, variability in subsurface infiltration should be anticipated.

Table 1 – Percolation Test Results				
Test	**Test Depth (inches)**	**Subsurface Conditions**	**Percolation Rate (inches/hour)**	**Infiltration Rate[1] (inches/hour)**
P-1	30	Silty SAND	27.0	3.92
P-2	30	Silty SAND	32.0	4.00

[1] Infiltration rate is percolation rate adjusted by a reduction factor to exclude percolation through sides of test hole.

7 CONCLUSIONS

Based on our review of the referenced background data, our site field reconnaissance, subsurface evaluation, and laboratory testing, it is our opinion that proposed construction is feasible from a geotechnical standpoint. Geotechnical considerations include the following:

- Our subsurface exploration encountered undocumented fill and alluvium. Fill was encountered to a depth of about 1½ feet in Boring B-2. The fill generally consisted of well graded gravel overlying a 5-inch thick layer of AC. The alluvium generally consisted of brown, dry to moist, medium dense, silty sand with gravel.

- Undocumented fill and soil containing roots or other organic matter are not suitable as subgrade below improvements or foundations. Recommendations for subgrade preparation and foundation embedment depth are provided.

- Groundwater was not encountered in the Borings to the depth explored of 5 feet. Previous geotechnical evaluations along Mission Road indicate that groundwater is at depth of about 30 feet below the ground surface. Variation and fluctuation in groundwater levels should be anticipated as discussed in Section 6.4.

- Excavations that remain unsupported and exposed to water, or encounter seepage, or granular soil may be unstable and prone to sloughing. Recommendations for excavation stabilization are provided.

- Excavations in the fill may encounter debris, rubble, oversize material, buried objects, or other potential obstructions.

- Static settlement should be tolerable for the proposed improvements provided that our recommendations for subgrade preparation and fill placement are implemented during design and construction.

- Percolation testing performed for this study indicates that the infiltration rate at the test holes (Figures 2 and 3) is consistent with Hydrologic Soil Group A.

- Based on the results of our limited soil corrosivity tests during this study and Caltrans corrosion guidelines (2018), the site does not meet the definition of a corrosive environment.

8 RECOMMENDATIONS

The following sections present our geotechnical recommendations for the design and construction of the proposed improvements. The project improvements should be designed and constructed in accordance with these recommendations, applicable codes, and appropriate construction practices.

8.1 Foundation Recommendations

Foundations should be designed in accordance with structural considerations and the following recommendations. In addition, requirements of the appropriate governing jurisdictions and applicable building codes should be considered in design of the structures.

8.1.1 Drilled Piers

The Rectangular Rapid Flashing Beacons (RRFB) systems may be supported on drilled pier foundations. Drilled piers should have embedment depths of 4 feet or more and diameters of 2 feet or greater.

Drilled piers 4 to 10 feet below grade may be designed for an allowable side friction of 300 psf to evaluate resistance to downward axial loads and 200 psf for upward axial loads. The allowable side friction includes a factor of safety of 2 for downward loading and 3 for upward loading. The allowable side friction may be increased by one-third when considering loads of short duration such as wind or seismic loads. The spacing between adjacent piers should be equivalent to eight pier diameters, or more to mitigate reduction due to group effects.

A lateral bearing pressure of 300 pounds per square foot (psf) per foot depth up to 3,000 psf may be used to evaluate resistance to lateral loads and overturning moments in accordance with Section 1806 of the 2016 CBC. The allowable lateral bearing pressure may be increased by one-third for wind or seismic load combinations and by an additional factor of two for structures that can accommodate ½ inch of lateral deflection of the top of the pier foundation. Drilled pier excavations should be cleaned of loose material prior to pouring concrete. Drilled pier excavations that encounter groundwater or cohesionless soil may be unstable and may need to be stabilized by temporary casing or use of drilling mud. Standing water should be removed from the pier excavation or the concrete should be delivered to the bottom of the excavation, below the water surface, by tremie pipe. Casing should be removed from the excavation as the concrete is placed. Concrete should be placed in the piers in a manner that reduces the potential for segregation of the components.

8.2 Concrete

Laboratory testing indicated that the concentration of sulfate and corresponding potential for sulfate attack on concrete is negligible for the soil tested. However, due to the variability in the on-site soil and the potential future use of reclaimed water at the site, we recommend that Type II/V or Type V cement be used for concrete structures in contact with soil. In addition, we recommend a water-to-cement ratio of no more than 0.45. A 3-inch thick, or thicker, concrete cover should be maintained over reinforcing steel where concrete is in contact with soil in accordance with recommendations of ACI Committee 318 (ACI, 2014).

8.3 Review of Construction Plans

The recommendations provided in this report are based on preliminary design information for the proposed construction. We recommend that a copy of the plans be provided to Ninyo & Moore for review before bidding to check the interpretation of our recommendations and that the designed improvements are consistent with our assumptions. It should be noted that, upon review of these documents, some recommendations presented in this report might be revised or modified to meet the project requirements.

8.4 Construction Observation and Testing

The recommendations provided in this report are based on subsurface conditions encountered in relatively widely spaced exploratory borings. During construction, the geotechnical engineer or his representative in the field should be allowed to check the exposed subsurface conditions. During construction, the geotechnical engineer or his representative should be allowed to:

- Observe preparation and compaction of subgrade.
- Observe mitigation of unsuitable materials by excavation.
- Check and test imported materials prior to use as fill.
- Observe placement and compaction of fill, aggregate base, and asphalt concrete.
- Perform field density tests to evaluate fill and subgrade compaction.
- Observe foundation excavations for bearing materials and cleaning prior to placement of reinforcing steel and concrete.

