APPENDIX E3

GEOTECHNCIAL SITE INVESTIGATIONS

Geotechnical Engineering Investigation
Proposed Multi-Unit Residential Development
North of Alessandro Boulevard and
East of Flaming Arrow Drive
City of Moreno Valley, California

Tran Chung
39903 Camden Court
Temecula, California 92591

Project Number 22686-21
August 27, 2021

NorCal Engineering

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Tran Chung
39903 Camden Court
Temecula, California 92591

RE: **Geotechnical Engineering Investigation** - Proposed Multi-Unit Residential Development - Located North of Alessandro Boulevard and East of Flaming Arrow Drive, in the City of Moreno Valley, California

Dear Mr. Chung:

Pursuant to your request, this firm has performed a Geotechnical Engineering Investigation for the above referenced project in accordance with your approval of our proposal dated July 13, 2021. The purpose of this investigation is to evaluate the geotechnical conditions of the subject site and to provide recommendations for the proposed multi-unit residential development.

The scope of work included the following: 1) site reconnaissance; 2) subsurface geotechnical exploration and sampling; 3) laboratory testing; 4) soil infiltration testing; 5) engineering analysis of field and laboratory data; 5) preparation of a geotechnical engineering report. It is the opinion of this firm that the proposed development is feasible from a geotechnical standpoint provided that the recommendations presented in this report are followed in the design and construction of the project.

1.0 Project Description

It is proposed to construct a two-story, 67-unit residential development as shown on the attached Site Plan by Irwin Partners Architects dated August, 5 2021. Other improvements will include asphalt and/or concrete driveways, hardscape and landscaping. The proposed grading will consist of cuts on the order of a few feet with minor fills to achieve finished grade elevations. Final building plans shall be reviewed by this firm prior to submittal for city approval to determine the need for any additional study and revised recommendations pertinent to the proposed development, if necessary.

2.0 Site Description

The subject property is located along the north side of Alessandro Boulevard, east of Flaming Arrow Drive, in the City of Moreno Valley. The generally rectangular shaped parcel is elongated in a north to south direction. The site is relatively level with topography descending gradually from north to south on the order of a few feet. The site is currently vacant and covered in light vegetation.

3.0 Site Exploration

The field investigation consisted of the placement of ten (10) subsurface exploratory trenches by a backhoe to depths ranging between 5 and 16 feet below current ground elevations. The explorations were visually classified and logged by a field engineer with location of the subsurface explorations shown on the attached Site Plan. The exploratory borings revealed the existing earth materials to consist of fill and natural soil. Detailed descriptions of the subsurface conditions are listed on the boring logs in Appendix A. It should be noted that the transition from one soil type to another as shown on the borings logs is approximate and may in fact be a gradual transition. The soils encountered are described as follows:

Fill: A fill soil classifying as a brown, clayey SILT with some sand and occasional gravel, concrete and rootlets was encountered across the site to a depth of 1 to 1½ feet below ground surface. These soils were noted to be soft to medium stiff and dry.

Natural: An undisturbed native soil classifying as brown, silty sandy CLAY was encountered beneath the fill soils. The native soils were observed to be medium stiff to stiff and dry to damp.

The overall engineering characteristics of the earth material were relatively uniform with each excavation. No groundwater was encountered to the depths of our borings and no caving occurred.

4.0 Laboratory Tests

Relatively undisturbed samples of the subsurface soils were obtained to perform laboratory testing and analysis for direct shear, consolidation tests, and to determine in-place moisture/densities. These relatively undisturbed ring samples were obtained by driving a thin-walled steel sampler lined with one-inch-long brass rings with an inside diameter of 2.42 inches into the undisturbed soils. The sampler was driven a total of six inches into undisturbed soils. Bulk bag samples were obtained in the upper soils for expansion index tests and maximum density tests. All test results are included in Appendix B, unless otherwise noted.

4.1 **Field Moisture Content** (ASTM: D 2216) and the dry density of the ring samples were determined in the laboratory. This data is listed on the logs of explorations.

4.2 **Maximum Density tests** (ASTM: D 1557) were performed on typical samples of the upper soils. Results of these tests are shown on Table I.

4.3 **Expansion Index tests** (ASTM: D 4829) were performed on remolded samples of the upper soils to determine expansive characteristics. Results of these tests are provided on Table II.

4.4 **Atterberg Limits** (ASTM: D 4318) consisting of liquid limit, plastic limit and plasticity index were performed on representative soil samples. Results are shown on Table III.

4.5 **Corrosion tests** consisting of sulfate, pH, resistivity and chloride analysis to determine potential corrosive effects of soils on concrete and underground utilities. Test results are provided on Table IV.

4.6 **R-Value test** per California Test Method 301 was performed on a representative sample, which may be anticipated to be near subgrade to determine pavement design. Results are provided within the pavement design section of the report.

4.7 **Direct Shear tests** (ASTM: D 3080) were performed on undisturbed and/or remolded samples of the subsurface soils. The test is performed under saturated conditions at loads of 1,000 lbs./sq.ft., 2,000 lbs./sq.ft., and 3,000 lbs./sq.ft. with results shown on Plate A.

4.8 **Consolidation tests** (ASTM: D 2435) were performed on undisturbed samples to determine the differential and total settlement which may be anticipated based upon the proposed loads. Water was added to the samples at a surcharge of one KSF and the settlement curves are plotted on Plates B and C.

5.0 Seismicity Evaluation

The proposed development lies outside of any Alquist-Priolo Special Studies Zone and the potential for damage due to direct fault rupture is considered unlikely. The San Jacinto (Valley Segment) Fault is located approximately 7 kilometers from the site and is capable of producing a Magnitude 6.9 earthquake. Ground shaking originating from earthquakes along other active faults in the region is expected to induce lower horizontal accelerations due to smaller anticipated earthquakes and/or greater distances to other faults. The seismic design acceleration parameters are provided below and are based on the 2019 California Building Code (CBC) for the referenced project. The data was obtained from the American Society of Civil Engineers (ASCE) website, https://asce7hazardtool.online/ and is attached in Appendix C.

Seismic Design Acceleration Parameters

Latitude	33.918
Longitude	-117.221
Site Class	D
Risk Category	II
Mapped Spectral Response Acceleration	S_S = 1.653 S_1 = 0.644
Adjusted Maximum Acceleration	S_{MS} = 1.653
Design Spectral Response Acceleration Parameters	S_{DS} = 1.102
Peak Ground Acceleration	PGA_M = 0.77

Use of these values is dependent on requirements of ASCE 7-16, 11-4.8, Exception 2 that requires the value of the seismic response coefficient C_s be determined by Equation 12.8.2 for values of $T \leq 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either 12.8-3 for $T_L \geq T \geq 1.5T_s$ or Equation 12.8-4 for $T > T_L$. Computations and verification of these conditions is referred to the structural engineer.

6.0 Liquefaction Evaluation

The site is expected to experience ground shaking and earthquake activity that is typical of the Southern California area. It is during severe shaking that loose, granular soils below the groundwater table can liquefy. Based on review of the *City of Moreno Valley Geological Faults and Liquefaction Map (September 22, 2016, revised May 2017)*, the site is *not* situated in an area of generalized liquefaction susceptibility. Thus, design of the proposed construction in conformance with the latest Building Code provisions for earthquake design is expected to provide mitigation of ground shaking hazards that are typical in Southern California.

7.0 Infiltration Characteristics

Infiltration tests within the site were performed to provide preliminary infiltration rates for the purpose of planning and design of an on-site water disposal system. The infiltration tests consisted of the double ring infiltration test per ASTM Method D 3385. The field infiltration rate was computed using a reduction factor – R_f based on the field measurements with our calculations given in Appendix D. Based upon the results of our testing, the soils encountered in the planned on-site drainage disposal system area exhibit the following infiltration rates.

Boring/Test No.	Depth	Soil Classification	Field Infiltration Rate	Design Rate
T-1	5'	Silty Sandy CLAY	0.58 in/hr	0.19 in/hr
T-2	7.5'	Silty SAND	0.64 in/hr	0.21 in/hr

Based on the results of our field testing, the subsurface soils encountered in the proposed on-site drainage disposal system shall utilize the design infiltration rates based on a safety factor of 3.0 or greater in compliance with the County of Riverside "Low Impact Development BMP Design" guidelines. All systems must meet the latest city and/or county specifications and the California Regional Water Quality Control Board (CRWQCB) requirements.

The infiltration rates at the depths tested indicate the stiff/dense soils encountered in our test locations *are not* suitable for storm water infiltration at the project site. The recommendations and conclusions contained in this report are based upon the soil conditions encountered in the test excavations.

