Appendix F:
Geology and Soils Supporting Information

THIS PAGE INTENTIONALLY LEFT BLANK

F.1 - Geotechnical Exploration

THIS PAGE INTENTIONALLY LEFT BLANK

THE RANCH AT ANTIOCH
ANTIOCH, CALIFORNIA

GEOTECHNICAL EXPLORATION

SUBMITTED TO
Mr. Kyle Masters
Richland Communities, Inc.
3000 Lava Ridge Court, Suite 115
Roseville, CA 95661

PREPARED BY
ENGEO Incorporated

September 26, 2018

PROJECT NO.
4371.000.001

ENGEO
Expect Excellence

GEOTECHNICAL
ENVIRONMENTAL
WATER RESOURCES
CONSTRUCTION SERVICES

Expect Excellence

Project No.
4371.000.001

September 26, 2018

Mr. Kyle Masters
Richland Communities, Inc.
3000 Lava Ridge Court, Suite 115
Roseville, CA 95661

Subject: The Ranch at Antioch
Antioch, California

GEOTECHNICAL EXPLORATION

Dear Mr. Masters:

ENGEO prepared this geotechnical report for Richland Communities, Inc. as outlined in our agreement dated August 2, 2018. We characterized the subsurface conditions at the site to provide the enclosed geotechnical recommendations for design.

Our experience and that of our profession clearly indicate that the risk of costly design, construction, and maintenance problems can be significantly lowered by retaining the design geotechnical engineering firm to review the project plans and specifications and provide geotechnical observation and testing services during construction. Please let us know when working drawings are nearing completion, and we will be glad to discuss these additional services with you.

If you have any questions or comments regarding this report, please call and we will be glad to discuss them with you.

Sincerely,

ENGEO Incorporated

Victoria Drake, EIT

Steven Harris, GE

REGISTERED PROFESSIONAL ENGINEER
STEVE HARRIS
No. 2804
GEOTECHNICAL
STATE OF CALIFORNIA

Cale Crawford, PE
vd/cc/sh/jf

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

ENGEO prepared this geotechnical report for design of The Ranch at Antioch in Antioch, California. We prepared this report as outlined in our agreement dated August 2, 2018. Richland Communities, Inc. authorized ENGEO to conduct the following scope of services:

- Review of previous geotechnical reports
- Subsurface field exploration to characterize potential undocumented fill
- Data analysis and conclusions
- Report preparation

We performed previous subsurface exploration at the site as referenced in our report titled "Geotechnical Exploration for Sand Creek Ranch Active Adult Community" dated May 24, 2006.

This report was prepared for the exclusive use of Richland Communities, Inc. and their consultants for design of this project. In the event that any changes are made in the character, design or layout of the development, we must be contacted to review the conclusions and recommendations contained in this report to evaluate whether modifications are recommended. This document may not be reproduced in whole or in part by any means whatsoever, nor may it be quoted or excerpted without our express written consent.

1.2 PROJECT LOCATION AND DESCRIPTION

The Ranch at Antioch is approximately 402 aces in size and is located west of Deer Valley Road, north and east of Empire Mine Road, and south of an existing residential development in Antioch, California (Figure 1). The site is currently undeveloped open space covered with seasonal grasses and trees. The majority of the site is used as grazing land for cattle.

Based on discussions with Richland Communities, Inc., we understand the proposed development will include:

- Approximately 1,200 low- to medium-density single-family homes
- A village center
- Public use facilities
- Parks
- Open space
- Associated improvements

The site is divided between the north and south by Sand Creek, which is a natural, meandering stream channel that trends from west-to-east across the site. The slopes adjacent to the creek generally vary in height between 5 feet and 40 feet, and can be as steep as 1:1 (horizontal:vertical). To connect the northern and southern portions of the site, a bridge is proposed to span Sand Creek approximately 0.8 mile west of Deer Valley Road.

At the southern portion of the site, rolling hills consisting of sandstone and shale extend approximately 200 feet above the rest of the site. Colluvial soils are located at the foot of these slopes, which generally consist of highly plastic clays and sands.

1.3 PREVIOUS GEOTECHNICAL STUDIES

ENGEO previously performed a geotechnical exploration for the Sand Creek Ranch property in 2006. The study area of the exploration consisted of the currently proposed development property, as well as an additional approximately 571 acres to the south of the property. ENGEO's field exploration included drilling 40 exploratory borings and excavating 23 test pits. The approximate locations of the historic explorations within the currently proposed site are shown on the Site Plan (Figure 2). The main geotechnical concern identified for The Ranch at Antioch property includes: (1) the presence of moderately to highly expansive soil considered susceptible to significant volume changes (swell and compression) when subjected to varying moisture conditions and (2) the presence of compressible colluvial deposits along swales considered susceptible to excessive total and differential settlement.

In 2017, ENGEO performed a geotechnical review of The Ranch at Antioch property. The review summarized the geotechnical and geologic hazards affecting the planned development in Antioch, California. The primary geological considerations for the planned development included: (1) the identification and removal of undocumented fill and (2) the benching and filling of the tributary stream channels. Locations potentially underlain by landslide deposits and existing fills are identified in Figure 2. As part of the 2017 evaluation, ENGEO noted two locations of potentially significant undocumented fill: a historic orchard within the central north portion of the site, and a historic farmstead near the western portion of the site.

2.0 FINDINGS

2.1 FIELD EXPLORATION

Our field exploration included excavating seven test pits within the historic orchard and the homestead, as shown in Figure 2. We performed our field exploration on August 29, 2018. The locations of our explorations are approximate and were estimated using handheld global positioning satellite (GPS) equipment; however, they should be considered accurate only to the degree implied by the method used.

An ENGEO representative observed the test pit excavation and logged the subsurface conditions at each location. We retained a backhoe to excavate the test pits using a 3-foot-wide bucket and logged the type, location, and uniformity of the underlying soil/rock. The maximum depth penetrated by the test pits was 4¼ feet.

The test pit logs present descriptions and graphically depict the subsurface conditions encountered. We used the field logs to develop the report logs in Appendix A. The logs depict subsurface conditions at the exploration locations for the date of exploration; however, subsurface conditions may vary with time.

2.2 GEOLOGY AND SEISMICITY

2.2.1 Geology

We present the following discussion of site geology based on our review of previous geotechnical reports, historical geologic maps, site observations, and subsurface exploration data. In general, the site is underlain by Pleistocene- to Holocene-age alluvium (Qa). These alluvial deposits consist primarily of sandy clay to clayey sand, and can extend upward of 30 feet below the ground surface within the vicinity of Sand Creek. Based on the subsurface explorations within the alluvial deposits, the materials within the vicinity of Sand Creek generally consist of shallow deposits of weathered alluvial clay and alluvial clayey sand to sandy clay.

Markley sandstone (Tkm) is located along the northern and southern boundaries of the site. The Markley sandstone was encountered in these areas during ENGEO's 2006 geotechnical exploration.

In addition, a small shallow landslide on the north bank of Sand Creek, approximately 1,100 feet northwest of the proposed bridge site, was noted during the site reconnaissance conducted by ENGEO in 2017. The landslide deposits that were identified are included in Figure 2.

2.2.2 Seismicity

The site is located in an area of moderate to high seismicity. No known active[1] faults are mapped across the property and the site is not located within an Alquist-Priolo Earthquake Fault Zone; however, large ($>M_w7$) earthquakes have historically occurred in the Bay Area and along the margins of the Central Valley and many earthquakes of low magnitude occur every year. The two nearest earthquake faults zoned as active by the State of California Geological Survey are the Greenville fault, located about 5 miles southwest, and the Great Valley fault, located about 6 miles to the east. The Great Valley fault is a blind thrust fault with no known surface expression; the postulated fault location has been based on regional seismic activity and isolated subsurface information.

Portions of the Great Valley fault are considered seismically active thrust faults; however, since the Great Valley fault segments are not known to extend to the ground surface, the State of California has not defined Earthquake Fault Hazard Zones around the postulated traces. The Great Valley fault is considered capable of causing significant ground shaking at the site, but the recurrence interval is believed longer than for more distant, strike-slip faults. Recent studies suggest that this boundary fault may have been the cause of the Vacaville-Winters earthquake sequence of April 1892 (Eaton, 1986; Wong and Biggar, 1989; Moores and others, 1991). Further seismic activity can be expected to continue along the western margin of the Central Valley, and as with all projects in the area, the development should be designed to accommodate strong earthquake ground shaking.

Other active faults in the San Francisco Bay Area capable of producing significant ground shaking at the site include the Green Valley fault, 11 miles west; the Calaveras fault, 15 miles southwest; the Hayward fault, 24 miles southwest; and the San Andreas fault, 42 miles southwest. Figure 4 shows the approximate locations of these faults and significant historic earthquakes recorded within the San Francisco Bay Region. Any one of these faults could generate an earthquake capable of causing strong ground shaking at the subject site. Earthquakes of Moment Magnitude 7 and larger have historically occurred in the Bay Area and Central Valley and numerous small magnitude earthquakes occur every year.

[1] An active fault is defined by the California Geologic Survey as one that has had surface displacement within Holocene time (about the last 11,000 years). The State of California has prepared maps designating zones for special studies that contain these active earthquake faults.

2.3 SURFACE CONDITIONS

Based on our review of published topographic information, elevations vary across the site from approximately 220 to 330 feet above mean sea level (msl). At the time of our field exploration, we observed the following site features:

- Existing farm compound with several structures, including two residences, a shed, and a barn.
- Trees and moderate vegetation along Sand Creek.
- A cluster of trees in the northern portion of the site, within the boundary of the historic orchard.
- A concrete-lined v-ditch trending west-east within the northern portion of the site, bordered by boulders to the north and south.
- Moderate growth of dry grasses and vegetation across the site.
- Small, ground squirrel burrows throughout the site.

Please refer to the Site Plan, Figure 2, for more information on site features.

2.4 SUBSURFACE CONDITIONS

The soil encountered in our test pits generally consisted of very stiff to hard lean clay with varying amounts of organic material and gravel in the upper 2½ to 3 feet below ground surface (bgs). In the majority of our test pits, this layer was underlain by hard lean clay with varying amounts of sand to the total depth explored. In 2-TP02 and 2-TP03, the surficial lean clay was underlain by silty sand from 2½ to 4½ feet bgs. In general, we did not encounter undocumented fills in either the historic orchard or the historic homestead.

Historic explorations within the project limits generally encountered stiff to very stiff silty lean clay, lean clay, and fat clay interbedded with layers of silty and clayey sand to depths of approximately 19 to 26½ feet bgs. Sand layers vary from 3 to 11½ feet in thickness. Laboratory results show the lean clays near the surface of the borings have a Plasticity Index (PI) range between 22 and 30.

Consult the Site Plan and exploration logs for specific subsurface conditions at each location. We include our test pit logs in Appendix A. Historic exploration logs and laboratory test data from previous explorations within the proposed site are included in Appendices B and C, respectively. The logs contain the soil type, color, consistency, and visual classification in general accordance with the Unified Soil Classification System. The logs graphically depict the subsurface conditions encountered at the time of the exploration.

2.5 GROUNDWATER CONDITIONS

We did not observe static or perched groundwater in any of our subsurface explorations. Our review of a Groundwater Evaluation report prepared for the site (ENGEO, 2017), indicated depth to groundwater is approximately 38 feet below the ground surface (bgs). Fluctuations in the level of groundwater may occur due to variations in rainfall, irrigation practice, and other factors not evident at the time measurements were made.

3.0 CONCLUSIONS

It is our opinion, based on this exploration and previous explorations, that the project site is suitable for the proposed development from a geotechnical standpoint. The primary geotechnical concern identified for the project is the potential for post-construction ground surface movement due to shrink and swell of expansive surficial soils. The geotechnical recommendations contained herein are appropriate to use to minimize the potential geotechnical impacts on the development of the residential site. We summarize our conclusions below.

3.1 EXISTING FILL

Based on our recent explorations, we did not identify undocumented fills within the historic orchard or the homestead. However, we do note that the existing farm compound on the eastern portion of the site may contain undocumented or non-engineered fills. Non-engineered fills can undergo excessive settlement, especially under new fill or building loads. If non-engineered fills are encountered during construction, we recommend complete removal and recompaction of the existing fill. We present fill removal recommendations in Section 5.2.

3.2 EXPANSIVE SOIL

As discussed in Section 2.4, we observed potentially expansive lean clay near the surface of the site in all of our test pits. Our laboratory testing from 2006 indicates that these soils have moderate to high shrink/swell potential with variations in moisture content.

Expansive soils change in volume with changes in moisture. They can shrink or swell and cause heaving and cracking of slabs-on-grade, pavements, and structures founded on shallow foundations. Building damage due to volume changes associated with expansive soils can be reduced by: (1) using a rigid mat foundation that is designed to resist the settlement and heave of expansive soil, (2) deepening the foundations to below the zone of moisture fluctuation, i.e. by using deep footings or drilled piers, and/or (3) using footings at normal shallow depths but bottomed on a layer of select fill having a low expansion potential.

Post-tensioned mat foundations are the preferred foundation system for the residential structures. Design criteria for this foundation type are presented in Section 6.0. Successful performance of structures on expansive soils requires special attention during construction. It is imperative that exposed soils be kept moist prior to placement of concrete for foundation construction. It can be difficult to remoisturize clayey soils without excavation, moisture conditioning, and recompaction.

We have also provided specific grading recommendations for compaction of clay soil at the site. The purpose of these recommendations is to reduce the swell potential of the clay by compacting the soil at a high moisture content and controlling the amount of compaction.

3.3 SEISMIC HAZARDS

Potential seismic hazards resulting from a nearby moderate to major earthquake can generally be classified as primary and secondary. The primary effect is ground rupture, also called surface faulting. The common secondary seismic hazards include ground shaking, and ground lurching. The following sections present a discussion of these hazards as they apply to the site. Based on topographic and lithologic data, the risk of regional subsidence or uplift, soil liquefaction, lateral spreading, landslides, tsunamis, flooding or seiches is considered low to negligible at the site.

3.3.1 Ground Rupture

Since there are no known active faults crossing the property and the site is not located within an Earthquake Fault Special Study Zone, it is our opinion that ground rupture is unlikely at the subject property.

3.3.2 Ground Shaking

An earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the site, similar to that which has occurred in the past. To mitigate the shaking effects, structures should be designed using sound engineering judgment and the 2016 California Building Code (CBC) requirements, as a minimum. Seismic design provisions of current building codes generally prescribe minimum lateral forces, applied statically to the structure, combined with the gravity forces of dead-and-live loads. The code-prescribed lateral forces are generally considered to be substantially smaller than the comparable forces that would be associated with a major earthquake. Therefore, structures should be able to: (1) resist minor earthquakes without damage, (2) resist moderate earthquakes without structural damage but with some nonstructural damage, and (3) resist major earthquakes without collapse but with some structural as well as nonstructural damage. Conformance to the current building code recommendations does not constitute any kind of guarantee that significant structural damage would not occur in the event of a maximum magnitude earthquake; however, it is reasonable to expect that a well-designed and well-constructed structure will not collapse or cause loss of life in a major earthquake (SEAOC, 1996).

3.3.3 Liquefaction

Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. Soils most susceptible to liquefaction are clean, loose, saturated, uniformly graded, fine-grained sands. Silty sands were encountered in two of the test pits. Silty and clayey sands were encountered in our previous borings at the site. The sands encountered in our explorations were generally medium dense to dense and contained a significant amount of fine-grained material. Groundwater was encountered at approximately 38 feet bgs in our previous explorations. Given the densities and high fine-grained material content in the sand, it is our opinion that the potential for liquefaction at the site is low during seismic shaking.

3.3.4 Ground Lurching

Ground lurching is a result of the rolling motion imparted to the ground surface during energy released by an earthquake. Such rolling motion can cause ground cracks to form in weaker soils. The potential for the formation of these cracks is considered greater at contacts between deep alluvium and bedrock. Such an occurrence is possible at the site as in other locations in the Bay Area Region, but based on the site location, it is our opinion that the offset is expected to be minor.

3.3.5 Flooding

Based on site elevation and distance from water sources, flooding may occur along the area in adjacent to Sand Creek; however, the Civil Engineer should review pertinent information relating to possible flood levels for the subject site based on final pad elevations and provide appropriate design measures for development of the project, if recommended.

