GEOTECHNICAL INVESTIGATION
Proposed Warehouse Development
Southwest Corner of Slover Avenue and
Cactus Avenue, Bloomington
San Bernardino County, California

Alere Property Group, LLC
100 Bayview Circle, Suite 310
Newport Beach, California 92660

Project Number 19834-17
September 6, 2017

NorCal Engineering

NorCal Engineering
SOILS AND GEOTECHNICAL CONSULTANTS
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September 6, 2017

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Alere Property Group, LLC
100 Bayview Circle, Suite 310
Newport Beach, California 92660

Attn: Clark Neuhoff

RE: **GEOTECHNICAL INVESTIGATION** - Proposed Warehouse Development - Located at the Southwest Corner of Slover Avenue and Cactus Avenue, Bloomington, in the County of San Bernardino, California

Dear Mr. Neuhoff:

Pursuant to your request, this firm has performed this Geotechnical Investigation for the above referenced project. The purpose of this investigation is to evaluate the geotechnical conditions of subject property 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 currently proposed to construct a new 257,915 square feet concrete tilt-up structure on the 13.16-acre parcel. Asphaltic and concrete pavement areas and landscaping will also be installed. Grading for the 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 rectangular shaped property is located at the southwest corner of Slover Avenue and Cactus Avenue, in the Bloomington area of the County of San Bernardino, as shown on the Vicinity Map, Figure 1.

2.2 **Existing Improvements:** The site is largely vacant except for four residences and a detached garage located on the east and west sides of the site. Some improvements related to the houses include concrete pavement, landscaping and other associated improvements.

2.3 **Drainage:** The site topography is generally flat and drainage appears to be via sheetflow in a southerly and easterly directions.

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 2016 California Building Code (CBC) as determined using the USGS Seismic Design tool (http://geohazards.usgs.gov/designmaps/us/application.php) for the referenced project. Design map summary report and the detailed report from the website are included in Appendix A.

Seismic Design Parameters

Site Location – Region 1	Latitude	34.0623°
	Longitude	-117.3850°
Seismic Use Group		II
Site Class		D
Risk Category		I/II/III
Maximum Spectral Response Acceleration	S_S	1.627g
	S_1	0.707g
Adjusted Maximum Acceleration	S_{MS}	1.627g
	S_{M1}	1.060g
Design Spectral Response Acceleration Parameters	S_{DS}	1.084g
	S_{D1}	0.707g

The San Jacinto (San Bernardino) Fault zone is located approximately 5.5 kilometers from the site and is capable of producing a Magnitude 6.7 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.

4.0 FIELD INVESTIGATION

4.1 Site Exploration

The investigation consisted of the placement of seventeen (17) subsurface exploratory borings by backhoe. Explorations extended to a maximum depth of 18.5 feet below current ground elevations. The explorations were placed at accessible locations throughout the site. Existing improvements limited the placement of the explorations.

The explorations were visually classified and logged by a field engineer with locations of the subsurface excavations are shown on the attached Figure 2. Detailed descriptions of the subsurface conditions are listed on the logs in Appendix A. It should be noted that the transition from one soil type to another as shown on the excavation logs is approximate and may in fact be a gradual transition. The soils encountered are described as follows:

Fill Soils– Fill soils classifying as silty SAND with some gravel, small cobbles, roots and occasional minor debris were encountered in the explorations to depths ranging from 12 to 18 inches. These soils were noted to be loose and dry to damp.

Native Soils – Native soils classifying as silty SAND with some gravel, and occasional cobbles were encountered beneath the upper fill soils. These soils were noted to be generally medium dense and dry to damp. Sand, silt and gravel/cobble content varied with depth of explorations.

4.2 Groundwater

Groundwater was not encountered in any of our test excavations. Historic high groundwater in the vicinity has been recorded greater than 100 to 200 feet below grade at wells approximately ¾ mile northwest of the site and 1¼ mile southeast, based upon information from the California Department of Water Resources database http://www.water.ca.gov/waterdatalibrary/.

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.

Bulk bag samples were obtained in the upper soils for expansion index tests, corrosion tests, resistance value and maximum density tests. Wall loadings on the order of 3,000 lbs./lin.ft. and maximum compression loads on the order of 30 kips were utilized for testing and design purposes. All test results are included in Appendix B, unless otherwise noted.

5.1 **Field moisture content** (ASTM:D 2216-10) 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-1557-12) 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-4829-11) 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 **Direct shear tests** (ASTM: D-3080-11) were performed on undisturbed and remolded samples of the subsurface soils. These tests were performed to determine parameters for the calculation of the allowable soil 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 - B.

5.5 **Consolidation tests** (ASTM: D-2435-11) were performed on remolded 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 C-E.

5.6 **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 III – VI and are discussed later in this report.

5.7 **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 VII and recommended pavement sections are provided later within the text of this report.

6.0 LIQUEFACTION EVALUATION

Based upon review of the *San Bernardino County – Land Use Services, Geologic Hazard Maps* website, the site is not located in an area subject to liquefaction during a seismic event. In addition, due to the deep groundwater in the vicinity, liquefaction potential is very low.

7.0 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 and grading will be safe from excessive settlements under the anticipated design loadings and conditions. The proposed grading and development shall meet all requirements of the City Building Ordinance and will not impose any adverse 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 and organic-laden soils shall be removed and hauled from proposed grading areas prior to and during the grading operations if encountered. 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 Recompaction Recommendations

The upper existing fill soils (18 inches) 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 pad and concrete paving shall be compacted to a minimum of 95%.* 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 not described in this report or materials disturbed during demolition operations will be encountered 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, cesspools, septic tanks, irrigation or utility lines. If encountered, these 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 potential for differential settlement of structures supported on both compacted fill and medium dense native soils, it is recommended that all foundations 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.

Building floor slabs should be underlain by a minimum of 1.5 feet of compacted fill soils.

7.1.3 Shrinkage and Subsidence

Results of our in-place density tests reveal that the soil shrinkage will be on the order of 12 to 15% 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 0.12 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 an embedded depth of 18 inches into approved 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)

Width (ft)	Continuous Foundation	Isolated Foundation
1.5	2000	2500
2.0	2100	2600
4.0	2400	2900
6.0	2800	3300

Property line screen wall foundations where proper overexcavation and recompaction is not possible due to property line restrictions may be designed using a reduced allowable soil bearing capacity of 1,500 psf for foundations a minimum of 18 inches in depth *and* at least 8 inches into the underlying medium dense native soils. A one-third increase may be used when considering short term loading from wind and seismic forces.

Steel reinforcement may be necessary due to soil expansion or proposed loadings and shall be further evaluated by the project engineers and/or architect. A representative of this firm shall observe foundation excavations prior placement of steel reinforcement and concrete.

