

**GEOTECHNICAL INVESTIGATION**  
Proposed Warehouse Development  
Northwest Corner Orange Show Road/South Lena Road  
San Bernardino, California

PSIP WR ORANGE SHOW, L.P.  
c/o Western Realco  
500 Newport Center Drive, Suite 630  
Newport Beach, California 92660

Project Number 17917-15  
June 3, 2015

**NorCal Engineering**

**NorCal Engineering**  
SOILS AND GEOTECHNICAL CONSULTANTS  
10641 HUMBOLT STREET LOS ALAMITOS, CA 90720  
(562)799-9469 FAX (562)799-9459

June 3, 2015

Project Number 17917-15

PSIP WR ORANGE SHOW, L.P.  
c/o Western Realco  
500 Newport Center Drive, Suite 630  
Newport Beach, California 92660

Attn: Jeremy Mape

RE: **GEOTECHNICAL INVESTIGATION** – Proposed Warehouse Development – Located at the northwest Corner of Orange Show Road and South Lena Road, in the City of San Bernardino, California

Dear Mr. Mape:

Pursuant to your request, this firm has performed a Geotechnical Investigation for the above referenced project. The purpose of this investigation is to evaluate the geotechnical conditions of the subject site and to provide recommendations for the proposed development. This geotechnical engineering report presents the findings of our study along with conclusions and recommendations for development.

## **1.0 STRUCTURAL CONSIDERATIONS**

### **1.1 Proposed Development**

It is proposed to develop the 14.64-acre site with two new concrete tilt-up buildings totaling approximately 268,705 square feet along with pavement and landscape areas. The attached Figure 1 provides the limits of the parcels that comprise the full 14.64 acres; the acquisition of some of these parcels is on-going at the date of this report. Grading for the future development will include cut and fill procedures. 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**

- 2.1 **Location:** The generally rectangular shaped property is located at the northwest corner of Orange Show Road and South Lena Road, in the City of San Bernardino, as shown on the attached Figure 2. Norman Road borders along the north and Waterman Avenue is located further to the west.
- 2.2 **Existing Improvements:** The property largely vacant and covered with low vegetation, some trees and scattered debris. Single family homes are located along Orange Show Road (1 home) and Norman Road (2 homes).
- 2.3 **Drainage:** Drainage of the relatively level site appears to sheetflow toward the south.

## **3.0 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 following seismic design parameters are provided and are in accordance with the 2013 California Building Code (CBC) as determined using the USGS Seismic Design tool (<http://geohazards.usgs.gov/designmaps/us/application.php>) for the referenced project.

Seismic Design Parameters

Site Location – Region 1	Latitude	34.0804°
	Longitude	-117.2737°
Seismic Use Group		II
Site Class		D
Risk Category		I/II/III
Maximum Spectral Response Acceleration	S <sub>S</sub>	2.297g
	S <sub>1</sub>	1.049g
Adjusted Maximum Acceleration	S <sub>MS</sub>	2.297g
	S <sub>M1</sub>	1.573g
Design Spectral Response Acceleration Parameters	S <sub>DS</sub>	1.531g
	S <sub>D1</sub>	1.049g

The site is located within a seismically active area and a peak ground acceleration of 0.884g (*USGS Design Maps – Detailed Report, ASCE 7-10 Standard 34.0804°N, 117.2737°W*) may occur from a Magnitude 6.7 earthquake along the San Jacinto fault zone, which is located approximately 3.5 kilometers southwest of the subject property. The San Andreas (M 7.4) fault is located 10.5 kilometers to the northeast. The seismic design printout is included in Appendix A.

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.

**4.0 FIELD INVESTIGATION**

**4.1 Site Exploration**

The purpose of the investigation was to explore the subsurface conditions and to provide preliminary geotechnical engineering design parameters for evaluation of the site with respect to the proposed development.

The investigation consisted of the placement of two subsurface exploratory borings by hollow-stem auger drill rig to a maximum depth of 51.5 feet below current ground elevations. The investigation was supplemented with thirteen excavations by backhoe. The explorations were placed at accessible locations on the site.

The explorations were visually classified and logged by a field engineer with locations of the subsurface explorations shown on the attached Figure 3 which depicts the currently proposed development. Detailed descriptions of the subsurface conditions are listed on the boring logs in Appendix B. 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/Disturbed Top Soils** – Fill and disturbed top soils classifying as silty SAND with some gravel and roots were encountered in the borings to depths ranging from 12 to 18 inches below existing surface. These fill soils were noted to be generally loose and damp.

**Native Soils** – Native soils generally classifying as silty SAND were encountered beneath the upper fill soils. These soils were noted to be medium dense to and damp. Sand, silt and clay content varied significantly with depth of borings. Caving occurred in some of the test pits due to cohesionless sandy soils.

#### 4.2 Groundwater

Groundwater was encountered at approximate depths of 27 and 31 feet in borings B-1 and B-2, respectively. Research of the *State of California Water Data Library*, ([www.water.ca.gov/waterdatalibrary/groundwater](http://www.water.ca.gov/waterdatalibrary/groundwater)), indicates a historic high groundwater level of 28 feet below ground surface in the vicinity.

## **5.0 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.

Standard penetration tests were obtained by driving a steel sampler lined with six-inch long brass rings with an inside diameter of 1.5 inches into the soils. This standard penetrometer sampler was driven a total of 18 inches with blow counts tallied every 6 inches. Blow count data is given on the Boring Logs in Appendix A.

Bulk bag samples were obtained in the upper soils for expansion index tests, corrosion tests and maximum density tests. Wall loadings on the order of 4,000 lbs./lin.ft. and maximum compression loads on the order of 100 kips were utilized for testing and design purposes. All test results are included in Appendix C, unless otherwise noted.

- 5.1 **Field moisture content** (ASTM:D 2216-05) and the dry density of the ring samples were determined in the laboratory. This data is listed on the logs of explorations.
- 5.2 **Maximum density tests** (ASTM: D-1557-07) were performed on typical samples of the upper soils. Results of these tests are shown on Table I.
- 5.3 **Expansion index tests** (ASTM: D-4829-07) were performed on remolded samples of the upper soils to determine the expansive characteristics and to provide any necessary recommendations for reinforcement of the slabs-on-grade and the foundations. Results of these tests are provided on Table II and are discussed later in this report.

- 5.4 **Atterberg Limits** (ASTM: D 4318-05) consisting of liquid limit, plastic limit and plasticity index were performed on selected soil samples. Results are shown on Table III.
- 5.5 **Sieve analyses** and the percent by weight of soil finer than the No. 200 sieve (ASTM: 1140-00) were performed on selected soil samples. These results are detailed later in this report along with discussion of the liquefaction potential at the site.
- 5.6 **Direct shear tests** (ASTM: D-3080-04) were performed on undisturbed and disturbed samples of the subsurface soils. These tests were performed to determine parameters for the calculation of the safe bearing capacity. 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 Plates A-C.
- 5.7 **Consolidation tests** (ASTM: D-2435-04) 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 D-F.
- 5.8 **Soluble sulfate, pH, Resistivity and Chloride tests** to determine potential corrosive effects of soils on concrete and metal structures were performed in the laboratory. Test results are given in Tables IV - VII.
- 5.9 **Resistance 'R' Value tests** (CA 301) were conducted on a representative soil sample to determine preliminary pavement section design for the proposed pavement areas. Test results are provided in Table VIII and recommended pavement sections are provided later within the text of this report.

## 6.0 LIQUEFACTION EVALUATION

The site lies within areas mapped as potentially liquefiable by San Bernardino County as detailed in their *General Plan – Geologic Hazard Overlays*, Figure FH30. The liquefaction potential of the property has been assessed using information obtained from our two deep borings.

The site is expected to experience ground shaking and earthquake activity that is typical of Southern California area. It is during severe ground shaking that loose, granular soils below the groundwater table can liquefy. A review of the exploratory boring logs B-1 and B-2 and the laboratory test results on selected soil samples obtained indicate the following soil classifications, field blowcounts and amounts of fines passing through the No. 200 sieve.

**Field Blowcount and Gradation Data – Boring B-1**

<u>Location</u>	<u>Classification</u>	<u>Blowcounts (blows/ft)*</u>	<u>Relative Density</u>	<u>% Passing No. 200 Sieve</u>
B-1 @ 5'	SM	5	Med. Dense	6
B-1 @ 10'	SM	11	Med. Dense	6
B-1 @ 15'	SW	33	Dense	4
B-1 @ 20'	SW	46	Very Dense	5
B-1 @ 25'	SM	37	Very Dense	6
B-1 @ 30'	ML	14	Stiff	56
B-1 @ 35'	SM	35	Dense	21
B-1 @ 40'	SM	26	Dense	11
B-1 @ 45'	SM	42	Very Dense	44
B-1 @ 50'	CL	49	Very Stiff	88

**Field Blowcount and Gradation Data – Boring B-2**

<u>Location</u>	<u>Classification</u>	<u>Blowcounts (blows/ft)*</u>	<u>Relative Density</u>	<u>% Passing No. 200 Sieve</u>
B-2 @ 5'	SM	4	Med. Dense	29
B-2 @ 10'	SM	13	Med. Dense	6
B-2 @ 15'	SM	16	Med. Dense	10
B-2 @ 20'	SM	10	Med. Dense	34
B-2 @ 25'	CL	10	Med. Stiff	88
B-2 @ 30'	ML	25	Stiff	76
B-2 @ 35'	SM	25	Dense	17
B-2 @ 40'	SM	21	Dense	8
B-2 @ 45'	SM	16	Stiff	97
B-2 @ 50'	ML	54	Very Stiff	22

Our liquefaction evaluation based upon results from borings B-1 and B-2, indicates the potential for liquefaction at this site is low due to a historic high groundwater level of 27 feet below grade and dense soil conditions below that level. Based on a Magnitude 6.7 earthquake with a peak ground acceleration of 0.884g at the site, seismic-induced settlements should be on the order of  $\frac{3}{4}$  inch. These settlements should occur rather uniformly across the lot with differential settlements on the order of  $\frac{1}{2}$  inch or less over a 50 feet (horizontal) distance in the building pad area. Our liquefaction analysis is included in Appendix D.

## **7.0 CONCLUSIONS AND RECOMMENDATIONS**

Based upon our evaluations, the proposed development is acceptable from a geotechnical engineering standpoint. The structures and grading will be safe from future landslides, slippage and settlements under the anticipated design loadings and conditions. The proposed development shall meet all requirements of the City/County Building Ordinance and will not impose any adverse geologic effect on existing adjacent land or 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.

## 7.1 Site Grading Recommendations

It is recommended that site inspections be 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. Any unusual conditions which may be encountered in the course of the project development may require the need for additional study and revised recommendations.

Any vegetation shall be removed and hauled from proposed grading areas 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 Placement of Compacted Fill*.

### 7.1.1 Removal and Recomposition Recommendations

The upper 18 inches of existing fill soils across the site shall be removed to competent native materials, the exposed surface scarified to a depth of 8 inches, brought to within 2% of optimum moisture content and compacted to a minimum of 90% of the laboratory standard (ASTM: D-1557-07) prior to placement of any additional compacted fill soils and pavement. The upper 12 inches of soils beneath building slabs shall be compacted to a minimum of 95% relative compaction. Grading shall extend a minimum of 5 horizontal feet outside the edges of foundations or equidistant to the depth of fill placed, whichever is greater. 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.

It is likely that isolated areas of undiscovered fill, subsurface structures and utility lines not described in this report or materials disturbed during demolition operations will be encountered during site grading. If found, these areas should be excavated and backfilled as discussed earlier. If encountered, any structures and lines shall be either removed or properly abandoned prior to the proposed construction. Abandonment procedures will be provided once underground structures are encountered.

If placement of slabs-on-grade and pavement is not performed 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.

