SUBSURFACE SOILS INVESTIGATION
CALIFORNIA STREET AND REDLANDS BOULEVARD WIDENING PROJECT
REDLANDS, CALIFORNIA

PROJECT NO. 63878.1
FEBRUARY 27, 2023

Prepared for:

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21470 Cooley Drive
Colton, California 92324

Attention: Mr. Patrick Flanagan

February 27, 2023

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Subject: Subsurface Soils Investigation, California Street and Redlands Boulevard Intersection Widening Project, Redlands, California.

LOR Geotechnical Group, Inc., is pleased to present this report of our geotechnical investigation for the subject project. In summary, it is our opinion that the proposed street improvements are feasible from a geotechnical perspective, provided the recommendations presented in the attached report are incorporated into design and construction. However, the contents of this summary should not be solely relied upon.

This report was based upon a scope of services generally outlined in our Proposal dated August 15, 2022 and other written and verbal communications with you.

The native materials should provide adequate support for the proposed culvert boxes within the project alignment. Geotechnical parameters for design and construction of the various project elements are provided within the attached report.

LOR Geotechnical Group, Inc.

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INTRODUCTION

During February of 2023, a Subsurface Soils Investigation was performed by LOR Geotechnical Group, Inc., for the California Street and Redlands Boulevard Intersection Widening Project, Redlands, California. The purpose of this investigation was to evaluate the subsurface conditions encountered in our exploratory borings and to provide geotechnical design recommendations for the proposed box culverts/transition structures and pavement sections to be utilized. The scope of our services included: 1) A subsurface field investigation; 2) Laboratory testing of selected soil samples obtained during the field investigation; 3) Development of geotechnical recommendations for excavation and construction of the proposed improvements, and, 4) Preparation of this report.

The findings of our investigation, as well as our conclusions and recommendations, are presented in the following sections of this report.

PROJECT CONSIDERATIONS

The project will consist of improvements to the existing Mission Channel located at the northwest corner of California Street and Redlands Boulevard. This will include new box culverts, transition structures, and new pavement sections. Invert depths of approximately 32 feet below the adjacent roadways were provided for the proposed culverts.

The approximate location of the project area within its regional setting is presented on Enclosure A-1, within Appendix A. The approximate location of our exploratory borings, is shown on the enclosed Boring Location Map, Enclosure A-2, within Appendix A.

FIELD INVESTIGATION

Our field exploration program was conducted on February 3, 2023 and consisted of drilling a total of 3 exploratory borings with a truck-mounted CME-75 drill rig equipped with 8-inch diameter hollow stem augers. The borings were drilled to depths of approximately 41.5 to 51.5 feet below the existing ground surface. The approximate locations of the borings are presented on the enclosed Site Plan, Enclosure A-2, within Appendix A.

A log of the subsurface conditions encountered in the exploratory borings was created by a geologist from this firm. Relatively undisturbed and bulk samples were obtained within the borings at a maximum depth interval of 5 feet. Observations for the borings are presented on Enclosures B-1 through B-3, along with a detailed description of the field exploration program, within Appendix B.

The relatively undisturbed soil samples and subgrade soil samples were placed in sealed containers and returned to our geotechnical laboratory for further testing and evaluation.

LABORATORY TESTING PROGRAM

Selected soil samples obtained during the field investigation were subjected to laboratory testing to evaluate their physical and engineering properties. Laboratory testing included in-place moisture content and dry density, laboratory compaction characteristics, direct shear, sieve analysis, sand equivalent, and R-value. Physical testing was conducted in our geotechnical laboratory and chemical testing was conducted by our subconsultant, Project X Corrosion Engineering. A detailed description of our geotechnical laboratory testing program, test results and the Project X Report are presented within Appendix C.

GEOLOGIC CONDITIONS

Regional Geologic Setting

The project area is situated near the southern end of an alluviated valley which lies between the San Bernardino Mountains to the northeast and the hills of the Redlands area to the south. This valley makes up the far northeastern portion of the Peninsular Ranges Geomorphic Province of southern California. The Peninsular Ranges Geomorphic Province incorporates the vast region extending from the San Gabriel and San Bernardino Mountains south into the Baja California Peninsula. This region is characterized by a series of northwest trending small mountain ranges. The San Bernardino Valley is underlain by units of younger alluvium, consisting of unconsolidated alluvium. The dominate drainage system in of the region is the Santa Ana River which lies approximately 1.75 miles north of the site. Erosion of the surrounding highlands and the subsequent deposition in the lower regions by the Santa Ana River and its watershed tributaries, such as the San Timoteo Wash, has resulted in the deposition of these relatively unconsolidated alluvial units over the valley floor. The subject site is located within the depositional plain of the San Timoteo Wash, which exits from the hills of the Badlands area approximately 1 mile to the south-southwest. While the flow of this wash is now relatively controlled and directed southwest of the site, in the past periodic flood events have deposited thick layers of sand and silt across the site. The depth of these units at the site was not determined during this study, but is considered to be on the order of several hundred feet or more to the older sedimentary bedrock and crystalline bedrock which underlies the valley floor.

The nearest known, active earthquake fault is the San Jacinto fault which is located approximately 3.4 kilometers (2.0 miles) to the southwest. While the Banning fault is shown as crossing approximately 0.75 kilometers (0.5 miles) southwest of the site, this fault is generally considered to be inactive (Matti et al, 2003). The Redlands fault of the Crafton Hills Fault complex is located approximately 4.8 kilometers (3.0 miles) to the south. However, the activity rating of this fault is not known. Other known, active earthquake faults in the region include the San Andreas fault located approximately 8.7 kilometers (5.4 miles) to the northeast and the Cucamonga fault located approximately 24.2 kilometers (15.0 miles) to the northwest.

The geologic conditions of the site and immediate surrounding region as mapped by the U.S.G.S. are shown on Enclosure A-3, within Appendix A. A partial legend is shown on Enclosure A-4, within Appendix A.

Site Geologic Conditions

As observed during this investigation, the subject site is underlain by fill/topsoil overlying native alluvial materials. These units are described in further detail in the following sections:

Surficial Deposits

Fill: The surface of the site contained a layer of fill materials. These materials were noted to generally consist of silty sand with gravel to well graded sand with gravel which was brown to gray, damp, and in a loose to medium dense state. These units were noted to be approximately 2 to 15 feet in thickness.

Alluvium: Underlying the surficial materials, natural units of alluvium were encountered. These units typically consisted of poorly graded sand, well graded sand, and silty sand with minor units of sandy silt/silty sand and lean clay with sand. Typically, the finer grained soils were tan to brown in color, and moist, while the coarser grained materials tended to be brown to white in color and damp. Based on the results of in-situ density tests and equivalent SPT blow counts, it was noted that the upper 2 to 7 feet of the alluvial units were typically in a loose/medium state becoming more stiff/dense with depth.

A detailed description of the subsurface soil conditions as encountered within our exploratory borings is presented on the Boring Logs within Appendix B.

A more detailed description of the subsurface conditions, as encountered within our exploratory borings is presented on the attached Boring Logs within Appendix B. A detailed description of the laboratory testing program and the test results are presented in Appendix C.

Groundwater Hydrology

Groundwater was not encountered in any of our excavations at the site. In order to estimate the approximate depth to groundwater in this area, a search was conducted for local municipal water wells on the Cooperative Well Measuring Program, Fall 2022 and State of California Department of Water Resources online water data library. The closest well found was listed as the 01S03W20P001S located to the northwest, approximately 0.75 kilometers (0.5 miles). In this well, groundwater measurements were available from 1985 to 1988. Groundwater fluctuated slightly at depths of approximately 110 to 139 feet during that time period. Elevation for the well was listed as 1,198 feet above mean sea level.

The elevation of the subject site is approximately 1,150 feet above mean sea level. Based on the information above, groundwater at the site appears to be at depths on the order of 60 feet.

Mass Movement

The majority of the site lies on a relatively flat surface. The occurrence of mass movement failures such as landslides, rockfalls or debris flows within such areas is generally not considered common and no evidence of mass movement was observed on the site.

Faulting

No active or potentially active faults are known to exist at the subject site. In addition, the subject site does not lie within a current State of California Earthquake Fault Zone (Hart and Bryant, 1997). No evidence of faulting projecting into or crossing the site was noted during our aerial photograph review or our review of published geologic maps. The site does not lie within a County of San Bernardino fault zone.

The closest known mapped fault is also associated with the San Jacinto fault, and lies approximately 3.4 kilometers (2.0 miles) to the southwest. Other active earthquake faults in the region include the San Andreas fault located approximately 8.7 kilometers (5.4 miles) to the northeast and the Cucamonga fault located approximately 24.2 kilometers (15.0 miles) to the north-northwest

The San Jacinto fault zone is a sub-parallel branch of the San Andreas fault zone, extending from the northwestern San Bernardino area, southward into the El Centro region. This fault has been active in recent times with several large magnitude events. It is believed that the San Jacinto fault is capable of producing an earthquake magnitude on the order of 6.5 or larger.

The Cucamonga fault is considered to be part of the Sierra Madre fault system which marks the southern boundary of the San Gabriel Mountains. This is a north dipping thrust fault which is believed to be responsible for the uplift of the San Gabriel Mountains. It is believed that the Cucamonga fault is capable of producing an earthquake magnitude on the order of 7.0.

The San Andreas fault is considered to be the major tectonic feature of California, separating the Pacific Plate and the North American Plate. While estimates vary, the San Andreas fault is generally thought to have an average slip rate on the order of 24mm/yr and capable of generating large magnitude events on the order of 7.5.

Current standards of practice often include a discussion of all potential earthquake sources within a 100 kilometer (62 mile) radius. However, while there are other large earthquake faults within a 100 kilometer (62 mile) radius of the site, none of these are considered as relevant to the site as the faults described above, due to their greater distance and smaller anticipated magnitudes.

Historical Seismicity

In order to obtain a general perspective of the historical seismicity of the site and surrounding region a search was conducted for seismic events at and around the area within various radii. This search was conducted utilizing the historical seismic search website of the U.S.G.S. (2023). This website conducts a search of a user selected cataloged seismic events database, within a specified radius and selected magnitudes, and then plots the events onto a map. At the time of our search, the database contained data from January 1, 1932 through February 24, 2023.

In our first search, the general seismicity of the region was analyzed by selecting an epicenter map listing all events of magnitude 4.0 and greater, recorded since 1932, within a 100 kilometer (62 mile) radius of the site, in accordance with guidelines of the California

Division of Mines and Geology. This map illustrates the regional seismic history of moderate to large events. As depicted on Enclosure A-4, within Appendix A, the site lies within a relatively active region mainly associated with the San Jacinto fault and the faults of the desert region.

In the second search, the micro seismicity of the area lying within a 10 kilometer (6.2 miles) radius of the site was examined by selecting an epicenter map listing events on the order of 2.0 and greater since 1978. The results of this search is a map that presents the seismic history around the area of the site with much greater detail, not permitted on the larger map. The reason for limiting the time period for the events on the detail map is to enhance the accuracy of the map. Events recorded prior to the mid to late1970's are generally considered to be less accurate due to advancements in technology. As depicted on this map, Enclosure A-5, numerous small events have taken place in the general location of the San Jacinto fault.

In summary, the historical seismicity of the site entails numerous small to medium magnitude earthquake events occurring in the region around the subject site. Any future developments at the subject site should anticipate that moderate to large seismic events could occur very near the site.

Secondary Seismic Hazards

Other secondary seismic hazards generally associated with severe ground shaking during an earthquake include liquefaction, seismic-induced settlement, seiches and tsunamis, earthquake induced flooding, landsliding, and rockfalls.

Liquefaction: The potential for liquefaction generally occurs during strong ground shaking within granular loose sediments where the groundwater is usually less than 50 feet below the ground surface. Because groundwater is believed to lie at a depth in excess of 50 feet beneath the site and the site is underlain by relatively dense alluvial materials, the possibility of liquefaction at the site is considered very low.