7.4 Settlement Analysis

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

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.

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. All walls shall be waterproofed as needed and protected from hydrostatic pressure by a reliable permanent subdrain system.

During a local Magnitude 6.7 earthquake along the San Jacinto fault zone, additional lateral pressures will occur along the back of retaining walls. The seismic-induced lateral soil pressure 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 given in our previous report may be increased by 1/3 during short-term wind and seismic loading conditions.

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. 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.

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 III.

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 – VI. Soil pH indicates a slightly alkaline condition. Resistivity is representative of slightly corrosive soils and metallic structures should be protected as necessary. Chloride content measured 203 ppm.

7.11 Preliminary Pavement Design

The table below provides a preliminary pavement design based upon an R-Value of 50 for the proposed pavement areas. Actual R-Value test results are given in Table VII. 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

Type of Traffic	Traffic Index	Inches Asphalt	Inches Base
Auto Parking/Circulation	5.0	3.0	3.0
Truck	7.0	3.5	6.0

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 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 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

KEITH D. TUCKER
No. 841
Exp. 12/31/18

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

Mark A. Burkholder
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 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-1557-12).

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-1557-12) 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.

NorCal Engineering

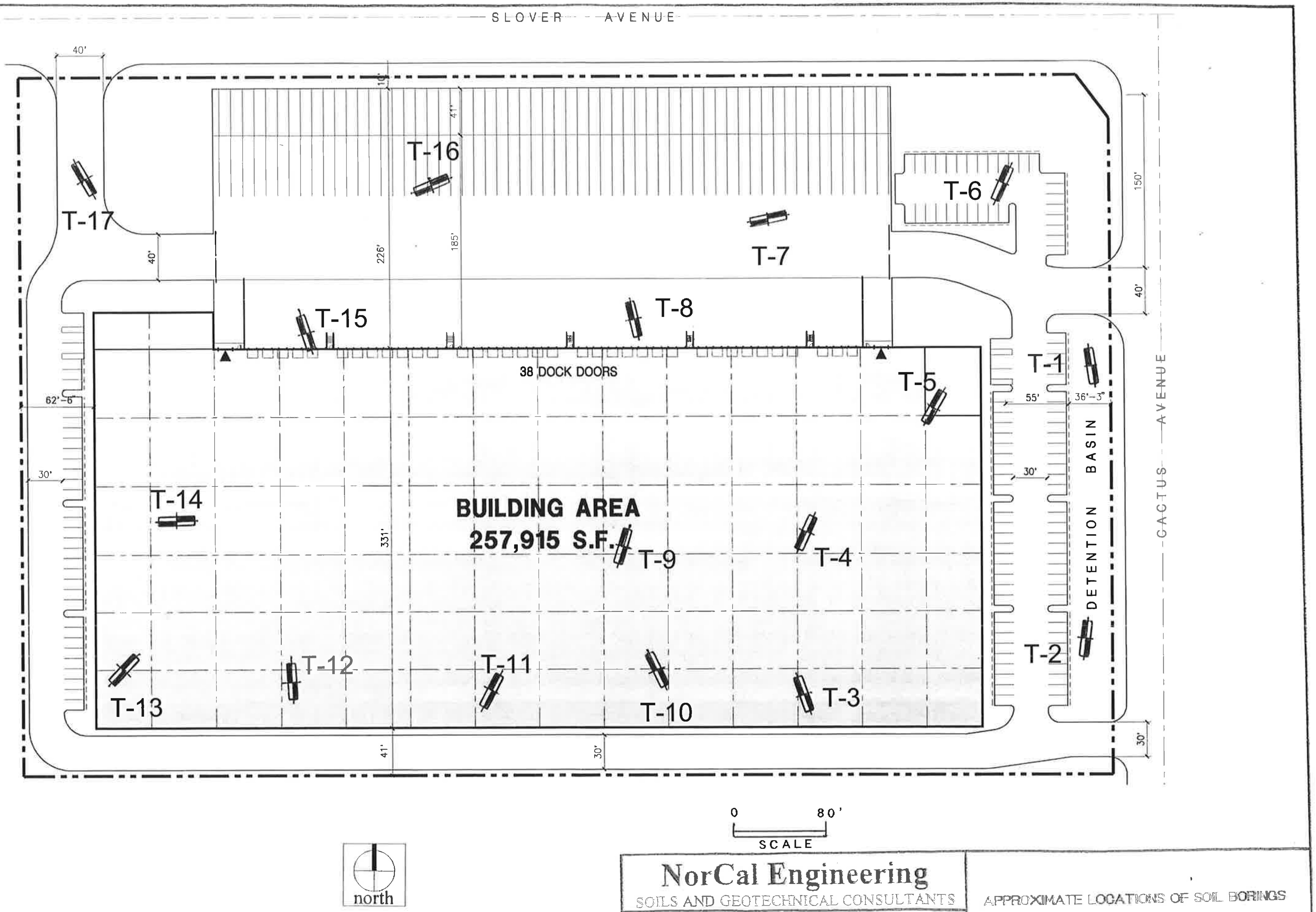
SOILS AND GEOTECHNICAL CONSULTANTS

VICINITY MAP

FIG. 1

PROJECT 19834-17

DATE 9/2017



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SOILS AND GEOTECHNICAL CONSULTANTS

PROJECT 19834-17 DATE 9/2017

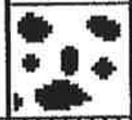
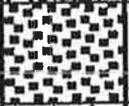
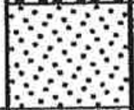
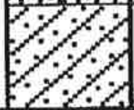
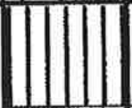
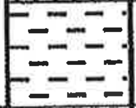
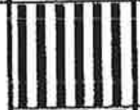
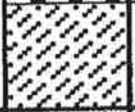
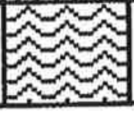
APPROXIMATE LOCATIONS OF SOIL BORINGS

FIG. 2

APPENDICES

(In order of appearance)

APPENDIX A

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

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Log of Trench T-1

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
	▦		NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
5			Boring completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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Log of Trench T-2

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

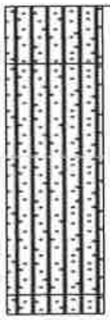
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
			NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
5								
			Silty SAND Light brown, medium dense, damp					
			Boring completed at depth of 8'					
10								
15								
20								
25								
30								
35								

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Log of Trench T-3

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

Groundwater Depth: None Encountered

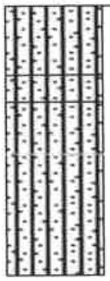
Drilling Method: Backhoe

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 SOILS Silty SAND with gravel, small cobbles, roots, concrete pieces Brown, loose, dry					
		NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp	⊠		1.2		
5		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp Decrease in cobbles with depth	■		2.6	107.8	
		Boring completed at depth of 7'					
10							
15							
20							
25							
30							
35							