8.0 Conclusions and Recommendations

Based upon our evaluations, the proposed development is acceptable from a geotechnical engineering standpoint. By following the recommendations and guidelines set forth in our report, the structures will be safe from excessive settlements under the anticipated design loadings and conditions. The proposed development shall meet all requirements of the City Building Ordinance and will not impose any adverse effect on existing adjacent structures.

The following recommendations are based upon soil conditions encountered in our field investigation; these near-surface soil conditions could vary across the site. Variations in the soil conditions may not become evident until the commencement of grading operations for the proposed development and revised recommendations from the soils engineer may be necessary based upon the conditions encountered.

It is recommended that site inspections are performed by a representative of this firm during all grading and construction of the development to verify the findings and recommendations documented in this report. The following sections present a discussion of geotechnical related requirements for specific design recommendations of different aspects of the project.

8.1 Site Grading Recommendations

All vegetation and demolition debris shall be removed and hauled prior to the start of grading operations. Existing vegetation shall not be mixed or disced into the soils. Any removed soils may be reutilized as compacted fill once any deleterious material or oversized materials (in excess of eight inches) is removed. Grading operations shall be performed in accordance with the attached "Specifications for Compacted Fill Operations".

8.1.1 Removal and Recompaction Recommendations

All disturbed soils and/or fill (about 1 to 1½ feet below ground surface) shall be removed to competent native material, the exposed surface scarified to a depth of 12 inches, brought to within 2% of optimum moisture content and compacted to a minimum of 90% of the laboratory standard (ASTM: D 1557) prior to placement of any additional compacted fill soils, foundations, slabs-on-grade and pavement. Grading shall extend a minimum of five horizontal feet outside the edges of foundations or equidistant to the depth of fill placed, whichever is greater.

It is possible that isolated areas of undiscovered fill not described in this report are present on site; if found, these areas should be treated as discussed earlier. A diligent search shall also be conducted during grading operations in an effort to uncover any underground structures, irrigation or utility lines. If encountered, these structures and lines shall be either removed or properly abandoned prior to the proposed construction.

Any imported fill material should be preferably soil similar to the upper soils encountered at the subject site. All soils shall be approved by this firm prior to importing at the site and will be subjected to additional laboratory testing to assure concurrence with the recommendations stated in this report.

If placement of slabs-on-grade and pavement is not completed immediately upon completion of grading operations, additional testing and grading of the areas may be necessary prior to continuation of construction operations. Likewise, if adverse weather conditions occur which may damage the subgrade soils, additional assessment by the soils engineer as to the suitability of the supporting soils may be needed.

Care should be taken to provide or maintain adequate lateral support for all adjacent improvements and structures at all times during the grading operations and construction phase. Adequate drainage away from the structures, pavement and slopes should be provided at all times.

8.1.2 Fill Blanket Recommendations

Due to the potential for differential settlement of foundations placed on compacted fill and medium stiff native materials, it is recommended that all foundations be underlain by a uniform compacted fill blanket at least two feet in thickness. This fill blanket shall extend a minimum of five horizontal feet outside the edges of foundations or equidistant to the depth of fill placed, whichever is greater.

8.2 Temporary Excavations

Temporary *unsurcharged* excavations in the existing site materials may be made at vertical inclinations up to 4 feet in height unless cohesionless soils are encountered. In areas where soils with little or no binder are encountered, where adverse geological conditions are exposed, or where excavations are adjacent to existing structures, shoring or flatter excavations may be required. The temporary cut slope gradients given above do not preclude local raveling and sloughing. Once finalized sections are made available, this firm shall review and provide stability calculations with updated excavation recommendations.

Temporary shoring design may utilize an active earth pressure of 25 pcf without any surcharge due to adjacent traffic, equipment or structures. The passive fluid pressures of 250 pcf may be doubled to 500 pcf for temporary design. Any drilled caissons will require to be cased due to the potential of caving. Shoring members should not be vibrated or driven due to the potential for damage to nearby improvements. All excavations shall be made in accordance with the requirements of the geotechnical engineer, CAL-OSHA and other public agencies having jurisdiction. Care should be taken to provide or maintain adequate lateral support for all adjacent improvements and structures at all times during the grading operations and construction phase.

8.3 Foundation Design

All foundations may be designed utilizing an allowable bearing capacity of 2,000 psf for a minimum embedded depth of 24 inches into approved engineered fill. The bearing value may be increased by 500 psf for each additional foot of depth in excess of the 24-inch minimum depth, up to 3,000 psf. A one-third increase may be used when considering short-term loading and seismic forces. All foundations shall be reinforced a minimum of one No. 4 bar, top and bottom. A representative of this firm shall inspect all foundation excavations prior to pouring concrete.

8.4 Settlement Analysis

Resultant pressure curves for the consolidation tests are shown on Plates B and C. Computations utilizing these curves and the recommended allowable soil bearing capacities reveal that the foundations will experience settlements on the order of ¾ inch and differential settlements of less than ¼ inch.

8.5 Lateral Resistance

The following values may be utilized in resisting lateral loads imposed on the structure. Requirements of the California Building Code should be adhered to when the coefficient of friction and passive pressures are combined.

Coefficient of Friction - 0.35

Equivalent Passive Fluid Pressure = 200 lbs./cu.ft.

Maximum Passive Pressure = 2,000 lbs./cu.ft.

The passive pressure recommendations are valid only for approved compacted fill soils or competent native materials.

8.6 Retaining Wall Design Parameters

Active earth pressures against retaining walls will be equal to the pressures developed by the following fluid densities. These values are for **granular backfill material** placed behind the walls at various ground slopes above the walls.

Surface Slope of Retained Materials (Horizontal to Vertical	Equivalent Fluid Density (lb./cu.ft.)
Level	30
5 to 1	35
4 to 1	38
3 to 1	40
2 to 1	45

Any applicable short-term construction surcharges and seismic forces should be added to the above lateral pressure values. An equivalent fluid pressure of 45 pcf may be utilized for the restrained wall condition with a level grade behind the wall.

The seismic-induced lateral soil pressure for walls greater than 6 feet may be computed using a triangular pressure distribution with the maximum value at the top of the wall. The maximum lateral pressure of (20 pcf) H where H is the height of the retained soils above the wall footing should be used in final design of retaining walls. Sliding resistance values and passive fluid pressure values may be increased by 1/3 during short-term wind and seismic loading conditions.

All walls shall be waterproofed as needed and protected from hydrostatic pressure by a reliable permanent subdrain system. The subsurface drainage system shall consist of a 4-inch diameter perforated PVC pipe encased with gravel and wrapped with filter fabric. The granular backfill to be utilized immediately adjacent to retaining walls shall consist of an approved granular soil with a sand equivalency greater than 30. This backfill zone of free draining material shall consist of a wedge beginning a minimum of one horizontal foot from the base of the wall extending upward at an inclination of no less than ¾ to 1 (horizontal to vertical).

8.7 <u>Slab Design</u>

All slabs shall be a minimum of four inches in thickness reinforced a minimum of No. 3 bars, sixteen inches in each direction and placed on approved subgrade soils. The subgrade soils shall be moisture conditioned 3% over optimum moisture levels in the upper eighteen inches. All concrete slabs for hardscape and driveway areas situated near existing street levels shall be a minimum of four inches in thickness and placed on approved subgrade soils. The subgrade soils shall be moisture conditioned over optimum moisture levels in the upper foot.

A vapor retarder should be utilized in areas which would be sensitive to the infiltration of moisture. This retarder shall meet requirements of ASTM E 96, *Water Vapor Transmission of Materials* and ASTM E 1745, *Standard Specification for Water Vapor Retarders used in Contact with Soil or Granular Fill Under Concrete Slabs.* The vapor retarder shall be installed in accordance with procedures stated in ASTM E 1643, *Standard practice for Installation of Water Vapor Retarders used in Contact with Earth or Granular Fill Under Concrete Slabs.*

The moisture retarder may be placed directly upon compacted subgrade soils conditioned to near optimum moisture levels, although one to two inches of sand beneath the membrane is desirable. The subgrade upon which the retarder is placed shall be smooth and free of rocks, gravel or other protrusions which may damage the retarder. Use of sand above the retarder is under the purview of the structural engineer; if sand is used over the retarder, it should be placed in a dry condition.

8.8 Pavement Section Design

The table below provides a preliminary pavement design based upon a R-Value of 33 for the subgrade soils for the proposed pavement areas. Final pavement design may need to be based on R-Value testing of the subgrade soils near the conclusion of site grading to assure that these soils are consistent with those assumed in this preliminary design.

Type of Traffic	Traffic Index	Asphalt (in.)	Base Material (in.)
Automobile Parking Stalls	4.0	3.0	4.0
Light Vehicle Traffic Areas	5.5	3.5	6.5

Any concrete slab-on-grade in pavement areas shall be a minimum of six inches in thickness reinforced and placed on approved subgrade soils. All pavement areas shall have positive drainage toward an approved outlet from the site. Drain lines behind curbs and/or adjacent to landscape areas should be considered by client and the appropriate design engineers to prevent water from infiltrating beneath pavement. If such infiltration occurs, damage to pavement, curbs and flow lines, especially on sites with expansive soils, may occur during the life of the project.