The recommendations provided in this report assume that Ninyo & Moore will be retained as the geotechnical consultant during the construction phase of the project. If another geotechnical consultant is selected, we request that the selected consultant provide a letter to the architect and the owner (with a copy to Ninyo & Moore) indicating that they fully understand Ninyo &

Moore's recommendations, and that they are in full agreement with the recommendations contained in this report.

9 LIMITATIONS

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

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

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

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

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

10 REFERENCES

American Concrete Institute, 2014, Building Code Requirements for Structural Concrete and Commentary, 318-14.

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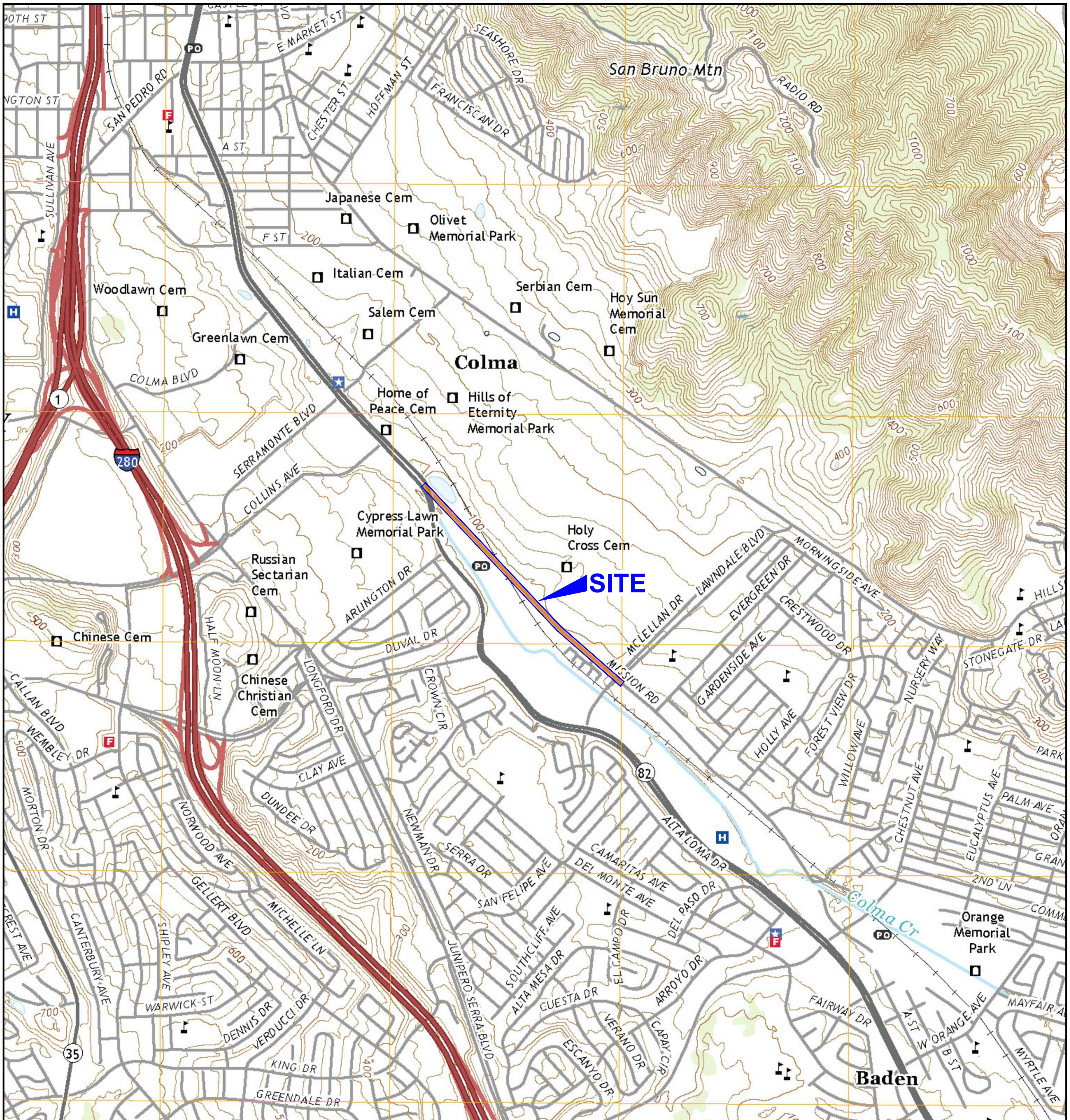
FIGURES



N

SCALE (FEET)

0 2,000 4,000

NOTE: DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE I REFERENCE: USGS, 2018