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Log of Trench T-4

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17 | **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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
				▽ ■ ▽		1.5	114.7	
			NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp					
5			Slightly silty SAND with gravel Light brown, medium dense, dry to damp	■		1.0	130.1	
10				■		2.7	107.1	
			Silty SAND Brown, medium dense, damp					
15				■		4.2	97.8	
				■		3.4	98.1	
			Boring completed at depth of 18.5'					
20								
25								
30								
35								

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Log of Trench T-5

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
	▨ GWT not encountered	NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	☐				
	▨		☐		2.5		
5		Boring completed at depth of 5'					
10							
15							
20							
25							
30							
35							

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Log of Trench T-6

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, roots Brown, loose, dry					
		NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	■		2.9	116.9	
5		Boring completed at depth of 5'					
10							
15							
20							
25							
30							
35							

SuperLog CivilTech Software, USA www.civiltech.com File: C:\Superlog4\PROJECT\19834-17.log Date: 9/7/2017

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Log of Trench T-7

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

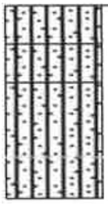
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, roots Brown, loose, dry	☒				
		NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp					
5		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
		Boring completed at depth of 5'					
10							
15							
20							
25							
30							
35							

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Log of Trench T-8

Boring Location: Slover & Cactus, Bloomington	
Date of Drilling: 8/19/17	**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 SOILS Silty SAND with gravel, roots Brown, loose, dry	■		5.3	100.3	
	▨		NATURAL SOILS Silty SAND with gravel, occasional small cobbles Brown, medium dense, dry to damp					
5			Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
			Boring completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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Log of Trench T-9

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

Groundwater Depth: None Encountered

Drilling Method: Backhoe

Hammer Weight:

Drop:

Surface Elevation: Not Measured

GWT not encountered

Depth (feet)	Material Description	Samples		Laboratory		
		Type	Blow Counts	Moisture	Dry Density	Fines Content %
0	FILL SOILS Silty SAND with gravel, roots Brown, loose, dry	■		5.9	106.5	
	NATURAL SOILS Silty SAND with gravel Brown, medium dense, damp	☐		2.7		
5	Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	■		5.1	112.6	
10	Boring completed at depth of 10'					
15						
20						
25						
30						
35						

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Log of Trench T-10

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
		NATURAL SOILS Silty SAND with gravel, occasional small cobbles Brown, medium dense, dry to damp					
5		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	■		3.9	109.9	
10			■		2.7	113.0	
		Boring completed at depth of 10.5'					
15							
20							
25							
30							
35							

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Log of Trench T-11

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

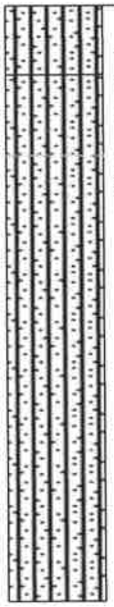
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, roots, organics Brown, loose, dry					
	NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
5		■		3.7	124.1	
10		■		2.9	121.5	
	No cobbles below 11.5'					
15		■		3.8	104.2	
	Boring completed at depth of 15.5'					
20						
25						
30						
35						

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Log of Trench T-12

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

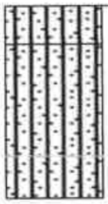
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry NATURAL SOILS Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
5			Boring completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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Log of Trench T-13

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

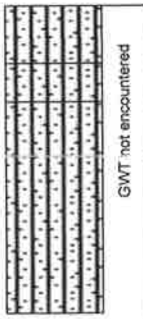
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, roots Brown, loose, dry					
		NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp	■		2.9	117.5	
5		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp No cobbles below 3.5'	■		3.2	122.4	
		Boring completed at depth of 8'					
10							
15							
20							
25							
30							
35							

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Log of Trench T-14

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

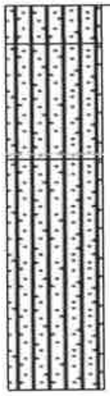
Groundwater Depth: None Encountered

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry	■		1.6	120.7	
	NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp					
5	Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	■		3.9	114.1	
10	Boring completed at depth of 10'					
15						
20						
25						
30						
35						

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Log of Trench T-15

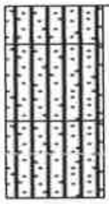
Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17 **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 SOILS Silty SAND with gravel, roots, plastic pieces Brown, loose, dry					
		NATURAL SOILS Silty SAND with gravel Brown, medium dense, dry to damp					
5		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
		Boring completed at depth of 5'					
10							
15							
20							
25							
30							
35							

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Log of Trench T-16

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
			NATURAL SOILS Silty SAND Brown, medium dense, dry to damp					
5			Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp					
			Boring completed at depth of 5'					
10								
15								
20								
25								
30								
35								

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Log of Trench T-17

Boring Location: Slover & Cactus, Bloomington

Date of Drilling: 8/19/17

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 SOILS Silty SAND with gravel, small cobbles, roots Brown, loose, dry					
	▨		NATURAL SOILS Silty SAND with gravel, occasional small cobbles Brown, medium dense, dry to damp					
5	▨		Slightly silty SAND with gravel, occasional cobbles Light brown, medium dense, dry to damp	■		4.1	109.9	
10			Boring completed at depth of 10'					
15								
20								
25								
30								
35								

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APPENDIX B

TABLE I
MAXIMUM DENSITY TESTS
(ASTM: D-1557-12)

Sample	Classification	Optimum Moisture	Maximum Dry Density (lbs./cu.ft.)
T-4 @ 2-4'	silty SAND w/gravel	9.0	134.0

TABLE II
EXPANSION INDEX TESTS
(ASTM: D-4829-11)

Sample	Classification	Expansion Index
T-4 @ 2-4'	silty SAND w/gravel	00

TABLE III
SOLUBLE SULFATE TESTS
(CT 417)

Sample	Sulfate Concentration (%)
T-4 @ 1-2'	.0002

TABLE IV
pH TESTS

Sample	pH
T-4 @ 1-2'	7.6

TABLE V
RESISTIVITY TESTS
(CT 643)

Sample	Resistivity (ohm-cm)
T-4 @ 1-2'	37,954

TABLE VI
CHLORIDE TESTS
(CT 422))