3.4 2016 CBC SEISMIC DESIGN PARAMETERS

The 2016 CBC utilizes design criteria set forth in the 2010 ASCE 7 Standard. Based on the subsurface conditions encountered, we characterized the site as Site Class D in accordance with the 2016 CBC. We provide the 2016 CBC seismic design parameters in Table 3.4-1 below, which include design spectral response acceleration parameters based on the mapped Risk Targeted Maximum Considered Earthquake (MCER) spectral response acceleration parameters.

TABLE 3.4-1: 2016 CBC Seismic Design Parameters, Latitude: 37.95065° **Longitude:** -121.78853°

PARAMETER	VALUE
Site Class	D
Mapped MCE_R Spectral Response Acceleration at Short Periods, S_S (g)	1.50
Mapped MCE_R Spectral Response Acceleration at 1-second Period, S_1 (g)	0.59
Site Coefficient, F_A	1.00
Site Coefficient, F_V	1.50
MCE_R Spectral Response Acceleration at Short Periods, S_{MS} (g)	1.50
MCE_R Spectral Response Acceleration at 1-second Period, S_{M1} (g)	0.89
Design Spectral Response Acceleration at Short Periods, S_{DS} (g)	1.00
Design Spectral Response Acceleration at 1-second Period, S_{D1} (g)	0.59
Mapped MCE Geometric Mean (MCE_G) Peak Ground Acceleration, PGA (g)	0.51
Site Coefficient, F_{PGA}	1.00
MCE_G Peak Ground Acceleration adjusted for Site Class effects, PGA_M (g)	0.51
Long period transition-period, T_L	8 sec

4.0 CONSTRUCTION MONITORING

Our experience and that of our profession clearly indicate that the risk of costly design, construction, and maintenance problems can be significantly lowered by retaining the design geotechnical engineering firm to:

1. Review the final grading and foundation plans and specifications prior to construction to evaluate whether our recommendations have been implemented, and to provide additional or modified recommendations, as needed. This also allows us to check if any changes have occurred in the nature, design or location of the proposed improvements and provides the opportunity to prepare a written response with updated recommendations.

2. Perform construction monitoring to check the validity of the assumptions we made to prepare this report. Earthwork operations should be performed under the observation of our representative to check that the site is properly prepared, the selected fill materials are satisfactory, and that placement and compaction of the fills has been performed in accordance with our recommendations and the project specifications. Sufficient notification to us prior to earthwork is important.

If we are not retained to perform the services described above, then we are not responsible for any party's interpretation of our report (and subsequent addenda, letters, and verbal discussions).

5.0 EARTHWORK RECOMMENDATIONS

The relative compaction and optimum moisture content of soil and aggregate base referred to in this report are based on the most recent ASTM D1557 test method. Compacted soil is not acceptable if it is unstable. It should exhibit only minimal flexing or pumping, as observed by an ENGEO representative.

As used in this report, the term “moisture condition” refers to adjusting the moisture content of the soil by either drying if too wet or adding water if too dry.

We define “structural areas” as any area sensitive to settlement of compacted soil. These areas include, but are not limited to building pads, sidewalks, pavement areas, and retaining walls.

5.1 GENERAL SITE CLEARING

Areas to be developed should be cleared of surface and subsurface deleterious materials, including existing building foundations, slabs, buried utility and irrigation lines, pavements, debris, and designated trees, shrubs, and associated roots. Clean and backfill excavations extending below the planned finished site grades with suitable material compacted to the recommendations presented in Section 5.5. ENGEO should be retained to observe and test backfilling.

The surface vegetation should be cut as close to the surface as possible and removed from the site. The remaining vegetation should be thoroughly disked or mulched in the upper 12 inches of site soils until ENGEO determines that the soil is adequately mixed. If desired, ENGEO can evaluate site vegetation at the time of grading to assess the feasibility of mulching organics in place.

5.2 EXISTING FILL REMOVAL

Remove existing fill to competent native soil, as evaluated by ENGEO. If existing fill is encountered during grading, it should be treated as unsuitable and should be subexcavated within all building areas to expose underlying competent native soil that is approved by a representative of our firm. The base of excavations should be processed, moisture conditioned, as needed, and compacted in accordance with the subsequent recommendations for engineered fill. We expect that some nonengineered fill will exist within the limits of the existing farm compound. Once the structures are removed, the upper 2 feet of soil in this area should be removed, the base of the excavation should be ripped, moisture conditioned and compacted and the material can then be placed back as an engineered fill.

5.3 CUT/FILL TRANSITION OR CUT LOTS

Building pads constructed in cuts may encounter variably expansive subsurface conditions in the near-surface soil and rock; these pads may therefore be subject to damaging differential soil movements. Building pads that transition from cut to fill within the building pad area also can experience differential soil movements.

We recommend such building pads be reconstructed to create uniform subgrade conditions. This can be accomplished by subexcavating the soil on the building pads to a minimum depth of 2 feet below finished pad grade on cut lots or lots constructed over cut-and-fill transitions and replacing the subexcavated material with uniformly mixed compacted fill. The subexcavation should be performed over the entire flat pad area. Compacted fill used to replace subexcavated soil should be placed in accordance with Section 5.5.

5.4 OVER-OPTIMUM SOIL MOISTURE CONDITIONS

The contractor should anticipate encountering excessively over-optimum (wet) soil moisture conditions during winter or spring grading, or during or following periods of rain. Wet soil can make proper compaction difficult or impossible. Wet soil conditions can be mitigated by:

1. Frequent spreading and mixing during warm dry weather.
2. Mixing with drier materials.
3. Mixing with a lime or cement product; or
4. Stabilizing with aggregate, geotextile stabilization fabric, or both.

Options 3 and 4 should be evaluated by ENGEO prior to implementation.

5.5 ACCEPTABLE FILL

With the exception of any organically contaminated materials, the site soils are suitable as engineered fill. The Geotechnical Engineer should be informed when import materials are planned for use at the site.

All imported fill materials should be submitted and approved by ENGEO prior to delivery at the site, and should be free of organic material, debris, and fragments larger than 6 inches in greatest dimension. Import materials should have a Plasticity Index equivalent or less than the onsite material.

5.6 FILL COMPACTION

5.6.1 Grading in Structural Areas

Perform subgrade compaction prior to fill placement, following cutting operations, and in areas left at grade as follows.

1. Scarify to a depth of at least 12 inches.
2. Moisture condition soil to at least 3 percentage point above the optimum moisture content; **and**
3. Compact the subgrade to at least 90 percent relative compaction. Compact the upper 12 inches of finish pavement subgrade to at least 95 percent relative compaction prior to aggregate base placement.

After the subgrade soil has been compacted, place and compact acceptable fill as follows:

1. Spread fill in loose lifts that do not exceed 12 inches.
2. Moisture condition lifts to at least 3 percentage point above the optimum moisture content; **and**
3. Compact fill to a minimum of 90 percent relative compaction; Compact the upper 12 inches of fill in pavement areas to 95 percent relative compaction prior to aggregate base placement.

Compact the pavement Caltrans Class 2 Aggregate Base section to at least 95 percent relative compaction (ASTM D1557). Moisture condition aggregate base to or slightly above the optimum moisture content prior to compaction.

5.6.2 Underground Utility Backfill

Recommendations for fill compaction of underground utility backfill within structural areas are provided in this section. Jetting of backfill is not an acceptable means of compaction. Where utility trenches cross underneath buildings, we recommend that a plug be placed within the trench backfill to help prevent the normally granular bedding materials from acting as a conduit for water to enter beneath the building. The plug should be constructed using a sand cement slurry (minimum 28-day compressive strength of 500 psi) or relatively impermeable native soil for pipe bedding and backfill. We recommend that the plug extend for a distance of at least 3 feet in each direction from the point where the utility enters the building perimeter.

The contractor is responsible for conducting trenching and shoring in accordance with CALOSHA requirements. Project consultants involved in utility design should specify pipe bedding materials.

Place and compact trench backfill as follows:

1. Trench backfill should have a maximum particle size of 6 inches.
2. Moisture condition trench backfill to 3 percent above the optimum moisture content. Moisture condition backfill outside the trench.
3. Place fill in loose lifts not exceeding 12 inches;
   and
4. Compact fill to a minimum of 90 percent relative compaction (ASTM D1557).

5.7 SITE DRAINAGE

The project civil engineer is responsible for designing surface drainage improvements. With regard to geotechnical engineering issues, we recommend that finish grades be sloped away from buildings and pavements to the maximum extent practical to reduce the potentially damaging effects of expansive soil. The latest California Building Code Section 1804.4 specifies minimum slopes of 5 percent away from foundations. Where lot lines or surface improvements restrict meeting this slope requirement, we recommend that specific drainage requirements be developed. As a minimum, we recommend the following:

1. Discharge roof downspouts into closed conduits and direct away from foundations to appropriate drainage devices.
2. Consider the use of rear lot surface drainage collection systems to reduce overland surface drainage from back to front of lot.
3. Do not allow water to pond near foundations, pavements, or exterior flatwork.

6.0 FOUNDATION RECOMMENDATIONS

We developed structural improvement recommendations using data obtained from our field explorations, laboratory test results, and engineering analysis. We recommend that the proposed single-family residential structures be supported on post-tensioned (PT) mat foundations bearing on prepared native soil or engineered fill.

We recommend that PT mats be approximately 10 inches thick or greater and have a thickened edge at least 2 inches greater than the mat thickness. The Structural Engineer should determine the actual PT mat thickness using the geotechnical recommendations in this report; we defer to the professional judgment of the Structural Engineer on the necessary mat thickness. ENGEO should be retained to review the PT mat foundation design. We recommend that the thickened edge be at least 12 inches wide.

PT mats may be designed for an average allowable bearing pressure of up to 1,000 pounds per square foot (psf) for dead-plus-live loads with maximum localized bearing pressures of 1,500 psf at column or wall loads. Allowable bearing pressures can be increased by one-third for wind or seismic loads. Design PT mats using the criteria presented in Table 6.0-1 below.

TABLE 6.0-1: Post-Tensioned Mat Design Recommendations

CONDITION	CENTER LIFT	EDGE LIFT
Edge Moisture Variation Distance, e_m (feet)	9.0	4.8
Differential Soil Movement, y_m (inches)	0.4	1.1

The above values are based on the procedure presented by the Post-Tensioning Institute “Design of Post-Tensioned Slabs-on-Ground” Third Edition, including appropriate addenda (2004).

Underlay PT mats with a moisture reduction system as recommended below. In addition, moisture conditioning of the building foundation subgrade should be to a moisture content at least 4 percentage points above optimum immediately prior to foundation construction. The subgrade should not be allowed to dry prior to concrete placement. We also recommend that ENGEO be retained to observe the pre-pour moisture conditions to check that our report recommendations have been followed.

6.1 SLAB MOISTURE VAPOR REDUCTION

When buildings are constructed with post-tensioned mats, water vapor from beneath the mat will migrate through the concrete and into the building. This water vapor can be reduced but not stopped. Vapor transmission can negatively affect floor coverings and lead to increased moisture within a building. When water vapor migrating through the mat would be undesirable, we recommend the following to reduce, but not stop, water vapor transmission upward through the mat foundation.

1. Install a vapor retarder membrane directly beneath the slab. Seal the vapor retarder at all seams and pipe penetrations. Vapor retarders shall conform to Class A in the current ASTM E 1745 “Standard Specification for Plastic Water Vapor Retarders used in Contact with Soil or Granular Fill under Concrete Slabs”.

2. Concrete shall have a concrete water-cement ratio of no more than 0.50.

3. Provide inspection and testing during concrete placement to check that the proper concrete and water cement ratio are used.

The structural engineer should be consulted as to the use of a layer of clean sand (less than 5 percent passing the U.S. Standard No. 200 Sieve) placed on top of the vapor retarder membrane to assist in concrete curing.

6.2 FOUNDATION LATERAL RESISTANCE

Lateral loads may be resisted by friction along the base of the mat using an allowable coefficient of friction of 0.30.

7.0 SECONDARY SLABS-ON-GRADE

This section provides guidelines for secondary slabs such as walkways, driveways, and steps. Construct secondary slabs-on-grade structurally independent of the foundation system. This allows slab movement to occur with a reduced potential for foundation distress. Where slabs-on-grade construction is anticipated, care must be exercised in attaining a near-saturation condition of the subgrade soil before concrete placement.

The structural engineer should design slab reinforcement. The site soil has moderate to high expansion potential; therefore, cracking of conventional slabs should be expected in the future. As a minimum requirement, reinforce slabs-on-grade to reduce cracking. Provide frequent control joints to control the cracking. In our experience, welding wire mesh is not sufficient to control slab cracking. Reinforce slabs-on-grade with No. 4 bars spaced 18 inches on center each way, as a minimum.

Provide a minimum section of 4 inches of concrete over 4 inches of aggregate base. Compact the aggregate base to at least 90 percent relative compaction (ASTM D1557). Thicken flatwork edges to at least 10 inches to help control moisture variations in the subgrade and place rebar within the middle third of the slab to help control the width and offset of cracks. Construct control and construction joints in accordance with current Portland Cement Association Guidelines.

8.0 RETAINING AND SOUND WALLS

8.1 LATERAL SOIL PRESSURES

For drained and restrained retaining walls, at-rest lateral earth pressures should be considered. Table 8.1-1 provides lateral earth pressures for retaining wall design with level backfill conditions.

TABLE 8.1-1: Lateral Earth Pressures for Drained Retaining Walls with Level Backfill

ACTIVE PRESSURE (PCF)	AT-REST PRESSURE (PCF)
45	65

Appropriate surcharge loads from buildings, hardscape, and vehicles should be incorporated when the surcharge loading is situated above a 1:1 (horizontal:vertical) line of projection extending up the rear base edge of the bottom of the footing. A uniform horizontal surcharge load of 50 percent of the vertical surcharge load should be assumed to act over the height of the wall.

The above lateral earth pressures assume level backfill conditions and sufficient drainage behind the walls to prevent any build-up of hydrostatic pressures from surface water infiltration and/or a rise in the groundwater level. If adequate drainage is not provided, we recommend that an additional equivalent fluid pressure of 40 pcf be added to the values recommended above for both restrained and unrestrained walls. Damp-proofing of the walls should be included in areas where wall moisture would be problematic. Construct a drainage system, as recommended in Section 8.2 below, to reduce hydrostatic forces behind the retaining wall.

Passive pressures acting on foundations and keyways may be assumed as 300 pounds per cubic foot (pcf) provided that the area in front of the retaining wall is level for a distance of at least 10 feet or three times the depth of foundation and keyway, whichever is greater. The friction factor for sliding resistance may be assumed as 0.30. The upper 1 foot of soil should be excluded from passive pressure computations unless it is confined by pavement or a concrete slab.

8.2 RETAINING WALL DRAINAGE

Construct either graded rock drains or geosynthetic drainage composites behind the retaining walls to reduce hydrostatic lateral forces. For rock drain construction, we recommend two types of rock drain alternatives:

1. A minimum 12-inch-thick layer of Class 2 Permeable Filter Material (Caltrans Specification 68-2.02F) placed directly behind the wall, or

2. A minimum 12-inch-thick layer of washed, crushed rock with 100 percent passing the ¾-inch sieve and less than 5 percent passing the No. 4 sieve. Envelop rock in a minimum 6-ounce, nonwoven geotextile filter fabric.

For both types of rock drains:

1. Place the rock drain directly behind the walls of the structure.

2. Extend rock drains from the wall base to within 12 inches of the top of the wall.

3. Place a minimum of 4-inch-diameter perforated pipe (glued joints and end caps) at the base of the wall, inside the rock drain and fabric, with perforations placed down.

4. Place pipe at a gradient at least 1 percent to direct water away from the wall by gravity to a drainage facility.

ENGEO should review and approve geosynthetic composite drainage systems prior to use.

8.3 BACKFILL

Backfill behind retaining walls should be placed and compacted in accordance with Section 5. Use light compaction equipment within 5 feet of the wall face. If heavy compaction equipment is used, the walls should be temporarily braced to avoid excessive wall movement.

8.4 FOUNDATIONS

Retaining walls may be supported on continuous footings designed for an allowable bearing pressure of 2,000 psf embedded to a minimum depth of 24 inches.

9.0 PAVEMENT DESIGN

9.1 FLEXIBLE PAVEMENTS

Based on the predominance of medium to high plasticity surficial clay soil across the site, it is our opinion that a Resistance Value (R-value) of 5 is applicable for design. We developed the following recommended pavement sections using Topic 633 of the Caltrans Highway Design Manual (including the asphalt factor of safety), presented in Table 9.1-1 below.