Any approved base material shall consist of a Class II aggregate or equivalent and should be compacted to a minimum of 95% relative compaction. All pavement materials shall conform to the requirements set forth by the City of Riverside. The base material; and asphaltic concrete should be tested prior to delivery to the site and during placement to determine conformance with the project specifications. A pavement engineer shall designate the specific asphalt mix design to meet the required project specifications.

8.9 Utility Trench and Excavation Backfill

Trenches from installation of utility lines and other excavations may be backfilled with on-site soils or approved imported soils compacted to a minimum of 90% relative compaction. All utility lines shall be properly bedded with clean sand having a sand equivalency rating of 30 or more. This bedding material shall be thoroughly water jetted around the pipe structure prior to placement of compacted backfill soils.

8.10 Corrosion Design Criteria

Representative samples of the surficial soils, typical of the subgrade soils expected to be encountered within foundation excavations and underground utilities were tested for corrosion potential. The minimum resistivity value obtained for the samples tested is representative of an environment that may be severely corrosive to metals. The soil pH value was considered to be neutral and may not have a significant effect on soil corrosivity.

Consideration should be given to corrosion protection systems for buried metal such as protective coatings, wrappings or the use of PVC where permitted by local building codes. According to Table 4.3.1 of ACI 318 Building Code and Commentary, these contents revealed negligible sulfate concentrations. Therefore, a Type II cement according to latest CBC specifications may be utilized for building foundations at this time. It is recommended that additional sulfate tests be performed at the completion of site grading to assure that the as graded conditions are consistent with the recommendations stated in this design. Corrosion test results may be found on the attached Table III.

8.11 Expansive Soil

The upper on-site soils are low un expansion potential (EI 21-50). When soils have an expansion index (EI) of 20 or more, special attention should be given to the project design and maintenance. The attached *Expansive Soil Guidelines* should be reviewed by the engineers, architects, owner, maintenance personnel and other interested parties and considered during the design of the project and future property maintenance. Expansion test results may be found on the attached Table II.

9.0 Closure

The recommendations and conclusions contained in this report are based upon the soil conditions uncovered in our test excavations. No warranty of the soil condition between our excavations is implied. NorCal Engineering should be notified for possible further recommendations if unexpected to unfavorable conditions are encountered during construction phase. It is the responsibility of the owner to ensure that all information within this report is submitted to the Architect and appropriate Engineers for the project.

This firm should have the opportunity to review the final plans (72 hours required) to verify that all our recommendations are incorporated. This report and all conclusions are subject to the review of the controlling authorities for the project.

A preconstruction conference should be held between the developer, general contractor, grading contractor, city inspector, architect, and soil engineer to clarify any questions relating to the grading operations and subsequent construction. Our representative should be present during the grading operations and construction phase to certify that such recommendations are complied within the field.

This geotechnical investigation has been conducted in a manner consistent with the level of care and skill exercised by members of our profession currently practicing under similar conditions in the Southern California area. No other warranty, expressed or implied is made.

We appreciate this opportunity to be of service to you. If you have any further questions, please do not hesitate to contact the undersigned.

Respectfully submitted,
NORCAL ENGINEERING

Keith D Tucker

Keith D. Tucker
Project Engineer
R.G.E. 841

Keith D. Tucker
No. 841
Exp. 12/31/2022

MB

Mike Barone
Project Manager

SPECIFICATIONS FOR PLACEMENT OF COMPACTED FILL

Excavation

Any existing low-density soils and/or saturated soils shall be removed to competent natural soil under the inspection of the Geotechnical Engineering Firm. After the exposed surface has been cleansed of debris and/or vegetation, it shall be scarified until it is uniform in consistency, brought to the proper moisture content and compacted to a minimum of 90% relative compaction (in accordance with ASTM: D 1557).

In any area where a transition between fill and native soil or between bedrock and soil are encountered, additional excavation beneath foundations and slabs will be necessary in order to provide uniform support and avoid differential settlement of the structure.

Material for Fill

The on-site soils or approved import soils may be utilized for the compacted fill provided they are free of any deleterious materials and shall not contain any rocks, brick, asphaltic concrete, concrete or other hard materials greater than eight inches in maximum dimensions. Any import soil must be approved by the Geotechnical Engineering firm a minimum of 72 hours prior to importation of site.

Placement of Compacted Fill Soils

The approved fill soils shall be placed in layers not excess of six inches in thickness. Each lift shall be uniform in thickness and thoroughly blended. The fill soils shall be brought to within 2% of the optimum moisture content, unless otherwise specified by the Geotechnical Engineering firm. Each lift shall be compacted to a minimum of 90% relative compaction (in accordance with ASTM: D 1557) and approved prior to the placement of the next layer of soil. Compaction tests shall be obtained at the discretion of the Geotechnical Engineering firm but to a minimum of one test for every 500 cubic yards placed and/or for every 2 feet of compacted fill placed.

The minimum relative compaction shall be obtained in accordance with accepted methods in the construction industry. The final grade of the structural areas shall be in a dense and smooth condition prior to placement of slabs-on-grade or pavement areas. No fill soils shall be placed, spread or compacted during unfavorable weather conditions. When the grading is interrupted by heavy rains, compaction operations shall not be resumed until approved by the Geotechnical Engineering firm.

Grading Observations

The controlling governmental agencies should be notified prior to commencement of any grading operations. This firm recommends that the grading operations be conducted under the observation of a Geotechnical Engineering firm as deemed necessary. A 24-hour notice must be provided to this firm prior to the time of our initial inspection.

Observation shall include the clearing and grubbing operations to assure that all unsuitable materials have been properly removed; approve the exposed subgrade in areas to receive fill and in areas where excavation has resulted in the desired finished grade and designate areas of overexcavation; and perform field compaction tests to determine relative compaction achieved during fill placement. In addition, all foundation excavations shall be observed by the Geotechnical Engineering firm to confirm that appropriate bearing materials are present at the design grades and recommend any modifications to construct footings.

EXPANSIVE SOIL GUIDELINES

The following expansive soil guidelines are provided for your project. The intent of these guidelines is to inform you, the client, of the importance of proper design and maintenance of projects supported on expansive soils. ***You, as the owner or other interested party, should be warned that you have a duty to provide the information contained in the soil report including these guidelines to your design engineers, architects, landscapers and other design parties in order to enable them to provide a design that takes into consideration expansive soils.***

In addition, you should provide the soil report with these guidelines to any property manager, lessee, property purchaser or other interested party that will have or assume the responsibility of maintaining the development in the future.

Expansive soils are fine-grained silts and clays which are subject to swelling and contracting. The amount of this swelling and contracting is subject to the amount of fine-grained clay materials present in the soils and the amount of moisture either introduced or extracted from the soils. Expansive soils are divided into five categories ranging from "very low" to "very high". Expansion indices are assigned to each classification and are included in the laboratory testing section of this report. *If the expansion index of the soils on your site, as stated in this report, is 21 or higher, you have expansive soils.* The classifications of expansive soils are as follows:

Classification of Expansive Soil*

Expansion Index	Potential Expansion
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
Above 130	Very High

*From Table 18A-I-B of California Building Code (1988)

When expansive soils are compacted during site grading operations, care is taken to place the materials at or slightly above optimum moisture levels and perform proper compaction operations. Any subsequent excessive wetting and/or drying of expansive soils will cause the soil materials to expand and/or contract. These actions are likely to cause distress of foundations, structures, slabs-on-grade, sidewalks and pavement over the life of the structure. ***It is therefore imperative that even after construction of improvements, the moisture contents are maintained at relatively constant levels, allowing neither excessive wetting or drying of soils.***

Evidence of excessive wetting of expansive soils may be seen in concrete slabs, both interior and exterior. Slabs may lift at construction joints producing a trip hazard or may crack from the pressure of soil expansion. Wet clays in foundation areas may result in lifting of the structure causing difficulty in the opening and closing of doors and windows, as well as cracking in exterior and interior wall surfaces. In extreme wetting of soils to depth, settlement of the structure may eventually result. Excessive wetting of soils in landscape areas adjacent to concrete or asphaltic pavement areas may also result in expansion of soils beneath pavement and resultant distress to the pavement surface.

Excessive drying of expansive soils is initially evidenced by cracking in the surface of the soils due to contraction. Settlement of structures and on-grade slabs may also eventually result along with problems in the operation of doors and windows.