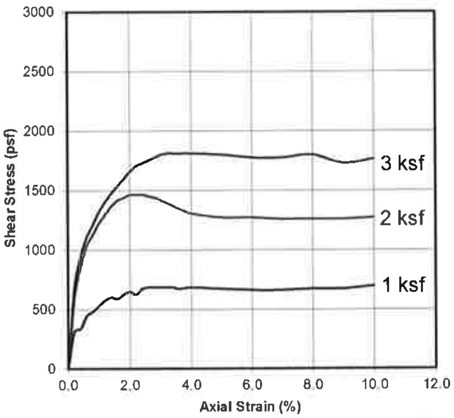
Sample	Concentration (ppm)
T-4 @ 1-2'	203

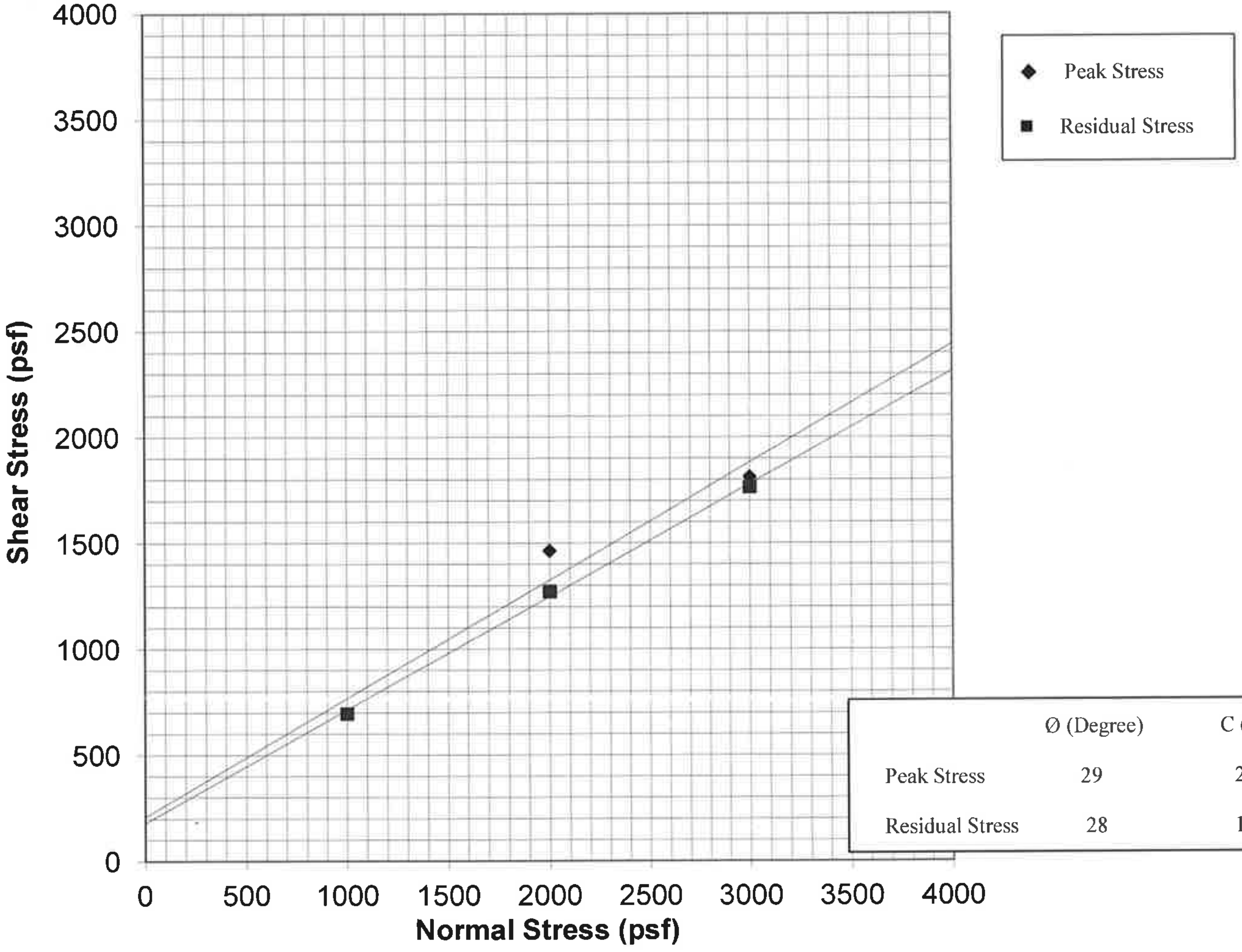
TABLE VII
RESISTANCE 'R' VALUE TESTS
(CA 301))

Sample	'R' Value
T-7 @ 1-2'	66

Sample No. T4@2'
Sample Type: Remolded/Saturated
Soil Description: Fine-Coarse Grained Sand w/ Some Silt & Small Gravel

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	696	1464	1812
Displacement	(in)	0.250	0.050	0.080
Residual Stress	(psf)	696	1272	1764
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	120.6	120.6	120.6
In Situ Water Content	(%)	8.5	8.5	8.5
Saturated Water Content	(%)	14.7	14.7	14.7
Strain Rate	(in/min)	0.020	0.020	0.020





	Ø (Degree)	C (psf)
Peak Stress	29	210
Residual Stress	28	180

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PROJECT NUMBER: 19834-17 DATE: 8/31/2017