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FIGURE 1

SITE LOCATION

MISSION ROAD IMPROVEMENT PROJECT
MISSION ROAD
COLMA, CALIFORNIA

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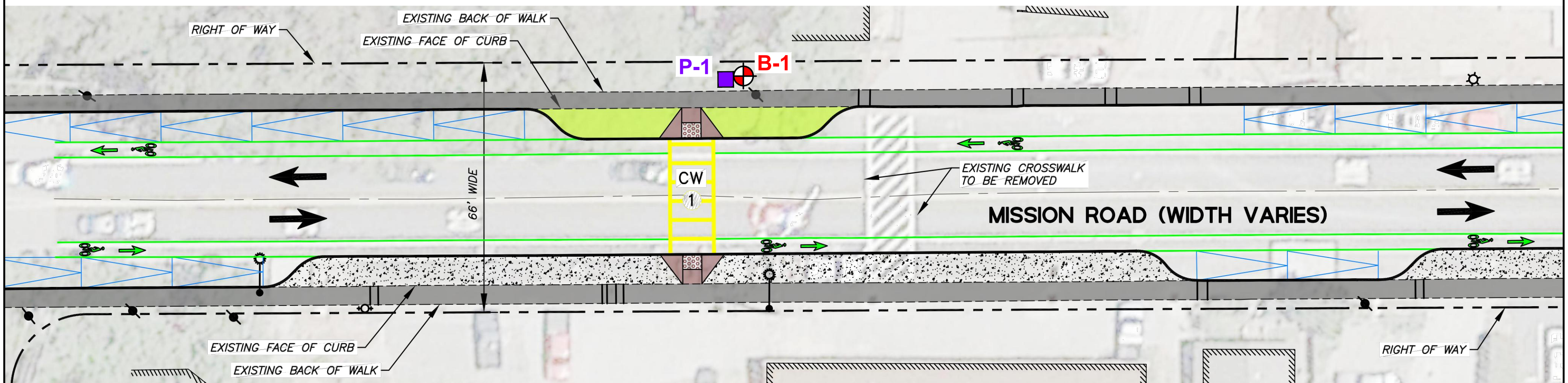

LEGEND

B-1 BORING LOCATION   P-1 PERCOLATION TEST

SCALE (FEET)
0 50 100

NOTE: DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE | REFERENCE: CSG, 2019

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FIGURE 2

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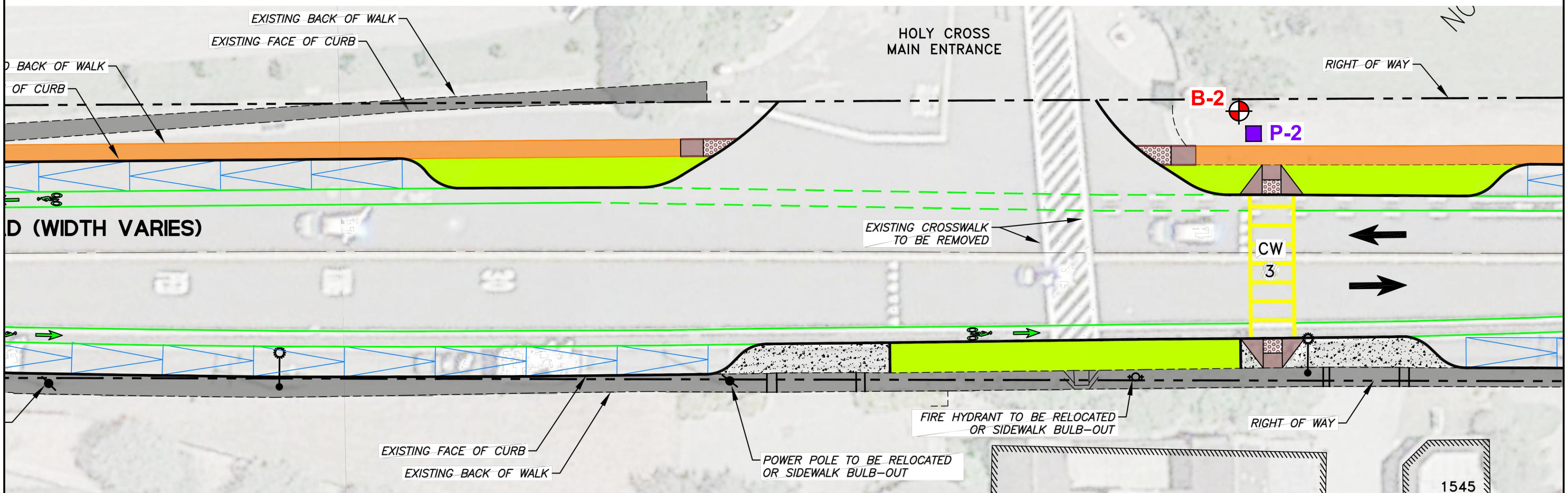
EXPLORATION LOCATIONS (CW NO.1)

MISSION ROAD IMPROVEMENT PROJECT
MISSION ROAD
COLMA, CALIFORNIA
403573001 | 08/19



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LEGEND

B-2 BORING LOCATION **P-2** PERCOLATION TEST

NOTE: DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE | REFERENCE: CSG, 2019

SCALE (FEET)