#### **7.1.2 Fill Blanket Recommendations**

Due to the medium density of the upper native soils and the potential for differential settlement of structures supported on both compacted fill and native soils, it is recommended that all foundations and floor slabs be underlain by a uniform compacted fill blanket at least 3 feet in thickness. The fill blanket shall extend a minimum of 5 horizontal feet outside the edges of foundations or equidistant to the depth of fill placed, whichever is greater.

### **7.1.3 Shrinkage and Subsidence**

Results of our in-place density tests reveal that the soil shrinkage will be on the order of 14 to 16% due to excavation and recompaction, based upon the assumption that the fill is compacted to 92% of the maximum dry density per ASTM standards. Subsidence should be 0.15 feet due to earthwork operations. The volume change does not include any allowance for vegetation or organic stripping, removal of subsurface improvements or topographic approximations.

Although these values are only approximate, they represent our best estimate of shrinkage values which will likely occur during grading. If more accurate shrinkage and subsidence factors are needed, it is recommended that field testing using the actual equipment and grading techniques should be conducted.

### **7.2 Temporary Excavations and Shoring Design**

Temporary unsurcharged excavations less than 4 feet in height may be excavated at vertical inclinations. Excavations over 4 feet in height in the existing site materials may be trimmed at a 1 to 1 (horizontal to vertical) gradient for the entire height of the cut. 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, slot-cutting, or flatter excavations may be required.

The temporary cut slope gradients given above do not preclude local raveling and sloughing. All excavations shall be made in accordance with the requirements of the soils engineer, CAL-OSHA and other public agencies having jurisdiction.

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.

### 7.3 Foundation Design

All foundations may be designed utilizing the following allowable soil bearing capacities for embedded depths of 18 inches into dense compacted fill materials with the corresponding widths. Footings shall not traverse from compacted fill to native soils due to the potential for differential settlement of structures.

#### Allowable Soil Bearing Capacity (psf)

<u>Width (ft)</u>	<u>Continuous Foundation</u>	<u>Isolated Foundation</u>
1.5	2000	2500
2.0	2075	2575
4.0	2375	2875
6.0	2675	3175

Building foundations at property line where the compacted fill blanket is installed beneath, but not outside of the foundation may be designed using a reduced allowable soil bearing capacity of 1,500 psf. The bearing value may be increased by 500 psf for each additional foot of depth in excess of the 18-inch minimum depth, up to a maximum of 3,500 psf. A one-third increase may be used when considering short term loading from wind and seismic forces. Steel reinforcement due to soil expansion or proposed loadings may be necessary and shall be determined by the project engineers and/or architect. A representative of this firm shall observe foundation excavations prior placement of concrete.

Foundations for property line screen walls may be supported on foundations a minimum of 18 inches in depth and at least 8 inches into medium dense native soils, and shall be designed using a reduced allowable soil bearing capacity of 1,000 psf.

#### 7.4 Settlement Analysis

Resultant pressure curves for the consolidation tests are shown on Plates D-F. Computations utilizing these curves and the recommended allowable soil bearing capacities reveal that the foundations will experience normal (not seismically induced) settlements on the order of 3/4 inch and differential settlements of less than 1/4 inch over 20 feet (horizontal) in the building pad area.

#### 7.5 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 - 0.40  
Equivalent Passive Fluid Pressure = 250 lbs./cu.ft.  
Maximum Passive Pressure = 2,500 lbs./cu.ft.

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

#### 7.6 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.

<u>Surface Slope of Retained Materials (Horizontal to Vertical)</u>	<u>Equivalent Fluid Density (lb./cu.ft.)</u>
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. All walls shall be waterproofed as needed and protected from hydrostatic pressure by a reliable permanent subdrain system.

### 7.7 Floor Slab Design

Concrete floor slabs-on-grade shall be a minimum of 4 and 6 inches in thickness in office and warehouse areas, respectively, and may be placed upon fill soils compacted to a minimum of 95% relative compaction in the upper 12 inches. Additional reinforcement requirements and an increase in thickness of the slabs-on-grade may be necessary based upon soils expansion potential and proposed loading conditions in the structures and should be evaluated further by the project engineers and/or architect.

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, although 1 to 2 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.

Subgrade soils shall be moistened to at or slightly above optimum moisture levels immediately prior to pouring of concrete. All concrete slab areas to receive floor coverings should be moisture tested to meet all manufacturer requirements prior to placement.

#### **7.8 Expansive Soil**

The upper soils at the site are very low (Expansion Index = 0-20) in expansion potential. Sites with expansive soils (Expansion Index >20) require special attention during 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.

#### **7.9 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 and shaded with clean sand having a sand equivalency rating of 30 or more. This material shall be thoroughly water jetted around the pipe structure prior to placement of compacted backfill soils.

### 7.10 Corrosion Design Criteria

Representative samples of the surficial soils revealed negligible sulfate concentrations and no special concrete design recommendations are deemed necessary at this time. It is recommended that additional sulfate tests be performed at the completion of rough grading to assure that the as graded conditions are consistent with the recommendations stated in this design. Sulfate test results may be found on the attached Table IV.

Tests were also conducted on a random representative sample of soils to determine the potential corrosive effects on buried metallic structures. Tests for pH, resistivity and chloride are included on Tables IV – VII. Soil pH indicates a slightly alkaline condition. Resistivity was measured at 5370 ohm-centimeters, a condition which may be considered mildly corrosive to metallic structures. Chloride content tested at 270 ppm.

### 7.11 Preliminary Pavement Design

The table below provides a preliminary pavement design based upon a tested R-Value of 60 for the proposed pavement areas. Final pavement design should be based on R-Value testing of the subgrade soils near the conclusion of rough grading to assure that the as-graded conditions are consistent with those used in this preliminary design.

#### On-Site Flexible (Asphaltic) Pavement Section Design

<u>Type of Traffic</u>	<u>Traffic Index</u>	<u>Inches Asphalt</u>	<u>Inches Base</u>
Auto Parking/Circulation	5.0	3.0	3.0
Truck	7.0	3.5	4.0

Subgrade soils to receive base material shall be compacted to a minimum of 90% relative compaction; base material shall be compacted to at least 95%. Any concrete slab-on-grade in pavement areas shall be a minimum of 6 inches in thickness and may be placed on subgrade soils compacted to at least 95% relative compaction. An increase in slab thickness and placement of steel reinforcement due to loading conditions and soil expansion may be necessary and should be reviewed by the structural engineer.

*The above recommendations are based upon estimated traffic loadings. Client should submit anticipated traffic loadings for the pavement areas to the soils engineer, when available, so that pavement sections may be reviewed to determine adequacy to support the proposed loadings.*

## **8.0 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 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 for review 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  
Project Engineer  
R.G.E. 841

Mark A. Burkholder  
Project Manager

**NorCal Engineering**

## **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 Soils 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-1557-07).

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. Verification of elevations during grading operations will be the responsibility of the owner or his designated representative.

### **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 Soils 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 Soils Engineering firm. Each lift shall be compacted to a minimum of 90% relative compaction (in accordance with ASTM: D-1557-07) and approved prior to the placement of the next layer of soil. Compaction tests shall be obtained at the discretion of the Soils 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 Soils 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 Soils 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 Soils 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.

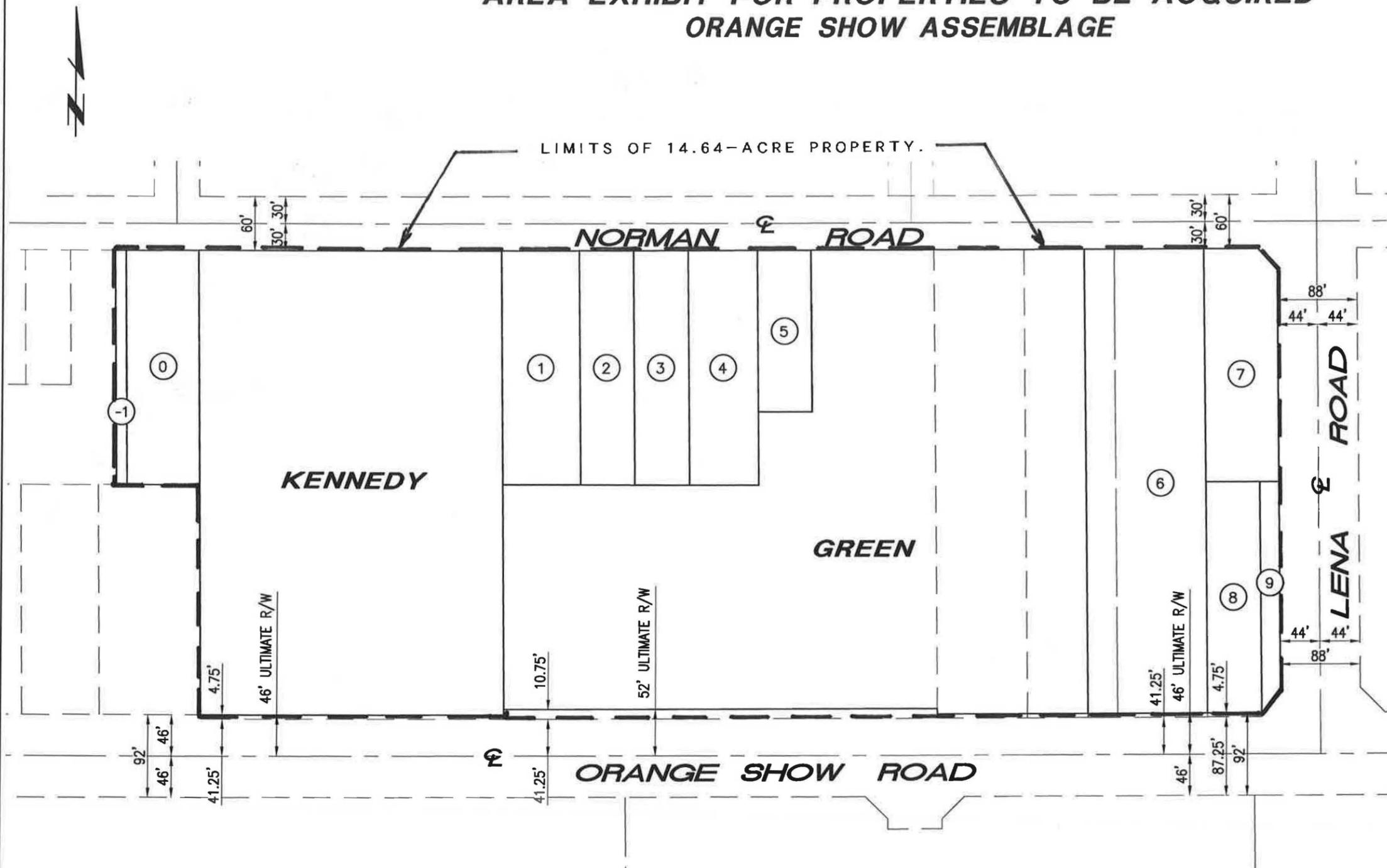
Excessive drying of expansive soils is initially evidenced by cracking in the surface of the soils due to contraction. Settlement of structures and on-grade slabs may also eventually result along with problems in the operation of doors and windows.

*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 of at least 3% should be designed 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.