Projects located in areas of expansive clay soils will be subject to more movement and "hairline" cracking of walls and slabs than similar projects situated on non-expansive sandy soils. There are, however, measures that developers and property owners may take to reduce the amount of movement over the life the development. The following guidelines are provided to assist you in both design and maintenance of projects on expansive soils:

- Drainage away from structures and pavement is essential to prevent excessive wetting of expansive soils. Grades should be designed to the latest building code and maintained to allow flow of irrigation and rain water to approved drainage devices or to the street. Any "ponding" of water adjacent to buildings, slabs and pavement after rains is evidence of poor drainage; the installation of drainage devices or regrading of the area may be required to assure proper drainage. Installation of rain gutters is also recommended to control the introduction of moisture next to buildings. Gutters should discharge into a drainage device or onto pavement which drains to roadways.

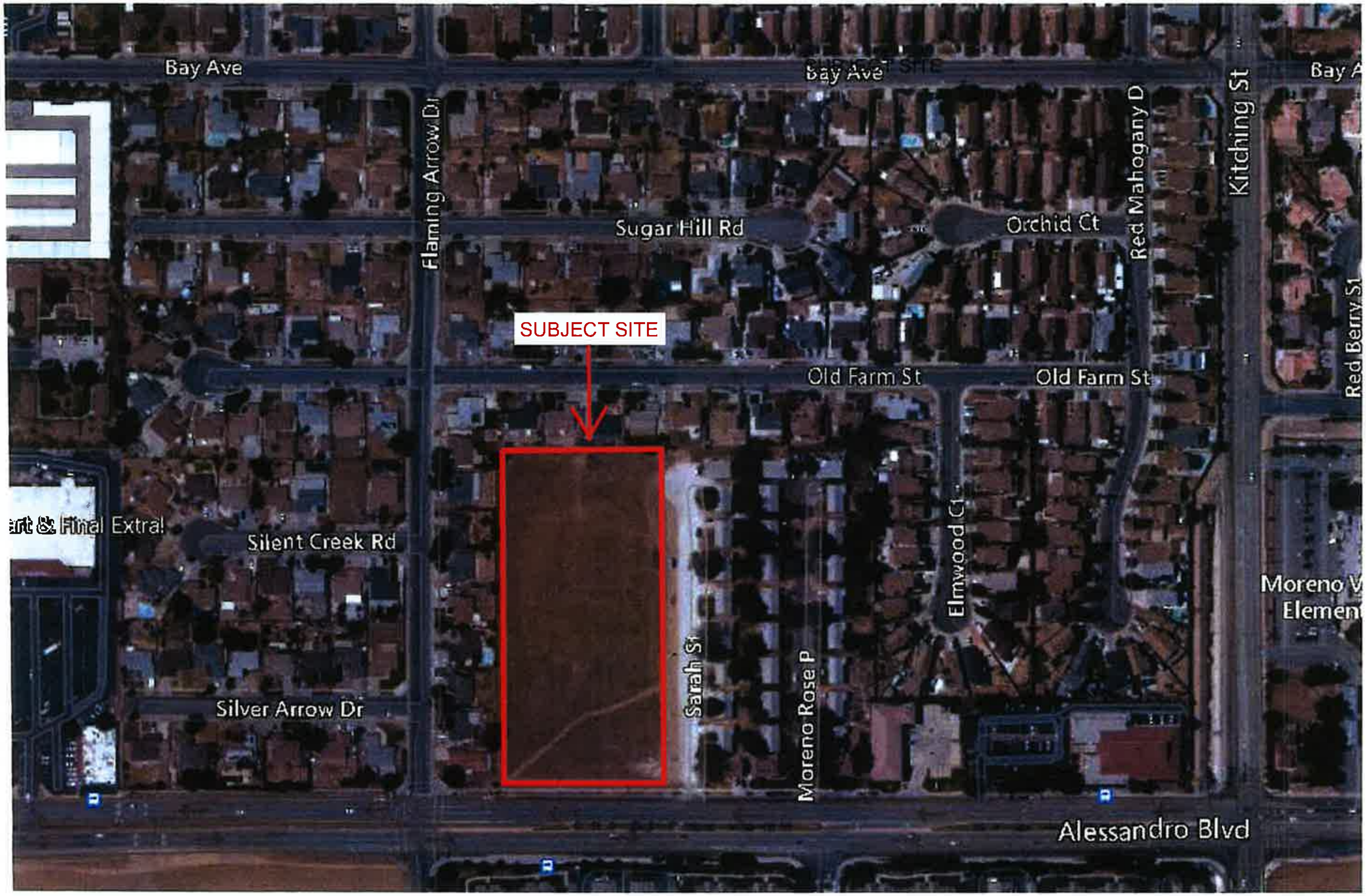
- Irrigation should be strictly controlled around building foundations, slabs and pavement and may need to be adjusted depending upon season. This control is essential to maintain a relatively uniform moisture content in the expansive soils and to prevent swelling and contracting. Over-watering adjacent to improvements may result in damage to those improvements. NorCal Engineering makes no specific recommendations regarding landscape irrigation schedules.

- Planting schemes for landscaping around structures and pavement should be analyzed carefully. Plants (including sod) requiring high amounts of water may result in excessive wetting of soils. Trees and large shrubs may actually extract moisture from the expansive soils, thus causing contraction of the fine-grained soils.

- Thickened edges on exterior slabs will assist in keeping excessive moisture from entering directly beneath the concrete. A six-inch thick or greater deepened edge on slabs may be considered. Underlying interior and exterior slabs with 6 to 12 inches or more of non-expansive soils and providing presaturation of the underlying clayey soils as recommended in the soil report will improve the overall performance of on-grade slabs.

- Increase the amount of steel reinforcing in concrete slabs, foundations and other structures to resist the forces of expansive soils. The precise amount of reinforcing should be determined by the appropriate design engineers and/or architects.

- Recommendations of the soil report should always be followed in the development of the project. Any recommendations regarding presaturation of the upper subgrade soils in slab areas should be performed in the field and verified by the Soil Engineer.



NorCal Engineering
SOILS AND GEOTECHNICAL CONSULTANTS

TRAN CHUNG

PROJECT: 22686-21	DATE: AUGUST 2021

VICINITY MAP

N
1" = +/- 50'

NorCal Engineering
SOILS AND GEOTECHNICAL CONSULTANTS
TRAN CHUNG

PROJECT 22686-21
DATE AUGUST 2021

SITE PLAN

List of Appendices

(in order of appearance)

Appendix A – Log of Excavations

Log of Borings T-1 to T-10

Appendix B – Laboratory Tests

Table I – Maximum Dry Density
Table II – Expansion
Table III – Atterberg Limits
Table IV - Corrosion
Plate A – Direct Shear
Plates B and C - Consolidation

Appendix C Seismic Design

ASCE Seismic Hazards Report

Moreno Valley Geological Faults and Liquefaction Map

Appendix D – Soil Infiltration

Soil Infiltration Data

Appendix A
Log of Excavations

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22686-21

Log of Trench T-1

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith- ology	Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	▨	FILL Clayey silty SAND with occasional gravel, concrete Brown, medium stiff, dry					
	▨	NATURAL Silty sandy CLAY Brown, stiff, damp					
5		Trench completed at depth of 5'					
10							
15							
20							
25							
30							
35							

GWT not encountered

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Log of Trench T-2

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith- ology		Material Description	Samples		Laboratory		
				Type	Blow Counts	Moisture	Dry Density	Fines Content %
0		GWT not encountered	FILL Clayey silty SAND with occasional rootlets Brown, medium stiff, dry					
			NATURAL Silty sandy CLAY Brown, stiff, damp					
5								
			Silty (fine to coarse grained) SAND with occasional gravel Brown, dense, moist					
10			Trench completed at depth of 10'					
15								
20								
25								
30								
35								

Tran Chung
22686-21

Log of Trench T-3

Boring Location: Alessandro & Flaming Arrow, Moreno Valle
Date of Drilling: 7/23/21
Groundwater Depth: None Encountered
Drilling Method: Backhoe
Hammer Weight:
Drop:
Surface Elevation: Not Measured

Depth (feet)	Lith-ology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	Fines Content %
0	▨	FILL Clayey silty SAND with occasional gravel, rootlets Brown, medium stiff, dry	▽ ■		4.1	117.1	
	▨	NATURAL Silty sandy CLAY Brown, medium stiff, damp					
5	▨		■		6.0	111.0	
10	▨		■		6.5	92.8	
	▩	Silty (fine to coarse grained) SAND with occasional gravel Brown, dense, moist					
	▨	Silty CLAY Brown, stiff, moist					
15	▨		■		11.9	105.5	
		Trench completed at depth of 16'					
20							
25							
30							
35							

GWT not encountered

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog4\PROJECT\22686-21.log Date: 8/24/2021

