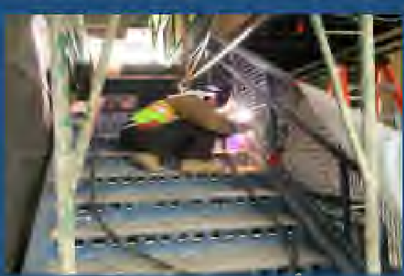
GEOTECHNICAL INVESTIGATION

CP20051 New Reservoir 5B-2
Rancho Cucamonga, California 91737

Cucamonga Valley Water District
10440 Ashford Street
Rancho Cucamonga, California 91729

Date: November 10, 2022
MTGL Project No.: 1186A05
MTGL Log No.: 22-0814






MTGL, Inc.
2992 East La Palma Avenue, Suite A
Anaheim, California 92806
714.632.2999 | www.mtglinc.com

GEOTECHNICAL ENGINEERING
CONSTRUCTION INSPECTION
MATERIALS TESTING
ENVIRONMENTAL

OFFICE LOCATIONS

ORANGE COUNTY
CORPORATE BRANCH
2992 E. La Palma Avenue
Suite A
Anaheim, CA 92806
Tel: 714.632.2999
Fax: 714.632.2974

SAN DIEGO
IMPERIAL COUNTY
6295 Ferris Square
Suite C
San Diego, CA 92121
Tel: 858.537.3999
Fax: 858.537.3990

INLAND EMPIRE
14467 Meridian Parkway
Building 2A
Riverside, CA 92518
Tel: 951.653.4999
Fax: 951.653.4666

OC/LA/INLAND EMPIRE
DISPATCH
800.491.2990

SAN DIEGO DISPATCH
888.844.5060

www.mtglinc.com

November 10, 2022

MTGL Project No.: 1186A05
MTGL Log No.: 22-0814
MTGL Branch: Anaheim

Tuan Truong, P.E.
Engineering Manager
Cucamonga Valley Water District
10440 Ashford Street
Rancho Cucamonga, California 91729

Subject: **GEOTECHNICAL INVESTIGATION**
CP20051 New Reservoir 5B-2
5196 Mayberry Avenue
Rancho Cucamonga, California 91737

Dear Mr. Truong,

MTGL Inc. is pleased to present this report describing the results of our geotechnical investigation for the subject project. With your authorization, we have performed this work in general accordance with our proposal dated July 26th, 2022. Based on the results of our investigation, we consider the planned developments feasible from a geotechnical perspective, provided the recommendations of this report are followed.

We appreciate this opportunity to be of continued service and look forward to providing additional consulting services during the planning and construction of the project. Should you have any questions regarding this report, please do not hesitate to contact us.

Respectfully submitted,
MTGL, Inc.

Jay Rowerdink, E.I.T.
Staff Engineer

Daniel Richardson, P.E.
Senior Engineer

REGISTERED PROFESSIONAL ENGINEER DANIEL J. RICHARDSON C 89379 CIVIL STATE OF CALIFORNIA

Isaac Chun, P.E., G.E.
Vice President

REGISTERED PROFESSIONAL ENGINEER ISAAC B. CHUN No. 2649 EXP. 12/31/23 GEOTECHNICAL STATE OF CALIFORNIA

Greg Wilson, P.G.
Senior Geologist

PROFESSIONAL GEOLOGIST GREGORY S. WILSON No. 9777 EXP. 07/31/24 STATE OF CALIFORNIA

EXECUTIVE SUMMARY

In accordance with your request and authorization, we have completed our geotechnical investigation for the subject site located at 5196 Mayberry Avenue, Rancho Cucamonga, California 91737. Based on our review of the provided RFP, supplemental addenda, and correspondence with the project development team, we understand the Cucamonga Valley Water District (CVWD) is currently proposing the design and construction of a new 3.7-Million Gallon (MG) welded steel tank, designated as Reservoir 5B-2, at the subject site. Cut excavations on the order of 10- to 20-feet below existing ground surface to the planned pad grades are anticipated.

Preliminary site plans do not include additional features; however, we assume associated civil improvements may include new utilities, pedestrian walks, site retaining walls, and other auxiliary structures. The purpose of our work was to provide conclusions and recommendations regarding the geotechnical aspects of the project.

Our subsurface investigation was performed between September 26th and September 28th, 2022, and consisted of drilling four (4) exploratory soil borings within the project site. The borings were drilled to depths between approximately 22- to 31-feet below existing ground surface (BGS) using a truck-mounted drilling rig equipped with 8-inch hollow stem augers and 6-inch solid stem air rotary augers and bit. An MTGL engineer logged the borings and collected samples of the encountered materials for geotechnical laboratory testing. Selected samples were tested in our laboratory to evaluate their engineering properties.

Alluvium was encountered in each of our borings and extended to the total depths explored. As encountered, the alluvium generally consisted of various shades of gray to brown, dense to very dense silty to gravelly sand. Abundant amounts of gravel, cobbles, and boulders were encountered within the alluvium. Additionally, cobbles and boulders were observed frequently at the ground surface of the project site.

The main geotechnical considerations affecting the project are the presence of potentially strong ground shaking as a result of movement along active faults in the vicinity of the site and potentially compressible near-surface soils. The tank should be designed to resist strong ground shaking and its secondary effects such as sloshing forces. To reduce the potential for settlement, remedial grading should be performed below the proposed structure and other settlement sensitive improvements.

In general, a mat slab or conventional shallow spread foundations bearing entirely on compacted fill may be used for the support of the proposed structures. To reduce the potential for expansive heave, concrete slabs-on-grade, hardscape, and site and retaining wall footings should be underlain by at least 2-feet of material with an expansion index of 50 or less.

Footings located adjacent to or within slopes should be extended to a depth such that a minimum horizontal distance of H/3 (where H is the height of the slope) or 40-feet, whichever is less, exists between the lower outside footing edge and the face of the descending slope in accordance with California Building Code (CBC) requirements.

TABLE OF CONTENTS

1.00 INTRODUCTION

In accordance with your request and authorization, MTGL, Inc. has completed a geotechnical investigation for the subject site. The following report presents a summary of our findings, conclusions and recommendations based on our field investigation, laboratory testing, and engineering analysis.

1.01 PLANNED CONSTRUCTION

Based on our review of the provided RFP, supplemental addenda, and correspondence with the project development team, we understand CVWD is currently proposing the design and construction of a new 3.7 Million Gallon (MG) welded steel tank (Reservoir 5B-2) at the subject site. Cut excavations on the order of 10- to 20-feet below existing ground surface to the planned pad grades are anticipated.

Preliminary site plans do not include additional features; however, we assume associated civil improvements may include new utilities, pedestrian walks, site retaining walls, and other auxiliary structures. The base square footage of the proposed tank will be on the order of 18,000 square feet.

1.02 SCOPE OF WORK

We conducted this investigation in general conformance with the scope of work presented in our proposal No. P-22-566. The scope of our geotechnical services included the following:

- Reviewing readily available literature and maps to obtain background information of regional geology, site development, seismicity, ground water, and other geological concerns.
- Marking out boring locations on the site and contacting Underground Service Alert (USA) to locate onsite utility lines.
- Drilling, logging, and sampling of four (4) exploratory borings using a truck-mounted drill rig equipped with 8-inch hollow stem augers as well as 6-inch solid stem air rotary augers and bit.
- Logging of the borings by an engineer for the purpose of characterizing subsurface materials and groundwater/seepage conditions encountered during the exploration.
- Collecting samples of the materials encountered in the borings and transporting to MTGL's geotechnical laboratory for testing.
- Performing geotechnical engineering review of compiled data and performing geotechnical engineering analyses.
- Preparation of this report summarizing our findings and presenting our conclusions and recommendations for the proposed construction.

1.03 SITE DESCRIPTION

The project site is located within and undeveloped lot in the northeast portion of the city of Rancho Cucamonga within the county of San Bernardino, California. The currently proposed location of the new reservoir is on the western portion of the property located at the address of 5196 Mayberry Avenue in Rancho Cucamonga, California. The site is generally bounded by Beaver Creek Court to the north, existing 1.0 MG reservoir 5B to the east, undeveloped land to the south, and residential properties to the west. The approximate site location is presented on the Site Location Map (Figure 1). The site slopes down from the north to south with surface elevations ranging from about 2082- to 2069-feet MSL (Google Earth, 2022).

The site was previously undeveloped land owned by CVWD. Minimal grading was performed prior to this investigation to allow drilling equipment to safely access the areas where borings were performed.

1.04 FIELD INVESTIGATION

Prior to performing our field investigation, a site reconnaissance was performed by an MTGL staff engineer to observe the existing surface conditions, mark out proposed boring and CPT locations, evaluate each location with respect to obvious subsurface structures, and assess site access for the drilling rig. Underground Service Alert (USA) was subsequently notified of the marked locations for utility clearance as required by law.

Our subsurface investigation was performed on September 26th, 27th, and 28th, 2022 and consisted of advancing four (4) exploratory soil borings within the project site.

1.04.1 HOLLOW STEM AUGER AND AIR ROTARY BORINGS

Two (2) borings (B-3 and B-4) were drilled to depths of approximately 30- to 31-feet (BGS) using a truck-mounted drilling rig equipped with an 8-inch hollow stem auger. The remaining two (2) borings (B-1 and B-2) were drilled to approximate depths of 22- to 30½-feet (BGS) first using the 8-inch hollow stem auger, then, when refusal was reached due to large cobbles/boulders (22-feet BGS for B-1 and 12½-feet BGS for B-2), were drilled to the desired depth or further refusal, due to caving, with the air rotary equipment. An MTGL engineer logged the borings and collected samples of the encountered materials for geotechnical laboratory testing. Representative disturbed bulk soil samples were obtained from the borings within the upper 5-feet. Relatively undisturbed samples were taken using Modified California (CAL) samplers and Standard Penetration Test (SPT) samplers at selected depth intervals. Samplers were driven into the bottom of the boring with successive drops of a 140-pound weight falling a vertical distance of 30-inches. The energy corrected number of blows per foot required to drive the CAL and SPT samplers are shown on the boring logs in the N_{60} column (Appendix B). A conversion factor of 0.65 was used to normalize N_{60} values obtained by CAL samplers. SPTs were performed in general accordance with the American Society for Testing and Materials (ASTM D1586 standard test method. See Appendix B for further discussion of the field exploration methods and logs of test borings.

Soils encountered were observed and described in general conformance with the Unified Soil Classification System (USCS). Samples were sealed and packaged for transportation to our geotechnical laboratory. After completion of drilling, borings were backfilled with soil cuttings.

1.05 LABORATORY TESTING

Laboratory testing was performed on select samples to verify the field classification of the recovered samples and evaluate the geotechnical properties of the subsurface materials. Laboratory tests were performed in general conformance with applicable ASTM or State of California Department of Transportation (Caltrans) standard methods. The results of our laboratory tests are presented in Appendix C.

2.00 FINDINGS

2.01 REVIEW OF PREVIOUS GEOTECHNICAL STUDIES

A records search for geotechnical related reports published within the project vicinity was discussed during the RFP process with the Cucamonga Water District; however, no geotechnical related reports were available for the site at this time.

2.02 GEOLOGY AND SUBSURFACE CONDITIONS

The site is located on the border between the Transverse Ranges and Peninsular Ranges Geomorphic Provinces of California. The Peninsular Ranges province stretches from the Los Angeles basin to the tip of Baja California in Mexico. This province is characterized as a series of northwest trending mountain ranges separated by subparallel fault zones and a coastal plain of subdued landforms. The mountain ranges are underlain primarily by Mesozoic metamorphic rocks that were intruded by plutonic rocks of the southern California batholith, while the coastal plain is underlain by subsequently deposited marine and non-marine sedimentary formations. The Transverse Ranges Province is an east-west trending series of steep mountain ranges and valleys (CGS, 2002). Intense north-south compression is squeezing the Transverse Ranges, and as a result makes the Transverse Ranges one of the most rapidly rising regions on earth. The site is located on the basal foothills of a steep mountain range.

As encountered in our borings, the site is generally underlain by alluvium (Qa). The subsurface materials encountered in our borings were generally consistent with the mapped geologic units presented by Dibblee, Jr. (2003). Approximate locations of the borings are presented on the Subsurface Exploration Map (Figure 2). Figure 3 presents a map of the regional geology within the vicinity of the site. Figure 4 presents geologic cross-sections A-A’ and B-B’. Descriptions of the materials encountered in the borings are presented below.

SUMMARY OF SUBSURFACE SOIL CONDITIONS

Boring No.	Depth Below Existing Grade (ft)	Latitude (Deg)	Longitude (Deg)	Surface Conditions	Existing Ground Elevation (ft)*	Approximate Thickness of Fill (ft)	Groundwater Depth Below Ground Surface (ft)
B-1	30½	34.16104	-117.58146	Soil	2,072	0	NE**
B-2	22	34.16104	-117.58114	Soil	2,080	0	NE**
B-3	30	34.16134	-117.58116	Soil	2,086	0	NE**
B-4	31	34.16082	-117.58114	Soil	2,070	0	NE**

* Approximated using Google Earth
** Not Encountered

Alluvium (Qa) – Alluvium was encountered at the ground surface in each of our borings and extended to the total depths explored. As encountered, the alluvium generally consisted of various shades of gray to brown, dense to very dense silty to gravelly sand. Abundant amounts of gravel, cobbles, and boulders were encountered within the alluvium. Additionally, boulders were observed at the ground surface at the project site.

2.03 GROUNDWATER CONDITIONS

Groundwater was not encountered in our borings during the subsurface investigation. The groundwater table is expected to be below a depth that will influence the planned construction. However, groundwater levels may fluctuate in the future due to rainfall, irrigation, broken pipes, or changes in site drainage. Because groundwater rise or seepage is difficult to predict, such conditions are typically mitigated if and when they occur.

2.04 GEOLOGIC HAZARDS

Geologic hazards are summarized and discussed with respect to the site and proposed development below.

2.04.1 STRONG GROUND MOTION AND MAPPED SEISMIC DESIGN PARAMETERS

A geologic hazard likely to affect the project is ground shaking as a result of movement along an active fault zone in the vicinity of the subject site (USGS, 2022). Based on the subsurface conditions encountered during our subsurface investigation, the site may be classified as Site Class C. The mapped site coefficients and maximum considered earthquake (MCER) spectral response acceleration parameters in accordance with the 2019 CBC are presented below:

2019 California Building Code – Mapped Site Coefficients

Site Coordinates	
Latitude	**Longitude**
33.20625°	-117.36186°
Site Coefficients and Spectral Response Acceleration Parameters	**Values**
Site Class	C
Site Coefficients, F_a	1.2
Site Coefficients, F_v	1.4
Mapped Spectral Response Acceleration at Short Period, S_s	1.944 g
Mapped Spectral Response Acceleration at 1-Second Period, S_1	0.732 g
Design Spectral Acceleration at Short Period, S_{DS}	1.555 g
Design Spectral Acceleration at 1-Second Period, S_{D1}	0.683 g
Nearest Zoned Active Fault	Sierra Madre fault zone (Cucamonga Section)
Fault Distance from Site	~¼ mile
Peak Ground Acceleration, PGA	0.832 g
Site Modified Peak Ground Acceleration, PGA_m	0.999 g

2.04.2 ACTIVE FAULTING AND FAULT-RUPTURE HAZARD

The closest known active fault is the Sierra Madre Fault zone (Cucamonga Section) located approximately ¼ mile northwest of the project site (USGS, 2020). Other regional faults capable of generating seismic hazards include the Newport-Inglewood-Rose Canyon and Elsinore faults to the west and the San Jacinto and San Andreas faults to the east. The site is not located within an Alquist-Priolo Earthquake Fault Zone. However, the site is mapped as being located as close as approximately 900-feet south of an Alquist-Priolo Earthquake Fault Zone. Based on our review of the referenced fault data bases, geologic maps, no active faults are known to underlie or project toward the site. Therefore, the probability of surface fault rupture at the site is considered low. Figure 5 presents a Regional Fault Map (CGS, 2010).