# AREA EXHIBIT FOR PROPERTIES TO BE ACQUIRED ORANGE SHOW ASSEMBLAGE



**PARCEL OWNERSHIP:**

- ①-1 APN: 0280-142-29  
OWNER: ROBINSON ALAN  
ADDRESS: E. NORMAN ROAD  
AREA: 3,065± SQ. FT. (NET)
- ①-0 APN: 0280-142-21  
OWNER: VESSUP RUDOLPH N SR  
ADDRESS: 425 E. NORMAN ROAD  
AREA: 20,885± SQ. FT. (NET)
- ①-1 APN: 0280-162-08  
OWNER: LISTER ANN - EST OF  
PEART CLEVELAND - EST  
ADDRESS: 485 E. NORMAN ROAD  
AREA: 22,564± SQ. FT. (NET)
- ①-2 APN: 0280-162-07  
OWNER: SHENG MARGARET MILI  
ADDRESS: 495 E. NORMAN ROAD  
AREA: 15,655± SQ. FT. (NET)
- ①-3 APN: 0280-162-12  
OWNER: VIOLLET GERARD J  
ADDRESS: 505 E. NORMAN ROAD  
AREA: 15,781± SQ. FT. (NET)
- ①-4 APN: 0280-162-09  
OWNER: CHICHIPA GUSTAVO  
ADDRESS: 515 E. NORMAN ROAD  
AREA: 20,127± SQ. FT. (NET)
- ①-5 APN: 0280-162-14  
OWNER: RANGEL WILLIAM G  
ADDRESS: 535 E. NORMAN ROAD  
AREA: 10,800 SQ. FT. (NET)
- ①-6 APN: 0280-172-07  
OWNER: HSB LAND L.P.  
ADDRESS: E. ORANGE SHOW ROAD  
AREA: 69,372 SQ. FT. (GROSS)  
68,741 SQ. FT. (NET)
- ①-7 APN: 0280-172-10  
OWNER: INLAND VALLEY  
DEVELOPMENT AGENCY  
ADDRESS: 605 E. NORMAN ROAD  
AREA: 20,846± SQ. FT. (NET)
- ①-8 APN: 0280-172-06  
OWNER: CANUL ANTONIO JR.  
ADDRESS: 604 E. ORANGE SHOW RD.  
AREA: 15,714± SQ. FT. (GROSS)  
15,429± SQ. FT. (NET)
- ①-9 APN: 0280-172-05  
OWNER: SAN BERNARDINO VALLEY  
MUNICIPAL WATER DISTRICT  
ADDRESS: NO SITE ADDRESS  
AREA: 5,143± SQ. FT. (NET)

**Thienes Engineering, Inc.**  
CIVIL ENGINEERING • LAND SURVEYING  
14349 FIRESTONE BOULEVARD  
LA MIRADA, CALIFORNIA 90638  
PH.(714)521-4811 FAX(714)521-4173



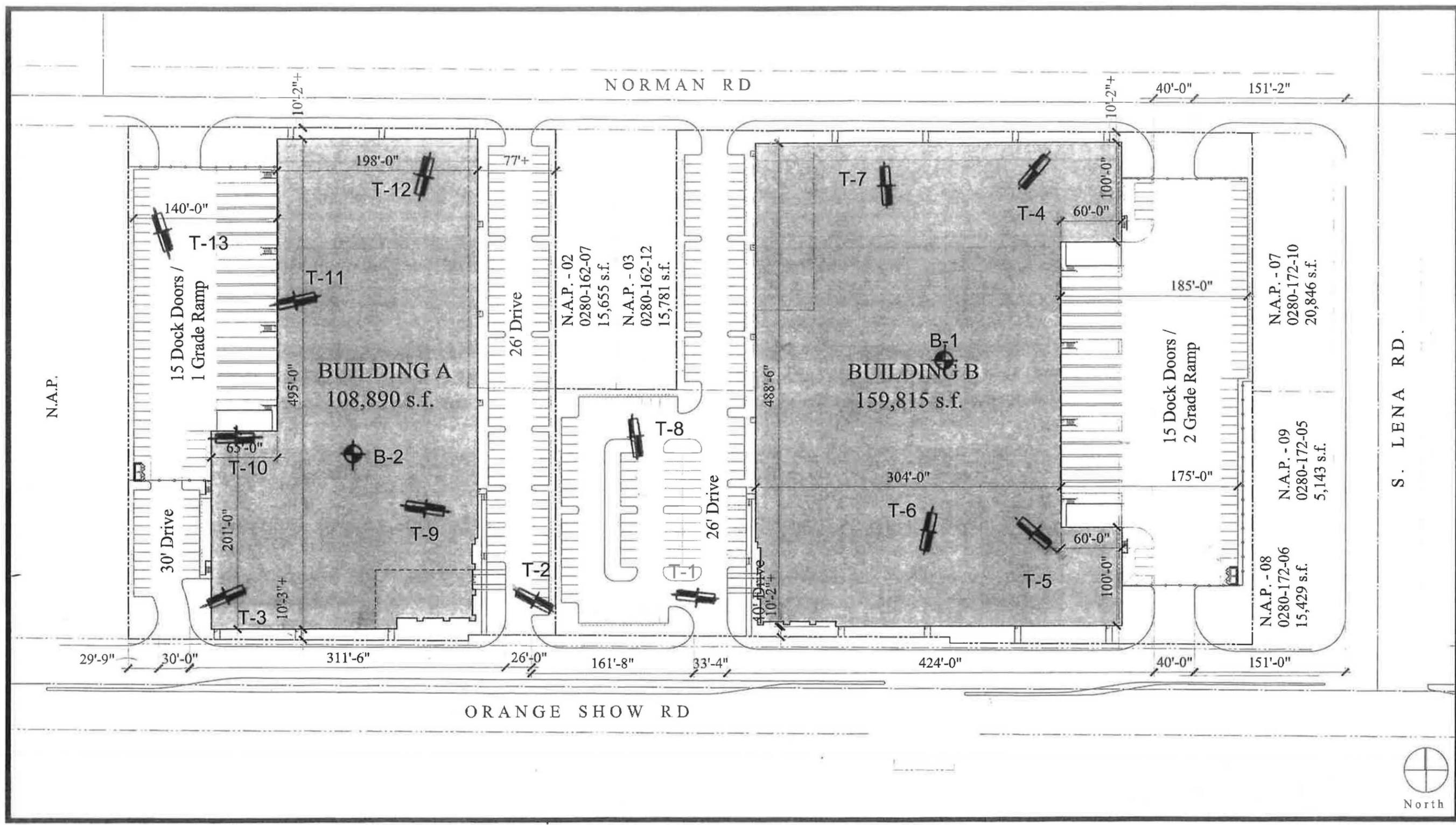
**NorCal Engineering**  
SOILS AND GEOTECHNICAL CONSULTANTS

VICINITY MAP

PROJECT 17917-15

DATE 6/2015

FIGURE 2



BUILDING A	
Gross Site Area (4.99 Acres)	217,190 s.f.
Ground Floor Area	108,890 s.f.
Coverage (Total Bldg Area/Gross Site)	50.14%
Parking Required (10k Office)	143 Spaces
Parking Provided	149 Spaces

MASTERPLAN TOTALS	
Gross Site Area (12.44 Acres)	541,892 s.f.
Ground Floor Area	268,705 s.f.
Coverage (Total Bldg Area/Gross Site)	49.59%

BUILDING B	
Gross Site Area (7.45 Acres)	324,702 s.f.
Ground Floor Area	159,815 s.f.
Coverage (Total Bldg Area/Gross Site)	49.22%
Parking Required (10k Office)	183 Spaces
Parking Provided	190 Spaces



WESTERN REALCO - ORANGE SHOW ROAD  
San Bernardino, California

**NorCal Engineering**  
SOILS AND GEOTECHNICAL CONSULTANTS

---

PROJECT 17917-15 | DATE 6/2015

APPROXIMATE LOCATIONS OF SOIL BORINGS

FIGURE 3

# **APPENDICES**

(In order of appearance)

## **Appendix A – USGS Seismic Design Report**

## **Appendix B - Logs of Test Explorations**

**\*Logs of Borings B-1 and B-2**

**\*Logs of Test Excavations T-1 to T-13**

## **Appendix C - Laboratory Analysis**

**\*Table I - Maximum Dry Density Tests**

**\*Table II - Expansion Index Tests**

**\*Table III - Atterberg Limits Tests**

**\*Table IV - Sulfate Tests**

**\*Table V - pH Tests**

**\*Table VI - Resistivity Tests**

**\*Table VII - Chloride Tests**

**\*Table VIII - Resistance 'R' Value Tests**

**\*Plates A - C- Direct Shear Tests**

**\*Plates D - F - Consolidation Tests**

## **Appendix D - Liquefaction Analysis**

# **APPENDIX A**

# USGS Design Maps Summary Report

## User-Specified Input

**Building Code Reference Document** ASCE 7-10 Standard  
(which utilizes USGS hazard data available in 2008)

**Site Coordinates** 34.0804°N, 117.2737°W

**Site Soil Classification** Site Class D – “Stiff Soil”

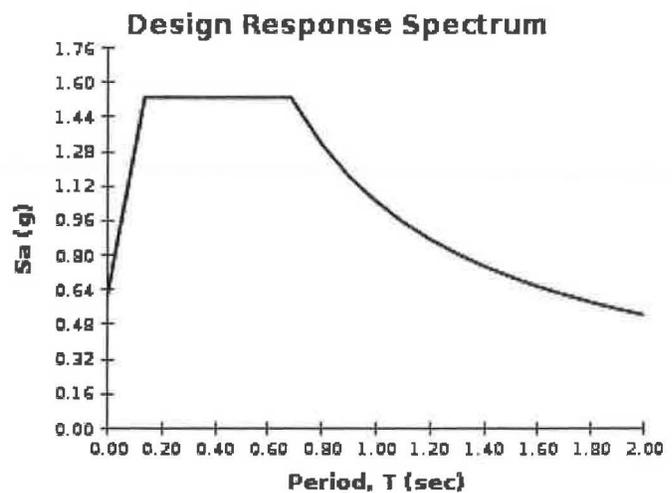
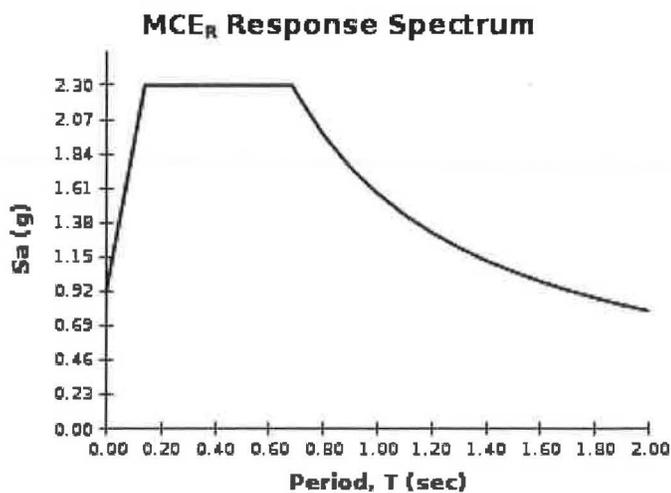
**Risk Category** I/II/III



## USGS-Provided Output

$S_s = 2.297$ g	$S_{MS} = 2.297$ g	$S_{DS} = 1.531$ g
$S_1 = 1.049$ g	$S_{M1} = 1.573$ g	$S_{D1} = 1.049$ g

For information on how the  $S_s$  and  $S_1$  values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.



For  $PGA_M$ ,  $T_L$ ,  $C_{RS}$ , and  $C_{R1}$  values, please [view the detailed report](#).

Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied,


**Design Maps Detailed Report**

ASCE 7-10 Standard (34.0804°N, 117.2737°W)

Site Class D – “Stiff Soil”, Risk Category I/II/III

**Section 11.4.1 — Mapped Acceleration Parameters**

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain  $S_s$ ) and 1.3 (to obtain  $S_1$ ). Maps in the 2010 ASCE-7 Standard are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 11.4.3.

**From Figure 22-1** <sup>[1]</sup> $S_s = 2.297$  g**From Figure 22-2** <sup>[2]</sup> $S_1 = 1.049$  g**Section 11.4.2 — Site Class**

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Chapter 20.