0 40 80

FIGURE 3

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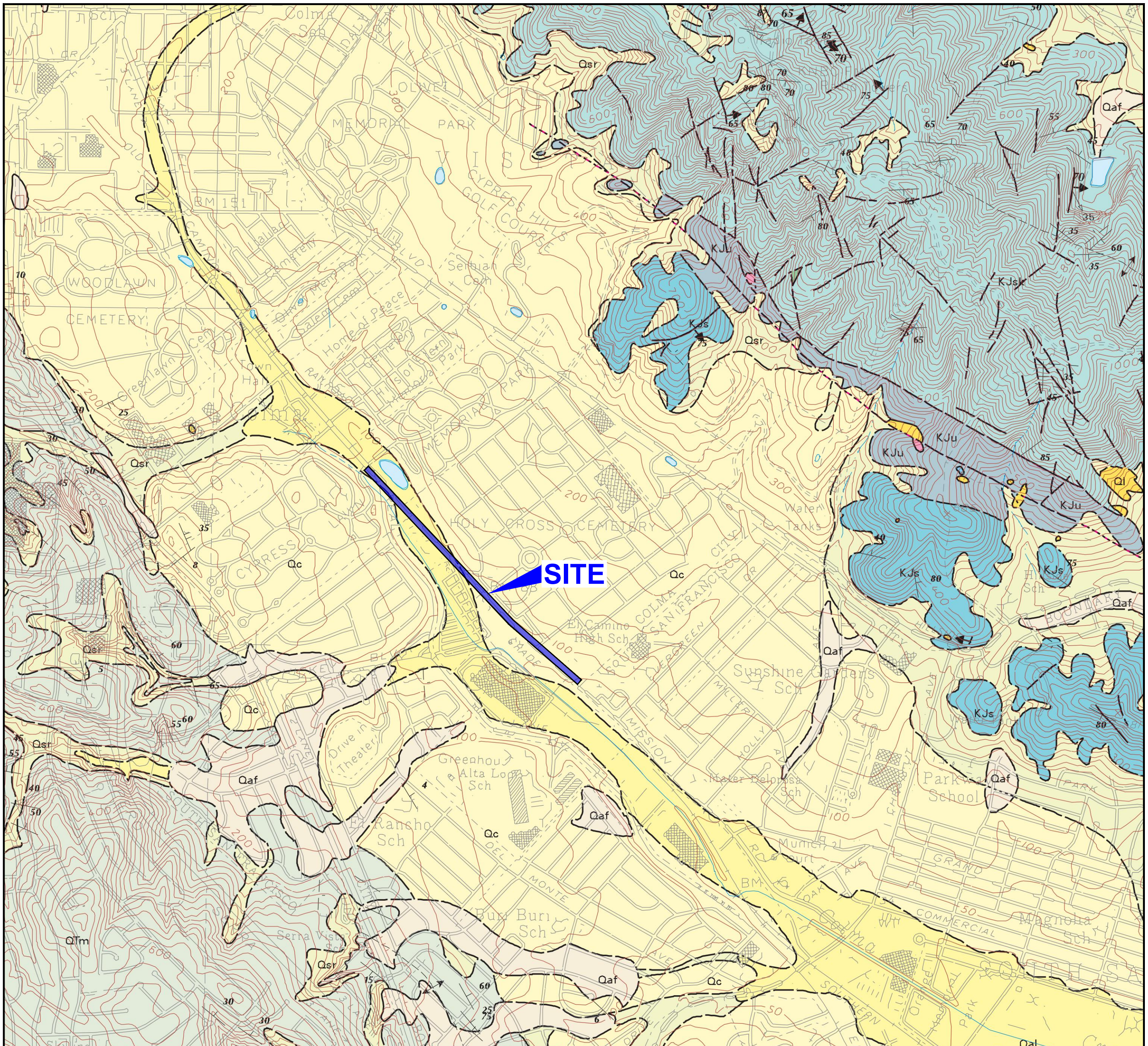
EXPLORATION LOCATIONS (CW NO.3)

MISSION ROAD IMPROVEMENT PROJECT
MISSION ROAD
COLMA, CALIFORNIA
403573001 | 08/19



LEGEND

Qaf	ARTIFICIAL FILL (HOLOCENE)
Ql	LANDSLIDE DEPOSITS (HOLOCENE)
Qal	ALLUVIUM (HOLOCENE)
Qsr	SLOPE DEBRIS & RAVINE FILL (HOLOCENE)
Qc	COLMA FORMATION (PLEISTOCENE)
Qtm	MERCED FORMATION (PLEISTOCENE & PLIOCENE)
KJs	SANDSTONE & SHALE (CRETACEOUS & JURASSIC)
KJsk	SANDSTONE & SHALE WITH FELDSPAR (CRETACEOUS & JURASSIC)
KJg	GREENSTONE (CRETACEOUS & JURASSIC)
sp	SERPENTINE (CRETACEOUS & JURASSIC)
KJu	SHEARED ROCKS (CRETACEOUS & JURASSIC)

THRUST FAULT

FAULT

GEOLOGIC CONTACT

STRIKE AND DIP OF BEDDING

N

SCALE (FEET)

0 2,000 4,000

NOTE: DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE I REFERENCE: DIBBLEE, 2005

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FIGURE 4

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REGIONAL GEOLOGY

MISSION ROAD IMPROVEMENT PROJECT
MISSION ROAD
COLMA, CALIFORNIA

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APPENDIX A

Boring Logs

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples
Disturbed soil samples were obtained in the field using the following methods.

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

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change. Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
15								
20								The total depth line is a solid line that is drawn at the bottom of the boring.