Tran Chung
22686-21

Log of Trench T-4

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith-ology		Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	▨	GWT not encountered	FILL Clayey silty SAND with occasional rootlets Brown, soft, dry	■		2.0	108.1	
	▨		NATURAL Silty sandy CLAY Brown, medium stiff, dry to damp					
5								
10			Trench completed at depth of 10'					
15								
20								
25								
30								
35								

Tran Chung
22686-21

Log of Trench T-5

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21 | **Groundwater Depth: None Encountered**

Drilling Method: Backhoe

Hammer Weight: | **Drop:**

Surface Elevation: Not Measured

GWT not encountered

Depth (feet)	Lith-ology	Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	▨	FILL Clayey silty SAND with occasional gravel, rootlets Brown, soft, dry					
5	▨	NATURAL Silty sandy CLAY Brown, stiff, damp	■		3.4	111.3	
10	▨	Sandy CLAY Brown, stiff, damp	■		8.6	106.6	
	▨	Silty CLAY Brown, stiff, damp	▯		8.5		
		Trench completed at depth of 12.5'					
15							
20							
25							
30							
35							

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Log of Trench T-6

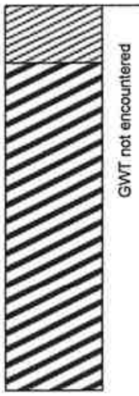
Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21
Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:
Drop:

Surface Elevation: Not Measured



Depth (feet)	Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	FILL Clayey silty SAND with occasional gravel, concrete Brown, soft, dry	■		6.2	111.9	
	NATURAL Silty sandy CLAY Brown, stiff, damp					
5		■		5.5	117.9	
10	Trench completed at depth of 10'					
15						
20						
25						
30						
35						

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog4\PROJECT\22686-21.log Date: 8/24/2021

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Tran Chung
22686-21

Log of Trench T-7

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

GWT not encountered

Depth (feet)	Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	FILL Clayey silty SAND with occasional rootlets Brown, soft, dry					
	NATURAL Silty sandy CLAY Brown, stiff, damp					
5		■		3.6	114.3	
	Silty (fine to coarse grained) SAND with occasional gravel Brown, dense, damp					
10						

Trench completed at depth of 11'

15

20

25

30

35

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Tran Chung
22686-21

Log of Trench T-8

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith- ology		Material Description	Samples: Type	Samples: Blow Counts	Laboratory: Moisture	Laboratory: Dry Density	Laboratory: Fines Content %
0	▨	GWT not encountered	FILL Clayey silty SAND with occasional gravel, rootlets Brown, medium stiff, dry					
	▨		NATURAL Silty sandy CLAY Brown, stiff, damp	■		4.9	114.3	
5			Trench completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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22686-21

Log of Trench T-9

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith- ology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	Fines Content %
0	▨	FILL Clayey silty SAND with occasional gravel Brown, medium stiff, dry					
	▨	GWT not encountered NATURAL Silty sandy CLAY Brown, medium stiff, damp					
5	▨		■		4.4	111.8	
10	▨	Silty (fine to coarse grained) SAND with occasional gravel Brown, dense, damp Trench completed at depth of 10'					
15							
20							
25							
30							
35							

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22686-21

Log of Trench T-10

Boring Location: Alessandro & Flaming Arrow, Moreno Valle

Date of Drilling: 7/23/21

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lith-ology		Material Description	Samples		Laboratory		
				Type	Blow Counts	Moisture	Dry Density	Fines Content %
0	▨	GWT not encountered	FILL Clayey silty SAND with occasional rootlets Brown, medium stiff, dry	■		1.3	116.7	
	▨		NATURAL Silty sandy CLAY Brown, stiff, dry to damp	■		4.7	114.6	
5			Trench completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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Appendix B
Laboratory Tests

TABLE I
MAXIMUM DENSITY TESTS

Sample	Classification	Optimum Moisture (%)	Maximum Dry Density (lbs/cu.ft)
T3 @ 1'	Silty Sandy CLAY	10.5	128.0

TABLE II
EXPANSION TESTS

Sample	Classification	Expansion Index
T3 @ 1'	Silty Sandy CLAY	33

TABLE III
ATTERBERG LIMITS

Sample	Liquid Limit	Plastic Limit	Plasticity Index
T-3 @ 5'	18	17	1
T-3 @ 10'	26	17	9

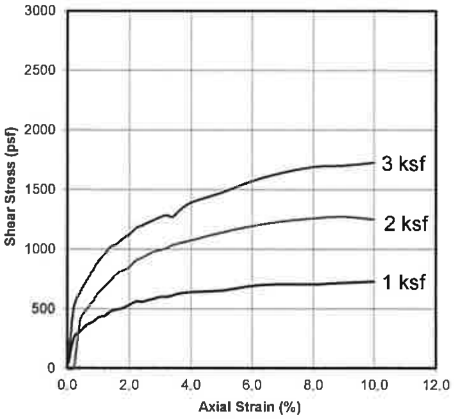
TABLE IV
CORROSION TESTS

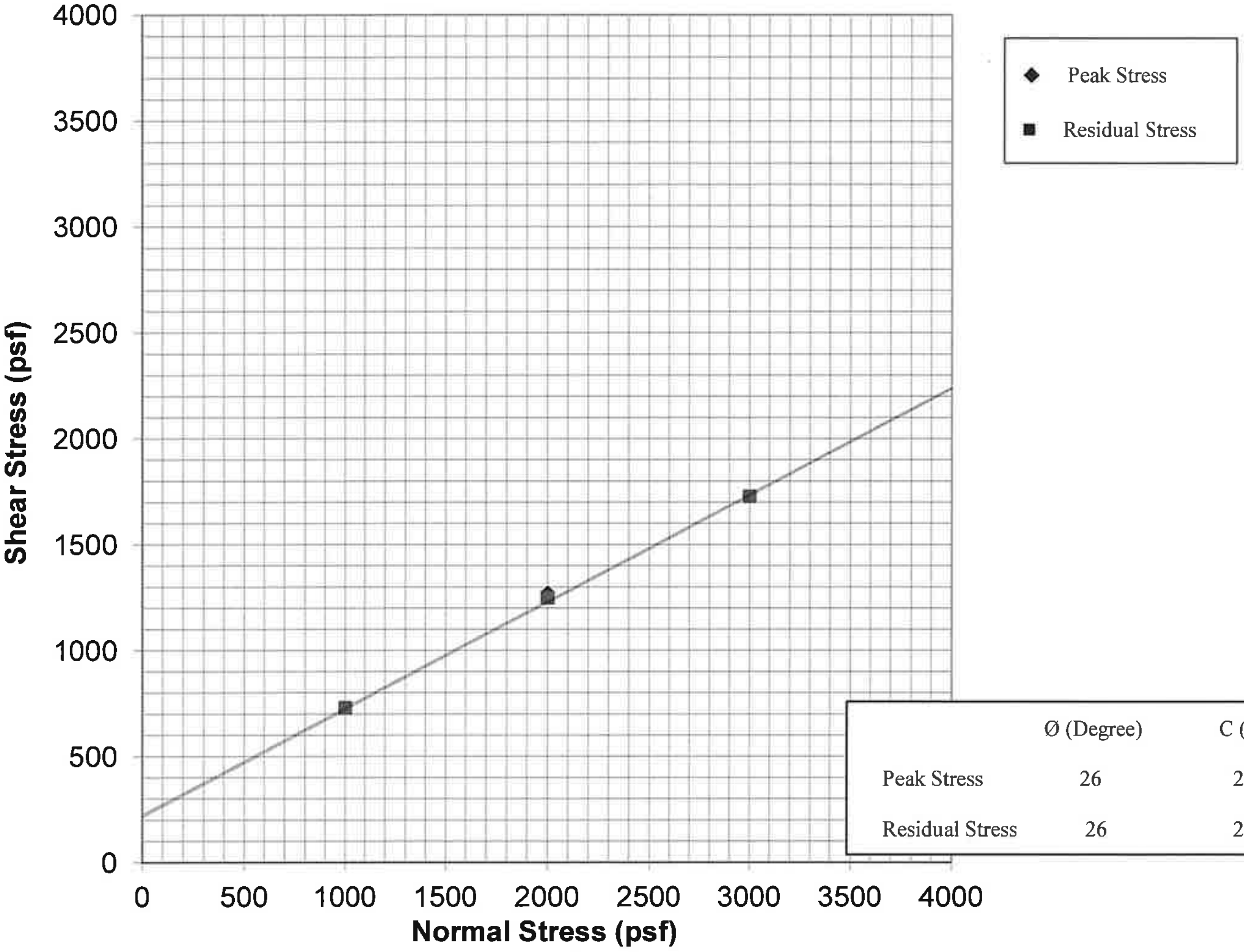
Sample	pH	Electrical Resistivity	Sulfate (%)	Chloride (ppm)
T-3 @ 1'	7.0	15,320	N.D.	111