Table 20.3–1 Site Classification

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
Any profile with more than 10 ft of soil having the characteristics: <ul style="list-style-type: none"> <li>• Plasticity index <math>PI &gt; 20</math>,</li> <li>• Moisture content <math>w \geq 40\%</math>, and</li> <li>• Undrained shear strength <math>\bar{s}_u &lt; 500</math> psf</li> </ul>			
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft<sup>2</sup> = 0.0479 kN/m<sup>2</sup>

### Section 11.4.3 — Site Coefficients and Risk-Targeted Maximum Considered Earthquake ( $MCE_R$ ) Spectral Response Acceleration Parameters

Table 11.4-1: Site Coefficient  $F_a$ 

Site Class	Mapped $MCE_R$ Spectral Response Acceleration Parameter at Short Period				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of  $S_s$

**For Site Class = D and  $S_s = 2.297$  g,  $F_a = 1.000$**

Table 11.4-2: Site Coefficient  $F_v$ 

Site Class	Mapped $MCE_R$ Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of  $S_1$

**For Site Class = D and  $S_1 = 1.049$  g,  $F_v = 1.500$**

**Equation (11.4-1):**

$$S_{MS} = F_a S_S = 1.000 \times 2.297 = 2.297 \text{ g}$$

**Equation (11.4-2):**

$$S_{M1} = F_v S_1 = 1.500 \times 1.049 = 1.573 \text{ g}$$

## Section 11.4.4 — Design Spectral Acceleration Parameters

**Equation (11.4-3):**

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 2.297 = 1.531 \text{ g}$$

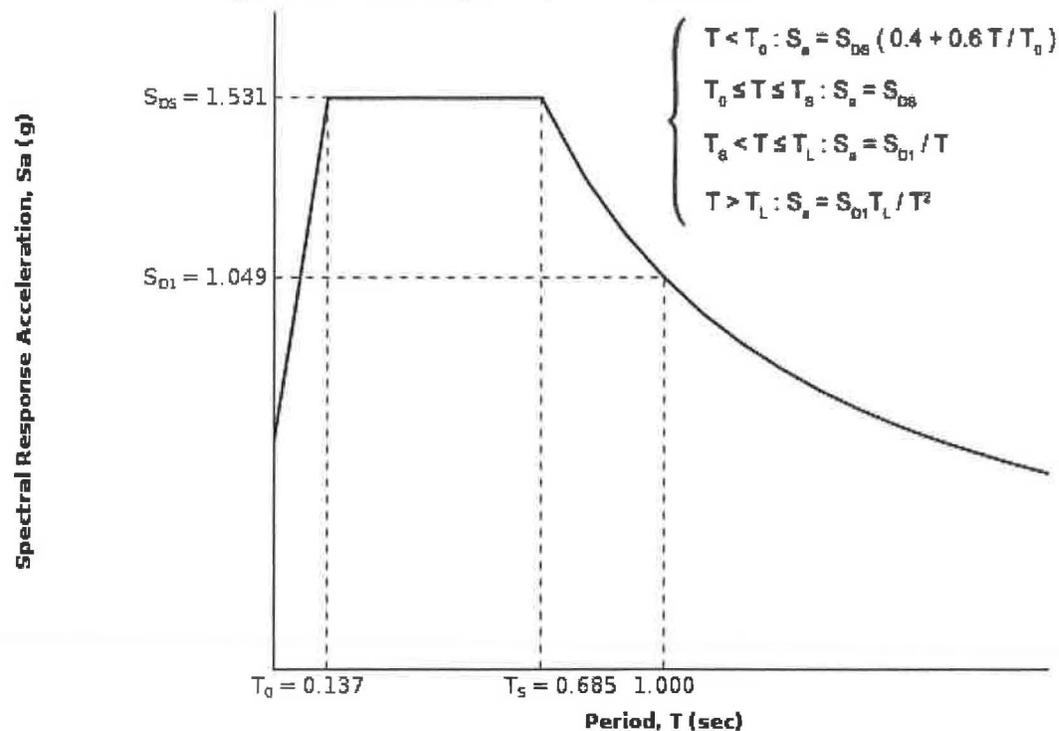
**Equation (11.4-4):**

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 1.573 = 1.049 \text{ g}$$

## Section 11.4.5 — Design Response Spectrum

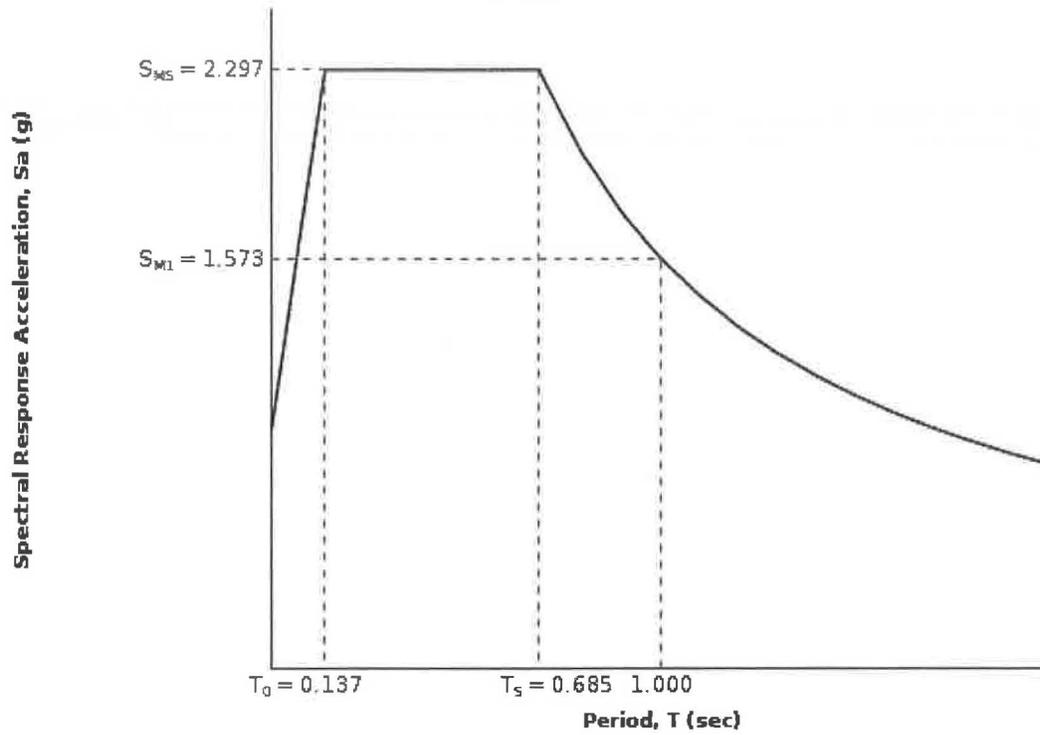
**From Figure 22-12** <sup>[3]</sup> $T_L = 8$  seconds

Figure 11.4-1: Design Response Spectrum



### Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE<sub>R</sub>) Response Spectrum

The MCE<sub>R</sub> Response Spectrum is determined by multiplying the design response spectrum above by 1.5.



### Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

From **Figure 22-7** <sup>[4]</sup>

$$\text{PGA} = 0.884$$

**Equation (11.8-1):**

$$\text{PGA}_M = F_{\text{PGA}} \text{PGA} = 1.000 \times 0.884 = 0.884 \text{ g}$$

Table 11.8-1: Site Coefficient  $F_{\text{PGA}}$

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.10	PGA = 0.20	PGA = 0.30	PGA = 0.40	PGA ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight-line interpolation for intermediate values of PGA

**For Site Class = D and PGA = 0.884 g,  $F_{\text{PGA}} = 1.000$**

### Section 21.2.1.1 — Method 1 (from Chapter 21 – Site-Specific Ground Motion Procedures for Seismic Design)

From **Figure 22-17** <sup>[5]</sup>

$$C_{RS} = 1.014$$

From **Figure 22-18** <sup>[6]</sup>

$$C_{R1} = 0.967$$

## Section 11.6 — Seismic Design Category

Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter

VALUE OF $S_{DS}$	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

**For Risk Category = I and  $S_{DS} = 1.531 g$ , Seismic Design Category = D**

Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter

VALUE OF $S_{D1}$	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

**For Risk Category = I and  $S_{D1} = 1.049 g$ , Seismic Design Category = D**

Note: When  $S_1$  is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category  $\equiv$  "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = E

Note: See Section 11.6 for alternative approaches to calculating Seismic Design Category.

### References

1. *Figure 22-1*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-1.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf)
2. *Figure 22-2*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-2.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf)
3. *Figure 22-12*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-12.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf)
4. *Figure 22-7*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-7.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf)
5. *Figure 22-17*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-17.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf)
6. *Figure 22-18*: [http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010\\_ASCE-7\\_Figure\\_22-18.pdf](http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf)

## **APPENDIX B**

MAJOR DIVISION			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS			
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES			
		MORE THAN 50% OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF 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		
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			
		MORE THAN 50% OF MATERIAL IS <u>LARGER</u> THAN NO. 200 SIEVE SIZE	SANDS WITH FINE (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES		
					SC	CLAYEY SANDS, SAND-CLAY MIXTURES		
			FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT <u>LESS</u> THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
					LIQUID LIMIT <u>GREATER</u> THAN 50		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						
MORE THAN 50% OF MATERIAL IS <u>SMALLER</u> THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT <u>GREATER</u> THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS			
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
				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

## UNIFIED SOIL CLASSIFICATION SYSTEM

**KEY:**

- Indicates 2.5-inch Inside Diameter. Ring Sample.
- ☒ Indicates 2-inch OD Split Spoon Sample (SPT).
- ☐ Indicates Shelby Tube Sample.
- ▢ Indicates No Recovery.
- ▣ Indicates SPT with 140# Hammer 30 in. Drop.
- ☑ Indicates Bulk Sample.
- ▤ Indicates Small Bag Sample.
- ▥ Indicates Non-Standard
- ⊠ Indicates Core Run.

**COMPONENT DEFINITIONS**

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 ( 4.5mm )
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 ( 4.5mm )
Sand	No. 4 ( 4.5mm ) to No. 200 ( 0.074mm )
Coarse sand	No. 4 ( 4.5 mm ) to No. 10 ( 2.0 mm )
Medium sand	No. 10 ( 2.0 mm ) to No. 40 ( 0.42 mm )
Fine sand	No. 40 ( 0.42 mm ) to No. 200 ( 0.074 mm )
Silt and Clay	Smaller than No. 200 ( 0.074 mm )

**COMPONENT PROPORTIONS**

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	1 - 5%
Few	5 - 10%
Little	10 - 20%
Some	20 - 35%
And	35 - 50%

**MOISTURE CONTENT**

DRY	Absence of moisture, dusty, dry to the touch.
DAMP	Some perceptible moisture; below optimum
MOIST	No visible water; near optimum moisture content
WET	Visible free water, usually soil is below water table.

**RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N -VALUE**

COHESIONLESS SOILS		COHESIVE SOILS		
Density	N ( blows/ft )	Consistency	N ( blows/ft )	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	Very Soft	0 to 2	< 250
Loose	4 to 10	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	Very Stiff	15 to 30	2000 - 4000
		Hard	over 30	> 4000

**Western Realco**  
17917-15

**Log of Boring B-1**

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: 27'

Drilling Method: Hollowstem Auger

Hammer Weight: 140 lbs

Drop: 30"

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Brown, loose, dry to damp					
5		NATURAL SOILS Silty SAND Light brown to brown, medium dense, damp Some variation in silt content with depth	⊗	2/2/3	2.5		6
10		Slightly silty SAND with occasional gravel, rock Light brown, medium dense to dense, dry	⊗	5/5/6	2.1		6
15			⊗	15/14/19	1.5		4
20			⊗	22/22/24	1.7		5
25			⊗	17/22/15	5.6		6
30		Sandy SILT Grey-brown, medium stiff, very moist to wet	⊗	11/6/8	22.1		56
35							

**NorCal Engineering**

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: 27'

Drilling Method: Hollowstem Auger

Hammer Weight: 140 lbs

Drop: 30"

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
35		Silty SAND Grey, dense, wet Increase in silt content with depth	⊗	13/20/15	22.4		21
40			⊗	8/12/14	20.9		11
45			⊗	16/19/23	22.2		44
50			⊗	11/21/25	30.6		88
51.5		Silty CLAY Grey, very stiff, wet Boring completed at depth of 51.5'					

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog4\PROJECT\17917-15.log Date: 2/19/2015

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: 31'

Drilling Method: Hollowstem Auger

Hammer Weight: 140 lbs

Drop: 30"

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND to Sandy SILT with roots Light brown, loose/soft, dry					
5		NATURAL SOILS Silty SAND Light brown, medium dense, damp	☒	2/2/2	5.8		29
10			☒	6/6/7	2.4		6
15			☒	12/8/8	3.1		10
20		Slightly silty SAND with gravel, rock Light brown, medium dense, damp					
25		Silty SAND Brown, medium dense, moist	☒	10/6/4	11.8		34
30		Silty CLAY Grey, medium stiff, saturated	☒	3/3/7	35.5		89
35		Sandy clayey SILT Grey-brown, stiff, very moist	☒	11/15/10	26.4		78

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: 31'

Drilling Method: Hollowstem Auger

Hammer Weight: 140 lbs

Drop: 30"

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
35		Silty SAND Grey, dense, wet		15/13/12	20.1		17
40				7/8/13	20.9		8
45		Silty CLAY Grey, stiff, saturated		9/7/9	35.3		97
50		Silty SAND Grey, very dense, saturated Boring completed at depth of 51.5'		23/26/29	21.0		22
55							
60							
65							
70							

**Western Realco**  
17917-15

**Log of Trench T-1**

Boring Location: Orange Show Rd. & Lena Rd.	
Date of Drilling: 2/4/15	Groundwater Depth: None Encountered
Drilling Method: Backhoe	
Hammer Weight:	Drop:
Surface Elevation: Not Measured	

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL/DISTUREBED TOP SOILS					
		Silty SAND with gravel, roots					
		Light brown, loose, dry to damp					
		NATURAL SOILS					
		Silty SAND					
5		Light brown, medium dense, damp					
		Sandy SILT					
		Light brown, medium stiff, damp					
		Trench completed at depth of 5'					
10							
15							
20							
25							
30							
35							

**NorCal Engineering**

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		DISTURBED TOP SOILS Silty SAND with roots Light brown, loose, dry to damp					
3		NATURAL SOILS Silty SAND Light brown, medium dense, damp					
5		Trench completed at depth of 3'					
10							
15							
20							
25							
30							
35							

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

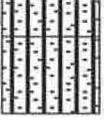
Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp					
3		NATURAL SOILS Silty SAND Light brown, medium dense, damp					
5		Trench completed at depth of 3'					
10							
15							
20							
25							
30							
35							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog4\PROJECT\17917-15.log Date: 2/19/2015

**Western Realco**  
17917-15

**Log of Trench T-4**

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp			3.4	91.4	
5		NATURAL SOILS Silty SAND Light brown, medium dense, dry to damp			1.5	94.2	
10		Sandy SILT Brown, firm, moist					
11		Slightly silty SAND with gravel Light brown, medium dense, dry			0.7		
11		Heavy caving occurred at depth of 11' - Excavation stopped					
30							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Supertog\PROJECT\17917-15.log Date: 2/19/2015

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp					
5		NATURAL SOILS Silty SAND with occasional gravel and rock Light brown, medium dense, damp	■		1.1	113.3	
			■		4.0	97.9	
		Heavy caving occurred at depth of 8' - Excavation stopped					
10							
15							
20							
25							
30							
35							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog\PROJECT\17917-15.log Date: 2/19/2015

Boring Location: Orange Show Rd. & Lena Rd.  
 Date of Drilling: 2/4/15 Groundwater Depth: None Encountered  
 Drilling Method: Backhoe  
 Hammer Weight: Drop:  
 Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp NATURAL SOILS Silty SAND Light brown, medium dense, damp	■				
5		Trench completed at depth of 6'					
10							
15							
20							
25							
30							
35							

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp					
5		NATURAL SOILS Silty SAND with occasional gravel Light brown, medium dense, damp Decrease in silt content with depth	■		5.6	102.6	
10		Slightly silty SAND with gravel Light brown, medium dense, dry	■		1.7	92.5	
11		Heavy caving occurred at depth of 11' - Excavation stopped	■		2.9	91.2	
15							
20							
25							
30							
35							

**Western Realco**  
17917-15

**Log of Trench T-8**

<b>Boring Location: Orange Show Rd. &amp; Lena Rd.</b>	
<b>Date of Drilling: 2/4/15</b>	<b>Groundwater Depth: None Encountered</b>
<b>Drilling Method: Backhoe</b>	
<b>Hammer Weight:</b>	<b>Drop:</b>
<b>Surface Elevation: Not Measured</b>	

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS	M				
		Silty SAND with gravel, roots					
		Light brown, loose, dry to damp					
		NATURAL SOILS					
		Silty SAND					
5		Light brown, medium dense, damp					
		Slightly silty SAND with gravel					
		Light brown, medium dense, dry					
		Trench completed at depth of 5'					
30							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog\PROJECT\17917-15.log Date: 2/19/2015

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp	■		3.3	91.6	
5		NATURAL SOILS Silty SAND Light brown, medium dense, damp	■		3.3	90.9	
10		Sandy SILT Light brown, firm, damp	■				
		Slightly silty SAND with occasional gravel Light brown, medium dense, dry					
		Refusal at depth of 10'	■		1.9	96.0	
15							
20							
25							
30							
35							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog\PROJECT\17917-15.log Date: 2/19/2015

Boring Location: Orange Show Rd. & Lena Rd.  
 Date of Drilling: 2/4/15 Groundwater Depth: None Encountered  
 Drilling Method: Backhoe  
 Hammer Weight: Drop:  
 Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp					
5		NATURAL SOILS Silty SAND Light brown, medium dense to dense, damp	■		1.9	92.4	
10		Slightly silty SAND Light brown, medium dense, dry Trench completed at depth of 10'	■		1.4	116.3	
30							

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory			
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve	
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp						
5		NATURAL SOILS Silty SAND Light brown, medium dense to dense, damp	■		3.7	101.1		
		Slightly silty SAND Light brown, medium dense, damp Some caving occurred Trench completed at depth of 7'	■		0.9	108.7		
10								
15								
20								
25								
30								
35								

Boring Location: Orange Show Rd. & Lena Rd.	
Date of Drilling: 2/4/15	Groundwater Depth: None Encountered
Drilling Method: Backhoe	
Hammer Weight:	Drop:
Surface Elevation: Not Measured	

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		FILL SOILS Silty SAND with gravel, roots Light brown, loose, dry to damp			3.2	97.2	
5		NATURAL SOILS Slightly silty SAND Light brown, medium dense, damp					
7		Heavy caving occurred at depth of 7' - Excavation stopped					
10							
15							
20							
25							
30							
35							

**Western Realco**  
17917-15

**Log of Trench T-13**

Boring Location: Orange Show Rd. & Lena Rd.

Date of Drilling: 2/4/15

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

Depth (feet)	Lithology	Material Description	Samples		Laboratory		
			Type	Blow Counts	Moisture	Dry Density	% Passing 200 Sieve
0		<p>FILL SOILS</p> <p>Silty SAND with gravel, roots, minor debris</p> <p>Light brown, loose, dry to damp</p> <p>NATURAL SOILS</p> <p>Slightly silty SAND</p> <p>Light brown, medium dense, damp</p> <p>Trench completed at depth of 4'</p>					
5							
10							
15							
20							
25							
30							
35							

## **APPENDIX C**

**TABLE I**  
**MAXIMUM DENSITY TESTS**  
**(ASTM: D-1557-07)**

<u>Sample</u>	<u>Classification</u>	<u>Optimum Moisture</u>	<u>Maximum Dry Density (lbs./cu.ft.)</u>
T-4 @ 2-3'	silty SAND	11.0	110.0
T-12 @ 2-3'	silty SAND	12.5	109.5

**TABLE II**  
**EXPANSION INDEX TESTS**  
**(ASTM: D-4829-07)**

<u>Sample</u>	<u>Classification</u>	<u>Expansion Index</u>
T-4 @ 2-3'	silty SAND	03

**TABLE III**  
**ATTERBERG LIMITS**  
**(ASTM: D-4318-05)**

<u>Sample</u>	<u>Liquid Limit</u>	<u>Plastic Limit</u>	<u>Plasticity Index</u>
B-1 @ 30'	24	17	7
B-2 @ 30'	24	21	3
B-2 @ 45'	42	24	18

**TABLE IV**  
**SOLUBLE SULFATE TESTS**  
**(CT 417)**

<u>Sample</u>	<u>Sulfate Concentration (%)</u>
T-4 @ 1-2'	.0018

**TABLE V**  
**pH TESTS**

<u>Sample</u>	<u>pH</u>
T-4 @ 1-2'	7.3

**TABLE VI**  
**RESISTIVITY TESTS**  
**(CT 643)**

<u>Sample</u>	<u>Resistivity (ohm-cm)</u>
T-4 @ 1-2'	5370

**TABLE VII**  
**CHLORIDE TESTS**  
**(CT 422)**

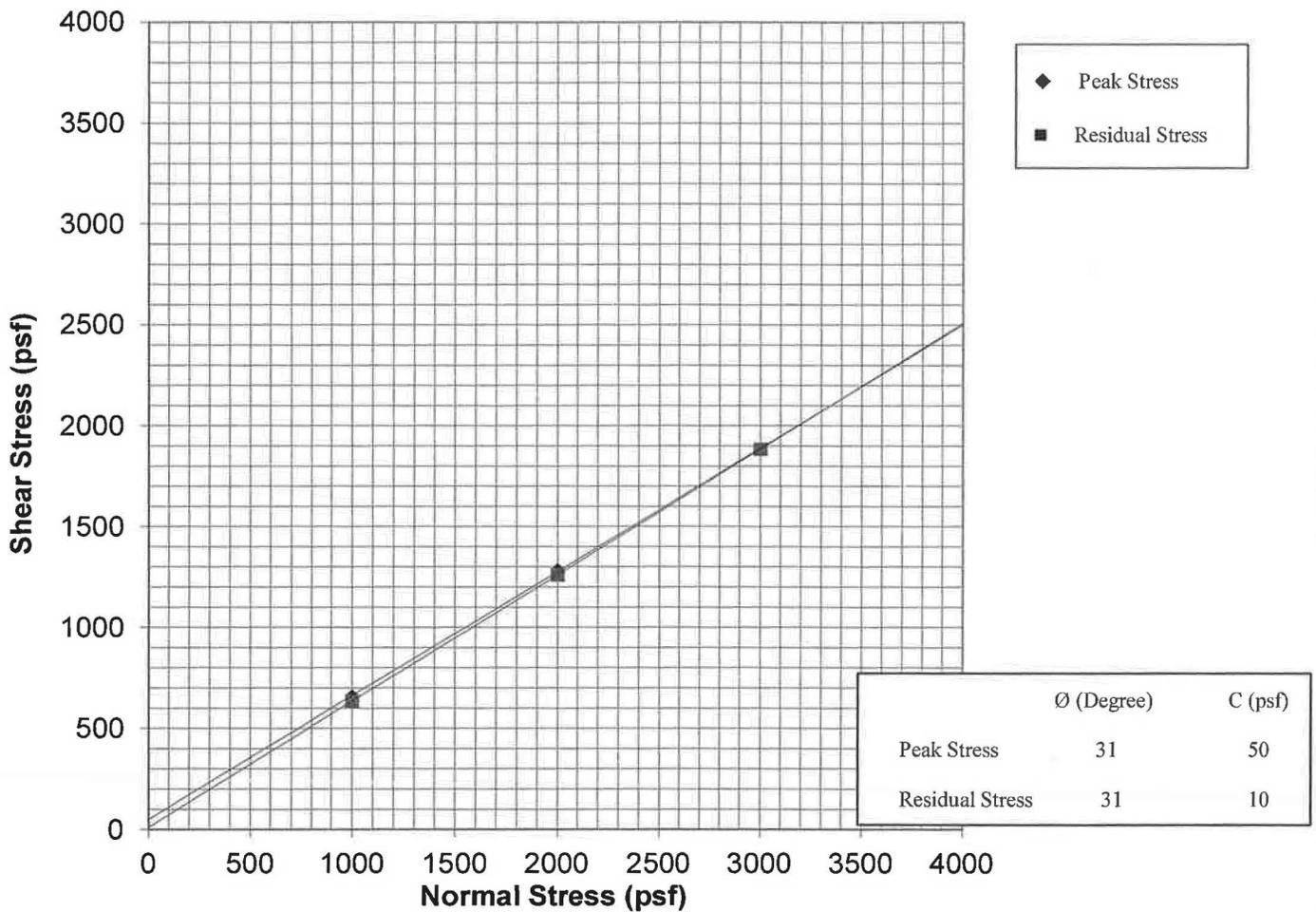
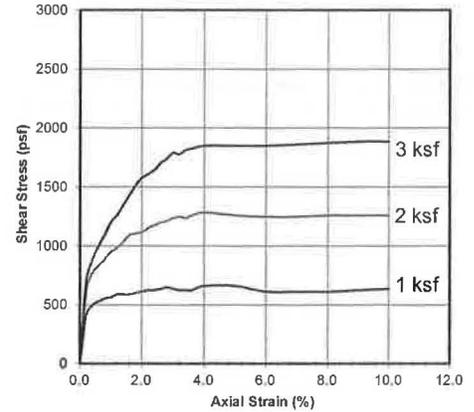
<u>Sample</u>	<u>Concentration (ppm)</u>
T-4 @ 1-2'	270