2.04.3 LIQUEFACTION AND DYNAMIC SETTLEMENT

Liquefaction is a phenomenon wherein earthquake induced ground vibrations increase the pore pressure in saturated, granular soils until it is equal to the confining, overburden pressure. When this occurs, the soil can lose its shear strength and enter a liquefied state. The possibility of liquefaction is dependent upon characteristics including grain size, relative density, confining pressure, saturation of the soils, strength of the ground motion and duration of ground shaking. Effects of severe liquefaction can include excessive settlements, bearing capacity failures, lateral spreading, and other mechanisms of failure.

The project site is not located within an area evaluated by CGS for liquefaction hazard. Due to the lack of shallow groundwater and given the dense nature of the materials beneath the site, the potential for liquefaction and dynamic settlement to occur is considered low.

2.04.3.1 BEARING FAILURE

When liquefaction occurs, the soil can completely lose its shear strength and lose its capacity to support the structure resulting in a foundation bearing failure. Lightweight structures which are embedded in liquefiable soil and extend below the groundwater table contain large void spaces which may "float" or lift up and out of the ground surface during or after an earthquake. Based on our analysis, the potential for bearing capacity failure due to liquefaction is low.

2.04.3.2 LATERAL SPREADING (LATERAL DISPLACEMENT)

Lateral spreading is a condition where a relatively stiff block of soil moves laterally toward a free face or slope on a liquefied zone of subsurface soil. Lateral spreads generally develop along gentle slopes and move toward a free face such as an incised river channel. Lateral spreads can cause significant horizontal movement causing fissures and scarps to develop at the surface. Lateral spreads have been observed to disrupt foundations located across a failure, to rupture sewers, pipelines, and other utilities, and compress or buckle structures at the toe of the spread. Given the dense nature of the materials beneath the site and understanding the site will be graded to a generally flat condition with new slopes prepared as indicated in this report, the potential for lateral spreading is considered negligible.

2.04.3.3 LIFELINE HAZARDS

Liquefaction, lateral spreading, and seismically induced settlement of structures may also pose problems for streets and lifelines. Specifically, natural gas pipelines may break and catch fire during an earthquake and water lines may break preventing firefighters from accessing water. Therefore, consideration should be given to providing isolated and flexible connections for gas and water utility lines as a preventive measure.

2.04.4 TSUNAMIS, SEICHES, AND FLOODING

The project site is not mapped as being located within an area susceptible to tsunami inundation (CGS, 2022). Additionally, given the surface elevation and inland location of the site, the potential hazard posed by tsunami is considered negligible.

Seiches are periodic oscillations in large bodies of water such as lakes, harbors, bays, or open reservoirs. The site is not located adjacent to any bodies of water subject to seiches. Therefore, the potential for seiches to affect the site is considered low.

According to the Flood Insurance Rate Map (FIRM), the site is mapped as being located within an area designated as Zone X (FEMA, 2016). Zone X is defined as an area of minimal flood hazard.

2.04.5 LANDSLIDES AND SLOPE STABILITY

Based on our review of available literature, no landslides have been mapped within the project boundaries. Additionally, no evidence of landslides was observed during our site reconnaissance and subsurface investigation. Given the gently sloping topography consisting of very dense materials, and lack of surficial landslide evidence at the site, the potential for landslides or slope instabilities to occur at the site is considered low.

2.04.6 SUBSIDENCE

The site is not located in an area of known subsidence associated with fluid withdrawal (groundwater or petroleum); therefore, the potential for subsidence due to the extraction of fluids is considered negligible.

2.04.7 HYDRO-CONSOLIDATION

Hydro-consolidation can occur in recently deposited sediments (less than 10,000 years old) that were deposited in a semi-arid environment. Examples of such sediments are aeolian sands, alluvial fan deposits, and mudflow sediments deposited during flash floods. The pore spaces between the particle grains can re-adjust when inundated by groundwater causing the material to consolidate. Given the relatively dense nature of the materials underlying the site, the potential for hydro-consolidation is considered negligible.

3.00 CONCLUSIONS

3.01 GENERAL CONCLUSIONS

Based on the results our geotechnical investigation, it is our opinion that the proposed improvements are feasible from a geotechnical standpoint; however, there are existing geotechnical conditions associated with the proposed improvements that will require mitigation. The conclusions and recommendations provided herein should be incorporated into the design of the proposed structures and improvements and implemented during grading and construction.

The main geotechnical considerations affecting the project are the presence of potentially strong ground shaking as a result of movement along active faults in the vicinity of the site and potentially compressible near-surface soils. The tank should be designed to resist strong ground shaking and its secondary effects such as sloshing forces. To reduce the potential for settlement, remedial grading should be performed below the proposed structure and other settlement sensitive improvements.

In general, mat slab or conventional shallow spread foundations bearing entirely on compacted fill may be used for the support of the proposed structures. To reduce the potential for expansive heave, concrete slabs-on-grade, hardscape, and site and retaining wall footings should be underlain by at least 2-feet of material with an expansion index of 50 or less. The granular onsite soils are expected to meet this criteria.

Footings located adjacent to or within slopes should be extended to a depth such that a minimum horizontal distance of H/3 (where H is the height of the slope) or 40-feet, whichever is less, exists between the lower outside footing edge and the face of the slope in accordance with California Building Code (CBC) requirements.

4.00 RECOMMENDATIONS

The following recommendations are provided to address the geotechnical aspects of this project and are considered minimum. They may be superseded by more conservative requirements of the architect, structural engineer, building code, or governing agencies. In addition to the recommendations in this section, additional general earthwork and grading specifications are included in Appendix E.

4.01 EARTHWORK

4.01.1 SITE PREPARATION AND CLEARING

Site preparation should begin with the removal of surface vegetation, trash, debris, and existing structures or improvements. Abandoned underground improvements such as utility pipes and tanks should be removed from the site and capped or rerouted at the project perimeter. Resulting excavations should be backfilled and compacted in accordance with the recommendations provided in this report.

Removal of underground tanks is subject to state law as regulated by the County, City and/or Fire Department. If storage tanks containing hazardous or unknown substances are encountered, the proper authorities must be notified prior to any attempts at removing such objects. If water wells are encountered during construction, they should be exposed and capped in accordance with the requirements of the regulating agencies.

4.01.2 EXCAVATION CHARACTERISTICS

Based on the materials encountered during our investigation, it is anticipated that excavations can be achieved with conventional heavy duty earthwork equipment in good working order. However, the grading contractor should be responsible for their own assessment of site excavatability. As previously noted, abundant gravel, cobbles, and boulders were encountered within the alluvium and should be anticipated in removals and excavations. Additionally, refusal was encountered within our borings within very dense alluvium, and boulders were observed on site at the ground surface. Therefore, very difficult excavation should be anticipated within the alluvium. Cemented zones may also exist within the alluvium. Excavation sidewall instabilities or raveling may develop in zones of low cohesion materials and should be expected. Contract documents should specify that the contractor mobilize equipment capable of excavating and compacting very dense materials containing gravel, cobbles, and boulders. Rock breakers, carbide tipped augers, or carbide/diamond tipped coring equipment may be required to excavate/drill very dense materials containing gravel, cobbles, and boulders.

4.01.3 REMOVALS AND OVER EXCAVATIONS

Recommendations for over excavation of the existing materials are provided for the reservoir area supported on shallow foundations and for non-structural areas. Structural plans and foundation elevations were not available at the time of our investigation. Therefore, once formal plans are prepared and available for review, this office should review these plans from a geotechnical viewpoint, comment on any changes, and revise the recommendations of this report, if necessary.

4.01.3.1 STRUCTURES SUPPORTED ON CONVENTIONAL OR MAT FOUNDATIONS

Existing fills, if encountered, should be removed in their entirety. Additionally, the native alluvium should be over-excavated beneath the proposed tank and other settlement sensitive structures to a depth of at least 5-feet below the pad elevation or 2-feet below the bottom of footings, whichever is greater. Removal bottoms should be observed by MTGL to assess whether additional removals are recommended. Additionally, the proposed tank should not be underlain by cut/fill transitions. Horizontally, the excavations should extend to at least 5-feet outside the perimeter footings or up to existing improvements, whichever is less.

4.01.3.2 NON-STRUCTURAL AREAS

Non-structural areas such as sidewalks and other miscellaneous flatwork areas including paved areas will require a minimum depth of 2-feet of removal and re-compaction below the lowest adjacent grade or bottom of bearing elevation. Excavation for hardscape areas should extend a minimum distance of 2-feet outside the hardscape limits.

The exposed soils beneath over-excavation and in cut areas not otherwise requiring over-excavation should be scarified to a minimum depth of 12-inches, moisture conditioned and compacted to a minimum of 90% relative compaction.

The above recommendations are based on the assumption that soils encountered during field exploration are representative of soils throughout the site. Removal and over-excavation depths must be verified, and adjusted if necessary, at the time of grading.

4.01.4 FILL MATERIALS

Removed and/or over-excavated soils, except for roots, debris, and rocks greater than 6-inches, may be used as compacted fill.

Prior to placing fill, exposed surfaces at the bottom of the excavations should be scarified to a depth of 8-inches, moisture conditioned to near optimum moisture content, and compacted to at least 90% relative compaction. Fill should be placed in horizontal lifts at a thickness appropriate for the equipment spreading, mixing, and compacting the material, but generally should not exceed 8-inches in loose thickness. Fill should be moisture conditioned to near optimum moisture content and compacted to at least 90% relative compaction. Fill should be benched into sloping ground inclined steeper than 5:1 (horizontal to vertical). The maximum dry density and optimum moisture content for evaluating relative compaction should be determined in accordance with ASTM D1557.

4.01.5 EXPANSIVE SOILS

To reduce the potential for expansive heave, soils with an expansion index greater than 50 should be excavated a minimum of 2-feet below the planned structure or exterior slab subgrade elevations. Horizontally, excavations should extend at least 2-feet outside the perimeter of the slab or up to temporary shoring or existing improvements, whichever is less. Granular material with an expansion index of 50 or less should be used as replacement fill. Based on our laboratory testing results, we expect that the majority of the onsite soils will meet this criteria.

4.01.6 IMPORTED SOILS

Imported soil should consist of predominately granular soil, free of organic matter and rocks greater than 4-inches. Imported soil should have an expansion index of 20 or less and should be inspected and, if appropriate, tested prior to transport to the site.

4.01.7 OVERSIZED MATERIALS

Excavations are anticipated to generate oversized material. Oversized material is defined as rocks or cemented clasts greater than 6-inches in largest dimension. Oversized material should be broken down to no greater than 6-inches in largest dimension for use in fill, used as landscape material, or disposed of off-site.

4.01.8 TEMPORARY EXCAVATIONS

Temporary excavations 3-feet deep or less can be made vertically. Deeper temporary excavations in fill and alluvium should be laid back no steeper than 1½:1 (horizontal: vertical).

The faces of temporary slopes should be inspected daily by the Contractor’s Competent Person before personnel are allowed to enter the excavation. Zones of potential instability, sloughing, or raveling should be brought to the attention of the engineer and corrective action implemented before personnel begin working in the excavation. Excavated soils should not be stockpiled behind temporary excavations within a distance equal to the depth of the excavation. MTGL should be notified if other surcharge loads are anticipated so that lateral load criteria can be developed for the specific situation. If temporary slopes are to be maintained during the rainy season, berms are recommended along the tops of slopes to prevent runoff water from entering the excavation and eroding the slope faces.

Temporary slopes and excavations should be made in conformance with applicable OSHA standards and requirements. Based on the results of our investigation, the subsurface materials can be categorized as Type C soil.

Slopes steeper than those described above will require shoring. Additionally, temporary excavations that extend below a plane inclined at 1½:1 (horizontal:vertical) downward from the outside bottom edge of existing structures or improvements will require shoring. Soldier piles and lagging could be used.

4.01.9 TEMPORARY SHORING

For design of cantilevered shoring, an active soil pressure equal to a fluid weighing 35 pcf can be used for level retained ground. The surcharge loads on shoring from traffic and construction equipment adjacent to the excavation can be modeled by assuming an additional 2-feet of soil behind the shoring.

For design of soldier piles, an allowable passive pressure of 350 psf per foot of embedment over 2.5 times the pile diameter or the spacing of the piles, whichever is less, up to a maximum of 4,000 psf can be used for soil. Hydrostatic pressure should be applied below the groundwater level, if encountered.

Soldier piles should be spaced at least three pile diameters, center to center. Continuous lagging will be required throughout. The soldier piles should be designed for the full-anticipated lateral pressure; however, the pressure on the lagging will be less due to arching in the soils. For design of lagging, the earth pressure can be limited to a maximum value of 300 psf.

Installation of soldier piles below groundwater (or dewatered soil) will require special construction techniques and equipment, such as temporary casing and/or drilling slurry to cope with groundwater and potential heavy caving. Other installation methods may be available. Contract documents should specify that the contractor mobilize equipment capable of installing piles below groundwater (or dewatered soil) to reduce the potential that claims for delays or extra work will arise.

Piles should be filled with concrete immediately after drilling. The concrete should be pumped to the bottom of the drilled holes using the tremie method. If casing is used, the casing should be removed as the concrete is placed, keeping the level of the concrete at least 5-feet above the bottom of the casing at all times.

4.01.10 SLOPES

All permanent slopes should be constructed no steeper than 2:1 (horizontal: vertical). Faces of fill slopes should be compacted either by rolling with a sheepsfoot roller or other suitable equipment or by overfilling and cutting back to design grade. Fills should be benched into sloping ground when inclined steeper than 5:1 (horizontal: vertical). It is our opinion that cut slopes constructed no steeper than 1½:1 (horizontal: vertical) will possess an adequate factor of safety. An engineering geologist should observe all cut slopes during grading to ascertain that no unforeseen adverse geologic conditions are encountered that require revised recommendations.

All slopes are susceptible to surficial slope failure and erosion. Water should not be allowed to flow over the top of slope. Additionally, slopes should be planted with vegetation that will reduce the potential for erosion.

4.02 FOUNDATIONS

Proposed improvements can be supported on conventional shallow spread or continuous footings or mat foundations with bottom levels bearing entirely on compacted fill. Site walls or retaining walls can be supported on spread footings with bottom levels bearing on compacted fill.

Our recommendations are only minimum criteria based on geotechnical factors and should not be considered a structural design, or to preclude more restrictive criteria of governing agencies or by the structural engineer. The foundation system should be designed by the project's structural engineer, incorporating the geotechnical parameters described herein and the requirements of applicable building codes.

The foundation recommendations provided herein are considered generally consistent with methods typically used in Southern California, however, other alternatives may be available. Based on the results of our geotechnical investigation, recommendations for various foundation systems are presented in the following sections.

4.02.1 CONVENTIONAL SHALLOW FOUNDATIONS

The planned structure can be supported on shallow conventional spread and/or continuous footings bearing entirely on compacted fill. An allowable bearing capacity of 2,500 psf can be used for shallow footings supported on compacted fill. The allowable bearing capacity can be increased by 200 psf for each foot of width and 400 psf for each foot of depth beyond the minimum to a maximum value of 4,000 psf on compacted fill. The bearing value can be increased by ⅓ when considering the total of all loads, including wind or seismic forces.

