FINAL GEOTECHNICAL REPORT

Marina Coast Water District
Regional Urban Water Augmentation Project – Distribution Mains
Monterey County, California

Prepared by:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services
Taber Since 1954
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June 18, 2019

Prepared for:

carollo
Engineers...Working Wonders With Water®
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June 18, 2019
CAInc File No. 19-513.1

Jon Marshall, PE
Carollo Engineers, Inc
2700 Ygnacio Valley Road, Suite 300
Walnut Creek, California 94598

Subject: **Marina Coast Water District**
Regional Urban Water Augmentation Project – Distribution Mains
Monterey County, California

Dear Mr. Marshall,

Crawford & Associates, Inc., (CAInc) prepared this Final Geotechnical Report for the Marina Coast Water District, Regional Urban Water Augmentation Project in Monterey County, California. We prepared this report to provide geotechnical data, conclusions, and recommendations for the proposed trenchless crossing at the intersection of Reservation and Blanco Roads. A separate Geotechnical Report was prepared by others for the remaining portions of the distribution project. CAInc prepared this report in accordance with our March 2019 agreement and task order.

Thank you for the opportunity to be part of your design team. Please call if you have questions or require additional information.

Sincerely,

Crawford & Associates, Inc.,

Reviewed By;

Benjamin D. Crawford, PE, GE
Principal Geotechnical Engineer

W. Eric Nichols, C.E.G., P.E.
Senior Project Manager

Taber
Since 1954

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1 INTRODUCTION

1.1 PURPOSE

Crawford & Associates, Inc., (CAInc) is pleased to submit this Final Geotechnical Report for the Marina Coast Water District, Regional Urban Water Augmentation Project in Monterey County, California. We prepared this report to provide geotechnical data, conclusions, and recommendations for the proposed trenchless crossing at the intersection of Reservation and Blanco Roads. This report contains our findings and geotechnical recommendations exclusively developed for this project.

A separate Geotechnical Report was prepared by others for the remaining portions of the distribution project.

1.2 GEOTECHNICAL SERVICES

To prepare this report, CAInc:

- Discussed the project with you;
- Reviewed available published geologic and seismic mapping of the site;
- Drilled two exploratory borings to maximum depth of about 30 feet below ground surface (bgs) on March 12, 20019;
- Completed laboratory testing on samples obtained during our subsurface exploration; and,
- Performed engineering evaluation and analysis.

2 PROJECT DESCRIPTION

The project site is in Marina, Monterey County, California. The site coordinates are approximately latitude 36.666935° N and longitude 121.756757° W. See the Figure 1 for the site vicinity map.

The overall project includes the design of about 30,000 lineal feet of recycled water distribution pipelines for irrigation purposes. We understand that the project will be installed using traditional open cut methods with the exception of the Reservation and Blanco Road intersection which will be installed via trenchless methods to minimize impacts to traffic. This report addresses the trenchless design. In general, the trenchless project will include the installation of about 430 lineal feet of recycled water line approximately 14 to 16 feet below existing grade. The proposed trenchless pits will be located in the Blanco Road shoulder to the west of Blanco Road and south of the intersection in Reservation Road shoulder/east bound travel way.

3 FIELD EXPLORATION

3.1 SUBSURFACE EXPLORATION

CAInc retained Taber Drilling to drill and sample two borings on March 12, 2019 near the proposed trenchless pit locations.

Taber Drilling used a CME 55 track mounted drill rig to complete the borings using 4-inch solid-stem auger. Soil samples were recovered by means of a 2.0-inch O.D. "Standard Penetration" (SPT) split-spoon sampler with liners and a 3.0-inch O.D. "Modified California" split-spoon sampler with liners. Both samplers were advanced with standard 350 ft-lb striking force using an auto-hammer. The CME auto-hammer is reported by Taber Drilling to have an efficiency ratio of 91.0%. Sampler penetration resistance was recorded to provide a field measure of relative densities and can be correlated to soils strength and bearing characteristics. The field-recorded (uncorrected) blow counts are shown on the soil logs attached in Appendix I.

The test borings were logged consistent with the Unified Soil Classification System (USCS) and the Caltrans 2010 Logging Manual. Selected portions of recovered drive samples were retained in sealed containers for laboratory testing and reference. Additionally, bulk soil samples were retained in sealed bags for laboratory testing and reference. No groundwater was observed during drilling operations. At completion, test borings were backfilled with cement grout and native soil. The locations of test borings are shown on Figure 1.

3.2 SOIL CONDITIONS

In general, our subsurface exploration indicates that the site is underlain by 20 feet of loose to medium dense, poorly graded sand followed by dense to very dense, poorly graded sand to the depths explored (about 30 ft below grade). For more detailed boring information/data refer to the logs in Appendix I.

3.3 GROUNDWATER

No groundwater was encountered in our borings. DWR well MCFD22632, located about 2 miles northeast of the site shows the groundwater elevation fluctuating between elevations -5 and -25 feet (approximately 150 to 170 ft below existing grade) between 2005 and August of 2018.

4 LABORATORY TESTING

The following laboratory tests were completed on representative soil samples obtained from the exploratory borings:

- Moisture Content/Dry Density (ASTM D2216/D2937)
- Particle Size Analysis (ASTM D2487)
- Direct Shear (ASTM D3080)

Laboratory test results are shown in Appendix II.

5 SEISMIC DATA

5.1 GROUND MOTION

The USGS Unified Hazard Tool[1] indicated a maximum peak horizontal ground acceleration (PGA) on the order of 0.47g for a seismic event with a 5% probability of exceedance in 50 years (design basis earthquake).

[1] http://earthquake.usgs.gov/hazards/interactive/

Based on our exploratory borings, we provide the California Building Code (CBC) design parameters below. CAInc determined these values using a site latitude of 36.667223°N and longitude of 121.756662°W and the U.S. Seismic Design Maps tool[2] developed by the United States Geological Survey. The CBC design parameters are shown in Table 1.