TABLE 9.1-1: Recommended Asphalt Concrete Pavement Sections

TRAFFIC INDEX	ASPHALT CONCRETE (INCHES)	CLASS 2 AB (INCHES)
5.0	3.0	10.0
6.0	3.5	13.0
7.0	4.0	15.5
8.0	5.0	17.5
9.0	5.5	20.5
10.0	6.5	23.0
11.0	7.0	25.0

Note: AB is aggregate base Class 2 material with minimum R = 78.

The civil engineer should determine the appropriate traffic indices based on the estimated traffic loads and frequencies.

9.2 SUBGRADE AND AGGREGATE BASE COMPACTION

Compact finish subgrade and aggregate base in accordance with Section 5.5. Aggregate Base should meet the requirements for ¾-inch maximum Class 2 AB in accordance with Section 26-1.02B of the latest Caltrans Standard Specifications.

9.3 CUT-OFF CURBS

Saturated pavement subgrade or aggregate base can cause premature failure or increased maintenance of asphalt concrete pavements. This condition often occurs where landscape areas directly abut and drain toward pavements. If desired to install pavement cutoff barriers, they should be considered where pavement areas lie downslope of any landscape areas that are to be sprinklered or irrigated, and should extend to a depth of at least 4 inches below the base rock layer. Cutoff barriers may consist of deepened concrete curbs or deep-root moisture barriers.

If reduced pavement life and greater than normal pavement maintenance are acceptable to the owner, then the cutoff barrier may be eliminated.

10.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report presents geotechnical recommendations for design of the improvements discussed in Section 1.3 for The Ranch at Antioch Geotechnical Update project. If changes occur in the nature or design of the project, we should be allowed to review this report and provide additional recommendations, if any. It is the responsibility of the owner to transmit the information and recommendations of this report to the appropriate organizations or people involved in design of the project, including but not limited to developers, owners, buyers, architects, engineers, and designers. The conclusions and recommendations contained in this report are solely professional opinions and are valid for a period of no more than 2 years from the date of report issuance.

We strived to perform our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty is expressed or implied. There are risks of earth movement and property damages inherent in building on or with earth materials. We are unable to eliminate all risks or provide insurance; therefore, we are unable to guarantee or warrant the results of our services.

This report is based upon field and other conditions discovered at the time of report preparation. We developed this report with limited subsurface exploration data. We assumed that our subsurface exploration data is representative of the actual subsurface conditions across the site. Considering possible underground variability of soil, rock, stockpiled material, and groundwater, additional costs may be required to complete the project. We recommend that the owner establish a contingency fund to cover such costs. If unexpected conditions are encountered, notify ENGEO immediately to review these conditions and provide additional and/or modified recommendations, as necessary.

Our services did not include excavation sloping or shoring, soil volume change factors, flood potential, or a geohazard exploration. In addition, our geotechnical exploration did not include work to determine the existence of possible hazardous materials. If any hazardous materials are encountered during construction, notify the proper regulatory officials immediately.

This document must not be subject to unauthorized reuse, that is, reusing without written authorization of ENGEO. Such authorization is essential because it requires ENGEO to evaluate the document's applicability given new circumstances, not the least of which is passage of time.

Actual field or other conditions will necessitate clarifications, adjustments, modifications or other changes to ENGEO's documents. Therefore, ENGEO must be engaged to prepare the necessary clarifications, adjustments, modifications or other changes before construction activities commence or further activity proceeds. If ENGEO's scope of services does not include on-site construction observation, or if other persons or entities are retained to provide such services, ENGEO cannot be held responsible for any or all claims arising from or resulting from the performance of such services by other persons or entities, and from any or all claims arising from or resulting from clarifications, adjustments, modifications, discrepancies or other changes necessary to reflect changed field or other conditions.

We determined the lines designating the interface between layers on the exploration logs using visual observations. The transition between the materials may be abrupt or gradual. The exploration logs contain information concerning samples recovered, indications of the presence of various materials such as clay, sand, silt, rock, existing fill, etc., and observations of groundwater encountered. The field logs also contain our interpretation of the subsurface conditions between sample locations. Therefore, the logs contain both factual and interpretative information. Our recommendations are based on the contents of the final logs, which represent our interpretation of the field logs.

SELECTED REFERENCES

American Society of Civil Engineers, 2010, Minimum Design Loads for Buildings and Other Structures, ASCE Standard, ASCE/SEI 7-10.

Bryant, W. and Hart, E. (2007). Special Publication 42, "Fault-Rupture Hazard Zones in California", Interim Revision 2007, California Department of Conservation.

California Building Standards Commission, 2016. California Building Code 2016, Volumes 1 and 2, Sacramento, California, July 2016.

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

California Department of Transportation, 2012, Highway Design Manual.

Division of Mines and Geology, 1997, Special Publication 117, Guidelines for Evaluation and Mitigating Seismic Hazards in California, Adopted March 13.

ENGEO, 2006, Geotechnical Exploration, Sand Creek Ranch Active Adult Community, Antioch, California; May 24, 2006; Project No. 4371.4.050.01.

ENGEO, 2017, Geotechnical Review, The Ranch at Antioch, Antioch, California; February 24, 2017; Project No. 4371.000.000.

ENGEO, 2017, Groundwater Evaluation, The Ranch at Antioch, Antioch, California; May 24, 2017; Project No. 4371.000.000.

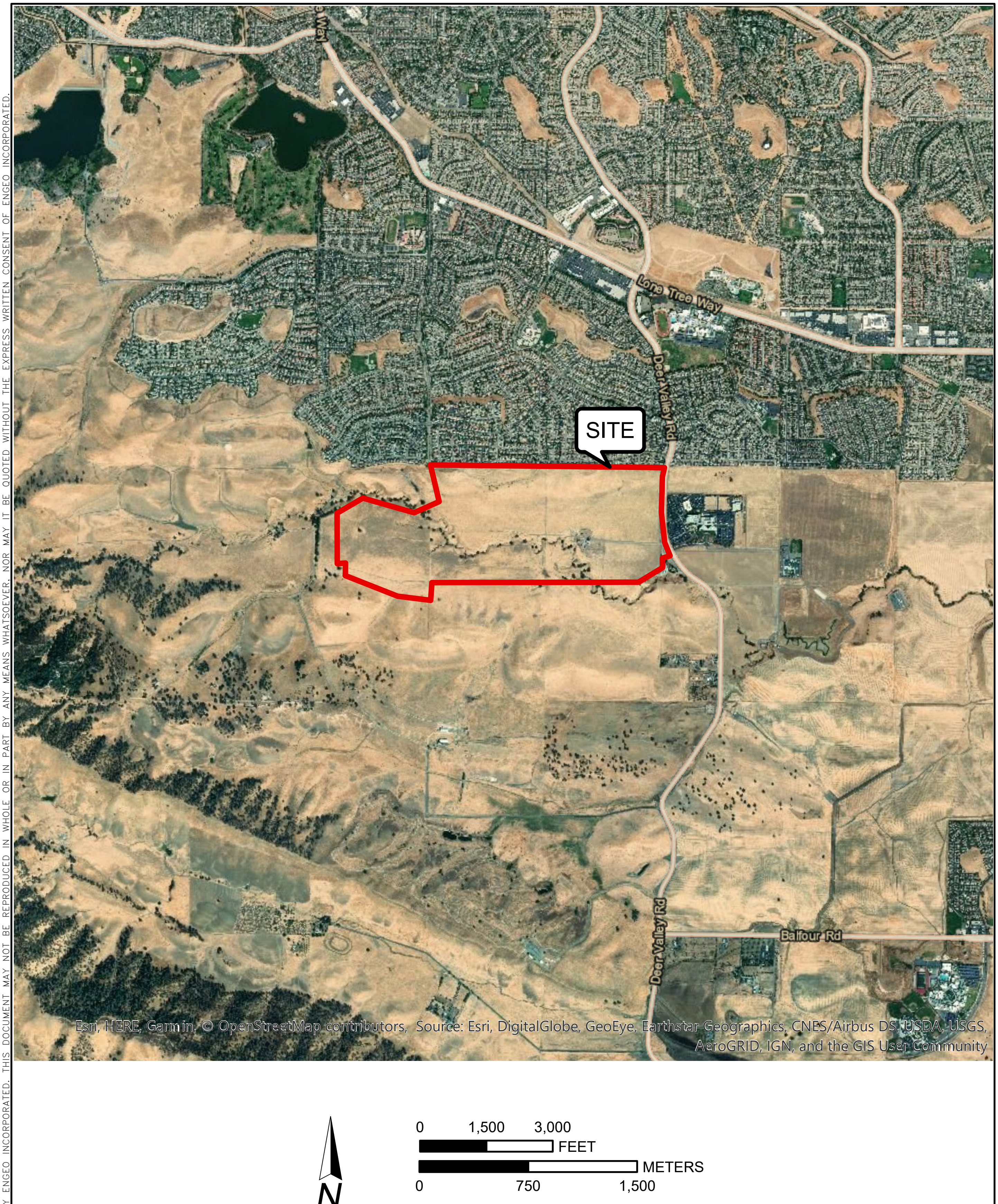
Hart, E.W. and Bryant W.A., 1997. Fault Rupture Hazard in California: Alquist-Priolo earthquake fault zoning act with index to earthquake fault zone maps: California Division of Mines and Geology Special Publication 42, San Francisco South Quadrangle, California, 7.5 Minute Series (Topographic), effective January 1, 1982.

SEAOC, 1991, Recommended Lateral Force Requirements and Tentative Commentary.

United States Geologic Survey (USGS); 2008, National Seismic Hazard Maps Fault Parameters, accessed August 10, 2018.

Wagner, D.L., Bortgno, E.J., and McJunkin, R.D. (1990). Geologic Map of the San Francisco-San Jose quadrangle, California.

FIGURES



ENGEO
Expect Excellence

VICINITY MAP
THE RANCH AT ANTIOCH
ANTIOCH, CALIFORNIA

PROJECT NO. : 4371.000.001		FIGURE NO. 1
SCALE: AS SHOWN		
DRAWN BY: QRL	CHECKED BY: CAC	

ORIGINAL FIGURE PRINTED IN COLOR

N

0 500 1,000 FEET

0 250 500 METERS

ENGEO Expect Excellence

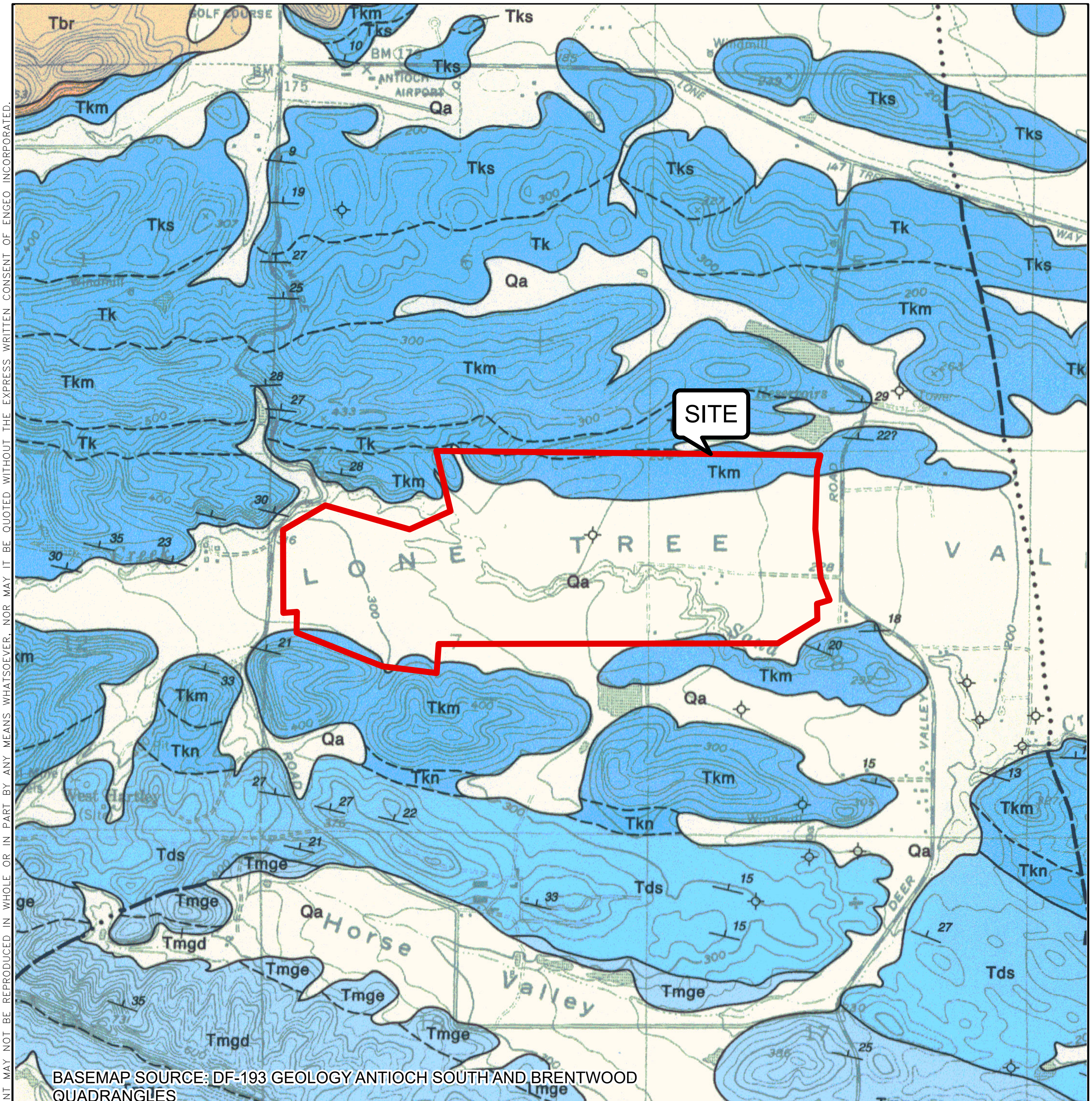
SITE PLAN

THE RANCH AT ANTIOCH

ANTIOCH, CALIFORNIA

PROJECT NO. : 4371.000.001	FIGURE NO. 2
SCALE: AS SHOWN	
DRAWN BY: QRL	CHECKED BY: CAC

ORIGINAL FIGURE PRINTED IN COLOR



BASEMAP SOURCE: DF-193 GEOLOGY ANTIOCH SOUTH AND BRENTWOOD QUADRANGLES

N

0 1,000 2,000 FEET

0 500 1,000 METERS

EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

- - - GEOLOGIC CONTACT

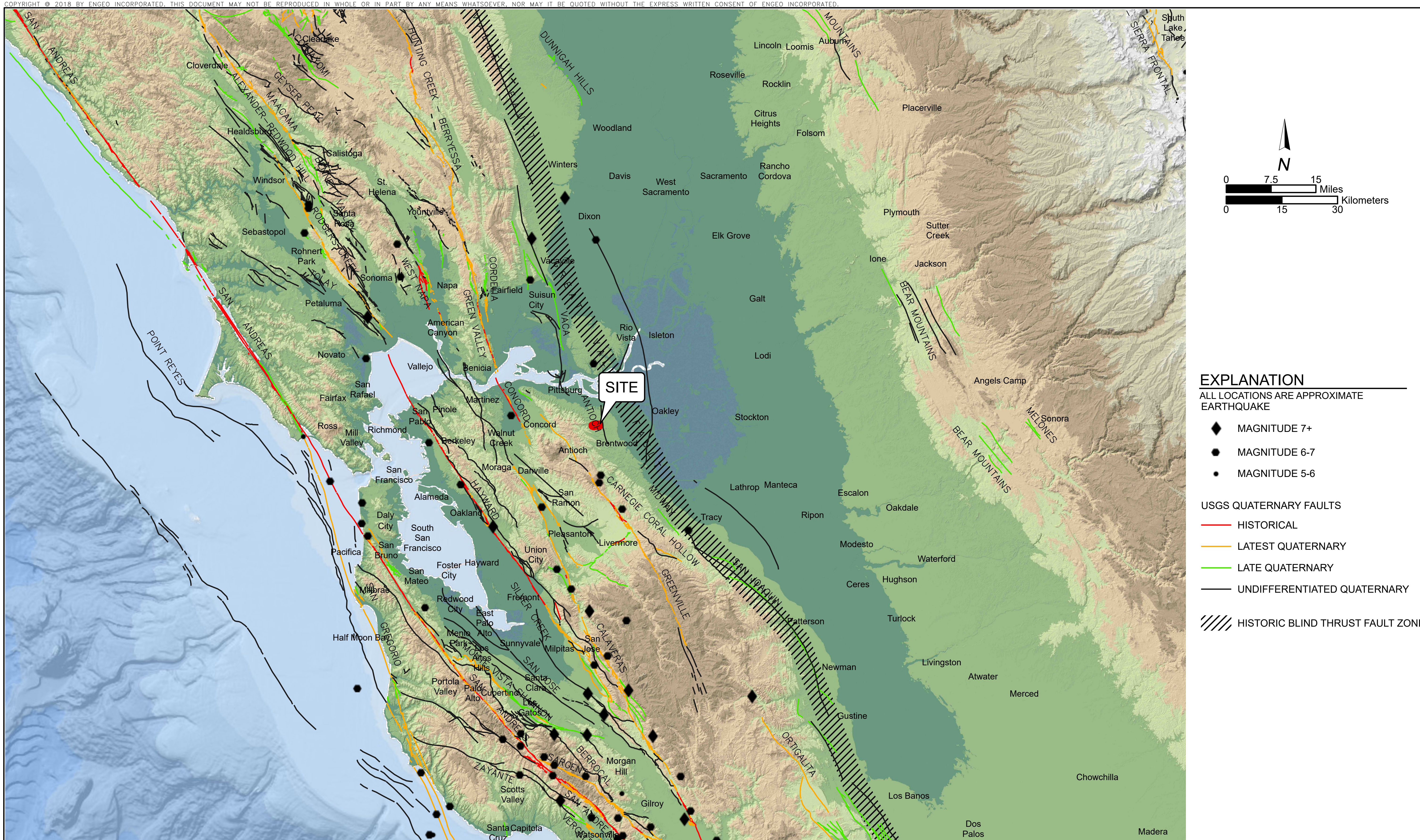
Qa	ALLUVIAL PEBBLE GRAVEL
Tbr	BRIONES OR CIERBO SANDSTONE
Tks	SHALE
Tk	CLAY SHALE
Tkm	MARKLEY SAND STONE MEMBER
Tkn	NORTONVILLE SHALE MEMBER
Tds	SANDSTONE
Tmge	GREENISH-GRAY TO LIGH GRAY
Tmgd	BRIONES OR CIERBO SANDSTONE
Tmgc	SANDSTONE WITH BASAL CONGLOMERATE