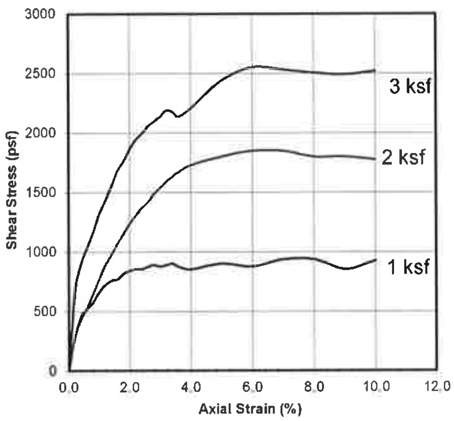
DIRECT SHEAR TEST

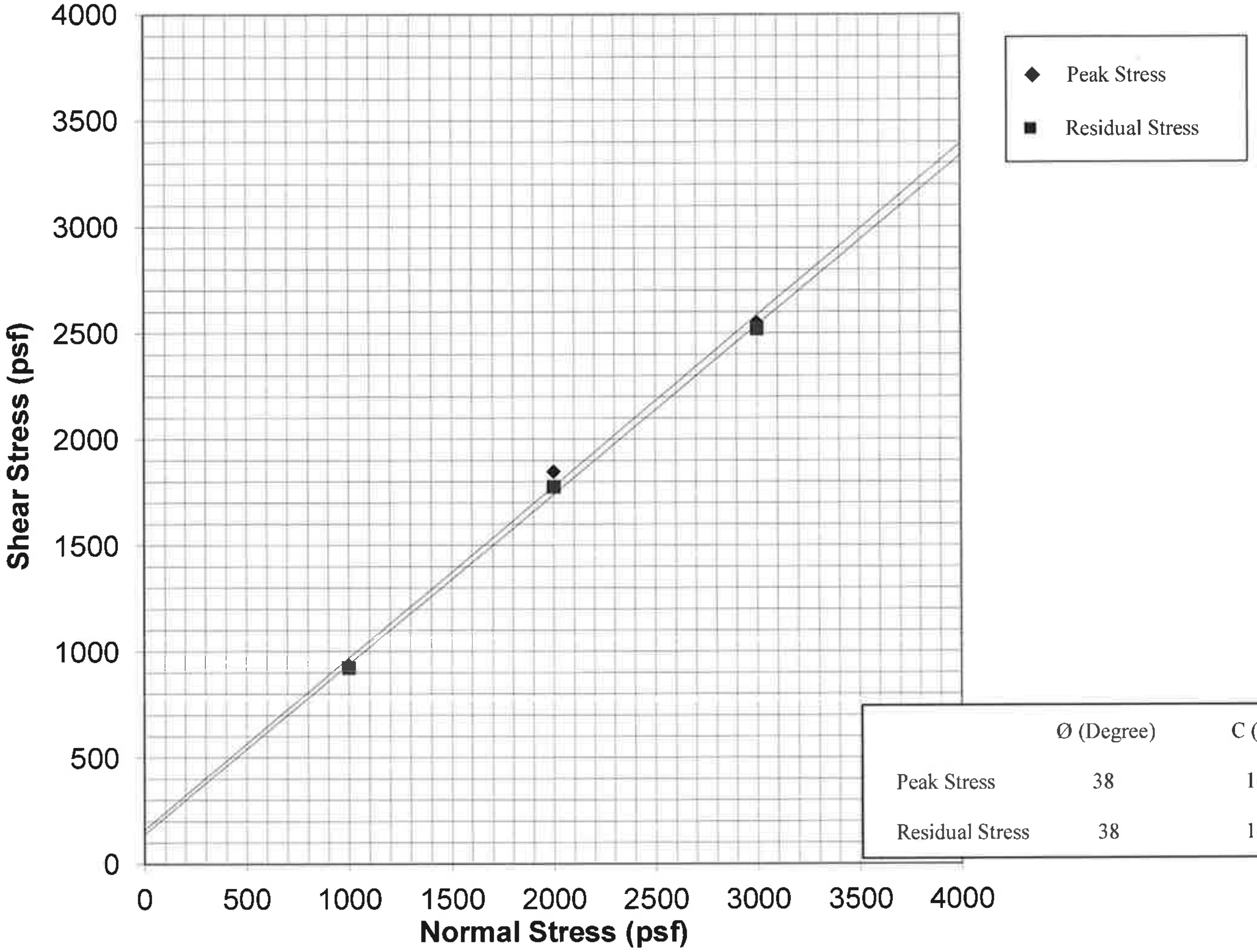
ASTM D3080

Plate A

Sample No. T13@3'
Sample Type: Undisturbed/Saturated
Soil Description: Fine-Coarse Grained Sand w/ Some Small Gravel & Trace Silt

		1	2	3
Normal Stress	(psf)	1000	2000	3000
Peak Stress	(psf)	936	1848	2550
Displacement	(in.)	0.175	0.150	0.150
Residual Stress	(psf)	924	1776	2520
Displacement	(in.)	0.250	0.250	0.250
In Situ Dry Density	(pcf)	117.5	117.5	117.5
In Situ Water Content	(%)	2.9	2.9	2.9
Saturated Water Content	(%)	16.0	16.0	16.0
Strain Rate	(in/min)	0.020	0.020	0.020