Table 1: CBC Design Parameters

Site Class	D
Risk Category	**II**
S_s—Acceleration Parameter	1.546 g
S_1—Acceleration Parameter	0.554 g
F_a—Site Coefficient	1.0
F_v—Site Coefficient	1.5
S_{MS}—Adjusted MCE* Spectral Response Acceleration Parameter	1.546 g
S_{M1}—Adjusted MCE* Spectral Response Acceleration Parameter	0.831 g
S_{DS}—Design Spectral Acceleration Parameter	1.031 g
S_{D1}—Design Spectral Acceleration Parameter	0.554 g
T_L—Long-Period Transition Period**	12 Seconds

Note: *Maximum Considered Earthquake / **Figure 22-12, ASCE 7-10

5.2 FAULT RUPTURE

The site does not lie within an Alquist–Priolo Earthquake Fault Zone. The California Geological Survey (CGS) considers a fault to be active if it has shown evidence of ground displacement during the Holocene period, defined as within the last 11,700 years. According to CGS, the closest active fault is the Chupines fault zone located about 5.5 miles southwest of the project. Therefore, the potential for fault rupture at the project site is considered low.

Nearby faults are shown in Figure 3.

5.3 LIQUEFACTION POTENTIAL

Soil liquefaction can occur when saturated, relatively loose sand and specific soft, fine-grained saturated soils are subject to ground shaking strong enough to create soil particle separation that results from increased pore pressure. This separation and subsequent pore pressure dissipation can lead to decreased soil shear strength and settlement. Liquefaction is known to occur in soils ranging from low plasticity silts to gravels (generally within 50 feet of the surface). However, soils most susceptible to liquefaction are clean sands to silty sands and non-plastic silts.

Based on the nearby groundwater elevations (greater than 150 ft below grade) and the presence of medium dense to dense soil conditions encountered 10 ft below existing grade, we consider the potential for liquefaction at the site to be low to nonexistence.

[2] https://earthquake.usgs.gov/designmaps/us/application.php

6 CONCLUSIONS AND RECOMMENDATIONS

We conclude that the proposed trenchless installation is feasible from a geotechnical standpoint at this location. Based on our subsurface exploration, the trenchless crossing will be located within medium dense, poorly graded sand. Above the trenchless zone we encountered loose poorly graded sand layers that will require consideration during construction. Recommendations for the trenchless crossing installation are included below.

6.1 TRENCHLESS

Due to the presence of loose poorly graded sand within the upper 10 feet of the site we recommend the top of the steel casing be installed at least 10 feet below existing ground surface.

The contractor is responsible for selecting appropriate trenchless installation methods that do not cause detrimental settlement, surface heave, damage to existing facilities, and that maintain the designed horizontal and vertical pipe alignments and tolerances. Issues that may affect pipe installation operations include the depth of soil cover, existing surface facilities, existing underground utilities, and presence of loose sandy soils along the pipe alignment.

Shoring should be designed to prevent material from entering the shaft during all construction operations. If the granular soil layers become saturated due to infiltration of surface water there is a potential for excavation face caving and flowing of soil into the casing during operations. The contractor should use trenchless installation techniques that prevent significant caving and flowing of soil into casing. The contractor should also have appropriate contingency plans and equipment in place for stabilizing the excavation face if excessive caving/flowing conditions occur. Contingency plans may include a closed-face excavation system, face shield at the leading edge of the first pipe casing, use of grouting techniques, dewatering of the trenchless alignment or other suitable methods. The face of the excavation should not extend more than 1 foot beyond the end of the casing pipe.

6.1.1 PIT BOTTOM SUPPORT

Based on our subsurface exploration, the bottom of jacking and receiving pits (approximately 15 to 17 feet below existing ground surface) will be founded in medium dense poorly graded sand. Using an allowable bearing capacity of 3,500 psf, we expect pit floors to be stable. We estimate the total settlement will be under 1-inch.

6.1.2 PIT THRUST WALL DESIGN

Based on the results of our fieldwork and laboratory tests an unfactored passive earth pressure of 400 pounds per square foot is available within the planned pipe zone. The designer should apply an appropriate factor of safety to this passive pressure.

Once the trenchless portion of the pipe is installed, the launching and receiving shafts should be backfilled per county/district requirements.

6.2 CONSTRUCTION CONSIDERATIONS

6.2.1 EXCAVATABILITY AND STABILITY

Based on the data collected during this and previous field explorations, the onsite poorly graded sands will be excavatable with typical grading equipment such as backhoes and excavators.

At a minimum, shoring and temporary construction slopes should be in accordance with current OSHA requirements. The loose to medium dense cohesionless sands will be susceptible to caving. Our data indicates Cal OSHA Soil Type C will be primarily encountered during construction. The contractor is responsible for all shoring and temporary slope design based on actual excavation conditions encountered during construction.

7 LIMITATIONS

CAInc performed services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. Do not use this report for different locations and/or projects without written consent of CAInc. Where referenced, CAInc used ASTM or Caltrans standards as a general (not strict) guideline only.

CAInc based this report on the current site conditions. We assumed the soil and groundwater conditions are representative of the subsurface conditions on the site. Actual conditions between explorations could be different.

Our scope did not include evaluation of on-site hazardous materials.

Logs of our explorations are presented in Appendix I. The lines designating the interface between soil types are approximate. The transition between soil types may be abrupt or gradual. Our recommendations are based on finals logs, which represent our interpretation of the field logs and general knowledge of the site and geological conditions.

Modern design and construction are complex, with many regulatory sources/restrictions, involved parties, construction alternatives, etc. It is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