ENGEO
Expect Excellence

GEOLOGIC MAP
THE RANCH AT ANTIOCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.000.001
SCALE: AS SHOWN
DRAWN BY: QRL
CHECKED BY: CAC
FIGURE NO. 3

ORIGINAL FIGURE PRINTED IN COLOR



BASE MAP SOURCE
ESRI, GARMIN, GEBCO, NOAA NGDC, AND OTHER CONTRIBUTORS
COLOR HILLSHADE IMAGE BASED ON THE NATIONAL ELEVATION DATA SET (NED) AT 30 METER RESOLUTION
U.S.G.S. QUATERNARY FAULT DATABASE, 2018
U.S.G.S. HISTORIC EARTHQUAKE DATABASE (1800-PRESENT)

ENGEO
Expect Excellence

REGIONAL FAULTING AND SEISMICITY
THE RANCH AT ANTIOCH
ANTIOCH, CALIFORNIA

PROJECT NO. : 4371.000.001	
SCALE: AS SHOWN	
DRAWN BY: QRL	CHECKED BY: CAC

FIGURE NO. 4

ORIGINAL FIGURE PRINTED IN COLOR

APPENDIX A

TEST PIT LOGS

ENGEO Expect Excellence	TEST PIT LOG		Test Pit Number 2-TP01
Project Name: **The Ranch at Antioch**			Lat.: **37.9531**
Project Location: **Antioch, California**			Long.: **-121.7883**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **4 feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 3	LEAN CLAY (CL) – Dark brown, very stiff, dry to moist, medium plasticity, contains gravel up to approximately 1-inch diameter, pocket penetrometer = 3.5 tsf.
3 – 4	SANDY LEAN CLAY (CL) – Dark reddish brown mottled with dark red and white, low plasticity, medium- to coarse-grained sand, contains calcium carbonate.

ENGEO Expect Excellence	TEST PIT LOG		Test Pit Number 2-TP02
Project Name: **The Ranch at Antioch**			Lat.: **37.9530**
Project Location: **Antioch, California**			Long.: **-121.7899**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **4 feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 2½	LEAN CLAY (CL) – Dark brown, very stiff, dry to moist, medium plasticity, contains rootlets in the upper 1½ feet.
2½ – 4	SILTY SAND (SM) – Pale yellow to light yellowish brown, dry to moist, hardpan, contains calcium carbonate (hardpan).

ENGEO Expect Excellence	TEST PIT LOG		Test Pit Number 2-TP03
Project Name: **The Ranch at Antioch**			Lat.: **37.9529**
Project Location: **Antioch, California**			Long.: **-121.7915**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **4¼ feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 2½	LEAN CLAY (CL) – Dark brown, dry to moist, medium plasticity, contains rootlets in the upper 1½ feet.
2½ – 4¼	SILTY SAND (SM) – Pale yellow to light yellowish brown, dry to moist, contains calcium carbonate (hardpan).

TEST PIT LOG

Project Name: **The Ranch at Antioch**			Lat.: **37.9523**
Project Location: **Antioch, California**			Long.: **-121.7905**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **4¼ feet**	Groundwater: **N/A**

Test Pit Number
2-TP04

Depth (ft)	Soil/Rock Descriptions
0 – 4¼	LEAN CLAY (CL) – Dark brown to dark reddish brown, dry to moist, hard, medium plasticity, contains rootlets and gravel, pocket penetrometer ≥ 4.5 tsf.

	TEST PIT LOG	Test Pit Number 2-TP05

Project Name: **The Ranch at Antioch**			Lat.: **37.9526**
Project Location: **Antioch, California**			Long.: **-121.7910**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **3½ feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 3½	LEAN CLAY (CL) – Dark brown to dark reddish brown, dry to moist, very stiff to hard, medium plasticity, contains rootlets in the upper 1½ feet, contains gravel ½- to ¾-inch diameter, pocket penetrometer = 4.0 to 4.5 tsf.

ENGEO Expect Excellence	TEST PIT LOG		Test Pit Number 2-TP06
Project Name: **The Ranch at Antioch**			Lat.: **37.9499**
Project Location: **Antioch, California**			Long.: **-121.8018**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **3½ feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 3½	LEAN CLAY (CL) – Dark brown, dry to moist, hard, medium plasticity, pocket penetrometer > 4.5 tsf.

Expect Excellence

TEST PIT LOG

Test Pit Number
2-TP07

Project Name: **The Ranch at Antioch**			Lat.: **37.9501**
Project Location: **Antioch, California**			Long.: **-121.8023**
Project No.: **4371.000.001**	Logged By: **Victoria Drake**	Contr.: **Central Pacific Services**	Equipment: **Backhoe**
Date Started: **8/29/2018**	Date Completed: **8/29/2018**	Total Depth: **4 feet**	Groundwater: **N/A**

Depth (ft)	Soil/Rock Descriptions
0 – 4	LEAN CLAY (CL) – Dark brown to dark reddish brown, dry to moist, hard, medium plasticity, contains rootlets in the upper 2 feet, pocket penetrometer = 4.5 tsf.

APPENDIX B

HISTORIC EXPLORATION LOGS (2006)

KEY TO BORING LOGS

MAJOR TYPES			DESCRIPTION
COARSE-GRAINED SOILS MORE THAN HALF OF MAT'L LARGER THAN #200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW - Well graded gravels or gravel-sand mixtures
			GP - Poorly graded gravels or gravel-sand mixtures
		GRAVELS WITH OVER 12 % FINES	GM - Silty gravels, gravel-sand and silt mixtures
			GC - Clayey gravels, gravel-sand and clay mixtures
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW - Well graded sands, or gravelly sand mixtures
			SP - Poorly graded sands or gravelly sand mixtures
		SANDS WITH OVER 12 % FINES	SM - Silty sand, sand-silt mixtures
			SC - Clayey sand, sand-clay mixtures
FINE-GRAINED SOILS MORE THAN HALF OF MAT'L SMALLER THAN #200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50 % OR LESS		ML - Inorganic silt with low to medium plasticity
			CL - Inorganic clay with low to medium plasticity
			OL - Low plasticity organic silts and clays
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50 %		MH - Inorganic silt with high plasticity
			CH - Inorganic clay with high plasticity
			OH - Highly plastic organic silts and clays
	HIGHLY ORGANIC SOILS		PT - Peat and other highly organic soils

GRAIN SIZES

U.S. STANDARD SERIES SIEVE SIZE: 200, 40, 10, 4 — CLEAR SQUARE SIEVE OPENINGS: 3/4 ", 3", 12"

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

RELATIVE DENSITY

SANDS AND GRAVELS	BLOWS/FOOT (S.P.T.)
VERY LOOSE	0-4
LOOSE	4-10
MEDIUM DENSE	10-30
DENSE	30-50
VERY DENSE	OVER 50

CONSISTENCY

SILTS AND CLAYS	STRENGTH*	BLOWS/FOOT (S.P.T.)
VERY SOFT	0-1/4	0-2
SOFT	1/4-1/2	2-4
MEDIUM STIFF	1/2-1	4-8
STIFF	1-2	8-15
VERY STIFF	2-4	15-30
HARD	OVER 4	OVER 30

MOISTURE CONDITION

DRY	Absence of moisture, dusty, dry to touch
MOIST	Damp but no visible water
WET	Visible freewater
SATURATED	Below the water table

MINOR CONSTITUENT QUANTITIES (BY WEIGHT)

TRACE	Particles are present, but estimated to the less than 5%
SOME	5 to 15%
WITH	15 to 30%
........Y	30 to 50%

SAMPLER SYMBOLS

- Modified California (3" O.D.) sampler
- California (2.5" O.D.) sampler
- S.P.T. - Split spoon sampler
- Shelby Tube
- Continuous Core
- Bag Samples
- Grab Samples
- NR No Recovery

LINE TYPES

- Solid - Layer Break
- ------ Dashed - Gradational or approximate layer break

GROUND-WATER SYMBOLS

- ∇ Groundwater level during drilling
- ▼ Stabilized groundwater level

ENGEO INCORPORATED
EXCELLENT SERVICE SINCE 1971

(S.P.T.) Number of blows of 140 lb. hammer falling 30" to drive a 2-inch O.D. (1-3/8 inch I.D.) sampler

* Unconfined compressive strength in tons/sq. ft., asterisk on log means determined by pocket penetrometer

ENGEO INCORPORATED

LOG OF BORING 1-B1

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: March 22, 2006
HOLE DEPTH (FT): 26 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 229 ft.

LOGGED / REVIEWED BY: Z.Crawford / J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		SILTY CLAY (CL), yellowish brown, stiff to very stiff, moist, with fine to medium-grained sand.			20			*3.75
	1		SILTY CLAY (CL), yellowish brown and gray, stiff to very stiff, moist, some fine-grained sand.			8			
5	2					25	32.6	85	*2.0
			CLAY (CL/CH), olive brown, stiff to very stiff, moist, with silt, trace organics.						
10	3		CLAY (CL), dark brown, very stiff, moist, with silt.			24	31.0	90	*2.25
	4		SILTY CLAY (CL), yellowish brown, very stiff, moist to saturated, trace sand.						
15	5				▼ ▽	36	29.2	92	*3.25
20	6		CLAYSTONE, grayish brown, highly weathered, friable.			58	25.7	93	*4.25
25	7, 8					41	31.6	90	*4.5
30	9		Bottom of boring at approximately 26 1/2 feet. Groundwater encountered at 15 1/2 feet during drilling. Stabilized groundwater measured at 14 1/2 feet.						

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B1.bor

ENGEO INCORPORATED

LOG OF BORING 1-B2

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: March 22, 2006
HOLE DEPTH (FT): 26 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 245 ft.

LOGGED / REVIEWED BY: Z.Crawford / J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		SILTY CLAY (CL), yellowish brown, stiff, moist, with fine to medium-grained sand, trace organics.			45			
	1		SILTY SAND (SM), yellowish brown, medium dense to dense, moist, fine to medium-grained sand.						
5	2					68/8"			
			SANDSTONE, with claystone interbeds, highly weathered, friable.						

Drilling refusal at 7 1/2 feet.
Bottom of boring at approximately 7 1/2 feet.
Groundwater not encountered during drilling.

Depth scale: 0, 5, 10, 15, 20, 25, 30 ft; 0–9 m.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B2.bor

ENGEO INCORPORATED

LOG OF BORING 1-B3

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: March 22, 2006
HOLE DEPTH (FT): 26 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 251 ft.
LOGGED / REVIEWED BY: Z.Crawford / J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	DESCRIPTION	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	CLAY (CL/CH), dark brown, medium stiff, moist, trace sand, trace organics.				
	SILTY CLAY (CL), dark brown, stiff, moist, trace sand.	15			*0.75
5	(no sand)	25	20.3	105	*3.5
10	SILTY CLAY (CL), brown, stiff to very stiff, moist, trace sand.	29	18.4	102	*4.5
15		39	18.2	107	*4.5
	SILTY CLAY (CL), yellowish brown, very stiff to hard, moist, some fine-grained sand.				
20		37	18.6	109	*4.5+

Bottom of boring at approximately 21 1/2 feet.
Groundwater not encountered during drilling.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B3.bor

ENGEO INCORPORATED

LOG OF BORING 1-B4

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: March 22, 2006
HOLE DEPTH (FT): 26 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 283 ft.

LOGGED / REVIEWED BY: Z.Crawford / J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CH/CL), dark olive brown, medium stiff to stiff, moist, with silt, trace sand.						
						15	27.1	96	*1.0
	1								
5			CLAY (CL), dark brown, hard, moist, with silt.						
						68	14.3	110	*4.5+
	2								
			SILTY CLAY (CL), light yellowish brown, very stiff, moist, with fine-grained sand.						
10	3								
						27	15.8	103	*4.5+
	4								
			SILTY CLAY (CL), olive brown, hard, moist.						
15									
						49	18.4	99	*4.5+
	5								
			SILTY CLAY (CL), olive brown, very stiff, moist, some fine-grained sand.						
20	6								
	7								
25									
						35	22.7	90	*3.5
	8								
			Bottom of boring at approximately 26 1/2 feet. Groundwater not encountered during drilling.						
	9								
30									

LOG OF BORING 1-B8

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 304 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL/CH), very dark brown, stiff, moist, with silt.						
2	1		SILTY CLAY (CL), dark grayish brown, very stiff, moist, trace sand.			23			*2.5
4			SILTY CLAY (CL), grayish brown, hard, moist, trace sand.						
6	2					57			*3.75
10	3		SILTY CLAY (CL), grayish olive brown, stiff, moist, some fine-grained sand.						
12	4					12			*4.5+
14			SILTY CLAY (CL), brown, hard, moist, trace sand.						
20	6					38			

Bottom of boring at approximately 21 1/2 ft.
Groundwater not encountered during drilling.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B8.bor

LOG OF BORING 1-B9

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 31 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 298 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff to very stiff, moist, with silt and fine-grained sand.						
	1					31			*2.5
5			SILTY CLAY (CL), grayish olive brown, very stiff, moist, some fine to medium-grained sand.						
	2								
						30			*4.5+
10	3								
	4		SILTY CLAY(CL), grayish brown, hard, moist, with fine to medium-grained sand.						
15	5					37			*4.5+
20	6								
	7					37			*4.5+
25	8		SILTY CLAY (CL), brown, very stiff, moist, some fine-grained sand.						
30	9					33			*4.5+
	10		Bottom of boring at approximately 31 1/2 ft. Groundwater not encountered during drilling.						
35									

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B9.bor

ENGEO INCORPORATED

LOG OF BORING 1-B10

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 302 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff, moist, with silt and fine-grained sand, trace organics (colluvium).						
		■				12	20.2	104	*0.75
5	1		SANDY CLAY (CL), grayish brown, hard, moist, with fine-grained sand and silt.						
	2	■				82	10.3	121	
10	3		SANDY CLAY (CL), yellowish brown and gray mottled, very stiff, moist, fine to medium-grained sand, with silt, trace gravel.						
		◣				21	16.1		
	4		SILTY CLAY (CL), grayish brown, very stiff, saturated, with fine-grained sand.		▼				
15	5		SANDY CLAY (CL), grayish brown and reddish brown mottled, very stiff, saturated fine-grained sand with silt.		▽				
20	6	◣				31			

Bottom of boring at approximately 21 1/2 feet.
Groundwater encountered at 17 1/2 feet.
Stabilized groundwater measured at 13 1/2 feet.