**TABLE VIII**  
**RESISTANCE 'R' VALUE TESTS**  
**(CA 301)**

<u>Sample</u>	<u>'R' Value</u>
T-8 @ 1-2'	60

Sample No. T4@2'  
 Sample Type: Remolded/Saturated  
 Soil Description: Silty Fine-Coarse Grained Sand

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	660	1284	1884
Displacement	(in)	0.100	0.100	0.225
Residual Stress	(psf)	636	1260	1884
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	99.0	99.0	99.0
In Situ Water Content	(%)	11.0	11.0	11.0
Saturated Water Content	(%)	25.9	25.9	25.9
Strain Rate	(in/min)	0.020	0.020	0.020



**NorCal Engineering**  
 SOILS AND GEOTECHNICAL CONSULTANTS

**Western Realco**

PROJECT NUMBER: 17917-15

DATE: 2/16/2015

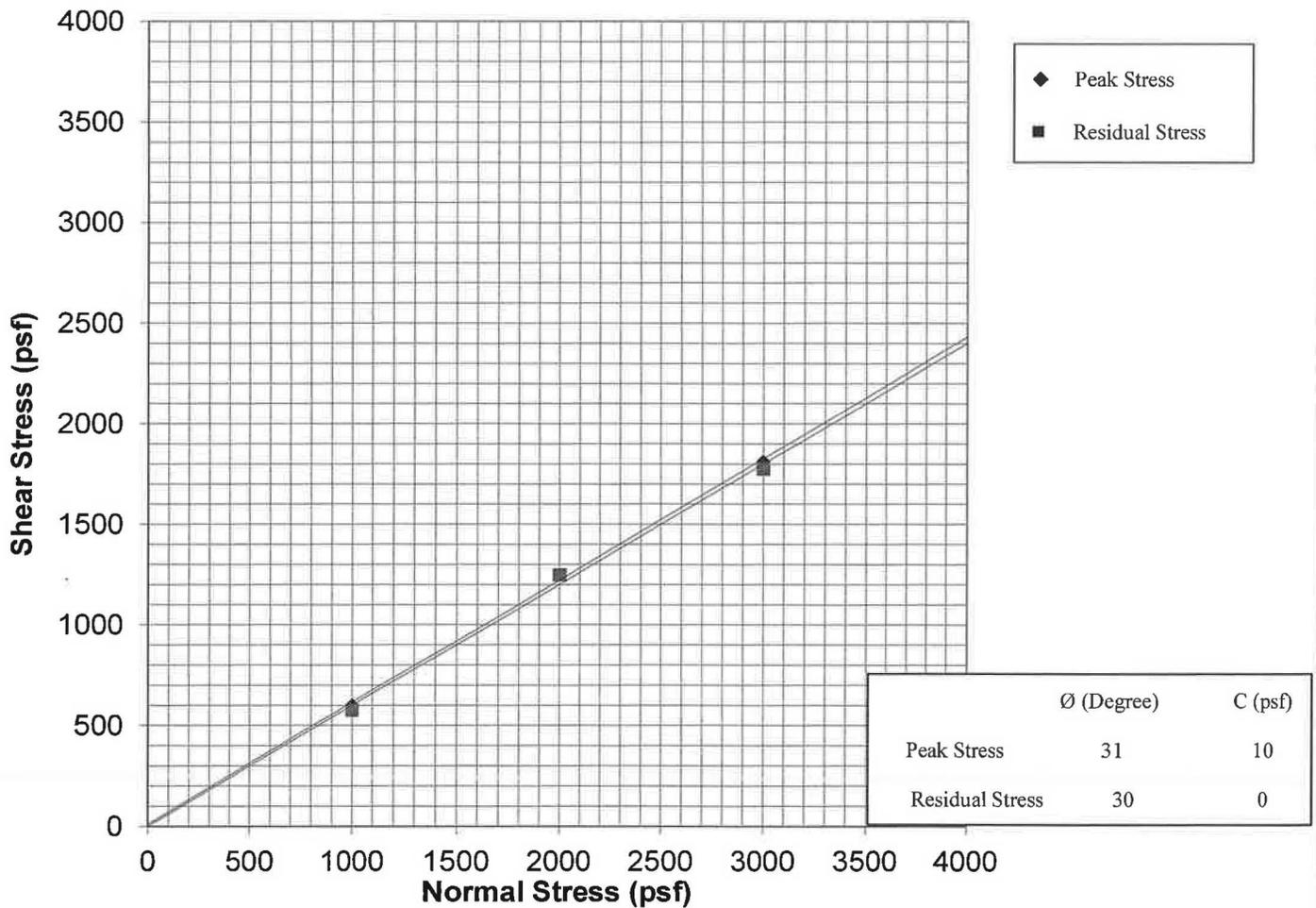
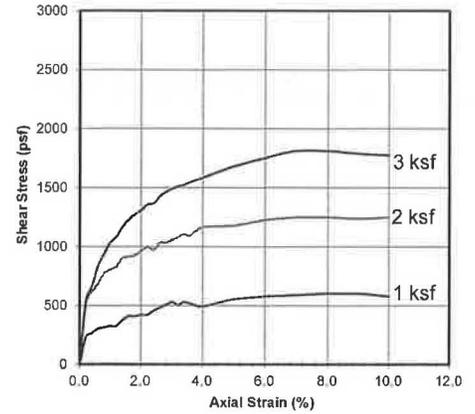
**DIRECT SHEAR TEST**

**ASTM D3080**

**Plate A**

Sample No. T7@6'  
 Sample Type: Undisturbed/Saturated  
 Soil Description: Silty Fine Grained Sand

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	600	1248	1812
Displacement	(in.)	0.200	0.175	0.175
Residual Stress	(psf)	576	1248	1776
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	91.2	91.2	91.2
In Situ Water Content	(%)	1.7	1.7	1.7
Saturated Water Content	(%)	31.2	31.2	31.2
Strain Rate	(in/min)	0.020	0.020	0.020



**NorCal Engineering**  
 SOILS AND GEOTECHNICAL CONSULTANTS

**Western Realco**

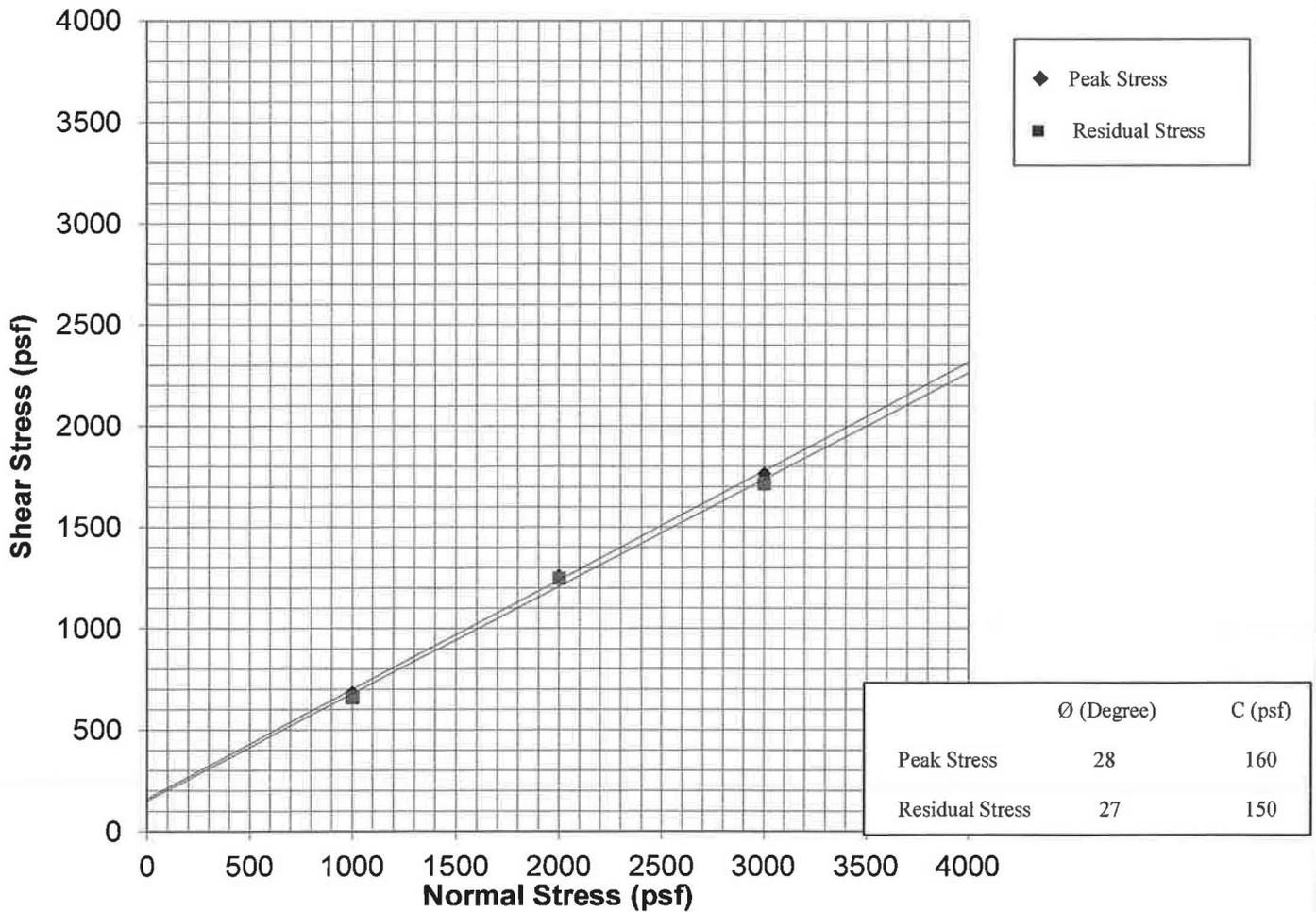
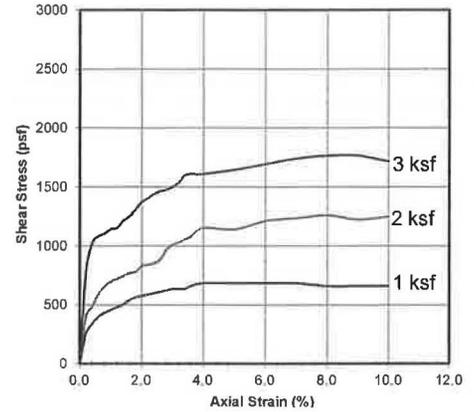
PROJECT NUMBER: 17917-15