FIGURES

North

LEGEND

A-19-001 BORING LOCATIONS

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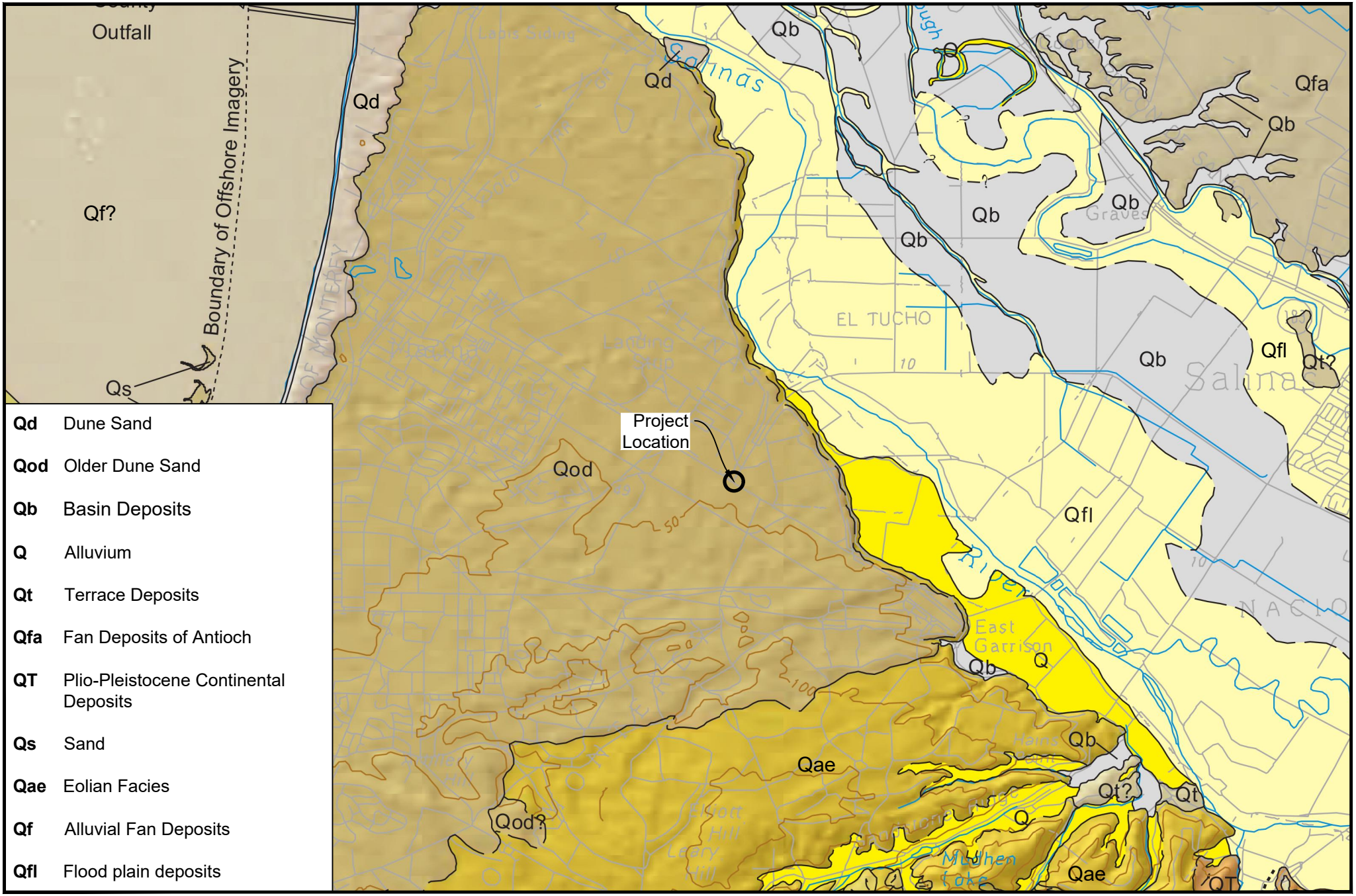
Marina Coast Water District RUWAP
Distribution Mains

Monterey County, California

Figure 1
Exploration Location Map

Proj. No: 19-513.1
Scale: 1"=70'
Date: 4/9/19



Qd	Dune Sand
Qod	Older Dune Sand
Qb	Basin Deposits
Q	Alluvium
Qt	Terrace Deposits
Qfa	Fan Deposits of Antioch
QT	Plio-Pleistocene Continental Deposits
Qs	Sand
Qae	Eolian Facies
Qf	Alluvial Fan Deposits
Qfl	Flood plain deposits

North

Source: Wagner, D.L., Greene, H.G., Saucedo, G.J., and Pridmore, C.L.. Geologic map of the Monterey 30' x 60' quadrangle and adjacent areas, California. 1:100,000. California: California Geologic Survey, 2002.

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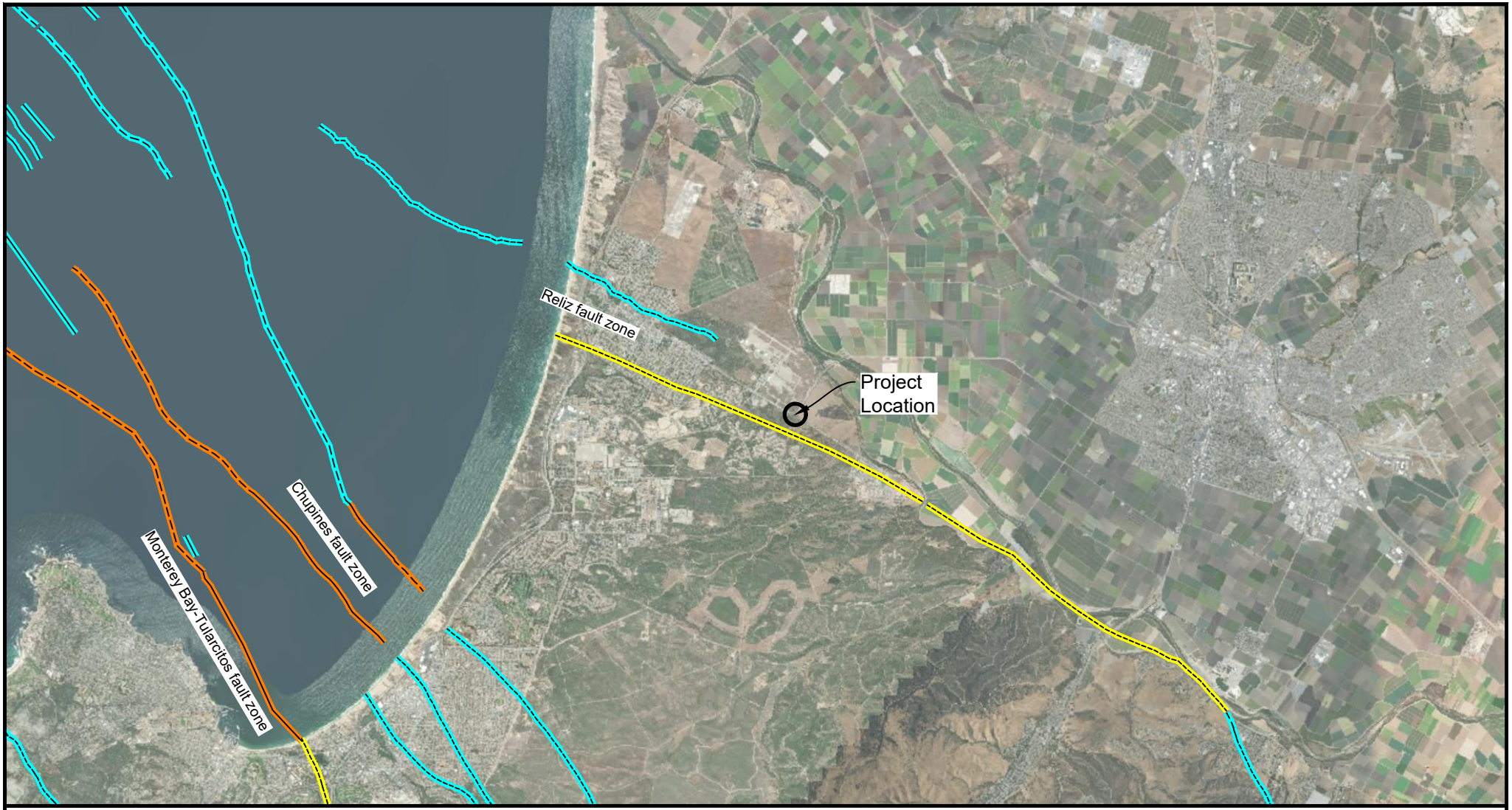
Marina Coast Water District RUWAP Distribution Mains