Seiches/Tsunamis: The potential for the site to be affected by a seiche or tsunami (earthquake generated wave) is considered nil due to absence of any large bodies of water near the site.

Flooding (Water Storage Facility Failure): There are no large water storage facilities located on or near the site which could possibly rupture during in earthquake and affect the site by flooding.

Seismically-Induced Landsliding: Due to the low relief of the site and surrounding region, the potential for landslides to occur at the site is considered nil.

Rockfalls: No large, exposed, loose or unrooted boulders are present above the site that could affect the integrity of the site.

Seismically-Induced Settlement: Settlement generally occurs within areas of loose, granular soils with relatively low density. Since the site is underlain by relatively dense alluvial materials, the potential for settlement is considered very low. In addition, the recommended earthwork operations to be conducted during the development of the site should mitigate any near surface loose soil conditions.

SOILS AND SEISMIC DESIGN CRITERIA (California Building Code 2022)

Design requirements for structures can be found within Chapter 16 of the 2022 California Building Code (CBC) based on building type, use, and/or occupancy. The classification of use and occupancy of all proposed structures at the site, shall be the responsibility of the building official.

Site Classification

Chapter 20 of the ASCE 7-16 defines six possible site classes for earth materials that underlie any given site. Bedrock is assigned one of three of these six site classes and these are: A, B, or C. Soil is assigned as C, D, E, or F. Per ASCE 7-16, Site Class A and Site Class B shall be measured on-site or estimated by a geotechnical engineer, engineering geologist or seismologist for competent rock with moderate fracturing and weathering. Site Class A and Site Class B shall not be used if more than 10 feet of soil is between the rock surface and bottom of the spread footing or mat foundation. Site Class C can be used for very dense soil and soft rock with Ñ values greater than 50 blows per foot. Site Class D can be used for stiff soil with Ñ values ranging from 15 to 50 blows per foot. Site Class E is for soft clay soils with Ñ values less than 15 blows per foot. Our investigation, mapping by others, and our experience in the site region indicates that the materials beneath the site are considered Site Class D stiff soils.

CBC Earthquake Design Summary

Earthquake design criteria have been formulated in accordance with the 2022 CBC and ASCE 7-16 for the site based on the results of our investigation to determine the Site Class and an assumed Risk Category II. However, these values should be reviewed and the final design should be performed by a qualified structural engineer familiar with the region. In addition, the building official should confirm the Risk Category utilized in our design (Risk Category II). Our design values are provided within Appendix D.

CONCLUSIONS

The subsurface conditions encountered in our exploratory borings are indicative of the location explored. It is not to be construed that these conditions are present the same throughout the project alignment.

On the basis of our limited field investigation and testing program, it is the opinion of LOR Geotechnical Group, Inc., that the proposed improvements are feasible from a soil engineering standpoint, provided that the following recommendations are incorporated into design and implemented during construction.

Due to the coarse grained composition of the native soils, caving of the site excavations should be anticipated. Thus, proper construction techniques such as safe sloped excavations and/or shored excavations should be used.

Preliminary alternatives for support of the excavations for the culverts include a steel sheet pile wall or a soldier pile wall consisting of H piles and timber lagging. We believe that sheet piling is not a practical choice in many of the areas investigated due to the various amounts of oversized materials (cobbles and possible occasional boulders) in the alluvium which may hinder the desired penetration of the pilings or may damage the pilings. A more suitable alternative for hard driving conditions is a soldier pile wall with H piles because of the high strength and moment of inertia of the H piles. However, if large cobbles and boulders are found blocking the pile driving, driving operations may need to be supplemented by pre-drilling to install the pile to the required depth.

The site soils should provide adequate quality fill material, excluding pipe zones provided they are free from organic matter and other deleterious materials. However, they will require the removal of rocks or similar irreducible materials with a maximum dimension greater than 6 inches from the fills in order to facilitate the compaction of the soils and/or placement of the proposed culverts. For fills placed directly against concrete elements the rock size should be further reduced to 3 inches.

On the basis of our exploratory boring and testing program, the native materials should provide adequate support for the proposed culverts within the project alignment.

Details for geotechnical parameters for project design and construction are provided in the **RECOMMENDATIONS** section of this report.

Because the site is not located within an Earthquake Fault Zone and no known active faults are known to traverse the site, the potential for fault rupture hazards appears to be low.

Corrosion Screening

Select representative samples from our borings were taken to Project X Corrosion Engineering for full corrosion series testing. Results from soil corrosivity testing completed by Project X Corrosion Engineering are presented within Appendix C.

The corrosivity test results indicate that soluble sulfate concentrations in the samples was less than 0.10 percent by weight. These concentrations indicate an exposure class S0 for sulfate (ACI 318). No special mitigation methods are considered necessary.

The corrosivity test results indicate that chloride concentrations were below 500 ppm. This concentration indicates an exposure class C1 for chloride (ACI 318). Special mitigation measures are not considered necessary.

Soil pH for the samples was 8.4 to 8.5, slightly basic. Therefore, the need for specialized design is not anticipated.

Concentrations of ammonium and nitrate indicate the soil may be aggressive towards copper.

Resistivity results for the samples indicate the soils tested are mildly corrosive to ferrous metals.

LOR Geotechnical does not practice corrosion engineering. If further information concerning the corrosion characteristics, or interpretation of the results submitted herein, is required, then a competent corrosion engineer could be consulted.

RECOMMENDATIONS

Excavations

Standard equipment should be suitable for the excavation for the proposed improvements. Excavation safety and precautions, including safe slope excavation inclinations, should be implemented and are the responsibility of the contractor.

Following the California Occupational Safety and Health Act (CAL-OSHA) requirements, excavations 5 feet deep and greater should be sloped or shored. All excavations and shoring should conform to CAL-OSHA requirements.

Short-term excavations of 5 feet deep and greater shall conform to Title 8 of the California Code of Regulations, Construction Safety Orders, Section 1504 and 1539 through 1547. Based on our exploratory borings, it appears that Type C soil is the predominant type of soil material on the project and all short-term excavations should be based on this type of soil material. In accordance with Title 8 of the California Code of Regulations, simple slope excavations up to 20 feet in depth made in Type C soil material should have maximum allowable slopes of 1.5 horizontal to 1 vertical. However, due to the granular, cohesionless state of the natural soils, extreme care should be taken in the construction and maintenance of short term excavating within such soils as they tend to be less stable. Deviation from the standard short term slopes are permitted using option 4, Design by a Registered Professional Engineer (Section 1541.1).

It should be stated that, depending on the proximity of the excavations relative to any other nearby existing utility trenches, short-term excavations may expose the existing old trench backfill materials. The compaction characteristics and shear strength properties of the existing trench backfills is unknown. Typically, excavations exposing trench backfill are potentially unstable.

The construction and maintenance of short-term excavations is the responsibility of the contractor and should be a consideration of his methods of operation and the actual soil conditions encountered.

Shoring Design Parameters

General: Shoring placed below grade that is restrained against free movement at the top should be designed to resist a lateral earth pressure between active and at rest conditions. For this condition we recommend a uniform lateral earth pressure, rectangular distribution of 20H pounds per square foot (psf). Additional surcharge loads (i.e. equipment, excavation spoil, etc.) placed within a horizontal distance equal to the height of the excavation should be added to the above recommended pressure at a rate of 0.40 times the surcharge load.

Culvert Areas

To facilitate the construction of box culverts and retaining walls, a soldier pile shoring system appears to be the most practical method for support of the culvert excavations. The system will likely include H piles and wooden lagging.

The construction sequence for the subject culvert excavations will probably involve the driving or drilling of the soldier piles first, then placing the timber lagging between the soldier piles for soil retention, as the excavation proceeds. The soldier piles will be probably left in place after construction and backfilling of the culvert.

The soldier pile shoring should be designed to resist a lateral active earth pressure. For this condition, we recommend using an equivalent fluid density of 35 pounds per cubic foot (pcf). Passive pressures below the base of the excavation should be calculated using an equivalent fluid density of 300 pcf. The passive pressure should be ignored for a distance of 1.5 times the effective width of the pile below the depth of the excavation. Additional surcharge loads (i.e. equipment, excavation spoil, etc.) placed within a horizontal distance equal to the height of the excavation should be added to the above recommended pressure at a rate of 0.40 times the surcharge load.

The soldier piles should be embedded below the bottom of the excavation a sufficient distance to prevent lateral movement of the piles.

As shown in the attached boring logs, the subject culvert locations are underlain by granular soils of silty to well graded sand with gravel to the maximum depths explored. Thus, pile driving may encounter some difficulty. A hardened steel point at the tip of the pile is recommended to facilitate the pile installation and to protect the end of the pile. The selected pile section should be able to resist not only the bending moments of the system but also to withstand the driving stresses.

Preparation of Box Culvert and Retaining Wall Areas

Upon excavation of the proposed box culvert and retaining wall areas to the planned line and grade, observations and in-place density testing should be conducted to ensure that no loose materials are present. Where feasible, the bottom of the excavation should be scarified to a depth of at least 6 inches. The scarified soil should be brought to near optimum moisture content and recompacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D 1557.

After construction of the cast-in-place reinforced concrete box culvert, or retaining walls backfill materials should then be placed around the box wall in accordance with the recommendations given in the Engineered Compacted Fill section of this report. Standard backfill placement will most likely be feasible for the culverts' walls, where open, sloped excavations will be performed. However, for culverts walls built against the soldier pile wall, backfill placement will not be necessary. In the event that gaps between the soldier pile wall and the box wall are created during construction a backfill of sand/slurry should be applied to fill in the void.

Culvert Box and Retaining Wall Design

Provided that the box culvert and retaining wall areas are prepared as recommended, the proposed cast-in-place concrete box and wall may be designed using a maximum soil bearing pressure of 2,000 pounds per square foot for foundation 1 foot deep by 1 foot wide. For each additional foot of depth or width, an increase of 500 psf can be used up to a maximum of 4,000 psf. For design of retaining wall footings, the resultant of the applied loads should act in the middle one third of the footing, and the maximum edge pressure should not exceed the basic allowable value without increase.

A coefficient of subgrade reaction of 200 psi/in may be used in the design of the box culvert and retaining wall foundations.

Total settlement of box culvert and retaining wall foundations will vary depending on the width of the foundation and the actual load supported. Maximum settlement of foundations designed and constructed in accordance with the preceding recommendations are estimated to be on the order of 1.0 inch. Differential settlement should be about one-half of the total settlement. Settlement of all foundations is expected to occur rapidly, primarily as a result of elastic compression of supporting soils as the loads are applied, and should be essentially completed shortly after initial application of the loads.

The vertical walls of boxes, retaining compacted native soil backfill, should be designed to resist a lateral earth pressure between active and at-rest conditions. For this condition, we recommend an equivalent fluid density of 45 pcf be used above. A pseudostatic lateral earth pressure of 25 psf/ft should be added to the design. The loading is triangular with the resultant load acting 1/3 H from the bottom for both cases.

For design of retaining walls unrestrained against movement at the top, we recommend an active pressure of 35 psf per foot of depth be used. A pseudostatic lateral earth pressure developed at a rate of 15 psf/ft should be added to the design. The loading is triangular with the resultant load acting 1/3H from the bottom in both cases. In the areas of the retaining wall braced against movement vertically, the earth pressures and pseudostatic static lateral earth pressure values for boxes given above should be used. This loading should be considered for the length of wall equal to the height of the vertical bracing extending from the bracing.

The above assumes level backfill consisting of compacted, non-expansive, soils placed against the structures and with the backcut slope extending upward from the base of the stem at 35 degrees from the vertical or flatter. To avoid overstressing or excessive tilting during placement of backfill behind walls, heavy compaction equipment should not be allowed within the zone delineated by a 45 degree line extending from the base of the wall to the fill surface. The backfill directly behind the walls should be compacted using light equipment such as hand operated vibrating plates and rollers. No material larger than 3-inches in diameter should be placed in direct contact with the wall. Import material, if required, should have an angle of internal friction of at least 30 degrees. Import materials, if required, should be tested for their shear strength to confirm the use of the assumed design values above.