The recommended minimum footing width and embedment depth below the lowest adjacent grade are as follows:

Foundation Type	Minimum Width	Minimum Depth
Continuous (Interior)	24-inches	24-inches
Continuous (Perimeter)	24-inches	24-inches
Spread Footings	24-inches	24-inches

Lateral loads will be resisted by friction between the bottoms of footings and passive pressure on the faces of footings and other structural elements below grade. An allowable coefficient of friction of 0.35 can be used. Passive pressure can be computed using an allowable lateral pressure of 350 psf per foot of depth below the ground surface for level ground conditions. The passive pressure can be increased by ⅓ when considering the total of all loads, including wind or seismic forces. The upper 12-inches of soil should not be relied on for passive support unless the ground is covered with pavements or slabs.

4.02.2 MAT FOUNDATIONS

The planned structures can be supported on a structural mat slab bearing compacted fill. An allowable bearing capacity of 2,000 psf can be used to design the foundations. This value can be increased by ⅓ when considering the total of all loads, including wind or seismic forces. Thickness and reinforcement of the slab foundation should be in accordance with the recommendations of the project's structural engineer. Mat foundations typically experience some deflection due to loads placed on the mat and the reaction of the soils underlying the mat. A design modulus of subgrade reaction, K, of 175 pounds per cubic inch (pci) may be used for bearing in compacted fill in evaluating such deflections. This value is based on an area of one square foot and should be adjusted for large mats. Adjusted values of the modulus of subgrade reaction, Kv, can be obtained from the following equation for square mats of various widths on sand:

$$K_V = K\left[\frac{B+1}{2B}\right]^2 \text{ (pci); for B} \leq 20 \text{ Feet}$$

$$K_V = \frac{K}{2}\left[\frac{B+1}{2B}\right]^2 \text{ (pci); for B} \geq 40 \text{ Feet}$$

Adjusted values of the modulus of subgrade reaction, K', can be obtained from the following equation for rectangle mats of various widths:

$$K' = \frac{K_v\left[1+0.5\left(\frac{B}{L}\right)\right]}{1.5} \text{ (pci)}$$

Where, B is width the and L is the length of the mat in feet.

Lateral loads will be resisted by friction between the bottom of the mat foundation and underlying soil, and passive pressure on the faces of the mat foundations. A coefficient of friction of 0.35 can be used. Passive pressure can be computed using an allowable lateral pressure of 350 psf per foot of depth below the ground surface for level ground conditions. The passive pressure can be increased by ⅓ when considering the total of all loads, including wind or seismic forces. The upper 1-foot of soil should not be relied on for passive support unless the ground is covered with pavements or slabs.

The slab thickness and reinforcement should be designed by the structural engineer. The corrosion potential of on-site soils with respect to reinforced concrete will need to be considered in the concrete mix design.

4.02.3 SETTLEMENT CONSIDERATIONS

Foundations should be designed for the anticipated settlements. Static settlement of an individual foundation member will vary depending on the plan dimensions of the foundation and the actual load supported.

We estimate maximum static settlement of foundations designed and constructed in accordance with the recommendations presented to be on the order of 1-inch. Differential settlement between similarly loaded and adjacent footings are expected to be less than ½-inch across 40-feet, provided footings are founded on similar materials. Static settlement of foundations is expected to occur rapidly and should be essentially complete shortly after initial application of the loads.

4.03 INTERIOR CONCRETE SLABS ON GRADE

The project's structural engineer should design concrete slabs-on-grades for buildings. However, it is recommended that interior slabs be at least 5-inches thick and reinforced with at least No. 4 bars at 18-inches on center each way.

Moisture protection should be installed beneath slabs where moisture sensitive floor coverings will be used. The project's architect should review the tolerable moisture transmission rate of the proposed floor covering and specify an appropriate moisture protection system. Typically, a plastic vapor barrier is used. Minimum 10-mil plastic is recommended. The plastic should comply with ASTM E1745. The vapor barrier installation should comply with ASTM E1643. The floor covering manufacturer should be contacted to determine the volume of moisture vapor allowable and treatment needed to reduce moisture vapor emissions to acceptable limits for the particular type of floor covering installed.

4.04 HARDSCAPE

Hardscape and other exterior concrete slabs-on-grade not subject to vehicular loads should be underlain by at least 2-feet of material with an expansion index of 50 or less. Exterior slabs should be at least 4-inches thick and reinforced with at least No. 3 bars at 18-inches on center each way. Slabs should be provided with weakened plane joints. Joints should be placed in accordance with the American Concrete Institute (ACI) guidelines. The project's architect should select the final joint patterns. A 1-inch maximum size aggregate mix is recommended for concrete for exterior slabs. The corrosion potential of on-site soils with respect to reinforced concrete will need to be taken into account in concrete mix design. Coarse and fine aggregate in concrete should conform to the "Greenbook" Standard Specifications for Public Works Construction.

4.05 PREWETTING RECOMMENDATIONS

Prior to placing concrete slabs and flatwork, the underlying soils should be moisture conditioned to within 2% above its optimum moisture content for a depth of 12-inches prior to the placement of concrete. The geotechnical consultant should perform in-situ moisture tests to verify that the appropriate moisture content has been achieved a maximum of 24-hours prior to the placement of concrete or moisture barriers.

Once the slab subgrade soil has been pre-wetted and compacted, the soil should not be allowed to dry prior to concrete placement. If the subgrade soil is dry, the moisture content of the soil should be restored prior to placement of concrete and re-tested.

Proper moisture conditioning and compaction of subgrade soils prior to concrete placement is recommended. Even with proper site preparation, some soil moisture changes of the subgrade soils supporting the concrete flatwork due to edge effects (shrink/swell) may occur. Drying and/or wetting of subgrade soils adjacent to landscaped areas or open fields may increase the potential of shrink/swell effects beneath concrete flatwork areas. To help reduce edge effects, lateral cutoffs, such as inverted curbs are recommended. Control joints should be used to reduce the potential for flatwork panel cracks as a result of minor soil shrink/swell.

4.06 CORROSIVITY

Soluble sulfate tests indicate that concrete at the subject site will have a moderate exposure to water soluble sulfate in the soil. We recommend that the concrete be designed to resist a moderate exposure category. Our recommendations for concrete exposed to sulfate-containing soils are presented below.

RECOMMENDATIONS FOR CONCRETE EXPOSED TO SULFATE CONTAINING SOILS

Sulfate Exposure Severity	Class	Water soluble sulfate (SO_4) in soil (% by wgt)	Sulfate (SO_4) in water (ppm)	Max Water to Cement Ratio by Weight	Minimum Compressive Strength (psi)	Cement Type	Calcium Chloride Admixture
Negligible	**S0**	**0.00 - 0.10**	**0-150**	**---**	**2,500**	**---**	**No Restriction**
Moderate	S1	0.10 - 0.20	150-1,500	0.50	4,000	II/V	No Restriction
Severe	S2	0.20 - 2.00	1,500-10,000	0.45	4,500	V	Not Permitted
Very Severe	S3	Over 2.00	Over 10,000	0.45	4,500	V Plus Pozzolan	Not Permitted

Corrosivity testing consisting of soils reactivity (pH) and resistivity (ohms-cm) were also tested on select soil samples. The test results indicate that the soils have a soil reactivity ranging from 7.2 to 7.5 and a resistivity ranging from 3,800 to 10,040 ohms-cm. A neutral or non-corrosive soil has a reactivity value ranging from 5.5 to 8.4. Generally, soils that could be considered corrosive to metal have resistivities less than 3,000 ohms-cm. Those soils with resistivity values of less than 1000 ohms-cm can be considered extremely corrosive.

Based on our test results, it is our opinion that the underlying soils at the site have a negligible corrosion potential. Protection of buried pipes can be performed by utilizing coatings on underground pipes; clean backfills and a cathodic protection system can also be effective in controlling corrosion. A qualified corrosion engineer should be consulted to further assess the corrosive properties of the soil and provide mitigation measures appropriate to the improvements.

4.07 RETAINING STRUCTURES

Embedded structural walls should be designed for lateral earth pressures exerted on the walls. The magnitude of these earth pressures will depend on the amount of deformation that the wall can yield under the load. If the wall can yield sufficiently to mobilize the full shear strength of the soils, it may be designed for the active condition. If the wall cannot yield under the applied load, then the shear strength of the soil cannot be mobilized, and the earth pressures will be higher. These walls such as basement walls and swimming pools should be designed for the at rest condition. If a structure moves towards the retained soils, the resulting resistance developed by the soil will be the passive resistance.

For design purposes, the recommended equivalent fluid pressure for each case for walls constructed above the static groundwater table and backfilled with non-expansive soils is provided below. Retaining wall backfill should be compacted to at least 90% relative compaction based on the maximum density defined by ASTM D1557. Retaining structures should be designed to resist the following lateral earth pressures.

- Coefficient of Friction (Soil to Footing) – 0.35
- Passive Earth Pressure - equivalent fluid weight of 350 pcf (Maximum of 3,500 psf)
- At rest lateral earth pressure - 55 pcf
- Active Earth Pressures (equivalent fluid weights):

Slope of Retained Material	Equivalent Fluid Weight (pcf)
Level	35
2:1 (H:V)	55

It is recommended that retaining wall footings be embedded at least 24-inches below the lowest adjacent finish grade. In addition, the wall footings should be designed and reinforced as required for structural considerations. The wall areas should be over-excavated to a minimum depth of 2-feet below the bottom of the proposed footings. The required horizontal limits of the over excavation area shall be a minimum distance of 2-feet.

Lateral resistance parameters provided above are ultimate values. Therefore, a suitable factor of safety should be applied to these values for design purposes. The appropriate factor of safety will depend on the design condition and should be determined by the project's structural engineer. These parameters do not include loading from adjacent structures. If any super-imposed loads are anticipated, this office should be notified so that appropriate recommendations for earth pressures may be provided.

Retaining structures should be designed with effective drainage to prevent the accumulation of subsurface water behind the walls. Back drains should be installed behind retaining walls exceeding 3-feet in height. Backdrains may consist of a 2-feet wide zone of ¾-inch crushed rock. The backdrain should be separated from the adjacent soils using a non-woven filter fabric, such as Mirafi 140N or equivalent. Weep holes should be provided, or a perforated pipe should be installed at the base of the backdrain and sloped to discharge to a suitable storm drain facility. As an alternative, a geo-composite drainage system such as Miradrain 6000 or equivalent placed behind the wall and connected to a suitable storm drain facility can be used. The project's architect should provide waterproofing specifications and details. A typical detail for retaining wall back drains is presented as Figure 7. Backdrains should be outletted to suitable drainage devices.

4.08 SEISMIC EARTH PRESSURES

If required, the seismic earth pressure can be taken as equivalent to the pressure of a fluid weighing 21 pcf. This value is for level backfill and does not include a factor of safety. Appropriate factors of safety should be incorporated into the design. This pressure is in addition to the un-factored, static active earth pressure. The passive pressure and bearing capacity can be increased by ⅓ in determining the seismic stability of the wall.

4.09 PAVEMENT STRUCTURAL SECTIONS

Recommended pavement structural sections are based on the procedures outlined in "Design Procedures for Flexible Pavements" of the Highway Design Manual, California Department of Transportation. This procedure uses the principal that the pavement structural section must be of an adequate thickness to distribute the load from the design traffic (TI) to the subgrade soils in such a manner that the stresses from the applied loads do not exceed the strength of the soil (R value). The onsite soils tested have an R-value of 66. However, preliminary pavement sections were designed based on an R-Value of 50. The recommend structural sections are as follows:

ASPHALT PAVEMENT STRUCTURAL SECTIONS

Pavement Area	Traffic Index	Asphalt Thickness (inches)	Base Thickness (inches)
Parking Areas	5.0	3	4
Driveways	6.0	3	5
Fire Access Lanes	7.5	4	6

PORTLAND CEMENT CONCRETE PAVEMENT STRUCTURAL SECTION

Pavement Area	Traffic Index	Asphalt Thickness (inches)	Base Thickness (inches)
Concrete Pavement (min f’c = 4,500 psi)	5.0 – 8.0	6½	6

The top 12-inches of subgrade should be scarified, moisture conditioned to near optimum moisture content, and compacted to at least 95% relative compaction. Soft or yielding areas should be removed and replaced with compacted fill or aggregate base. Aggregate base and asphalt concrete should conform to the Caltrans Standard Specifications or the “Greenbook” and should be compacted to at least 95% relative compaction. Aggregate base should have an R-value of not less than 78. Materials and methods of construction should conform to good engineering practices.

4.10 UTILITY TRENCHES

Cal/OSHA construction safety orders should be observed during all underground work. Utility trench backfill within street right of way, utility easements, under or adjacent to sidewalks, driveways, or building pads should be observed and tested by the geotechnical consultant to verify proper compaction. Trenches excavated adjacent to foundations should not extend within the footing influence zone defined as the area within a line projected at a 1:1 (horizontal to vertical) drawn from the bottom edge of the footing. Trenches crossing perpendicular to foundations should be excavated and backfilled prior to the construction of the foundations. The excavations should be backfilled in the presence of the geotechnical engineer and tested to verify adequate compaction beneath the proposed footing.

4.10.1 THRUST BLOCKS

For level ground conditions, a passive earth pressure of 350 psf per foot of depth below the lowest adjacent final grade can be used to compute allowable thrust block resistance. A value of 175 psf per foot should be used below groundwater level, if encountered.

4.10.2 MODULUS OF SOIL REACTION

A modulus of soil reaction (E’) of 1,000 psi can be used to evaluate the deflection of buried flexible pipelines. This value assumes that granular bedding material is placed adjacent to the pipe and is compacted to at least 90% relative compaction.

4.10.3 BEDDING

Pipe bedding as specified in the “Greenbook” Standard Specifications for Public Works Construction can be used. Bedding material should consist of clean sand having a sand equivalent not less than 30 and should extend to at least 12-inches above the top of pipe. Alternative materials meeting the intent of the bedding specifications are also acceptable. Samples of materials proposed for use as bedding should be provided to the engineer for inspection and testing before the material is imported for use on the project. The on-site materials are not expected to meet “Greenbook” bedding specifications. The pipe bedding material should be placed over the full width of the trench. After placement of the pipe, the bedding should be brought up uniformly on both sides of the pipe to reduce the potential for unbalanced loads. No voids or uncompacted areas should be left beneath the pipe haunches. Ponding or jetting the pipe bedding should not be allowed.

4.10.4 BACKFILL

Excavated material free of organic debris and rocks greater than 6-inches in largest dimension are generally expected to be suitable for use as backfill. Imported material should not contain rocks greater than 4-inches in largest dimension or organic debris. Imported material should have an expansion index of 20 or less. MTGL should observe and, if appropriate, test proposed imported materials before they are delivered to the site. Backfill should be placed in lifts 8-inches or less in loose thickness, moisture conditioned to optimum or slightly above optimum moisture content and compacted to at least 90% relative compaction. The top 12-inches of soil beneath pavement subgrade should be compacted to at least 95% relative compaction.

4.11 CONSTRUCTION CONSIDERATIONS

4.11.1 MOISTURE SENSITIVE SOILS AND WEATHER-RELATED CONCERNS

The upper soils encountered at this site may be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil's strength and its support capabilities. In addition, soils that become excessively wet may be slow to dry and thus significantly delay the progress of the grading operations. Therefore, it is recommended to perform earthwork and foundation construction activities during the dry season. Much of the on-site soils may be susceptible to erosion during periods of inclement weather. As a result, the project's Civil Engineer/Architect and Grading Contractor should take appropriate precautions to reduce the potential for erosion during and after construction.

4.11.2 DRAINAGE AND GROUNDWATER CONSIDERATIONS

Based on our subsurface investigation, groundwater is expected to be at a depth below the anticipated depths of grading. However, variations in the groundwater table may result from fluctuation in the ground surface topography, subsurface stratification, precipitation, irrigation, and other factors such as impermeable and/or cemented formational materials overlain by fill soils. In addition, during retaining wall excavations, seepage may be encountered. Therefore, we recommend that a representative of MTGL be present during grading operations to evaluate areas of seepage. Drainage devices for reduction of water accumulation can be recommended should these conditions occur.