% by weight
ppm – mg/kg
N.D. = Non-Detect

Sample No. T6@2'
Sample Type: Undisturbed/Saturated
Soil Description: Silty Sandy Clay

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	730	1273	1728
Displacement	(in)	0.250	0.225	0.250
Residual Stress	(psf)	730	1250	1728
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	111.9	111.9	111.9
In Situ Water Content	(%)	6.2	6.2	6.2
Saturated Water Content	(%)	18.7	18.7	18.7
Strain Rate	(in/min)	0.020	0.020	0.020





	Ø (Degree)	C (psf)
Peak Stress	26	225
Residual Stress	26	215

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SOILS AND GEOTECHNICAL CONSULTANTS

Tran Chung

PROJECT NUMBER: 22686-21 DATE: 8/17/2021

DIRECT SHEAR TEST

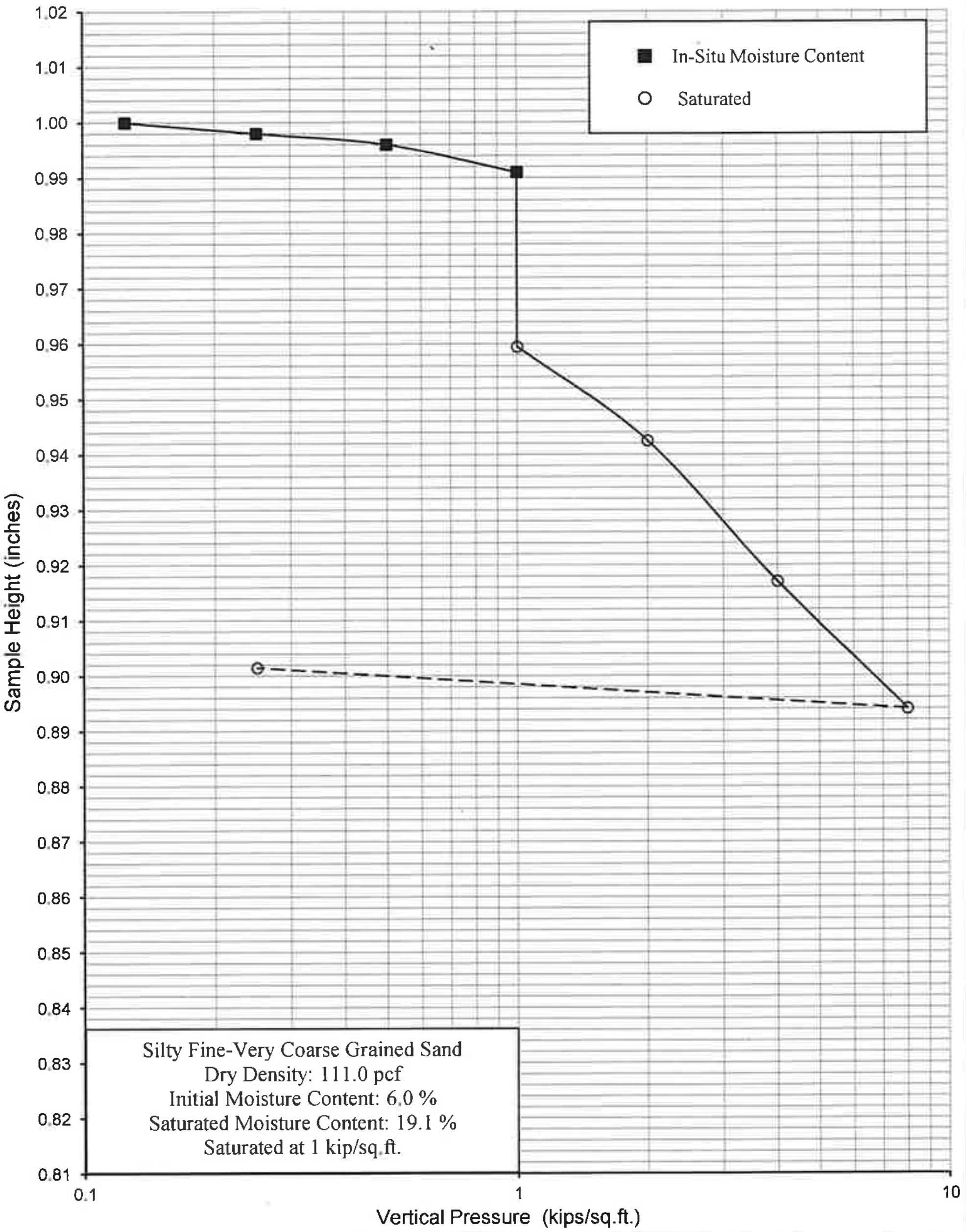
ASTM D3080

Plate A

Sample No. T3 | Depth 5' | Date 8/17/2021

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)	
0.125	1.0000	0.0	
0.25	0.9980	0.2	
0.5	0.9960	0.4	
1	0.9910	0.9	
1	0.9595	4.1	Saturated
2	0.9425	5.8	
4	0.9170	8.3	
8	0.8940	10.6	
0.25	0.9015	9.9	

Date Tested: 8/12/2021
Sample: T3
Depth: 5'



Silty Fine-Very Coarse Grained Sand
Dry Density: 111.0 pcf
Initial Moisture Content: 6.0 %
Saturated Moisture Content: 19.1 %
Saturated at 1 kip/sq.ft.

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Tran Chung

PROJECT NUMBER: 22686-21 DATE: 8/17/2021

CONSOLIDATION TEST

ASTM D2435

Plate B

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)
0.125	1.0000	0.0
0.25	0.9980	0.2
0.5	0.9960	0.4
1	0.9940	0.6
1	0.9480	5.2
2	0.9260	7.4
4	0.8920	10.8
8	0.8600	14.0
0.25	0.8790	12.1

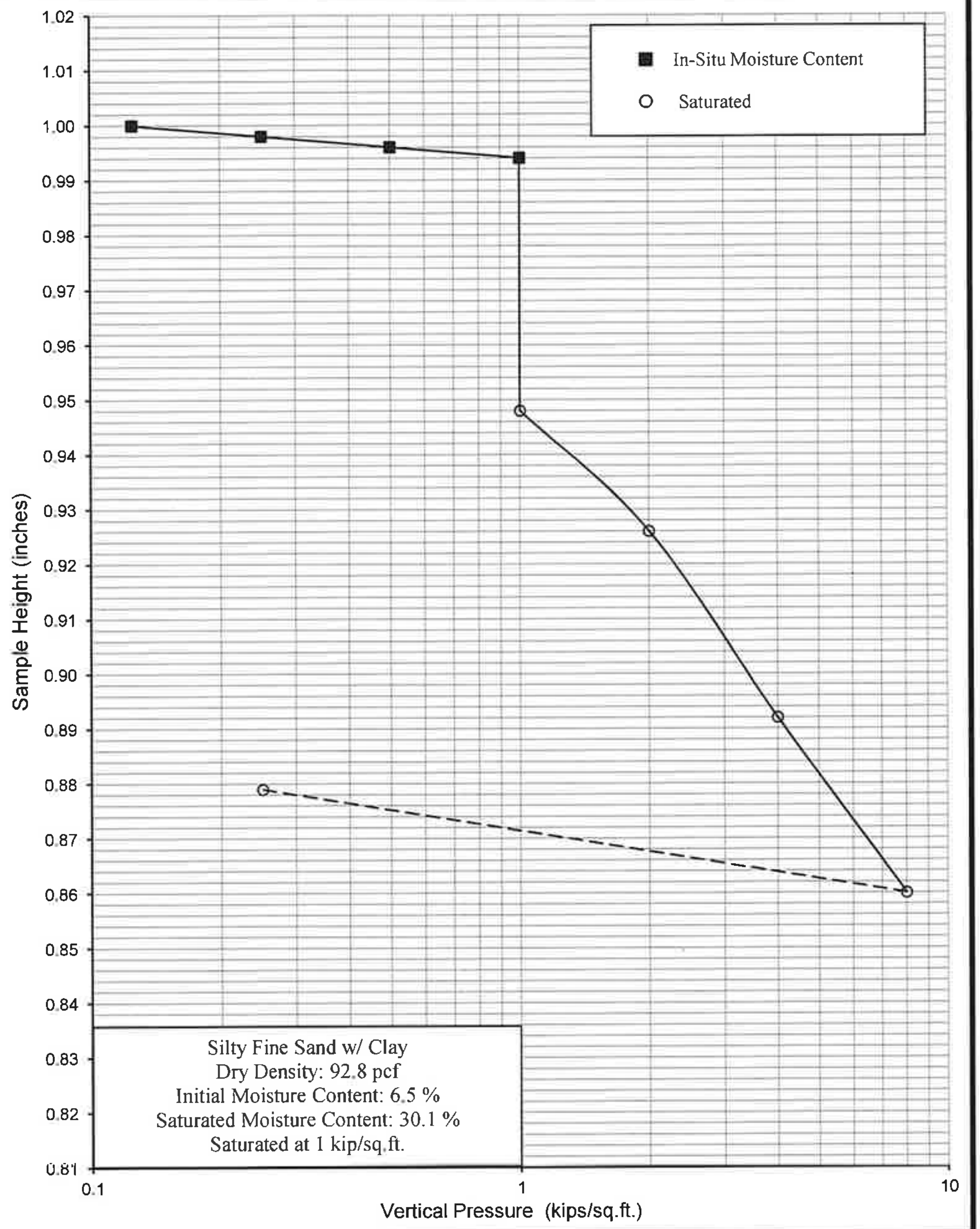
Saturated

Sample No. T3

Depth 10'

Date 8/17/2021

Date Tested: 8/12/2021
Sample: T3
Depth: 10'



Silty Fine Sand w/ Clay
Dry Density: 92.8 pcf
Initial Moisture Content: 6.5 %
Saturated Moisture Content: 30.1 %
Saturated at 1 kip/sq.ft.