	Ø (Degree)	C (psf)
Peak Stress	38	160
Residual Stress	38	140

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DIRECT SHEAR TEST

ASTM D3080

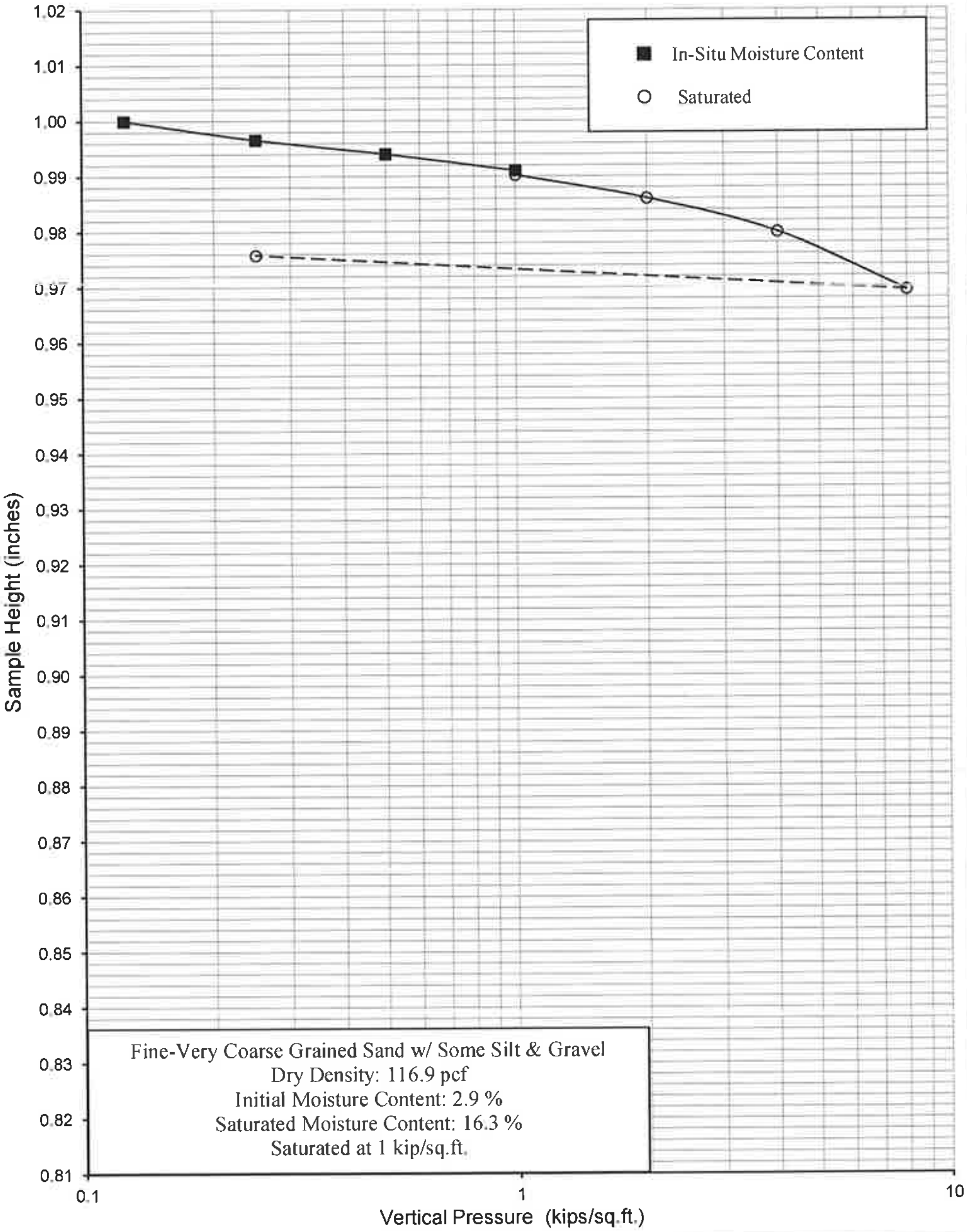
Plate B

Sample No. T6 | Depth 4' | Date 8/31/2017

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)
0.125	1.0000	0.0
0.25	0.9966	0.3
0.5	0.9940	0.6
1	0.9910	0.9
1	0.9902	1.0
2	0.9860	1.4
4	0.9799	2.0
8	0.9694	3.1
0.25	0.9758	2.4

Saturated

Date Tested: 8/28/2017
Sample: T6
Depth: 4'



Fine-Very Coarse Grained Sand w/ Some Silt & Gravel
Dry Density: 116.9 pcf
Initial Moisture Content: 2.9 %
Saturated Moisture Content: 16.3 %
Saturated at 1 kip/sq.ft.

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PROJECT NUMBER: 19834-17 DATE: 8/31/2017

CONSOLIDATION TEST

ASTM D2435

Plate C

Sample No. T9

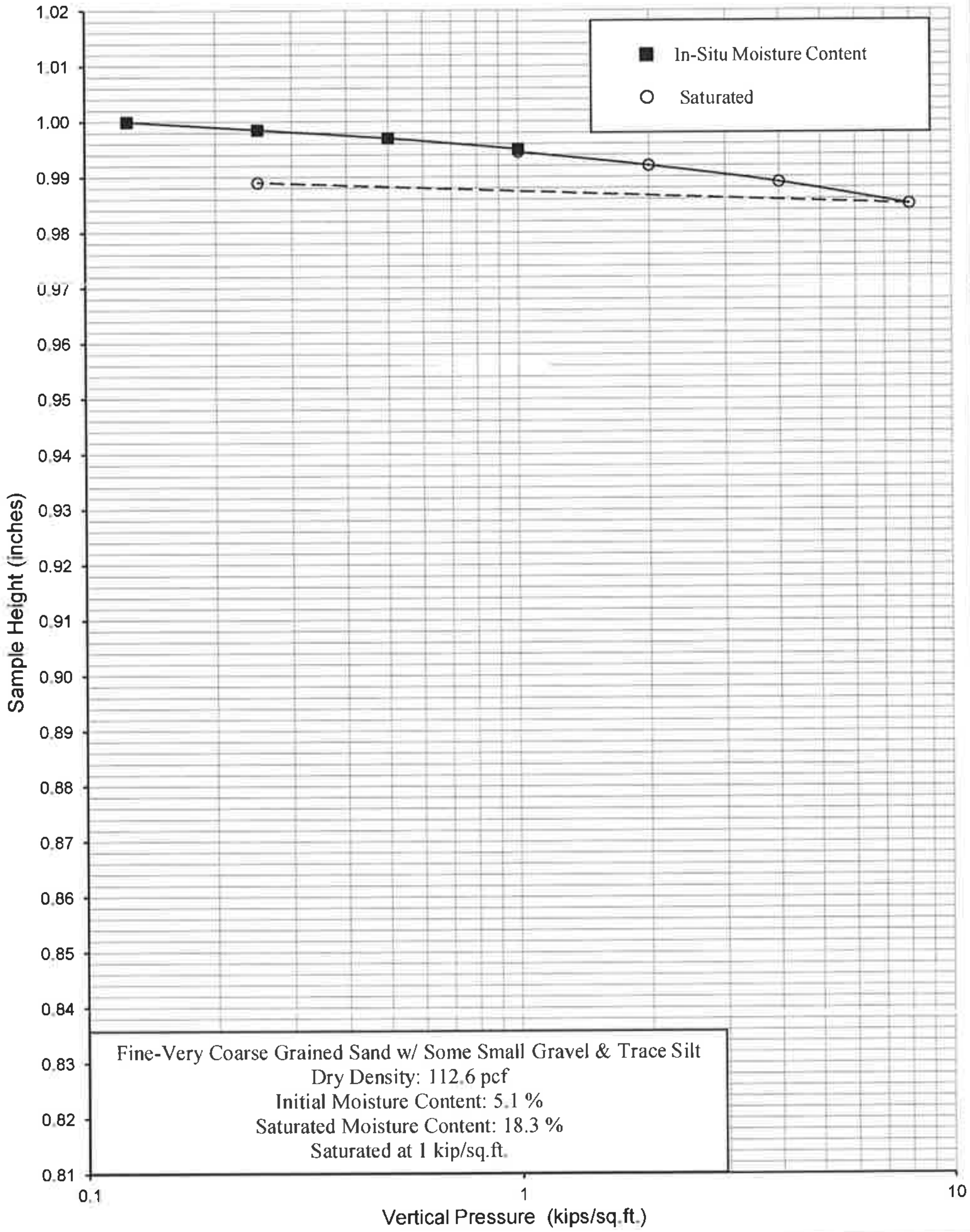
Depth 8'

Date 8/31/2017

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)
0.125	1.0000	0.0
0.25	0.9985	0.2
0.5	0.9970	0.3
1	0.9950	0.5
1	0.9945	0.6
2	0.9920	0.8
4	0.9890	1.1
8	0.9850	1.5
0.25	0.9890	1.1

Saturated

Date Tested: 8/29/2017
Sample: T9
Depth: 8'



Fine-Very Coarse Grained Sand w/ Some Small Gravel & Trace Silt
Dry Density: 112.6 pcf
Initial Moisture Content: 5.1 %
Saturated Moisture Content: 18.3 %
Saturated at 1 kip/sq.ft.