Water should not be allowed to collect in the foundation excavation, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped to facilitate removal of any collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the structure and beneath the floor slabs. The grades should be sloped away from the structure and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas.

4.11.3 SITE DRAINAGE

The site should be designed to provide for positive drainage away from structures in accordance with the building code and applicable local requirements. Unpaved areas should slope no less than 2% away from structure. Paved areas should slope no less than 1% away from structures. Concentrated roof and surface drainage from the site should be collected in engineered, non-erosive drainage devices and conducted to a safe point of discharge. The site drainage should be designed by a civil engineer.

4.12 PLAN REVIEW

MTGL should review the grading and foundation plans to verify that the intent of the recommendations presented in this report has been implemented and that revised recommendations are not necessary as a result of changes after this report was completed.

5.00 GEOTECHNICAL OBSERVATION AND TESTING

The recommendations provided in this report are based on preliminary design information and subsurface conditions as interpreted from the investigation. Our preliminary conclusions and recommendations should be reviewed and verified during site grading and revised accordingly if exposed geotechnical conditions vary from our preliminary findings and interpretations. The geotechnical consultant should perform geotechnical observation and testing during the following phases of grading and construction:

- During site grading and over-excavation.
- During foundation excavations and placement.
- Upon completion of retaining wall footing excavation prior to placing concrete.
- During excavation and backfilling of utility trenches.
- During processing and compaction of the subgrade for the access and parking areas and prior to construction of pavement sections.
- When any unusual or unexpected geotechnical conditions are encountered during any phase of construction.

6.00 LIMITATIONS

The findings, conclusions, and recommendations contained in this report are based on the site conditions as they existed at the time of our investigation, and further assume that the subsurface conditions encountered during our investigation are representative of conditions throughout the site. Should subsurface conditions be encountered during construction that are different from those described in this report, this office should be notified immediately so that our recommendations may be re-evaluated.

This report was prepared for the exclusive use and benefit of the owner, architect, and engineer for evaluating the design of the facilities as it relates to geotechnical aspects. It should be made available to prospective contractors for information on factual data only, and not as a warranty of subsurface conditions included in this report.

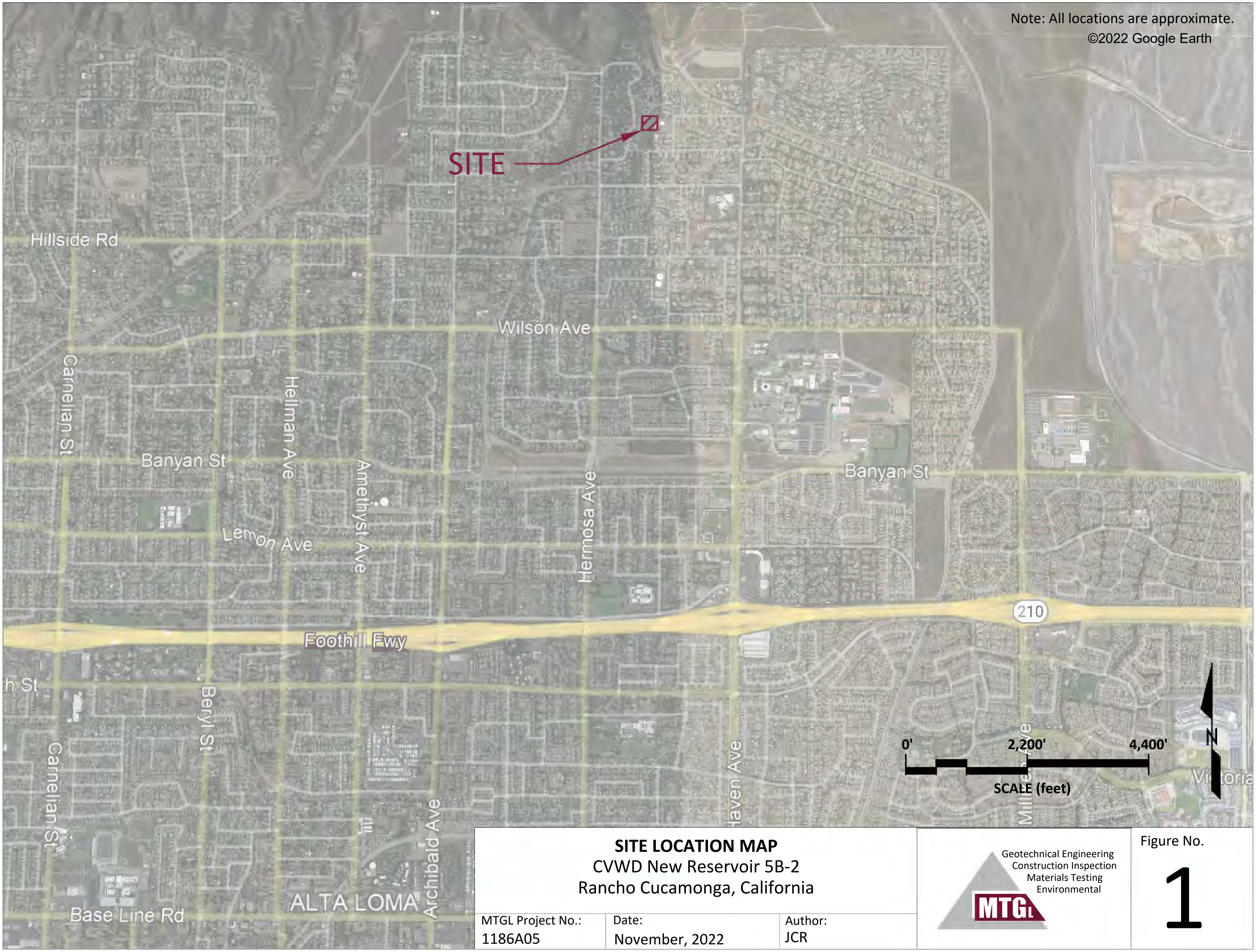
Our investigation was performed using the standard of care and level of skill ordinarily exercised under similar circumstances by reputable soil engineers and geologists currently practicing in this or similar localities. No warranty, express or implied, is made as to the conclusions and professional advice included in this report.

This firm does not practice or consult in the field of safety engineering. We do not direct the Contractor's operations, and we are not responsible for their actions. The contractor will be solely and completely responsible for working conditions on the job site, including the safety of all persons and property during performance of the work. This responsibility will apply continuously and will not be limited to our normal hours of operation.

The findings of this report are considered valid as of the present date. However, changes in the conditions of a site can occur with the passage of time, whether they are due to natural events or to human activities on this or adjacent sites. In addition, changes in applicable or appropriate codes and standards may occur, whether they result from legislation or the broadening of knowledge.

Accordingly, this report may become invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and revision as changed conditions are identified.

FIGURES



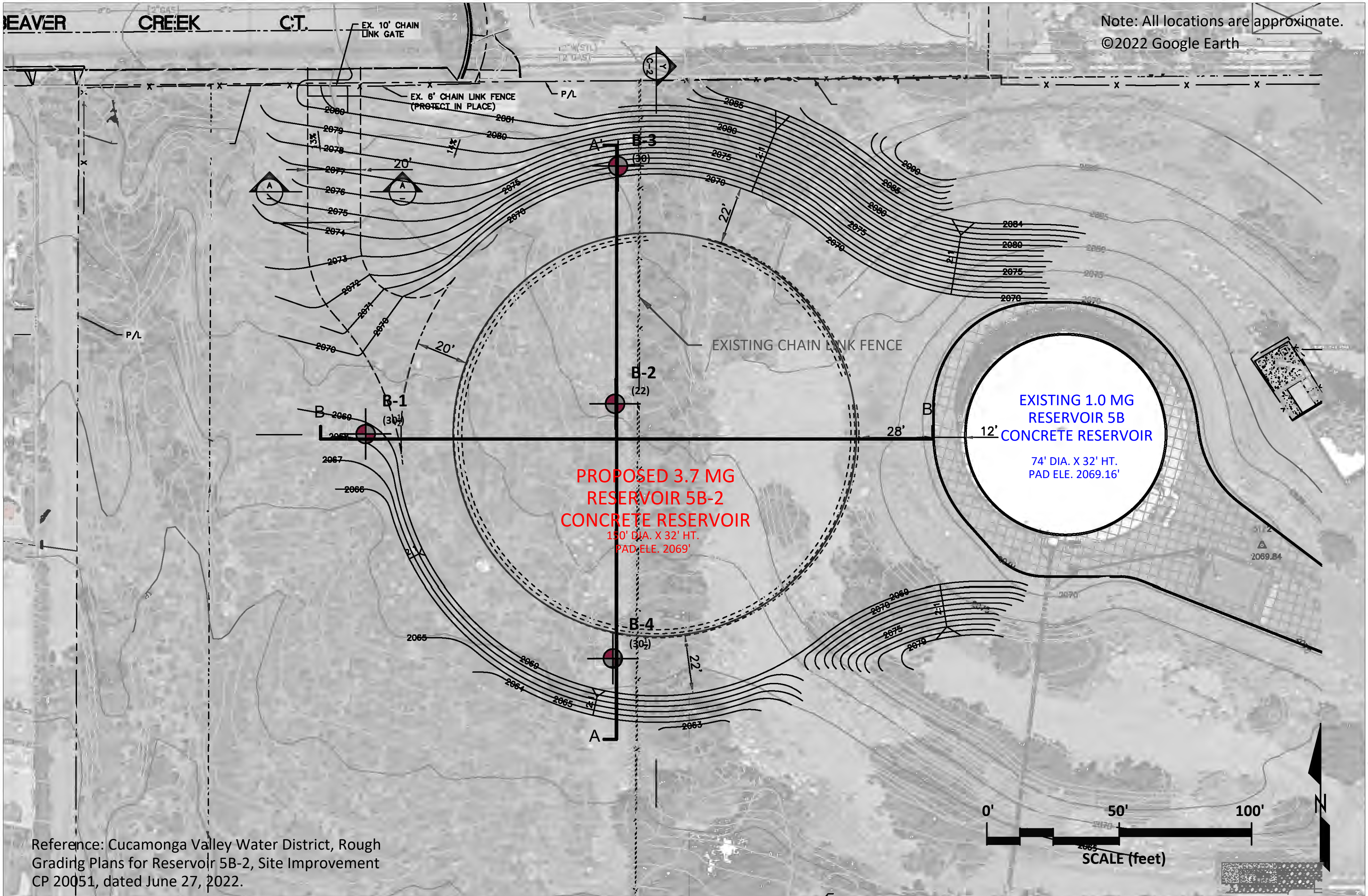
SITE LOCATION MAP
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

MTGL Project No.:	Date:	Author:
1186A05	November, 2022	JCR

Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental

MTGL

Figure No.
1



LEGEND

A A' - Geologic Cross Section

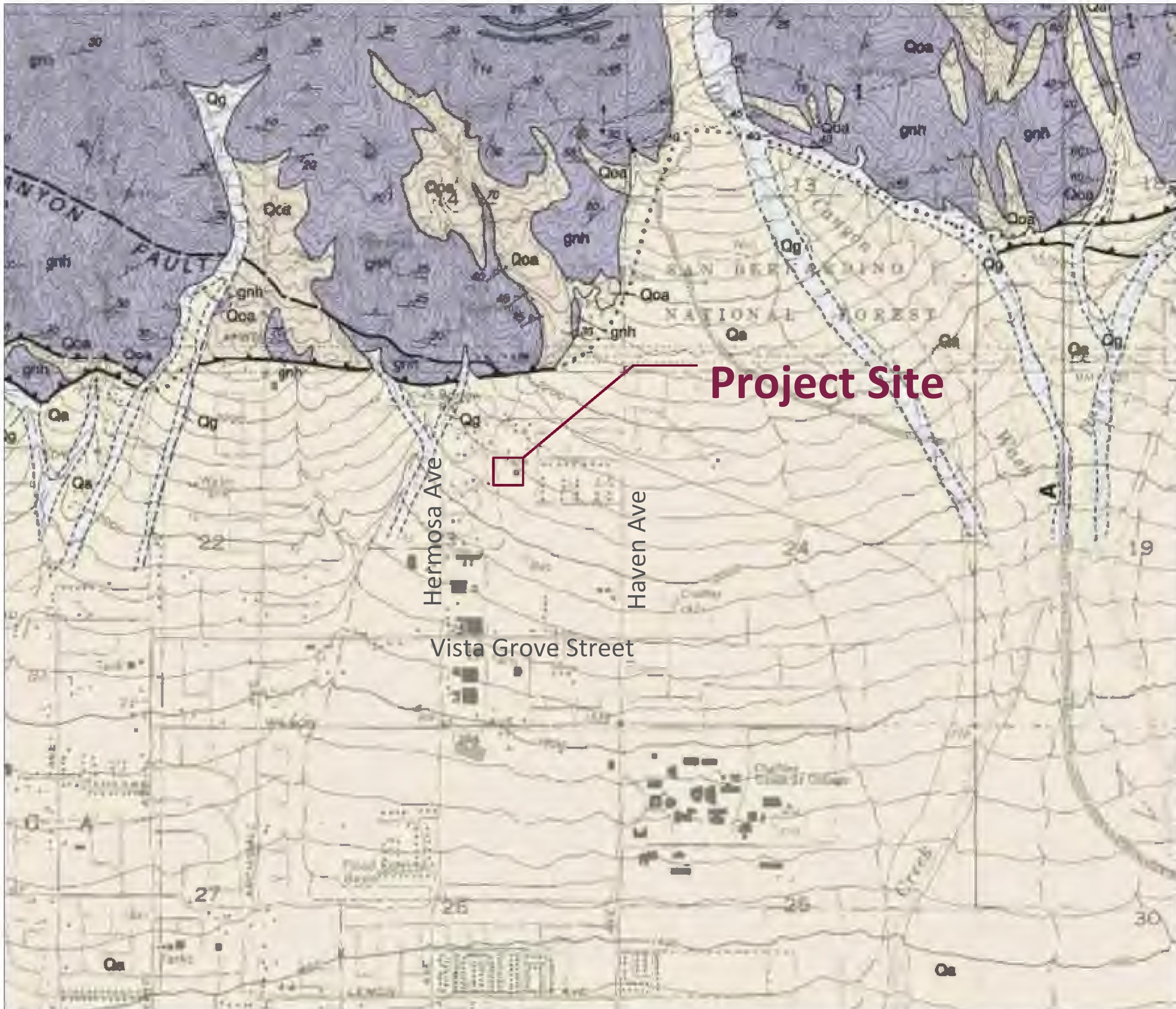
B-4 (30½) - Proposed Boring Location (Target Depth in Feet)

SUBSURFACE EXPLORATION MAP
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

MTGL Proposal No.:	Date:	Author:
1186A05	November, 2022	JCR

MTGL
Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental

Figure No.
2



EXPLANATION:

Qa — **Alluvium (Holocene)** – Surficial sediments. Alluvial gravel and sand of valley areas, composed of boulder gravel in mountain areas, grading outward into finder gravel and sand in alluvial plain.

Qg — **Alluvium (Holocene)** – Surficial sediments. Alluvial gravel and sand of stream channels and washes.

Qoa — **Alluvium (Pleistocene)** – Older dissected surficial sediments. Low elevated remnants of alluvial gravel and sand.

gnh — **Hornblende Gneiss (Precambrian)** – Gneissic rocks. Gray, thin layered with dark hornblende / biotite-rich laminae alternating with white to light gray quartz-feldspar rich laminae.

Contact

Observed or approximately located; queried where gradational or inferred.