DATE: 2/16/2015

**DIRECT SHEAR TEST**  
 ASTM D3080  
 Plate B

Sample No. T11@4'  
 Sample Type: Undisturbed/Saturated  
 Soil Description: Silty Fine-Coarse Grained Sand

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	684	1260	1764
Displacement	(in.)	0.100	0.200	0.200
Residual Stress	(psf)	660	1248	1716
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	101.1	101.1	101.1
In Situ Water Content	(%)	3.7	3.7	3.7
Saturated Water Content	(%)	24.6	24.6	24.6
Strain Rate	(in/min)	0.020	0.020	0.020



**NorCal Engineering**  
 SOILS AND GEOTECHNICAL CONSULTANTS

**Western Realco**

PROJECT NUMBER: 17917-15

DATE: 2/16/2015

**DIRECT SHEAR TEST**

**ASTM D3080**

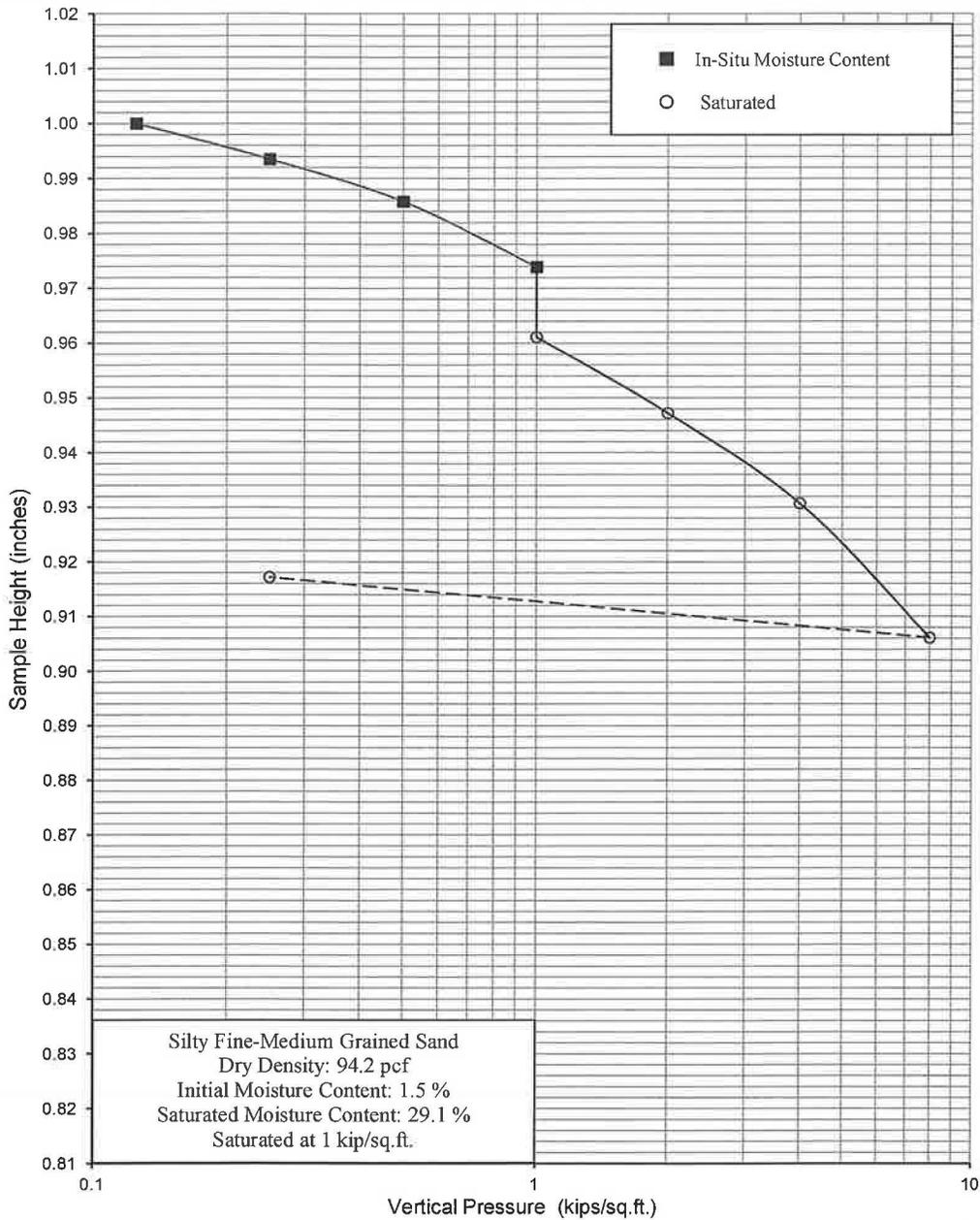
**Plate C**

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)	Sample No.	T4	Depth	5'	Date	2/16/2015
------------------------------------	---------------------------	----------------------------	------------	----	-------	----	------	-----------

0.125	1.0000	0.0
0.25	0.9935	0.6
0.5	0.9858	1.4
1	0.9739	2.6
1	0.9611	3.9
2	0.9472	5.3
4	0.9307	6.9
8	0.9061	9.4
0.25	0.9172	8.3

Saturated

Date Tested: 2/10/2015  
Sample: T4  
Depth: 5'



**NorCal Engineering**  
SOILS AND GEOTECHNICAL CONSULTANTS  
**Western Realco**  
PROJECT NUMBER: 17917-15      DATE: 2/16/2015

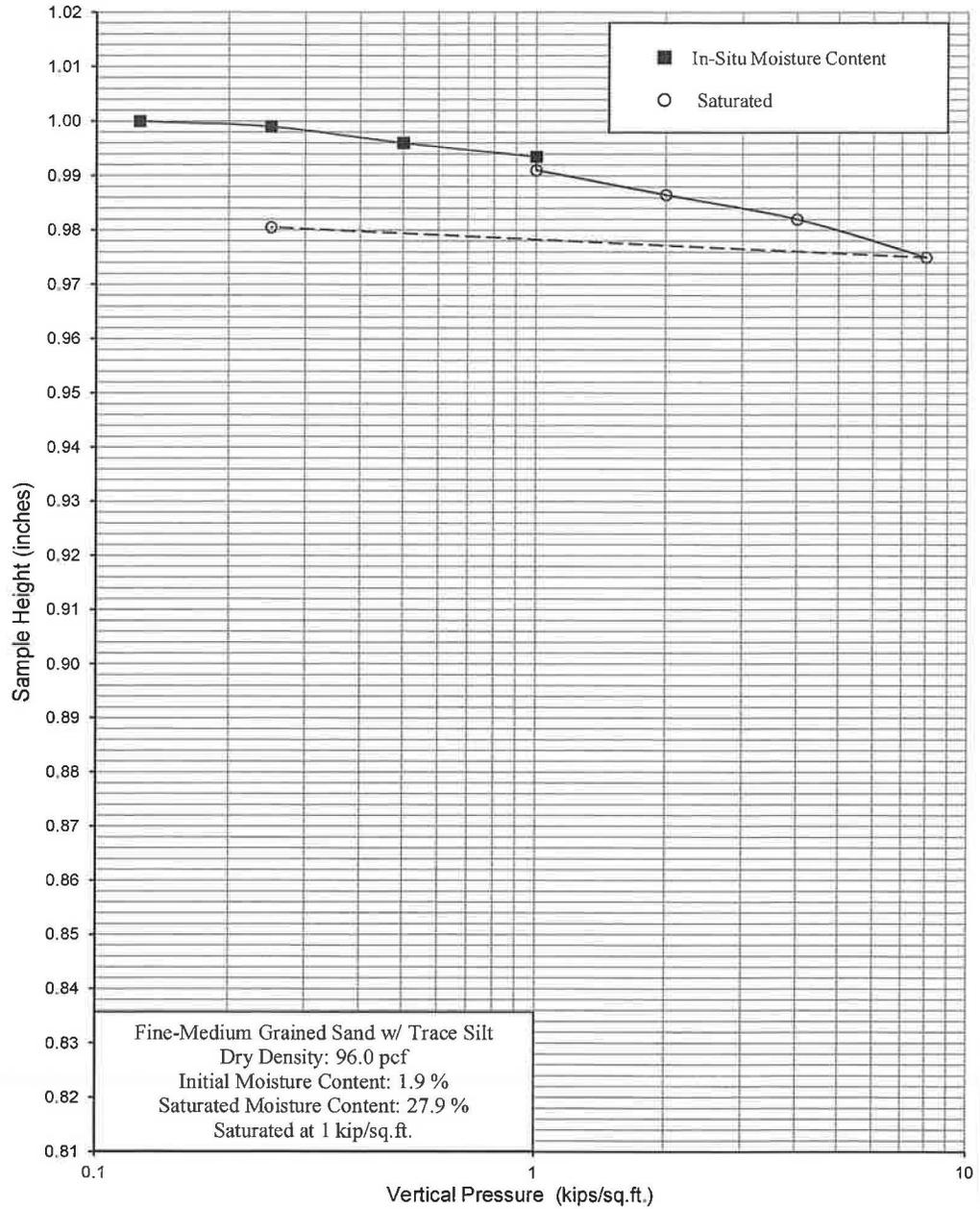
**CONSOLIDATION TEST**  
ASTM D2435  
Plate D

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)	Sample No.	T9	Depth	10'	Date	2/16/2015
------------------------------------	---------------------------	----------------------------	------------	----	-------	-----	------	-----------

0.125	1.0000	0.0
0.25	0.9990	0.1
0.5	0.9960	0.4
1	0.9935	0.6
1	0.9910	0.9
2	0.9865	1.4
4	0.9820	1.8
8	0.9750	2.5
0.25	0.9805	2.0

Saturated

Date Tested: 2/11/2015  
Sample: T9  
Depth: 10'