Resistance to lateral loads will be provided by passive earth pressure and base friction. For footings bearing against compacted fill, passive earth pressure may be considered to be developed at a rate of 300 psf per foot of depth. Base friction may be computed at 0.30 times the normal load. Base friction and passive earth pressure may be combined without reduction. The lateral passive earth pressure and base friction values recommended include factors of safety of 1.25.

The soils encountered throughout the channel alignment were granular and are considered free draining. Therefore, standard drainage of the box culvert and retaining walls may be used.

A unit weight of 125 pcf may be used for compacted fill.

Wall pressures should be verified prior to construction, when the actual backfill materials and conditions have been determined. Recommended pressures are applicable only to non-expansive, properly drained backfill, and with no additional surcharge loadings.

Engineered Compacted Fill

The majority of the soils along the project alignment are clean, free-draining, granular soils (well graded sand and with gravel and poorly graded sand).

The site soils are generally suitable for use as backfills and fills. However, all rocks or similar irreducible materials with a maximum dimension greater than 6 inches should not be buried or placed in fills without prior approval by the geotechnical engineer. For fill placed in direct contact with concrete elements the rock size should be less than 3 inches. In addition, prior to the mechanical compaction of the fills, the materials will need to be moisture conditioned in order to achieve the desired optimum moisture content.

Import fill, if required, should be inorganic, non-expansive, granular soils free from rocks or lumps greater than 3 to 6 inches in maximum dimension. Sources for import fill should be approved by the geotechnical engineer prior to their use.

Backfill and fill materials should be free from organic material, trash, debris, and other objectionable materials. Backfill should be mechanically compacted to at least 90 percent relative compaction (ASTM D 1557) to at or near optimum moisture content. The upper 12 inches of subgrade materials that are to be paved should be compacted to at least 95 percent relative compaction (ASTM D 1557).

Preliminary Pavement Design

Testing and design for preliminary pavement of the subject channel access road and associated reconstruction of existing roadway was conducted in accordance with the California Highway Design Manual. Based upon our preliminary sampling and testing, and upon assumed Traffic Indices, it appears that the structural section tabulated below should provide satisfactory pavements for the subject improvement:

AREA	T.I.*	DESIGN R-VALUE	PRELIMINARY SECTION
Channel Access Road	5.0	50	0.25'AC/0.35'AB or 0.35'AC/Native
Various Public Roadways	8.0	50	0.40' AC/0.45' AB or 0.65' AC/Compacted Native
	9.0	50	0.45' AC/0.55' AB or 0.75' AC/Compacted Native
	10.0	50	0.50' AC/0.65' AB or 0.85' AC/Compacted Native

* to be determined by project engineer
AC - Asphalt Concrete
AB - Aggregate Base, Class 2 or equivalent

The above structural sections are predicated upon 90 percent relative compaction (ASTM D 1557) of all utility trench backfills and 95 percent relative compaction (ASTM D 1557) of the upper 12 inches of pavement subgrade soils and of any aggregate base utilized.

In addition, the aggregate base should meet Caltrans specifications for Class 2 Aggregate Base.

The above pavement design was based upon the results of preliminary sampling and testing, and should be verified by additional sampling and testing when the actual subgrade soils are exposed.

Corrosion Protection

Based on the test results, this soil is classified as mildly corrosive to ferrous metals and potentially aggressive towards copper. The laboratory data above should be reviewed and corrosion design should be completed by a qualified corrosion engineer.

In lieu of corrosion design for metal piping, ABS/PVC may be used. Soil corrosion is not considered a factor with ABS/PVC materials. ABS/PVC is considered suitable for use due to the corrosion potential of the on-site soils with respect to metals.

LOR Geotechnical does not practice corrosion engineering. If further information concerning the corrosion characteristics, or interpretation of the results submitted herein, is required, then a competent corrosion engineer could be consulted.

Construction Monitoring

Post investigative services are an important and necessary continuation of this investigation. Project plans and specifications should be reviewed by the project geotechnical consultant prior to construction to confirm that the intent of the recommendations presented in this report have been incorporated into the design. Additional R-value, expansion, and corrosion testing may be needed after/during site rough grading.

During construction, sufficient and timely geotechnical observation and testing should be provided to correlate the findings of this investigation with the actual subsurface conditions exposed during construction. Items requiring observation and testing include, but are not necessarily limited to, the following:

1. Site preparation-stripping and removals.

2. Excavations, including approval of the bottom of excavations prior to the processing and preparation of the bottom areas for fill placement.

3. Scarifying and recompacting prior to fill placement.

4. Foundation excavations.

5. Subgrade preparation for pavements.

6. Placement of engineered compacted fill and backfill, including approval of fill materials and the performance of sufficient density tests to evaluate the degree of compaction being achieved.

LIMITATIONS

This report contains geotechnical conclusions and recommendations developed solely for use by CASC Engineering & Consulting, and their sub-consultants, for the purposes described earlier. It may not contain sufficient information for other uses or the purposes of other parties. The contents should not be extrapolated to other areas or used for other facilities without consulting LOR Geotechnical Group, Inc.

The recommendations are based on interpretations of the subsurface conditions concluded from information gained from subsurface explorations. The interpretations may differ from actual subsurface conditions, which can vary horizontally and vertically across the site. If conditions are encountered during the construction of the project, which differ significantly from those presented in this report, this firm should be notified immediately so we may assess the impact to the recommendations provided. Due to possible subsurface variations, all aspects of field construction addressed in this report should be observed and tested by the project geotechnical consultant.

The report was prepared using generally accepted geotechnical engineering practices under the direction of a state licensed geotechnical engineer. No warranty, expressed or implied, is made as to conclusions and professional advice included in this report. Any persons using this report for bidding or construction purposes should perform such independent investigations as deemed necessary to satisfy themselves as to the surface and subsurface conditions to be encountered and the procedures to be used in the performance of work on this project.

TIME LIMITATIONS

The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the Standards-of-Practice and/or Governmental Codes may occur. Due to such changes, the findings of this report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a significant amount of time without a review by LOR Geotechnical Group, Inc., verifying the suitability of the conclusions and recommendations.

CLOSURE

It has been a pleasure to assist you with this project. We look forward to being of further assistance to you as construction begins. Should conditions be encountered during construction that appear to be different than indicated by this report, please contact this office immediately in order that we might evaluate their effect.

Should you have any questions regarding this report, please do not hesitate to contact this office at your convenience.

Respectfully submitted,
LOR Geotechnical Group, Inc.

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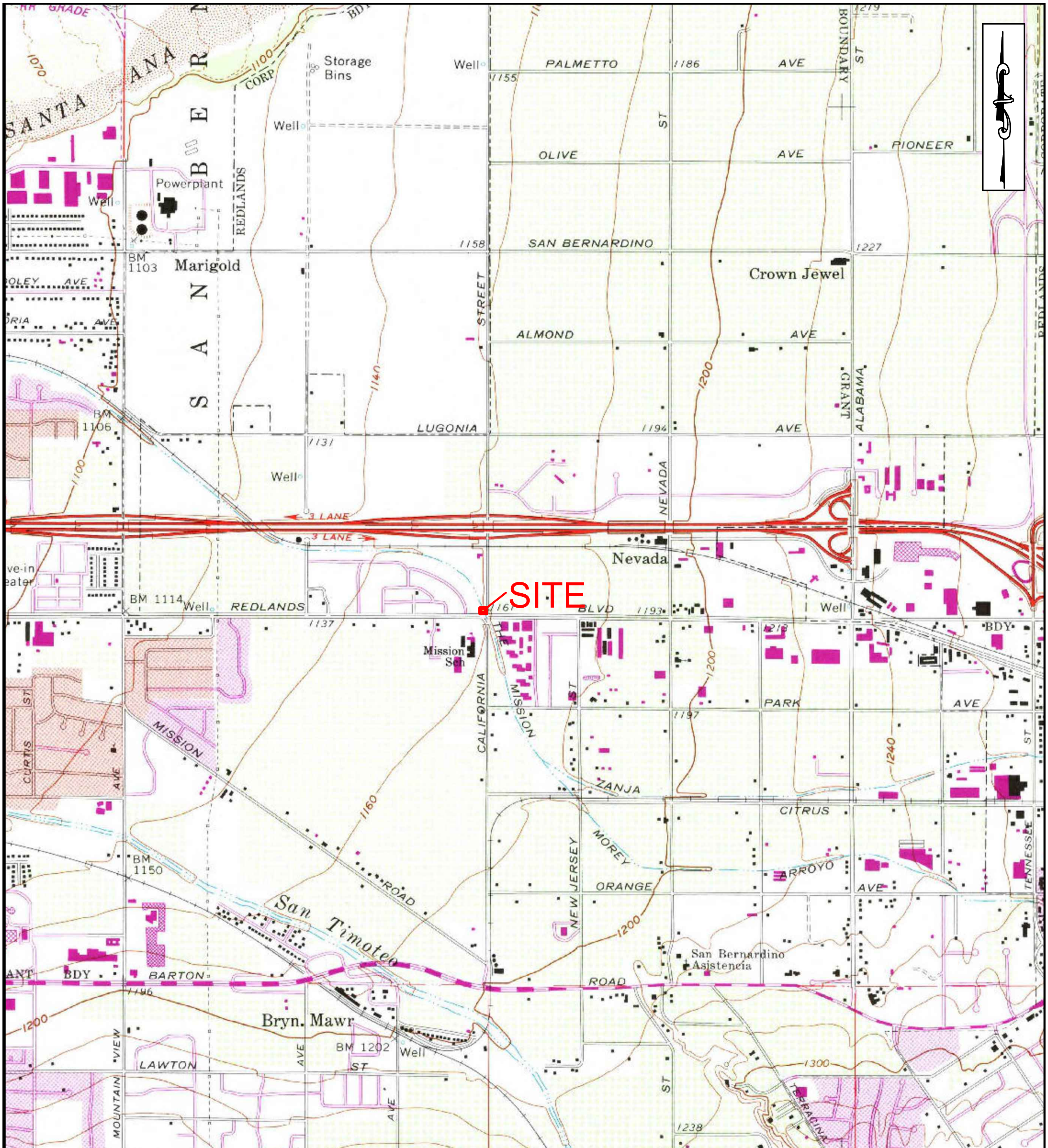
APPENDIX A