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Tran Chung

PROJECT NUMBER: 22686-21 DATE: 8/17/2021

CONSOLIDATION TEST

ASTM D2435

Plate C

R-VALUE TEST REPORT

☑ CT-301 ☐ ASTM-D2844

PROJECT NAME: Norcal: Tran Cheng 22686-21

PROJECT NUMBER: L-210801

SAMPLE LOCATION: N of Alessandro Boulevard and E of Flaming Arrow Drive, Moreno Valley

SAMPLE NUMBER: T1

SAMPLE DESCRIPTION: CLAYEY SAND (SC), brown

SAMPLE DEPTH: 2'

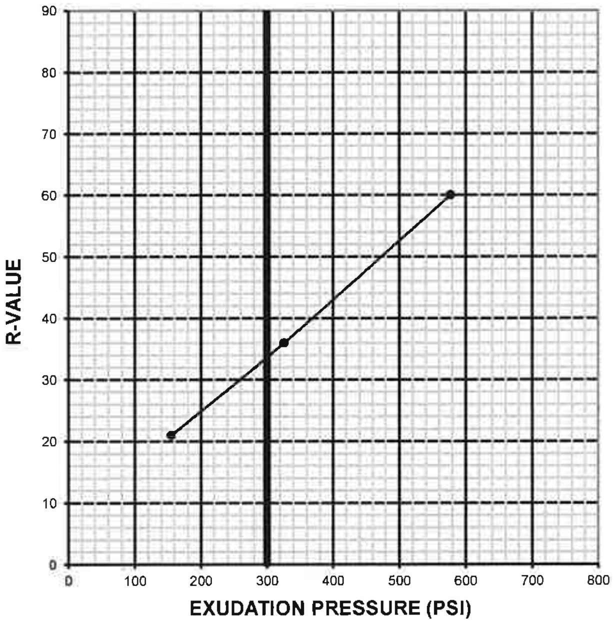
SAMPLED BY: Norcal 7/23/21

TESTED BY: ER

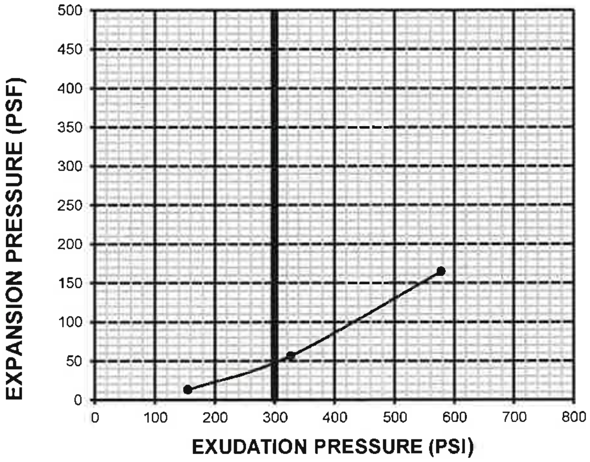
DATE TESTED: 8/8/2021

TEST SPECIMEN	A	B	C
MOISTURE AT COMPACTION %	8.7	9.7	10.7
WEIGHT OF SAMPLE, grams	1042	1086	1124
HEIGHT OF SAMPLE, Inches	2.33	2.35	2.48
DRY DENSITY, pcf	124.8	127.7	124.1
COMPACTOR AIR PRESSURE, psi	280	220	130
EXUDATION PRESSURE, psi	577	326	155
EXPANSION, Inches x 10exp-4	38	13	3
STABILITY Ph 2,000 lbs (160 psi)	40	72	100
TURNS DISPLACEMENT	4.07	4.68	5.80
R-VALUE UNCORRECTED	65	40	21
R-VALUE CORRECTED	60	36	21
EXPANSION PRESSURE (psf)	164.2	56.2	13.0

R-VALUE VS. EXUDATION PRESSURE



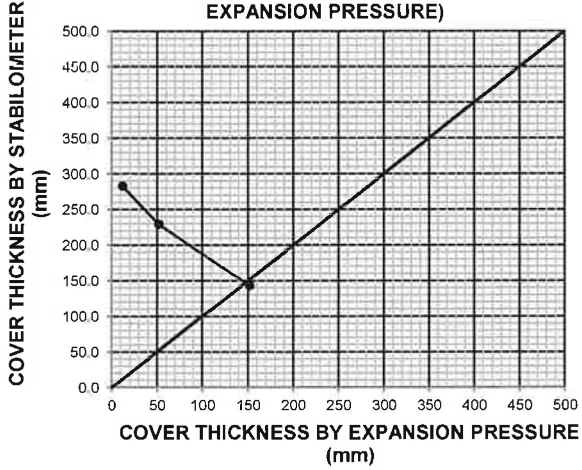
EXPANSION PRESSURE VS. EXUDATION PRESSURE



R-VALUE AT EQUILIBRIUM:	33

R-VALUE BY EXUDATION PRESSURE:	33
R-VALUE BY EXPANSION PRESSURE:	58
EXPANSION PRESSURE AT 300 PSI EXUDATION:	45
TRAFFIC INDEX (Assumed):	5.5
GRAVEL FACTOR (Assumed):	1.5
UNIT MASS OF COVER MATERIAL, kg/m^3 (Assumed):	2100.0

COVER THICKNESS (STABILOMETER BY EXPANSION PRESSURE)



Appendix C
Seismic Hazard Report

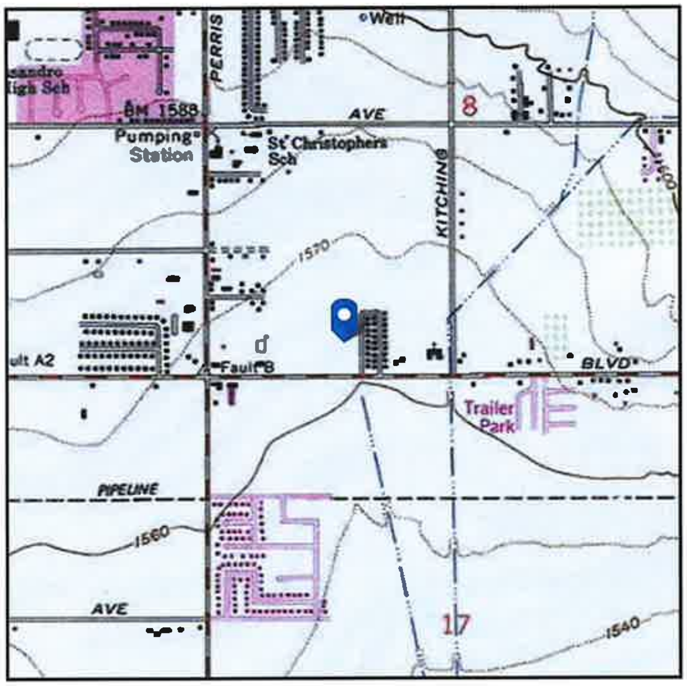
ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard: ASCE/SEI 7-16
Risk Category: II
Soil Class: D - Stiff Soil

Elevation: 1566.66 ft (NAVD 88)
Latitude: 33.918062
Longitude: -117.221483



Seismic

Site Soil Class: D - Stiff Soil

Results:

S_S :	1.653	S_{D1} :	N/A
S_1 :	0.644	T_L :	8
F_a :	1	PGA :	0.7
F_v :	N/A	PGA_M :	0.77
S_{MS} :	1.653	F_{PGA} :	1.1
S_{M1} :	N/A	I_e :	1
S_{DS} :	1.102	C_v :	1.431

Ground motion hazard analysis may be required. See ASCE/SEI 7-16 Section 11.4.8.