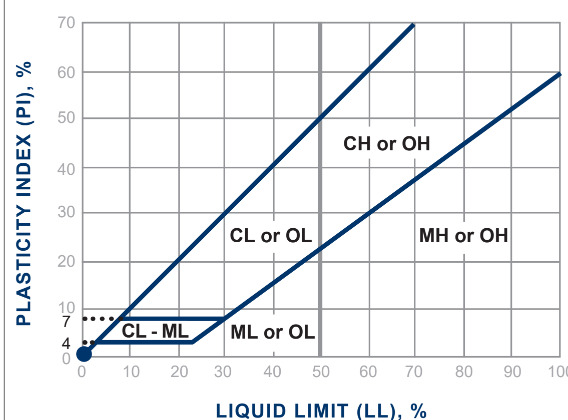
Soil Classification Chart Per ASTM D 2488

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

Grain Size

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

Plasticity Chart



Apparent Density - Coarse-Grained Soil

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

Consistency - Fine-Grained Soil

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

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USCS METHOD OF SOIL CLASSIFICATION

DATE DRILLED	8/15/2019
BORING NO.	B-1
GROUND ELEVATION	96' ± (MSL)
SHEET	1 OF 1
METHOD OF DRILLING	3 inch hand auger
DRIVE WEIGHT	N/A
DROP	N/A
SAMPLED BY	KCC
LOGGED BY	KCC
REVIEWED BY	DCS

DEPTH (feet)	SAMPLES: Bulk	SAMPLES: Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	■						SM	ALLUVIUM: Brown, dry, medium dense, silty SAND with gravel.
			Qc=25					
				4.7				
			Qc=20					Increase in sand and gravel content.
			Qc=25					
			Qc=30	4.9				
5								Total Depth = 5.0 feet Backfilled the hole with clean sand on 8/15/19. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretation of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

DATE DRILLED	8/15/2019	BORING NO.	B-2				
GROUND ELEVATION	90' ± (MSL)	SHEET	1	OF	1		
METHOD OF DRILLING	3 inch hand auger						
DRIVE WEIGHT	N/A	DROP	N/A				
SAMPLED BY	KCC	LOGGED BY	KCC	REVIEWED BY	DCS		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GW	FILL: Gray, dry, dense, well graded GRAVEL with sand.
								ASPHALT CONCRETE: Approximately 4.5 inches thick.
				5.8			SM	ALLUVIUM: Brown, moist, medium dense, silty SAND with gravel.
								Total Depth = 3.0 feet (Hand auger refusal).
								Backfilled the hole with clean sand on 8/15/19.
5								Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
								The ground elevation shown above is an estimation only. It is based on our interpretation of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
10								
15								
20								

APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Classification
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488-00. Soil classifications are indicated on the logs of the exploratory boring in Appendix A.

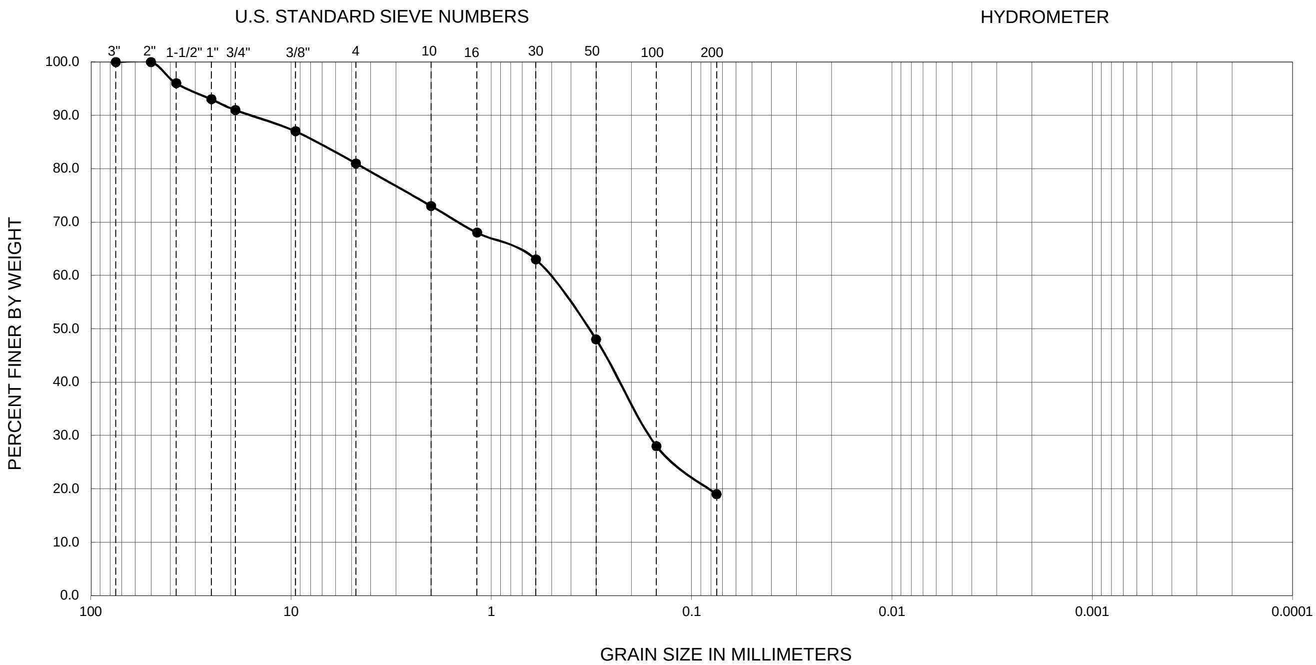
Moisture Content
The moisture content of samples obtained from the exploratory boring was evaluated in accordance with ASTM D 2216. The test results are presented on the boring logs in Appendix A.