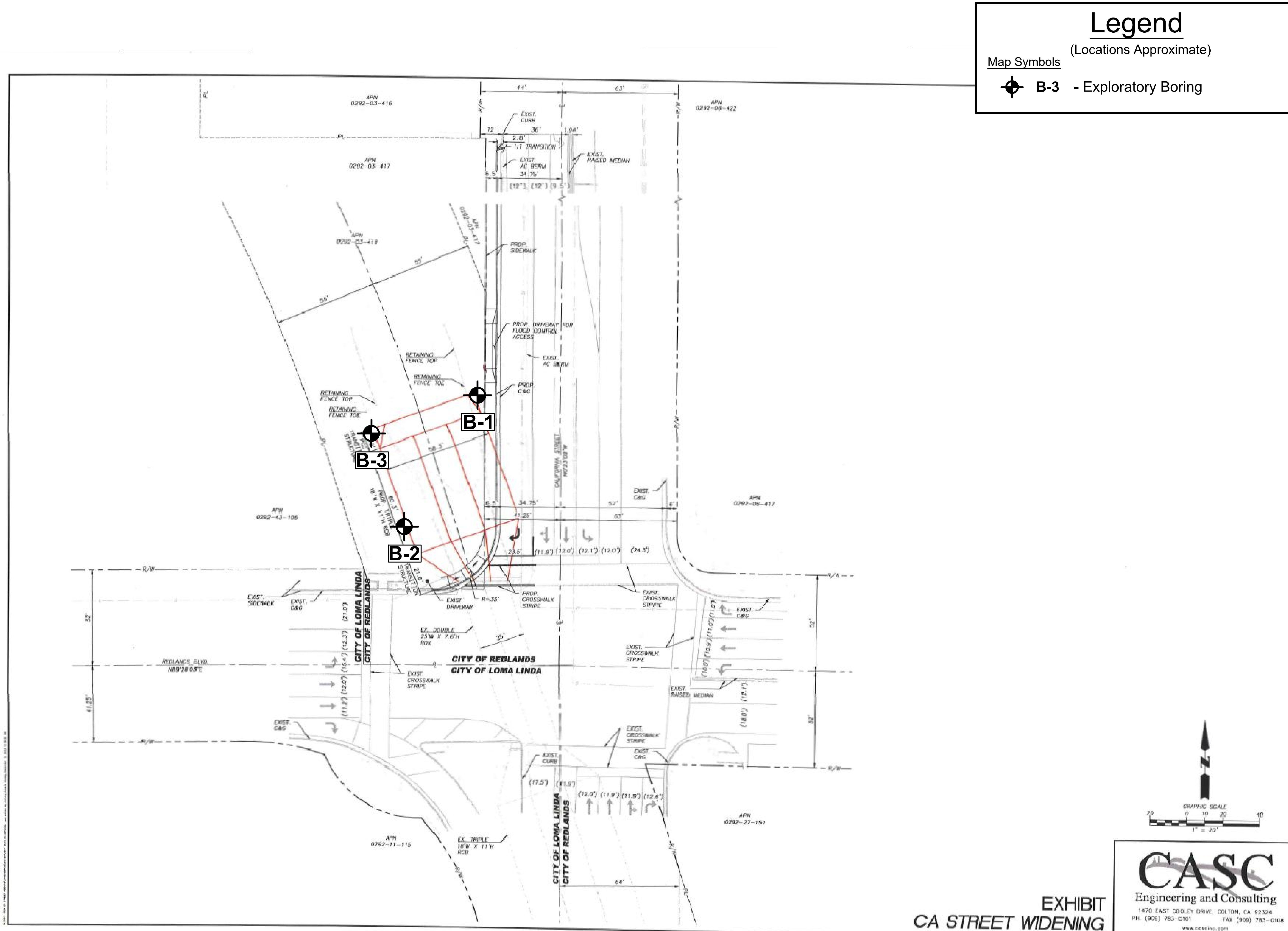
Index Map, Geotechnical Map, Regional Geologic Map, and Historical Seismicity Maps



INDEX MAP

PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering and Consulting	**ENCLOSURE:**	A-1
LOR GEOTECHNICAL GROUP, INC.		**DATE:**	February 2023
		SCALE:	1" ≈ 2,000'

SITE PLAN



PROJECT: California St. & Redlands Blvd. Intersection Widening, Redlands, California

CLIENT: CASC Engineering and Consulting

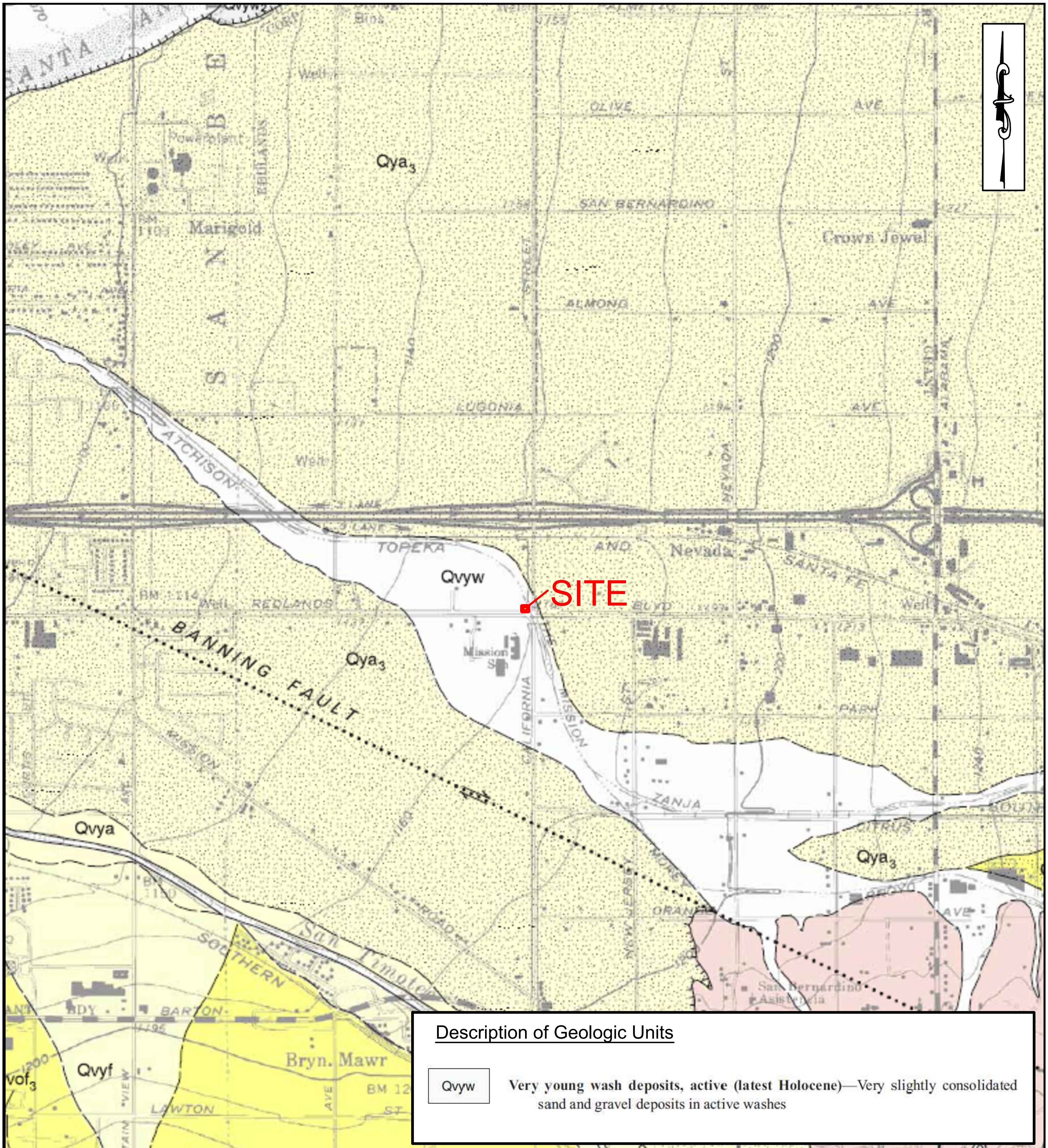
PROJECT NO.: 63878.1

ENCLOSURE: A-2

DATE: February 2023

SCALE: 1" ≈ 50'

LOR GEOTECHNICAL GROUP, INC.



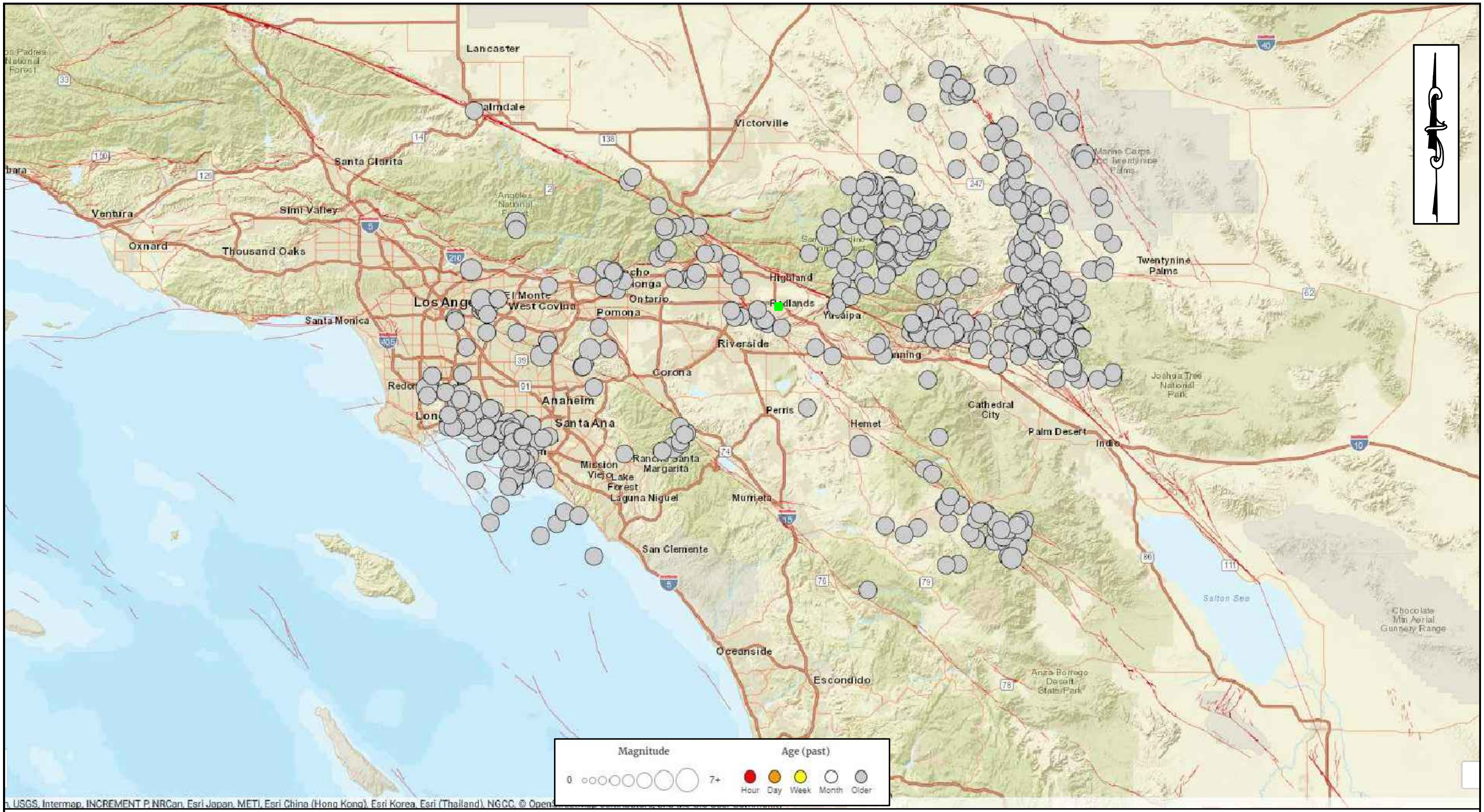
Description of Geologic Units

Qvyw	**Very young wash deposits, active (latest Holocene)**—Very slightly consolidated sand and gravel deposits in active washes

REGIONAL GEOLOGIC MAP

(Matti, et al, 2003)