**NorCal Engineering**  
SOILS AND GEOTECHNICAL CONSULTANTS

Western Realco

PROJECT NUMBER: 17917-15

DATE: 2/16/2015

CONSOLIDATION TEST

ASTM D2435

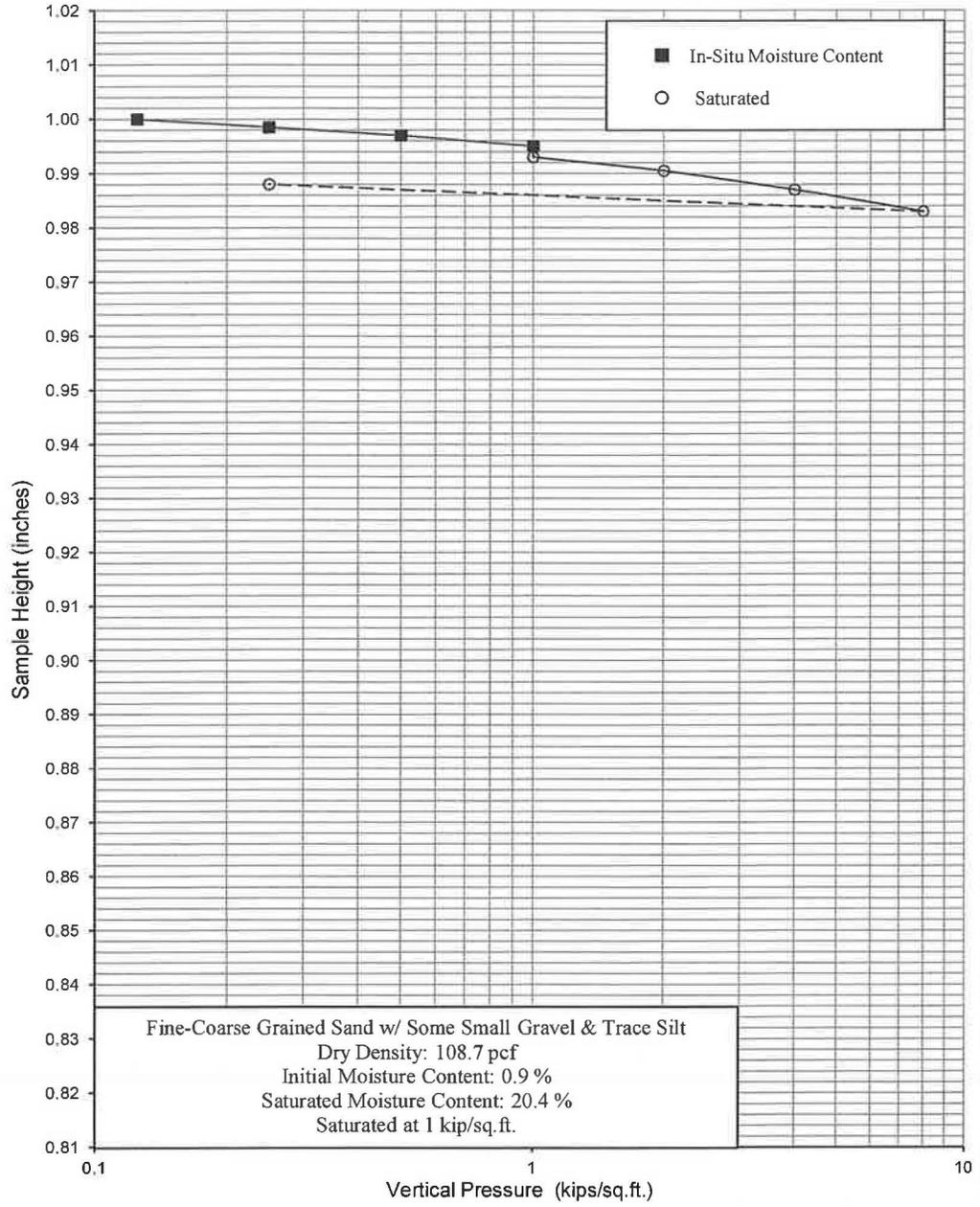
Plate E

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)	Sample No.	T11	Depth	6'	Date	2/16/2015
------------------------------------	---------------------------	----------------------------	------------	-----	-------	----	------	-----------

0.125	1.0000	0.0
0.25	0.9985	0.2
0.5	0.9970	0.3
1	0.9950	0.5
1	0.9930	0.7
2	0.9905	1.0
4	0.9870	1.3
8	0.9830	1.7
0.25	0.9880	1.2

Saturated

Date Tested: 2/11/2015  
Sample: T11  
Depth: 6'



<b>NorCal Engineering</b> SOILS AND GEOTECHNICAL CONSULTANTS		<b>CONSOLIDATION TEST</b> ASTM D2435 Plate F	
<b>Western Realco</b>			
PROJECT NUMBER: 17917-15		DATE: 2/16/2015	

# **APPENDIX D**

SITE LOCATION: \_\_\_\_\_  
 GEOTECHNICAL REPORT: \_\_\_\_\_  
 GEOLOGY REPORT: \_\_\_\_\_

DEPTH TO WATER TABLE = 27'  
 EARTHQUAKE MAGNITUDE = 6.7  
 PEAK GROUND ACCELERATION = 0.88g

DEPTH BELOW FINAL GRADE (FEET)	MOIST DENSITY (PCF)	$\sigma_0$ TOTAL STRESS (PSF)	$\bar{\sigma}_0$ EFFECTIVE STRESS (PSF)	$\sigma_v/\bar{\sigma}_0$ (-)	$r_d$ (-)	$\tau_h/\bar{\sigma}_0$ (-)	N VALUE (BLOWS/FT)	RELATIVE DENSITY (%)	$C_N$ (-)	$C_E$ (-)	$C_B$ (-)	$C_R$ (-)	$C_S$ (-)	( $N_1$ ) <sub>60</sub> (BLOWS/FT)	FINES (%)	CRR M=7.5	MSF (-)	CRR M=6.7	LIQ. F.S.
5	100	500	same	1.00	0.99	0.57	5	55	>1.6	1.00	1.05	0.70	1.20	>7	6	0.08	1.5	0.12	0.2
10	↓	1000	↓	↓	0.96	0.55	11	70	1.4	↓	↓	0.75	↓	14.5	6	0.17	↓	0.26	0.5
15	↓	1500	↓	↓	0.92	0.52	33	>90	1.15	↓	↓	0.85	↓	40.5	4	>0.50	↓	>0.75	>1.4
20	↓	2000	↓	↓	0.87	0.50	46	>90	1.0	↓	↓	0.90	↓	52	5	>0.50	↓	>0.75	>1.5
25	↓	2500	↓	↓	0.80	0.46	37	>90	0.9	↓	↓	0.95	↓	40	6	>0.50	↓	>0.75	>1.6
30	120	3100	2788	1.11	0.74	0.47	14	60	0.87	↓	↓	1.00	↓	15	56	>0.26	↓	>0.39	>0.8
35	↓	3700	3076	1.20	0.68	0.47	35	85	0.83	↓	↓	↓	↓	36.5	21	>0.50	↓	>0.75	>1.6
40	↓	4300	3364	1.28	0.64	0.47	26	70	0.80	↓	↓	↓	↓	26	11	0.40	↓	0.60	1.3
45	↓	4900	3652	1.34	0.61	0.47	42	90	0.78	↓	↓	↓	↓	41	44	>0.50	↓	>0.75	>1.6
50	↓	5500	3940	1.40	0.58	0.46	49	>90	0.75	↓	↓	↓	↓	46	88	>0.50	↓	>0.75	>1.6

① INDUCED CYCLIC STRESS RATIO =  $\tau_{ave}/\bar{\sigma}_0 = 0.65 \cdot \frac{\alpha_{max}}{g} \cdot \frac{\sigma_0}{\bar{\sigma}_0} \cdot r_d$

•  $C_E$  = Corr. - Energy Ratio = Energy Ratio / 60%

•  $C_B$  = Corr. - Borehole Dia. = 1.15 for 8" dia. borehole

•  $C_R$  = Corr. - Rod Length

•  $C_S$  = Corr. - Sampling Method

Actual Energy Ratio = 0.67-1.17 (Safety Hammer)  
 = 0.50-1.00 (Downdrop Hammer)

Sampling Method = 1.0 Standard sampler  
 = 1.2 Sampler w/o liners

**NorCal Engineering**  
 SOILS AND GEOTECHNICAL CONSULTANTS

PROJECT 17917-15      DATE

EVALUATION OF LIQUEFACTION POTENTIAL

SITE LOCATION: \_\_\_\_\_  
 GEOTECHNICAL REPORT: \_\_\_\_\_  
 GEOLOGY REPORT: \_\_\_\_\_

DEPTH TO WATER TABLE = 27'  
 EARTHQUAKE MAGNITUDE = 6.7  
 PEAK GROUND ACCELERATION = 0.88g

DEPTH BELOW FINAL GRADE (FEET)	MOIST DENSITY (PCF)	$\sigma_0$ TOTAL STRESS (PSF)	$\bar{\sigma}_0$ EFFECTIVE STRESS (PSF)	$\sigma_v/\bar{\sigma}_0$ (-)	$r_d$ (-)	$\tau_{h/\bar{\sigma}_0}$ (-)	N VALUE (BLOWS/FT)	RELATIVE DENSITY (%)	$C_N$ (-)	$C_E$ (-)	$C_B$ (-)	$C_R$ (-)	$C_S$ (-)	( $N_1$ ) <sub>60</sub> (BLOWS/FT)	FINES (%)	CRR M=1.5	MSF (-)	CRR M=6.7	LIQ. F.S.
5	100	500	same	1.00	0.99	0.57	4	50	>1.6	1.00	1.05	0.70	1.20	>5.5	29	>0.12	1.5	>0.18	>0.3
10	↓	1000	↓	↓	0.96	0.55	13	70	1.4	↓	↓	0.75	↓	17	6	0.19	↓	0.29	0.5
15	↓	1500	↓	↓	0.92	0.52	16	70	1.15	↓	↓	0.85	↓	20	10	0.25	↓	0.38	0.7
20	↓	2000	↓	↓	0.87	0.50	10	60	1.0	↓	↓	0.90	↓	11	34	0.20	↓	0.30	0.6
25	↓	2500	↓	↓	0.80	0.46	10	55	0.9	↓	↓	0.95	↓	11	88	>0.20	↓	>0.30	>0.7 (NL)
30	120	3100	2788	1.11	0.74	0.47	25	75	0.87	↓	↓	1.00	↓	27	76	>0.50	↓	>0.75	>1.6
35	↓	3700	3076	1.20	0.68	0.47	25	70	0.83	↓	↓	↓	↓	26	17	>0.50	↓	>0.75	>1.6
40	↓	4300	3364	1.28	0.64	0.47	21	65	0.80	↓	↓	↓	↓	21	8	0.25	↓	0.38	0.8
45	↓	4900	3652	1.34	0.61	0.47	16	60	0.78	↓	↓	↓	↓	16	97	>0.27	↓	>0.41	>0.9 (NL)
50	↓	5500	3940	1.40	0.58	0.46	54	>90	0.75	↓	↓	↓	↓	51	22	>0.50	↓	>0.75	>1.6

① INDUCED CYCLIC STRESS RATIO =  $\tau_{ave}/\bar{\sigma}_0 = 0.65 \cdot \frac{a_{max}}{g} \cdot \frac{\sigma_0}{\bar{\sigma}_0} \cdot r_d$

•  $C_E$  = Corr. - Energy Ratio = Energy Ratio / 60%

•  $C_B$  = Corr. - Borehole Dia. = 1.15 for 8" dia. borehole

•  $C_R$  = Corr. - Rod Length

•  $C_S$  = Corr. - Sampling Method

Actual Energy Ratio = 0.67-1.17 (Safety Hammer)  
 = 0.50-1.00 (Donut Hammer)

Sampling Method = 1.0 Standard Sampler  
 = 1.2 Sampler w/o liners

**NorCal Engineering**  
 SOILS AND GEOTECHNICAL CONSULTANTS

---

PROJECT 17915-15      DATE \_\_\_\_\_

EVALUATION OF LIQUEFACTION POTENTIAL

# SEISMIC SETTLEMENT EVALUATION $\Rightarrow$ GWT @ 27'

EQ Magnitude = 6.7, Hor. Ground Acceleration = 0.88g

Depth (ft)	$N_{60}$ (Blows/ft)	Fines (%)	EQ CSR	$M_{design}$ $M_{7.5}$	Design CSR	Vert. Strain	Seismic Settle	Liquefaction F.S.
B-1 27-32'	15 (23)	56 (5)	0.47	1.5	0.31	1.2%	0.7"	>0.8
B-2 37-42'	21	8	0.47	1.5	0.31	1.4%	0.8"	0.8
42-47'	16 (2A)	97 (5)	0.46	↓	0.30	1.1%	0.7" x	>0.9 (NL)

Say  $\Delta_{EQ} \leq 3/4"$  ←

$\Sigma S = 1.5"$

NL - non liquefiable soil layer

with  $LL > 35\%$

$PI > 15\%$

Say  $\Delta_{EQ} = 3/4"$  ←