Gradation Analysis
A gradation analysis test was performed on selected representative soil samples in general accordance with ASTM D 422. The grain size distribution curve is shown on Figures B-1 through B-3. The test results were utilized in evaluating the soil classification in accordance with the Unified Soil Classification System (USCS).

Atterberg Limits
Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-4.

Soil Corrosivity Tests
Soil pH, and resistivity tests were performed on a representative sample in general accordance with California Test (CT) 643. The soluble sulfate and chloride content of selected samples were evaluated in general accordance with CT 417 and CT 422, respectively. The test results are presented on Figure B-5.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-1	0.0-3.0	--	--	--	--	0.17	0.54	--	--	19	SM

PERFORMED IN ACCORDANCE WITH ASTM D 422 / D6913

FIGURE B-1

GRADATION TEST RESULTS

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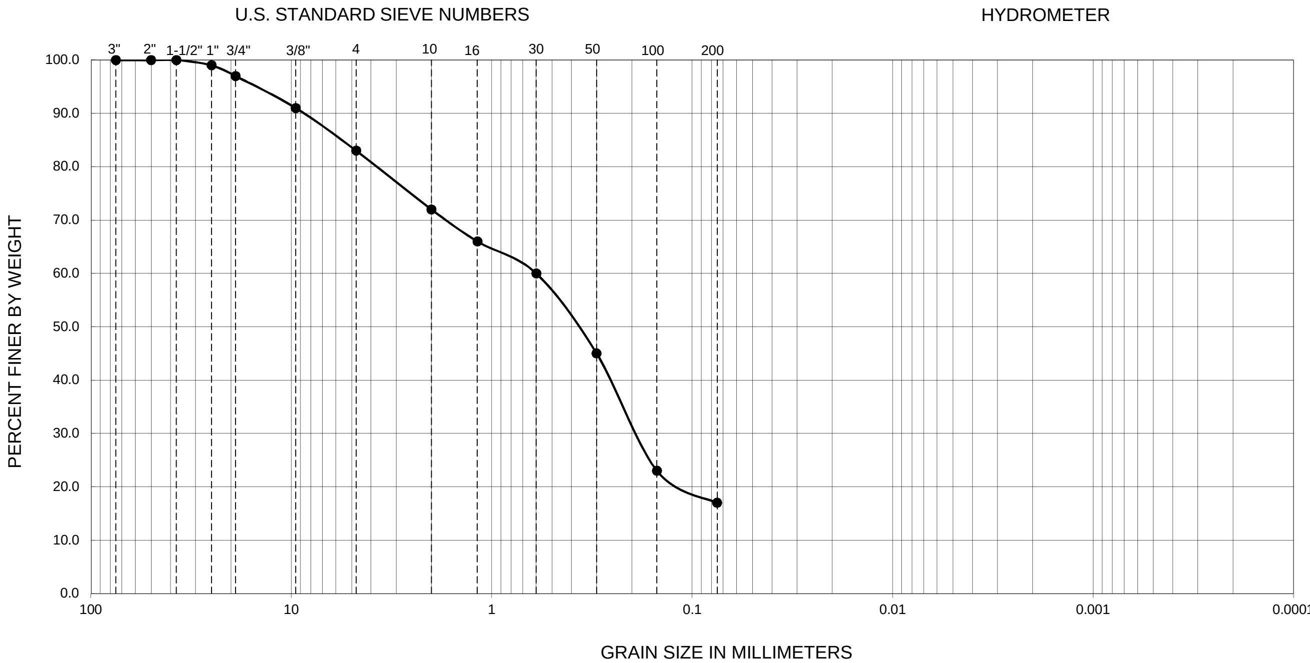
MISSION ROAD IMPROVEMENT PROJECT
COLMA, CALIFORNIA

403573001 | 8/19

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-1	3.0-5.0	--	--	--	--	0.20	0.60	--	--	17	SM