Depth in Feet	Depth in Meters
25	7, 8
30	9
35	10

LOG OF BORING 1-B14

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 263 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		SILTY CLAY (CL), dark grayish brown, stiff to very stiff, moist, with sand.						
	1					19			*1.25
5			SILTY CLAY (CL), yellowish brown, very stiff to hard, moist, with fine-grained sand.						
	2					35			*4.5+
10	3								
	4					50			
15	5								
			SILTY SAND (SM), yellowish brown, dense, moist, fine to medium-grained sand, with clay, some fine gravel.						
20	6					64			
	7		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						
25	8								
30	9								
	10								
35									

LOG OF BORING 1-B15

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 250 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL/CH), very dark grayish brown, stiff, moist, with silt, trace sand, trace organics.						
						17	23.1	98	*1.25
5	1		SILTY CLAY (CL), grayish brown, very stiff, moist, some fine-grained sand.						
	2					28	21.7	103	*2.5
10	3								
	4		SILTY CLAY (CL), light grayish brown, stiff, moist, with fine-grained sand.						
15						15	22.8	102	
	5								

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35 feet; 0–10 meters.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B15.bor

ENGEO INCORPORATED

LOG OF BORING 1-B24

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 285 ft.

LOGGED / REVIEWED BY: R. Gandolfo/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	DESCRIPTION	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0	CLAY (CL), dark olive brown, stiff, moist, with silt, trace sand.	12	25.1	98	*1.5
5	2	SILTY CLAY (CL), brown, hard, moist, with fine-grained sand.	58			*4.0
10	3	CLAYEY SAND (SC), yellowish brown, medium dense, moist, fine-grained sand, with silt.	26			
	4	SILTY CLAY (CL), light olive brown, stiff to very stiff, moist, trace sand.				
15	5	SILTY CLAY (CL), olive brown, very stiff, moist, with fine-grained sand.	33			*3.5

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35 feet; 0–10 meters.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B24.bor

LOG OF BORING 1-B25

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 24, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 287 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	DESCRIPTION	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0	CLAY (CL), dark olive brown, stiff to very stiff, moist, with silt, trace fine grained sand.				
			27	22.1	103	*3.5
5		CLAYEY SAND (SC), light olive brown, dense, moist, fine-grained sand, trace silt.				
			60	15.9	103	
		CLAYEY SAND (SC), yellowish brown, dense, moist, fine-grained sand, trace silt.				
10	3	SILTY SAND (SM), olive brown, medium dense, moist, fine-grained sand, trace clay.				
			23	10.2	110	
20	6		43	16.7	111	

Bottom of boring at approximately 21 1/2 feet.
Groundwater not encountered during drilling.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B25.bor

ENGEO INCORPORATED

LOG OF BORING 1-B26

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 15 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 260 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark olive brown, very stiff, moist, with silt, trace sand.						
						33			*4.5+
	1								
5			CLAYEY SAND (SC), light olive brown, very stiff, moist, fine-grained sand, with silt.						
	2		CLAYEY SAND (SC), light yellowish brown, very stiff, moist, fine-grained sand, some silt.			54			
10	3		SILTY SAND (SM), yellowish brown, very stiff, moist, fine-grained sand, trace clay.						
	4					30			
15									
	5		Bottom of boring at approximately 15 feet. Groundwater not encountered during drilling.						
20	6								
	7								
25	8								
30	9								
	10								
35									

LOG OF BORING 1-B27

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 1, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 238 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff, moist, some fine-grained sand, with silt.						
						16	23.2	95	*0.75
	1		SILTY CLAY(CL), grayish brown, hard, moist, with medium to fine-grained sand.						
5						70	12.8	110	
	2								
10	3					48			
	4								
15	5								
20	6					54	19.4	108	

Bottom of boring at approximately 21 1/2 feet.
Groundwater not encountered during drilling.

Depth scale: 0–35 ft (0–10 m)

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B27.bor

ENGEO INCORPORATED

LOG OF BORING 1-B28

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 1, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 229 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff to very stiff, moist, some fine-grained sand, with silt.						*1.0
	1		SILTY CLAY (CL), dark brown, very stiff to hard, moist, some fine to medium-grained sand.			38	19.2	109	*4.5+
5	2		SILTY CLAY (CL), grayish brown, hard, moist, with fine to medium-grained sand.			53	13.0	112	
10	3		SILTY CLAY (CL), yellowish brown, very stiff, moist, some fine-grained sand.						
	4					31	15.2	99	
15	5								
20	6					38	17.5	109	
	7		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						
25	8								
30	9								
35	10								

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B28.bor

LOG OF BORING 1-B29

ENGEO INCORPORATED

GEOTECHNICAL EXPLOATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 1, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 270 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff, moist, some fine-grained sand, with silt.	▨					
	1	■		▨		22	22.6	103	*2.0
5			SILTY CLAY (CL), yellowish brown, hard, moist, with fine-grained sand.	▨					
	2	■		▨		62	14.2	107	*4.5+
10	3			▨					
	4	■		▨		31	18.9	98	*4.5+
15	5			▨					
20	6	■		▨		74	16.3	115	
	7		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						
25	8								
30	9								
	10								
35									

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B29.bor

ENGEO INCORPORATED

LOG OF BORING 1-B30

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 1, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 265 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		SILTY CLAY (CL), dark grayish brown, stiff, moist, some fine-grained sand.						
						11			*1.0
	1								
5			SILTY CLAY (CL), yellowish brown, very stiff, moist, fine to medium-grained sand.						
						22			*2.0
	2								
			(hard)						
10	3								
						61			*4.5+
	4		SILTY CLAY (CL), yellowish olive brown, very stiff, moist, some fine-grained sand.						
15									
	5					37			

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35 feet; 0–10 meters.

LOG OF BORING 1-B31

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 1, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 246 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), very dark grayish brown, stiff, moist, with silt, trace sand.						
5	1		SILTY CLAY (CL), dark grayish brown, hard, moist, fine to medium-grained sand, trace gravel.						
10	3		SILTY CLAY (CL), grayish brown, very stiff, moist, with fine-grained sand.						
	4					31			*4.5+
15						18			
			SILTY CLAY (CL), brown, very stiff to hard, moist, trace sand.			43			*4.5+

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

ENGEO INCORPORATED

LOG OF BORING 1-B32

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 228 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL), dark grayish brown, stiff to very stiff, moist, with silt and fine-grained sand, trace organics.	▨					
	1	■		▨		25			*2.25
5			SILTY CLAY (CL), grayish olive brown, hard, moist, with fine to medium grained sand, trace gravel.	▨					
	2	■		▨		51			*4.5+
10	3		SILTY CLAY (CL), grayish brown, hard, moist, trace sand..	▨					
	4			▨					
15	5	■		▨		50			*4.5+
20	6								
	7								
25	8								
30	9								
	10								
35									

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

LOG OF BORING 1-B33

ENGEO INCORPORATED

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 16 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 241 ft.

LOGGED / REVIEWED BY: Z. Crawford/J.T.
DRILLING CONTRACTOR: PDI
DRILLING METHOD: Solid Flight
HAMMER TYPE: 140 Lb. w/ 30 in. Drop

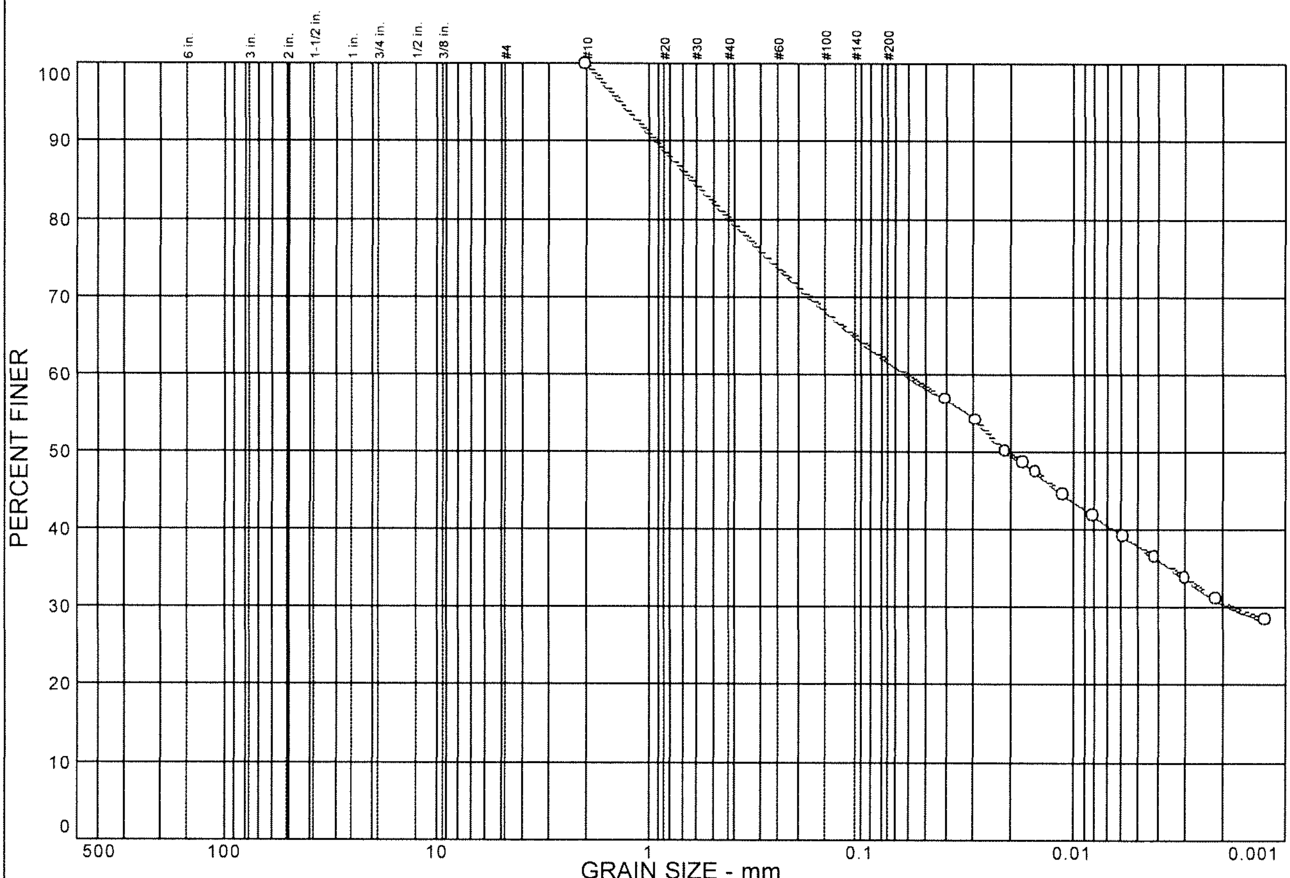
Depth in Feet	Depth in Meters	Sample Type	DESCRIPTION	Log Symbol	Water Level	Blow Count / Foot	Moisture Content (% dry weight)	Dry Unit Weight (pcf)	Unconfined Strength (tsf) *field approx
0	0		CLAY (CL/CH), very dark grayish brown, stiff, moist, with fine-grained sand, with silt.			16	25.8	97	*1.75
5	1		SILTY CLAY (CL), grayish olive brown, hard, moist, trace sand.			69			*4.5+
10	3		SILTY CLAY (CL) yellowish olive brown, very stiff, moist, with fine-grained sand, trace gravel.			38			*4.5+

Bottom of boring at approximately 16 1/2 feet.
Groundwater not encountered during drilling.

APPENDIX C

HISTORIC LABORATORY TEST DATA (2006)

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	38.4	23.6	38.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		

* (no specification provided)

Soil Description

Atterberg Limits

PL= 16 LL= 42 PI= 26

Coefficients

D_{85}= 0.631 D_{60}= 0.0619 D_{50}= 0.0209
D_{30}= 0.0018 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

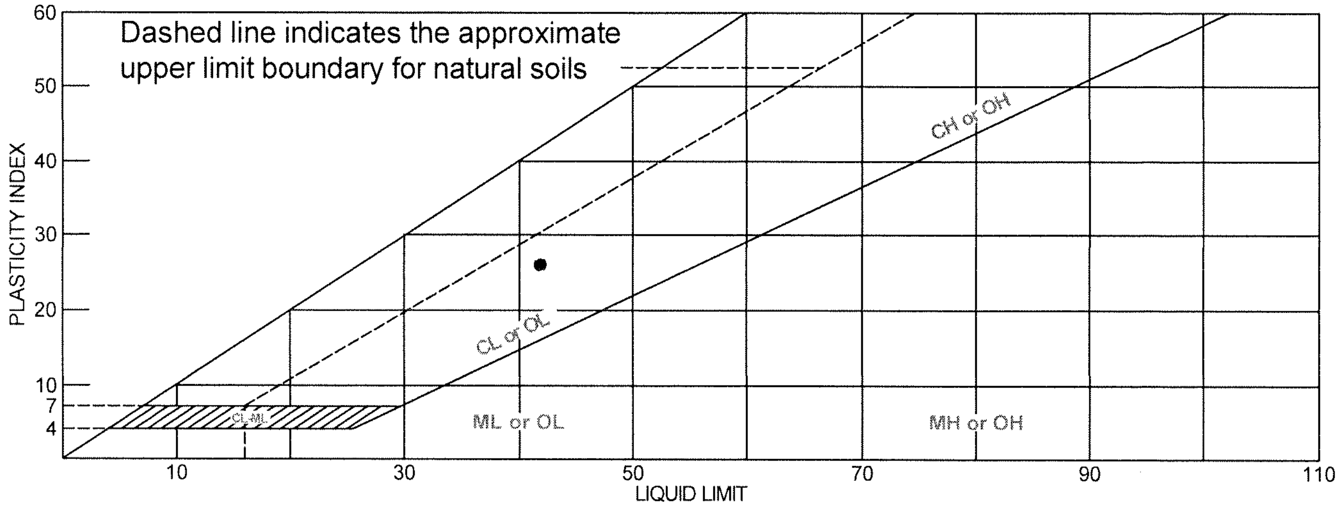
Remarks

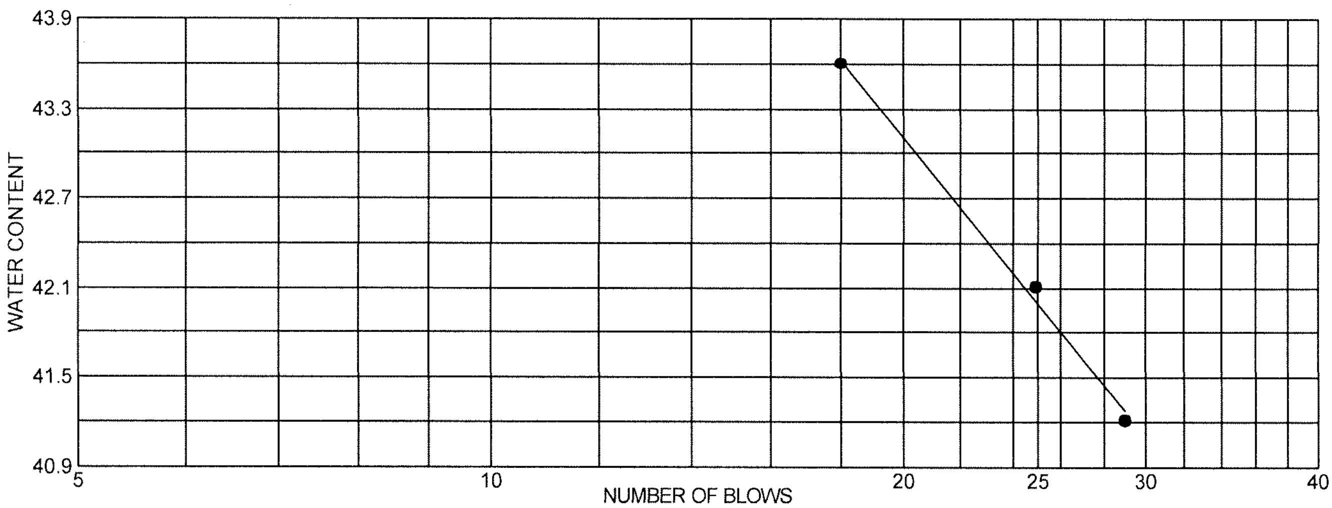
Sample No.: B3 @ 2.5' **Source of Sample:** **Date:** 3-31-06
Location: **Elev./Depth:** 2.5'

ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Client:
Project: Sand Creek Ranch
Project No: 4371.4.050.01 **Plate**

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		42	16	26	80.1	61.6	

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B3 @ 2.5' **Elev./Depth:** 2.5'

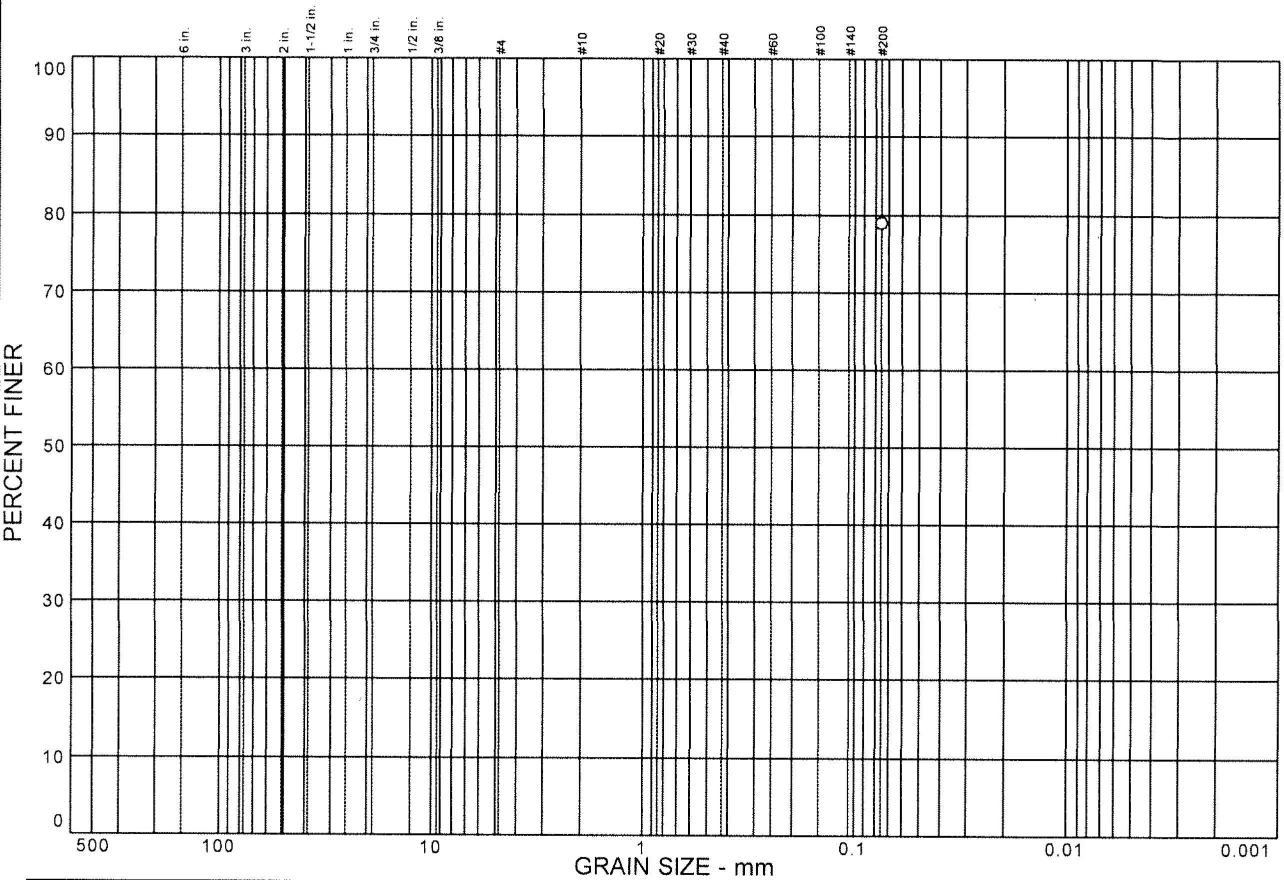
ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Remarks:

●

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
			78.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	78.8		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

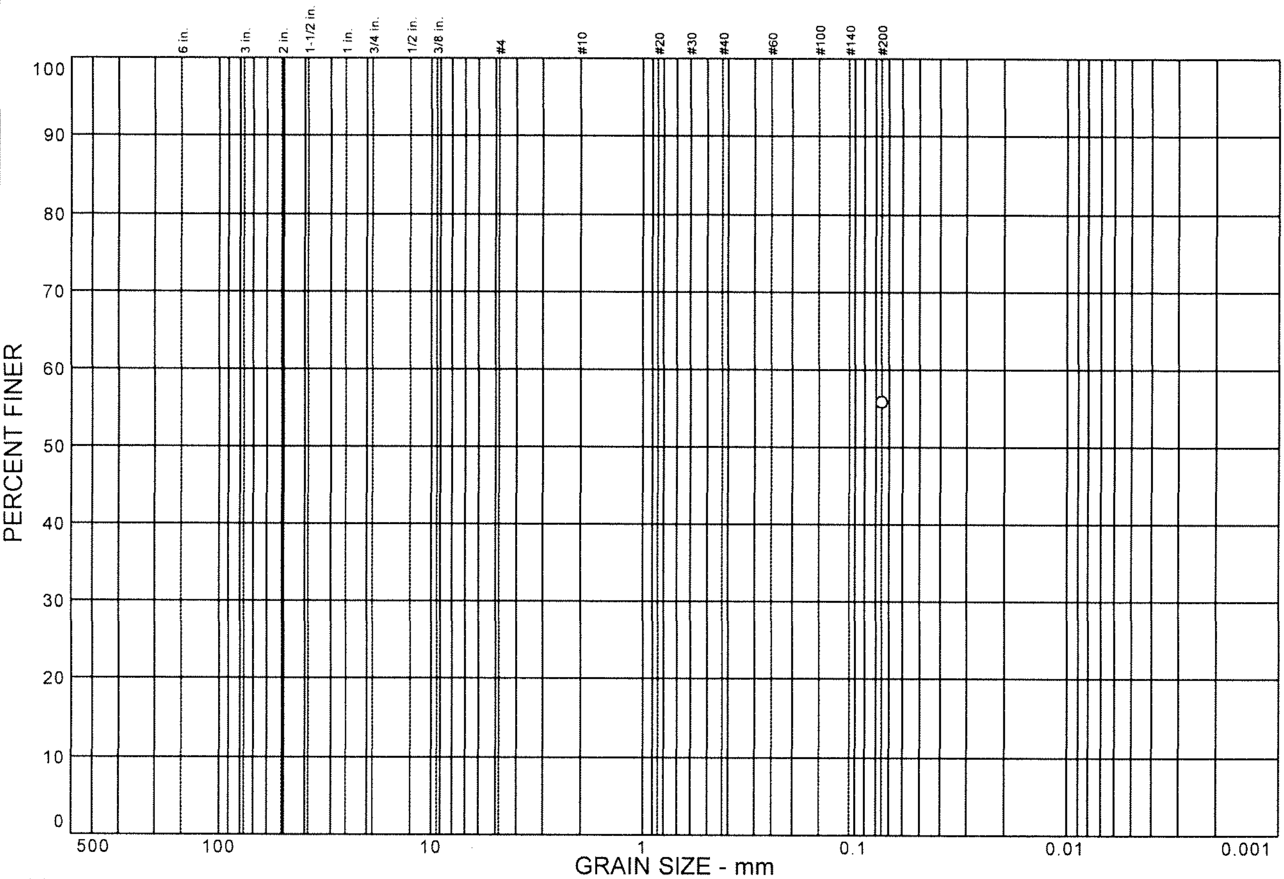
Remarks

Sample No.: B9 @ 17' **Source of Sample:** **Date:** 5-8-6
Location: **Elev./Depth:** 17'

ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Client:
Project: Sand Creek Ranch
Project No: 4371.4.050.01 **Plate**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
			55.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	55.7		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

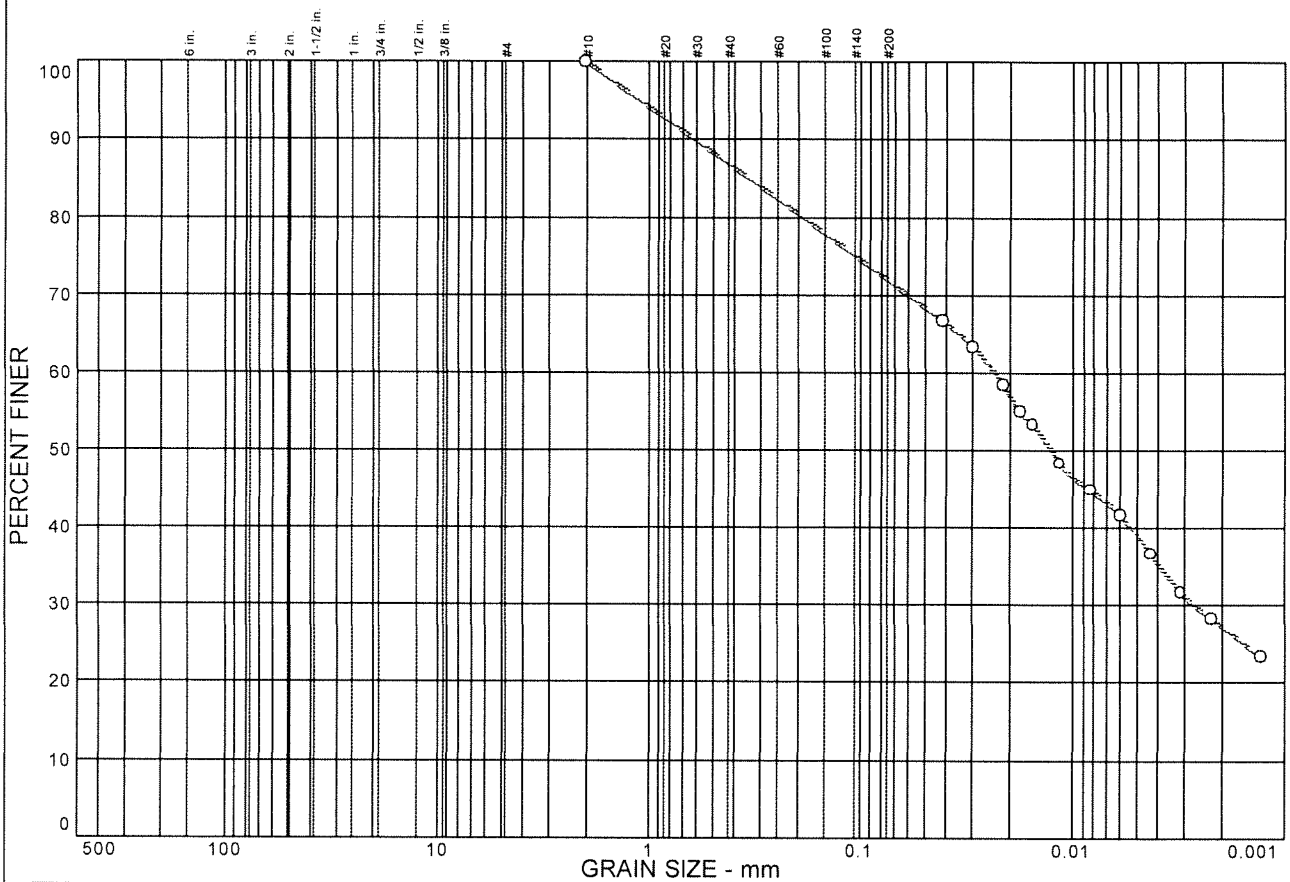
Remarks

Sample No.: B10 @ 21' **Source of Sample:** **Date:** 5-8-06
Location: **Elev./Depth:** 21'

ENGEO INCORPORATED — GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS, MATERIALS TESTING

Client:
Project: Sand Creek Ranch
Project No: 4371.4.050.01 **Plate**

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	28.1	32.9	39.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		

* (no specification provided)

Soil Description

Atterberg Limits

PL= 16 LL= 46 PI= 30

Coefficients

D_{85}= 0.340 D_{60}= 0.0236 D_{50}= 0.0128
D_{30}= 0.0027 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

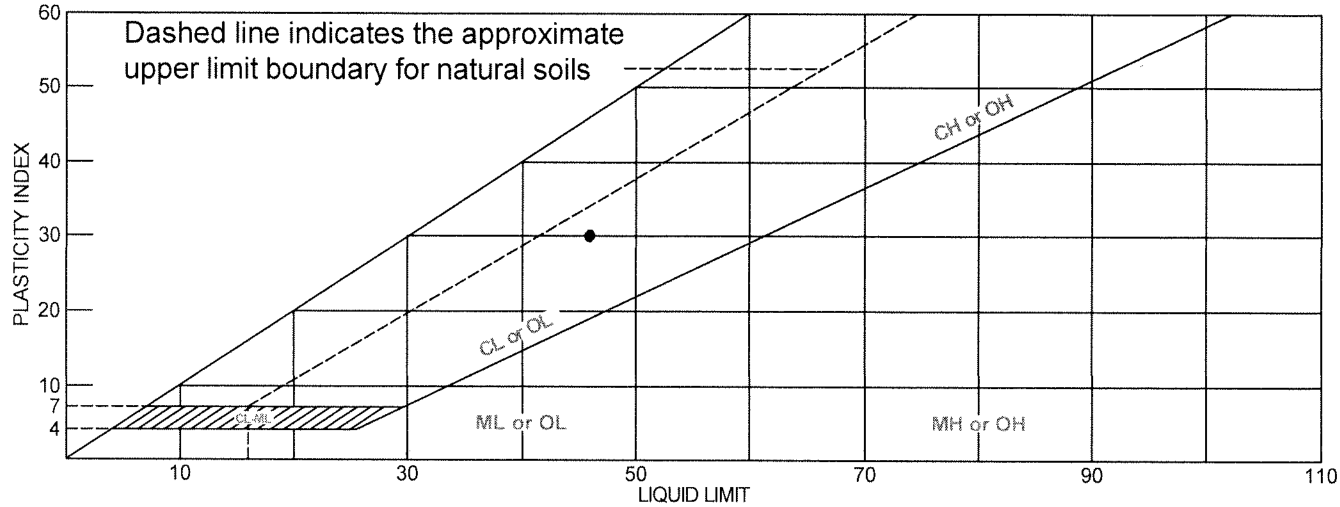
Sample No.: B14 @ 3' **Source of Sample:** **Date:** 5-9-06
Location: **Elev./Depth:** 3'

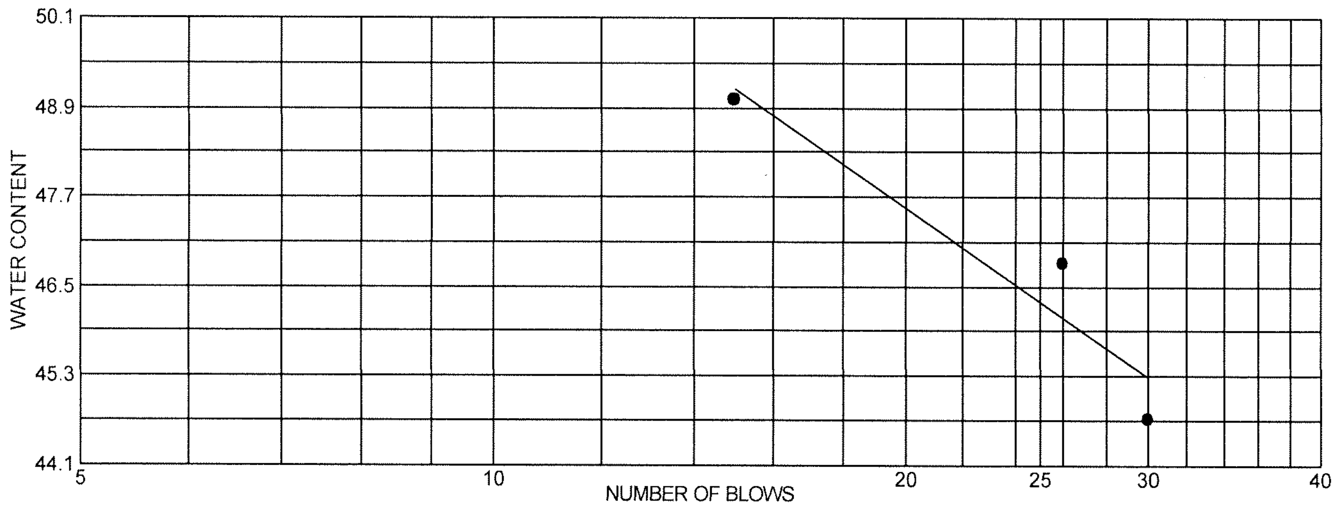
ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Client:
Project: Sand Creek Ranch