Data Accessed: Wed Aug 25 2021

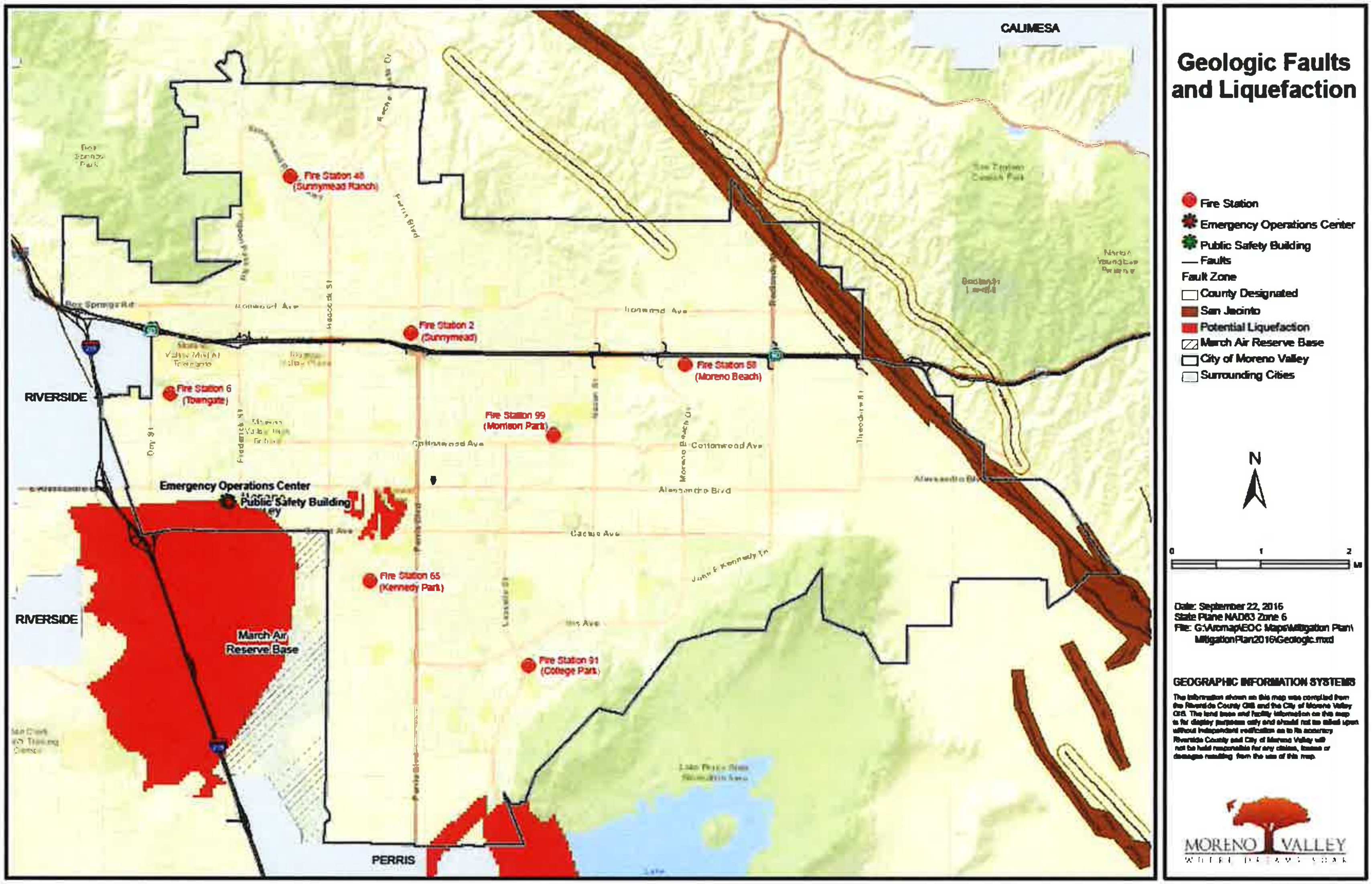
Date Source: USGS Seismic Design Maps

The ASCE 7 Hazard Tool is provided for your convenience, for informational purposes only, and is provided "as is" and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE 7 standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

ASCE does not intend, nor should anyone interpret, the results provided by this Tool to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this Tool or the ASCE 7 standard.

In using this Tool, you expressly assume all risks associated with your use. Under no circumstances shall ASCE or its officers, directors, employees, members, affiliates, or agents be liable to you or any other person for any direct, indirect, special, incidental, or consequential damages arising from or related to your use of, or reliance on, the Tool or any information obtained therein. To the fullest extent permitted by law, you agree to release and hold harmless ASCE from any and all liability of any nature arising out of or resulting from any use of data provided by the ASCE 7 Hazard Tool.

Figure 4-1.1: Moreno Valley Geologic Faults and Liquefaction



Appendix D
Soil Infiltration Data

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ENGINEERING

SOILS AND GEOTECHNICAL CONSULTANTS

Project: Tran Chung
Project No.: 22686-21
Date: 7/23/2021
Test No. 1
Depth: 5’
Tested By: D.L.

TIME (hr/min)	CHANGE TIME (min)	CUMULATIVE TIME (min)	INNER RING READING (cm)	INNER RING CHANGE	INNER RING FLOW (cc)	OUTER RING READING (cm)	OUTER RING CHANGE	OUTER RING FLOW (cc)	INNER RING INF RATE (cm/hr)	OUTER RING INF RATE (cm/hr)	INNER RING INF RATE (ft/hr)
7:58			100.7			37.6					
8:13	15	15	101.6	0.9		38.1	0.5				
8:13			101.6			38.1					
8:28	15	30	102.6	1.0		38.6	0.5				
8:28			102.6			38.6					
8:43	15	45	103.6	1.0		39.3	0.7				
8:43			103.6			39.3					
8:58	15	60	104.4	0.8		40.0	0.7				
8:58			104.4			40.0					
9:13	15	75	105.1	0.7		40.6	0.6				
9:13			105.1			40.6					
9:28	15	90	105.9	0.8		41.1	0.5				
9:28			105.9			41.1					
9:43	15	105	106.6	0.7		41.7	0.6		2.8	2.4	
9:43			104.2			40.6					
9:58	15	120	104.6	0.4		41.1	0.5		1.6	2.0	
9:58			104.6			41.1					
10:13	15	135	104.9	0.3		41.5	0.4		1.2	1.6	
10:13			104.9			41.5					
10:28	15	150	105.2	0.3		41.9	0.4		1.2	1.6	
10:28			105.2			41.9					
10:43	15	165	105.4	0.2		42.3	0.4		0.8	1.6	
10:43			105.4			42.3					
10:58	15	180	105.2	0.3		42.9	0.6		1.2	2.4	

Average = 1.46 / 1.93 cm/hr

NORCAL
ENGINEERING

SOILS AND GEOTECHNICAL CONSULTANTS

Project: Tran Chung
Project No.: 22686-21
Date: 7/23/2021
Test No. 2
Depth: 10'
Tested By: D.L.

TIME (hr/min)	CHANGE TIME (min)	CUMULATIVE TIME (min)	INNER RING READING (cm)	INNER RING CHANGE	INNER RING FLOW (cc)	OUTER RING READING (cm)	OUTER RING CHANGE	OUTER RING FLOW (cc)	INNER RING INF RATE (cm/hr)	OUTER RING INF RATE (cm/hr)	INNER RING INF RATE (ft/hr)
9:09			132.1			42.0					
9:24	15	15	132.5	0.4		43.0	1.0				
9:24			132.5			43.0					
9:39	15	30	133.0	0.5		43.8	0.8				
9:39			133.0			43.8					
9:54	15	45	133.6	0.6		44.7	0.9				
9:54			133.6			44.7					
10:09	15	60	134.2	0.6		45.5	0.8				
10:09			134.2			45.5					
10:24	15	75	134.4	0.2		46.1	0.6				
10:24			134.4			46.1					
10:39	15	90	137.7	0.3		46.8	0.7				
10:39			137.7			46.8					
10:54	15	105	138.1	0.4		47.5	0.7		1.6	2.8	
10:54			138.1			47.5					
11:09	15	120	138.5	0.4		48.1	0.6		1.6	2.4	
11:09			138.5			48.1					
11:24	15	135	138.8	0.3		48.8	0.7		1.2	2.8	
11:24			128.8			41.2					
11:39	15	150	129.1	0.3		42.1	0.9		1.2	3.6	
11:39			129.1			42.1					
11:54	15	165	129.6	0.6		42.9	0.8		2.4	3.2	
11:54			129.6			42.9					
12:09	15	180	130.0	0.4		43.5	0.6		1.6	2.4	

Average = 1.6 / 2.86 cm/hr