U D

Fault

Solid where well located; dashed where approximately located or inferred; queried where continuation or existance is uncertain; dotted where concealed by younger rocks. Arrows show relative or apparent direction of movement. U, upthrown side and D, downthrown side (relative or apparent).

Thrust fault - barbs on the upper plate. Generally dips less than 45°, but locally may have been subsequently steepened. Dashed where approximately located or inferred; dotted where concealed by younger rocks; queried where continuation or existance is uncertain.

Anticlinal fold

Dashed where inferred; dotted where concealed by younger rocks.

Reference:
T. W. Dibblee, Jr. (2003), Geologic Map of the Cucamonga Peak Quadrangle, San Bernardino County, California, 1:24,000, National Geologic Map Database, https://ngmdb.usgs.gov/ngm-bin/pdp/zui_viewer.pl?id=34321.

0 ½ 1

SCALE (Mile)

Note: All locations are approximate.

N

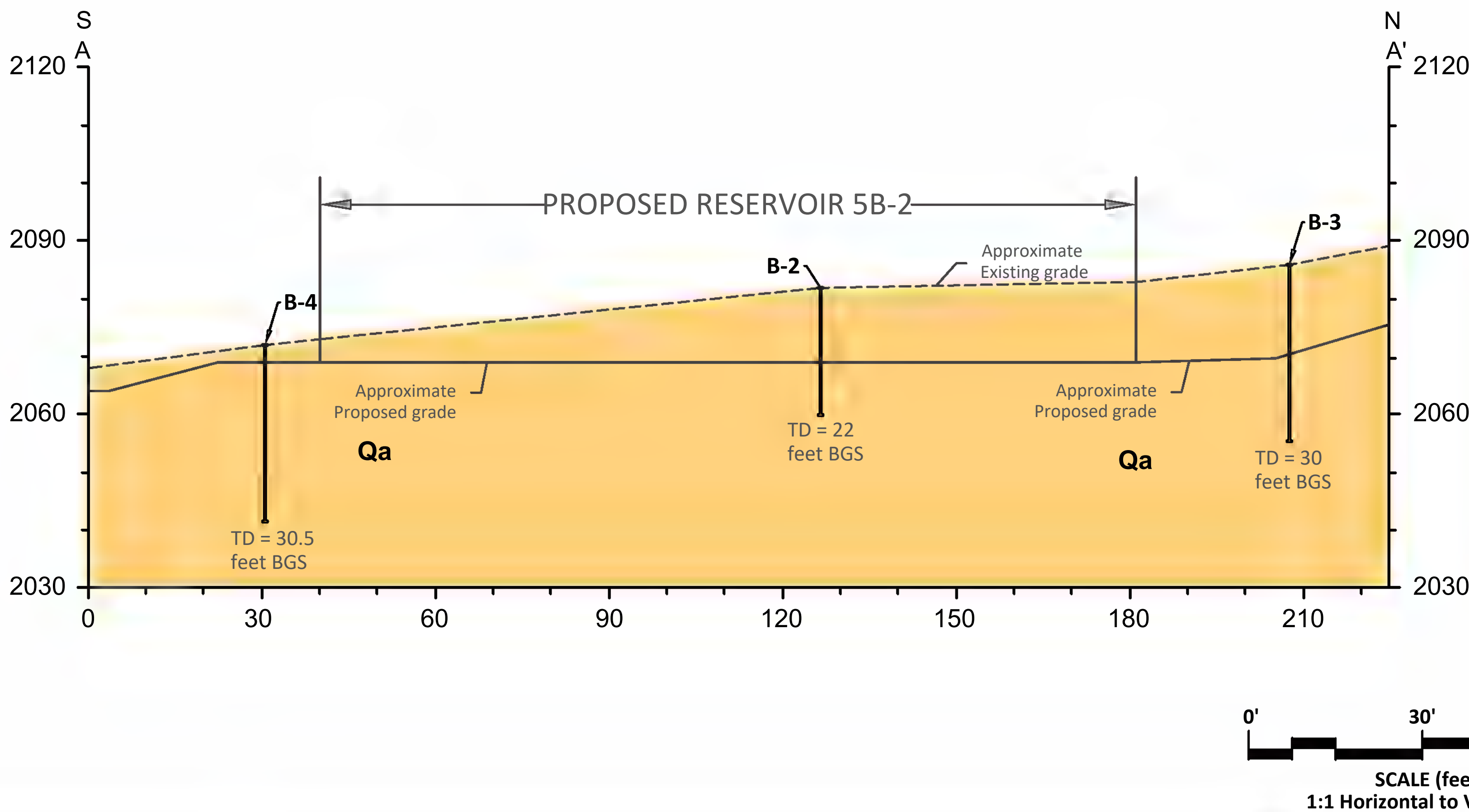
REGIONAL GEOLOGY MAP
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

MTGL Project No.:	Date:	Author:
1186A05	November, 2022	JCR

Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental
MTGL

Figure No.
3

Note: All locations and elevations are approximate.



LEGEND

B-4 Boring Location | Qa Alluvium

Proposed Grade (Solid) | Existing Grade (Dashed)

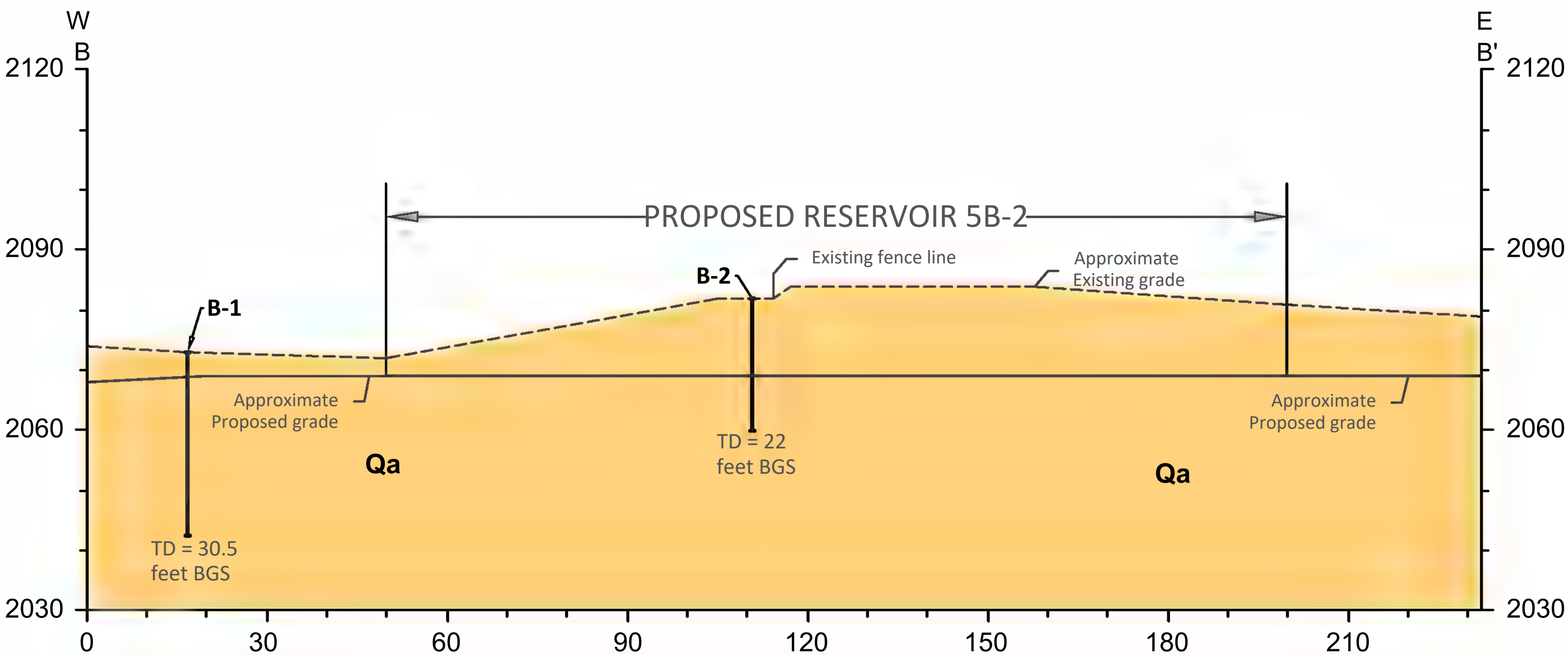
GEOLOGIC CROSS SECTION
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

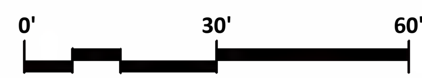
MTGL Project No.: 1186A05 | Date: November, 2022 | Author: JCR

Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental

Figure No.
4A

Note: All locations and elevations are approximate.





SCALE (feet)
1:1 Horizontal to Vertical

LEGEND

B-2 Boring Location

Qa Alluvium

Proposed Grade (Solid)

Existing Grade (Dashed)

GEOLOGIC CROSS SECTION
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

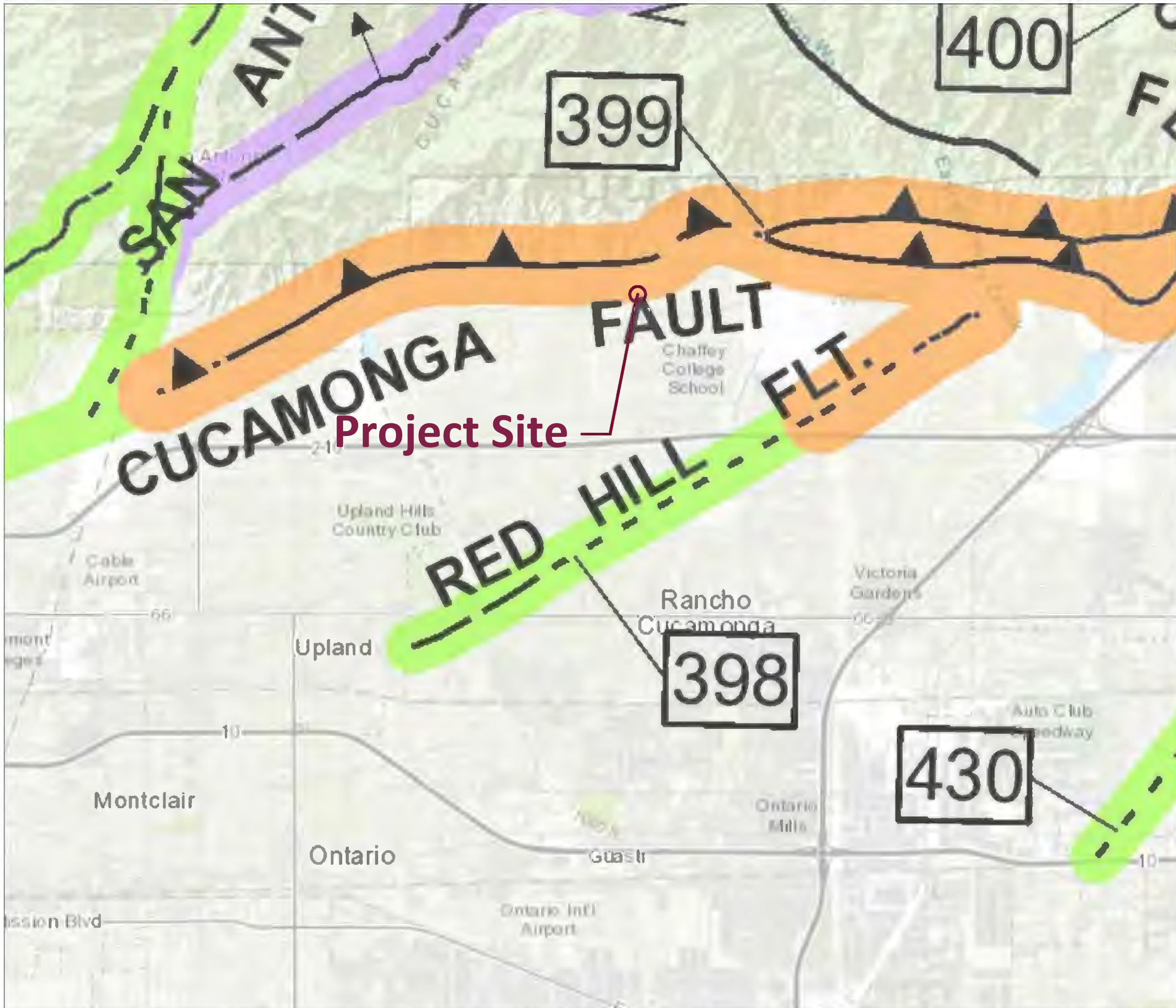
MTGL Project No.:	Date:	Author:
1186A05	November, 2022	JCR

Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental

MTGL

Figure No.

4B



EXPLANATION:

Holocene fault displacement (during past 11,700 years) without historic record.

Late Quaternary fault displacement (during past 700,000 years).

Quaternary fault (age undifferentiated).

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement.

ADDITIONAL FAULT SYMBOLS

Bar and ball on downthrown side (relative or apparent).

Arrows along fault indicate relative or apparent direction of lateral movement.

Arrow on fault indicates direction of dip.

JENNINGS ID NUMBER:

398	Red Hill-Etiwanda Avenue Fault
399	Cucamonga Fault, Sierra Madre fault zone, Cucamonga section

Reference:
California Geological Survey, 2015, Fault Activity Map, C.W. Jennings, W.A. Bryant, accessed on November 3, 2022, at https://maps.conservation.ca.gov/cgs/fam.

Fault traces on land are indicated by solid lines where well located, by dashed lines where approximately located or inferred, and by dotted lines where concealed by younger rocks or by lakes or bays. Fault traces are queried where continuation or existence is uncertain. All offshore faults based on seismic reflection profile records are shown as solid lines where well defined, dashed where inferred, queried where uncertain.

0' 2 4

SCALE (Miles)

Note: All locations are approximate.

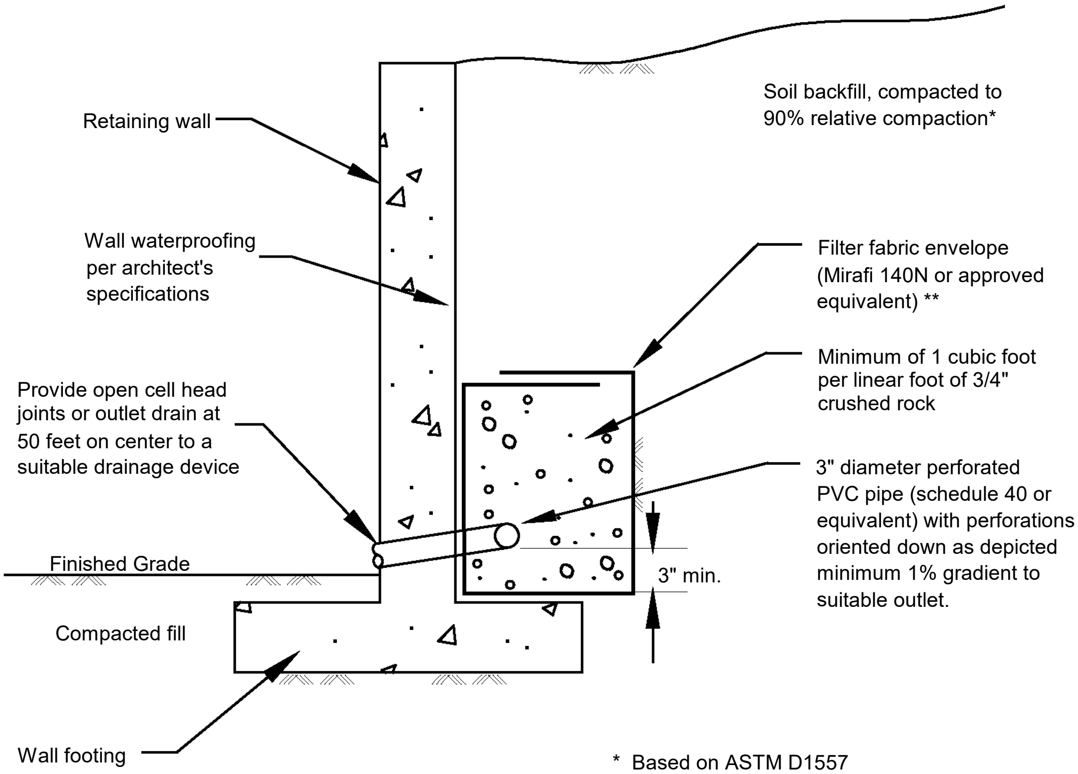
N

REGIONAL FAULT MAP
CVWD New Reservoir 5B-2
Rancho Cucamonga, California

MTGL Project No.:	Date:	Author:
1186A05	November, 2022	JCR

Geotechnical Engineering
Construction Inspection
Materials Testing
Environmental

Figure No.
5



* Based on ASTM D1557

** If class 2 permeable material (See gradation to left) is used in place of 3/4" - 1 1/2" gravel. Filter fabric may be deleted. Class 2 permeable material compacted to 90% relative compaction. *

SPECIFICATIONS FOR CLASS 2 PERMEABLE MATERIAL (CAL TRANS SPECIFICATIONS)

Sieve Size	% Passing
1"	100
3/4"	90-100
3/8"	40-100
No.4	25-40
No.8	18-33
No.30	5-15
No.50	0-7
No.200	0-3

RETAINING WALL DRAINAGE DETAIL

Figure 6

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

American Society of Civil Engineers, 2017, ASCE 7-16 Minimum Design Loads and Associated Criteria for Building and Other Structures.

California Building Standards Commission, 2019, California Building Code, Title 24, California Code of Regulations.

California Geological Survey, 2002, California Geomorphic Provinces, Note 36.

California Geological Survey, 2007, Fault-Rupture Hazard Zones in California, Special Publication 42.

California Geological Survey, 2008, Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117.

California Geological Survey, 2022, Tsunami Hazard Area map, County of Los Angeles, dated March 22nd, 2022.

Dibblee Jr., Thomas W., 2003, Geologic Map of the Cucamonga Peak Quadrangle, San Bernardino County, California, Dibblee Geology Center Map #DF-106, Scale 1:24,000.

Federal Emergency Management Agency, 2016, Flood Insurance Rate Map, National Flood Hazard Layer FIRMette, FEMA Map 06071C7890J, dated September 2.

Historic Aerials, https://www.historicaerials.com, accessed November 2022.

OSHPD, 2022, Seismic Design Maps Calculator, https://seismicmaps.org/, accessed November.

Seed, H.B. and Whitman, R.V., 1970, Design of Earth Structures for Dynamic Loads in ASCE Specialty Conference, Lateral Stresses in the Ground and Design of Earth-Retaining Structures.

United States Geological Survey, 2022, U.S. Quaternary Faults, https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf, accessed November 2022.

APPENDIX B

FIELD EXPLORATION PROGRAM

APPENDIX B

FIELD EXPLORATION PROGRAM

The subsurface conditions for this Geotechnical Investigation were explored by excavating exploratory borings with an 8-inch hollow-stem-auger, a 6-inch air rotary bit and hand tools. Driven samples were obtained by SPT or a Modified California Tube Sampler. The approximate locations of the borings are shown on the Subsurface Exploration Map (Figure 2). The field exploration was performed under the supervision of our engineer and geologist who maintained a continuous log of the subsurface soils encountered and obtained samples for laboratory testing.

Subsurface conditions are summarized on the accompanying Logs of Borings. The logs contain descriptive information and interpretation of subsurface conditions based on the obtained samples. The stratum indicated on these logs represents the approximate boundary between earth units, however, transitions may be gradual. The logs show subsurface conditions at the dates and locations indicated and may not be representative of subsurface conditions at other locations and times.

Identification of the soils encountered during the subsurface exploration was made using the field identification procedure of the Unified Soils Classification System (ASTM D2488). A legend indicating the symbols and definitions used in this classification system and a legend defining the terms used in describing the relative compaction, consistency or firmness of the soil are attached in this appendix. Bag samples of the major earth units were obtained for laboratory inspection and testing, and the in-place density of the various strata encountered in the exploration was determined

The exploratory borings were backfilled in general accordance with DEH requirements and patched where appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM					
No. 200 U.S. Standard Sieve is the smallest particle visible	Coarse-grained soils >1/2 of materials is larger than #200 sieve	GRAVELS are more than half of coarse fraction larger than #4 sieve	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			Gravels with fines	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		SANDS are more than half of coarse fraction larger than #4 sieve	Clean Sands (less than 5% fines)	GM	Silty Gravels, poorly-graded gravel-sand-silt mixtures
			Sands with fines	GC	Clayey Gravels, poorly-graded gravel-sand-clay mixtures
	Fine-grained Soils >1/2 of materials is smaller than #200 sieve	SILTS AND CLAYS Liquid Limit Less than 50		SW	Well-graded sands, gravelly sands, little or no fines
				SP	Poorly graded sands, gravelly sands, little or no fines
				SM	Silty Sands, poorly-graded sands-gravel-clay mixtures
				SC	Clayey Sands, poorly-graded sand-gravel-silt mixtures
				ML	Inorganic clays of low to med plasticity, gravelly, sandy, silty, or lean clays
		SILTS AND CLAYS Liquid Limit Greater than 50		CL	Inorganic clays of low to med plasticity, gravelly, sandy, silty, or lean clays
				OL	Organic silts and clays of low plasticity
				MH	Inorganic silts, micaceous or diatomaceous fine sands or silts
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic silts and clays of medium to high plasticity
Highly Organic Soils				PT	Peat, humus swamp soils with high organic content

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	¾”- 3”	¾”- 3”	Thumb-sized
	Fine	#4 - ¾”	0.19” - 0.75”	Peat-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 or smaller

SIZE PROPORTION
Trace – Less than 5%
Few – 5% to 10%
Little – 15% to 20%
Some – 30% to 45%
Mostly – 50% to 100%

MOISTURE CONTENT
Dry – Absence of moisture
Moist – Damp but not visible
Wet – Visible free water

CONSISTENCY FINE GRAINED SOILS		
Apparent Density	SPT (Blows/Foot)	Mod CA Sampler (Blows/Foot)
Very Soft	<2	<3
Soft	2-4	3-6
Firm	5-8	7-12
Stiff	9-15	13-25
Very Stiff	16-30	26-50
Hard	>30	>50

RELATIVE DENSITY COARSE GRAINED SOILS		
Apparent Density	SPT (Blows/Foot)	Mod CA Sampler (Blows/Foot)
Very Loose	<4	<5
Loose	4-10	5-12
Medium Dense	11-30	13-35
Dense	31-50	36-60
Very Dense	>50	>60

Project: **CVWD Reservoir 5B-2**
Project Location: **Rancho Cucamonga, California**
Project Number: **1186A05**

Key to Log of Boring

Sheet 1 of 1

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1 Elevation (feet): Elevation (MSL, feet).
2 Depth (feet): Depth in feet below the ground surface.
3 Sample Type: Type of soil sample collected at the depth interval shown.
4 Sampling Resistance: Number of blows to advance driven sampler 0.5 feet (or distance shown) beyond seating interval using the hammer identified on the boring log.
5 N60: N60 Value calculated from blow counts
6 Material Type: Type of material encountered.
7 Graphic Log: Graphic depiction of the subsurface material encountered.
8 MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
9 Water Content, %: Water content of the soil sample, expressed as percentage of dry weight of sample.
10 Dry Unit Weight, pcf: Dry weight per unit volume of soil sample measured in laboratory, in pounds per cubic foot.
11 Lab Testing: Lab Tests being run on sampes taken back to lab
12 REMARKS: Comments and observations regarding drilling or sampling made by driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

AL: Atterberg Limits
EI: Expansion Index
DS: Direct Shear Test
COR: Corrosivity
MAX: Maximum Density Test
CONS: One-dimensional consolidation test
PD: Particle Size Distribution (percent passing No. 200 sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

Silty GRAVEL (GM)
Silty SAND (SM)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
Bulk Sample
3-inch-OD California w/ brass rings
CME Sampler
Grab Sample
2.5-inch-OD Modified California w/ brass liners
Pitcher Sample
2-inch-OD unlined split spoon (SPT)
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
? Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Project: **CVWD Reservoir 5B-2**

Project Location: **Rancho Cucamonga, California**

Project Number: **1186A05**

Log of Boring B-1

Sheet 1 of 2

Date(s) Drilled **9/26/22**	Logged By **JCR**	Checked By **DJR**
Drilling Method **Hollow Stem Auger / Air Rotary**	Drill Bit Size/Type **8" HSA / 6" Air Rotary**	Total Depth of Borehole **30.5 Feet BGS**
Drill Rig Type **Truck-Mounted Sabercat CME-55, Air Rotary**	Drilling Contractor **Pacific Drilling**	Approximate Surface Elevation **2072 feet MSL**
Groundwater Level and Date Measured **Not Encountered**	Sampling Method(s) **Bulk, SPT, Cal**	Hammer Data **140 lb / 30" Drop**
Borehole Backfill **Soil Cuttings**	Location **34.16104, -117.58146**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2072	0				GM		**ALLUVIUM (Qa):** GRAVELLY fine to coarse SAND with SILT produced by pulverizing large rock/cobble, dense, light grayish brown, dry, abundant gravel, cobbles, and boulders.			EI, MAX, DS, COR	Grinding 3.5'-4'.
2067	5		24 42 34-5	64							No recovery.
			35 50-5"	42	SM		SILTY fine to coarse SAND with GRAVEL, very dense, light grayish brown, dry.				Rock in sampler.
2062	10		17 27 36	85	SM		Pulverized rock material in sampler.			PD	Grinding 12'-15'.
2057	15		50-3"	65	SM						Grinding 17.5'-22'.
2052	20		50-1"	65							No recovery. Switch to air rotary drill at 22'.
2047	25										
2042	30										

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2042	30		50-5"	65	SM		**ALLUVIUM (Qa):** SILTY fine to coarse SAND with GRAVEL, very dense, light grayish brown, dry.				No recovery.
							Boring terminated at 30.5 feet BGS as planned. No groundwater encountered. Caving occurred at 8 feet BGS. Boring backfilled with soil cuttings on 9/26/22.				
2037	35										
2032	40										
2027	45										
2022	50										
2017	55										
2012	60										
2007	65										

Project: **CVWD Reservoir 5B-2**
Project Location: **Rancho Cucamonga, California**
Project Number: **1186A05**

Log of Boring B-2

Date(s) Drilled **9/28/22**	Logged By **JCR**	Checked By **DJR**
Drilling Method **Hollow Stem Auger / Air Rotary**	Drill Bit Size/Type **8" HSA / 6" Air Rotary**	Total Depth of Borehole **22 feet BGS**
Drill Rig Type **Truck-Mounted Sabercat CME-55, Air Rotary**	Drilling Contractor **Pacific Drilling**	Approximate Surface Elevation **2080 feet MSL**
Groundwater Level and Date Measured **Not Encountered**	Sampling Method(s) **SPT**	Hammer Data **140 lb / 30" Drop**
Borehole Backfill **Soil Cuttings**	Location **34.16104, -117.58114**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2080	0				GM		**ALLUVIUM (Qa):** GRAVELLY fine to coarse SAND with SILT produced by pulverizing large rock/cobble, dense, grayish brown, dry, abundant gravel, cobble, and boulders.				Grinding 1'-4'.
2075	5		50-2"	65	GM		Very dense.			PD	Small Recovery. Grinding 6'-7.5'.
			48 22 30	68	SM		SILTY fine to coarse SAND with GRAVEL produced by pulverizing large rock/cobble, very dense, light grayish brown, dry.				Grinding 8'-10'.
2070	10		27 50-6"	65	SM		Pulverized rock material in sampler.				
											Grinding 12'-12.5'. Switch to air rotary drill at 12.5'.
2065	15										Grinding 16'-18'.
											Grinding 19'-22'.
2060	20										
							Boring terminated due to refusal by caving down hole with air rotary drill at 22 feet BGS. No groundwater encountered. Caving at 20 feet BGS. Boring backfilled with soil cuttings on 9/28/22.				
2055	25										
2050	30										

Date(s) Drilled **9/27/22**	Logged By **JCR**	Checked By **DJR**
Drilling Method **Hollow Stem Auger**	Drill Bit Size/Type **8" HSA**	Total Depth of Borehole **30 feet BGS**
Drill Rig Type **Truck-Mounted Sabercat CME-55**	Drilling Contractor **Pacific Drilling**	Approximate Surface Elevation **2086 feet MSL**
Groundwater Level and Date Measured **Not Encountered**	Sampling Method(s) **Bulk, SPT**	Hammer Data **140 lb / 30" Drop**
Borehole Backfill **Soil Cuttings**	Location **34.16134, -117.58116**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2086	0	Bulk			GM		**ALLUVIUM (Qa):** GRAVELLY fine to coarse SAND with SILT produced by pulverizing large rock/cobble, dense, grayish brown, dry, abundant gravel, cobbles, and boulders.			AL	Grinding 4'-5'.
2081	5	SPT	10 18 16	44	SM		SILTY fine to coarse SAND with GRAVEL produced by pulverizing large rock/cobble, dense, light grayish brown, dry.				
		SPT	50-2"	65	SM		Pulverized rock material in sampler, very dense.			PD	Small recovery.
2076	10	SPT	16 18 15	43	SM		Dense.				Grinding 12.5'-14'.
2071	15	SPT	36 46 50-3"	125	SM		Very dense.				Grinding 16'-18'. Sampled to break through rock at 18'.
		SPT	50-1"								
2066	20	SPT	10 24 50-5"	96							Grinding 22.5'-25'.
2061	25	SPT	50-3"	65							Grinding 26.5'-30'.
2056	30										

Project: **CVWD Reservoir 5B-2**	Log of Boring B-3
Project Location: **Rancho Cucamonga, California**	**Sheet 2 of 2**
Project Number: **1186A05**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2056	30		50-0"		SM		**ALLUVIUM (Qa):** SILTY fine to coarse SAND with GRAVEL produced by pulverizing large rock/cobble, very dense, light grayish brown, dry.				No recovery.
							Boring terminated at 30 feet BGS as planned. No groundwater encountered. Caving at 8 feet BGS. Boring backfilled with soil cuttings on 9/27/22.				
2051	35										
2046	40										
2041	45										
2036	50										
2031	55										
2026	60										
2021	65										

Project: **CVWD Reservoir 5B-2**

Project Location: **Rancho Cucamonga, California**

Project Number: **1186A05**

Log of Boring B-4

Date(s) Drilled **9/27/22**	Logged By **JCR**	Checked By **DJR**
Drilling Method **Hollow Stem Auger**	Drill Bit Size/Type **8" HSA**	Total Depth of Borehole **31 feet BGS**
Drill Rig Type **Truck-Mounted Sabercat CME-55**	Drilling Contractor **Pacific Drilling**	Approximate Surface Elevation **2070 feet MSL**
Groundwater Level and Date Measured **Not Encountered**	Sampling Method(s) **Bulk, SPT**	Hammer Data **140 lb / 30" Drop**
Borehole Backfill **Soil Cuttings**	Location **34.16082, -117.58114**	

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2070	0				GM		**ALLUVIUM (Qa):** GRAVELLY fine to coarse SAND with SILT produced by pulverizing large rock/cobble, dense, grayish brown, dry, abundant gravel, cobbles, and boulders.			COR	Grinding 2.5'-5'.
2065	5		20 50-3"	65	SM		SILTY fine to coarse SAND with GRAVEL produced by pulverizing large rock/cobble, very dense, light grayish brown, dry.			PD	
			27 32 31	82	SM		Pulverized rock material in sampler.				Grinding 8'-9.5'.
2060	10		27 23 31	70							
											Grinding 12.5'-14'.
2055	15		29 50-6"	65							
											Grinding 17'-20'.
2050	20		50-3"	65							No recovery.
											Grinding 22'-24'.
2045	25		19 50-6"	65							
											Grinding 26'-30'.
2040	30										

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance	N60	Material Type	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Lab Testing	REMARKS
2040	30	X	21 50-5"	65	SM		**ALLUVIUM (Qa):** SILTY fine to coarse SAND with GRAVEL produced by pulverizing large rock/cobble, very dense, light grayish brown, dry.				
							Boring terminated at 31 feet BGS as planned. No groundwater encountered. Caving at 6 feet BGS. Boring backfilled with soil cuttings on 9/27/22.				
2035	35										
2030	40										
2025	45										
2020	50										
2015	55										
2010	60										
2005	65										

APPENDIX C

LABORATORY TEST PROCEDURES

APPENDIX C

LABORATORY TESTING PROCEDURES

1. Particle Size Analysis
   Particle size analysis on representative soil samples were determined using the standard test method of the ASTM D6913.

2. Atterberg Limits
   The liquid limit, plastic limit, and the plasticity index of the major soil types encountered were determined using the standard test methods of the ASTM D4318.

3. Expansion Index
   Expansion index of materials encountered were determined using the standard test methods of the ASTM D4829.

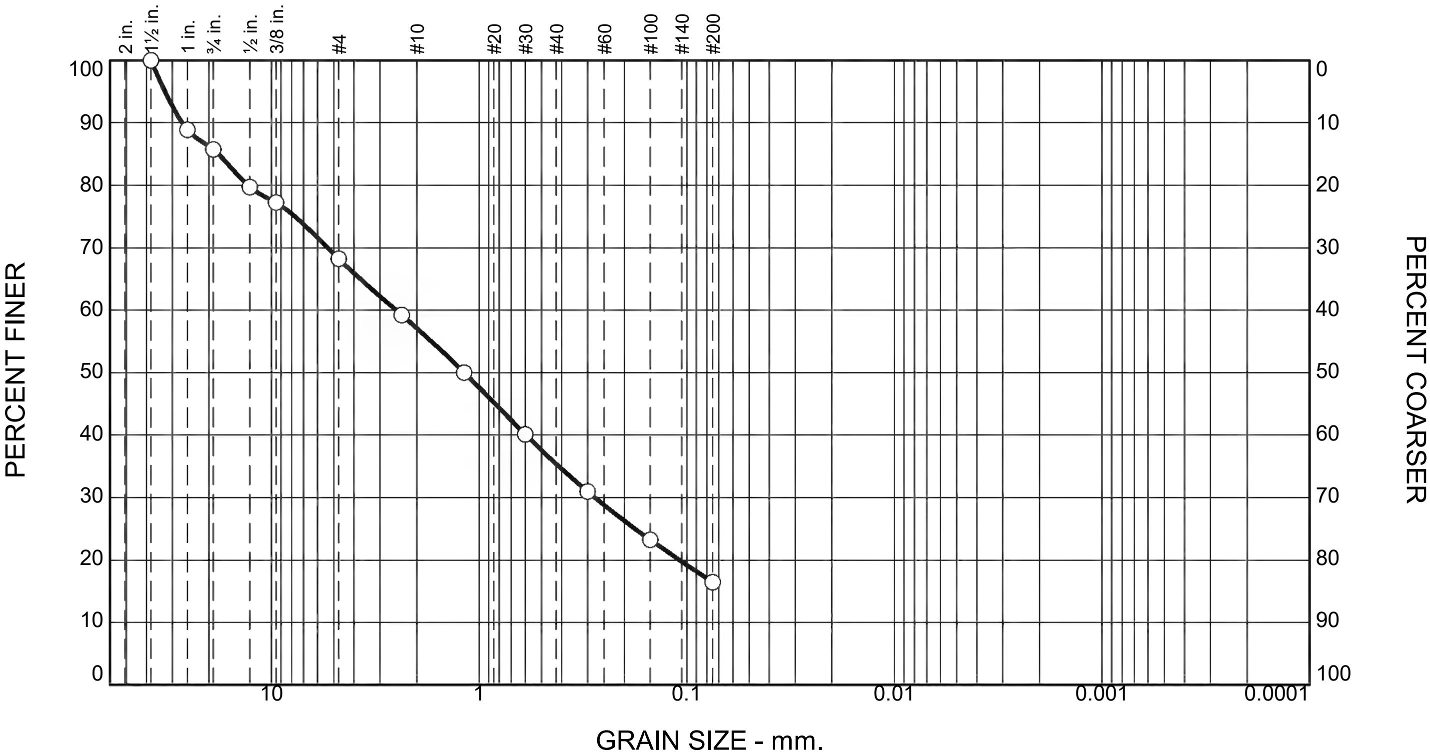
4. Maximum Density
   Maximum density tests were performed on a representative bag sample of the near surface soils in accordance with ASTM D1557.

5. Direct Shear
   Direct Shear Tests were performed on in-place samples of site soils in accordance with ASTM D3080.

6. Resistance Value Testing
   R-Value testing was completed in substantial compliance with Caltrans Test Method 301. Graphical plots of our tests are included in this appendix.

7. Corrosion
   Chemical testing was performed on representative samples to determine the corrosion potential of the onsite soils. Testing consisted of pH, chlorides (CTM 422), soluble sulfates (CTM 417), and resistivity (CTM 643).

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	14.3	17.5	11.1	21.7	19.0	16.4	

Test Results (ASTM C 136 & ASTM C 117)			
Opening Size	Percent Finer		
1-1/2"	100.0		
1"	88.9		
3/4"	85.7		
1/2"	79.7		
3/8"	77.2		
#4	68.2		
#8	59.2		
#16	50.0		
#30	40.1		
#50	30.9		
#100	23.2		
#200	16.4		

Group Symbol: Group Name:

BROWN SILTY SAND (SM)

Remarks

SAMPLED BY JAY ROWERDINK
F.M.=3.65

Date Received: 09-30-2022 **Date Tested:** 10-04-2022

Tested By: JA

Checked By: IC

Title: PE,GE

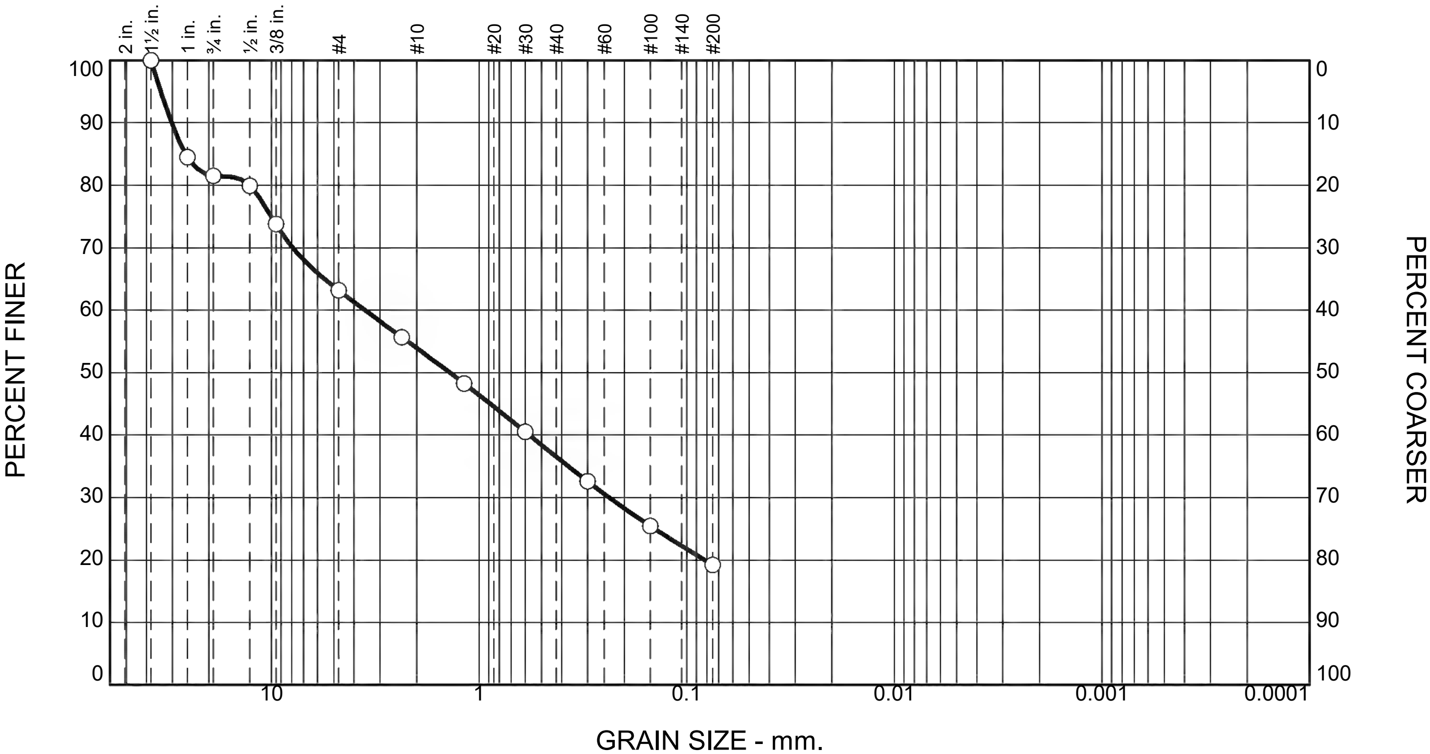
Location: SPT B-1 at 10 Feet
Sample Number: 1197 **Depth:** 10 Feet **Date Sampled:** 09-26-2022

MTGL

Client: CUCAMONGA VALLEY WATER DISTRICT
Project: CVWD NEW RESERVOIR 5B-2

Project No: 1186A05

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	18.5	18.3	9.3	17.4	17.3	19.2	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer		
1-1/2"	100.0		
1"	84.5		
3/4"	81.5		
1/2"	79.9		
3/8"	73.8		
#4	63.2		
#8	55.7		
#16	48.3		
#30	40.5		
#50	32.6		
#100	25.4		
#200	19.2		

Group Symbol: **Group Name:**

BROWN SILTY SAND (SM)

Remarks

SAMPLED BY JAY ROWERDINK
F.M.=3.79

Date Received: 09-30-2022 **Date Tested:** 10-03-2022

Tested By: JA

Checked By: IC

Title: PE,GE

Location: SPT B-2 at 5 Feet
Sample Number: 1197 **Depth:** 5 Feet

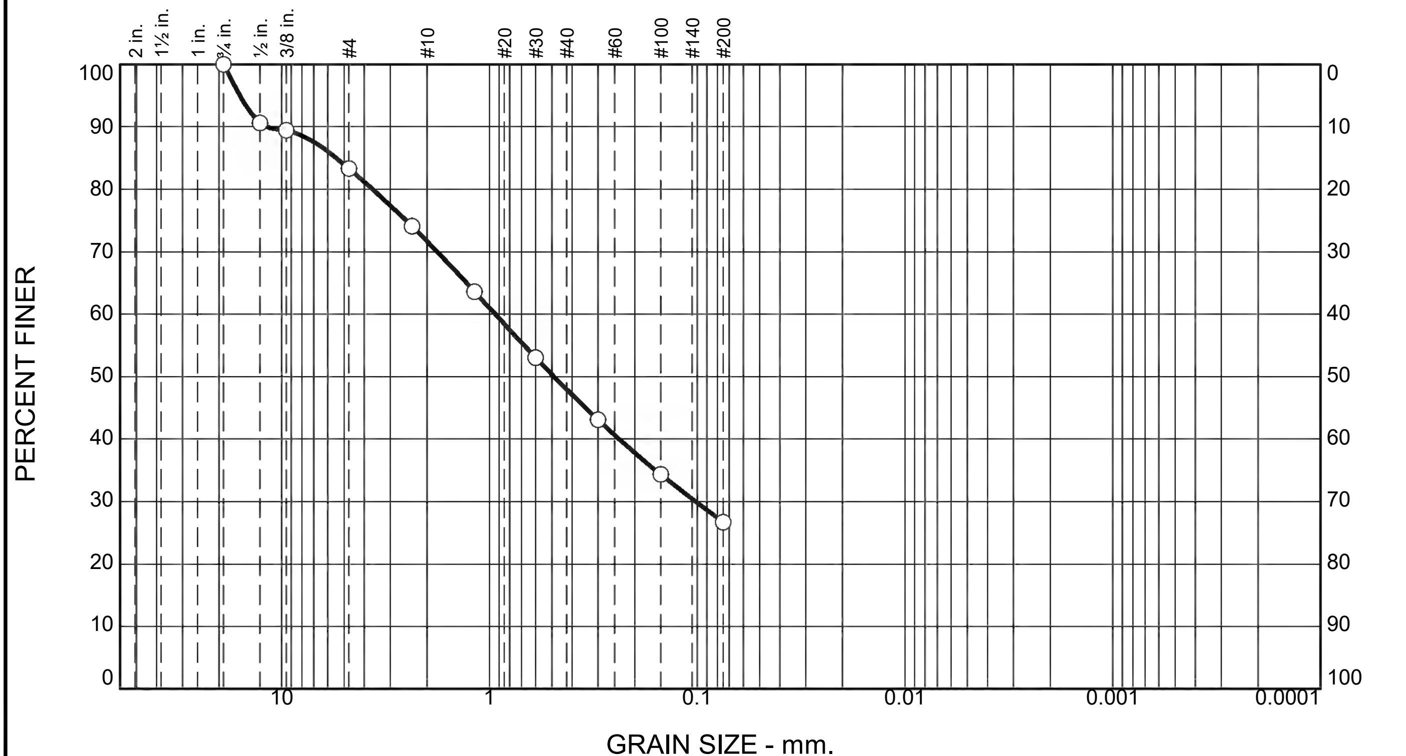
Date Sampled: 09-26-2022

MTGL

Client: CUCAMONGA VALLEY WATER DISTRICT
Project: CVWD NEW RESERVOIR 5B-2

Project No: 1186A05

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	16.7	11.6	23.7	21.3	26.7	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer		
3/4"	100.0		
1/2"	90.6		
3/8"	89.4		
#4	83.3		
#8	74.1		
#16	63.6		
#30	53.1		
#50	43.1		
#100	34.4		
#200	26.7		

Group Symbol: **Group Name:**

BROWN SILTY SAND (SM)

Remarks

SAMPLED BY JAY ROWERDINK
F.M.=2.59

Date Received: 09-30-2022 **Date Tested:** 10-03-2022

Tested By: JA

Checked By: IC

Title: PE,GE

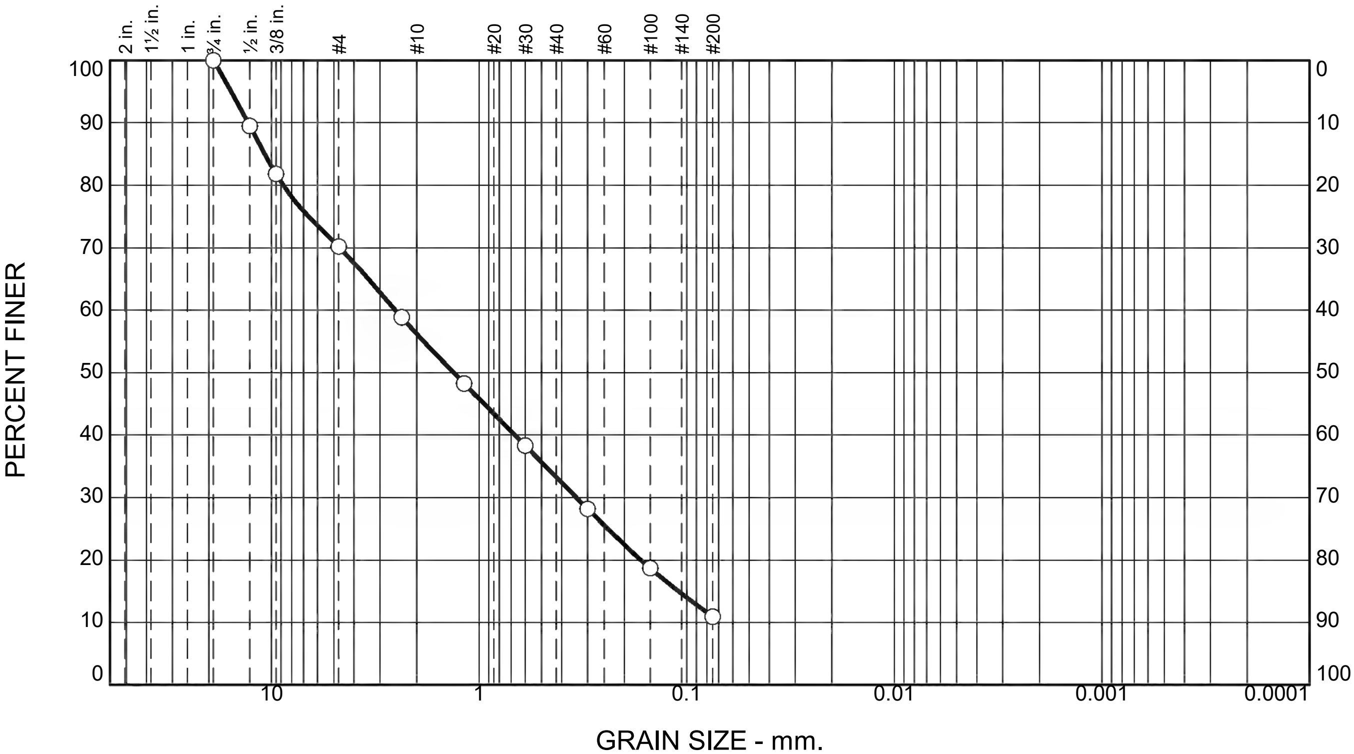
Location: BULK B-3 at 7.5 Feet
Sample Number: 1197
Depth: 7.5 Feet
Date Sampled: 09-26-2022

MTGL

Client: CUCAMONGA VALLEY WATER DISTRICT
Project: CVWD NEW RESERVOIR 5B-2

Project No: 1186A05

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	29.8	14.0	22.9	22.4	10.9	

Test Results (ASTM C 136 & ASTM C 117)

Opening Size	Percent Finer		
3/4"	100.0		
1/2"	89.5		
3/8"	81.8		
#4	70.2		
#8	58.8		
#16	48.3		
#30	38.3		
#50	28.2		
#100	18.7		
#200	10.9		

Group Symbol: **Group Name:**

BROWN SILTY SAND (SM)

Remarks

SAMPLED BY JAY ROWERDINK
F.M.=3.56

Date Received: 09-30-2022 **Date Tested:** 10-03-2022

Tested By: JA

Checked By: IC

Title: PE,GE

Location: SPT B-4 at 5 Feet
Sample Number: 1197 **Depth:** 5 Feet

Date Sampled: 09-26-2022

MTGL

Client: CUCAMONGA VALLEY WATER DISTRICT
Project: CVWD NEW RESERVOIR 5B-2

Project No: 1186A05

R-VALUE

CALIFORNIA TEST 301

SAMPLE	DESCRIPTION	R-VALUE
B-3 at 0 to 5 Feet	SILTY SAND (SM)	66

MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT

ASTM D1557

SAMPLE	DESCRIPTION	MAXIMUM DRY DENSITY (pcf)	OPTIMUM MOISTURE (%)
B-1 at 0 to 5 Feet	SILTY SAND (SM)	127.2	9.8

EXPANSION INDEX

ASTM D4829

SAMPLE	DESCRIPTION	EXPANSION INDEX
B-1 at 0 to 5 Feet	SILTY SAND (SM)	3

Classification of Expansive Soil [1]

Expansion Index	Expansion Potential
1-20	Very Low
21-50	Low
51-90	Medium
91-130	High
Above 130	Very High

1. ASTM - D4829

RESISTIVITY, pH, SOLUBLE CHLORIDE and SOLUBLE SULFATE

Resitivity (CT.643), Soluble Sulfates (CT.417) Soluble Chlorides (CT.442)

SAMPLE	pH	RESISTIVITY (Ω-cm)	SULFATE (ppm)	CHLORIDE (ppm)
B-1 at 0 to 5 Feet	7.2	3,800	119	14
B-4 at 0 to 5 Feet	7.5	10,040	94	9

ATTERBERG LIMITS

ASTM D4318

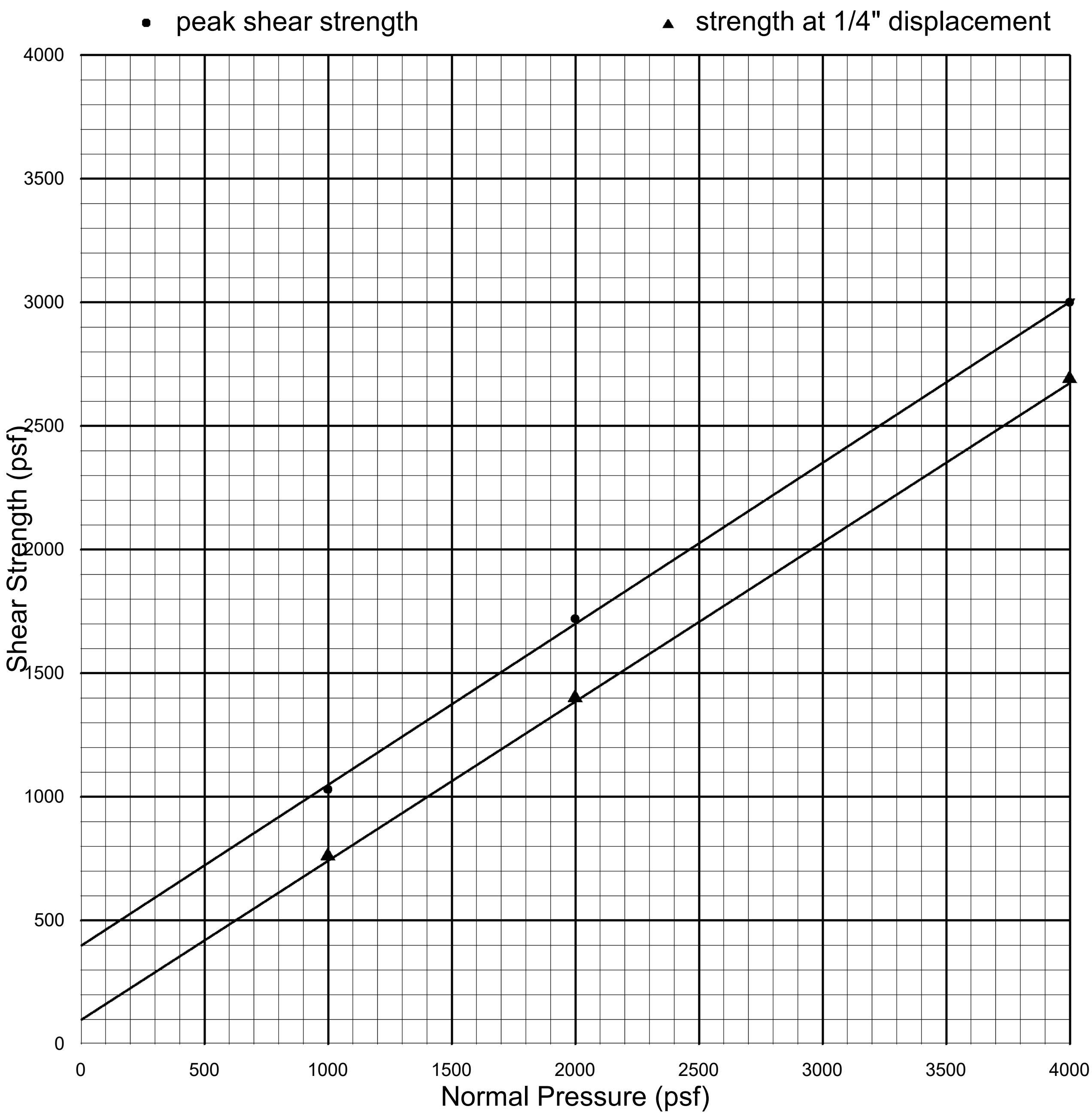
SAMPLE	DESCRIPTION	Liquid Limit	Plastic Limit	Plastic Index
B-3 at 0 to 5 Feet	SILTY SAND	NV	NP	NP

* NP indicates non plastic

MTGL

CVWD New Reservoir 5B-2 Rancho Cucamonga, California			
By:	GSW	Date:	November, 2022
Job Number:	4095B14	Figure:	C-5

DIRECT SHEAR TEST - ASTM D-3080



Strain Rate: 0.0084 in. / min.

Sample	Type	Description	Dry Density (pcf)	Initial W.C. (%)	Final W.C. (%)
B-1 at 0-5'	Remolded & Saturated	Silty Sand	114.5 (90% Max Density)	10.0	16.5

Normal Pressure (psf)	Peak Shear Strength (psf)	Ultimate Shear Strength (psf)
1000	1030 @ 0.0655"	760
2000	1720 @ 0.0750"	1400
4000	3070 @ 0.0950"	2690
	C = 400 psf	C = 100 psf
	ϕ = 32.5 deg.	ϕ = 32.5 deg.

Date: 10-09-2022

APPENDIX D

GENERAL EARTHWORK AND GRADING SPECIFICATIONS

APPENDIX D

GENERAL EARTHWORK AND GRADING SPECIFICATIONS

GENERAL

These specifications present general procedures and requirements for grading and earthwork as shown on the approved grading plans, including preparation of areas to be filled, placement of fill, installation of subdrains, and excavations. The recommendations contained in the attached geotechnical report are a part of the earthwork and grading specifications and shall supersede the provisions contained herein in the case of conflict. Evaluations performed by the Consultant during the course of grading may result in new recommendations, which could supersede these specifications, or the recommendations of the geotechnical report.

EARTHWORK OBSERVATION AND TESTING

Prior to the start of grading, a qualified Geotechnical Consultant (Geotechnical Engineer and Engineering Geologist) shall be employed for the purpose of observing earthwork procedures and testing the fills for conformance with the recommendations of the geotechnical report and these specifications. It will be necessary that the Consultant provide adequate testing and observation so that he may determine that the work was accomplished as specified. It shall be the responsibility of the Contractor to assist the Consultant and keep them apprised of work schedules and changes so that he may schedule his personnel accordingly.

It shall be the sole responsibility of the Contractor to provide adequate equipment and methods to accomplish the work in accordance with applicable grading codes or agency ordinances, these specifications, and the approved grading plans.

Maximum dry density tests used to determine the degree of compaction will be performed in accordance with the American Society for Testing and Materials Test Method (ASTM) D1557.

PREPARATION OF AREAS TO BE FILLED

Clearing and Grubbing: All brush, vegetation and debris shall be removed or piled and otherwise disposed of.

Processing: The existing ground which is determined to be satisfactory for support of fill shall be scarified to a minimum depth of 8-inches. Existing ground, which is not satisfactory, shall be over-excavated as specified in the following section.

Over-excavation: Soft, dry, spongy, highly fractured, or otherwise unsuitable ground, extending to such a depth that surface processing cannot adequately improve the condition, shall be over-excavated down to firm ground, approved by the Consultant.

Moisture conditioning: Over-excavated and processed soils shall be watered, dried-back, blended, and mixed as required to have a relatively uniform moisture content near the optimum moisture content as determined by ASTM D1557.

Re-compaction: Over-excavated and processed soils, which have been mixed, and moisture conditioned uniformly shall be recompacted to a minimum relative compaction of 90-percent of ASTM D1557.

Benching: Where soils are placed on ground with slopes steeper than 5:1 (horizontal to vertical), the ground shall be stepped or benched. Benches shall be excavated in firm material for a minimum width of 4-feet.

FILL MATERIAL

General: Material to be placed as fill shall be free of organic matter and other deleterious substances and shall be approved by the Consultant.

Oversize: Oversized material defined as rock, or other irreducible material with a maximum dimension greater than 6-inches, shall not be buried or placed in fill, unless the location, material, and disposal methods are specifically approved by the Consultant. Oversize disposal operations shall be such that nesting of oversized material does not occur, and such that the oversize material is completely surrounded by compacted or densified fill. Oversize material shall not be placed within 10-feet vertically of finish grade or within the range of future utilities or underground construction, unless specifically approved by the Consultant.

Import: If importing of fill material is required for grading, the import material shall meet the general requirements.

FILL PLACEMENT AND COMPACTION

Fill Lifts: Approved fill material shall be placed in areas prepared to receive fill in near-horizontal layers not exceeding 8-inches in compacted thickness. The Consultant may approve thicker lifts if testing indicates the grading procedures are such that adequate compaction is being achieved with lifts of greater thickness. Each layer shall be spread evenly and shall be thoroughly mixed during spreading to attain uniformity of material and moisture in each layer.

Fill Moisture: Fill layers at a moisture content less than optimum shall be watered and mixed, and wet fill layers shall be aerated by scarification or shall be blended with drier material. Moisture conditioning and mixing of fill layers shall continue until the fill material is at uniform moisture content at or near optimum.

Compaction of Fill: After each layer has been evenly spread, moisture conditioned, and mixed, it shall be uniformly compacted to not less than 90-percent of maximum dry density in accordance with ASTM D1557. Compaction equipment shall be adequately sized and shall be either specifically designed for soil compaction or of proven reliability, to efficiently achieve the specified degree of compaction.

Fill Slopes: Compacting on slopes shall be accomplished, in addition to normal compacting procedures, by backrolling of slopes with sheepsfoot rollers at frequent increments of 2- to 3-feet as the fill is placed, or by other methods producing satisfactory results. At the completion of grading, the relative compaction of the slope out to the slope face shall be at least 90-percent in accordance with ASTM D1557.

Compaction Testing: Field tests to check the fill moisture and degree of compaction will be performed by the consultant. The location and frequency of tests shall be at the consultant's discretion. In general, these tests will be taken at an interval not exceeding 2-feet in vertical rise, and/or 1,000 cubic yards of fill placed. In addition, on slope faces, at least one test shall be taken for each 5,000 square feet of slope face and/or each 10-feet of vertical height of slope.

SUBDRAIN INSTALLATION

Subdrain systems, if required, shall be installed in approved ground to conform to the approximate alignment and details shown on the plans or herein. The subdrain location or materials shall not be changed or modified without the approval of the Consultant. The Consultant, however, may recommend and, upon approval, direct changes in subdrain line, grade, or materials. All subdrains should be surveyed for line and grade after installation and sufficient time shall be allowed for the surveys, prior to commencement of fill over the subdrain.

EXCAVATION

Excavations and cut slopes will be examined during grading. If directed by the Consultant, further excavation or over-excavation and refilling of cut areas, and/or remedial grading of cut slopes shall be performed. Where fill over cut slopes are to be graded, unless otherwise approved, the cut portion of the slope shall be made and approved by the Consultant prior to placement of materials for construction of the fill portion of the slope.