Project No: 4371.4.050.01 **Plate**

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		46	16	30	86.9	71.9	

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B14 @ 3' **Elev./Depth:** 3'

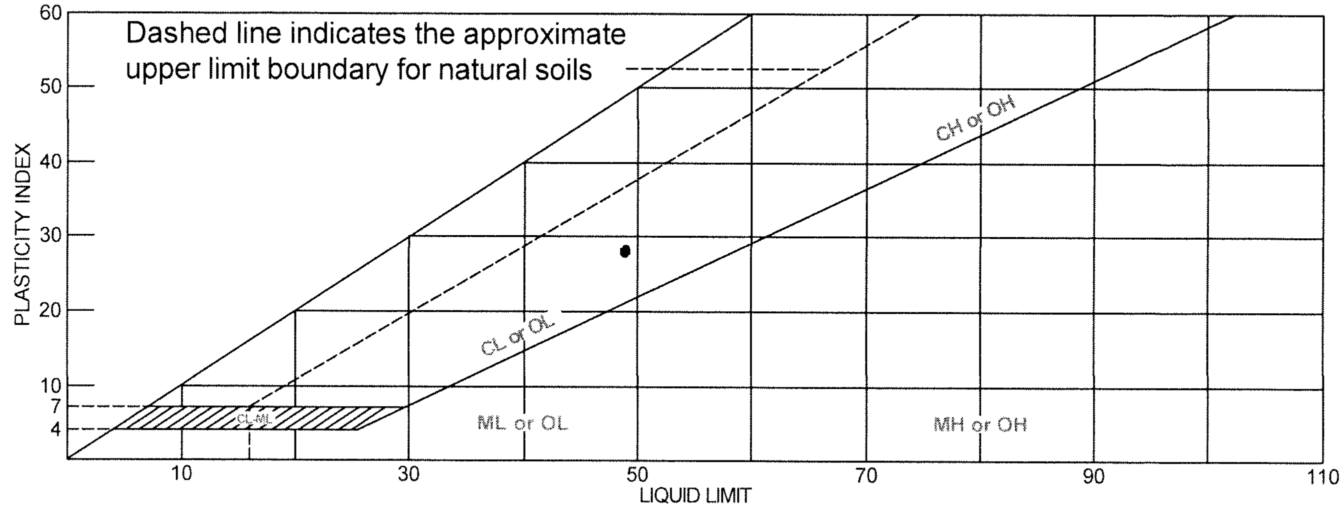
Remarks:

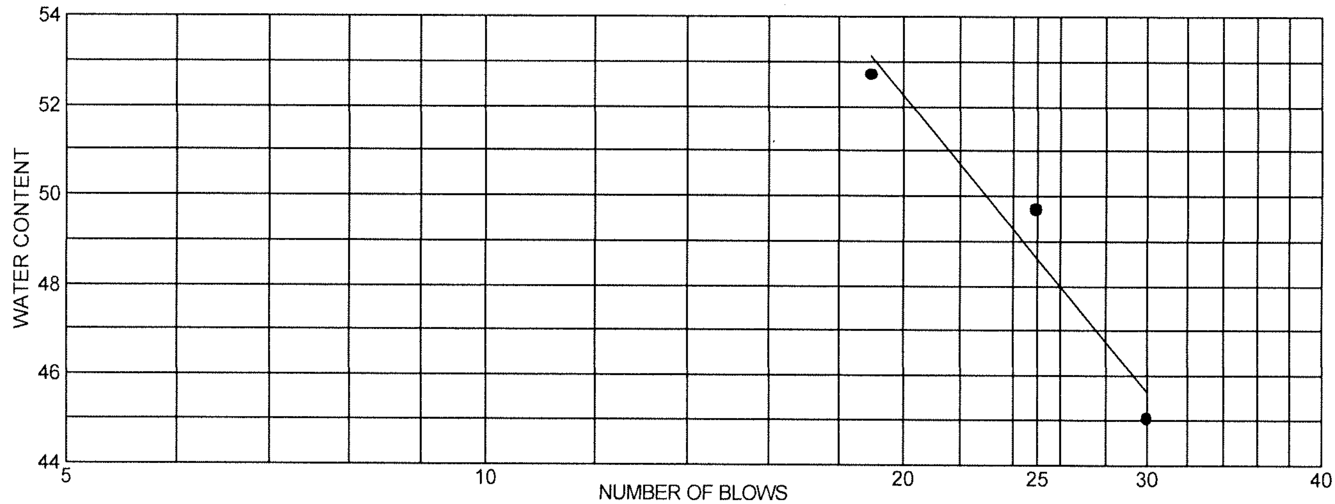
●

ENGEO INCORPORATED — GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		49	21	28			

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B25 @ 3' **Elev./Depth:** 3'

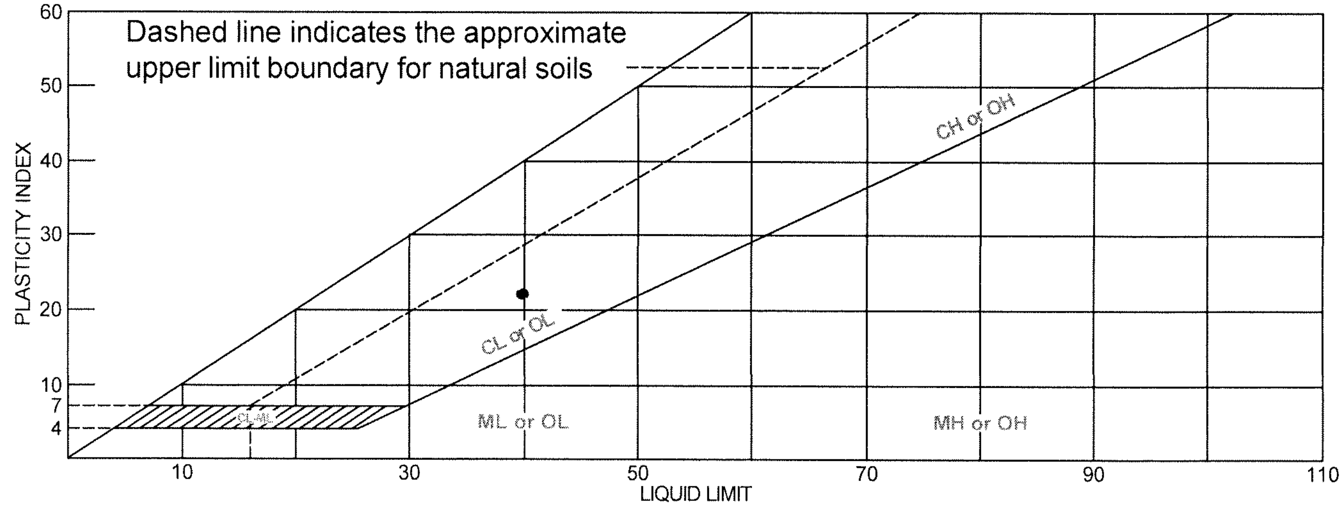
Remarks:

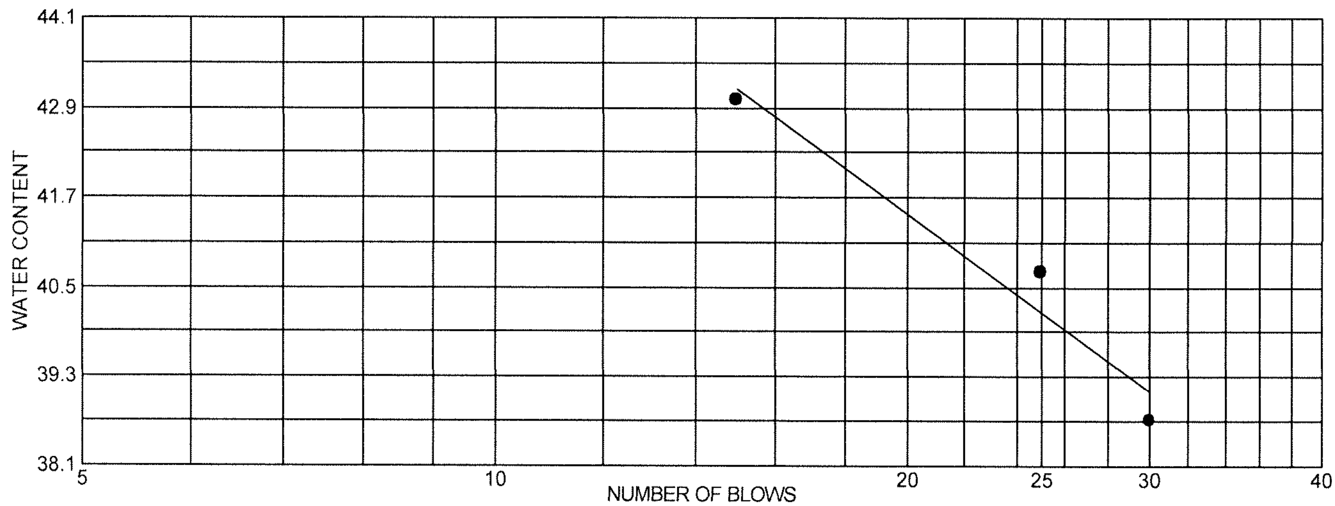
●

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		40	18	22			

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B1 @ 1' **Elev./Depth:** 1'

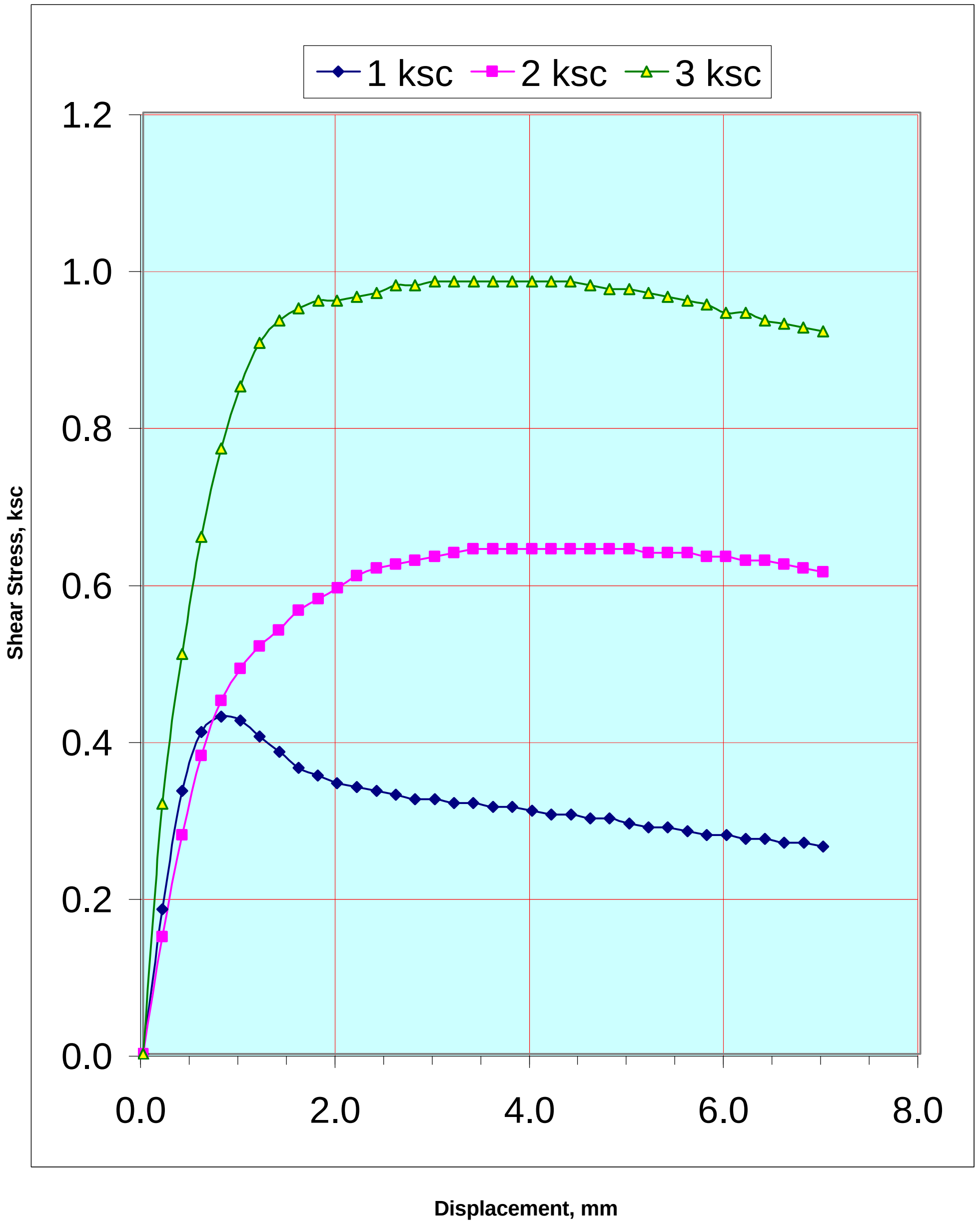
Remarks:

●

ENGEO INCORPORATED — GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

Direct Shear Test
ASTM Test Method D3080



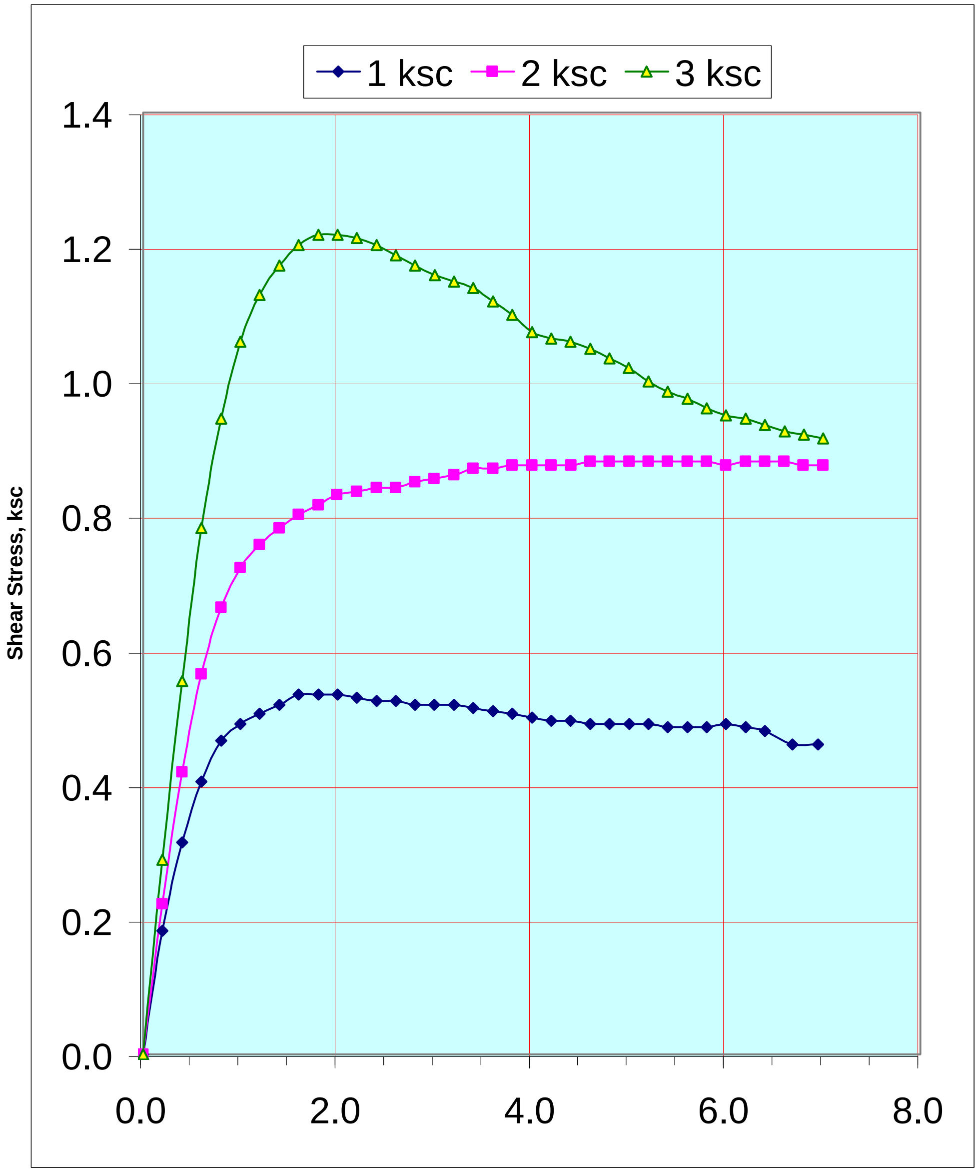
6

LOAD, (ksc)	PEAK	SOFTENED
1	**0.43** ksc	**0.28** ksc
2	**0.64** ksc	**0.63** ksc
3	**0.99** ksc	**0.96** ksc