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CONSOLIDATION TEST

ASTM D2435

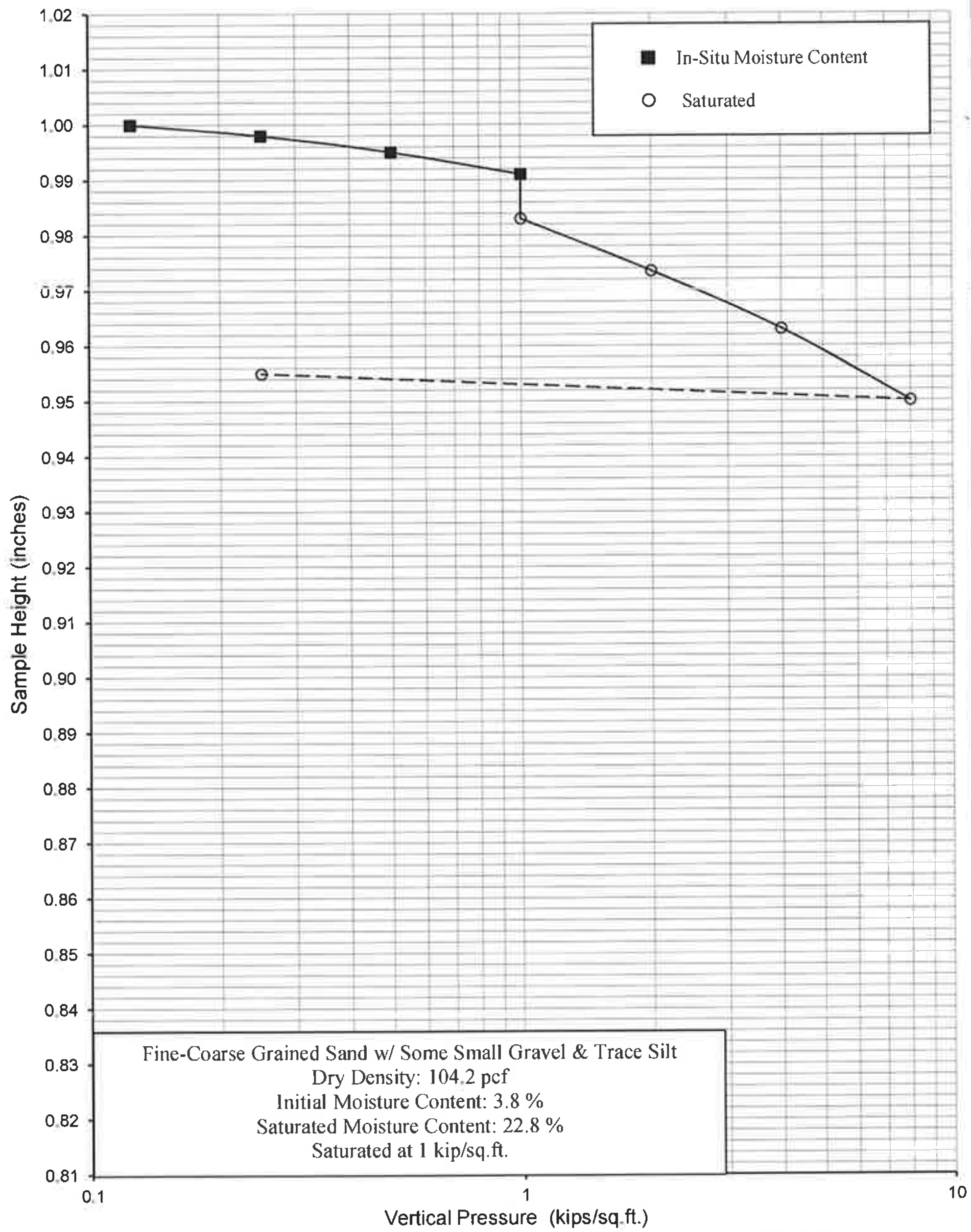
Plate D

Sample No. T11 **Depth** 15' **Date** 8/31/2017

Vertical Pressure (kips/sq.ft.)	Sample Height (inches)	Consolidation (percent)
0.125	1.0000	0.0
0.25	0.9980	0.2
0.5	0.9950	0.5
1	0.9910	0.9
1	0.9830	1.7
2	0.9735	2.7
4	0.9630	3.7
8	0.9500	5.0
0.25	0.9550	4.5

Saturated

Date Tested: 8/29/2017
Sample: T11
Depth: 15'



Fine-Coarse Grained Sand w/ Some Small Gravel & Trace Silt
Dry Density: 104.2 pcf
Initial Moisture Content: 3.8 %
Saturated Moisture Content: 22.8 %
Saturated at 1 kip/sq.ft.

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PROJECT NUMBER: 19834-17 DATE: 8/31/2017

CONSOLIDATION TEST

ASTM D2435

Plate E

APPENDIX C

USGS Design Maps Summary Report

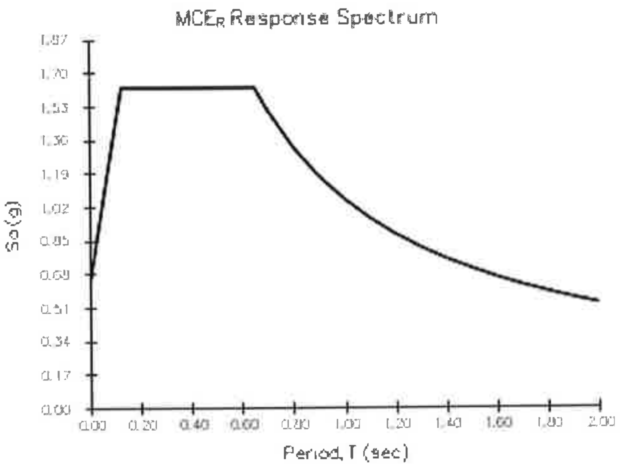
User–Specified Input

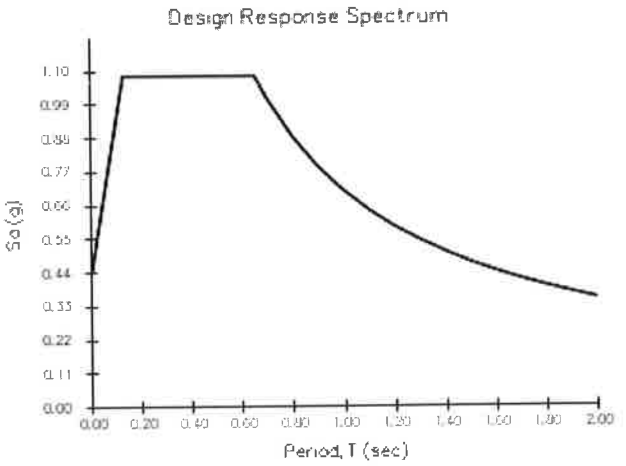
Report Title	Slover and Cactus Wed September 6, 2017 18:36:03 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.0623°N, 117.385°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

$S_S =$ 1.627 g	$S_{MS} =$ 1.627 g	$S_{DS} =$ 1.084 g
$S_1 =$ 0.707 g	$S_{M1} =$ 1.060 g	$S_{D1} =$ 0.707 g

For information on how the SS and S1 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.