PERFORMED IN ACCORDANCE WITH ASTM D 422 / D6913

FIGURE B-2

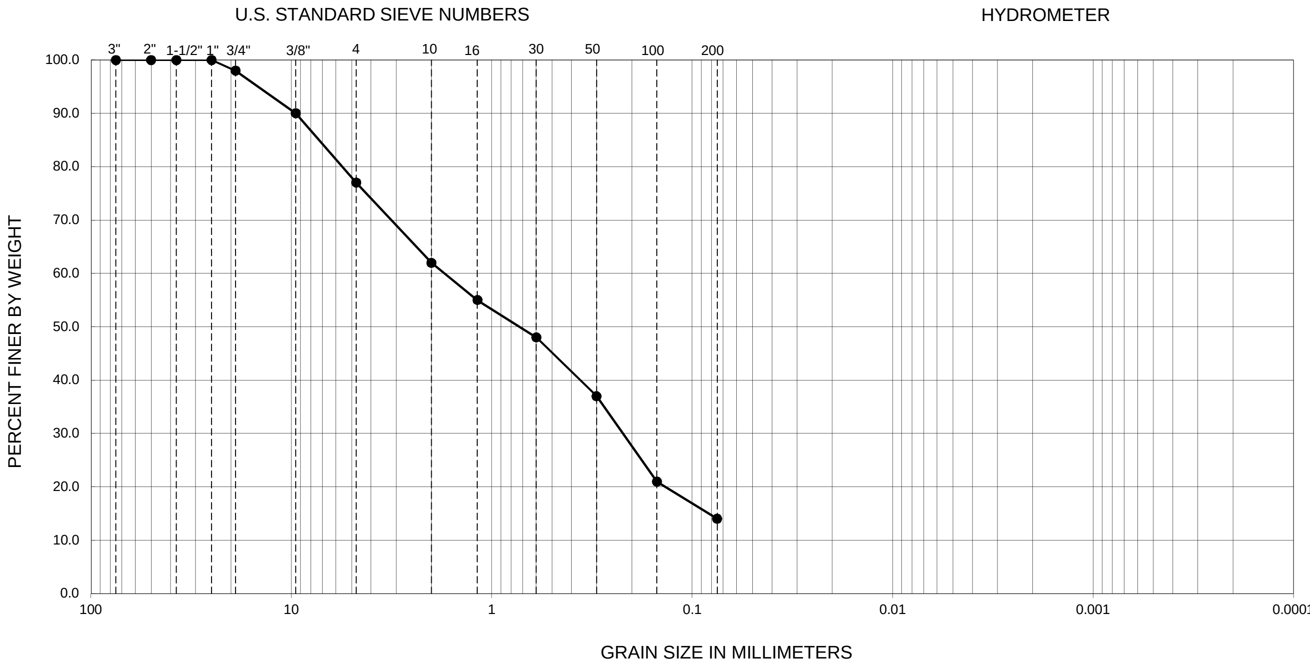
GRADATION TEST RESULTS

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

MISSION ROAD IMPROVEMENT PROJECT
COLMA, CALIFORNIA

403573001 | 8/19

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	USCS
●	B-2	1.5-3.0	--	--	--	--	0.23	1.77	--	--	14	SM

PERFORMED IN ACCORDANCE WITH ASTM D 422 / D6913

FIGURE B-3

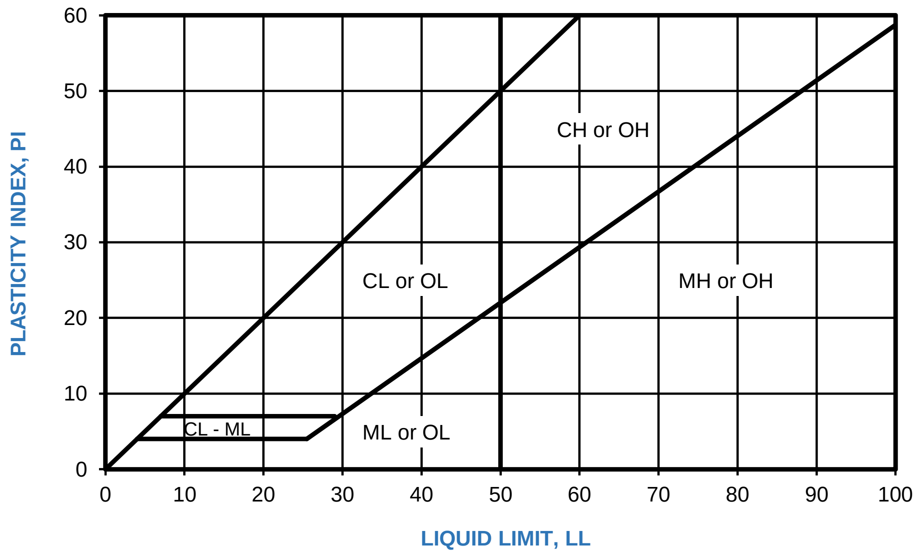
GRADATION TEST RESULTS

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

MISSION ROAD IMPROVEMENT PROJECT
COLMA, CALIFORNIA

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS
●	B-2	1.5-3.0				NP	SM

NP - INDICATES NON-PLASTIC



PERFORMED IN ACCORDANCE WITH ASTM D 4318

FIGURE B-4

ATTERBERG LIMITS TEST RESULTS

MISSION ROAD IMPROVEMENT PROJECT
COLMA, CALIFORNIA

403573001 | 8/19

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SAMPLE LOCATION	SAMPLE DEPTH (ft)	pH [1]	RESISTIVITY [1] (ohm-cm)	SULFATE CONTENT [2]		CHLORIDE CONTENT [3] (ppm)
				(ppm)	(%)	
B-1	3.0-5.0	8.4	3,400	20	0.002	190

[1] PERFORMED IN ACCORDANCE WITH CALIFORNIA TEST METHOD 643
[2] PERFORMED IN ACCORDANCE WITH CALIFORNIA TEST METHOD 417
[3] PERFORMED IN ACCORDANCE WITH CALIFORNIA TEST METHOD 422