Monterey County, California

Figure 2
Geology Map

Proj. No:	19-513.1
Scale:	1"=5,000'
Date:	4/9/19



LEGEND

Quaternary Fault (Age)	Location
<15,000 years	Well Constrained
<130,000 years	Moderately Constrained
<1.6 million years	Inferred

North

Sources:
Basemap: AutoCAD Geolocation tool using Bing Maps

Fault Data: USGS GIS Data

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Distribution Mains

Monterey County, California

Figure 3
Fault Activity Map

Proj. No: 19-513.1
Scale: 1"=10,000'
Date: 4/9/19

APPENDIX I

Boring Log Legend
Borings Logs

UNIFIED SOIL CLASSIFICATION (ASTM D 2487-06)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GRAPHIC SYMBOL	GROUP SYMBOL	SOIL GROUP NAMES
COARSE-GRAINED SOILS >50% RETAINED ON NO. 4 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS <5% FINES	Cu ≥ 4 AND 1 ≤ Cc ≤ 3		GW	WELL-GRADED GRAVEL
			Cu < 4 AND/OR 1 > Cc > 3		GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH		GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH		GC	CLAYEY GRAVEL
	SANDS <50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN SANDS <5% FINES	Cu ≥ 6 AND 1 ≤ Cc ≤ 3		SW	WELL-GRADED SAND
			Cu < 6 AND/OR 1 > Cc > 3		SP	POORLY-GRADED SAND
		SANDS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH		SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH		SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT <50	INORGANIC	PI>7 AND PLOTS ON OR ABOVE "A" LINE		CL	LEAN CLAY
			PI>4 AND PLOTS BELOW "A" LINE		ML	SILT
		ORGANIC	LL (oven dried)<0.75/LL (not dried)		OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT >50	INORGANIC	PI PLOTS ON OR ABOVE "A" LINE		CH	FAT CLAY
			PI PLOTS BELOW "A" LINE		MH	ELASTIC SILT
		ORGANIC	LL (oven dried)<0.75/LL (not dried)		OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK COLOR, ORGANIC ODOR			PT	PEAT

NOTE: $Cu = D_{60}/D_{10}$

$Cc = (D_{30})^2 / D_{10} \times D_{60}$

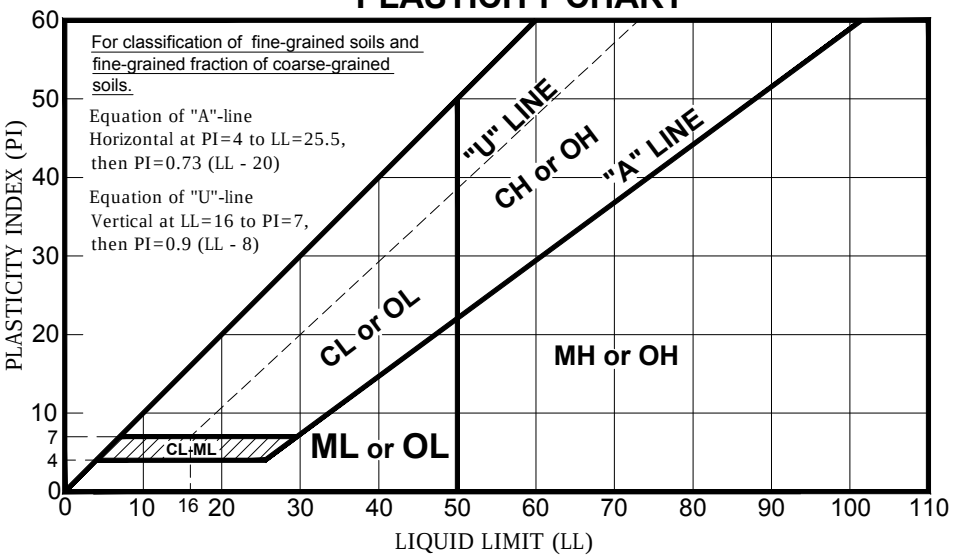
BLOW COUNT

The number of blows of a 140-lb. hammer falling 30-inches required to drive the sampler the last 12-inches of an 18-inch drive. The notation 50/0.4 indicates 4-inches of penetration achieved in 50 blows.

SAMPLE TYPES

- Auger or backhoe cuttings
- Shelby tube
- Standard Penetration (SPT)
- Bulk Sample
- Modified California 2"
- California Standard 2.5"
- Rock core

PLASTICITY CHART



ADDITIONAL TESTS

C	- Consolidation
CP	- Compaction Curve
CR	- Corrosivity Testing
CU	- Consolidated Undrained Triaxial
DS	- Direct Shear
EI	- Expansion Index
P	- Permeability
PA	- Partical Size Analysis
PI	- Plasticity Index
PP	- Pocket Penetrometer
R	- R-Value
SE	- Sand Equivalent
SG	- Specific Gravity
SL	- Shrinkage Limit
SW	- Swell Potential
TV	- Pocket Torvane Shear Test
UC	- Unconfined Compression
UU	- Unconsolidated Undrained Triaxial

GROUND WATER LEVELS

- Later water level after drilling
- Water level at time of drilling

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BORING LOG / TEST PIT LEGEND AND SOIL DESCRIPTIONS

LOG OF BORING A-19-001

PROJECT NO: 19-513.1
PROJECT: DMFD (RUWAP)
LOCATION: Marina, CA
COUNTY: Monterey
CLIENT: Carollo Engineers
LOGGED BY: AC
DEPTH OF BORING: 31 (ft)

BEGIN DATE: 3/12/19
COMPLETION DATE: 3/12/19
SURFACE ELEVATION: 147 ft
SURFACE CONDITION:
WATER DEPTH: NA
READING TAKEN:
HAMMER EFFICIENCY: 91%