USGS Design Maps Detailed Report

ASCE 7-10 Standard (34.0623°N, 117.385°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 [1]	$S_S = 1.627$ g
From Figure 22-2 [2]	$S_1 = 0.707$ 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: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
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/ft² = 0.0479 kN/m²

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				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
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	$\boxed{1.0}$
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 = 1.627 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				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
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	$\boxed{1.5}$
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 = 0.707 g, F_v = 1.500

Equation (11.4-1): $S_{MS} = F_aS_S = 1.000 \times 1.627 = 1.627$ g

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Equation (11.4-2): $S_{M1} = F_vS_1 = 1.500 \times 0.707 = 1.060$ g

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Section 11.4.4 — Design Spectral Acceleration Parameters

Equation (11.4-3): $S_{DS} = ⅔\ S_{MS} = ⅔ \times 1.627 = 1.084$ g

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Equation (11.4-4): $S_{D1} = ⅔\ S_{M1} = ⅔ \times 1.060 = 0.707$ g

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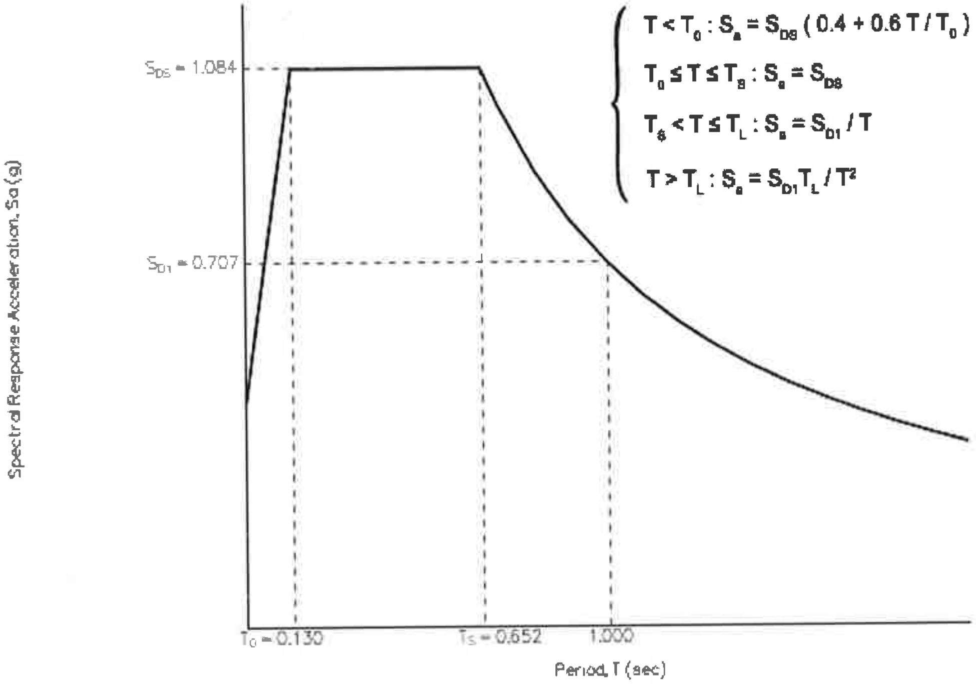
Section 11.4.5 — Design Response Spectrum

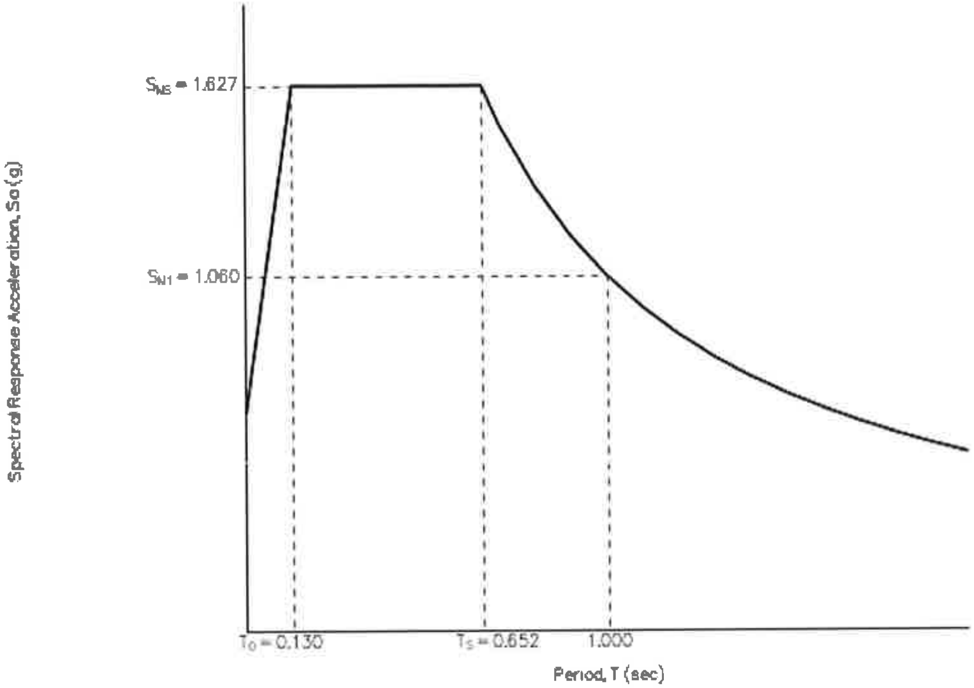
From Figure 22-12 [3] $T_L = 8$ seconds

Figure 11.4-1: Design Response Spectrum



Section 11.4.6 — Risk-Targeted Maximum Considered Earthquake (MCE$_R$) Response Spectrum

The MCE$_R$ 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 [4] PGA = 0.640

Equation (11.8–1): $PGA_M = F_{PGA}PGA = 1.000 \times 0.640 = 0.64$ g

Table 11.8–1: Site Coefficient F_{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 = 0.640 g, F_{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 [5] $C_{RS} = 1.066$

From Figure 22-18 [6] $C_{R1} = 1.023$

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
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 1.084 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
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.707 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 ≡ "the more severe design category in accordance with Table 11.6-1 or 11.6-2" = D

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

References

1. *Figure 22-1*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-1.pdf
2. *Figure 22-2*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-2.pdf
3. *Figure 22-12*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-12.pdf
4. *Figure 22-7*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-7.pdf
5. *Figure 22-17*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-17.pdf
6. *Figure 22-18*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/2010_ASCE-7_Figure_22-18.pdf