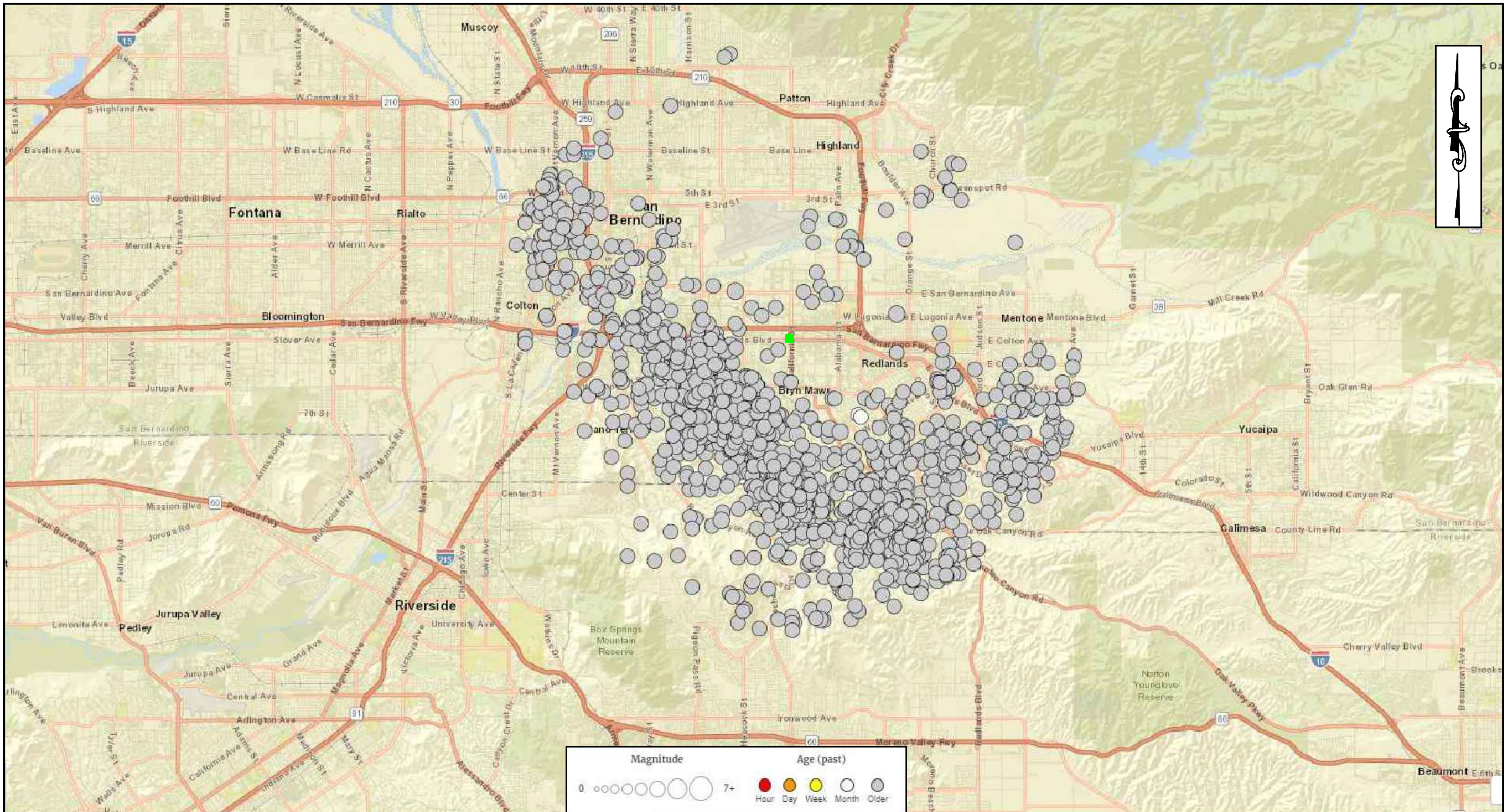
PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering and Consulting	**ENCLOSURE:**	A-3
LOR GEOTECHNICAL GROUP, INC.		**DATE:**	February 2023
		SCALE:	1" ≈ 2,000'



U.S. Geologic Survey (2023) real-time earthquake epicenter map. Plotted are 541 epicenters of instrument-recorded events from 01/01/32 to present (02/24/23) of local magnitude 4+ within a radius of ~62 miles (100 kilometers) of the site. Location accuracy varies. The site is indicated by the green square (■). The selected magnitude corresponds to a threshold intensity value where very light damage potential begins. These events are also generally widely felt by persons. Red lines mark the surface traces of known Quaternary-age faults.

HISTORICAL SEISMICITY MAP - 100km Radius

PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering and Consulting	**ENCLOSURE:**	A-4
LOR GEOTECHNICAL GROUP, INC.		**DATE:**	February 2023
		SCALE:	1" ≈ 40km



U.S. Geologic Survey (2023) real-time earthquake epicenter map. Plotted are 1,431 epicenters of instrument-recorded events from 01/01/78 to present (02/24/23) of local magnitude 2+ within a radius of ~9.2 miles (10 kilometers) of the site. Location accuracy varies. The site is indicated by the green square (■). The selected magnitude corresponds to a threshold intensity value where very light damage potential begins. These events are also generally widely felt by persons. Red lines mark the surface traces of known Quaternary-age faults.

HISTORICAL SEISMICITY MAP - 10km Radius

PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering and Consulting	**ENCLOSURE:**	A-5
LOR GEOTECHNICAL GROUP, INC.		**DATE:**	February 2023
		SCALE:	1" ≈ 10km

APPENDIX B

Field Investigation Program and Boring Logs

APPENDIX B
FIELD INVESTIGATION

Subsurface Exploration

The site was investigated on February 3, 2023 and consisted of advancing 3 exploratory borings to depths of approximately 41.5 t0 51.5 feet below the existing ground surface within the areas requested. The approximate locations of the borings are shown on Enclosure A-2, within Appendix A.

The boring exploration was conducted using a CME-75 drill rig equipped with 8-inch diameter hollow stem augers. The soils were continuously logged by our geologist who inspected the site, created detailed logs of the borings, obtained undisturbed, as well as disturbed, soil samples for evaluation and testing, and classified the soils by visual examination in accordance with the Unified Soil Classification System.

Relatively undisturbed samples of the subsurface soils were obtained at a maximum interval of 5 feet. The samples were recovered by using a California split barrel sampler of 2.40-inch inside diameter and 3.25-inch outside diameter. The samplers were driven by a 140-pound automatic trip hammer dropped from a height of 30 inches. The number of hammer blows required to drive the sampler into the ground the final 12 inches were recorded and further converted to an equivalent SPT-value. Factors such as efficiency of the automatic trip hammer used during this investigation (80%), inner diameter of the hollow-stem auger (3.75 inches), and rod lengths at the test depth were considered for further computing of equivalent SPT-values corrected for field procedures ($\approx N_{60}$) which are included in the boring logs. The soil samples were retained in brass sample rings of 2.41 inches in diameter and 1.00 inch in height, and placed in sealed plastic containers. Disturbed soil samples were obtained at selected levels within the boring and placed in sealed containers for transport to our geotechnical laboratory.

All samples obtained were taken to our geotechnical laboratory for storage and testing. Detailed logs of the borings are presented on the attached Boring Logs, Enclosures B-1 through B-3. Our Boring Log Legend and Soil Classification Chart are presented as Enclosures B-i and B-ii, respectively.

CONSISTENCY OF SOIL

SANDS

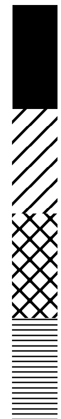
SPT BLOWS	CONSISTENCY
0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
Over 50	Very Dense

COHESIVE SOILS

SPT BLOWS	CONSISTENCY
0-2	Very Soft
2-4	Soft
4-8	Medium
8-15	Stiff
15-30	Very Stiff
30-60	Hard
Over 60	Very Hard

SAMPLE KEY

Symbol / **Description**



INDICATES CALIFORNIA SPLIT SPOON SOIL SAMPLE

INDICATES BULK SAMPLE

INDICATES SAND CONE OR NUCLEAR DENSITY TEST

INDICATES STANDARD PENETRATION TEST (SPT) SOIL SAMPLE

TYPES OF LABORATORY TESTS

1	Atterberg Limits
2	Consolidation
3	Direct Shear (undisturbed or remolded)
4	Expansion Index
5	Hydrometer
6	Organic Content
7	Proctor (4", 6", or Cal216)
8	R-value
9	Sand Equivalent
10	Sieve Analysis
11	Soluble Sulfate Content
12	Swell
13	Wash 200 Sieve

BORING LOG LEGEND

PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering & Consulting	**ENCLOSURE:**	B-i
LOR GEOTECHNICAL GROUP, INC.		**DATE:**	February 2023

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO.200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

PARTICLE SIZE LIMITS

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

12" 3" 3/4" No . 4 No. 10 No. 40 200

(U.S. STANDARD SIEVE SIZE)

SOIL CLASSIFICATION CHART

PROJECT:	California St. & Redlands Blvd. Intersection Widening, Redlands, California	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering & Consulting	**ENCLOSURE:**	B-ii
		DATE:	February 2023

LOR GEOTECHNICAL GROUP, INC.

LOG OF BORING B-1

DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)		DRY DENSITY *(PCF)*	SAMPLE TYPE	LITHOLOGY	U.S.C.S.	DESCRIPTION
0	15	7, 8, 9, 10	6.1		105.6			SM	@ 0 feet, FILL: SILTY SAND, approximately 15 gravel to 1.5", 5% coarse grained sand, 15% medium grained sand, 30% fine grained sand, 30% silty fines, brown, dry.
									@ 2 feet, ALLUVIUM: SILTY SAND, approximately 5% coarse grained sand, 30% medium grained sand, 50% fine grained sand, 15% silty fines, brown, damp, some pinhole porosity.
5	10		6.8		139.0				@ 5 feet, slightly finer grained, tan.
	8	3	7.4		97.5				@ 7 feet, SILTY SAND, approximately 10% medium grained sand, 70% fine grained sand, 20% silty fines, strong brown, damp.
10	13		7.9		102.7				@ 10 feet, SILTY SAND, approximately 85% fine grained sand, 15% silty fines, gray brown, damp.
	14		3.6		99.2			SP	@ 12 feet, POORLY GRADED SAND, approximately 40% medium grained sand, 55% fine grained sand, 5% silty fines, gray, damp.
15	19		2.0		106.9			SW	@ 15 feet, WELL GRADED SAND, approximately 25% coarse grained sand, 35% medium grained sand, 35% fine grained sand, 5% silty fines, gray, dry.
20	16		8.5		100.8				@ 20 feet, becomes damp.
25	34		18.4		91.2			ML SM	@ 25 feet, SANDY SILT/SILTY SAND, approximately 50% fine grained sand, 50% silty fines, brown, moist.
30	52		6.1		104.6			SW	@ 30 feet, WELL GRADED SAND, approximately 35% coarse grained sand, 35% medium grained sand, 35% fine grained sand, 5% silty fines, white, damp.
35	60	3	4.7		108.9				@ 35 feet, slightly finer grained, some 1 to 2" thick SILT layers.
40	32		7.5					SP	@ 40 feet, POORLY GRADED SAND, approximately 15% coarse grained sand, 35% medium grained sand, 45% fine grained sand, 5% silty fines, gray brown, damp.
45	34		7.7						
50	32		18.6						@ 50 feet, becomes moist.
									END OF BORING @ 51.5' Fill to 2' No groundwater No bedrock
55									

PROJECT: California St & Redlands Blvd Widening	**PROJECT NO.:** 63878.1
CLIENT: CASC Engineering & Consulting	**ELEVATION:** --
LOR GEOTECHNICAL GROUP, INC.	**DATE DRILLED:** February 3, 2023
	EQUIPMENT: CME-75
	HOLE DIA.: 8" **ENCLOSURE:** B-1

LOG OF BORING B-2

TEST DATA

DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)		DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	U.S.C.S.
0								SM
								SW
	10		3.3					SM
5	9		7.0		100.0			
								SP SM
	6		6.3		102.0			
								SM
10	13		3.9		49.8			SP
	10		13.6		99.5			
15	16	3	25.0		92.6			CL
20	17		4.0		96.6			SP
25	16	3	23.7		94.7			
30	64		7.0		116.2			SW
35	60		7.3		103.1			
40	40		7.2					CL SP
45								

DESCRIPTION

@ 0 feet, FILL: SILTY SAND, approximately 10% gravel to 1/2", 20% coarse grained sand, 25% medium grained sand, 25% fine grained sand, 20% silty fines with trace clay, brown, dry.

@ 1 foot, WELL GRADED SAND with GRAVEL, approximately 30% gravel to 2", 20% coarse grained sand, 20% medium grained sand, 25% fine grained sand, 5 silty fines, gray, brown, dry.