DRILLING CONTRACTOR: Taber
DRILLING METHOD: Solid-Stem Auger
DRILL RIG: CME 55
HAMMER TYPE: Auto: 140 lb; 30 in Drop
SAMPLER TYPE & SIZE: Bulk; MCAL (2.5" ID); SPT (1.4" ID)
BOREHOLE DIAMETER: 4
BACKFILL METHOD: Tremie Grout

FIELD										LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD / CASING DEPTH	REMARKS
	1							Poorly graded SAND with SILT (SP-SM); loose; light brown; moist; about 90% medium to fine SAND; about 10% nonplastic fines.									
	2																
	3																
	4																
	5		1	4 3 3	6				78				7.4	103.3	10		
	6																
	7		2	3 3 3	6				100								
	8																
	9							SILTY SAND (SM); medium dense; brown; moist; about 78% medium to fine SAND; about 22% nonplastic fines.									
	10		3	8 8 8	16				100				5.9	111	22		
	11																
	12																
	13																
	14																
	15		4	8 4 6	10			Tan.	89				11	101.4			Direct Shear Cohesion = 0 psf Friction Angle = 34.7 degrees
	16																
	17																
	18							CLAYEY SAND (SC); dense; tan; moist; mostly fine SAND; little medium plasticity fines.									
	19																
	20		5	12 17 20	37				94								
	21							Poorly graded SAND (SP); dense; tan; moist; mostly medium SAND; trace fines.					7.7	106.9			
	22																
	23																
	24																

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PROJECT NUMBER: 19-513.1
PROJECT: DMFD (RUWAP)
EXPLORATION: A-19-001
ENTRY BY: BJU
CHECKED BY: BDC

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
	26		6	20 30 37	67			Poorly graded SAND (SP) *(continued)*. Pale brown; fine SAND. Very dense; tan; mostly medium SAND; trace nonplastic fines.	100				6.4	111.9				
	27																	
	28																	
	29							Gray; mostly fine SAND.										
	30		7	18 50/5.5	50/6				78									
	31							Bottom of borehole at 31.0 ft bgs										
	32																	
	33																	
	34																	
	35																	
	36																	
	37																	
	38																	
	39																	
	40																	
	41																	
	42																	
	43																	
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	50																	
	51																	
	52																	
	53																	
	54																	
	55																	

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PROJECT NUMBER: 19-513.1
PROJECT: DMFD (RUWAP)
EXPLORATION: A-19-001
ENTRY BY: BJU
CHECKED BY: BDC

LOG OF BORING A-19-002

PROJECT NO: 19-513.1
PROJECT: DMFD (RUWAP)
LOCATION: Marina, CA
COUNTY: Monterey
CLIENT: Carollo Engineers
LOGGED BY: AC
DEPTH OF BORING: 31.5 (ft)

BEGIN DATE: 3/12/19
COMPLETION DATE: 3/12/19
SURFACE ELEVATION: 147 ft
SURFACE CONDITION:
WATER DEPTH: NA
READING TAKEN:
HAMMER EFFICIENCY: 91%

DRILLING CONTRACTOR: Taber
DRILLING METHOD: Solid-Stem Auger
DRILL RIG: CME 55
HAMMER TYPE: Auto: 140 lb; 30 in Drop
SAMPLER TYPE & SIZE: Bulk; MCAL (2.5" ID); SPT (1.4" ID)
BOREHOLE DIAMETER: 4
BACKFILL METHOD: Tremie Grout

FIELD										LABORATORY							
ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	PLASTIC LIMIT	LIQUID LIMIT	MOISTURE (%)	D. DENSITY (PCF)	% PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
	1		Bulk					Poorly graded SAND (SP); loose; dark brown; moist; about 95% medium to fine SAND; about 5% nonplastic fines.										
	2																	
	3		1	3 4 4	8				94				6.3	99.2				
	4																	
	5		2	6 4 6	10				100						5			
	6		3	3 4 4	8				100									
	7																	
	8																	
	9							Poorly graded SAND with SILT (SP-SM); medium dense; light brown; moist; about 94% medium SAND; about 6% nonplastic fines.										
	10		4	7 7 11	18				83				6.7	104.1	6			
	11																	
	12																	
	13																	
	14																	
	15		5	9 15 14	29			Tan. Poorly graded SAND (SP); medium dense; tan; moist; mostly medium SAND; trace nonplastic fines.	83				4.2	102.4				
	16																	
	17																	
	18																	
	19																	
	20		6	21 22 26	48				100				8.4	111.2				
	21																	
	22																	
	23																	
	24																	

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PROJECT NUMBER: 19-513.1
PROJECT: DMFD (RUWAP)
EXPLORATION: A-19-002
ENTRY BY: BJU
CHECKED BY: BDC

ELEVATION (ft)	DEPTH (ft)	SAMPLE	SAMPLE NO	BLOWS PER 6 IN.	BLOWS PER FOOT	POCKET PEN. (TSF)	GRAPHIC LOG	DESCRIPTION	RECOVERY(%)	RQD (%)	LABORATORY: PLASTIC LIMIT	LABORATORY: LIQUID LIMIT	LABORATORY: MOISTURE (%)	LABORATORY: D. DENSITY (PCF)	LABORATORY: % PASSING 200 SIEVE	DRILL METHOD	CASING DEPTH	REMARKS
	26		7	14 18 22	40			Dense. Poorly graded SAND (SP) *(continued)*.	100									
	27																	
	28																	
	29																	
	30		8	23 30 43	73			Very dense.	100									
	31							Bottom of borehole at 31.5 ft bgs										
	32																	
	33																	
	34																	
	35																	
	36																	
	37																	
	38																	
	39																	
	40																	
	41																	
	42																	
	43																	
	44																	
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	51																	
	52																	
	53																	
	54																	
	55																	