Dry Density:	107.0 pcf
Moisture Content:	23.4 %
USCS Classification:	CL
Shear Type:	CD
Shear Rate:	Slow

***EN* GEO** INCORPORATED	**SAND CREEK RANCH** **Antioch, California**	**Job No.:**	**4371.1.050.01**
		Sample Number:	**B9@3**
		Date:	**5/11/2006**

Direct Shear Test
ASTM Test Method D3080



6

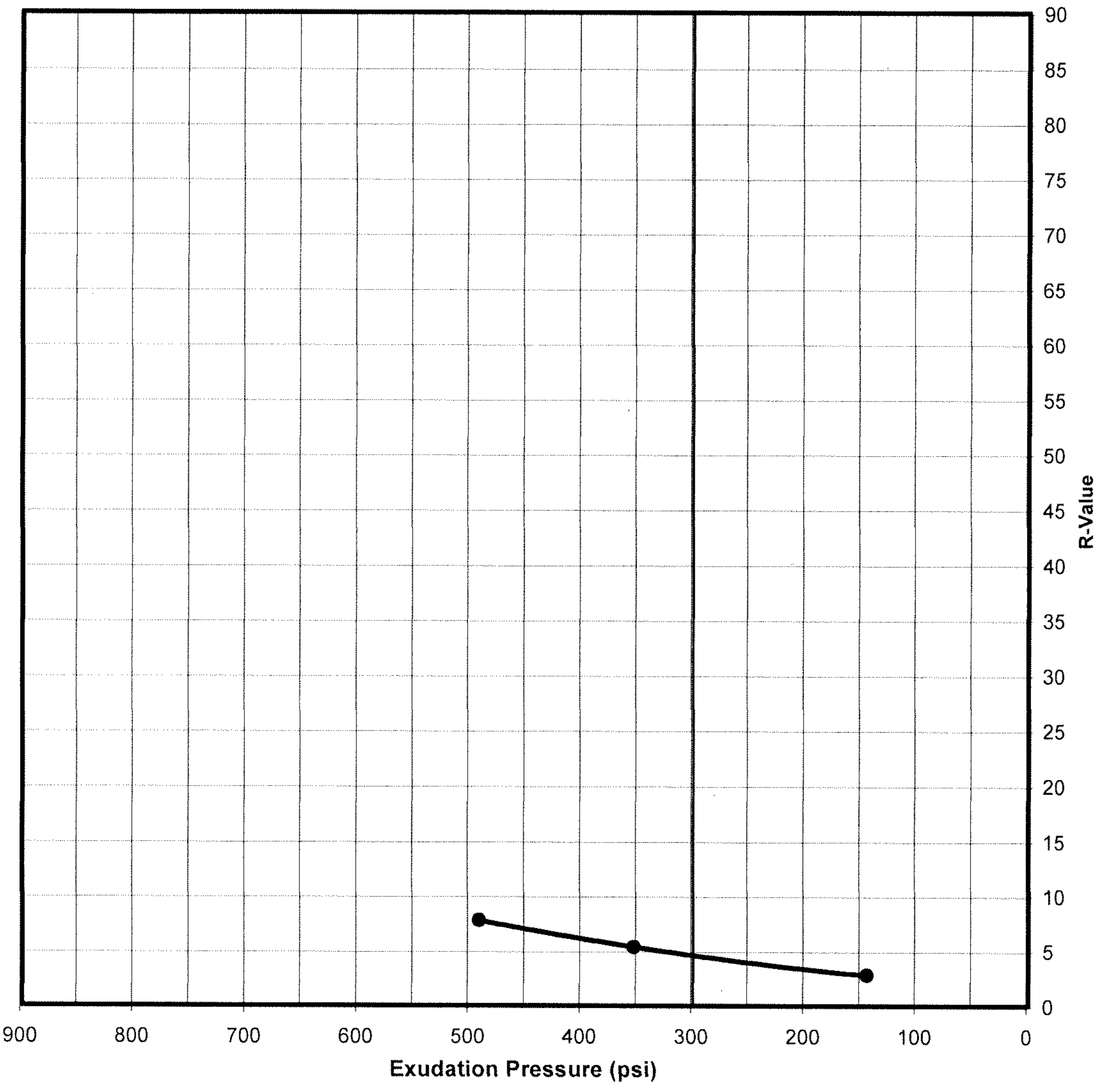
LOAD, (ksc)	PEAK	SOFTENED
1	**0.54** ksc	**0.49** ksc
2	**0.88** ksc	**0.88** ksc
3	**1.22** ksc	**0.95** ksc

Dry Density:	103.3 pcf
Moisture Content:	16.7 %
USCS Classification:	CL
Shear Type:	CD
Shear Rate:	Slow

***EN* GEO** INCORPORATED	**SAND CREEK RANCH** **Antioch, California**	**Job No.:**	**4371.1.050.01**
		Sample Number:	**B9-9**
		Date:	**5/11/2006**

ENGEO
INCORPORATED

R VALUE TEST REPORT
CAL-301



Date: 5/10/06
Project Name: Sand Creek
Project Number: 4371.4.050.01
Sample: Rv #1@surface
Description: Dark grayish brown CLAY

Specimen	A	B	C
Exudation Pressure, p.s.i.	492	353	145
Expansion dial (.0001")	0	0	0
Expansion Pressure, p.s.f.	0	0	0
Resistance Value, "R"	8	5	3
% Moisture at Test	23.6	26.5	29.5
Dry Density at Test, p.c.f.	100.9	95.6	95.1
"R" Value at 300 p.s.i., Exudation Pressure	4		

ENGEO

Expect Excellence

THIS PAGE INTENTIONALLY LEFT BLANK

F.2 - Paleontological Records Search

THIS PAGE INTENTIONALLY LEFT BLANK

Kenneth L. Finger, Ph.D.
Consulting Paleontologist

18208 Judy St., Castro Valley, CA 94546-2306   510.305.1080   klfpaleo@comcast.net

June 10, 2019

Dana DePietro
FirstCarbon Solutions
1350 Treat Boulevard, Suite 380
Walnut Creek, CA 94597

Re: Paleontological Records Search: The Ranch Project (3623.0007), Antioch, Contra Costa County

Dear Dr. DePietro:

As per your request, I have performed a records search on the University of California Museum of Paleontology (UCMP) database for The Ranch project site in Antioch. The project site is in Lone Tree Valley between Empire Road to the west and Deer Valley Road to the east. It slopes gently to the east, is flanked by hillsides, and is transected by Sand Creek. Its PRS locality is NW½ & N½ of SW¼, Sec. 7 and NW¼, Sec. 8, T1N, R2E, Antioch South quadrangle (USGS 7.5-series topographic map). It appears from Google Earth imagery that all of this parcel is relatively undisturbed and mostly barren, with trees only along the stream.

Geologic Units

On the part of the Dibblee and Minch (2006) geologic map shown here, the surface of the project site (yellow outline at center) consists of Holocene alluvium (Qa), which is too young to be fossiliferous, and Eocene Markley Sandstone Member (Tkm) of the Kreyenhagen Formation. Also within the half-mile search perimeter (dashed black outline) are Eocene rocks assigned to the other members of the Kreyenhagen Formation, and older Eocene rocks of the Domengine (Tds) and Meganos Formation (Tmgd), Tmgd).

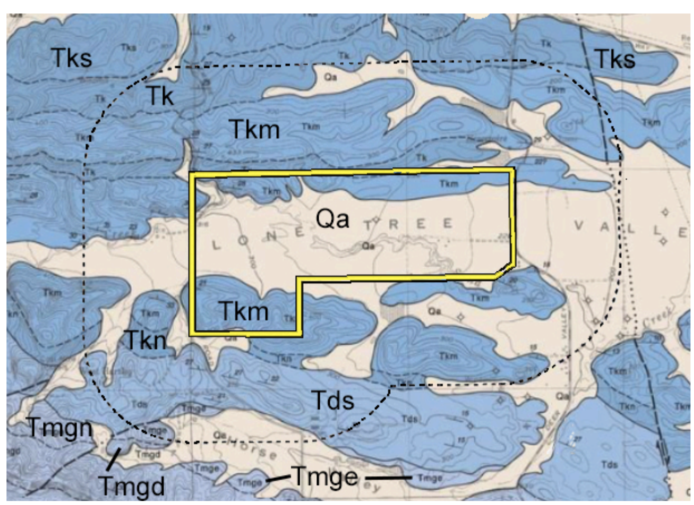
Geologic Units Shown on Map

Qa Surficial deposits of alluvial pebble gravel, sand, and clay. (Holocene)

Kreyenhagen Formation (Middle Eocene)
- **Tks** Semi-siliceous to clayey shale
- **Tk** Clayey shale
- **Tkm** Markley Sandstone Member
- **Tkn** Nortonville Shale Member

Tds Domengine Formation (Middle Eocene)

Meganos Formation (Early to Middle Eocene)
- **Tmge** Sandstone member
- **Tmgd** Silty mudstone member



Records Search

The records search was performed on the University of California Museum of Paleontology database and focused on the Kreyenhagen, Domengine, and Meganos formations. The Kreyenhagen has 5 vertebrate localities, all in Fresno County, from which 71 fish fossils were collected, and 3 plant localities, two in Fresno County and one in Contra Costa County. No plant specimens are recorded for the latter, which is the Nortonville Shale microfossil (radiolarian) locality south of Mt. Diablo of Clark and Campbell (1942). Six vertebrate and no plant localities are recorded in the Markley Sandstone: 2 in Solano County and 4 in Contra Costa County. The Domengine is represented by a single locality in Fresno County that yielded 6 fish specimens, and one plant locality in San Benito County. The Meganos has only a plant locality recorded in Monterey County.

Approximately one mile northwest of the project site, UCMP locality V4719 (Heldorn) yielded what was identified as late Pleistocene *Equus* (horse) cheek teeth. About a mile north of that site, a *Mammut* (mastodon) skull fragment of that age was collected at UCMP locality V6650 (Antioch Dam). The geologic mapping, however, indicates only Holocene alluvium at those locations. It therefore appears that either Dibblee and Minch (2006) were unaware of the UCMP fossils or the fossils were from older alluvium (Qoa) in the subsurface. In either case, the potential of finding late Pleistocene (Rancholabrean) vertebrates in Lone Tree Valley must be taken into account. There 62 late Pleistocene vertebrate localities in Contra Costa County and their composite Rancholabrean assemblage (see attached list) totals 9930 specimens.

The local paleontological rankings of the units are summarized below:

Unit	Potential	Sensitivity
Qa	none	none
Qoa	low to moderate	**high**
Tks	none	none
Tk	none	none
Tkn	none	none
Tkm	low	**high**
Tds	none	none
Tmge	none	none
Tmgd	none	none

Hence, it is the unmapped older alluvium and the Markley Sandstone that are of concern here.

Remarks and Recommendations

A pre-construction paleontological walkover survey of the project site is recommended because its terrain is relatively undisturbed and both of the geologic units (Markley Sandstone and Quaternary alluvium) mapped within its confines have produced significant paleontological resources in the vicinity of Antioch. The results of the survey will enable the paleontologist to formulate an appropriate paleontological monitoring program for earth-disturbing construction activities. It also would be prudent to have a professional paleontologist train the construction crew to recognize potentially significant fossils and to know how to proceed should any of be unearthed.

If I can be of further assistance on this project, please do not hesitate to contact me.

Sincerely,

Ken Finger

References Cited

Clark, B.L., and Campbell, A.S., 1942, Eocene radiolarian fauna from the Mt. Diablo area, California. Geological Society of America, Special Papers, 39: 1–112.

Dibblee, T.W., Jr., and Minch, J.A., 2006. Geologic map of the Antioch South and Brentwood quadrangles, Contra Costa County, California. USGS Open-File Report OF-80-536. Dibblee Foundation DF-193, 1:24,000.

LATE PLEISTOCENE VERTEBRATES FROM CONTRA COSTA COUNTY

Class Amphibia
- Order Anura
  - *Pseudoacris* (chorus frog)
  - *Rana* (pond frog)
- Order Caudata or Urodela
  - *Ambystoma* (mole salamander)
  - *Aneides lugubris* (arboreal salamander)
  - *Taricha* (newt)

Class Reptilia
- Order Sauria
  - *Elgaria* (alligator lizards)
  - *Gerrhonotus coeruleus* (northern alligator lizard)
  - *Scleoporus* (spiny lizards)
  - *Uta* (sideblotched lizard)
- Order Serpentes
  - *Crotalus* (rattlesnake)
- Order Testudines
  - *Clemmys marmorata* (western pond turtle)

Class Chondrichthyes (cartilaginous fish)
- Order Myliobatiformes (sting rays)
  - *Myliobatus* (bat ray)

Class Osteichthyes (bony fish)
- Order Cypriniformes (carps, minnows, loaches, etc.)
  - *Orthodon* (Sacramento blackfish)
- Order Gasterosteiformes (sticklebacks)
  - *Gasterosteus aculeatus* (three-spined stickleback)

Class Aves
- Order Anseriformes
  - *Anas acuta* (pintail duck)
  - *Melanitta* (scoter)
- Order Ciconiformes
  - ardeidid (heron)
- Order Culidae
  - *Geococcyx* (roadrunner)
- Order Galliformes
  - *Callipepia* (quail)
  - *Centrocercus* (sage grouse)
- Order Passeriformes
  - *Euphagus* (New World blackbirds)
  - *Turdus* (true thrushes)
- Order Piciformes
  - picidid (woodpecker)
- Order Podicipedformes
  - *Aechmophorus occidentalis* (western grebe)
- Order Strigiformes
  - *Asio flammeus* (short-eared owl)

Class Mammalia
- Order Insectivora
  - *Scapanus latimanus* (broad-footed mole)
  - *Sorex ornatus* (ornate shrew)
- Order Xenartha
  - *Glossotherium harlani* (Harlan's ground sloth)
  - *Megalonyx jeffersoni* (Jefferson's flat-footed ground sloth)
- Order Lagomorpha
  - *Sylvilagus bachmani* (cottontail rabbit)
  - *Lepus* (jackrabbit)
- Order Rodentia
  - *Dipodomys* (kangaroo rat)
  - *Microtus californicus* (California meadow vole)
  - *Neotoma fuscipes* (dusky-footed wood rat)
  - *Perognathus* (pocket mouse)
  - *Peromyscus boylii* (brush mouse)
  - *Peromyscus californicus* (California deer mouse)
  - *Peromyscus maniculatus* (white-footed mouse)
  - *Peromyscus truei* (pinyon mouse)
  - *Reithrodontomys raviventris* (salt marsh harvest mouse)
  - *Sciurus* (squirrel)
  - *Tamias* (chipmunk)
  - *Otospermophilus beecheyi* (California ground squirrel)
  - *Thomomys bottae* (Botta's pocket gopher)
- Order Chiroptera
  - *Antrozous pallidus* (pallid bat)
  - *Eptesicus fuscus* (big brown bat)
  - *Lasiurus* (hairy-tailed bat)
- Order Carnivora
  - *Cynodesmus thooides* (extinct canid)
  - *Enhydra lutris* (sea otter)
  - *Procyon lotor* (racoon)
  - *Taxidea* (badger)
  - *Ursus americanus* (American black bear)
- Order Proboscidea
  - *Mammut americanum* (American mastodon)
  - *Mammuthus columbi* (Columbian mammoth)
- Order Perissodactyla
  - *Equus pacificus* (Pacific horse)
  - *Pliohippus interpolatus* (Pliocene horse)
  - *Tapirus merriami* (tapir)
- Order Artiodactyla
  - *Antilocapra pacifica* (Pacific pronghorn)
  - *Bison bison antiquus* (ancient bison)
  - *Bison latifrons* (long-horned bison)
  - *Camelops hesternus* (yesterday's camel)
  - *Capromeryx minor* (diminutive pronghorn)
  - *Cervus* (elk)
  - *Odocoileus* (mule deer)
  - *Sphenophalos* (pronghorn)