@ 2 feet, SILTY SAND, approximately 70% fine grained sand, 30% silty fines, red brown, some metal debris, damp, rings disturbed.

@ 6 feet, ALLUVIUM: POORLY GRADED SAND with SILT, approximately 90% fine grained sand, 10% silty fines, red brown, damp.

@ 8 feet, SILTY SAND, approximately 5% coarse grained sand, 10% medium grained sand, 65% fine grained sand, 20% silty fines, gray brown, damp.

@ 10 feet, POORLY GRADED SAND, approximately 20% fine grained sand, 65% fine grained sand, 15% silty fines, gray, damp.
@ 12 feet, becomes moist.

@ 15 feet, LEAN CLAY with SAND, approximately 5% medium grained sand, 15% fine grained sand, 80% clayey fines of low plasticity, tan to brown, moist.

@ 20 feet, POORLY GRADED SAND, approximately 10% coarse grained sand, 35% medium grained sand, 50% fine grained sand, 5% silty fines, gray, damp.

@ 25 feet, becomes slightly coarser grained, brown, moist.

@ 30 feet, WELL GRADED SAND, approximately 25% coarse grained sand, 30% medium grained sand, 40% fine grained sand, 5% silty fines, gray, damp.

@ 39.5 feet, LEAN CLAY with SAND, approximately 15% fine grained sand, 85% clayey fines of low plasticity, brown, moist to wet.

@ 40 feet, POORLY GRADED SAND, approximately 15% coarse grained sand, 30% medium grained sand, 50% fine grained sand, 5% silty fines, gray, damp.

END OF BORING @ 41.5'

Fill to 6'
No groundwater
No bedrock

PROJECT:	California St & Redlands Blvd Widening	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering & Consulting	**ELEVATION:**	--
		DATE DRILLED:	February 3, 2023
LOR GEOTECHNICAL GROUP, INC.		**EQUIPMENT:**	CME-75
		HOLE DIA.: 8"	**ENCLOSURE:** B-2

LOG OF BORING B-3

DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)		DRY DENSITY (PCF)	U.S.C.S.	DESCRIPTION
0		9, 10				SM	@ 0 feet, FILL: SILTY SAND, approximately 20% gravel to 1/2", 5% coarse grained sand, 20% medium grained sand, 30% fine grained sand, 25% silty fines, brown, dry.
	22		3.7		115.2	SW	@ 2 feet, WELL GRADED SAND with GRAVEL, approximately 25% gravel to 2", 20% coarse grained sand, 25% medium grained sand, 25% fine grained sand, 5% silty fines, gray, damp.
5	30						@ 5 feet, rig chatter, no recovery, some angular gravel to 3".
	9		3.6		99.6	SM	@ 7 feet, SILTY SAND with GRAVEL, approximately 20% angular gravel to 2", 15% coarse grained sand, 25% medium grained sand, 25% fine grained sand, 15% silty fines, brown, damp.
10	30		3.7				@ 10 feet, rings disturbed, cobble in tip of sampler.
15	11		14.4		100.7		@ 15 feet, ALLUVIUM: SILTY SAND, approximately 10% medium grained sand, 55% fine grained sand, 35% silty fines, brown, moist.
20	22		8.8		99.3	SP	@ 20 feet, POORLY GRADED SAND, approximately 5% coarse grained sand, 30% medium grained sand, 60% fine grained sand, 5% silty fines, gray, moist.
25	30		6.2		105.1	SW	@ 25 feet, WELL GRADED SAND, approximately 25% coarse grained sand, 30% medium grained sand, 40% fine grained, 5% silty fines, gray, damp.
30	61		5.5		109.9		@ 30 feet, contains approximately 5% gravel to 1/2".
35	64		6.9		104.4		
40	32		11.9		115.6	SM	@ 40 feet, SILTY SAND, approximately 10% coarse grained sand, 35% medium grained sand, 40% fine grained sand, 15% silty fines, gray, moist.
45							

END OF BORING @ 41.5'

Fill to 15'
No groundwater
No bedrock

PROJECT:	California St & Redlands Blvd Widening	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering & Consulting	**ELEVATION:**	--
		DATE DRILLED:	February 3, 2023
		EQUIPMENT:	CME-75
		HOLE DIA.: 8"	**ENCLOSURE:** B-3

LOR GEOTECHNICAL GROUP, INC.

APPENDIX C

Laboratory Testing Program and Test Results

APPENDIX C
LABORATORY TESTING

General

Selected soil samples obtained from the borings were tested in our geotechnical laboratory to evaluate their physical and engineering properties. The laboratory testing program performed in conjunction with our investigation included in-place moisture content and dry density, laboratory compaction characteristic, direct shear, sieve analysis, sand equivalent, R-value, and corrosion. Descriptions of the laboratory tests are presented in the following paragraphs:

Moisture-Density Tests

The moisture content and dry density information provides an indirect measure of soil consistency for each stratum, and can also provide a correlation between soils on this site. The dry unit weight and field moisture content were determined in accordance with ASTM D 2937 and 2216, respectively, for selected undisturbed samples, and the results are shown on the boring logs, Enclosures B-1 through B-3, within Appendix B, for convenient correlation with the soil profile.

Laboratory Compaction

A selected soil sample was tested in the laboratory to determine compaction characteristics using the ASTM D 1557 compaction test method. The results are presented in the following table:

LABORATORY COMPACTION				
Boring Number	**Sample Depth (feet)**	**Soil Description (U.S.C.S.)**	**Maximum Dry Density (pcf)**	**Optimum Moisture Content (percent)**
B-1	0-3	(SM) Silty Sand with Gravel	133.0	8.0

Direct Shear Tests

Shear tests are performed with a direct shear machine at a constant rate-of-strain (usually 0.04 inches/minute). The machine is designed to test a sample partially extruded from a sample ring in single shear. Samples are tested at varying normal loads in order to evaluate the shear strength parameters, angle of internal friction and cohesion in accordance with ASTM D 3080. Samples are tested in a relatively undisturbed state and soaked, to represent the worst case conditions expected in the field. The results of the direct shear tests are presented in the following table:

DIRECT SHEAR TESTS				
Boring Number	**Sample Depth (ft)**	**Material Description (U.S.C.S.)**	**Apparent Cohesion (psf)**	**Angle of Internal Friction (degrees)**
B-1	7	(SM) Silty Sand with Gravel	80	30
B-1	30	(SW) Well Graded Sand	300	43
B-2	15	(CL) Lean Clay with Sand	150	32
B-2	25	(SP) Poorly Graded Sand	100	39

Sieve Analysis

A quantitative determination of the grain size distribution was performed for selected samples in accordance with the ASTM D 422 laboratory test procedure. The determination is performed by passing the soil through a series of sieves, and recording the weights of retained particles on each screen. The results of the grain size distribution analyses are presented graphically on Enclosure C-1.

Sand Equivalent

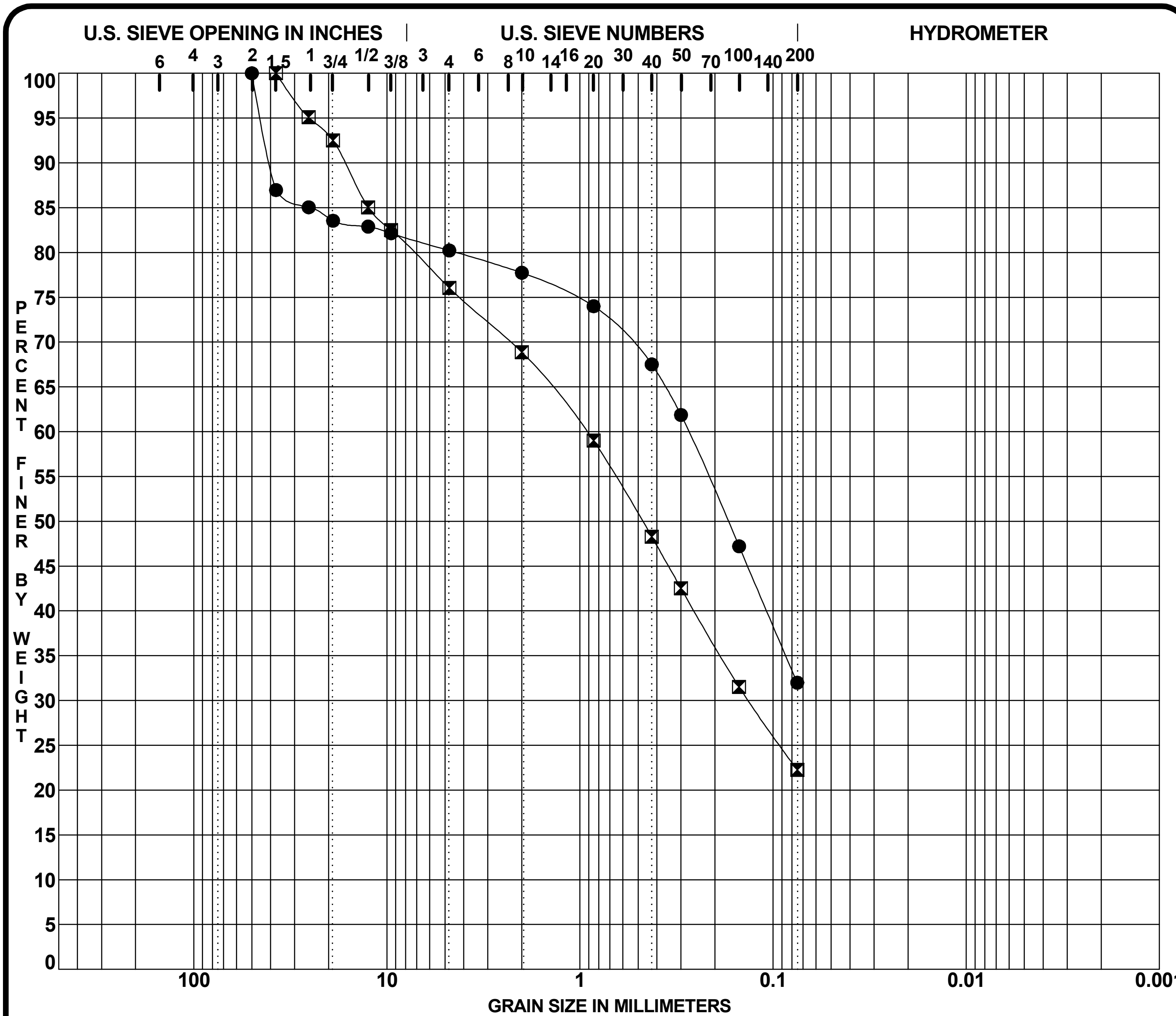
The sand equivalent of selected soils were evaluated using the California Sand Equivalent Test Method, Caltrans Number 217. The results of the sand equivalent tests are presented with the grain size distribution analyses on Enclosure C-1.

R-Value Test

Soil samples were obtained at probable pavement subgrade level and sieve analysis and sand equivalent tests were conducted. A selected soil sample was tested to determine its R-value using the California R-Value Test Method, Caltrans Number 301. The results of the sieve analysis, sand equivalent, and R-value tests are presented on Enclosure C-1.

Corrosion

Corrosion testing was conducted by our subconsultant, Project X Corrosion Engineering. Test results are enclosed.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Soil Classification	SE	RV	PL	PI	Cc	Cu
●	*B-1*	*@ 0-3'*	*(SM) Silty Sand with Gravel*	*15*	*39*				
⊠	*B-3*	*@ 0-3'*	*(SM) Silty Sand with Gravel*	*19*	*--*				

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	*B-1*	*@ 0-3'*	*50.00*	*0.27*			*19.8*	*48.2*	*32.0*
⊠	*B-3*	*@ 0-3'*	*37.50*	*0.93*	*0.134*		*24.0*	*53.8*	*22.3*

PROJECT:	California St & Redlands Blvd Widening	**PROJECT NO.:**	63878.1
CLIENT:	CASC Engineering & Consulting	**DATE:**	February 2023

GRADATION CURVES

LOR GEOTECHNICAL GROUP, INC.