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(916) 455-4225

PROJECT NUMBER: 19-513.1
PROJECT: DMFD (RUWAP)
EXPLORATION: A-19-002
ENTRY BY: BJU
CHECKED BY: BDC

APPENDIX II

Laboratory Testing

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW

MOISTURE-DENSITY TESTS - D2216

	1	2	3	4	5
Sample No.	A-19-001-1A	A-19-001-3A	A-19-001-5A	A-19-001-6A	A-19-002-1A
USCS Symbol	SP-SM	SM	SP	SP-SM	SP-SC
Depth (ft.)	6	11	21	26	3.5
Sample Length (in.)	5.431	5.828	5.980	5.314	5.985
Diameter (in.)	2.435	2.396	2.398	2.403	2.411
Sample Volume (ft^3)	0.01464	0.01521	0.01563	0.01395	0.01581
Total Mass Soil+Tube (g)	964.0	1086.1	1091.0	1032.4	1032.5
Mass of Tube (g)	227.9	275.7	274.1	279.1	276.7
Tare No.	A8	C7	B6	D5	B7
Tare (g)	11.2	11.3	11.4	11.5	11.6
Wet Soil + Tare (g)	47.9	51.2	50.2	39.0	42.4
Dry Soil + Tare (g)	45.4	49.0	47.4	37.4	40.6
Dry Soil (g)	34.2	37.7	36.0	25.8	29.0
Water (g)	2.5	2.2	2.8	1.7	1.8
Moisture (%)	**7.4**	**5.9**	**7.7**	**6.4**	**6.3**
Dry Density (pcf)	**103.3**	**111.0**	**106.9**	**111.9**	**99.2**

Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW

MOISTURE-DENSITY TESTS - D2216

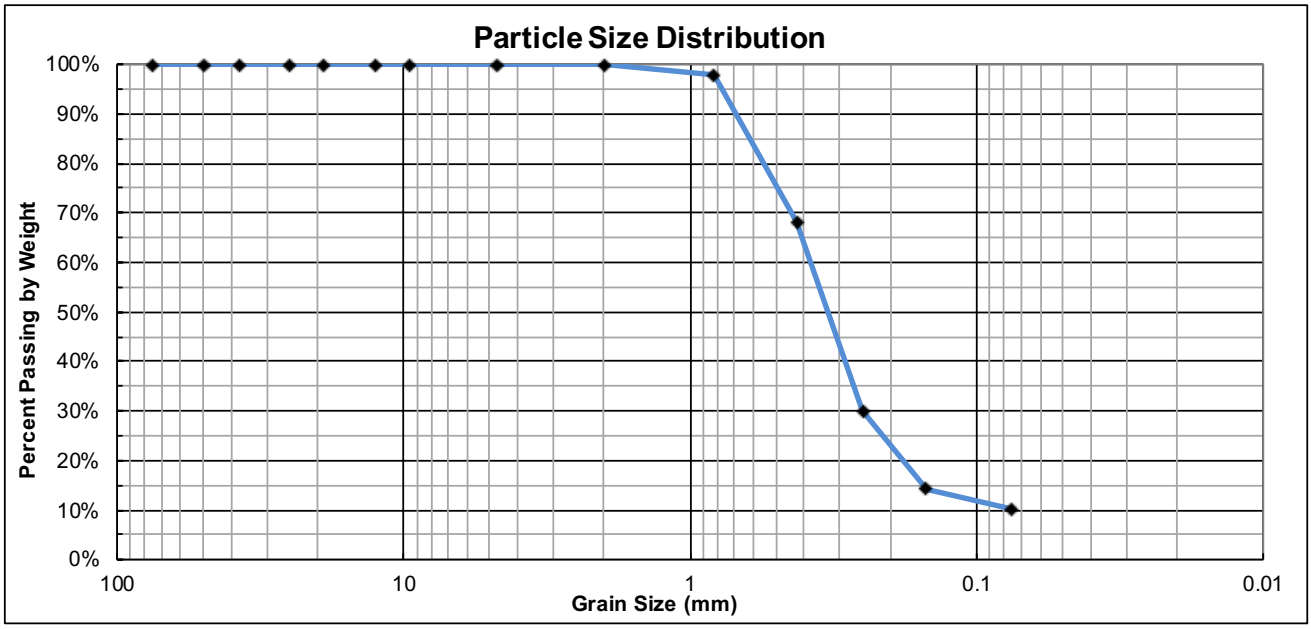
	1	2	3	4	5
Sample No.	A-19-002-2A	A-19-002-4A	A-19-002-5A	A-19-002-6A	
USCS Symbol	SP-SM	SP-SM	SP	SP	
Depth (ft.)	6	11	16	21	
Sample Length (in.)	5.985	5.982	5.982	5.976	
Diameter (in.)	2.393	2.392	2.400	2.405	
Sample Volume (ft^3)	0.01558	0.01556	0.01566	0.01571	
Total Mass Soil+Tube (g)	1038.6	1057.7	1032.5	1136.1	
Mass of Tube (g)	280.1	273.4	274.2	277.2	
Tare No.	A7	B1	H11	C10	
Tare (g)	11.5	11.5	13.3	13.7	
Wet Soil + Tare (g)	58.5	49.4	58.5	75.9	
Dry Soil + Tare (g)	55.8	47.0	56.7	71.1	
Dry Soil (g)	44.3	35.6	43.4	57.5	
Water (g)	2.8	2.4	1.8	4.8	
Moisture (%)	**6.2**	**6.7**	**4.2**	**8.4**	
Dry Density (pcf)	**101.1**	**104.1**	**102.4**	**111.2**	

Notes:

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW
Sample ID: A-19-001-1A
Depth (ft): 6
USCS Classification: Poorly graded SAND with SILT (SP-SM)

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	0	0	32	58	
0	**0**		**90**			**10**