APPENDIX C

Percolation Testing

APPENDIX C

PERCOLATION TESTING

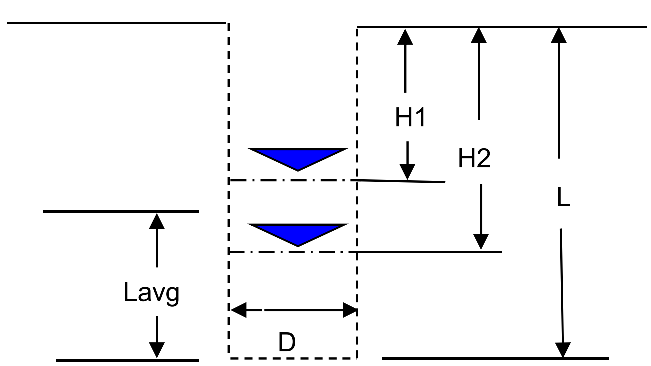
Field Procedure for Percolation Testing

The infiltration characteristics of the site soil were evaluated by field percolation testing. The test hole was excavated with hand tools to a depth of approximately 2 ½ feet, with a diameter of up to 7 inches. The subsurface conditions encountered in the test holes consisted of silty sand. The conditions encountered in the test holes were consistent with Borings B-1 and B-2 in Appendix A. After cleaning the test hole of loose material, water was added to the test hole to achieve a water level approximately 6 inches below the top of the surface of the hole. The drop in the water level was recorded over periodic intervals. Water was added to the test hole between measurement intervals to maintain sufficient water levels in the hole for percolation. The percolation rate reported is the percolation rate over the last measurement interval. The infiltration rate is the percolation rate adjusted by a reduction factor to exclude exfiltration occurring through the sidewalls of the test hole. The results of the percolation testing are presented on Figures C-1 and C-2.

FIGURE C-1: Percolation Test Data Sheet

Project =	MISSION ROAD IMPROVEMENT PROJECT
Project No. =	403573001
Depth of Test Hole, L (ft) =	2.5
Diameter, D (in) =	7.0
Initial Water Depth, d1 (in) =	24.0
Average/Final Water Level Drop, Δd (in) =	6.8
Reduction factor, Rf =	6.9

Test Hole No.	Time (hr:min)	Elapsed Time (min)	Water Level (in)	Change in Water Level (in)	Time Interval (hour)	Pre-Adjusted Percolation Rate (inch/hour)	Adjusted Percolation Rate (inch/hour)
P-1	7:20		30.00				
	8:03	43.00	6.00	-24.00	0.72	33.5	4.86
	8:03		24.00				
	8:18	15.00	15.00	-9.00	0.25	36.0	5.22
	8:19		24.00				
	8:34	15.00	16.50	-7.50	0.25	30.0	4.35
	8:37		24.00				
	8:52	15.00	17.25	-6.75	0.25	27.0	3.92
	8:54		24.00				
	9:09	15.00	17.25	-6.75	0.25	27.0	3.92
	9:10		24.00				
	9:25	15.00	17.25	-6.75	0.25	27.0	3.92
	9:26		24.00				
	9:41	15.00	17.25	-6.75	0.25	27.0	3.92
	9:42		24.00				
	9:57	15.00	17.25	-6.75	0.25	27.0	3.92
	10:00		24.00				
	10:15	15.00	17.25	-6.75	0.25	27.0	3.92
	10:16		24.00				
	10:31	15.00	17.25	-6.75	0.25	27.0	3.92

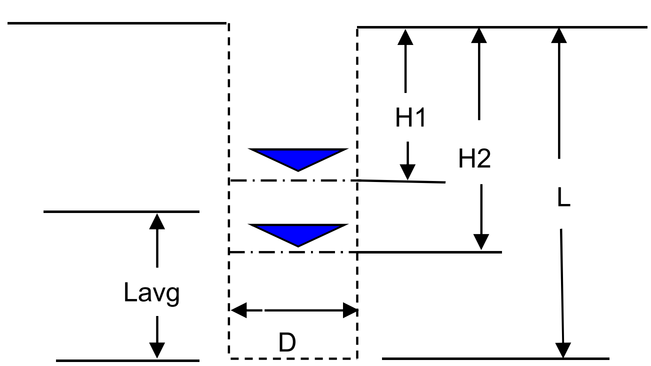


d1 = L - H1 (in inches)

FIGURE C-2: Percolation Test Data Sheet

Project =	MISSION ROAD IMPROVEMENT PROJECT
Project No. =	403573001
Depth of Test Hole, L (ft) =	2.5
Diameter, D (in) =	4.0
Initial Water Depth, d1 (in) =	18.0
Average/Final Water Level Drop, Δd (in) =	8.0
Reduction factor, Rf =	8.0

Test Hole No.	Time (hr:min)	Elapsed Time (min)	Water Level (in)	Change in Water Level (in)	Time Interval (hour)	Pre-Adjusted Percolation Rate (inch/hour)	Adjusted Percolation Rate (inch/hour)
P-2	1:00		30.00				
	1:30	30.00	14.00	-16.00	0.50	32.0	4.00
	1:32		18.00				
	1:47	15.00	9.25	-8.75	0.25	35.0	4.38
	1:48		18.00				
	2:03	15.00	9.50	-8.50	0.25	34.0	4.25
	2:13		18.00				
	2:28	15.00	9.50	-8.50	0.25	34.0	4.25
	2:30		18.00				
	2:45	15.00	9.75	-8.25	0.25	33.0	4.13
	2:46		18.00				
	3:01	15.00	10.00	-8.00	0.25	32.0	4.00
	3:02		18.00				
	3:17	15.00	10.00	-8.00	0.25	32.0	4.00
	3:18		18.00				
	3:33	15.00	10.00	-8.00	0.25	32.0	4.00
	3:34		18.00				
	3:49	15.00	10.00	-8.00	0.25	32.0	4.00
	3:50		18.00				
	4:05	15.00	10.00	-8.00	0.25	32.0	4.00



d1 = L - H1 (in inches)

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