ENCLOSURE: C-1

Results Only Soil Testing for Redlands Blvd/California St

February 10, 2023

Prepared for:

Andrew Tardie
LOR Geotechnical
6121 Quail Valley Ct
Riverside, CA
atardie@lorgeo.com

Project X Job#: S230209B
Client Job or PO#: 63878.1

Respectfully Submitted,

Eduardo Hernandez, M.Sc., P.E.
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REGISTERED PROFESSIONAL ENGINEER
EDUARDO HERNANDEZ
No. M37102
MECHANICAL
STATE OF CALIFORNIA

Soil Analysis Lab Results

Client: LOR Geotechnical
Job Name: Redlands Blvd/California St
Client Job Number: 63878.1
Project X Job Number: S230209B
February 10, 2023

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM G51	ASTM G200	SM 4500-D	ASTM D4327	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D6919	ASTM D4327	ASTM D4327
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd	Minimum	**pH**	**Redox**	**Sulfide** S^{2-}	**Nitrate** NO_3^-	**Ammonium** NH_4^+	**Lithium** Li^+	**Sodium** Na^+	**Potassium** K^+	**Magnesium** Mg^{2+}	**Calcium** Ca^{2+}	**Fluoride** F_2^{--}	**Phosphate** PO_4^{3-}
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)		(mV)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
R-6 - B-1 - (SW) Well Graded Sand	15.0	25.6	0.0026	28.0	0.0028	428,800	26,130	8.4	167	0.4	6.3	7.5	ND	33.2	5.6	21.7	122.5	2.0	2.8
R-27 - B-2 (SW) Well Graded Sand	30.0	11.9	0.0012	16.0	0.0016	214,400	38,860	8.5	123	0.3	0.0	9.1	ND	19.2	5.0	20.4	108.4	3.2	6.1

Cations and Anions, except Sulfide and Bicarbonate, tested with Ion Chromatography
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
ND = 0 = Not Detected | NT = Not Tested | Unk = Unknown
Chemical Analysis performed on 1:3 Soil-To-Water extract
PPM = mg/kg (soil) = mg/L (Liquid)

Project X
Corrosion Engineering
Corrosion Control - Soil, Water, and Metallurgy Lab

Lab Request Sheet Chain of Custody
Phone: (213) 928-7213 · Fax (951) 226-1720 · www.projectxcorrosion.com

Ship Samples To: 29990 Technology Dr, Suite 13, Murrieta, CA 92563

Project X Job Number S230209B LOR 63878.1 Redlands 2 Full

IMPORTANT: Please complete Project and Sample Identification Data as you would like it to appear in report & include this form with samples.

Company Name:	LOR Geotechnical Group, Inc.	**Contact Name:**	Andrew Tardie — **Phone No:** 951-653-1760
Mailing Address:	6121 Quail Valley	**Contact Email:**	atardie@lorgeo.com
Accounting Contact:	John Leuer	**Invoice Email:**	atardie@lorgeo.com
Client Project No:	63878.1	**Project Name:**	Redlands Blvd/California St
P.O. #:	--		

	3-5 Day Standard	3 Day Guarantee 50% mark-up	24 Hour RUSH 100% mark-up
(Business Days) Turn Around Time:	●		

For Corrosion Control Recommendations (350g soil sample):
NEED (1) Groundwater depth and
(2) Soil Sample Locations Map

FOR THERMAL RESISTIVITY PROVIDE (1,500g soil sample):
(1) Optimal Moisture %
(2) Dry Density{PCF}
(3) Desired Compaction
Date & Received By:

METHOD ANALYSIS REQUESTED (Please circle)

Group	Analysis	Caltrans / ASTM	AASHTO / SM / ASTM	Default Method
Full Corrosion Series – Geo Quad	Soil Resistivity	Caltrans CTM643	AASHTO T2888	ASTM G187
Full Corrosion Series – Geo Quad	pH	Caltrans CTM643	AASHTO T 289	ASTM G 51
Full Corrosion Series – Geo Quad	Sulfate	Caltrans CTM417	AASHTO T 290	ASTM D4327
Full Corrosion Series – Geo Quad	Chloride	Caltrans CT422	AASHTO T 291	ASTM D4327
Full Corrosion Series	Redox Potential		SM 2580B	ASTM G200
Full Corrosion Series	Sulfide			SM 4500-S2
Full Corrosion Series	Ammonia		SM 4500-NH3	ASTM D4327
Full Corrosion Series	Nitrate		SM 4500-NO3	ASTM D4327
Full Corrosion Series	Flouride			SM 2320B
Full Corrosion Series	Phosphate			ASTM D4327
Full Corrosion Series	Lithium			ASTM D4327
Full Corrosion Series	Sodium			ASTM D4327
Full Corrosion Series	Potassium			ASTM D4327
Full Corrosion Series	Magnesium			ASTM D4327
Full Corrosion Series	Calcium			ASTM D4327
	Full Corrosion Series	350g Sample		
Reports	Soil Corrosivity Evaluation Report	*Req: Min. 3 Samples, site map, and groundwater info		
Reports	Water Corrosivity Mini Report			
	Moisture Content			ASTM D2216
	Total Alkalinity			SM 2520B
	Soil Remolding		ASTM D2216	ASTM D698
	Thermal Resistivity		ASTM D5334 8-inch	IEEE 442 6-inch
	(ANC) Alk Neutr Cap		1,500g Sample	
	(SRB) Sulfate Reducing			HACH BART
	Puckorius Index			
	XRF Elemental Analysis	ASTM A751	ASTM E322	ASTM E1621
	Water Hardness			

	#	SAMPLE ID - BORE # - Description	DEPTH (ft)	DATE COLLECTED	Soil Resistivity	pH	Sulfate	Chloride	Redox Potential	Sulfide	Ammonia	Nitrate	Flouride	Phosphate	Lithium	Sodium	Potassium	Magnesium	Calcium	Full Corrosion Series	Soil Corrosivity Evaluation Report	Water Corrosivity Mini Report	Moisture Content	Total Alkalinity	Soil Remolding	Thermal Resistivity	(ANC) Alk Neutr Cap	(SRB) Sulfate Reducing	Puckorius Index	XRF Elemental Analysis	Water Hardness
94	1	R-6 - B-1 - (SW) Well Graded Sand	15	02/03/23																●											
95	2	R-27 - B-2 - (SW) Well Graded Sand	30	02/03/23																●											
	3																														
	4																														
	5																														
	6																														
	7																														
	8																														
	9																														
	10																														
	11																														
	12																														
	13																														
	14																														
	15																														

APPENDIX D

Seismic Design Spectra

SITE-SPECIFIC GROUND MOTION ANALYSIS
(ASCE 7-16)

Project: Cailfornia St & Redlands Blvd
Project Number: 63878.1
Client: CASC Engineering & Consulting
Site Lat/Long: 34.0623/-117.2264
Controlling Seismic Source: San Jacinto

REFERENCE	NOTATION	VALUE
Site Class	C, D, D default, or E	D measured
Site Class D - Table 11.4-1	F_a	1.0
Site Class D - 21.3(ii)	F_v	2.5
0.2*(S_{D1}/S_{DS})	T_0	0.198
S_{D1}/S_{DS}	T_S	0.990
Fundamental Period (12.8.2)	T	Period
Seismic Design Maps or Fig 22-14	T_L	8
Equation 11.4-4 - 2/3*S_{M1}	S_{D1}	1.3267
Equation 11.4-2 - F_V*S_1 [1]	S_{M1}	1.9900

[1] - F_V as determined by Section 21.3

REFERENCE	NOTATION	VALUE
Fv (Table 11.4-2)[Used for General Spectrum]	F_v	1.7
Design Maps	S_s	2.011
Design Maps	S_1	0.796
Equation 11.4-1 - F_A*S_S	S_{MS}	2.011*
Equation 11.4-3 - 2/3*S_{MS}	S_{DS}	1.341*
Design Maps	PGA	0.934
Table 11.8-1	F_{PGA}	1.1
Equation 11.8-1 - F_{PGA}*PGA	PGA_M	1.027*
Section 21.5.3	80% of PGA_M	0.822
Design Maps	C_{RS}	0.916
Design Maps	C_{R1}	0.891

REFERENCE	NOTATION	VALUE
0.2*(S_{D1}/S_{DS})	T_0	0.135*
S_{D1}/S_{DS}	T_S	0.673*
Equation 11.4-4 - 2/3*S_{M1}	S_{D1}	0.9021*
Equation 11.4-2 - F_V*S_1	S_{M1}	1.3532*

RISK COEFFICIENT

Cr - At Perods <=0.2, Cr=C_{RS}	C_{RS}	0.916
Cr - At Periods >=1.0, Cr=C_{R1}	C_{R1}	0.891

Cr - At Periods between 0.2 and 1.0 use trendline formula to complete

Period	Cr
0.200	0.916
0.300	0.913
0.400	0.910
0.500	0.907
0.600	0.904
0.680	0.901
1.000	0.891

* **Code based design value.** See accompanying data for Site Specific Design values.

Mapped values from https://hazards.atcouncil.org/

LOR GEOTECHNICAL GROUP, INC.

PROBABILISTIC SPECTRA[1]
2% in 50 year Exceedence

Project No: 63878.1

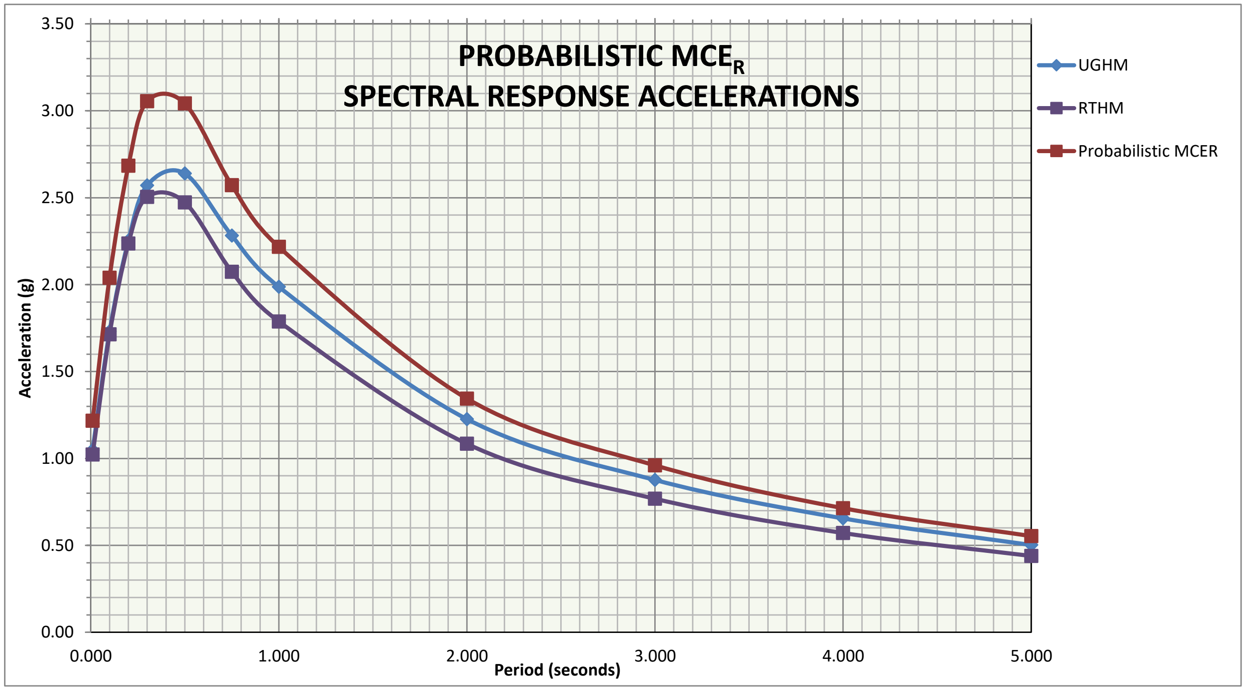
Period	UGHM	RTGM	Max Directional Scale Factor[2]	Probabilistic MCE
0.010	1.048	1.022	1.19	1.216
0.100	1.730	1.714	1.19	2.040
0.200	2.253	2.236	1.20	2.683
0.300	2.571	2.504	1.22	3.055
0.500	2.639	2.473	1.23	3.042
0.750	2.282	2.074	1.24	2.572
1.000	1.987	1.788	1.24	2.217
2.000	1.226	1.084	1.24	1.344
3.000	0.876	0.768	1.25	0.960
4.000	0.655	0.571	1.25	0.714
5.000	0.502	0.439	1.26	0.553

Probabilistic PGA: 1.048

Is Probabilistic $Sa_{(max)}<1.2F_a$? NO

[1] Data Sources:
https://earthquake.usgs.gov/hazards/interactive/
https://earthquake.usgs.gov/designmaps/rtgm/

[2] Shahi-Baker RotD100/RotD50 Factors (2014)



DETERMINISTIC SPECTRUM

Largest Amplitudes of Ground Motions Considering All Sources Calculated using Weighted Mean of Attenuation Equations[1]

Controlling Source: San Jacinto

Is Probabilistic $Sa_{(max)}$<1.2Fa? NO

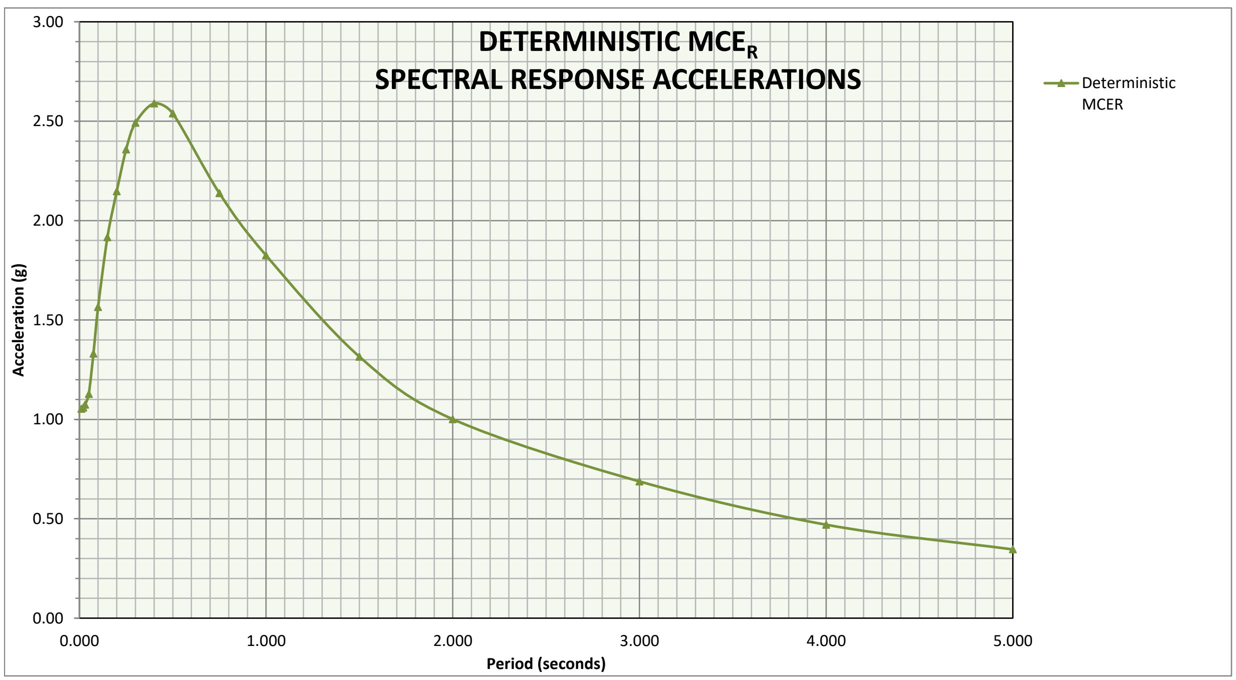
Project No: 63878.1

Period	Deterministic PSa Median + 1.σ for 5% Damping	Max Directional Scale Factor[2]	Deterministic MCE	Section 21.2.2 Scaling Factor Applied
0.010	0.884	1.19	1.053	1.053
0.020	0.890	1.19	1.060	1.060
0.030	0.902	1.19	1.074	1.074
0.050	0.948	1.19	1.128	1.128
0.075	1.118	1.19	1.331	1.331
0.100	1.315	1.19	1.565	1.565
0.150	1.596	1.20	1.916	1.916
0.200	1.789	1.20	2.147	2.147
0.250	1.948	1.21	2.357	2.357
0.300	2.042	1.22	2.491	2.491
0.400	2.105	1.23	2.589	2.589
0.500	2.064	1.23	2.539	2.539
0.750	1.724	1.24	2.137	2.137
1.000	1.472	1.24	1.825	1.825
1.500	1.061	1.24	1.315	1.315
2.000	0.807	1.24	1.001	1.001
3.000	0.550	1.25	0.688	0.688
4.000	0.376	1.25	0.470	0.470
5.000	0.274	1.26	0.346	0.346

Is Determinstic $Sa_{(max)}$<1.5*Fa?	NO
Section 21.2.2 Scaling Factor:	N/A
Deterministic PGA:	0.884
Is Deterministic PGA >=F_{PGA}*0.5?	YES

[1] NGAWest 2 GMPE worksheet and Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) - Time Dependent Model

[2] Shahi-Baker RotD100/RotD50 Factors (2014)



SITE SPECIFIC SPECTRA

Period	Probabilistic MCE	Deterministic MCE	Site-Specific MCE	Design Response Spectrum (Sa)
0.010	1.216	1.053	1.053	0.702
0.100	2.040	1.565	1.565	1.043
0.200	2.683	2.147	2.147	1.431
0.300	3.055	2.491	2.491	1.661
0.500	3.042	2.539	2.539	1.693
0.750	2.572	2.137	2.137	1.425
1.000	2.217	1.825	1.825	1.216
2.000	1.344	1.001	1.001	0.667
3.000	0.960	0.688	0.688	0.458
4.000	0.714	0.470	0.470	0.313
5.000	0.553	0.346	0.346	0.230

ASCE 7-16: Section 21.4
Site Specific

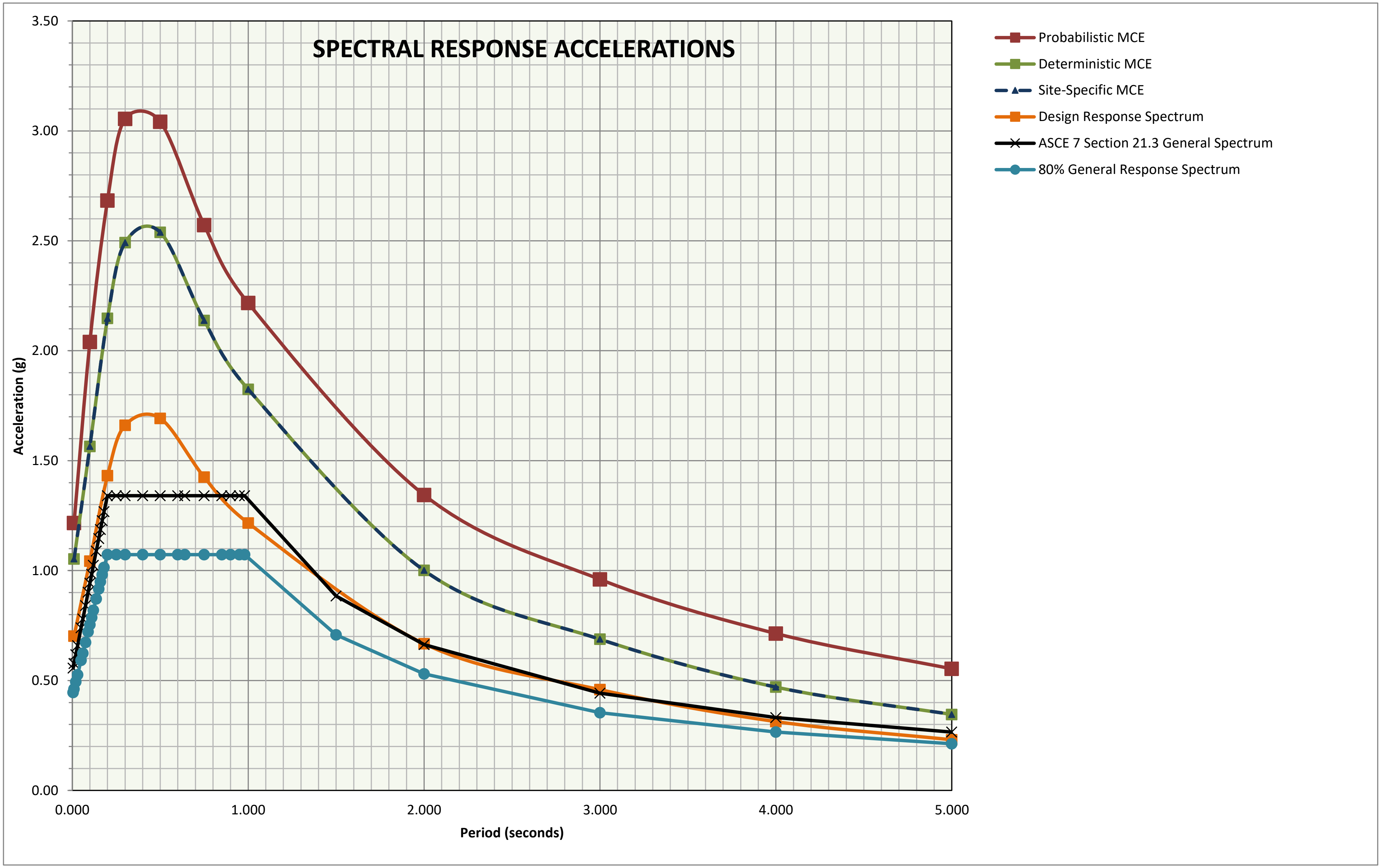
	Calculated Value	Design Value
SDS:	1.523	1.523
SD1:	1.375	1.375
SMS:	2.285	2.285
SM1:	2.063	2.063
Site Specific PGAm:	0.884	0.884
Site Class:	D measured	

Seismic Design Category - Short*	E
Seismic Design Category - 1s*	E

* Risk Categories I, II, or III

Period	ASCE 7 SECTION 21.3 General Spectrum	80% General Response Spectrum
0.005	0.557	0.445
0.010	0.577	0.462
0.020	0.618	0.494
0.030	0.658	0.527
0.050	0.739	0.592
0.060	0.780	0.624
0.075	0.841	0.673
0.090	0.902	0.722
0.100	0.943	0.754
0.110	0.983	0.787
0.120	1.024	0.819
0.136	1.089	0.871
0.150	1.146	0.917
0.160	1.187	0.949
0.170	1.227	0.982
0.180	1.268	1.014
0.200	1.341	1.073
0.250	1.341	1.073
0.300	1.341	1.073
0.400	1.341	1.073
0.500	1.341	1.073
0.600	1.341	1.073
0.640	1.341	1.073
0.750	1.341	1.073
0.850	1.341	1.073
0.900	1.341	1.073
0.950	1.341	1.073
0.980	1.341	1.073
1.500	0.884	0.708
2.000	0.663	0.531
3.000	0.442	0.354
4.000	0.332	0.265
5.000	0.265	0.212

Project No: 63878.1



Project No: 63878.1

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