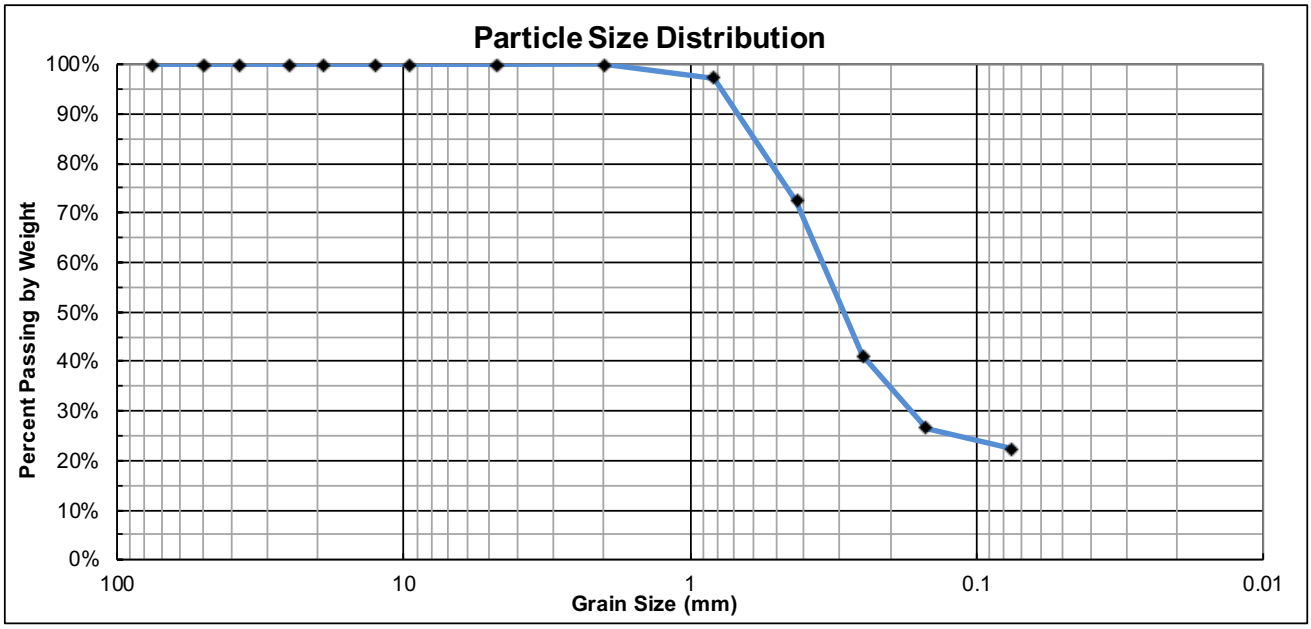
		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	0.0	100%
		#4	4.75	0.0	100%
Sand	Coarse	**#10**	2.00	0.0	100%
	Medium	**#20**	0.825	5.8	98%
		#40	0.425	80.5	68%
	Fine	**#60**	0.250	177.4	30%
		#100	0.150	217.1	14%
		#200	0.075	227.6	10%

Coefficient of Uniformity	Coefficient of Curvature
Cu = 5.2	Cc = 2.2

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW
Sample ID: A-19-001-3A
Depth (ft): 11
USCS Classification: Silty SAND (SM)

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	0	0	28	50	
0	**0**		**78**			**22**

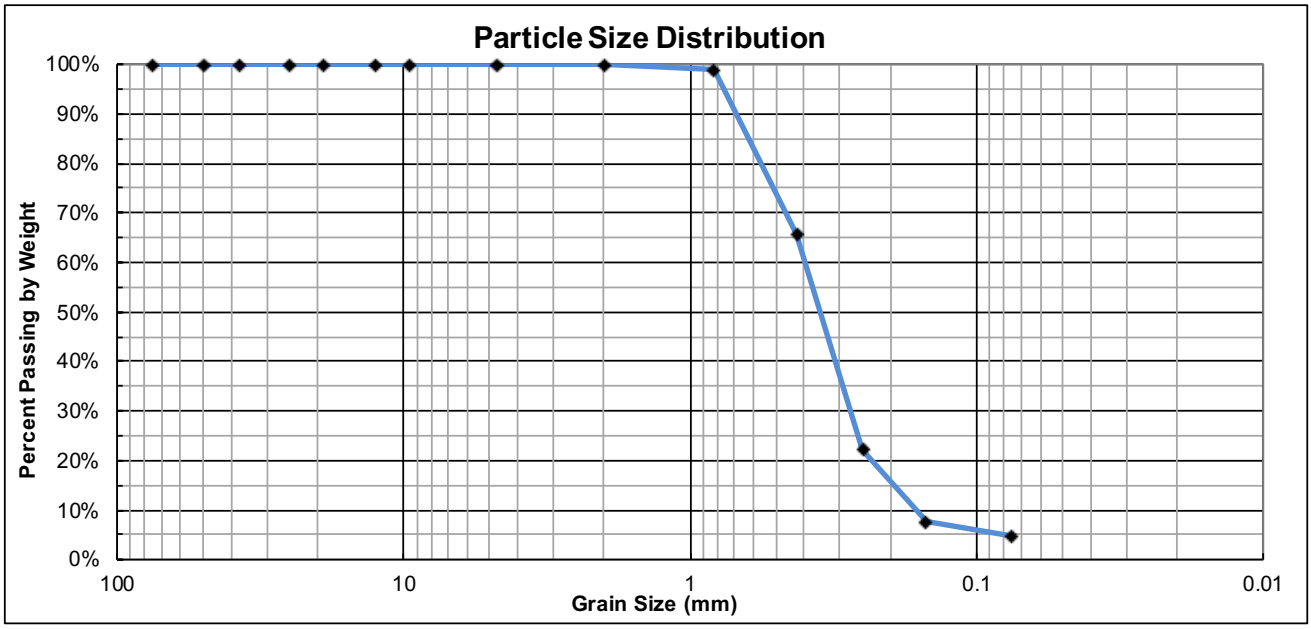
		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	0.0	100%
		#4	4.75	0.0	100%
Sand	Coarse	**#10**	2.00	0.1	100%
	Medium	**#20**	0.825	7.9	97%
		#40	0.425	77.5	72%
	Fine	**#60**	0.250	164.8	41%
		#100	0.150	205.4	27%
		#200	0.075	217.1	22%

Coefficient of Uniformity	Coefficient of Curvature
Cu = NA	Cc = NA

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW
Sample ID: A-19-002-2A
Depth (ft): 6-6.5
USCS Classification: Poorly graded SAND with SILT (SP-SM)

ASTM 6913 - Method A



% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	0	0	34	61	
0	**0**		**95**			**5**

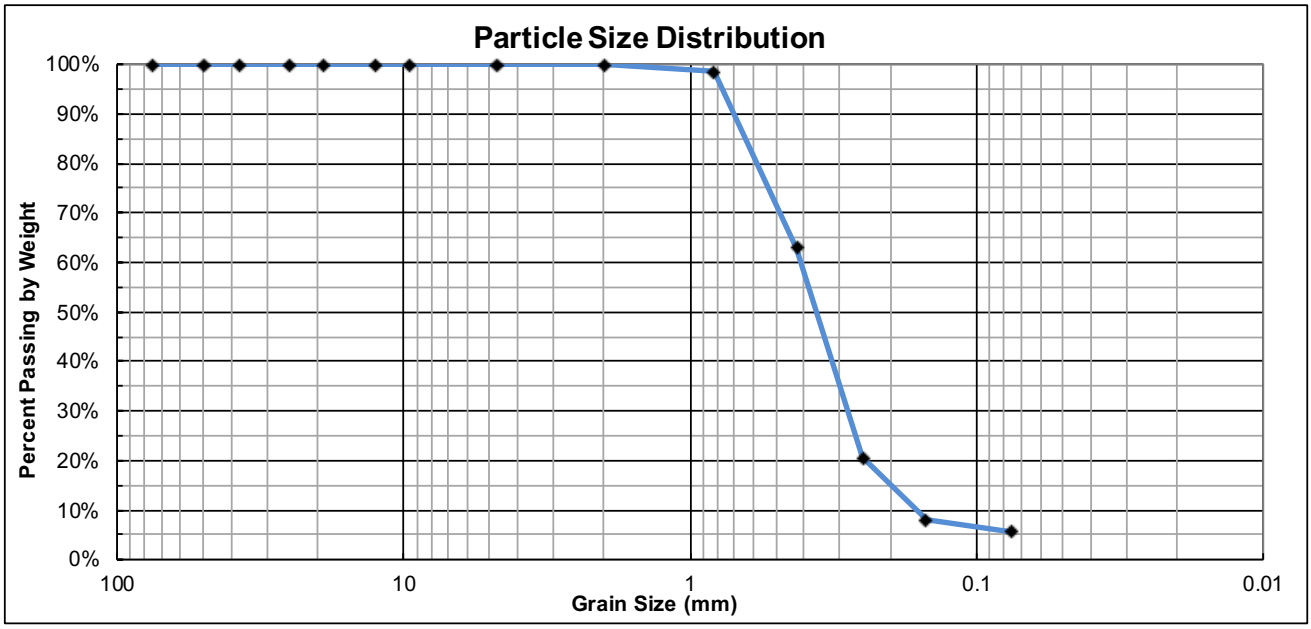
		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	0.0	100%
		#4	4.75	0.0	100%
Sand	Coarse	**#10**	2.00	0.0	100%
	Medium	**#20**	0.825	3.4	99%
		#40	0.425	99.2	66%
	Fine	**#60**	0.250	225.1	22%
		#100	0.150	267.2	8%
		#200	0.075	275.4	5%

Coefficient of Uniformity	Coefficient of Curvature
Cu = 2.4	Cc = 1.2

Crawford & Associates, Inc.
Geotechnical Engineering, Design and Construction Services

Project Name: MCWD RUWAP Distribution Mains
CAInc File No: 19-513.1
Date: 4/9/19
Technician: SRW
Sample ID: A-19-002-4A
Depth (ft): 11-11.5
USCS Classification: Poorly graded SAND with SILT (SP-SM)

ASTM 6913 - Method A

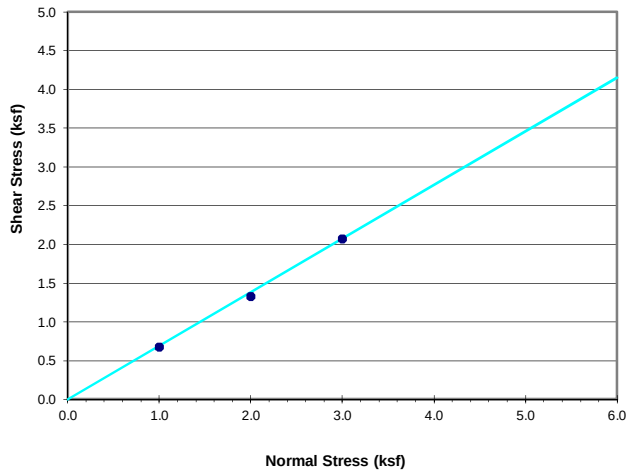


% Cobble	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
	0	0	0	37	57	
0	**0**		**94**			**6**

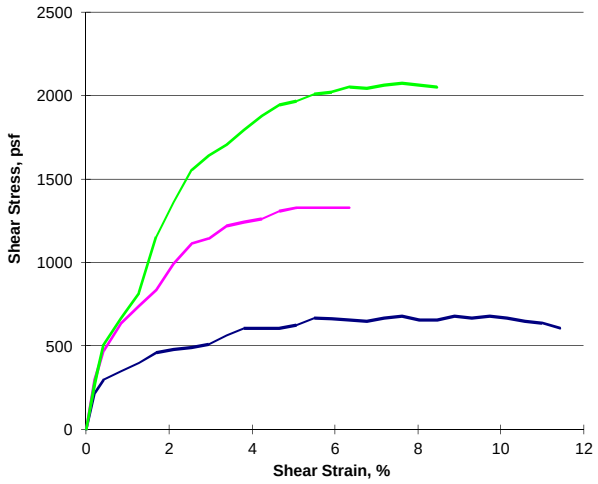
		Sieve #	Opening mm	Cummulative Mass Retained (g)	% Passing %
Cobbles		**3"**	75	0.0	100%
Gravel	Coarse	**2"**	50	0.0	100%
		1-1/2"	37.5	0.0	100%
		1"	25.0	0.0	100%
		3/4"	19.0	0.0	100%
	Fine	**1/2"**	12.5	0.0	100%
		3/8"	9.50	0.0	100%
		#4	4.75	0.0	100%
Sand	Coarse	**#10**	2.00	0.0	100%
	Medium	**#20**	0.825	4.0	98%
		#40	0.425	96.4	63%
	Fine	**#60**	0.250	207.4	21%
		#100	0.150	240.0	8%
		#200	0.075	246.4	6%

Coefficient of Uniformity	Coefficient of Curvature
Cu = 2.5	Cc = 1.2

SHEAR STRENGTH



STRESS-STRAIN



Sample Description			
Boring Number	A-19-001-4A		
Sample Depth (feet)			
Material Description	Yellowish Brown Silty SAND		
Initial Conditions at Start of Test			
Sample ID (psf)	**1000**	**2000**	**3000**
Height (inch)	1.00	1.00	1.00
Diameter (inch)	2.363	2.363	2.363
Moisture Content (%)	12.0	10.9	9.5
Dry Density (pcf)	101.4	105.1	99.9
Estimated Specific Gravity	2.85	2.70	2.70
Saturation (%)	45.2	48.8	37.3
Shear Test Conditions			
Strain Rate (%/min)	0.293	0.289	0.313
Major Principle Stress at Failure (psf)	677	1326	2074
Strain at Failure (%)	8.89	5.08	7.62
Test Results			
ϕ, degrees **34.7**			
c, psf **0**			

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Direct Shear Strength Test (ASTM D3080)

Project: Crawford 19-513.1
Location:
Number: S9763-05-154
Figure: