GEOTECHNICAL EXPLORATION

SAND CREEK RANCH
ACTIVE ADULT COMMUNITY

ANTIOCH, CALIFORNIA

SUBMITTED

TO

SHEA HOMES

LIVERMORE, CALIFORNIA

PREPARED

BY

ENGEO INCORPORATED

PROJECT NO. 4371.4.050.01

MAY 24, 2006

ENGEO
INCORPORATED

GEOTECHNICAL
ENVIRONMENTAL
WATER RESOURCES
CONSTRUCTION SERVICES

Project No.
4371.4.050.01

May 24, 2006

Mr. Randy Bauer
c/o Shea Homes
2580 Shea Center Drive
Livermore, CA 94551

Subject: Sand Creek Ranch - Active Adult Community
Empire Mine Road
Antioch, California

GEOTECHNICAL EXPLORATION

Dear Mr. Bauer:

With your authorization, we conducted a geotechnical exploration for the proposed San Creek Ranch project located in Antioch, California.

The accompanying report presents the results of our site exploration and geotechnical recommendations for the design of the proposed project development. Based on our study, it is our opinion that the currently proposed development is feasible from a geotechnical standpoint provided the recommendations included in this report are incorporated into the project design and implemented during construction.

We are pleased to have been of service to you on this project and will be glad to consult further with you and your design team.

Very truly yours,

ENGEO INCORPORATED

Steve Harris, PE

Kelsey Adams

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Reviewed by:

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GEOTECHNICAL
STATE OF CALIFORNIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

INTRODUCTION

Purpose and Scope

This study was undertaken to gather information regarding subsurface conditions at the subject property in order to prepare geotechnical recommendations for site grading, cut and fill slope criteria, foundation design, retaining walls, underground trench backfill, and preliminary asphalt pavement design. The scope of our work included the following:

1. Review of previously published maps and reports regarding geological and geotechnical characteristics of the subject site and nearby properties.
2. Excavation and logging of exploratory test pits.
3. Exploratory drilling, logging, and sampling.
4. Laboratory testing of subsurface materials.
5. Analysis of the geological and geotechnical data.
6. Preparation of this report summarizing our findings and our design recommendations.

Additional slope stability analyses and specific, detailed geotechnical engineering recommendations, including minimum keyway dimensions and subdrain locations, should be performed by ENGEO Incorporated during development and review of the final 40-scale (1" = 40') grading plans for the project. Supplemental recommendations and modifications to geotechnical recommendations presented herein are expected to be provided on an as-needed basis during grading based on site-specific subsurface conditions.

This report was prepared for the exclusive use of Shea Homes and its design team consultants. In the event that any changes are made in the character, design, or layout of the development, the conclusions and recommendations contained in this report should be reviewed by ENGEO to determine whether modifications to the report are necessary. This document may not be reproduced in whole or in part by any means whatsoever, nor may it be quoted or excerpted without the express written consent of ENGEO Incorporated.

Site Location and Description

The Sand Creek Ranch property consists of approximately 973 acres located north and east of Empire Mine Road and west of Deer Valley Road in Antioch, California, as shown on the Vicinity Map (Figure 1). The Sand Creek Ranch property is generally characterized by open, rolling, grass-covered hills with scattered trees and a relatively flat grass-covered valley with Sand Creek cutting across it from west to east.

Natural slope gradients range from essentially flat on the valley floor, in the northern and southern portion of the site, to 1:1 (horizontal:vertical) in isolated ridge-top areas in the northernmost, central and southern portions of the site. The slopes next to the creek are nearly vertical from the main valley down to the creek bottom and range in depth from 20 to 30 feet. Total relief on the site is approximately 283 feet, ranging from approximately 220 feet above mean sea level (msl) at the bottom of the creek near the eastern site boundary of the site to approximately 503 feet msl at the highest location at the peak of the hill near the southwestern property boundary. The valley floor in the northern portion of the site slopes gently down from 320 feet msl on the west side of the site at Empire Mine Road down to 225 feet msl on the east side of the site at Deer Valley Road. Drainage from the property is generally towards Sand Creek with the exception of the southern portion of the property which drains southeast to Empire Mine Road.

The site is bounded by Deer Valley Road and vacant fields to the east, existing residential development to the north, and Empire Mine Road to the south and west. A small portion of the site crosses Empire Mine Road in the southwest corner of the property (Figure 2). Vegetation primarily consists of various native trees and wild grasses growing across the site. The majority of the property is currently being used for cattle grazing and is surrounded with fencing. There is one residence located on the site. A gravel road leading up to the residence is accessed from Deer Valley Road. The residence consists of a mobile home, two large barns and various storage sheds. Additional structures are located on the southern portion of the property in the area of the former livestock feed lot. In this area there are currently two large barn structures and multiple small foundations which remain from past houses, storage sheds and stock yard related structures. Near the western property boundary along Empire Mine Road remnants of a former mining town (known as Judsonville) exist. The remains of this town include a wind mill, various mining related equipment, and debris piles.

Many areas of undocumented fill were located primarily within the southern portion of the property in the areas surrounding the former stock yard. Some of these fills were built to create level stock lots, canals, and stock pond berms, while others were used as debris fills and manure piles. Various debris piles were also observed near the Judsonville site and we expect that there me be as much as five feet of undocumented fills on or near this portion of the property. Approximate locations of undocumented fill are shown in Figure 3.

Proposed Development

At this time, it is our understanding that several land plans are being considered for the proposed site. Various combinations of hillside and non-hillside single family residences, a recreation center, and open space will cover a majority of the site. Based on discussions with Shea Homes and Carlson Barbee and Gibson, grading is expected to involve cuts and fills up to a maximum of 30 feet. Proposed cut and fill slopes are planned at slope gradients of about 3:1 (horizontal:vertical).

Structural loads and other details related to the proposed house structures and site improvements have not been developed at this time. However, we understand that the proposed residential houses are anticipated to consist of one- and two-story wood-framed structures. Based on similar type developments, the maximum wall loads are anticipated to be less than about 2,000 pounds per lineal foot (plf), and the maximum column loads are anticipated to be less than about 20 kips.

GEOTECHNICAL EXPLORATION

Our recent field exploration included drilling 40 exploratory borings and excavating 23 test pits. The approximate locations of our explorations are shown on the Site Plan (Figure 2). The logs of borings and test pits are presented in Appendix A. These explorations were conducted in April and May 2006. Geologic field mapping was undertaken concurrent with the exploration.

Test Borings

Exploratory borings 1-B1 through 1-B40 were drilled with a truck-mounted Mobil Drill B-35 drill rig equipped with 6-inch-diameter solid flight augers employing a manual trip hammer system. An ENGEO geologist logged the borings in the field and collected soil samples using either a 3-inch Outside Diameter (O.D.) California-type split-spoon sampler fitted with 6-inch-long brass liners, or a 2-inch O.D. Standard Penetration Test (SPT) split-spoon sampler. The samplers were advanced with a 140-pound safety hammer with a 30-inch drop, employing a manual trip cable and pulley system. The penetration of the samplers into the native materials was field recorded as the number of blows needed to drive the sampler 18 inches in 6-inch increments. Blow count results on the boring logs are recorded as the number of blows required for the last one foot of penetration, or the distance indicated if driving refusal was encountered. The field logs were then used to develop the boring logs as shown in Appendix A. The logs depict subsurface conditions within the borings for the date of drilling; however, subsurface conditions will vary with time.

Test Pits

Exploratory test pits 1-TP1 through 1-TP23 were excavated at the site using a rubber-tired tractor-mounted backhoe. The test pits were located by estimating distances from features shown on topographic and aerial photograph base maps. The field logs were then used to develop the test pit logs presented in this report (Appendix A).

The test pits were backfilled with nominal compactive effort. Test pits within the development area that are not completely removed by design cuts will require overexcavation and recompaction during site grading.

Laboratory Testing

Following the field exploration, the collected soil samples were reexamined in our laboratory to confirm field classifications. Representative soil samples recovered from the borings were tested for the following physical characteristics:

Characteristic	Test Method	Location of Results Within this Report
Natural Unit Weight and Moisture Content	ASTM D-2216	Boring Logs, Appendix A
Plasticity Index	ASTM D-4318	Appendix B
Gradation	ASTM D-422	Appendix B
Direct Shear	ASTM D-3080	Appendix B
Unconfined Compression	ASTM D-2166	Appendix B

Individual test results are presented in Appendix B and on the boring logs in Appendix A.

Corrosivity testing and evaluation was not performed as a part of this study. It should be emphasized that following mass grading, samples for corrosivity testing and evaluation should be performed in areas of proposed foundations and improvements.

GEOLOGY AND SEISMICITY

Regional Geology

The site is located in the Coast Ranges geomorphic province on the eastern side of Mount Diablo. In this part of the province, bedrock is mapped as Tertiary Eocene and Oligocene age marine sedimentary rock (Wagner 1991). Bedrock in the area generally consists of interbedded sandstone, and claystone that vary from friable to strong. Bedrock structure in the area generally strikes to the west, northwest and dips at an inclination of about 15 to 30 degrees to the north to northeast. The geologic setting of the site is shown on the attached Regional Geologic Map, Figure 5.

Faulting and Seismicity

The site is not located within a State of California Earthquake Fault Hazard Zone. Maps showing faulting prepared by Wagner (1991) and Dibblee (1980) show no active or potentially active faults on the site.

As shown on Figure 5, one segment of the Antioch Fault is mapped near the northwest corner of the site by Wagner. The fault mapping by Wagner appears to be the similar to earlier mapping by Dibblee (Figure 6). The most current USGS fault map does not classify the Antioch Fault as a Holocene active fault. It is currently listed as a Quaternary fault; and is therefore, considered not active.

Additional seismic sources near Antioch include the Greenville/Marsh Creek, Concord – Green Valley, and Calaveras faults. The Greenville/Marsh Creek and Concord – Green Valley faults are located about 5 miles and 11 miles, respectively, to the southwest of the site. The Calaveras fault is located about 15 miles to the west of the site. Additionally, three other significant seismic sources are the Hayward Fault, Rodgers Creek Fault, and the San Andreas Fault, located 24, 32, and 42 miles to the west of the site, respectively.

The San Andreas Fault represents an active crustal plate boundary that is expected to produce the maximum probable earthquake for the region. Other active faults of coastal California are lesser-order features of the same stress-strain system. A Regional Faulting and Seismicity Map is shown on Figure 7 that shows the approximate location of major active faults and significant historic earthquakes with respect to the site.

A segment of the Great Valley Fault has been identified within 5 miles of the site (Blake, 2005). 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; however, since this fault does not extend to the ground surface, it is not zoned as active by the State of California. The Great Valley fault is considered capable of causing high ground shaking at the site, but the recurrence interval is believed longer than for more distant, strike-slip faults. The Type B Great Valley fault has been omitted from both the jointly published CDMG and ICBO documents, “Maps of Known Active Fault Near-Source Zones in California and Adjacent Properties of Nevada (1998)” and “Determining Distances from Faults Within and Bordering the State of California (1997)” for the purpose of determining near source seismic factors used in structural design.

Soil Stratigraphy and Bedrock

Artificial Fill. Areas where existing fills were observed are identified on Figure 3 and on the Geologic Map, Figure 4. The existing fills include embankments for several stockponds, graded pads in the southern portion of the site, manure piles, and fill associated with the former stockyard in the southern portion of the site. In general, the existing fills appear to have been derived from on-site soils and bedrock materials with the exception of the manure piles. The existing fills appear to range in thickness from about 3 to 15 feet. No records pertaining to the placement of these artificial fills could be found and they are therefore considered to be non-engineered. Non-engineered fills can be highly variable and potentially compressible.

Residual Soil. Residual natural soils, derived by weathering of the underlying parent bedrock, were encountered in test pits excavated along ridgelines and hillside areas. The residual soils generally consisted of dark grayish brown clay with various amounts of silt and sand. The residual soil cover ranges from about 1 to 4 feet thick. Residual soils have a moderate to high plasticity, and are considered moderately to highly expansive when subjected to fluctuations in moisture content.

Colluvial Deposits. Colluvium “Qc” has been mapped along the base of slopes and in swales and valleys as a result of soil creep and transportation by erosion. These deposits consist of dark brown silty clay with lesser amounts of sand. The typical thickness of these deposits varied from about 3 to 15 feet. Atterberg Limits testing of colluvial soils resulted in a Plasticity Index (PI) of 30. Based on the results of the laboratory testing and our observation, the colluvial soils have a high plasticity. The colluvial materials are therefore considered highly expansive when subjected to fluctuations in moisture content. Onsite colluvial deposits are also considered to be potentially compressible.

Alluvial Deposits. Pleistocene to Holocene-age alluvium “Qal” has been mapped in the low-lying, northern portion of the site, north and south of Sand Creek; as well as, in the southernmost portion of the property, north of Empire Mine Road. Alluvial deposits consist primarily of unconsolidated silty clay, clay, and silty sand. Based on the findings of the exploratory borings and topography at the site, the alluvium varies in thickness. Alluvial deposits near the base of the site hills are as thick as five feet while alluvial deposits near Sand Creek are greater than 30 feet thick. The near-surface layers of these deposits are stiff to very stiff, and with greater depth, these deposits increase in stiffness to hard. Atterberg Limits testing of the near surface alluvium resulted in PI’s of 22 to 30. The surficial deposits range from moderate to high plasticity and are considered moderate to highly expansive.

Landslide Deposits. Regional landslide mapping by Nilsen (1975) shows one landslide area on the site located on a steep northerly facing slope adjacent the western site boundary near Empire Mine Road. Nilsen also maps a queried (uncertain) landslide on a north facing slope near the center of the property. Based on the findings of our exploration, three landslides “Qls”, in addition to those mapped by Nilsen, were identified. During our exploration the uncertain landslide identified by Nilsen was evaluated and was determined not to be a landslide. The landslide deposits that have been identified are shown on the Geologic Map, Figure 4. These landslide deposits appear to consist of shallow slump-type failures that predominately involve soil with some highly weathered bedrock material. Depth of movement is expected to be about 2 to 6 feet below the ground surface. These landslides are suspected to be due to the steep slopes and thin layers of residual soil covering massive sandstone bedrock.

Bedrock. Bedrock at the site consists of the Tertiary-age Markley, Nortonville, Domengine, and Meganos Formations. These rocks are composed of sandstone and claystone/shale, with some minor siltstone and conglomerate. The Meganos is the oldest bedrock at the site and is limited to the very southern portions where it is predominantly covered with alluvium. The Domengine is located in a band trending northwesterly through the south-central portion of the site. Bedding trends northwesterly with a shallow northerly dip. To the north of the Domengine are located a thin band of Nortonville shale, and a thicker section of Markley formation.

The Meganos formation (Tmge) is located in the southernmost portion of the site. It was found in our test pits and borings on the south facing slopes in the southern portion of the site and on a small hill located in the southwest corner of the property. This formation was found to consist primarily of interbedded siltstone and claystone. Siltstone and claystone of this unit were found to be friable to weak, very closely fractured, and vary from very thinly to thickly bedded. A backhoe was able to excavate this unit without difficulty.

Domengine sandstone (Tds) was encountered in the southern-central portions of the site. Where encountered in test pits, the Domengine sandstone was generally friable to moderately strong and thickly bedded to massive. Weathered sandstone encountered near the top of this unit was generally poorly cemented, friable, and highly fractured.

The Domengine Formation is the sandstone unit that contains coal seams in the Mt. Diablo area. A more detailed description of the coal mining history at the property is discussed in the Historic Coal Mining Activities section of this report, and in Appendix C.

The Nortonville Shale (Tkn) is located in an east-west trending band in the central portion of the site. It was found in our test pits and borings on the south facing slopes in the central portion of the site and in the small valley in the south central portion of the property. This formation was found to consist predominantly of claystone with some interbedded siltstone and shale. Bedrock of this unit was found to be friable to weak, very closely fractured, and vary from thinly to thickly bedded. The backhoe was able to excavate this unit without difficulty. Atterberg Limits testing of the claystone material from Boring 1-B23 resulted in a PI of 39. Based on the results of the laboratory testing and our observation, the claystone materials are considered highly expansive.

Markley sandstone (Tkm) was encountered in the central and northern portions of the site. It was found in our test pits and borings on the north facing slopes in the central portion of the site and in south facing slopes in the northern portion of the property. Where encountered in test pits, the Markley sandstone was generally friable to moderately strong and thickly bedded to massive. This sandstone was highly weathered near the top of the unit and became stronger, massive, and widely fractured with depth.

Bedrock structure was mapped in test pits and where exposed in outcrops. Bedding was found generally striking to the west, northwest and dipping at inclinations of about 15 to 30 degrees to the northeast.

Groundwater Conditions

Groundwater or perched water was encountered in borings and test pits at the following locations.

Boring Number	Depth to Groundwater	
	Encountered During Drilling (feet)	Recorded After Drilling (feet)
1-B1	15 ½	14 ½
1-B5	4 ½	2 ½
1-B10	17 ½	13 ½
1-B11	20 ½	NR
1-B17	10	9 ½
1-B18	10 ½	6
1-B19	12 ½	9 ½
1-B20	11 ½	10
1-B34	NR	1 (perched)
1-B35	10	NR
1-B36	10	5 ½
1-B37	9	5
1-B38	1 ½ (perched)	3 (perched)
1-B39	10	5
1-B40	8 ½	4 ½
1-TP9	NR	2 ½ (perched)
1-TP10	NR	3 ½ (perched)
1-TP11	NR	9 (perched)

NR = Not Recorded

Perched water may be due to poor site drainage and excessive rainfall prior to our exploration. It should be noted that the borings may not have been left open for a sufficient period of time to establish equilibrium groundwater conditions. In addition, fluctuations in groundwater levels occur seasonally and over a period of years because of variations in precipitation, temperature, irrigation, and other factors. Future irrigation may cause an overall rise in groundwater levels.

HISTORIC COAL MINING ACTIVITIES

Background

As previously discussed, geologic mapping by Dibblee (1980) shows the site underlain by bedrock of Tertiary age belonging to the Markley, Nortonville, Domengine and Meganos formations (Figure 4). The coal veins/seams are located within the Domengine Sandstone. The Domengine Sandstone is about 350 to 450 feet thick in this area. The majority of the Domengine consists of thick sand beds and thinner clay-rich shale beds. Three well known coal veins extend throughout the Domengine. In the Sand Creek area, the coal seams were 24 to 36 inches thick. Other coal veins were occasionally encountered. Those veins were typically thin and discontinuous, and were only occasionally mined. The Meganos Formation, Nortonville shale, and Markley formation were not mined for coal.

William C. Israel made the first documented discovery of coal in 1859, at what presumably was the Israel Mine on site, then called Horse Haven (Sullivan et al, 1980). As described by that source, the site was "about 6 miles south of Antioch. The discovery created some interest in the county, and other sites were soon found in the area." Mining concentrated predominantly to the west of the site, where towns such as Nortonville, Somersville and Stewartville prospered. The subject property is located in the southeastern portion of the coal field. This resulted in smaller mining enterprises being located in the vicinity. During the period from 1864 to 1874, the Mt. Diablo coal field was the leading supplier of coal for the rapidly industrializing city of San Francisco. In 1876, the Empire Coal Mine and Railroad Company was incorporated. The railroad line was built the following year (1877) in the approximate location of what is now Empire Mine Road south of Antioch. In 1881, a branch line was built towards Stewartville. This was the same year that the Empire Mine near West Hartley was closed due to excess water.

Increased costs, competition and the beginning of oil use for fuel led to the closing of mines in the Mt. Diablo coal field beginning as early as 1885. Even though all of the coal was not removed, the mining operation costs were high because of the methods used for mining the coal. The last mining of any significance ended with the closing of the Pittsburg Mine (Somersville) in 1902. Black Diamond Mine contracted on a limited basis through World War II. The coal mining industry was replaced with sand mining in the 1920's. In 1922, underground mining of silica glass sand began at the old Pittsburg Mine in Somersville. These sand deposits were mined until 1949. No records were found indicating that the Teutonia or Isreal mines were mined for sand. The towns of Nortonville, Stewartville, West Hartley and Judsonville became ghost towns very shortly after the coal mines closed.

Description of Coal Mining Operations

The only mining town that existed on the site appears to have been Judsonville (Figure 8), located approximately ¼ mile to the north in Lone Tree Valley. The town of West Hartley was located approximately ½ mile to the east. Neither of these towns currently exist. A description of the site mines was found in Goodyear (CDMG, 1887).

Teutonia Mine. "Next east of the Empire Mine came the old Teutonia." It was located in the southern portion of the SW quarter of Section 7, T.1N, R.2E. The mouth of the mine is only about 150 feet north of the section line. "This mine was furnished with steam hoisting and pumping machinery. But at the time of my first visit to it in September 1869, it had already been idle and abandoned for some two years, and nothing has been done there since. According to the best information which I have been able to obtain, however, relating to this mine, the slope, which was furnished with a double track and with sheet-iron mine-cars, went down upon a bed of coal about four hundred feet, with a pitch of about 26 degrees. From the bottom of the slope a gangway was driven east something like one hundred feet. Just west of the slope the bed was broken by a large fault jumping up to west, beyond which the work was never carried. The bed was about thirty-six inches thick, the lower half of it being bright, clean, shelly coal, not very hard and the upper half being "bony." It will be noticed that this description of the bed itself is remarkably like that of the bed which was struck by the tunnel in the Empire Mine the latter part of December 1876, and it is indeed not at all unlikely that it may be in reality the same bed."

Israel Mine. "On the northeast quarter of Section 18, T.1N, R.2E, there is another old slope, known as the 'Israel Opening'. This slope is said to be some two hundred feet deep, with a pitch of about 25°. It is said, furthermore, that at its bottom there was three feet of clean and tolerably hard coal, and that some rooms were opened and several cargoes of coal once shipped from here. It is supposed that this slope is on a bed which underlies the one which the Teutonia Slope is sunk."

The fourth Report of the State Mineralogist (1884) concludes that "while a great deal of money has been expended in this region prospecting for coal, only in a few instances have deposits sufficiently heavy been developed to warrant their being worked. The trouble with these Mt. Diablo mines is twofold, the coal, in the first place is of an inferior quality, and then the cost of extraction is great, the beds being small and much disturbed by faults, and dislocation."

The twelfth Report of the State Mineralogist (1894) states that "some little work was done in Sections 16, 18 and 7. The coal found here was dirty and crushed by faults, and the prospectors soon became discouraged and quit. In the next township toward the W. T.1N, R.1E, we find the Empire and West Hartley mines, both in Section 12. These have furnished considerable coal, but for the present are shut down. In both the coal has been mined to a level about 400 feet below the surface." It can be re-noted that the site is located in Sections 7 and 18. West Hartley is located in Section 12.

Mine Design

The mines in the area were all underground, consisting of adits (nearly level tunnels), slopes (sloping tunnels) or vertical shafts. The tunnels intersected the coal veins that then were mined along level "gangways" following the strike of the coal beds. The coal was mined by hand labor and loaded onto tram cars and hauled to the surface. The gangways required timbering because they were located on or just under the unstable coal seams. Fires destroyed the timbering in several mines.

It is probable that the mines on site consist of slopes and gangways that have partially collapsed. The report by Goodyear (CDMG,1887) indicates that the Teutonia Mine on site is approximately 400 feet deep and the Israel Mine approximately 200 feet deep. The Teutonia mine was evidently abandoned after a fault was found to offset the coal bed to the west of the slope. The Israel mine was evidently not very productive due to the small coal seam encountered.

<u>Air Photograph Analysis</u>

Aerial photographs were observed as part of our study. The photographs were observed in order to check the site for evidence of mine spoil piles. The earliest photographs available for our study were dated October 9, 1952, and were at a scale of 1:24000 inches. The 1952 photos indicate two areas of disturbed ground on site at that time. One is located in the south midwestern portion of the site and is assumed to be the Teutonia Mine as shown on Figure 8. This area shows a small square foundation with disturbed ground below it. The northern side of the hill directly opposite the foundation showed signs of digging and might have been a shaft opening. A rectangular foundation was noted in the south central portion of the site, as shown on Figure 8. This foundation is close to the assumed location of the Israel mine. Also noted on the 1952 photos were a house and barns along with corrals in the very southwestern portion of the site.

Photographs taken from the air in 1957 were also observed. These photographs were dated May 24, 1957, and were at a scale of 1:20000 inches. Excavation was noted on these photographs on a more easterly knoll. A dirt road can be seen accessing the excavation from the west and circling it. This area contained only a small barn or structure in 1952. Based on the data gathered to date, we conclude that this easterly excavation was not coal mine related.

On photographs taken on August 18, 1988, the site contained an enlarged cattle ranch. More barns had been built and paddocks had been constructed along the southern portion of the site. A big cut for a new barn had been made south of the supposed Israel mine location on the 1952 photos, and a second barn had been constructed south of this. Fill had been placed in southern portions of the site and a stock pond constructed, also in the southern portion of the site. The scale of these photographs is 1:12000 inches.

Later photographs taken in 1992 and 1996 show the cattle ranch relatively unchanged with the exception of additional stock ponds. A fire destroyed the ranch buildings at some time in the last few years. The disturbed old mine areas become more obscure in the newer photographs. Vegetation covers them nearly completely in the 1996 photographs and the disturbed ground appears to have been smoothed. This is probably an indication of the mine openings being buried and closed. The EIR for the Sand Creek Specific Plan indicates that the U.S. Bureau of Mines closed the mine openings.

Site Reconnaissance

A reconnaissance of the site was made to observe existing conditions and determine whether artifacts from the mining operations still remain. The ranch buildings on site have been burned and currently are not in use, as previously mentioned. We did observe cattle on site, and were able to find the probable Teutonia mine as shown on Figure 8. The area of the probable mine consists of a square, crumbled cement foundation of approximately 15 feet by 15 feet. No entrance was observed at the mine site. The area to the north, where a possible shaft opening was observed on the 1952 photos, was overgrown, but a small circular depression was observed. This depression was approximately 3 feet in diameter. This is consistent with the widths of coal mine air shafts.

The Israel mine location was not found during our reconnaissance. We observed the area delineated as the Israel mine on the Sand Creek EIR, and found only fill piles of soil and concrete that appeared recent in origin. We also excavated a test pit in the area of the suspected mine entrance to observe for evidence of the mine entrance. Various artifacts of metal and debris were observed, but the mine entrance was not located.

Vegetation in the areas of the old mines does not appear to be adversely affected by acidic leachate or other contaminated water. This observation would suggest that these constituents are not leaching from the spoils or mines and adversely affecting nearby vegetation.

Conclusions

The Teutonia and Israel coal mine operations occurred on site in the middle 1860's, but were abandoned prior to 1869. The remaining portions of the mines on site most likely consist of slopes and tunnels that have partially collapsed. Mining reports reviewed indicate that the Teutonia Mine is approximately 400 feet deep and the Israel Mine approximately 200 feet deep. The mine slopes extend towards the north along the dip of the coal seams and gangways extend laterally along the coal seams.

Although evidence of the mine openings was observed on old aerial photographs and to a lesser extent during our site visit, they appear at this time to be sealed and overgrown. Some extent of underground tunneling undoubtedly exists on site. The tunnels are probably partially collapsed. We have prepared Figure 8 showing what we consider to be the most likely remaining locations of the mines and their underground tunnels on site.

Additional figures, photographs, and information regarding the onsite mines were provided by Norfleet Consultants. Their entire report can be viewed in Appendix C.

Due to the uncertain extent of the underground mine tunnels on site, if structures are desired above the areas identified in Figure 8, we recommend further exploration to determine the nature of these voids. The underground tunnels can be explored through drilling and or geophysical tests. The areas of the slope tunnels can be subexcavated and reconstructed as necessary to alleviate the hazard of collapse.

CONCLUSION

The main geotechnical concerns for the proposed site development include: (1) existing landslides and slope stability, (2) the presence of moderately to highly expansive soils considered susceptible to significant volume changes (swell and compression) when subjected to varying moisture contents; (3) the presence of compressible colluvial deposits along swales considered susceptible to excessive total and differential settlements with the proposed surcharge loads, (4) the presence of non-engineered and undocumented fill, and (5) the underground mine workings considered capable of causing surface settlement due to collapsing underground mine excavations. These concerns and other geotechnical issues are discussed in the following sections of this report.

Slope Stability

It is our opinion that the identified landslide areas have a relatively high likelihood of experiencing future instability unless suitable mitigation measures are carried out. Appropriate measures to mitigate potential landslide hazards are dependent on factors such as the size and type of landslide, the relationship of the landslide to the proposed development, and to environmental factors such as visibility. In general, it is recommended that the existing landslides located within the limits of grading be removed in their entirety.

Clayey soils on steeper natural slopes are subject to soil creep. Soil creep is the slow downslope movement of soil that occurs with the annual cycle of wetting and drying under the influence of gravity. The potential for adverse impacts from soil creep can be minimized by benching through surficial soils during fill placement as recommended in this report.

Although slope instability can be a significant hazard, it can also be mitigated by proper grading measures. Recommendations for maximum slope gradients, slope rebuilding, and construction of debris benches between rear property lines and open-space slopes are provided in the recommendations section of this report.

Expansive Soils

The expansive nature of the native soil and claystone bedrock is of significant geotechnical concern in this region. The clayey soil and claystone materials at the subject area are considered moderately to highly expansive. Conversely, the sandstone and siltstone bedrock at the site is considered low to non-expansive.

Expansive soils are susceptible to shrink and swell resulting from variations in moisture content. Expansive soils and bedrock may cause heaving and cracking of slabs-on-grade, pavements, and foundations. Building damage due to volume changes associated with expansive soils may be reduced by the following measures: (1) performing proper moisture conditioning and compaction of fill materials within specified ranges to reduce their swell potential; and (2) supporting houses upon post-tensioned mats designed to resist the deflections associated with expansion/compression-related movements.

Compressible Colluvial Deposits

Excessive total and differential settlement at the site may also result from (1) consolidation of the compressible colluvial deposits in swale areas where fills will be placed, and (2) settlement of foundation elements supported directly over these compressible colluvial deposits. To reduce settlement resulting from these deposits, it is recommended that these deposits be overexcavated to expose stiff in-place materials and grades restored with properly compacted engineered fill material as discussed in the “Grading” section of this report. It is anticipated that these deposits may be reused as fill material.

Existing Fill

As described previously, undocumented fill, as much as 15 feet thick, was encountered at various locations across the site. Typically, this fill is relatively dry, loose in consistency and in many areas contains miscellaneous debris. Non-engineered fills can be highly variable and potentially compressible. Existing undocumented and/or non-engineered fill on the site, at the locations shown on Figure 3, should be subexcavated to firm competent material and recompacted as engineered fill, provided the soil meets the requirements for fill material presented in the recommendations section of this report. The subexcavation depth in these areas should be verified during grading.

Bedrock Rippability and Suitability

Some well-cemented, thickly-bedded sandstone layers are expected to be encountered during grading. In general, we anticipate that conventional heavy-duty grading equipment should be able to rip these bedrock units to the depths of the planned cuts, although some well-cemented beds or lenses may be encountered that will be very difficult to rip. It is expected that some oversized materials will be generated from well-cemented sandstone beds and lenses. Most of the bedrock is considered trenchable; although, as previously noted, localized well-cemented beds or lenses may be very difficult or require special excavation techniques. During mass grading, zones of hard rock exposed near finished grade should be identified; overexcavation in these areas may be appropriate to facilitate installation of utilities. Also, in these hard rock areas it may be appropriate to overexcavate cut lots and transition lots to facilitate foundation and/or pool installation.

If rocks greater than 6 inches in diameter are generated or encountered during grading, these should be placed in accordance with recommendations provided in the "Selection of Materials" section.

Coal Mines

As previously discussed two former coal mines exist in the southern portion of the property. Based on the ambiguity of their locations and the relatively unknown extent of underground workings, structures should not be constructed within the zones identified in Figure 8. Although it is unlikely that the subsurface voids created by the removal of coal will cause significant or any surface subsidence a more detailed study is recommend if project development is to occur in these areas.

Shallow Groundwater

Shallow groundwater was encountered in borings 1-B5 and 1-B35 through 1-B40 in the relatively flat area in the southern portion of the site. Groundwater was encountered at depths between 1 ½ and 10 feet below the existing ground surface. It is believed that the shallow groundwater in this area is due to stormwater and irrigation runoff from the surrounding hills. Shallow groundwater conditions were also encountered in borings 1-B17 through 1-B20 and 1-B34 in the east-west trending valley in the southern central portion of the property. At these locations, groundwater was encountered at depths between 6 and 12 ½ feet below the existing ground surface. Possible sources for the shallow groundwater in this area are an existing spring identified in Figure 4 and stormwater runoff from the surrounding hills.

The relatively shallow groundwater level beneath the site will likely affect the proposed development in these areas. Groundwater will likely be encountered during installation of underground utility lines, construction of detention basins, and could possibly be encountered during roadway subexcavation. The relatively shallow groundwater at the site may also influence roadway performance as it rises to shallow depths beneath the roadway. It may be necessary for roadway subgrade to be chemically treated with a lime-flyash mixture to improve performance of the roadway under these conditions.

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, ground lurching, soil liquefaction, lateral spreading and seismically-induced landsliding. These hazards are discussed in the following sections. Based on topographic and lithologic data, the risk from regional subsidence or uplift, or tsunamis or seiches is considered low to unlikely at the site.

Ground Rupture. The property is not within a State of California Earthquake Fault Hazard Zone and no indications of active faulting were found in our exploration of the site. Since there are no known active faults crossing the property, and the site is not located within an Alquist-Priolo Earthquake Fault Zone, it is our opinion that primary fault ground rupture is unlikely at the property.

Ground Shaking. An earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the site. The degree of shaking is dependent on the magnitude of the event, the distance to its epicenter, and local geologic conditions. To mitigate the ground shaking effects, all structures should be designed using sound engineering judgment and the latest Uniform Building Code (UBC) requirements as a minimum. Based on the subsurface soil conditions encountered and local seismic sources*, the site may be characterized for design based on Chapter 16 of the 1997 UBC using the following information:

Categorization/Coefficient	Design Value
Soil Profile Type (Table 16-J)	S_C
Seismic Zone (Figure 16A-2)	4
Seismic Zone Factor (Table 16-I)	0.4
Seismic Source Type (Table 16-U)	B
Near Source Factor N_a (Table 16-S)	1.1

Categorization/Coefficient	Design Value
Near Source Factor N_v (Table 16-T)	1.0
Seismic Coefficient C_a (Table 16-Q)	0.40
Seismic Coefficient C_v (Table 16-R)	0.60

*Greenville fault located 8 km from the site

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 equivalent 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 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).

Seismically-Induced Landslides. Seismically induced landslides are triggered by earthquake ground shaking. The risk of this hazard is greatest in the late winter when ground-water levels are highest and hillside colluvium is saturated. As with all slopes in the region, this risk is also present at the site to varying degrees depending on the slope conditions and time of year. The hazard of seismically-induced landslides to the proposed structures can be best mitigated by properly engineered stabilization of landslides or creation of sufficient buffers between the colluvial deposits and development areas.

Liquefaction. Liquefaction is a phenomenon in which saturated cohesionless soils are subject to a temporary but essentially total loss of shear strength because of pore pressure build up under the cyclic shear stresses associated with earthquakes. Based on the densities of granular materials and the groundwater levels encountered in our borings, the risk of liquefaction is considered low at this site.

Densification Due to Earthquake Shaking. Densification of loose granular soils above and below the groundwater level can cause settlement due to earthquake-induced vibrations. Since there are no loose granular deposits at the site, the potential for densification can be considered low.

Lateral Spreading. Lateral spreading is a failure within weaker soil materials, typically due to liquefaction, which causes the soil mass to move toward an open channel, or down a gentle slope. As described above, the site soils have a low susceptibility to liquefaction; therefore, the potential for liquefaction-induced lateral spreading is considered low.

In the hillside portion of the site, keying and benching through surficial soils as recommended in this report should reduce the potential for lateral movement of engineered slopes. In addition, Sand Creek is located along the northern side of the proposed project with steep banks ranging up to about 30 feet high. To reduce the potential for adverse impacts from lateral spreading along the creek, we recommend that all improvements be set back at least 90 feet from the top of the creek bank.

RECOMMENDATIONS

Grading

All grading and site development plans should be coordinated with the Engineering Geologist and/or the Geotechnical Engineer to modify the plans to mitigate any known soil and geologic hazards. Additional slope stability analyses and detailed geotechnical engineering recommendations for keyways and subdrains should be provided during review of the final 40-scale (1" = 40') grading plans for the project.

ENGEO should be notified at least 48 hours prior to grading in order to coordinate our schedule with the grading contractor. Grading operations should meet the requirements of the "Guide Contract Specifications" included in Appendix D and must be observed and tested by ENGEO's field representatives.

After the grading operations commence, geologic observations of cut slopes and keyways should be made at frequent intervals by the Engineering Geologist. This is advised so that modified geologic recommendations can be incorporated into updated grading plans as grading proceeds. The Engineering Geologist should be notified at least 48 hours prior to the start of cutting of significant slopes.

Existing Nonengineered Fill

Several areas of nonengineered fill material exist on the site in the approximate locations shown on Figure 3. The fill material consists primarily of onsite native stockpile material. All nonengineered fill should be subexcavated to expose native material, and placed back as engineered fill. All organically contaminated fill, such as manure piles, should be subexcavated to expose native material, and placed within landscape areas or off-hauled.

Demolition and Stripping. All above ground and below ground structures, nonengineered fill, existing utilities to be abandoned, vegetation, and soft or compressible soils should be removed as necessary for project requirements. The depth of removal of these materials should be determined by the Geotechnical Engineer's field representative at the time of grading. Evaluation of unsuitable deposits should be performed during grading by sampling and laboratory analyses.

In order to properly identify all areas of nonengineered fill, an ENGEO geologist should be onsite during subgrade preparation. Due to the previous site activities, buried structures and nonengineered fill are expected in the areas near the Judsonville former mining town and around the cattle stockyard. These areas should be explored during grading by subexcavting of up to 5 feet in order identify areas of nonengineered fill.

Areas to receive fill or structures, and those areas that serve as borrow for fill, should be stripped of existing vegetation. Topsoil is estimated to be about 2 to 3 inches in thickness depending on location. Tree roots should be removed to a depth of at least 3 feet below finished grade in cut lots and 3 feet below original grade in fill lots. Actual depths of removal of stripping and tree roots will be determined by the Geotechnical Engineer's field representative during grading.

Within the development areas, excavations resulting from demolition and stripping which extend below final grades should be cleaned to firm undisturbed soil as determined by the Geotechnical Engineer's representative. Following clearing and grubbing, all depressions in areas to be filled should be scarified, moisture-conditioned, and backfilled with compacted engineered fill. The requirements for backfill materials and placement procedures are the same as those for engineered fill as described in the "Monitoring and Testing" section.

Slope Stabilization. The recommended mitigation measures for slopes include stabilizing the landslide or colluvial materials by removing these deposits down to bedrock, constructing properly drained keyways, and recompacting the soil as engineered fill. In addition, observed seepage areas or suspected spring areas should be controlled in development areas through the use of subdrains. Where complete removal and replacement of the landslides are planned, the excavation of the landslides should be observed by the project Geotechnical Engineer or Engineering Geologist to verify removal of all debris including the slide plane. Keyways, subexcavated benches, and locations of subdrainage should be modified in the field based on the actual landslide and/or colluvial deposit depth and geometry.

Keyways. All fill slopes should be constructed with keyways along the toes of slopes. Typical keyway construction along fill slopes and subdrain installation are shown on Figures 9 and 11. Recommended keyway sizes and locations will be determined by the Geotechnical Engineer and will be approximately shown on the final grading plans. Subsurface benches should be constructed into slopes above the keyways as filling progresses. Unless otherwise recommended by the Geotechnical Engineer, such benches should be excavated horizontally into firm competent soil or bedrock. The actual size of the keyways and benches should be determined by the Geotechnical Engineer in the field during grading.

Graded Slopes. The following slope gradient guidelines may generally be applied for mass grading design of permanent slopes:

Slope Gradient	Fill	Cut
(horizontal:vertical)	(ft)	(ft)
2:1	<10	<8
2.5:1	10-30	8-15
3:1	>30	>15

More gentle slopes (4:1) may be recommended in the field during grading, based on observed field conditions. As an alternative to flatter slopes, cuts might be overexcavated and rebuilt as engineered fill slopes. Where steeper slopes than those indicated above are desired, supplemental slope stabilization techniques (e.g. geogrid reinforcing) may be required.

Slopes 3:1 (horizontal:vertical) or flatter do not require benches; however, it is recommended that where these slopes, as well as natural slopes steeper than 5:1, are adjacent to improvements a debris bench should be constructed as shown in Figure 10. The geotechnical engineer should delineate on the final 40-scale grading plans the location of debris benches. Standard fill slope construction including keyway, benching, and subdrainage is shown in Figures 9 and 11.

We recommend placing the topsoil strippings on graded slopes as an alternative to constructing intermediate benches. Site topsoil strippings should be placed over all open space cut and fill slopes immediately following grading and prior to the installation of erosion control measures. In our opinion, placing the site strippings on graded slopes reduces rainfall infiltration to natural levels, more actively promotes revegetation, enhances local slope stability, and provides a more natural slope appearance.

All cut slopes should be viewed by the Engineering Geologist during slope grading for adverse bedding, seepage, or bedrock conditions which may affect slope stability. In the event that adverse geologic conditions are detected during grading of the cut slopes, overexcavation and reconstruction of these slopes may be necessary. Track rolling to compact faces of slopes is not sufficient. Slopes should be overbuilt and cut back to design grades.

Selection of Materials. With the exception of the organically contaminated near-surface materials, the site soils and rocks are suitable for use as engineered fill. Rocks greater than 6 inches in size (if encountered) should be placed at depths greater than 10 feet from finished grade. Rocks greater than 18 inches in size (if any) should be broken down such that their maximum dimension is less than 12 to 18 inches, or otherwise removed from the site, or placed in a designated rock disposal fill area.

Import Materials. The Geotechnical Engineer should be informed if any importation of soil is contemplated. Import materials, if any are needed, must meet the requirements contained in Section 2.02B, Part I of the Guide Contract Specifications in Appendix D. A sample of the proposed import material should be submitted to the Geotechnical Engineer for evaluation by laboratory testing prior to site delivery.

Placement of Fill. Areas to receive fill should be scarified to a depth of 12 inches, moisture-conditioned, and recompacted to provide adequate bonding with the initial lift of fill. All fills should be placed in thin lifts. The lift thickness should not exceed 12 inches or the depth of penetration of the compaction equipment used, whichever is less. Track rolling to compact faces of slopes is usually not sufficient; typically, slopes should be overfilled and cut back to design grades.

Cut-Fill Transition Lots and Cut Lots. Some residential lots in this project will likely be entirely in cut or traversed by a cut-fill transition. We anticipate that significant variations in material properties may occur in areas of cut or cut-and-fill daylighting if not mitigated during site grading. Atterberg Limits test data indicate that there is a potential for a significant differential in swell characteristics across cut areas and cut/fill transitions. Such situations can be detrimental to building performance. In general, cut portions of transition lots should be overexcavated at least 2 feet below rough pad grade. The excavated surface should then be scarified to a minimum depth of 12 inches, moisture conditioned and recompacted as shown on Figure 12.

In cut areas, where alternating beds of claystone and sandstone are exposed, the upper 3 feet of subgrade material should be treated to provide a uniform soil layer below the mat. In these cases the exposed rock should be overexcavated at least 2 feet below rough pad grade. The excavated surface should then be scarified to a minimum depth of 12 inches, moisture conditioned and recompacted. The excavated material can be reused as engineered fill. The engineering geologist should designate in the field the areas to be overexcavated. As a minimum cut pads should be scarified to a minimum depth of 12 inches, moisture conditioned and recompacted.

Differential Fill Thickness. Some of the single-family residential lots planned on fills above existing slopes could have a differential fill thickness of more than about 20 feet if not graded properly. Differential building movements, although not seriously damaging, may become apparent for large differential fill thicknesses. Therefore, we recommend that the differential fill thickness under individual buildings be less than 10 feet. Local subexcavation of material and replacement by engineered fill will be necessary to achieve this requirement.

Monitoring and Testing. The Geotechnical Engineer's representative should be present during all phases of grading operations to observe demolition, site preparation, grading operations, and subdrain placement. The following compaction recommendations should be used for the placement and compaction of fills:

SUMMARY OF COMPACTION AND
MOISTURE CONDITIONING RECOMMENDATIONS
TEST PROCEDURE; ASTM D-1557 – Latest Revision

Moderate to Highly expansive soil, PI above 12

	Minimum Relative Compaction Percent	Minimum Moisture Content Percent Above Optimum
0 to 30 feet Below Finished Grade	90	3
Over 30 ft Below Finished Grade	95	2
Keyways	95	2
Upper 12 inches of streets subgrade	95	2

Non to Low Expansive Soil, PI less than 12

	Minimum Relative Compaction Percent	Minimum Moisture Content Percent Above Optimum
0-10 feet Below finished Grade	90	2
Over 10 ft Below finished Grade	95	2
Keyways	95	2
Upper 12 inches of streets subgrade	95	2

Relative compaction refers to in-place dry density of the fill material expressed as a percentage of the maximum dry density as determined by ASTM D-1557- Latest Revision. Optimum moisture is the moisture content corresponding to the maximum dry density.

Construction of Subsurface Drainage Facilities. Subsurface drainage systems should be installed in all keyways and in swales or natural drainage ways which are to be filled. The approximate locations of the recommended subdrains should be determined following review of the final 40-scale grading plans.

Drainage courses which are to be filled should be provided with adequate subsurface drainage prior to placement of any fill. Swales should be cleaned of soft or compressible material to a firm soil or rock base. A subdrain should then be installed through the center of the subexcavation (Figure 11). Desiccated, cracked surface clays and slumping soils located along the swale areas should be removed, and the slopes should be benched prior to the placement of fill. Actual limits of subexcavation should be determined in the field at the time of grading by the Geotechnical Engineer.

Additional subdrains should be added where seepage or wet conditions are encountered during excavation. Subdrain systems should consist of a minimum 6-inch-diameter perforated pipe encased in an 18-inch minimum thickness of Caltrans Class 2 Permeable Material or coarse rock wrapped in geotextile filter fabric. Typical subdrain details are shown in Figure 11. The subdrain pipe and drainage blanket should meet the requirements contained in Section 2.05, Part I of the Guide Contract Specifications presented in Appendix D.

Discharge from the subdrains will generally be low but in some instances may be continuous. Subdrains should outlet into the storm drain system or other approved outlets; their locations should be surveyed by the Civil Engineer and documented on an as-built subdrain plan for future maintenance.

Not all sources of seepage were uncovered during our field work because of the intermittent nature of some of these conditions and their dependence on long-term climatic conditions. Furthermore, new sources of seepage may be created by a combination of changed topography, irrigation patterns and potential utility leakage. Since uncontrolled water flows are one of the major causes of detrimental soil movements, it is of utmost importance that a Geotechnical Engineer be advised of any seepage conditions so that remedial action may be initiated, if necessary. All subdrain connections and tie-ins to storm drain inlets should be observed and approved by the Geotechnical Engineer.

Preliminary Foundation Design

The primary considerations for foundation design are the long-term heave and/or compression in deeper fill areas, and potential adverse affects of expansion from expansive soils and bedrock resulting differential movement. To resist potential differential movement, it is recommended that foundations on level pads consist of post-tensioned slabs. During grading, additional laboratory testing should be performed on various fill materials to confirm and modify (as needed) the foundation design criteria presented herein. The following preliminary foundation designs for level pads are recommended. Foundation criteria for sloping lots should be developed on a case-by-case basis.

Post-Tensioned Slab Foundations. Post-tensioned slabs should be designed according to the method recommended in the Design and Construction of Post-Tensioned Slabs-on-Ground (PTI-Latest edition). As a guideline, the following soil design criteria for the post-tensioned slab foundations may be used:

Center Lift Condition:

Edge Moisture Variation Distance, e_m = 5.0 feet

Differential Soil Movement, y_m = 2.7 inches

Edge Lift Condition:

Edge Moisture Variation Distance, e_m = 4.0 feet
Differential Soil Movement, y_m = 1.2 inches

These values should be confirmed after grading based upon soil conditions at subgrade level on the building pads. The post-tensioned slabs should be designed to impose a maximum allowable bearing pressure of 1,000 pounds per square foot (psf) for dead-plus-live loads. This value may be increased by one-third when considering total loads including wind or seismic loads. The resistance to lateral loads should be computed using a base friction factor of 0.30 acting between the bottom of the mat and subgrade. The final foundation plans should be reviewed by the Geotechnical Engineer when they become available to verify conformance with these recommendations.

Subgrade Treatment for Structural Mat Foundations. The subgrade material under post-tensioned slabs and structural mats should be uniform. The top 12 inches of pad subgrade should be moisture conditioned to a moisture content of at least 5 percent above optimum. The subgrade should be thoroughly soaked and should not be allowed to dry prior to concrete placement.

When buildings are constructed with concrete mat foundations, water vapor from beneath the concrete mat will migrate through the slab 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 slab would be undesirable, we recommend that the concrete be underlain by a moisture retarder that meets ASTM E 1745 – 97 Class A requirements for water vapor permeance, tensile strength, and puncture resistance. All joints and penetrations of the vapor retarder medium should be sealed. The Structural Engineer should be consulted on the advisability of using a 2-inch-thick sand cushion under slabs for concrete curing purposes.

Exterior Flatwork. This section provides guidelines for secondary slabs such as exterior patio slabs, walkways, driveways and steps. Small entry porch slabs should preferably be an integral portion of the post-tensioned mat foundation. Secondary slabs-on-grade should be constructed structurally independent of the foundation system. This allows slab movement to occur with a minimum of foundation distress. Where slab-on-grade construction is anticipated, care must be exercised in attaining a near-saturation condition of the subgrade soil before concrete placement.

Secondary slabs-on-grade should be designed specifically for their intended use and loading requirements. Some of the site soils have a moderate expansion potential; therefore, cracking of conventional slabs should be expected in the future. As a minimum recommendation, slabs-on-grade should be reinforced and provided with frequent control joints to reduce and control the cracking. The Structural Engineer should design the reinforcement; in our experience, welded wire mesh is not sufficient to control slab cracking.

Secondary slabs-on-grade should have a minimum thickness of 5 inches. A 4-inch-thick layer of clean, crushed rock or gravel should be placed under all concrete slabs.

Retaining Walls

Retaining walls are anticipated to consist of reinforced concrete and masonry walls. Alternatively, retaining walls may consist of Mechanically Stabilized Earth (MSE) structures. Retaining walls should derive support from competent bedrock materials or engineered fill material. Retaining wall foundations should consist of either: (1) deepened footings or (2) drilled piers extending at least 8 feet into competent bedrock or engineered fill materials. Retaining walls should be designed to withstand the following equivalent fluid pressures, which do not include increases due to seismic, surcharge, or hydrostatic forces.

Backfill Slope Condition (horizontal:vertical)	Active Pressure (pounds per cubic foot)
Level	50
4:1	55
3:1	60
2:1	70

If shallow continuous footings are used, they should be a minimum of 18 inches deep and designed for an allowable bearing pressure of 2,500 pounds per square foot (psf); this value may be increased by one-third for wind or seismic loads. A passive resistance corresponding to 300 pounds per cubic foot (pcf) may be used for design if the area in front of the wall is level for at least 10 feet. A base friction factor of 0.30 may be used in the design.

If piers are used to support retaining walls, these piers should be embedded not less than 8 feet into competent bedrock or engineered fill materials. The drilled piers should be at least 12 inches in diameter and designed for an allowable skin friction of 500 psf. Skin friction should be disregarded in the upper 12 inches of embedment. Resistance to lateral loads can be obtained from passive resistance against the drilled pier face using 300 pcf of equivalent fluid density and a shape factor of 2.0. Passive pressure should be neglected in the upper 1 foot of embedment below the toe of the wall. For piers located along slopes, the uppermost 4 feet of embedment should be neglected for passive resistance. Drilled piers should be free of loose soils and debris prior to concrete placement. If water collects in the pier shaft, it should be pumped out prior to the placement of concrete. Drilling into bedrock may be difficult and require drill rigs capable of drilling moderately-strong sandstone bedrock materials. The use of rock barrels/buckets may be needed to maintain plumbness and integrity of the pier holes.

All retaining walls should be provided with drainage facilities to prevent the build-up of hydrostatic pressures behind them. Wall drainage may be provided using 4-inch-diameter perforated pipes (SDR 35 or approved equivalent) embedded in Class 2 Permeable Material, or free-draining gravel surrounded by synthetic filter fabric. The thickness of the drain blanket should be at least 12 inches.

The drain blanket should extend to about one foot below the finished grades. As an alternative, prefabricated synthetic wall drain panels can be used. The upper one foot of wall backfill should consist of on-site soils. Drainage should be collected by perforated pipes and directed to an outlet approved by the Civil Engineer.

All backfill should be placed in accordance with recommendations provided above for engineered fill. Light equipment should be used during backfill compaction to minimize possible overstressing of the walls.

The following soil criteria should be used in the design of MSE walls:

	Cohesion (c') (pcf)	Friction Angle (ϕ') (degrees)	Unit Weight (γ) (pcf)
Reinforced Fill	0	28	125
Retained Soil	0	28	125
Foundation Soil	0	28	125

Sound Walls

Sound walls may be supported on spread footings or drilled piers in accordance with the foundation recommendations presented in the above Retaining Walls section of this report.

Preliminary Pavement Design

Two R-value samples were collected for laboratory testing during our field explorations, and R-values of less than 5 and 21 were determined. An R-value of 5 has been selected for preliminary design purposes. The following preliminary pavement sections have been determined for Traffic Indices of 5.0 to 11.0 and an assumed minimum R-value of 5. According to methods contained in

Topic 608 of Highway Design Manual by CALTRANS, the following minimum asphaltic concrete pavement sections are recommended:

PRELIMINARY PAVEMENT SECTIONS

Traffic Index	AC (inches)	AB (inches)
4.5	2.5	9.5
5	3.0	10.0
5.5	3.5	11.0
6	3.5	13.0
6.5	4.0	14.0
7	4.0	16.0
8	4.5	19.0
9	5.5	21.0
10	6.5	23.0
11	7.0	25.0

Notes: AC is asphaltic concrete
AB is aggregate base Class 2 Material with minimum R = 78

The Traffic Index should be determined by the Civil Engineer or appropriate public agency. These sections are for estimating purposes only. Actual sections to be used should be based on R-value tests performed on samples of actual subgrade materials recovered at the time of grading.

Pavement materials and construction should comply with the specifications and requirements of the Standard Specifications by the State of California Division of Highways, City of Antioch requirements, and the following minimum requirements:

- All pavement subgrades should be scarified to a minimum depth of 12 inches below finished subgrade elevation, moisture conditioned to 2 percentage points above optimum, and compacted to at least 95 percent relative compaction and in accordance with City of Antioch requirements.

- Subgrade soils should be in a stable, non-pumping condition at the time aggregate baserock materials are placed and compacted.

- Adequate provisions must be made such that the subgrade soils and aggregate baserock materials are not allowed to become saturated.
- Class 2 Aggregate Subbase Materials should meet current Caltrans specifications for Class 2 Aggregate Base, and should be compacted to at least 95 percent of maximum dry density at a minimum moisture content of optimum.
- Asphalt paving materials should meet current Caltrans specifications for asphalt concrete.
- All concrete curbs separating pavement and irrigated landscaped areas should extend into the subgrade and below the bottom of adjacent aggregate baserock materials.

Drainage Requirements

Ponding of storm water, other than within engineered detention basins, should not be permitted at the site, particularly during work stoppage for rainy weather. Before the grading is halted by rain, positive slopes should be provided to carry surface runoff to storm drainage structures in a controlled manner to prevent erosion damage.

Improper drainage may result in fill saturation with consequent loss of compaction and fill strength. It is very important that all lots be positively graded at all times to provide for rapid removal of surface water. Ponding of water under floors or seepage toward foundation systems at any time during or after construction must be prevented.

As a minimum requirement, finished grades should slope gradient away from exterior walls (perpendicular to the wall alignment) to allow surface water to drain positively away from the structures. Care should be exercised to ensure that landscape mounds will not interfere with these requirements. Sufficient area drains should be provided around the buildings to remove excess surface water.

All lots should be drained individually. Stormwater from roof downspouts should be conveyed in closed drain systems to a drainage facility. If planting adjacent to a building is desired, the use of drought-tolerant plants that require very little moisture is recommended.

Sprinkler systems should not be installed where they may cause ponding or saturation of foundation soils. Such ponding or saturation could result in undesirable soil swell, loss of compaction, and consequent foundation and slab movements. Irrigation of landscape areas should be limited strictly to that necessary for plant growth.

Uphill Slope Condition

Where a building pad is adjacent to uphill slopes, all permanent structures should be set back from the toe the equivalent distance of one-half the vertical graded slope height, with the maximum required setback of 15 feet from the toe of slope.

Downhill Slope Condition

All permanent structures should be set back from the top of a downhill slope the equivalent distance of one-third the vertical graded slope height, with the maximum setback distance of 40 feet from the top of slope. If a shorter setback distance is necessary, a buried retaining wall may be suitable as determined on a case-by-case basis.

Erosion Control

Due to the nature of the site soil and bedrock, graded slopes may experience severe erosion when grading is halted by heavy rain. Therefore, before work is stopped, a positive gradient away from the tops of slopes should be provided to carry the surface runoff away from the slopes to areas where erosion can be controlled. It is vital that no completed slope be left standing through a winter season without erosion control measures having been provided.

Because the existing bedrock is relatively nutrient-poor, it may be difficult for vegetation to become properly established, resulting in a potential for slope erosion. Revegetation of graded slopes can be aided by retaining the organic-rich strippings and spreading these materials in a thin layer (less than about 6 inches) trackwalked on the slopes prior to the winter rains and following rough grading. All landscaped slopes should be maintained in a vegetated state after project completion. The use of drought-tolerant vegetation requiring drip irrigation not more frequently than once a month during summer is recommended. No pressurized irrigation lines should be placed on or above graded slopes. The project landscape architect should also be consulted regarding revegetation of slopes.

Utilities

It is recommended that all utility trench backfill be done under the observation of a Geotechnical Engineer and in accordance with the City of Antioch requirements. Pipe zone backfill (i.e. material beneath and immediately surrounding the pipe) may consist of a well-graded import or native material less than ¾ inch in maximum dimension. Trench zone backfill (i.e. material placed between the pipe zone backfill and the ground surface) may consist of native soil compacted in accordance with recommendations for engineered fill.

Where import material is used for pipe zone backfill, we recommend it consist of fine- to medium-grained sand or a well-graded mixture of sand and gravel and that this material not be used within 2 feet of finish grades. In general, uniformly-graded gravel should not be used for pipe or trench zone backfill due to the potential for migration of: (1) soil into the relatively large void spaces present in this type of material, and (2) water along trenches backfilled with this type of material. All utility trenches entering buildings and paved areas must be provided with an impervious seal consisting of native materials or concrete where the trenches pass under building perimeters or curb lines. The impervious plug should extend at least 3 feet to either side of the crossing. This is to prevent surface water percolation into the sands under foundations and pavements where such water would remain trapped in a perched condition, allowing clays to develop their full expansion potential.

Utility trenches should not be located upslope of any foundation area unless the placement, depth and backfill material to be used are reviewed by the Geotechnical Engineer. Care should be exercised where utility trenches are located beside foundation areas. Utility trenches constructed parallel to foundations should be located entirely above a plane extending down from the lower edge of the footing at an angle of 45 degrees. Utility companies and Landscape Architects should be made aware of this information.

Utility trenches in areas to be paved should be constructed in accordance with City of Antioch requirements. Compaction of trench backfill by jetting shall not be allowed at this site. If there appears to be a conflict between City or other agency requirements and the recommendations contained in this report, this should be brought to the owner's attention for resolution prior to submitting bids.

Additional Geotechnical Exploration

Additional geotechnical explorations will be required for the proposed bridges, recreation center, and other major infrastructure improvements not identified at this time. The purpose of the explorations will be to provide site-specific recommendations for these proposed facilities.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report is issued with the understanding that it is the responsibility of the owner to transmit the information and recommendations of this report to developers, owners, buyers, architects, engineers, and designers for the project so that the necessary steps can be taken by the contractors and subcontractors to carry out such recommendations in the field. The conclusions and recommendations contained in this report are solely professional opinions.

The professional staff of ENGEO Incorporated strives to perform its services in a proper and professional manner with reasonable care and competence but is not infallible. There are risks of earth movement and property damages inherent in land development. We are unable to eliminate all risks or provide insurance; therefore, we are unable to guarantee or warrant the results of our work.

This report is based upon field and other conditions discovered at the time of preparation of ENGEO's work. This document must not be subject to unauthorized reuse, that is, reuse 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 work. 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.

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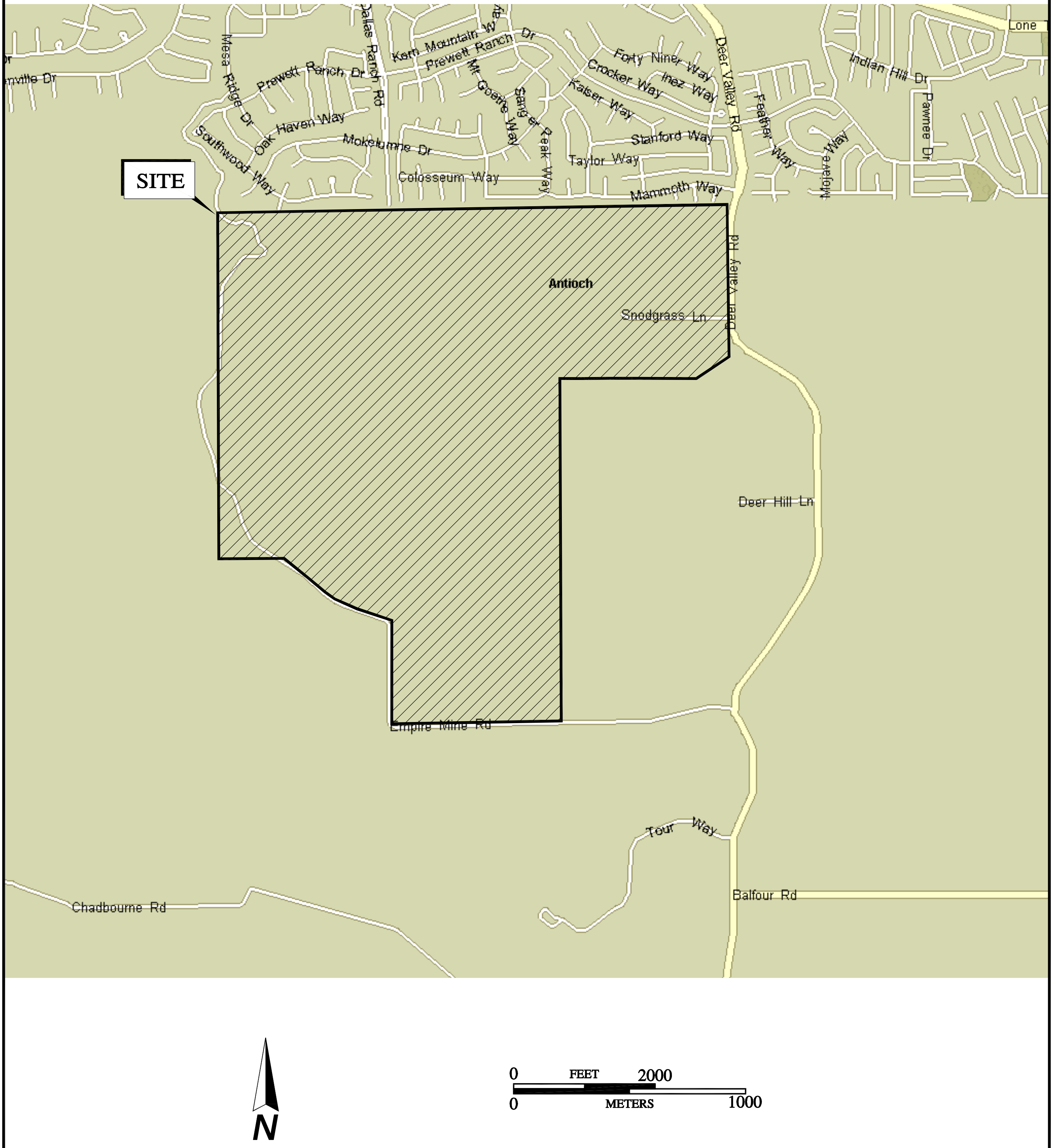
LIST OF FIGURES



BASE MAP SOURCE: MS STREETS AND TRIPS

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VICINITY MAP

SAND CREEK RANCH

ANTIOCH, CALIFORNIA

PROJECT NO.:	4371.4.050.01
DATE:	MAY 2006
DRAWN BY: PC	CHECKED BY: JT

FIGURE NO.
1

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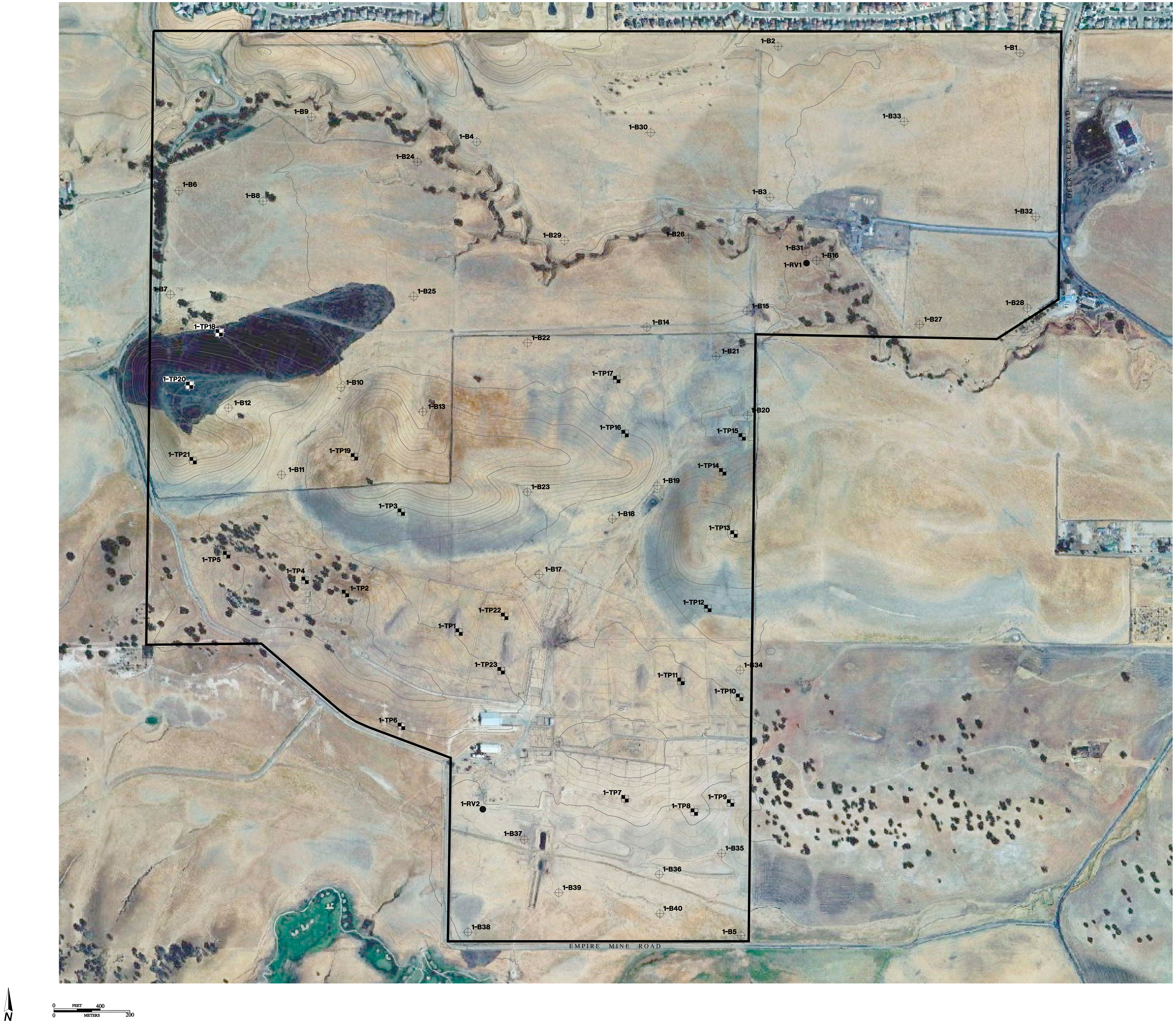

EXPLANATION

1-RV2 ● APPROXIMATE LOCATION OF R-VALUE

1-B40 ⊕ APPROXIMATE LOCATION OF BORING

1-TP23 ▨ APPROXIMATE LOCATION OF TEST PIT

BASE MAP SOURCE: CBG, GOOGLE EARTH PRO

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SITE PLAN
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01	FIGURE NO. 2
DATE: MAY 2006	
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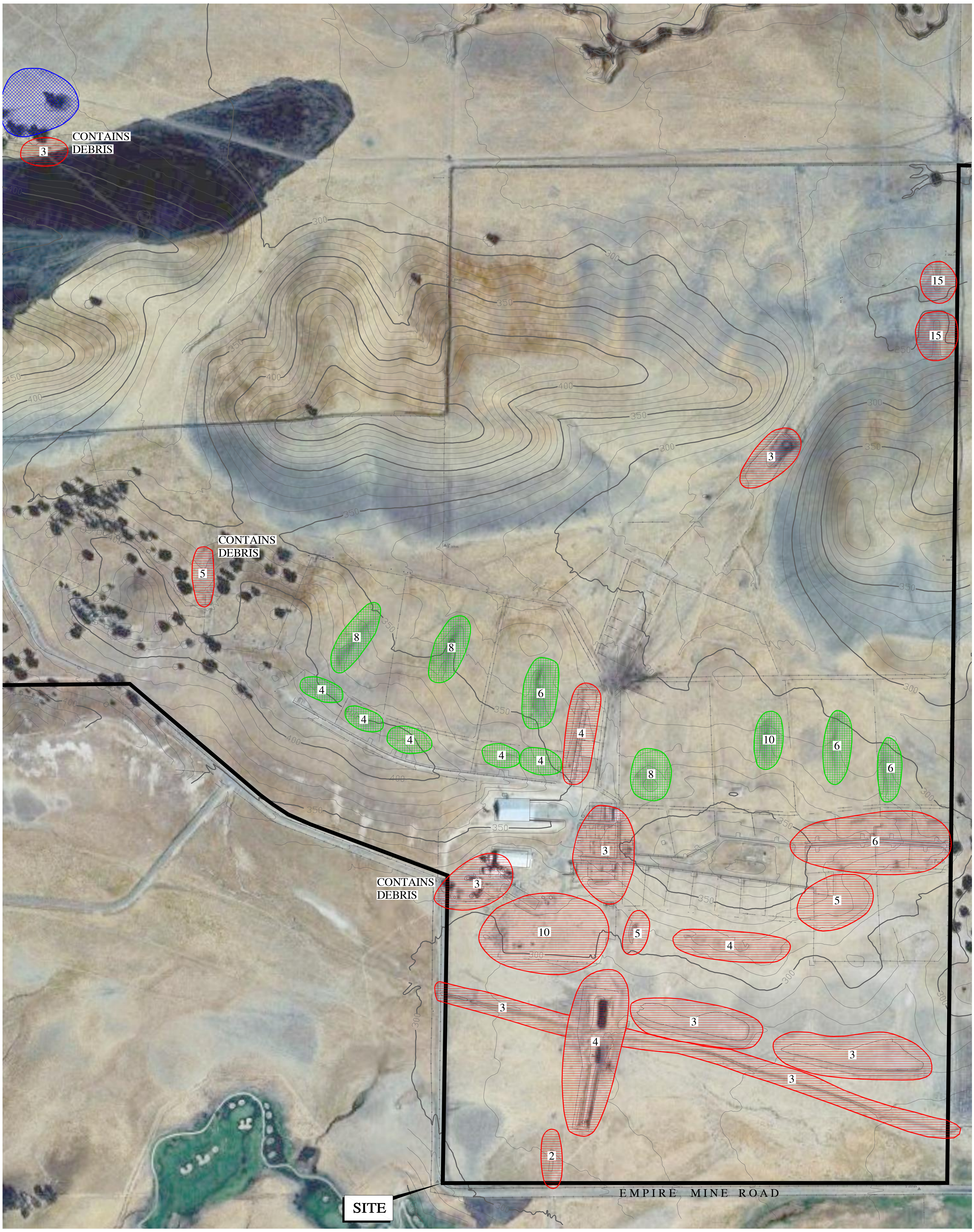

EXPLANATION

🟥 15 AREAS OF SUSPECTED AND CONFIRMED NON-ENGINEERING FILL WITH APPROXIMATE THICKNESS IN FEET

🟩 10 AREA OF SUSPECTED AND CONFIRMED MANURE PILES WITH APPROXIMATE THICKNESS IN FEET

▨ APPROXIMATE LOCATION OF JUDSONVILLE AND SUSPECTED NON-ENGINEERED FILL

N

0 FEET 500
0 METERS 250

BASE MAP SOURCE: CBG, GOOGLE EARTH PRO

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LOCATION OF UNDOCUMENTED FILL
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01	FIGURE NO. 3
DATE: MAY 2006	
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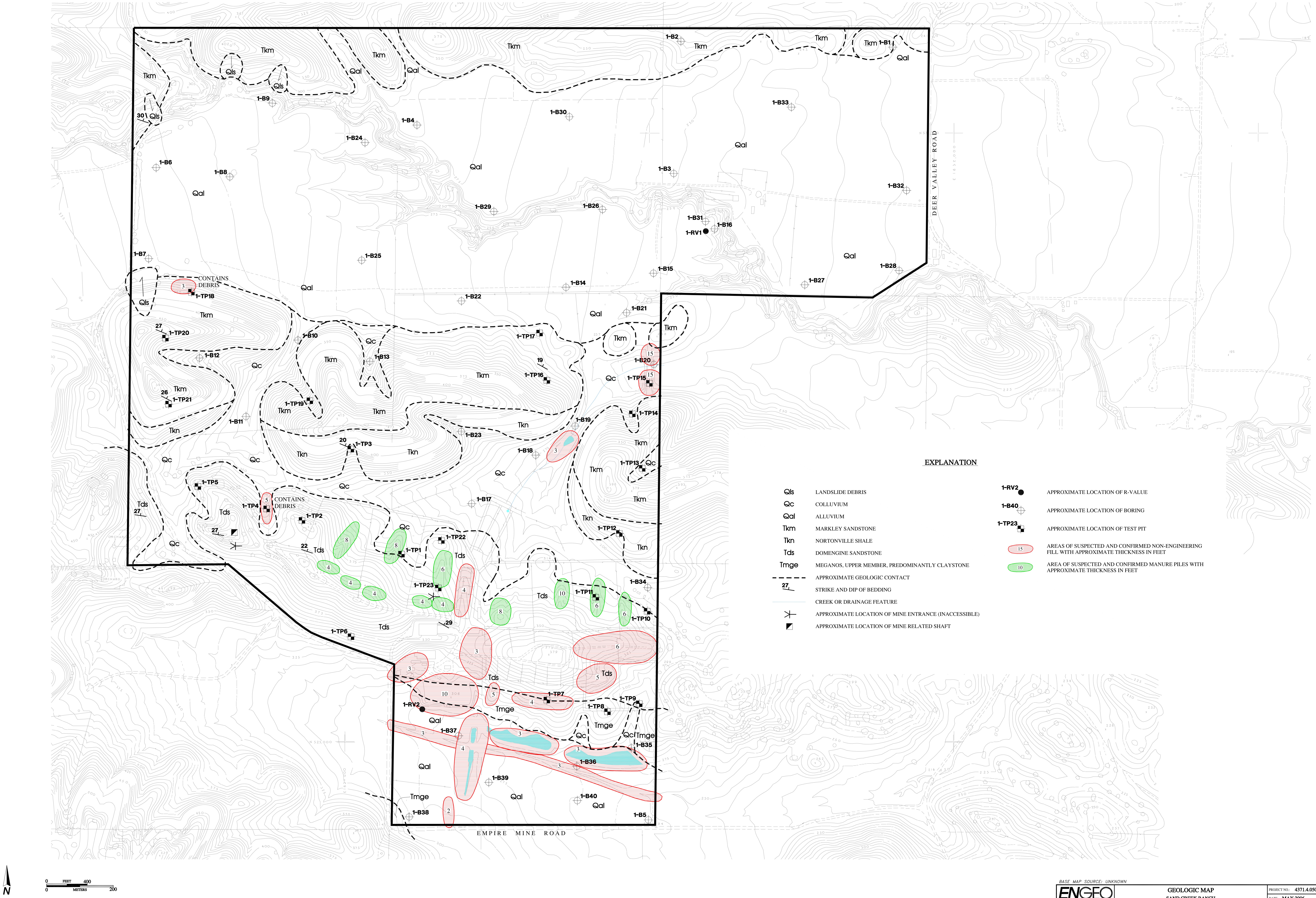

BASE MAP SOURCE: UNKNOWN

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GEOLOGIC MAP
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
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FIGURE NO. 4

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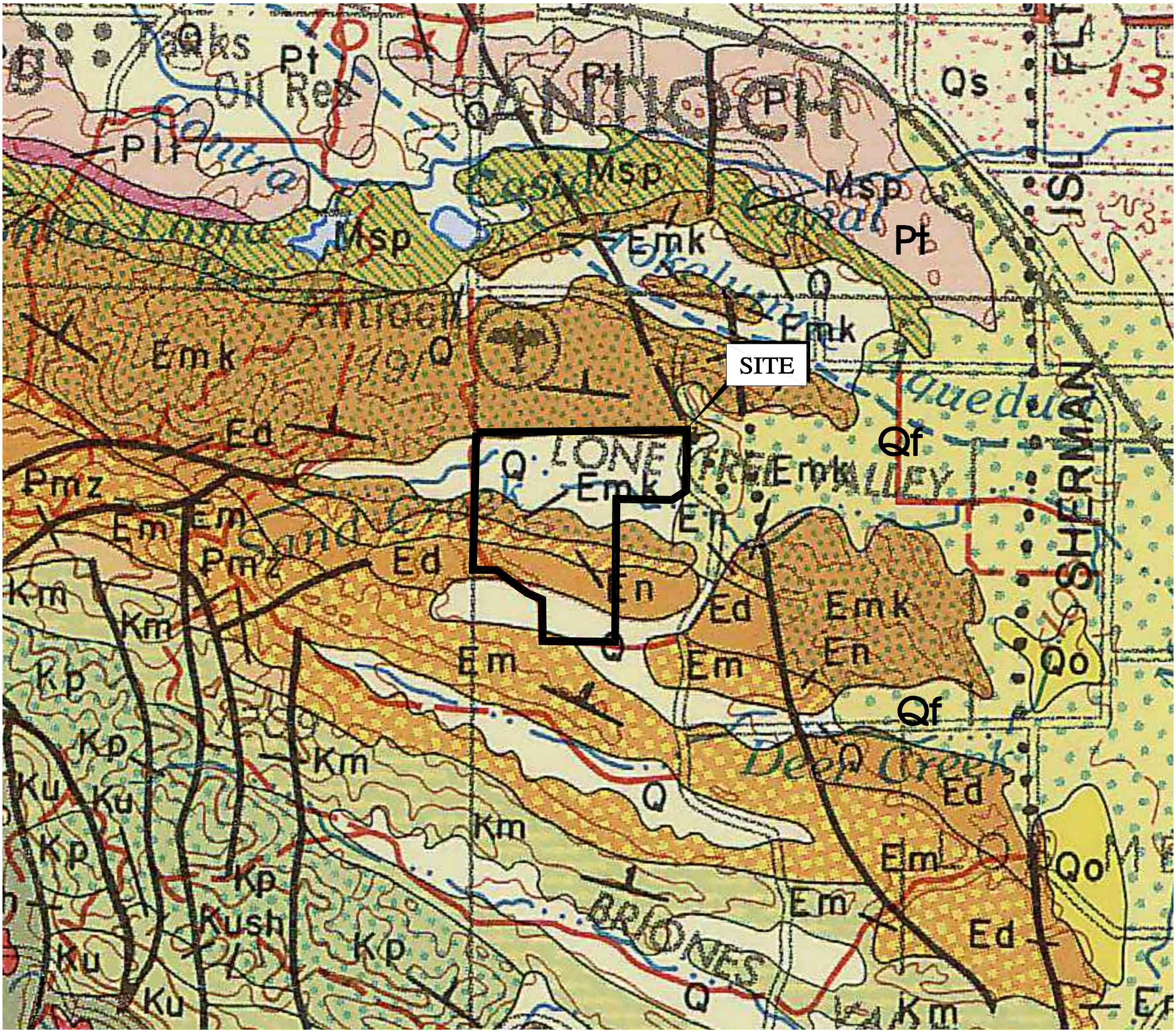

EXPLANATION

BEDROCK CONTACT-DASHED WHERE GRADATIONAL OR APPROXIMATELY LOCATED

FAULT-DASHED WHERE INFERRED, DOTTED WHERE CONCEALED, QUERIED WHERE EXISTENCE IS DOUBTFUL;

STRIKE AND DIP OF INCLINED STRATA

Q	ALLUVIUM
Qf	ALLUVIAL FAN DEPOSITS
Pt	TEHAMA FORMATION
Msp	SAN DIABLO GROUP
Emk	MARKLEY SANDSTONE
En	NORTONVILLE SHALE
Ed	DOMENGINE SANDSTONE
Em	MEGANOS FORMATION

N

0 FEET 6000
0 METERS 3000

BASE MAP SOURCE: WAGNER, 1991

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REGIONAL GEOLOGIC MAP
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
DATE: MAY 2006
DRAWN BY: PC
CHECKED BY: JT
FIGURE NO. 5

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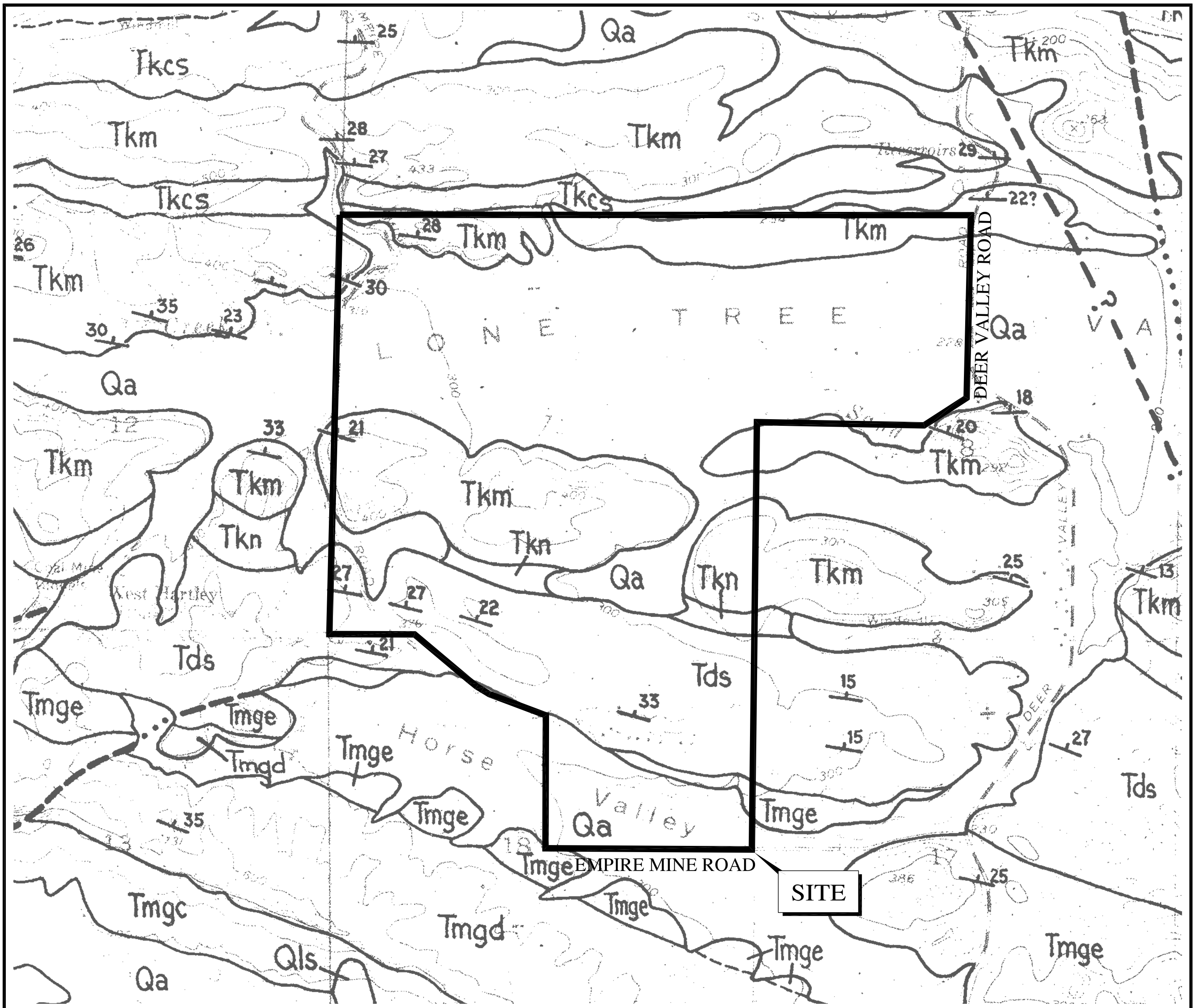


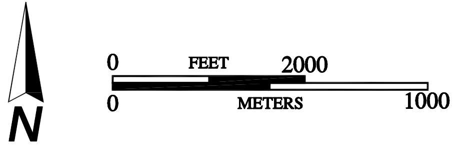
EXPLANATION

——— - - - - BEDROCK CONTACT-DASHED WHERE GRADATIONAL OR APPROXIMATELY LOCATED

——— - - - ·· FAULT-DASHED WHERE INFERRED, DOTTED WHERE CONCEALED, QUERIED WHERE EXISTENCE IS DOUBTFUL; DOUBLE ARROWS INDICATE STRIKE-SLIP MOVEMENT

STRIKE AND DIP OF STRATA

INCLINED VERTICAL OVERTURNED



Qa	ALLUVIUM
Qls	LANDSLIDE DEBRIS
Tkcs	KREYENHAGEN FORMATION; CLAY SHALE
Tkm	MARKLEY FORMATION
Tkn	NORTIONVILLE SHALE MEMBER
Tds	DOMENGINE SANDSTONE
Tmge	MEGANOS FORMATION; CLAY SHALE
Tmgd	MEGANOS FORMATION; ARKONSIC SANDSTONE
Tmgc	MEGANOS FORMATION; CLAY SHALE SANDSTONE

BASE MAP SOURCE: DIBBLEE, 1980

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REGIONAL GEOLOGIC MAP
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
DATE: MAY 2006
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FIGURE NO. 6

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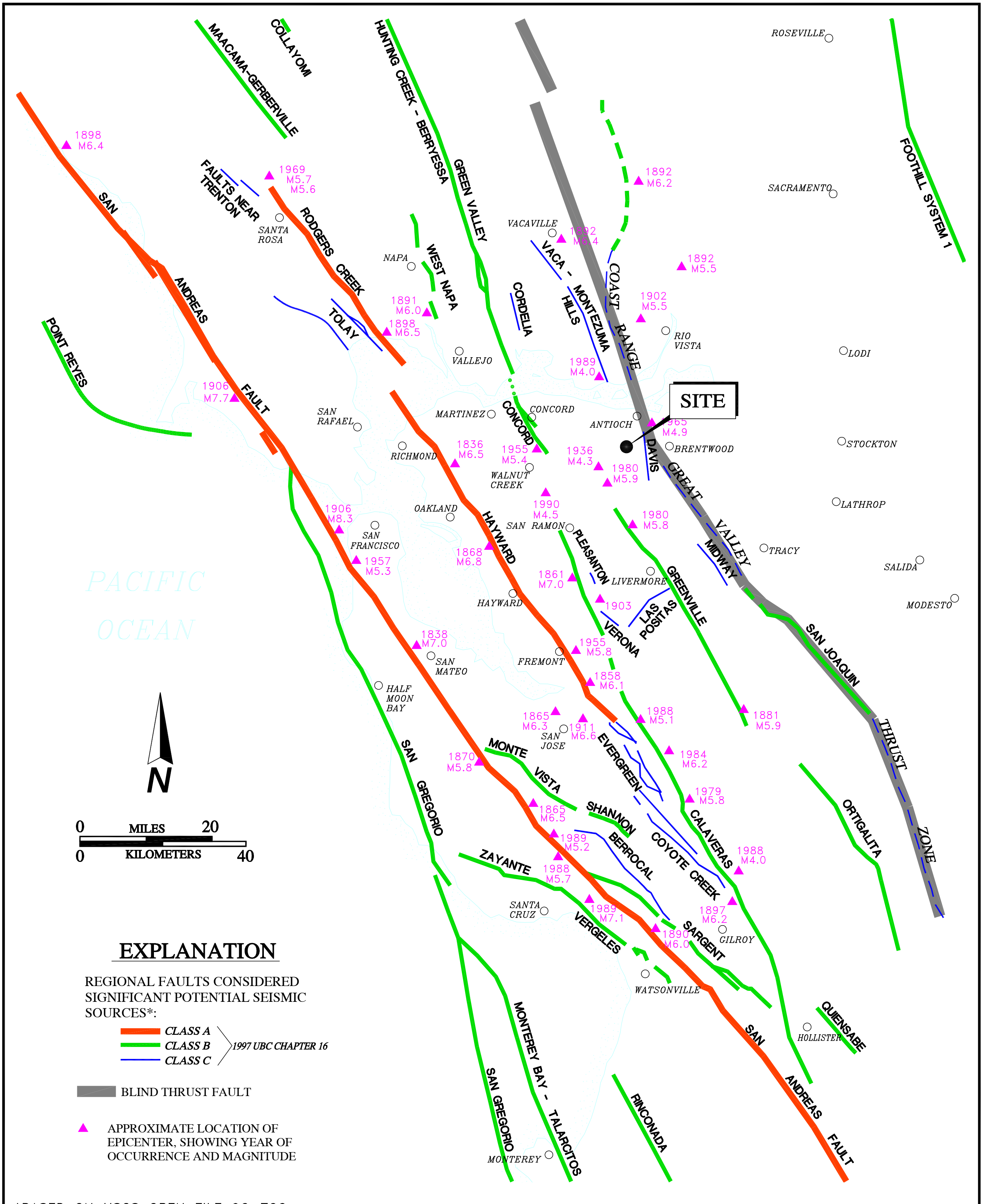

*BASED ON USGS OPEN FILE 96-706

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REGIONAL FAULTING AND SEISMICITY

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.:	4371.4.050.01
DATE:	MAY 2006
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FIGURE NO. 7

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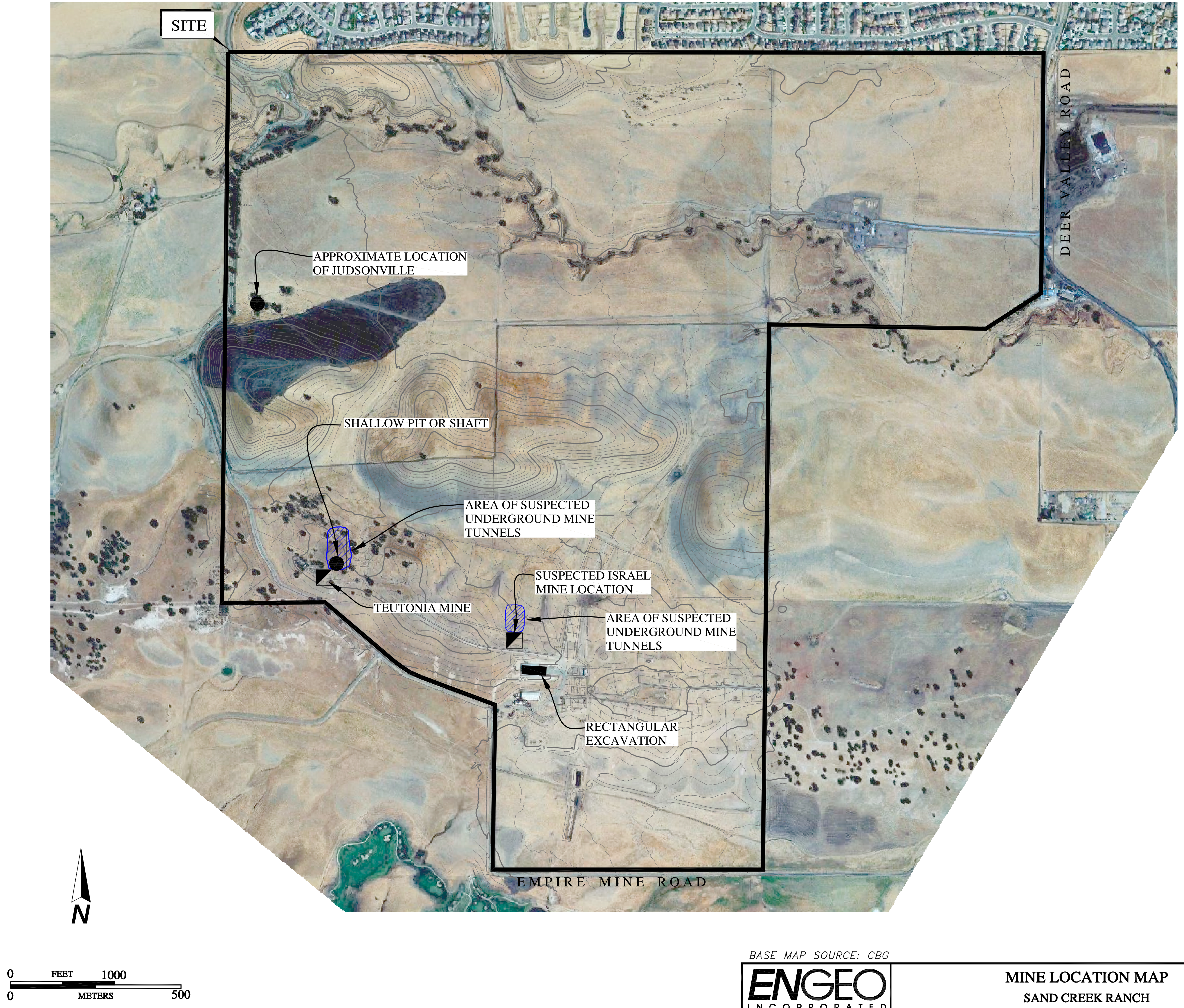

BASE MAP SOURCE: CBG

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MINE LOCATION MAP
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
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FIGURE NO. 8

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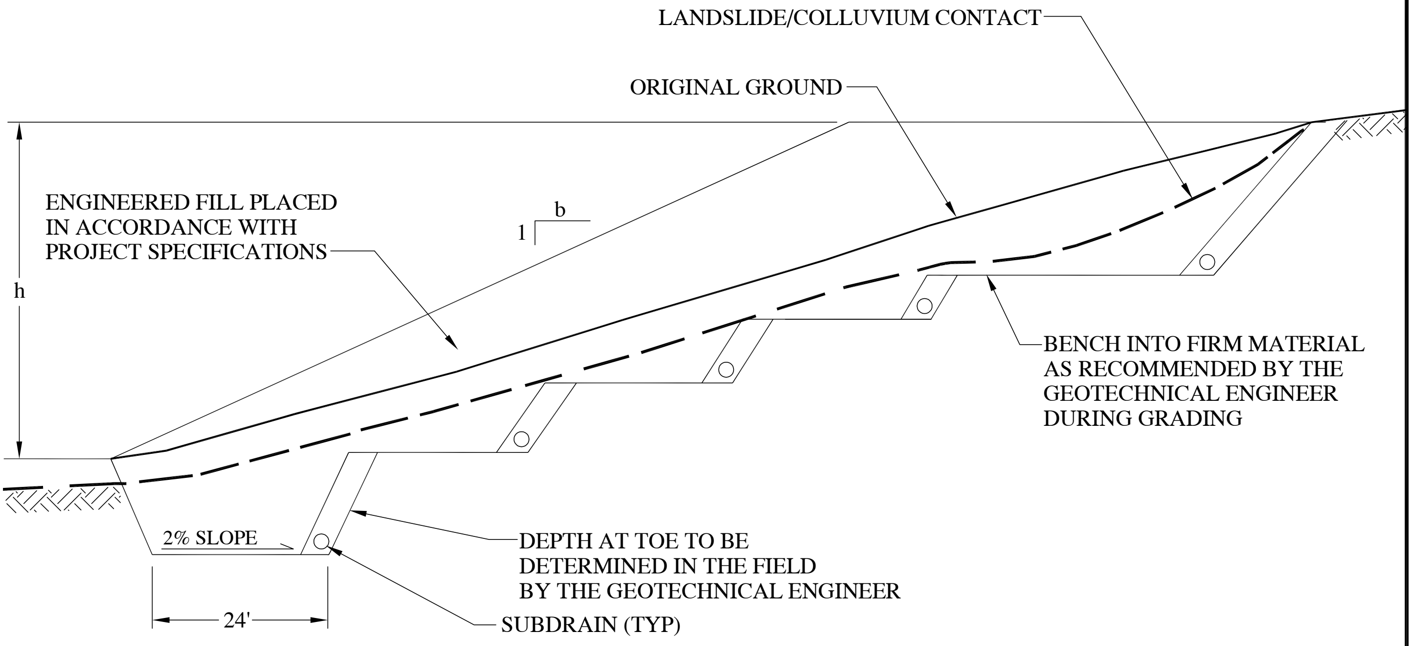

FOR SLOPE HEIGHT AND MAXIMUM SLOPE GRADIENT REFER TO GRADED SLOPES SECTION OF THE TEXT

NO SCALE

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TYPICAL KEYWAY SECTION

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
DATE: MAY 2006
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FIGURE NO. 9

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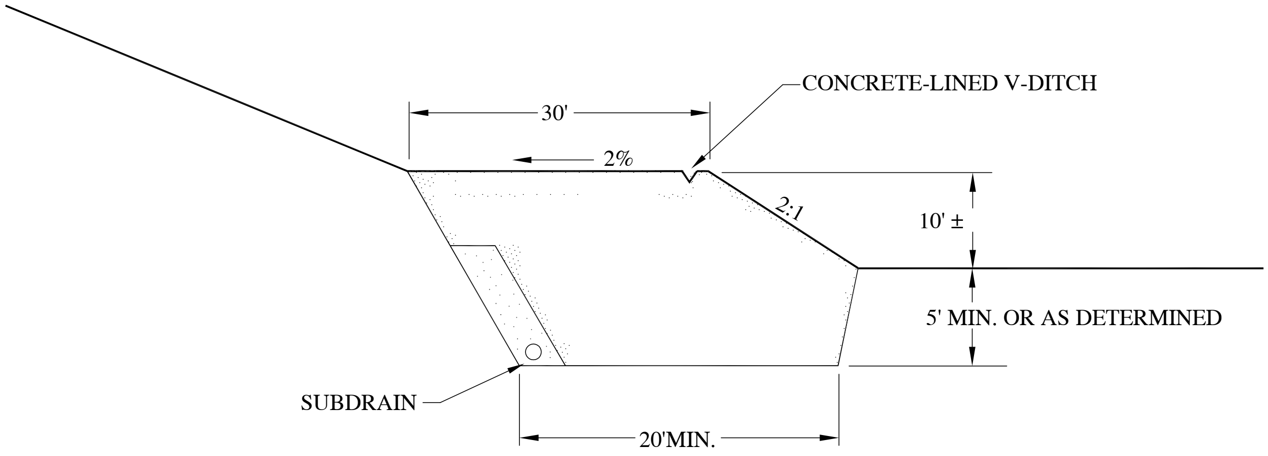
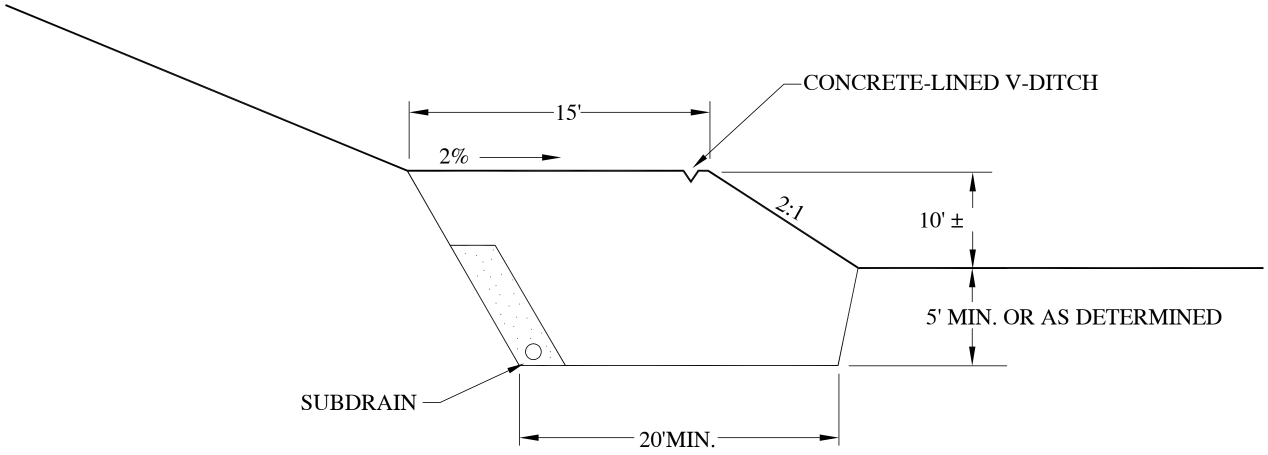


DEBRIS BENCH ADJACENT TO LOTS



DEBRIS BENCH ADJACENT TO ROADWAY

ACTUAL SIZE AND DEPTH OF KEYWAY TO BE DETERMINED IN THE FIELD BY THE GEOTECHNICAL ENGINEER

NO SCALE

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TYPICAL DEBRIS BENCH DETAIL
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
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FIGURE NO. 10

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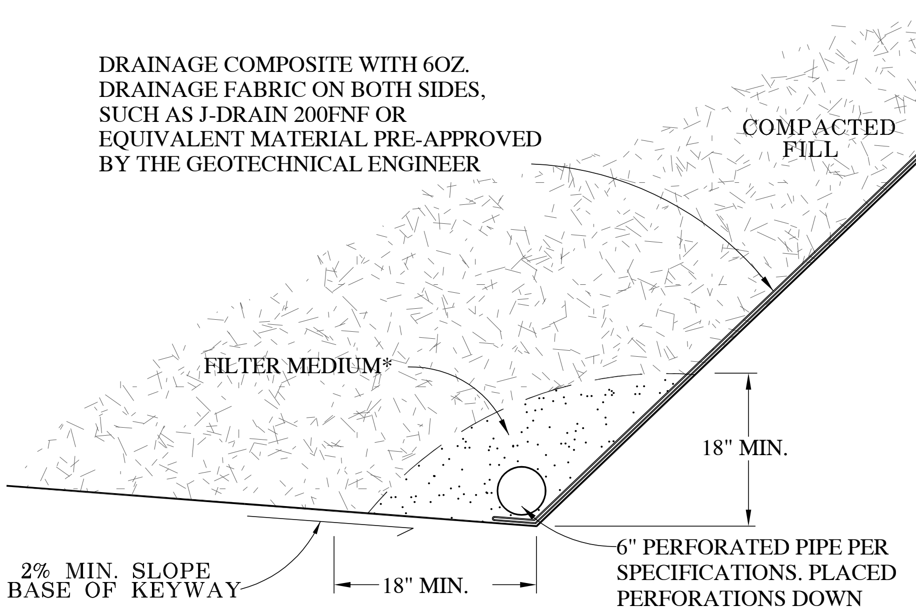
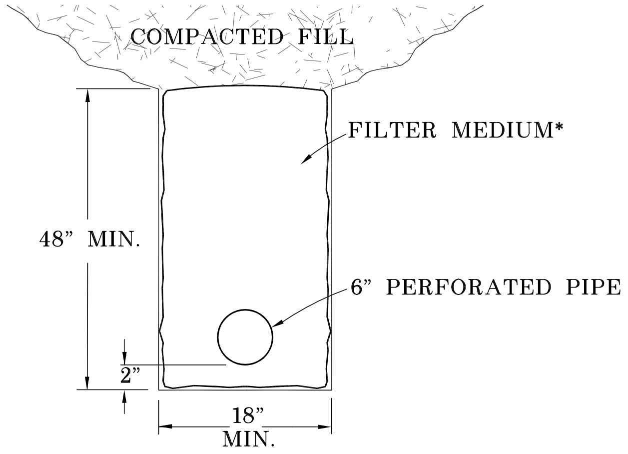
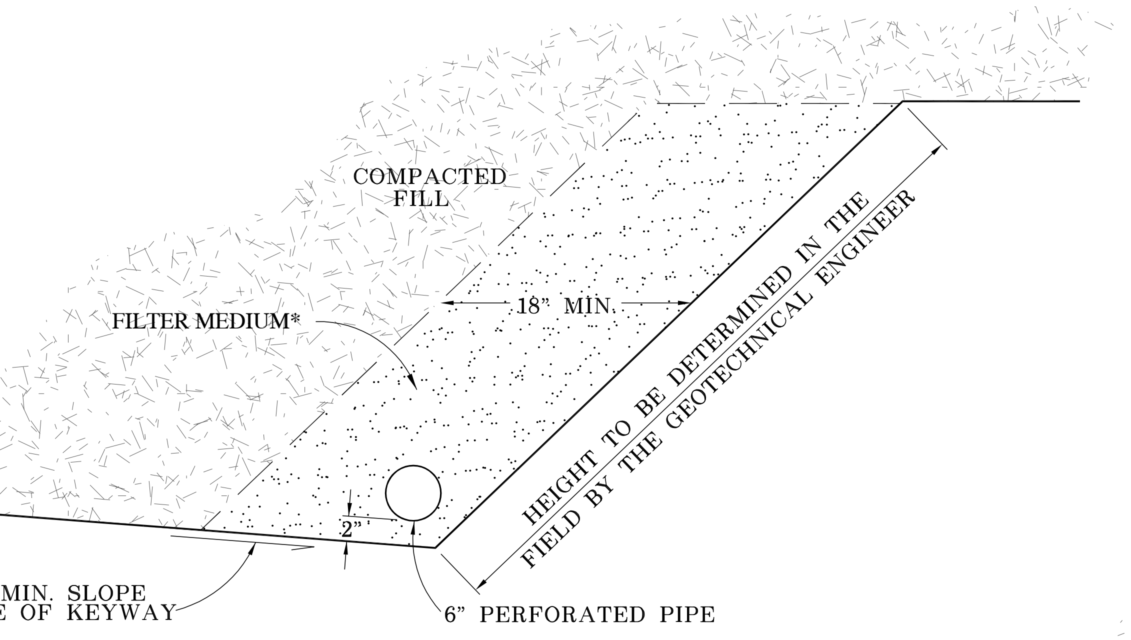


KEYWAY SUBDRAIN - OPTION 1



SWALE SUBDRAIN



KEYWAY SUBDRAIN - OPTION 2

*FILTER MEDIUM

ALTERNATIVE A

CLASS 2 PERMEABLE MATERIAL

MATERIAL SHALL CONSIST OF CLEAN, COARSE SAND AND GRAVEL OR CRUSHED STONE, CONFORMING TO THE FOLLOWING GRADING REQUIREMENTS:

SIEVE SIZE	% PASSING SIEVE
1"	100
3/4"	90–100
3/8"	40–100
#4	25–40
#8	18–33
#30	5–15
#50	0–7
#200	0–3

ALTERNATIVE B

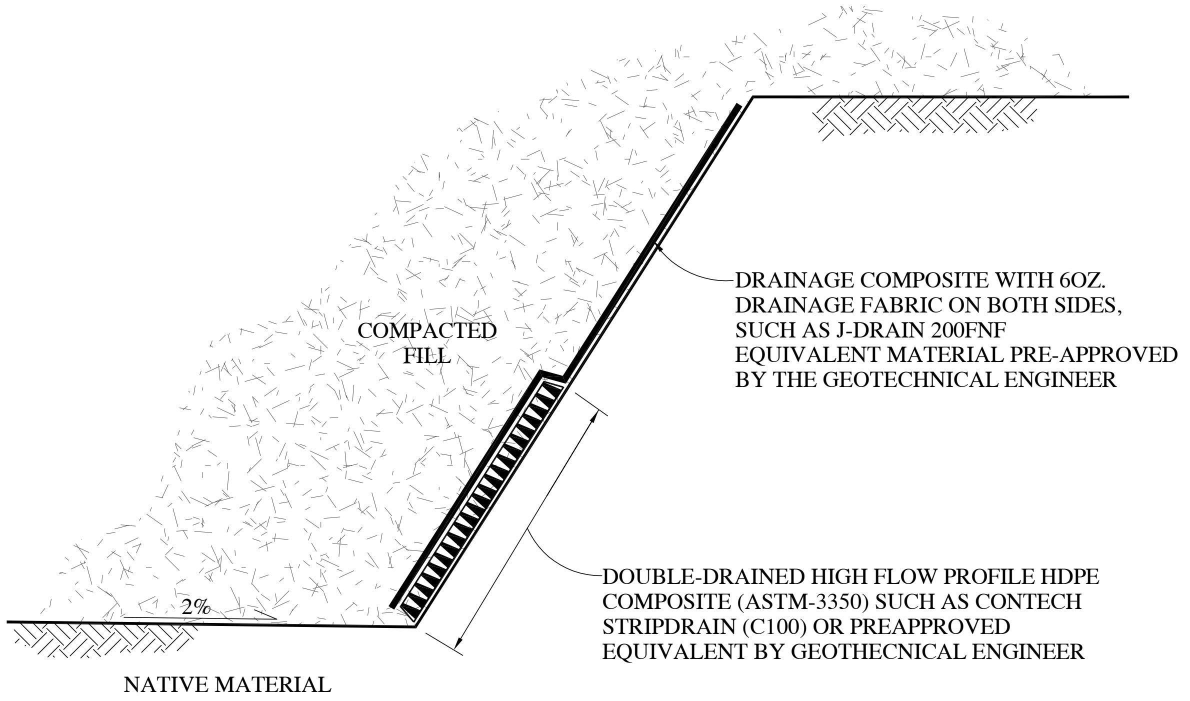
CLEAN CRUSHED ROCK OR GRAVEL WRAPPED IN FILTER FABRIC

ALL FILTER FABRIC SHALL MEET THE FOLLOWING MINIMUM AVERAGE ROLL VALUES UNLESS OTHERWISE SPECIFIED BY ENGEO:

GRAB STRENGTH (ASTM D-4632)	180 lbs
MASS PER UNIT AREA (ASTM D-4751)	6 oz/yd^2
APPARENT OPENING SIZE (ASTM D-4751)	70-100 U.S. STD. SIEVE
FLOW RATE (ASTM D-4491)	80 gal/min/ft
PUNCTURE STRENGTH (ASTM D-4833)	80 lbs

NOTES:

1. *ALL PIPE JOINTS SHALL BE GLUED*
2. *ALL PERFORATED PIPE PLACED PERFORATIONS DOWN*
3. *1% FALL (MINIMUM) ON ALL TRENCHES AND DRAIN LINES*



ALTERNATE KEYWAY SUBDRAIN - OPTION 3

(FOR DEPTHS LESS THAN 30 FEET)

NO SCALE

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TYPICAL SUBDRAIN DETAILS
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
DATE: MAY 2006
DRAWN BY: PC
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FIGURE NO. 11

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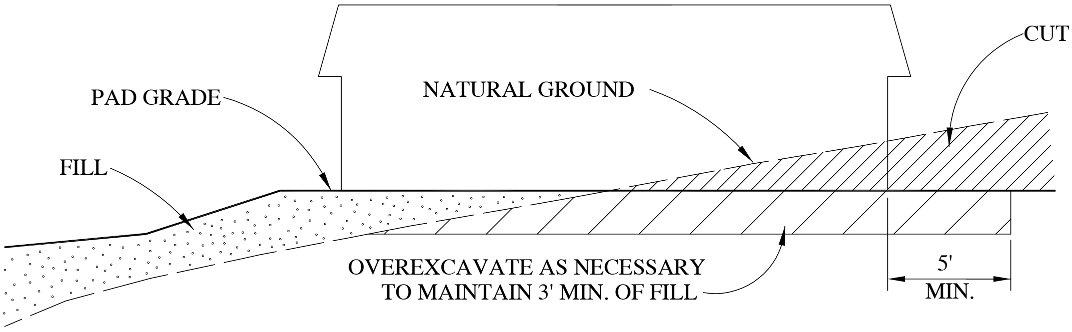
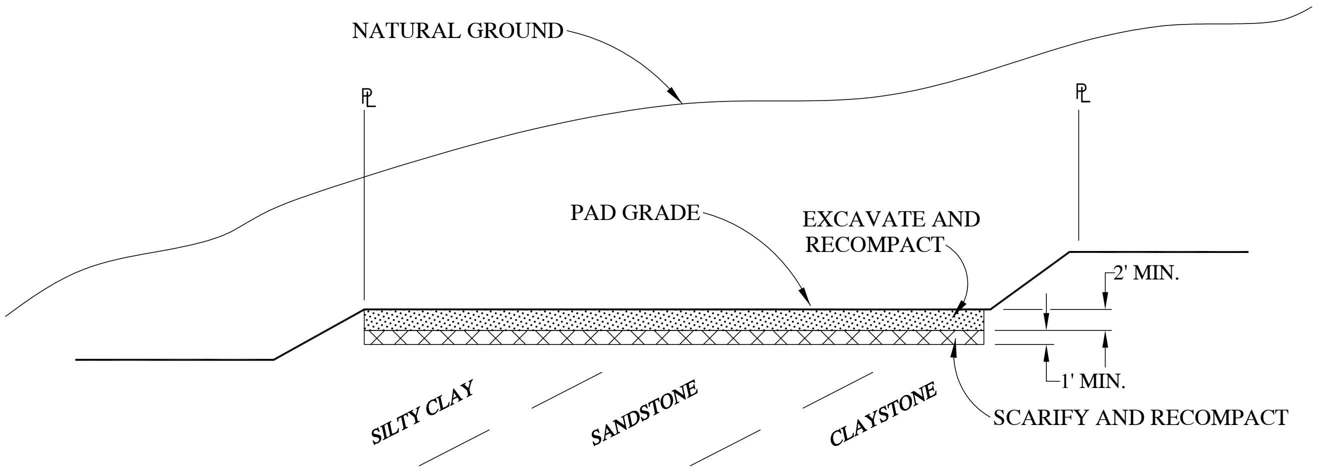


WHERE LOTS ARE PARTIALLY IN FILL, AND PARTIALLY IN CUT,
THE CUT PORTION MUST BE OVEREXCAVATED AS SHOWN.

CUT/FILL LOT



WHERE LOTS ARE COMPLETELY IN CUT, THE UPPER 2'
SHOULD BE EXCAVATED AND RECOMPACTED AS SHOWN

CUT LOT

NO SCALE

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OVEREXCAVATION FOR CUT/FILL & CUT LOTS
SAND CREEK RANCH
ANTIOCH, CALIFORNIA

PROJECT NO.: 4371.4.050.01
DATE: MAY 2006
DRAWN BY: PC
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FIGURE NO. 12

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APPENDIX A

Boring Logs 1-B1 through 1-B40 (40 Pages)

Test Pit Logs 1-TP1 through 1-TP23 (8 pages)

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

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(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
15	4 5	■	SILTY CLAY (CL), yellowish brown, very stiff, moist to saturated, trace sand.	▨	▼ ▽	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.

ENGEO
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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			
5	1 2	■	SILTY SAND (SM), yellowish brown, medium dense to dense, moist, fine to medium-grained sand.			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.

10 15 20 25 30
3 4 5 6 7 8 9

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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	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), dark brown, medium stiff, moist, trace sand, trace organics.	▨					
		■	SILTY CLAY (CL), dark brown, stiff, moist, trace sand.	▨		15			*0.75
5	2	■	(no sand)	▨		25	20.3	105	*3.5
10	3	■	SILTY CLAY (CL), brown, stiff to very stiff, moist, trace sand.	▨		29	18.4	102	*4.5
15	5	■		▨		39	18.2	107	*4.5
			SILTY CLAY (CL), yellowish brown, very stiff to hard, moist, some fine-grained sand.	▨					
20	6	■		▨		37	18.6	109	*4.5+
	7		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						
25	8								
30	9								

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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
			CLAY (CH/CL), dark olive brown, medium stiff to stiff, moist, with silt, trace sand.	▨		15	27.1	96	*1.0
			CLAY (CL), dark brown, hard, moist, with silt.	▨		68	14.3	110	*4.5+
			SILTY CLAY (CL), light yellowish brown, very stiff, moist, with fine-grained sand.	▨		27	15.8	103	*4.5+
			SILTY CLAY (CL), olive brown, hard, moist.	▨		49	18.4	99	*4.5+
			SILTY CLAY (CL), olive brown, very stiff, moist, some fine-grained sand.	▨		35	22.7	90	*3.5

Bottom of boring at approximately 26 1/2 feet.
Groundwater not encountered during drilling.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B4.bor

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LOG OF BORING 1-B5

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): 258 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		SANDY CLAY (CL), dark grayish brown, medium stiff, wet, fine grained sand, with silt, trace organics.	▨					
		■			▼	12			*1.0
	1	◪			▽	13			
5		■	SILTY CLAY (CL), yellowish brown, stiff, moist to saturated, with fine to medium-grained sand.	▨		18	23.9	102	*2.0
	2								
10	3	■				11	25.1	101	*1.0
	4								
15	5	■				16	22.6	105	*1.25
20	6								
			SILTY CLAY (CL), yellowish brown and grey mottled, very stiff to hard, moist, with fine-grained sand.	▨					
	7								
25	8	■				55			*1.75
	9								
30									

Bottom of boring at approximately 26 1/2 feet.
Groundwater encountered at 4 1/2 feet, during drilling
Stabilized groundwater measured at 2 1/2 feet.

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LOG OF BORING 1-B6

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): 314 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, medium stiff to stiff, moist, with silt, trace sand.	▨					
		■				10			*1.25
	1	◣				13			
			SILTY CLAY (CL), yellowish olive brown, very stiff, moist, trace sand.	▨					
5		■				36	14.3	102	*4.5+
	2								
			SILTY CLAY (CL), yellowish brown, very stiff to hard, moist, with fine-grained sand.	▨					
10	3	■				32	14	102	*4.5+
	4								
15	5	■				46	16.7	101	*4.5+
20	6								
	7		SILTY CLAY (CL), yellowish olive brown, hard, moist, trace sand.	▨					
25	8	■				50	18.9	107	*4.5
30	9		Bottom of boring at approximately 26 1/2 feet. Groundwater not encountered during drilling.						

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LOG OF BORING 1-B7

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): 315 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, very stiff, moist, trace sand.	▨					
		▮		▨		19	27.1	87	*2.25
	1			▨					
			SILTY CLAY (CL), olive gray, hard, moist.	▨					
5				▨					
		▮		▨		53	12.0	100	*4.5+
	2			▨					
			SILTY CLAY (CL), grayish brown, hard, moist, with fine to medium-grained sand.	▨					
10	3			▨					
		▮		▨		62	13.1	107	*4.5+
	4			▨					
15				▨					
		▮		▨		60	11.5	114	
	5			▨					
20	6			▨					
		▮	(very stiff, trace gravel)	▨		30	15.4	111	
	7		Bottom of boring at approximately 21 1/2 ft. Groundwater not encountered during drilling.						
25									
	8								
	9								
30									
	10								
35									

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LOG OF BORING 1-B8

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
			CLAY (CL/CH), very dark brown, stiff, moist, with silt.						
			SILTY CLAY (CL), dark grayish brown, very stiff, moist, trace sand.			23			*2.5
			SILTY CLAY (CL), grayish brown, hard, moist, trace sand.			57			*3.75
			SILTY CLAY (CL), grayish olive brown, stiff, moist, some fine-grained sand.			12			*4.5+
			SILTY CLAY (CL), brown, hard, moist, trace sand.			38			

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

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LOG OF BORING 1-B9

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
		■	CLAY (CL), dark grayish brown, stiff to very stiff, moist, with silt and fine-grained sand.	▨		31			*2.5
		■	SILTY CLAY (CL), grayish olive brown, very stiff, moist, some fine to medium-grained sand.	▨		30			*4.5+
		■	SILTY CLAY(CL), grayish brown, hard, moist, with fine to medium-grained sand.	▨		37			*4.5+
		■				37			*4.5+
		■	SILTY CLAY (CL), brown, very stiff, moist, some fine-grained sand.	▨		33			*4.5+

Bottom of boring at approximately 31 1/2 ft.
Groundwater not encountered during drilling.

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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	2	■	SANDY CLAY (CL), grayish brown, hard, moist, with fine-grained sand and silt.	▨		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		
15	5		SILTY CLAY (CL), grayish brown, very stiff, saturated, with fine-grained sand.	▨	▽				
20	6	◣	SANDY CLAY (CL), grayish brown and reddish brown mottled, very stiff, saturated fine-grained sand with silt.	▨		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.

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LOG OF BORING 1-B11

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): 325 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
			CLAYEY SAND (SC), dark grayish brown, loose, moist, fine to medium-grained sand, with silt, trace organics (colluvium).			7			
			SANDY CLAY (CL), grayish brown, very stiff, moist, fine to medium-grained sand, with silt.			18 34			 *4.5+
			SANDY CLAY (CL), grayish brown and brownish gray mottled, stiff, moist, fine to medium-grained sand, with silt.			13			
			SAND (SM), olive grayish brown, wet to saturated, dense, fine-grained sand, with silt and clay.		∇	32			

Bottom of boring at approximately 21 1/2 feet.
Groundwater encountered at 20 1/2 feet during drilling.

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LOG OF BORING 1-B12

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 20 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 388 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, fine-grained sand (colluvium).						
	1					12			*0.75
5	2		SILTY SAND (SM), yellowish brown, dense, moist, fine-grained sand, some clay.			46			
10	3		SANDY CLAY (CL), yellowish brown, hard, moist, fine-grained sand with silt.						
	4					58			
15	5		SANDSTONE, moderately weathered, moderately strong.						
20	6					50/4"	20		

Bottom of boring at approximately 20 1/2 feet.
Groundwater not encountered during drilling.

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LOG OF BORING 1-B13

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 16 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 342 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 1	■	CLAY (CL), dark grayish brown, moist to wet, medium stiff, with silt and fine to medium-grained sand (colluvium).	▨		10			*0.50
5 10	2 3	◣	SILTY CLAY (CL), dark yellowish brown, hard, moist, with fine-grained sand.	▨		30			
	4		SILTY CLAY (CL), light yellowish brown, stiff to very stiff, moist, with some fine-grained sand, trace rock fragments.	▨					
15		◣	SANDSTONE, yellowish grayish brown, moderately to highly weathered.	⠿		50/6"			
20 25 30 35	5 6 7 8 9 10		Bottom of boring at approximately 16 feet. Groundwater not encountered during drilling.						

ENGEO
INCORPORATED

LOG OF BORING 1-B14

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			

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

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LOG OF BORING 1-B15

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
			SILTY CLAY (CL), grayish brown, very stiff, moist, some fine-grained sand.			28	21.7	103	*2.5
			SILTY CLAY (CL), light grayish brown, stiff, moist, with fine-grained sand.			15	22.8	102	

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

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LOG OF BORING 1-B16

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 26, 2006
HOLE DEPTH (FT): 15 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/CH), very dark grayish brown, stiff, moist, with silt, trace sand.			15			*1.0
5	1		SILTY CLAY (CL), dark grayish brown, hard, moist, with medium to fine-grained sand, trace gravel.			50			
	4		SILTY CLAY (CL), grayish brown, moist, medium stiff, some fine-grained sand.			21			*4.5+

Bottom of boring at approximately 15 feet.
Groundwater not encountered during drilling.

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LOG OF BORING 1-B17

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 294 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 SAND (SM), dark brown, loose to very loose, moist to wet, fine-grained sand with clay, trace organics.				20.1	99	
			(saturated)			7	18.2	104	
	1		SILTY CLAY (CL), dark yellowish brown, very stiff, moist, with fine to medium-grained sand.			22	13.9		
	2					29	15.1	105	
					▼				
10	3		SANDY CLAY (CL), grayish brown and gray mottled, hard, saturated, fine to medium-grained sand, with silt.		▽				
	4					60	17.9	113	*4.5
			CLAYSTONE, gray and reddish brown mottled, friable, deeply weathered.						
						43	25.8	97	

Bottom of boring at approximately 21 1/2 feet.
Groundwater encountered at 10 feet during drilling.
Stabilized groundwater measured at 9 1/2 feet.

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LOG OF BORING 1-B18

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 21ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 274 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
			SANDY CLAY (CL), very dark grayish brown, stiff to very stiff, moist, with silt, trace organics.			20			*1.5
			SILTY SAND (SM), grayish olive brown, very dense, moist, fine-grained sand with clay.		▼	50/5"			
			SILTY CLAY (CL), gray and brown mottled, stiff, moist to saturated, with fine-grained sand.		▽	17			
			SILTY CLAY (CL), grayish brown and yellowish brown, saturated, medium dense, with fine-grained sand.			13			
			SANDY CLAY (CL), yellowish brown and gray, hard, saturated, fine-grained sand with silt.			50/6"			

Bottom of boring at approximately 21 feet.
Groundwater encountered at 10 1/2 feet.
Stabilized groundwater measured at 6 feet.

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LOG OF BORING 1-B19

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 264 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 5	0 1 2		CLAY (CL/CH), very dark brown, stiff, moist, with fine-grained sand and silt (colluvium).			22 30			*1.5 *3.25
10 15	3 4 5		SANDY CLAY (CL), olive grayish brown, very stiff to hard, moist to saturated, fine-grained sand with silt.		▼ ▽	52			
20	6		SANDY CLAY to CLAYEY SAND (CL-SC), grayish olive brown, stiff to medium dense, saturated, fine-grained sand, with silt.			17			
25 30 35	7 8 9 10		Bottom of boring at approximately 21 1/2 feet. Groundwater encountered at 12 1/2 feet during drilling. Stabilized groundwater measured at 9 1/2 feet.						

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LOG OF BORING 1-B20

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: April 27, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 244 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
			CLAY (CL/CH), very dark brown, stiff to very stiff, with fine sand and silt, trace organics.			21	23.2	95	*1.75
			CLAY (CL), dark brown, very stiff, moist, with silt, some fine-grained sand.			28	19.2	106	*3.25
			CLAYEY SAND (SC), olive gray and yellowish brown, medium dense, moist, fine-grained sand, with silt, moist.		▼	38			
			SILTY SAND (SM), yellowish brown, medium dense, saturated, fine to medium-grained sand, trace clay.		▽				
			CLAYEY SAND (SC), yellowish brown and olive gray, very stiff, saturated, fine-grained sand with silt.			26	19.4	99	
			SILTY SAND (SM), yellowish brown and olive gray, dense, saturated, fine-grained sand, trace rock fragments.			53	19.1	104	

Bottom of boring at approximately 21 1/2 feet.
Groundwater encountered at 11 1/2 feet during drilling.
Stabilized groundwater measured at 10 feet.

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LOG OF BORING 1-B21

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): 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	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, some fine-grained sand, trace organics.	▨					
		■		▨		43	21.0	98	*2.5
	1			▨					
5			SILTY CLAY (CL), yellowish olive brown, very stiff, moist, with fine-grained sand.	▨					
	2	■		▨		34	14.1	107	*4.5+
10	3			▨					
			SILTY CLAY (CL), grayish olive brown, very stiff, moist, trace sand.	▨					
	4			▨					
15		■		▨		34	20.3	99	*3.75
	5		Bottom of boring at approximately 16 1/2 feet. Groundwater not encountered during drilling.						
20	6								
	7								
25	8								
	9								
30									
	10								
35									

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LOG OF BORING 1-B22

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): 279 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 1	■	CLAY (CL/CH), dark grayish brown, soft to medium stiff, moist to wet, with fine-grained sand and silt.	▨		9	22.2	97	*0.25 *1.5
5	2	■	SILTY CLAY (CL), yellowish olive brown, stiff to very stiff, moist, with fine-grained sand.	▨		37	12.1	102	*4.5+
10	3 4	■	SILTY SAND (SM), yellowish brown, medium dense, moist, fine to medium-grained sand with clay.	░		30	12.9	103	
15	5	■		░		24	16.9	107	
20 25 30 35	6 7 8 9 10		Bottom of boring at approximately 16 1/2 feet. Groundwater not encountered during drilling.						

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LOG OF BORING 1-B23

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): 372 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), grayish brown, medium stiff to stiff, moist, with fine to medium-grained sand, trace gravel/rock fragments, (colluvium).	▨					
		■				13			*2.0
	1								
5		■				25			
	2								
			CLAYSTONE, light olive gray, friable, deep to moderate weathering.	▨					
10	3	■				68			
	4								
15		◣				35			
	5								

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

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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	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, stiff, moist, with silt, trace sand.	▨		12	25.1	98	*1.5
5	1 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 in Feet	Depth in Meters
20	6
	7
25	8
30	9
	10
35	

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LOG OF BORING 1-B25

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	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, stiff to very stiff, moist, with silt, trace fine grained sand.	▨					
	1	■		▨		27	22.1	103	*3.5
5			CLAYEY SAND (SC), light olive brown, dense, moist, fine-grained sand, trace silt.	▨					
	2	■		▨		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.	▒					
	4	■		▒		23	10.2	110	
15	5			▒					
20	6	■		▒		43	16.7	111	
	7		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						
25	8								
30	9								
	10								
35									

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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+
5	1		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.	░		30			

Bottom of boring at approximately 15 feet.
Groundwater not encountered during drilling.

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LOG OF BORING 1-B27

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
			CLAY (CL), dark grayish brown, stiff, moist, some fine-grained sand, with silt.						
						16	23.2	95	*0.75
			SILTY CLAY(CL), grayish brown, hard, moist, with medium to fine-grained sand.						
						70	12.8	110	
						48			
						54	19.4	108	

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

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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.	▨		38	19.2	109	*1.0 *4.5+
5	1		SILTY CLAY (CL), dark brown, very stiff to hard, moist, some fine to medium-grained sand.	▨					
10	2 3	■	SILTY CLAY (CL), grayish brown, hard, moist, with fine to medium-grained sand.	▨		53	13.0	112	
15	4 5	■	SILTY CLAY (CL), yellowish brown, very stiff, moist, some fine-grained sand.	▨		31	15.2	99	
20	6	■		▨		38	17.5	109	
25 30 35	7 8 9 10		Bottom of boring at approximately 21 1/2 feet. Groundwater not encountered during drilling.						

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LOG OF BORING 1-B29

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									

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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			▨					
			SILTY CLAY (CL), yellowish brown, very stiff, moist, fine to medium-grained sand.	▨					
5		■		▨		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		■		▨		37			
	5		Bottom of boring at approximately 16 1/2 feet. Groundwater not encountered during drilling.						
20	6								
	7								
25	8								
30	9								
	10								
35									

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LOG OF BORING 1-B31

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
			CLAY (CL), very dark grayish brown, stiff, moist, with silt, trace sand.	▨					
			SILTY CLAY (CL), dark grayish brown, hard, moist, fine to medium-grained sand, trace gravel.	▨					
			SILTY CLAY (CL), grayish brown, very stiff, moist, with fine-grained sand.	▨		31 18			*4.5+
			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.

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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.

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LOG OF BORING 1-B33

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 2	■	SILTY CLAY (CL), grayish olive brown, hard, moist, trace sand.	▨		69			*4.5+
10	3 4		SILTY CLAY (CL) yellowish olive brown, very stiff, moist, with fine-grained sand, trace gravel.	▨					
15	5	■		▨		38			*4.5+
20	6 7								
25	8 9								
30	10								
35									

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

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LOG OF BORING 1-B34

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 21 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 284 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 SAND (SM), grayish brown, very loose, moist to saturated, fine to medium-grained sand, some clay (perched water).		▼	6			
	1		SILTY CLAY (CL), brown, moist, very stiff, with fine-grained sand.			28			
5	2		CLAYEY SAND (SC), brownish olive gray, medium dense, moist, fine-grained sand, with silt.			36 34	16.1 18.4	108 88	
10	3, 4		SANDY CLAY (CL), browinsh gray, very stiff, moist, fine grained sand, with silt. (yellowish brown)						
15	5		SANDSTONE, yellowish brown and gray, friable, deep to moderate weathering.			50/5"	17.6	102	
20	6		SANDSTONE, bluish gray, moderately strong, moderate to little weathering.			50/4"	15.6		

Bottom of boring at approximately 21 feet.
Perched water encountered at 1 foot during drilling.

Depth in Feet: 0, 5, 10, 15, 20, 25, 30, 35
Depth in Meters: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

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LOG OF BORING 1-B35

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): 271 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 brown, stiff, moist, some fine-grained sand, with silt.	▨		20	23.1	100	*2.0
5	1	■	SILTY CLAY (CL), yellowish grayish brown, very stiff, moist, fine to medium-grained sand.	▨		23	24.6	98	*2.75
10	3	■	SILTY CLAY (CL), yellowish brown and gray mottled, very stiff, saturated, with fine-grained sand.	▨	▽	38	22.6	101	*3.5
15		■	(hard)	▨		52			

Bottom of boring at approximately 16 1/2 feet.
Groundwater encountered at 10 feet during drilling.

05-24-2006 G:\Active Projects\4371\4371.4.050.01 (GEX)\Bore Logs\1-B35.bor

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LOG OF BORING 1-B36

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 264 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 to medium-grained sand.	▨					
		■				18			*1.5
	1		SILTY CLAY (CL), yellowish brown and white mottled, very stiff, moist to saturated, with fine to medium-grained sand.	▨					
5					▼				
	2	■				38			*3.25
10	3		SILTY CLAY (CL), yellowish brown, very stiff, saturated, with fine-grained sand.	▨	▽				
	4	■				30			*3.25
15	5								
			SILTY CLAY (CL), grayish olive brown, hard, saturated, with fine-grained sand.	▨					
20	6	■				75			

Bottom of boring at approximately 21 1/2 feet.
Groundwater encountered at 10 feet during drilling.
Stabilized groundwater measured at 5 1/2 feet.

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LOG OF BORING 1-B37

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 21 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 286 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	■	SANDY CLAY (CL), very dark grayish brown, stiff, moist, fine-grained sand, with silt.	▨		15			
	1	◣	CLAY (CL), very dark grayish brown, very stiff, moist, with silt and fine-grained sand.	▨		17			
5	2	■	SILTY CLAY (CL), gray and yellowish brown mottled, very stiff, moist, with fine-grained sand.	▨	▼ ▽	30			*3.5
10	3 4	■	CLAYEY SAND (SC), yellowish olive brown, medium dense, saturated, fine-grained sand, with silt.	▨		32	16.1		
15 20	5 6	■	SANDY CLAY (CL), yellowish brown, very stiff, saturated, fine-grained sand, with silt.	▨		33			
25 30 35	7 8 9 10		Bottom of boring at approximately 21 1/2 feet. Groundwater encountered at 9 feet during drilling. Stabilized groundwater measured at 5 feet.						

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INCORPORATED

LOG OF BORING 1-B38

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): 294 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 brown, medium stiff to stiff, moist, with fine-grained sand.	▨					
		■	SILTY CLAY (CL), dark brown, very soft, saturated, some fine-grained sand.	▨	▽	2			
	1	◣	SILTY CLAY (CL), dark yellowish brown, medium stiff, saturated, with fine-grained sand.	▨	▼	7			
5	2	■		▨		9			*0.5
10	3		SILTY CLAY (CL), yellowish olive brown, stiff to very stiff, saturated, with fine-grained sand.	▨					
		■		▨		25			*2.0
	4		SILTY CLAY (CL), olive brown, very stiff, saturated, trace sand.	▨					
15	5	■		▨		34			

Bottom of boring at approximately 16 1/2 feet.
Perched water encountered at 1 1/2 feet during drilling.
Stabilized groundwater measured at 3 feet.

Depth in Feet	Depth in Meters
20	6
	7
25	8
30	9
	10
35	

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LOG OF BORING 1-B39

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): 279 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 brown, stiff, moist, with fine-grained sand.	▨					
		■				14			*0.75
	1		SILTY CLAY (CL), yellowish brown, very stiff, moist to saturated, with fine-grained sand.	▨					
5					▼				
	2	■				28			*1.5 *4.5
			SILTY CLAY (CL), olive brown and light gray mottled, very stiff, saturated, some fine-grained sand.	▨					
10	3	■			▽	33			*3.5
	4								
			SANDY CLAY (CL), yellowish brown and gray, hard, saturated, fine-grained sand, with silt, trace claystone fragments.	▨					
15		■				72			
	5								

Bottom of boring at approximately 16 1/2 feet.
Groundwater encountered at 10 feet during drilling.
Stabilized groundwater measured at 5 feet.

Depth in Feet	Depth in Meters
20	6
	7
25	8
30	9
	10
35	

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LOG OF BORING 1-B40

GEOTECHNICAL EXPLORATION
SAND CREEK RANCH
ANTIOCH, CALIFORNIA
4371.4.050.01

DATE DRILLED: May 2, 2006
HOLE DEPTH (FT): 11 1/2 ft.
HOLE DIAMETER: 6.0 in.
SURF ELEV (FT-MSL): 266 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 and fine-grained sand.	▨		17	23.4	103	
5	1 2	■	SILTY CLAY (CL), light gray and grayish-brown mottled, stiff, moist, with fine-grained sand.	▨	▼	11			*1.75
10	3	■	SILTY CLAY (CL), yellowish brown and grayish brown, very stiff, saturated, with fine-grained sand.	▨	▽	35			*3.75

Bottom of boring at approximately 11.5 feet.
Groundwater encountered at 8 1/2 feet during drilling.
Stabilized groundwater measured at 4 1/2 feet.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1-TP1	0 – 3 ½	SILTY SAND (SM), brown, loose, moist, trace organics.
	3 ½ -11	SILTY SAND (SM), grayish brown, loose to medium dense, moist to wet.
		Bottom of test pit at 11 feet. Groundwater not encountered.
1-TP2	0 – 1½	SILTY SAND (SM), dark brown, medium dense, moist.
	1½ – 3	SANDSTONE, reddish brown to gray, weak, closely fractured, thin bedding, deep weathering.
	3 – 6	SANDSTONE, light gray, moderately strong to strong, widely fractured, massive, little weathering.
		Bottom of test pit at 6 feet. Groundwater not encountered.
1-TP3	0 – 1 ½	CLAY (CL), dark brown, medium stiff, moist, with sand and silt. (Colluvium)
	1 ½ – 6	SILTY CLAY (CL), brown, stiff, moist, with sand. (Colluvium)
	6 – 7 ½	SILTY CLAY (CL), grayish brown, stiff, moist, some highly weathered claystone fragments. (Colluvium)
	7 ½ - 10	CLAYSTONE, brownish gray, friable, very closely fractured, thick bedding, deep to moderate weathering.
		Bottom of test pit at 11 feet. Groundwater not encountered.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1-TP4	0 – 3	SILTY SAND (SM), brown, loose, moist, with clay, miscellaneous debris in upper 3 feet. (Fill)
	3– 6	SILTY CLAY (CL), yellowish brown, stiff, moist, with sand, trace organics. (Native)
	6 – 10	SANDY SILTY CLAY (CL), yellowish brown, stiff to very stiff, moist, some sandstone fragments.
	10 - 13	SANDSTONE, light yellowish brown, weak, closely fractured, very thick bedding, deep weathering.
	13 – 15	SANDSTONE, very light brown, moderately strong, widely fractured, massive, little weathering.
		Bottom of test pit at 15 feet. Groundwater not encountered.
1-TP5	0 – 1 ½	SILTY CLAY (CL), brown, stiff, moist, with sand.
	1 ½ - 2 ½	SANDSTONE, reddish yellowish gray, weak to friable, closely fractured, deep weathering.
	2 ½ - 6	SANDSTONE, light gray, moderately strong, widely fractured, thin bedding, little weathering.
		Bottom of test pit at 6 feet. Groundwater not encountered.
1-TP6	0 – 1 ½	SANDSTONE, gray and reddish brown, weak to friable, very closely fractured, very thick bedding, deep weathering.
	1 ½ - 8	SANDSTONE, gray and reddish brown, friable to moderately strong, moderately fractured, very thick bedding to massive, moderate weathering. Bottom of test pit at 8 feet. Groundwater not encountered.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1-TP7	0 – 1 ½	SILTY CLAY (CL), light grayish brown, medium stiff to stiff, dry to moist, with sand. (Fill)
	1 ½ - 8	SITLY CLAY (CL), brown, stiff, moist, trace sand. (Fill)
	8 - 10	SILTY CLAY (CL), yellowish grayish brown, stiff to very stiff, moist, trace sand. (Native)
	10 – 11	CLAYSTONE, gray, friable, very closely fractured, thin bedding, deep to moderate weathering.
		Bottom of test pit at 11 feet. Groundwater not encountered.
1-TP8	0 – 1	SILTY CLAY (CL), light grayish brown and yellowish brown, stiff, moist, with sand.
	1 - 3 ½	CLAYSTONE, reddish brown and brown, weak, crushed, deep weathering, no apparent bedding.
	3 ½ - 10	CLAYSTONE, gray and yellowish brown, friable, very closely fractured, very thin bedding, deep to moderate weathering.
		Bottom of test pit at 10 feet. Groundwater not encountered.
1-TP9	0 – 2 ½	SANDY CLAY (CL), yellowish brown, soft to medium stiff, moist, with silt. (Colluvium.)
	2 ½ -5	SITLY SAND (SM), grayish brown, medium dense to dense, saturated, some clay.
	5 – 10	SANDSTONE, grayish brown, friable, moderately fractured, massive, deep to moderate weathering.
		Bottom of test pit at 10 feet. Perched groundwater at 2 ½ feet.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1-TP10	0 – 1	SILTY SAND (SM), brown, medium dense, moist, with clay. (Colluvium)
	1 – 3 ½	SILTY SAND (SM), grayish brown, very loose, saturated, trace clay, perched groundwater over bedrock.
	3 ½ - 5	SANDSTONE, grayish brown, friable to moderately strong, massive, deep to moderate weathering.
		Bottom of test pit at 5 feet. Perched groundwater at 3 ½ feet.
1-TP11	0 – 3 ½	SILTY SAND (SM), light yellowish brown, loose, moist. (Fill)
	3 ½ - 9	Manure, very dark brown to black, soft.
	9 – 12	SILTY SAND (SM), grayish brown, very loose, saturated. (perched water)
	12 – 13	SANDSTONE, grayish brown, dense, wet, weak to friable, massive, deep to moderate weathering.
		Bottom of test pit at 13 feet. Perched groundwater encountered at 9 feet.
1-TP12	0 – 5	CLAY (CH), dark grayish brown, stiff to very stiff, moist. (Colluvium)
	5 – 8	CLAYSTONE, white and yellowish brown, friable, very closely fractured, thin to thick bedding, deep weathering.
	8-10	CLAYSTONE, grayish and yellowish brown, friable, very closely fractured, thin to thick bedding, deep to moderate weathering.
		Bottom of test pit at 10 feet. Groundwater not encountered.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1-TP13	0 – 4	CLAY (CL-CH), very dark brown, stiff to very stiff, moist, with silt, some clay. (Colluvium)
	4 – 6 ½	CLAY (CL), yellowish brown, stiff to very stiff, moist, with silt and sand.
	6 ½ - 13	CLAYSTONE, olive brown, stiff to very stiff, moist, crushed, thin bedding, deep weathering.
	13 – 15	CLAYSTONE/SLATE, moderately strong, widely to moderately fractured, laminated moderate weathering.
		Bottom of test pit at 15 feet. Groundwater not encountered.
1-TP14	0 – 3 ½	CLAY (CL-CH), dark brown, moist, with silt and sand. (Colluvium)
	3 ½ - 6	SANDY CLAY (CL), yellowish brown, very stiff to hard, moist.
	6 - 9	SANDSTONE, yellowish brown, weak to friable, widely to moderately fractured, massive, deep weathering.
	9 – 11	SANDSTONE, light brown, friable to moderately strong, very widely fractured, massive, moderate weathering.
		Bottom of test pit at 11 feet. Groundwater not encountered.
1-TP15	0 – 1	SILTY CLAY (CL), light grayish brown, medium stiff, moist. (Fill)
	1 – 4	CLAY (CL-CH), very dark grayish brown, medium stiff to stiff, moist, with silt. (Fill)
	4 – 11	SILTY SAND (SM), very dark gray and brown, stiff, moist, with clay, mixtures of silty sand and blocky clay. (Fill)
	11 - 13	CLAY (CH), very dark grayish brown, stiff, moist, with silt, some organics. (Fill)

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
	13 – 14	SAND (SM), dark gray, medium dense, moist, with silt. (Native)
	14 – 15 ½	CLAY (CH), very dark gray, very stiff, moist, with silt, trace organics.
		Bottom of test pit at 15 ½ feet. Groundwater not encountered.
1-TP16	0 – 3	CLAY (CL-CH), dark grayish brown, stiff, moist, with silt. (Colluvium)
	3 – 6	SANDSTONE, light grayish brown, friable to moderately strong, closely fractured, massive, moderate weathering.
	6 – 7	CLAYSTONE, dark gray, friable to moderately strong, very closely fractured, thin bedding, moderate weathering.
	7 – 8	SANDSTONE, dark brownish gray, moderately strong, widely fractured, massive, moderate to little weathering.
		Bottom of test pit at 8 feet. Groundwater not encountered.
1- TP17	0 – 1 ½	SILTY CLAY (CL), brown, stiff, moist, with sand.
	1 ½ - 4 ½	SANDSTONE, brownish gray, moderately strong, widely fractured, massive, moderate to little weathering.
		Bottom of test pit at 4 ½ feet. Groundwater not encountered.
1-TP18	0 – 3	SILTY CLAY (CL), brown, soft to medium soft, with sand, miscellaneous debris. (Fill)
	3 – 4 ½	SILTY CLAY (CL), light yellowish brown, stiff, moist. (Native)
	4 ½ - 6	SANDSTONE, light grayish brown, friable to moderately strong, widely fractured, massive, moderate weathering.
		Bottom of test pit at 6 feet. Groundwater not encountered.

SAND CREEK RANCH
ANTIOCH, CALIFORNIA

TEST PIT LOGS

Test Pit Number	Depth (Feet)	Description
1- TP19	0 – 4 ½	CLAY (CL-CH), very dark brown, stiff to very stiff, moist, with silt, trace sand (Colluvium)
	4 ½ - 14	SILTY CLAY (CL), grayish brown, very stiff, moist, with sand.
	14 - 15	SANDSTONE, light yellowish brown, friable, moderately fractured, massive, deep to moderate weathering.
		Bottom of test pit at 14 feet. Groundwater not encountered.
1-TP20	0 – 2	SILTY CLAY (CL), grayish brown, stiff, with sand.
	2 – 6	SANDSTONE, light grayish brown, moderately strong, widely fractured, massive, moderate weathering.
		Bottom of test pit at 6 feet. Groundwater not encountered.
1-TP21	0 – 1 ½	SILTY CLAY (CL-CH), grayish brown, stiff, moist.
	1 ½ - 3	CLAYSTONE, gray and yellowish brown, friable, very closely fractured, very thin bedding to laminating, deep weathering.
	3 – 6	SANDSTONE, olive gray, moderately strong, widely fractured, massive, moderate weathering.
		Bottom of test pit at 6 feet. Groundwater not encountered.
1-TP22	0 – 1 ½	SILTY CLAY (CL), grayish brown, stiff, dry to moist, with sand.
	1 ½ - 4 ½	SANDSTONE, gray and yellowish brown, moderately strong, widely to moderately fractured, massive, moderate weathering.

TEST PIT LOGS

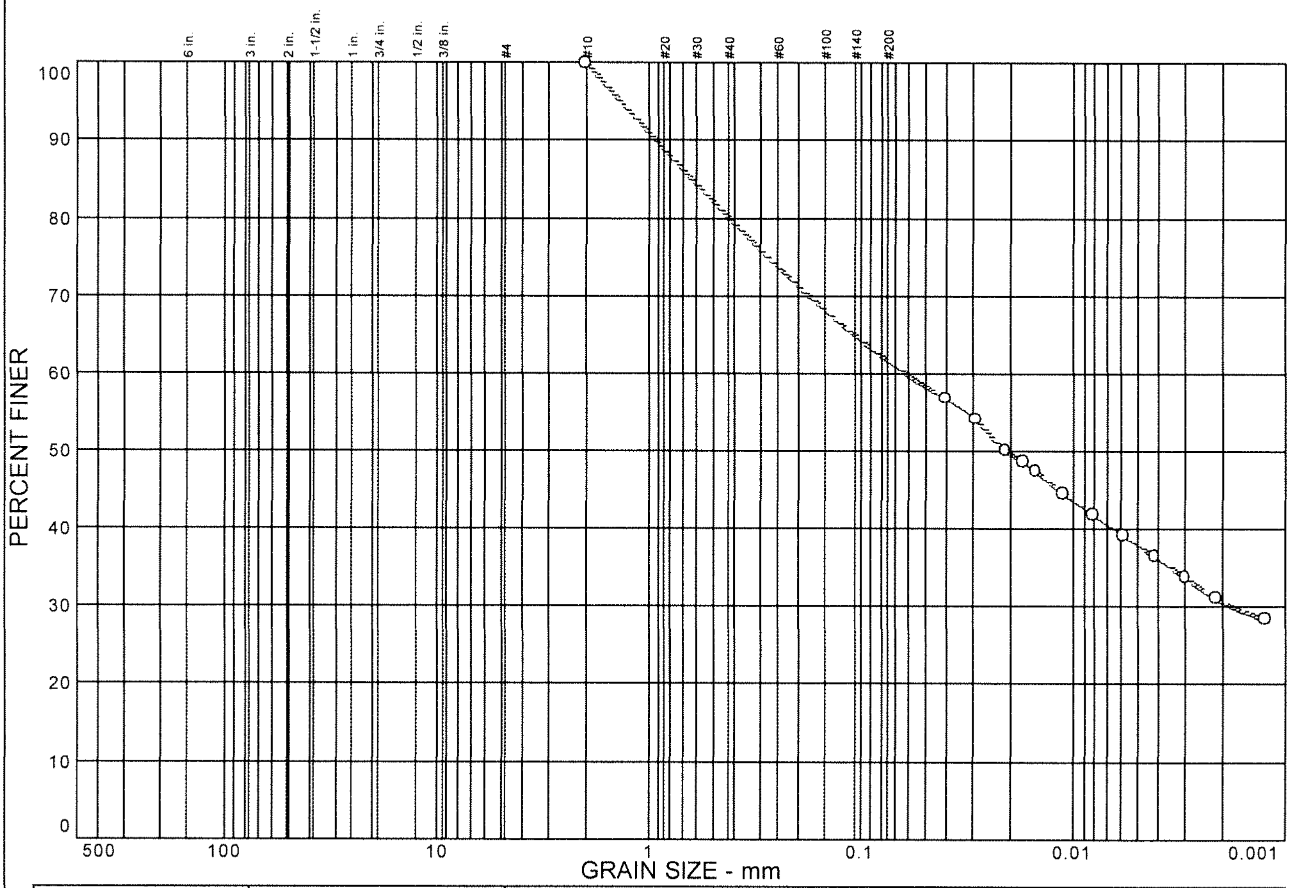
Test Pit Number	Depth (Feet)	Description
		Bottom of test pit at 4 ½ feet. Groundwater not encountered.
1-TP23	0 – 2	SILTY SAND (SM), grayish brown, stiff, moist, with clay.
	2 – 4	SANDSTONE, light brownish gray, moderately strong, widely fractured, massive, moderate weathering.
		Bottom of test pit at 4 feet. Groundwater not encountered.

APPENDIX B

Laboratory Test Results

Plasticity Index Charts
Grain Size Distribution Curves
Direct Shear Tests
Unconfined Compression Tests

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=

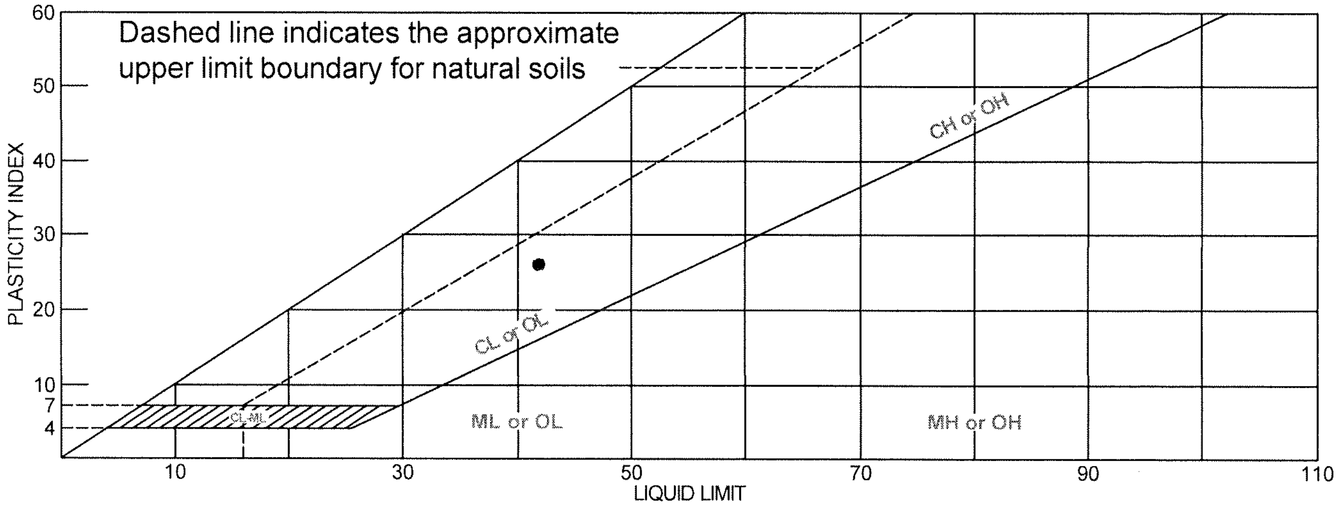
Remarks

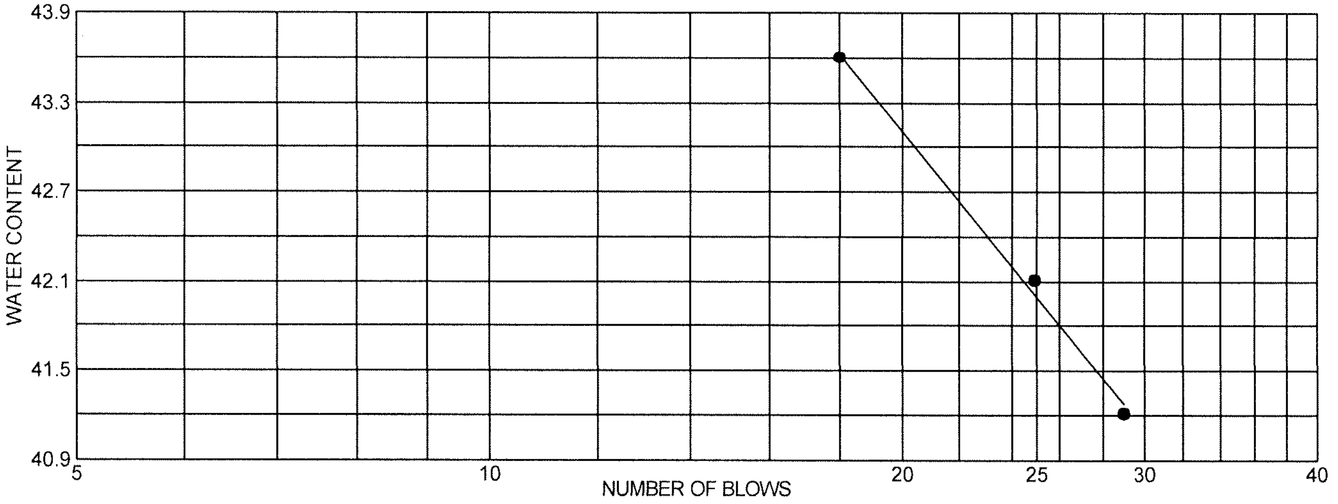
Sample No.: B3 @ 2.5' **Source of Sample:** **Date:** 3-31-06
Location: **Elev./Depth:** 2.5'

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'

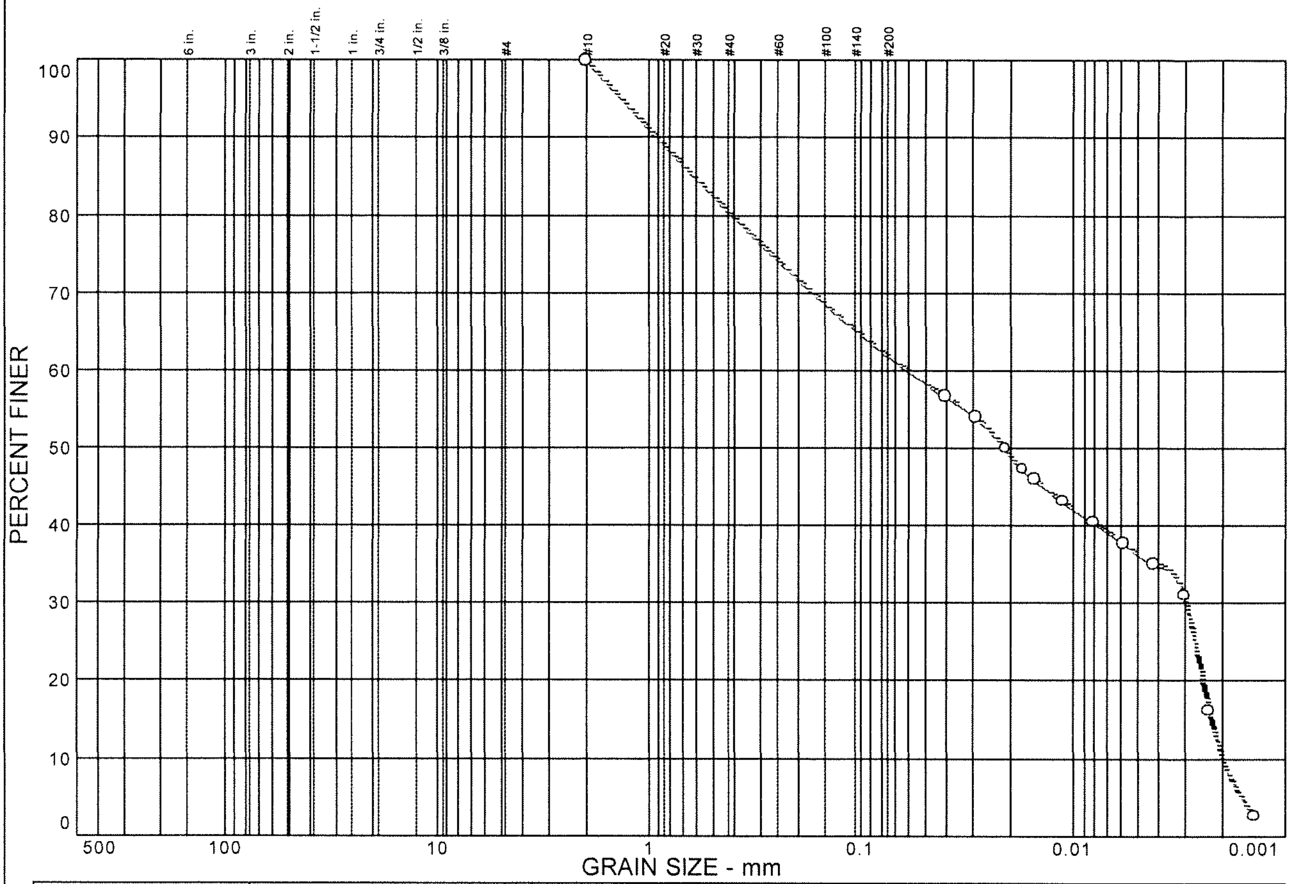
Remarks:

●

ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	38.1	25.6	36.3

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

* (no specification provided)

Soil Description

Atterberg Limits

PL= 13 LL= 36 PI= 23

Coefficients

D_{85}= 0.613 D_{60}= 0.0606 D_{50}= 0.0211
D_{30}= 0.0030 D_{15}= 0.0022 D_{10}= 0.0020
C_u= 30.50 C_c= 0.07

Classification

USCS= AASHTO=

Remarks

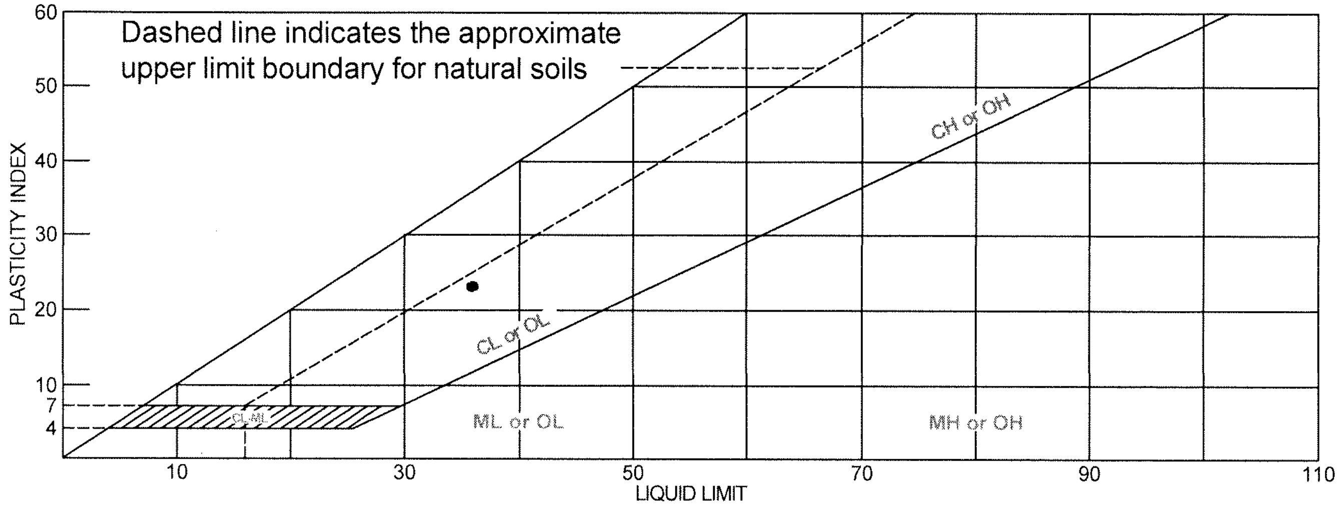
Sample No.: B5 @ 2' **Source of Sample:** **Date:** 3-31-06
Location: **Elev./Depth:** 2'

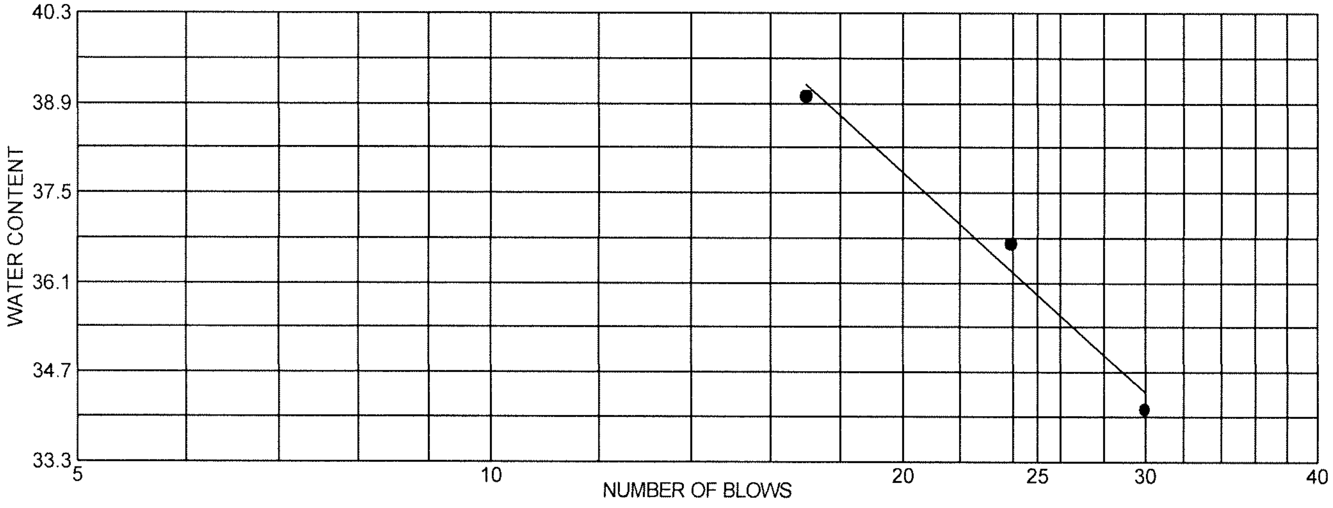
ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

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
●		36	13	23	80.5	61.9	

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B5 @ 2' **Elev./Depth:** 2'

Remarks:

●

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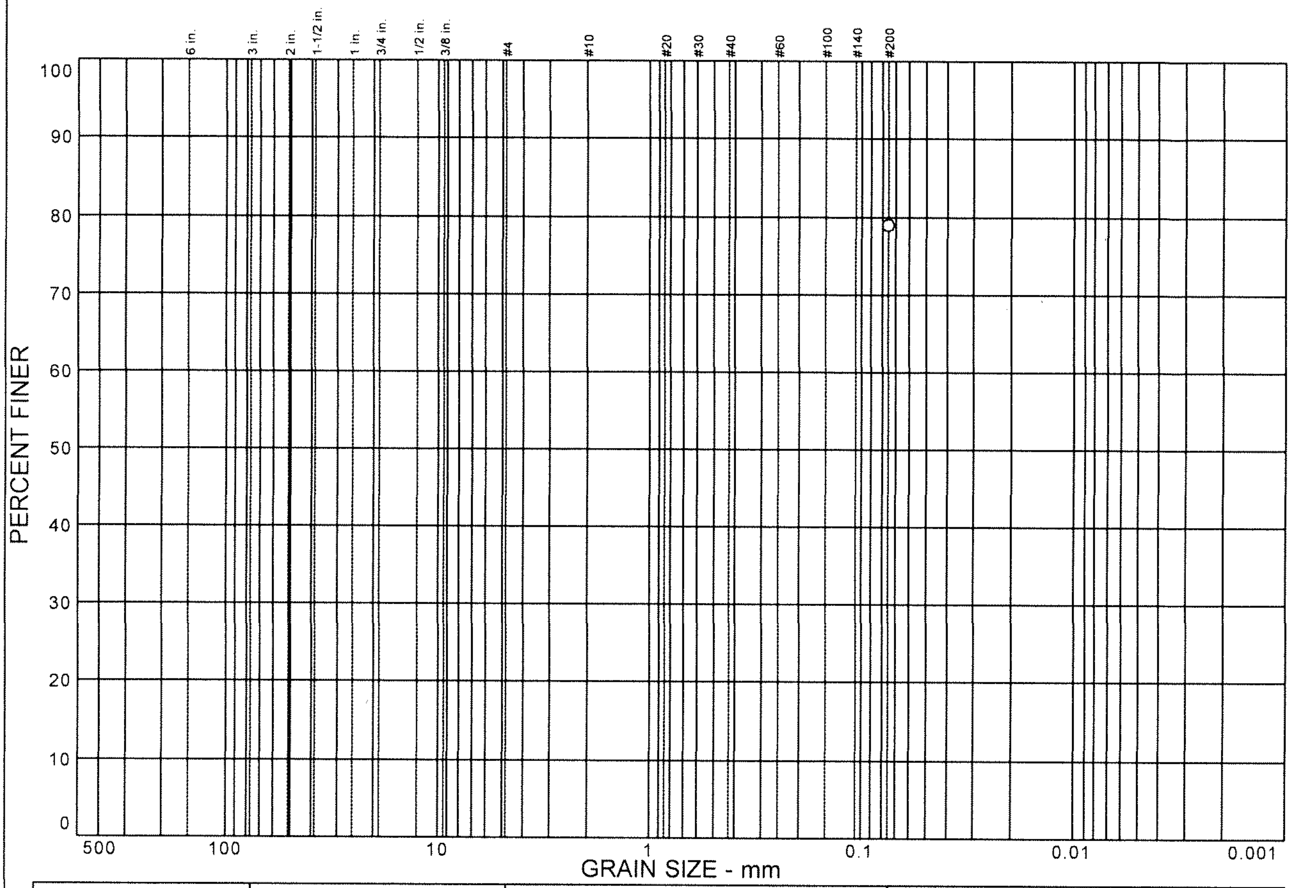
GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

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'

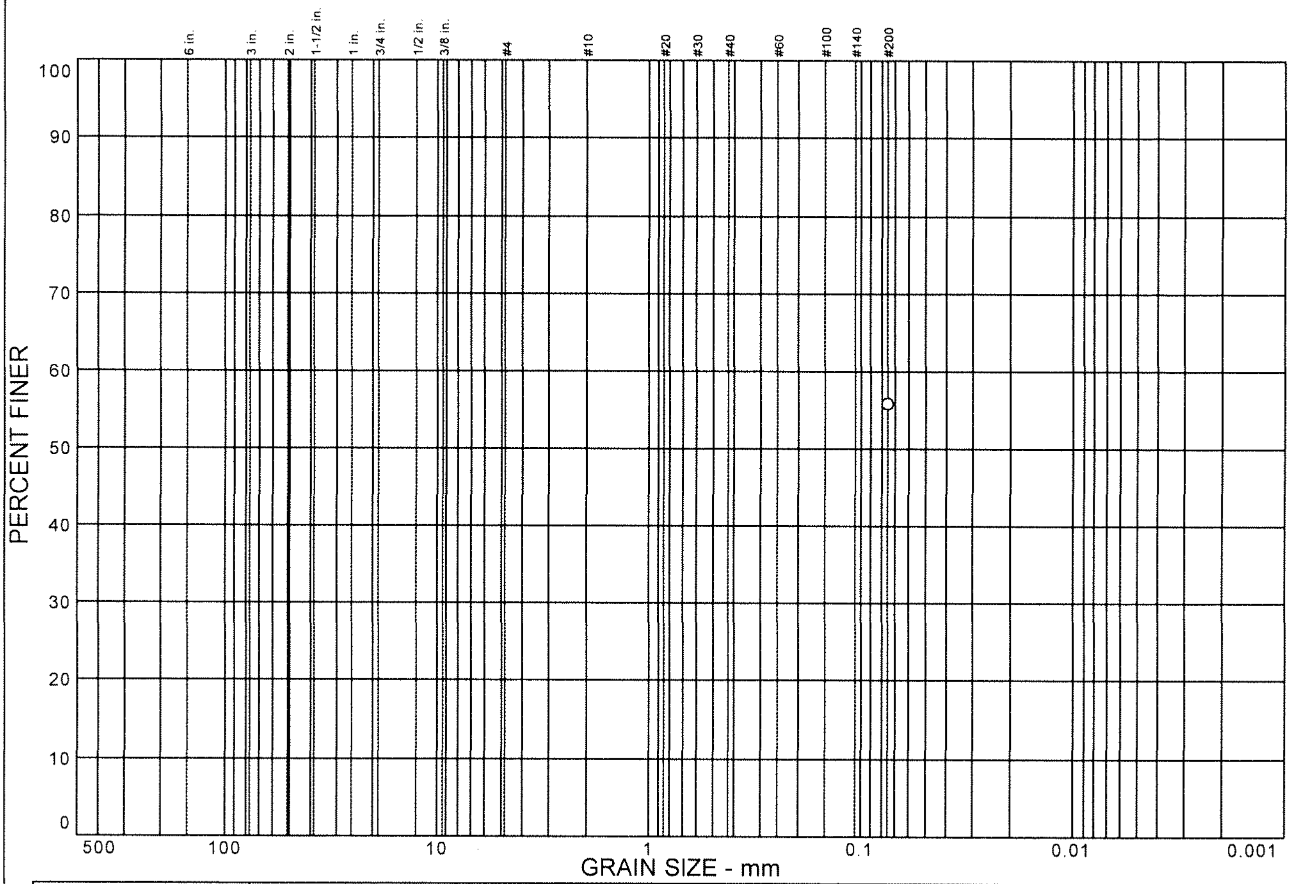
ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

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=

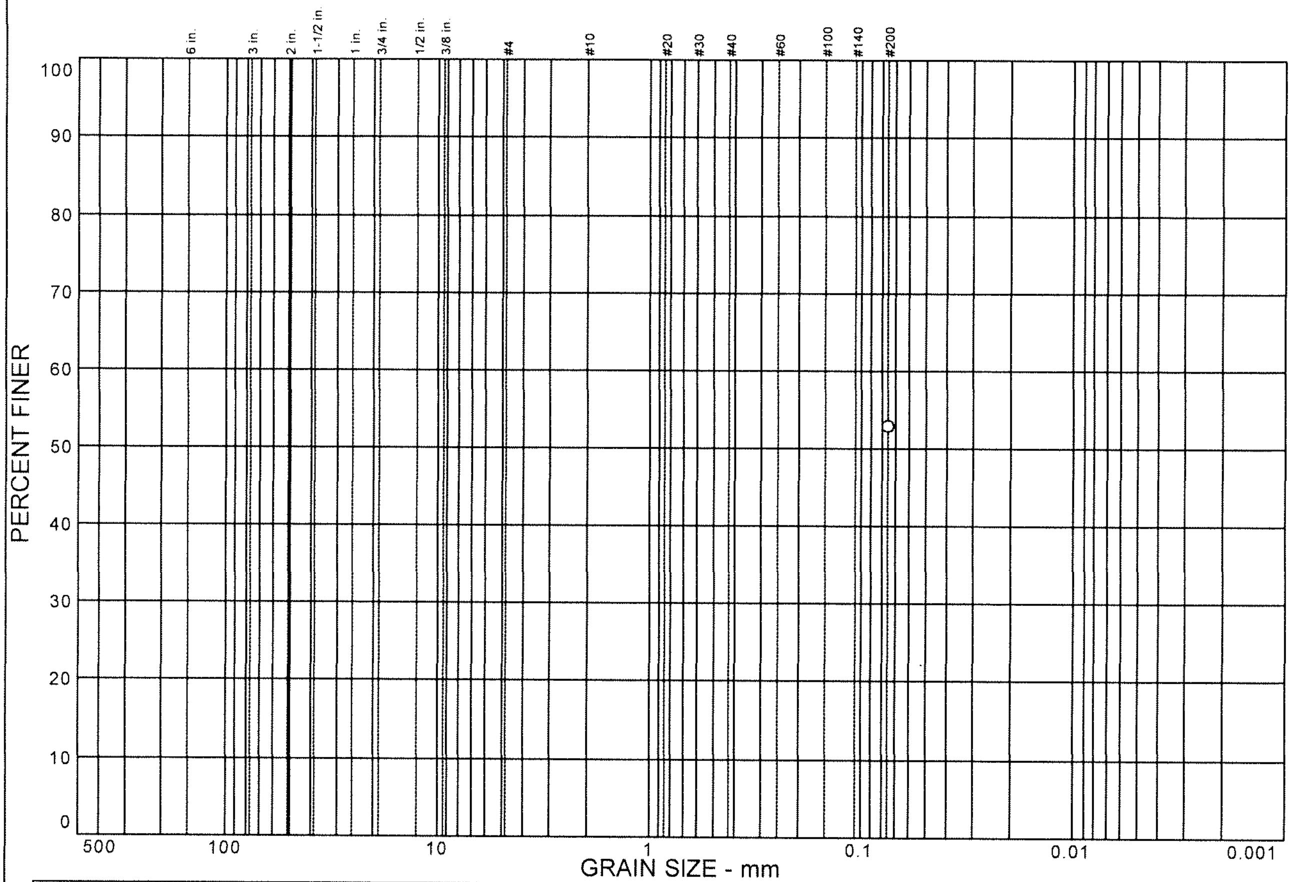
Remarks

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
			52.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	52.7		

* (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=

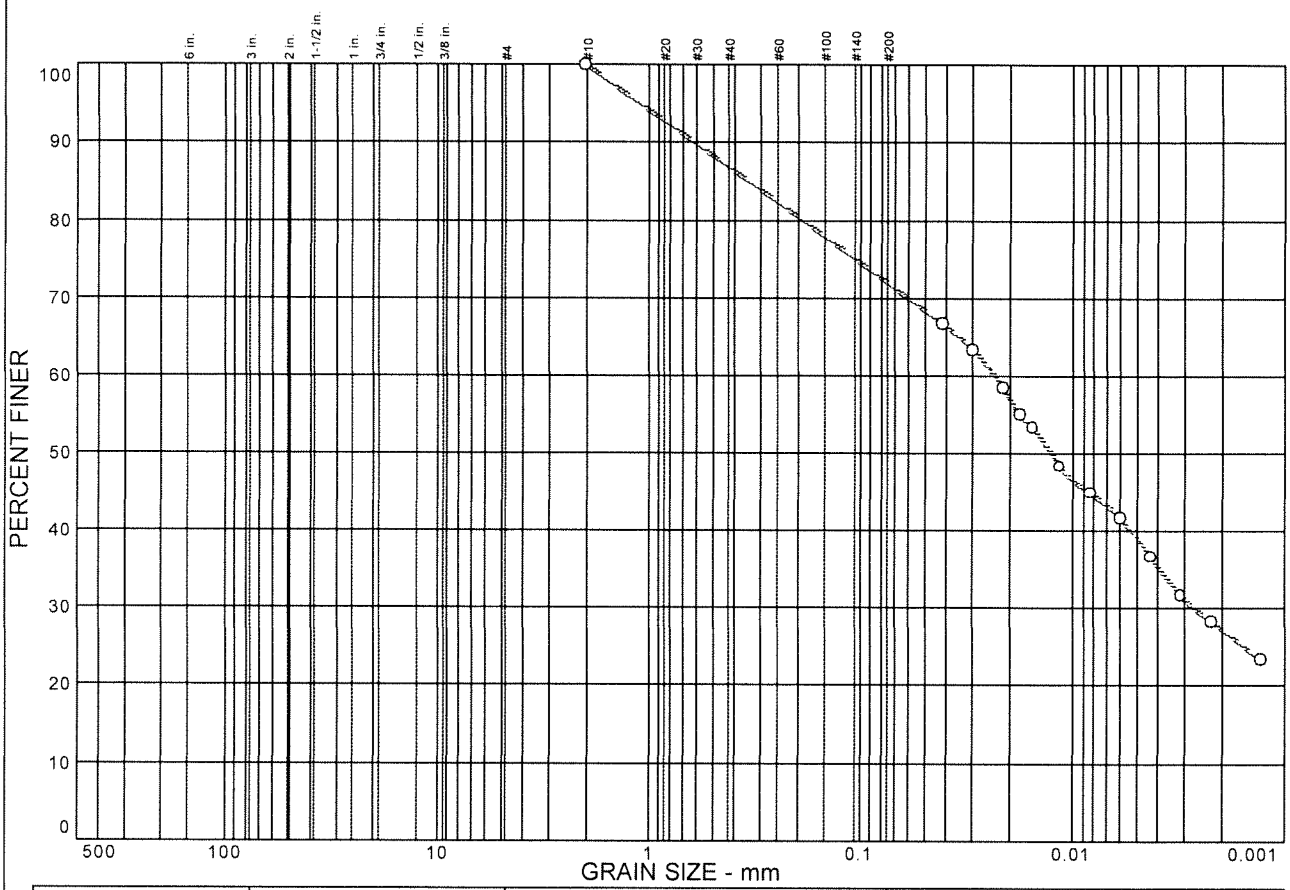
Remarks

Sample No.: B11 @ 13' **Source of Sample:** **Date:** 5-8-06
Location: **Elev./Depth:** 13'

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

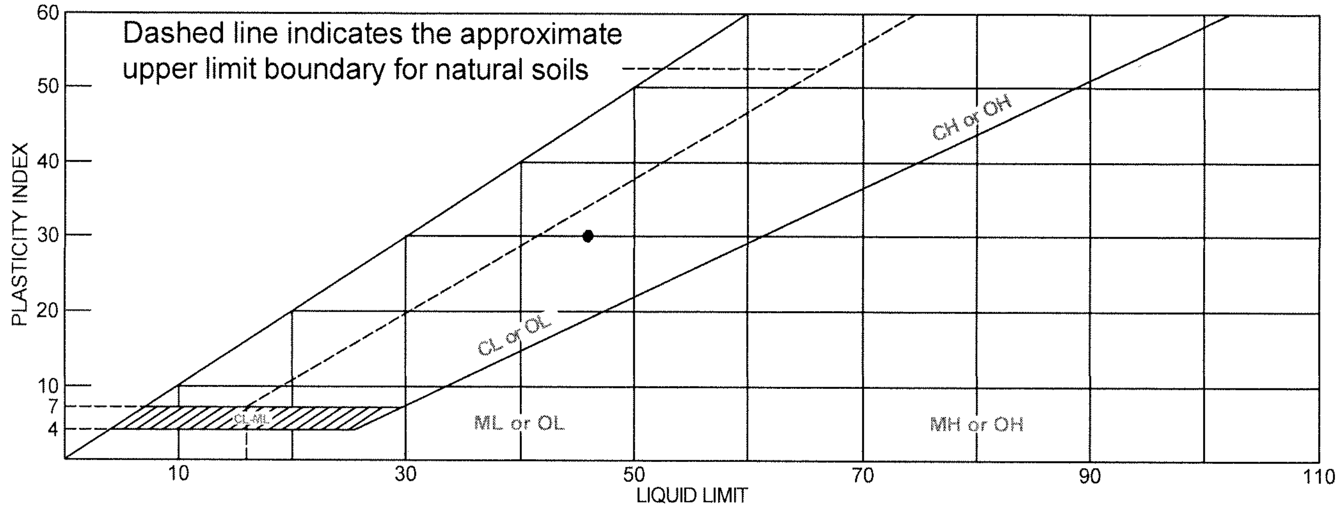
Sample No.: B14 @ 3' **Source of Sample:** **Date:** 5-9-06
Location: **Elev./Depth:** 3'

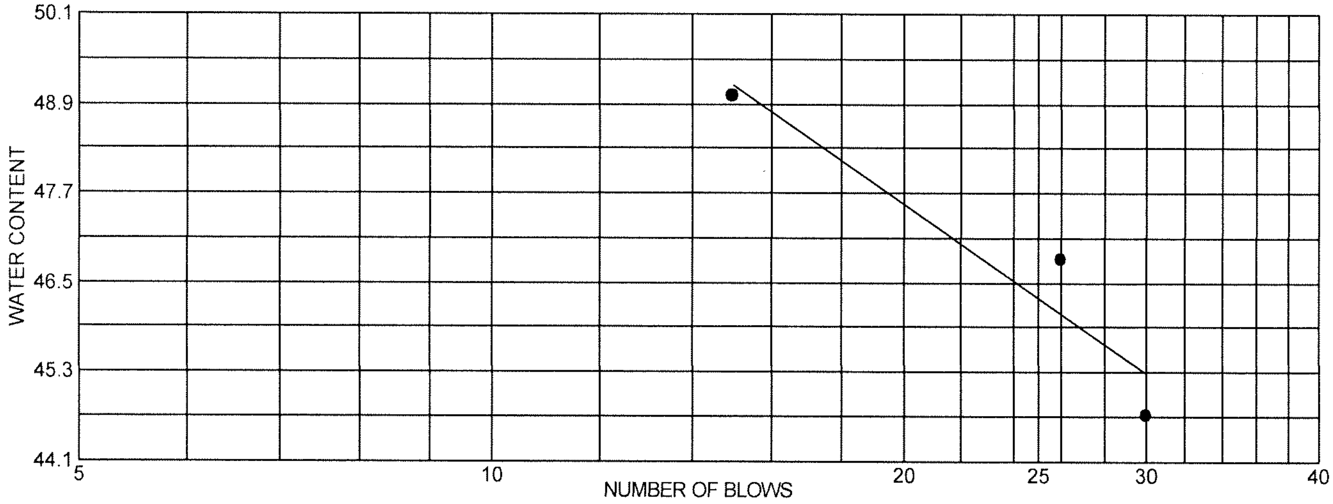
ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

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

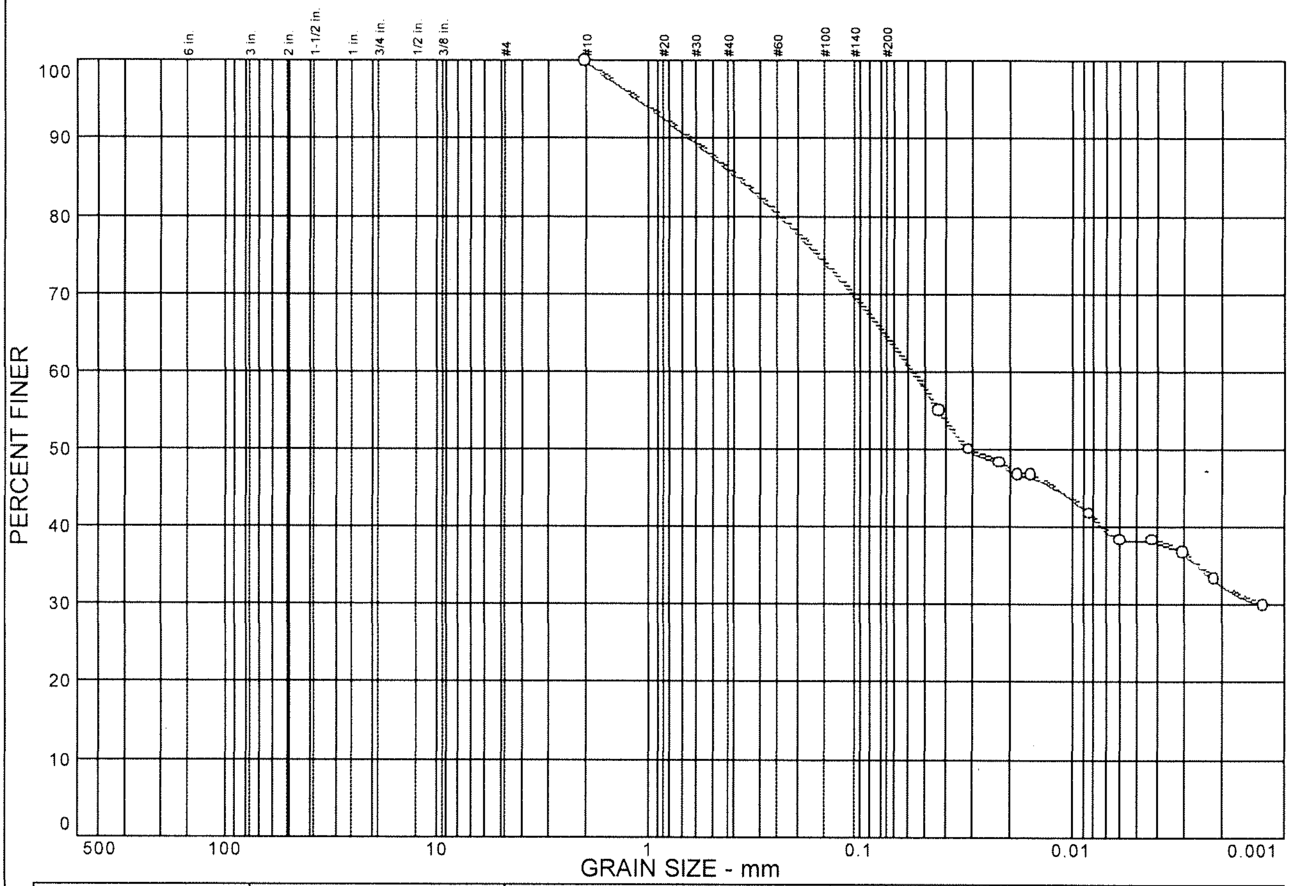
● **Source:** **Sample No.:** B14 @ 3' **Elev./Depth:** 3'

ENGEO
INCORPORATED
GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Remarks:
●

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	35.6	26.1	38.3

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}= 0.381 D_{60}= 0.0573 D_{50}= 0.0312
D_{30}= 0.0013 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

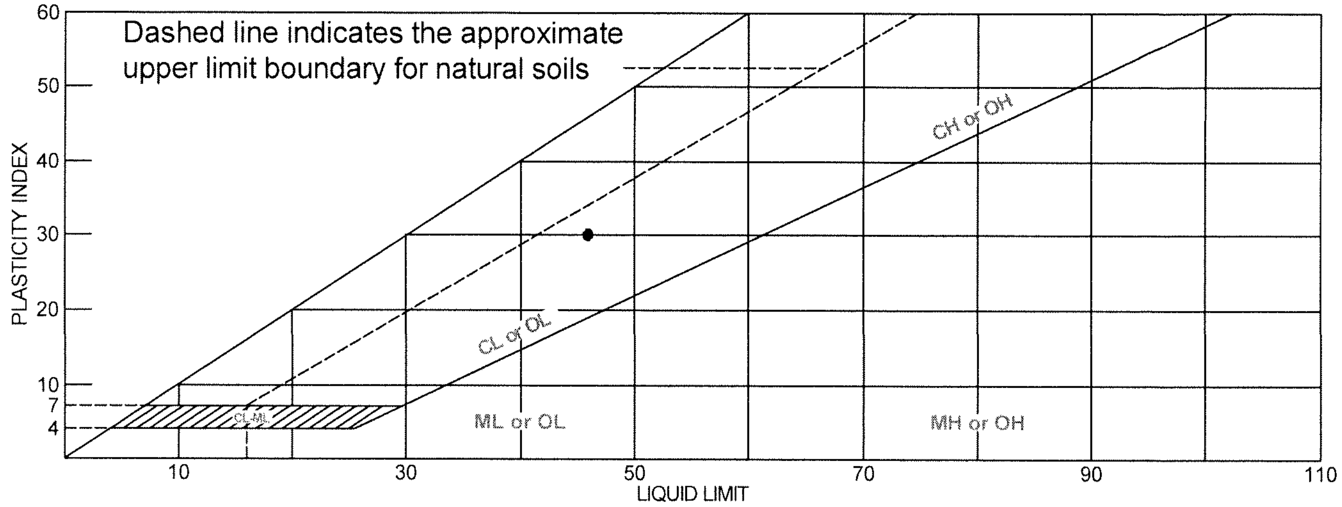
Remarks

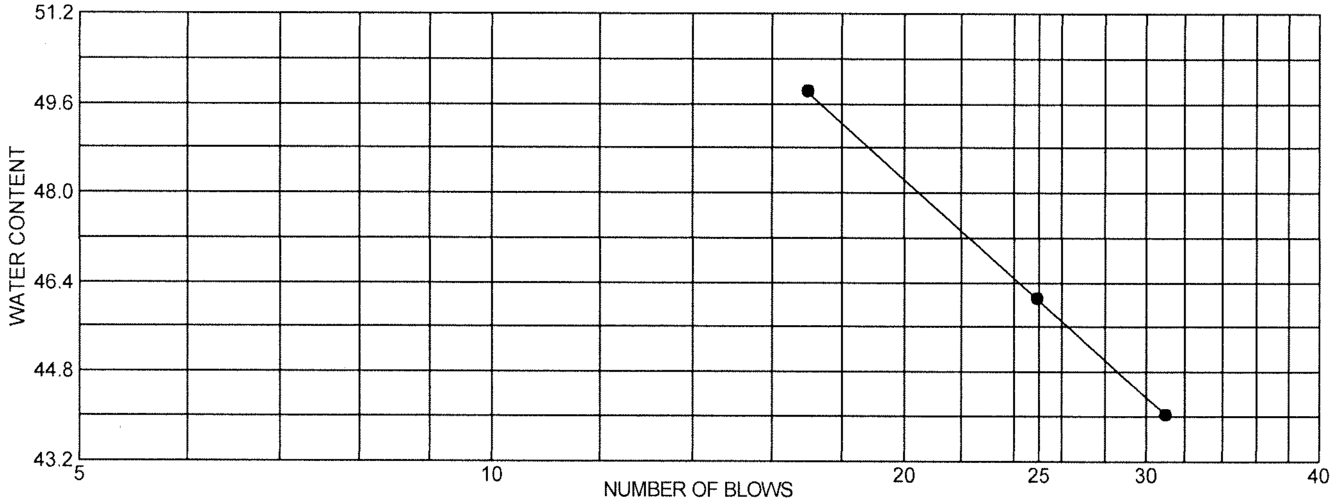
Sample No.: B18 @ 2' **Source of Sample:** **Date:** 5-9-06
Location: **Elev./Depth:** 2'

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	86.1	64.4	

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B18 @ 2' **Elev./Depth:** 2'

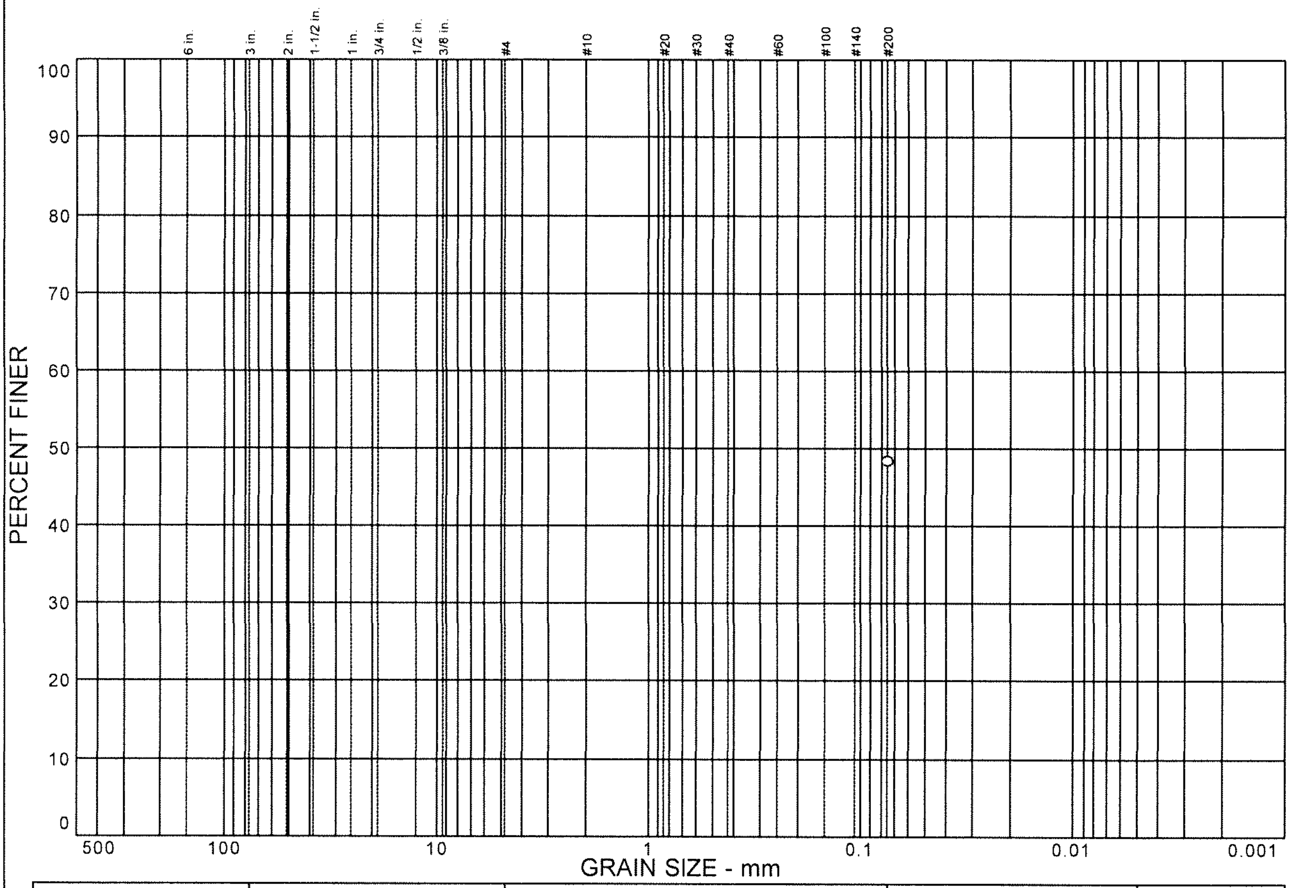
Remarks:

●

ENGEO
INCORPORATED
GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
			48.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	48.3		

* (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=

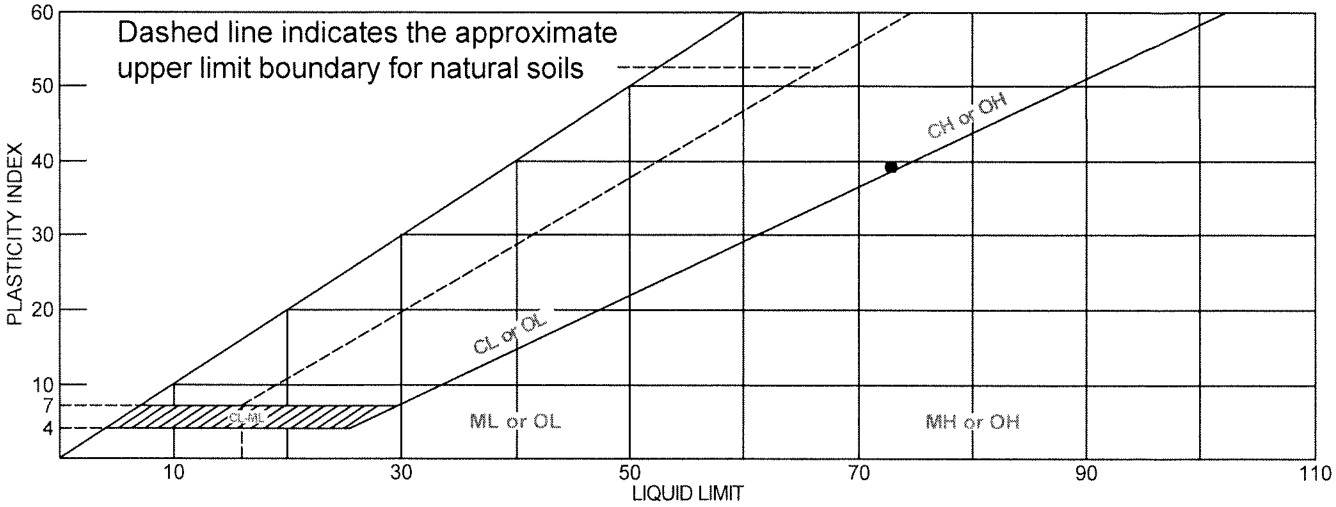
Remarks

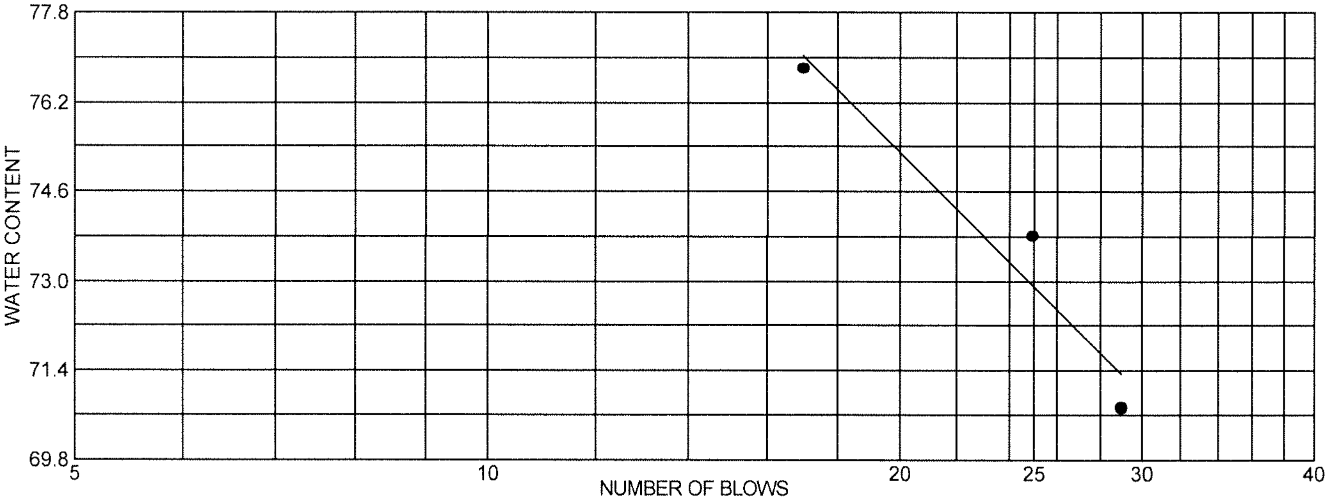
Sample No.: B20 @ 16' **Source of Sample:** **Date:** 5-8-06
Location: **Elev./Depth:** 16'

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
●		73	34	39			

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B23 @ 11' **Elev./Depth:** 11'

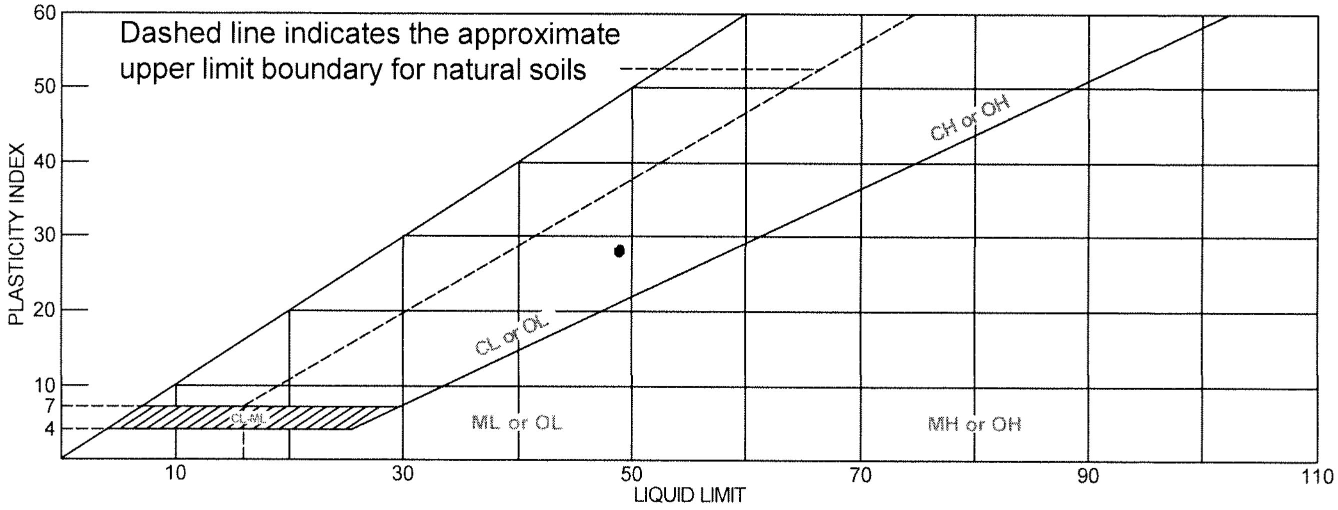
Remarks:

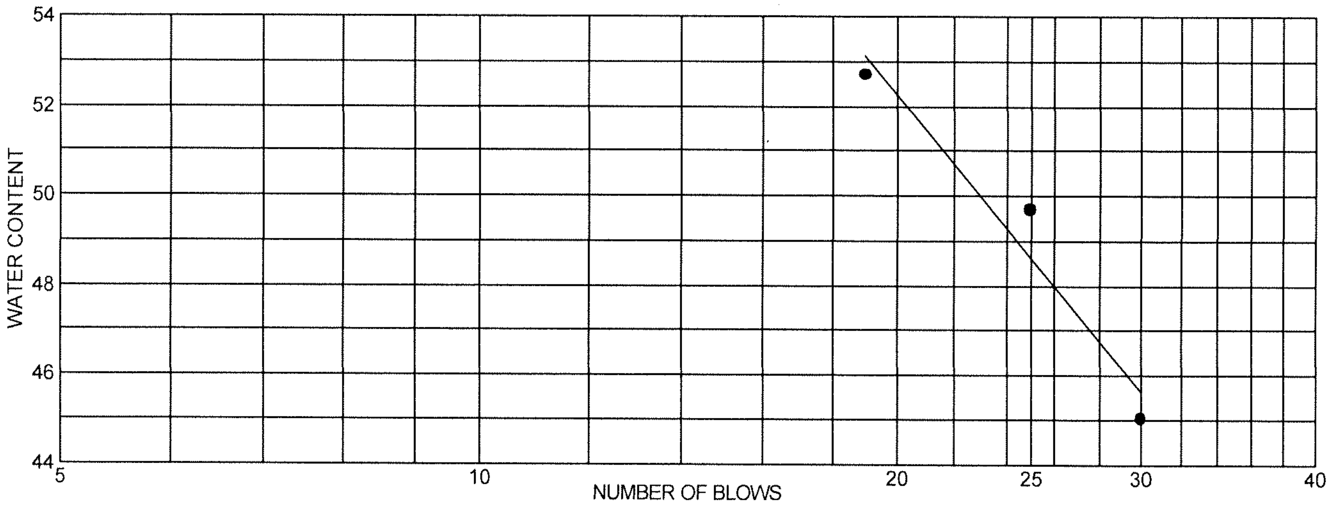
●

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'

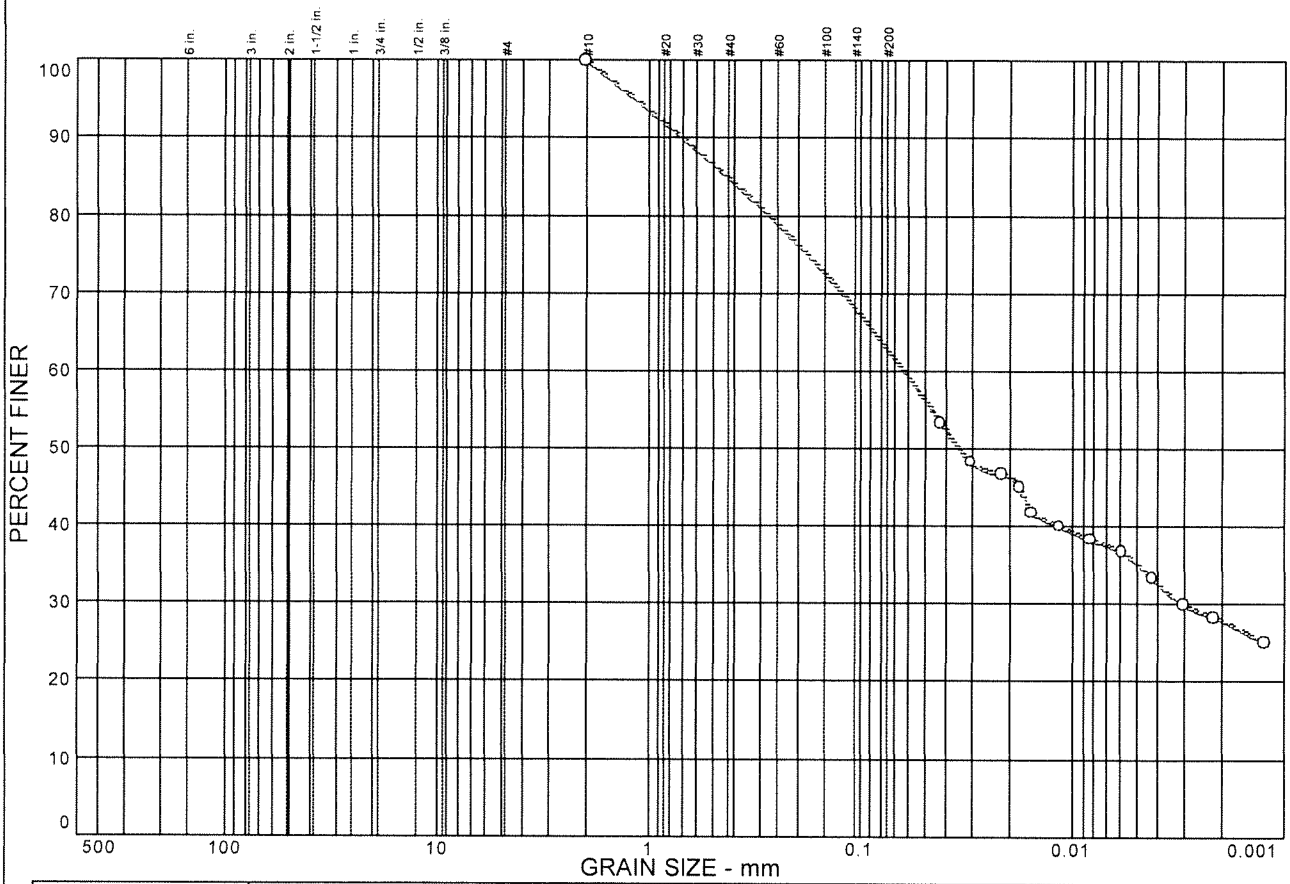
Remarks:

●

ENGEO
INCORPORATED
GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	37.3	27.6	35.1

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

* (no specification provided)

Soil Description

Atterberg Limits

PL= 12 LL= 37 PI= 25

Coefficients

D_{85}= 0.430 D_{60}= 0.0630 D_{50}= 0.0349
D_{30}= 0.0030 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

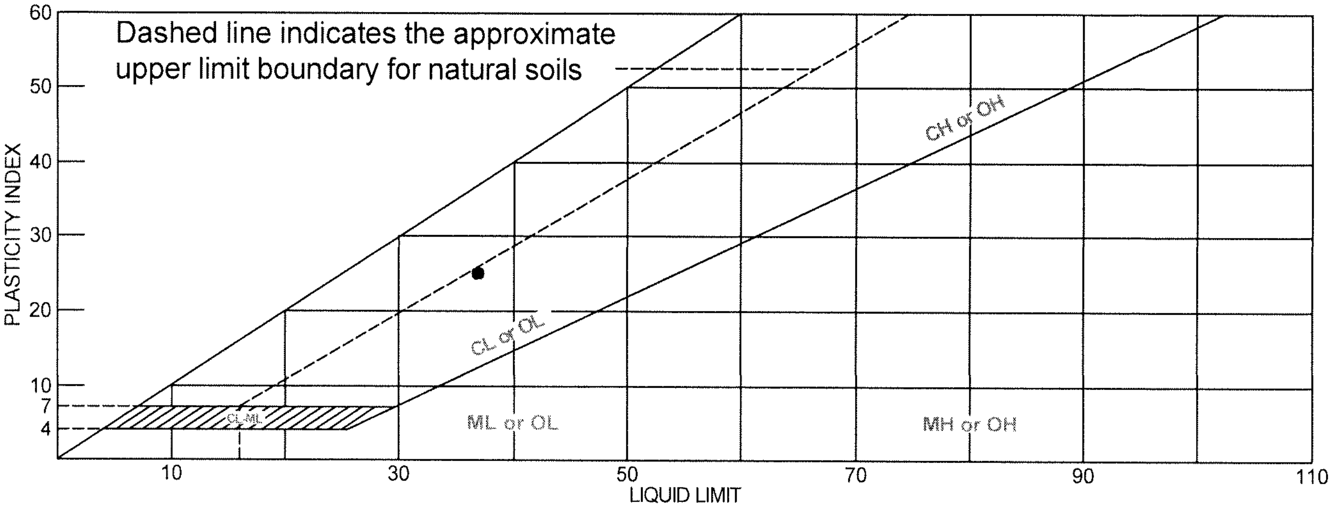
Sample No.: B37 @ Surface **Source of Sample:** **Date:** 5-12-06
Location: **Elev./Depth:** Surface

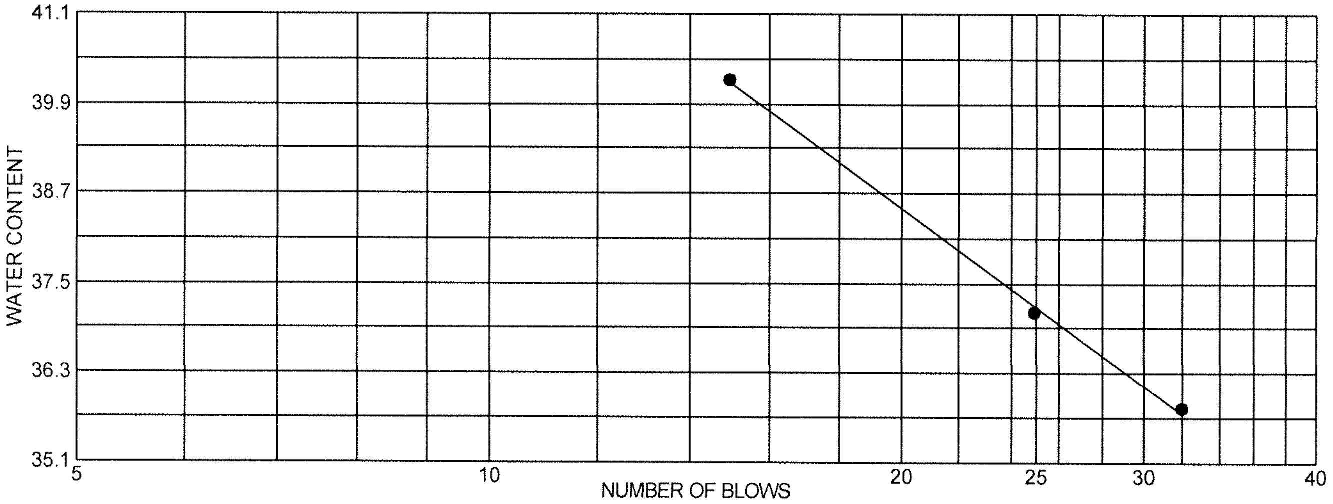
ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

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
●		37	12	25			

Project No. 4371.4.050.01 **Client:**

Project: Sand Creek Ranch

● **Source:** **Sample No.:** B37 @ **Elev./Depth:** Surface

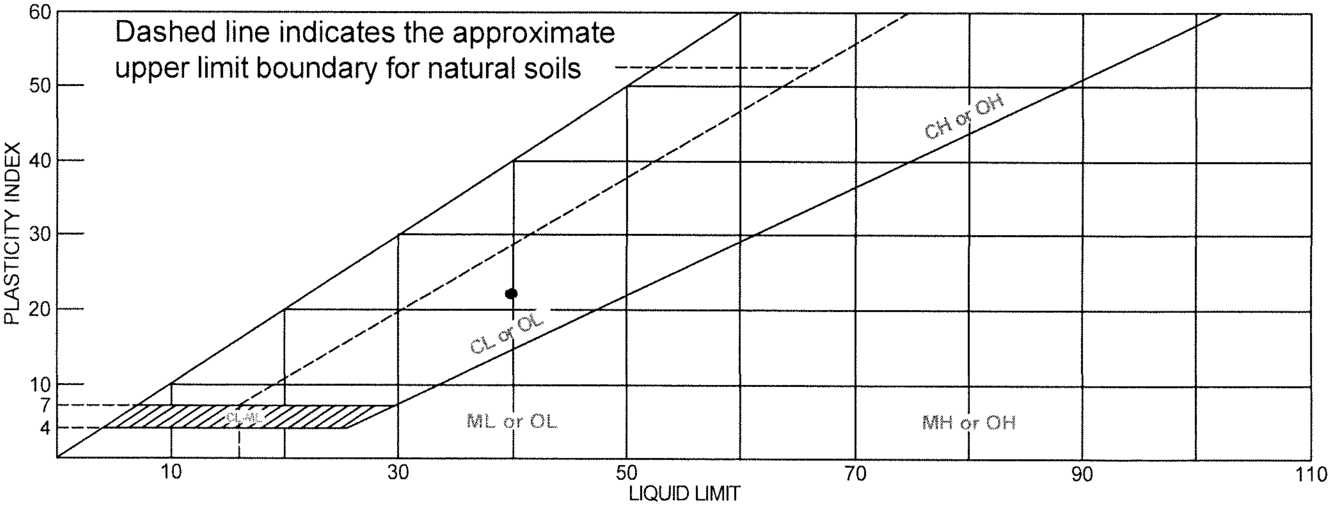
Remarks:

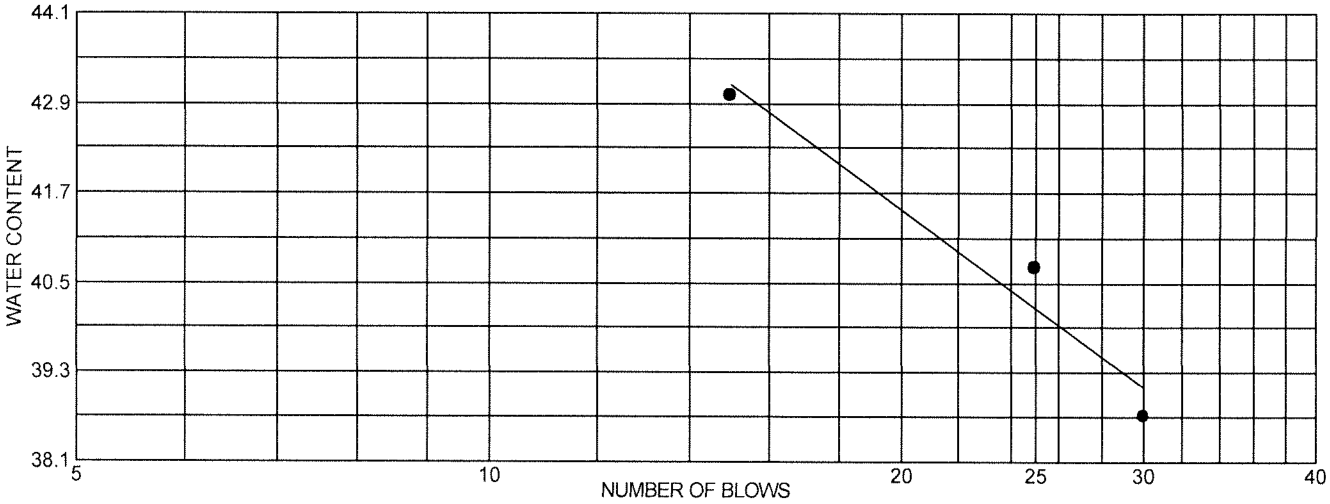
●

ENGEO INCORPORATED GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS MATERIALS TESTING

Plate

LIQUID AND PLASTIC LIMITS TEST REPORT


Dashed line indicates the approximate upper limit boundary for natural soils



	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'

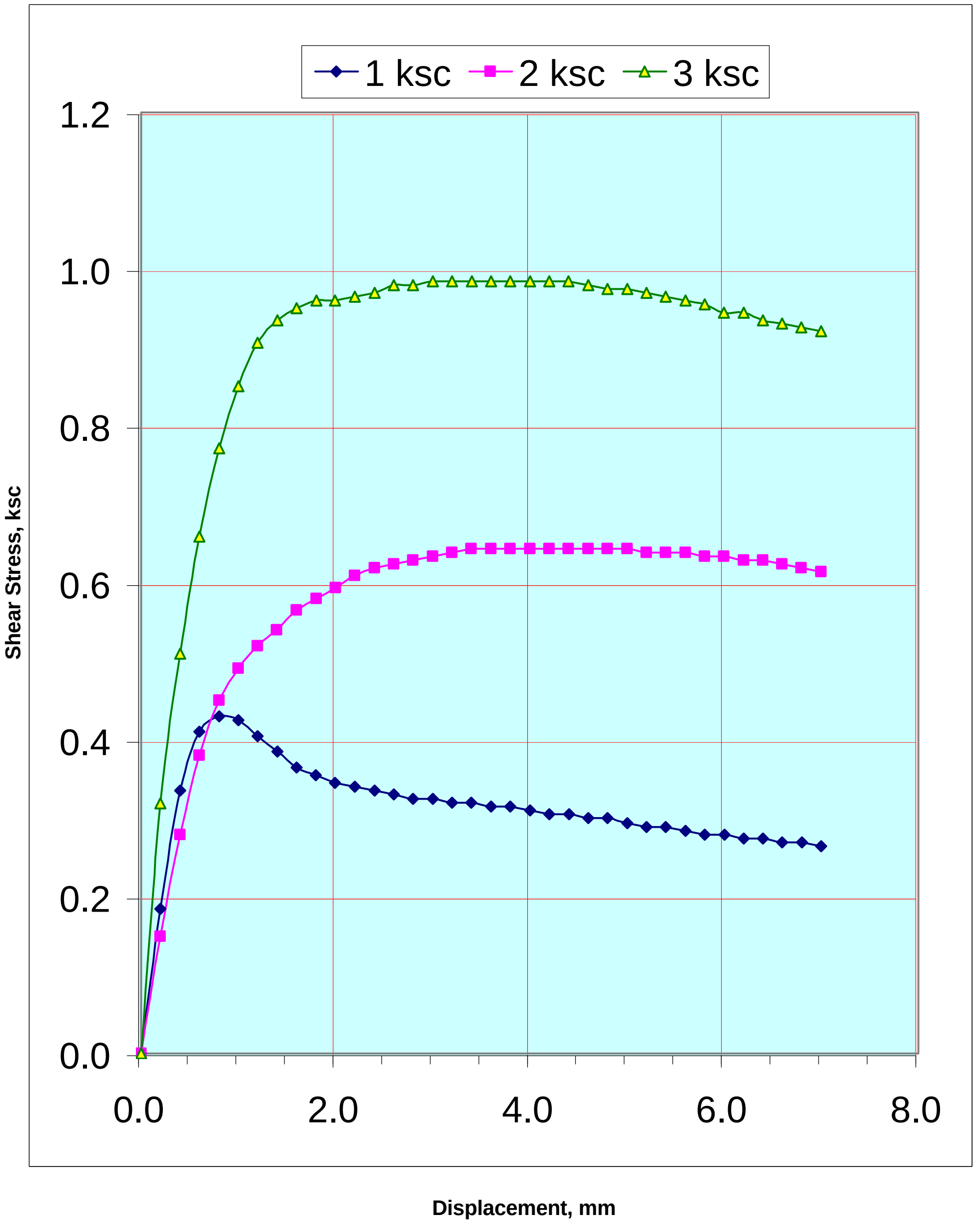
Remarks:

●

ENGEO
INCORPORATED
GEOTECHNICAL AND
ENVIRONMENTAL CONSULTANTS
MATERIALS TESTING

Plate

Direct Shear Test
ASTM Test Method D3080



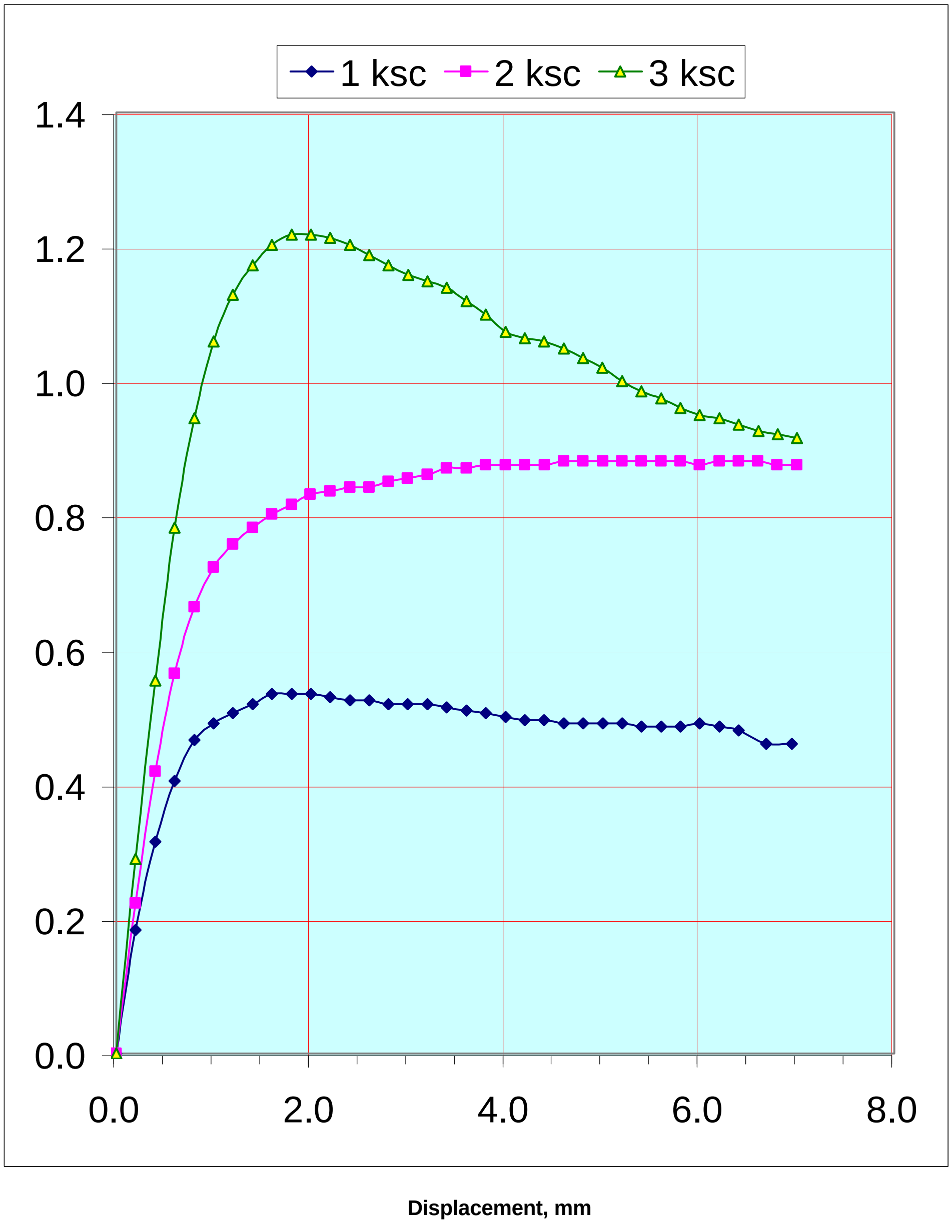
6

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



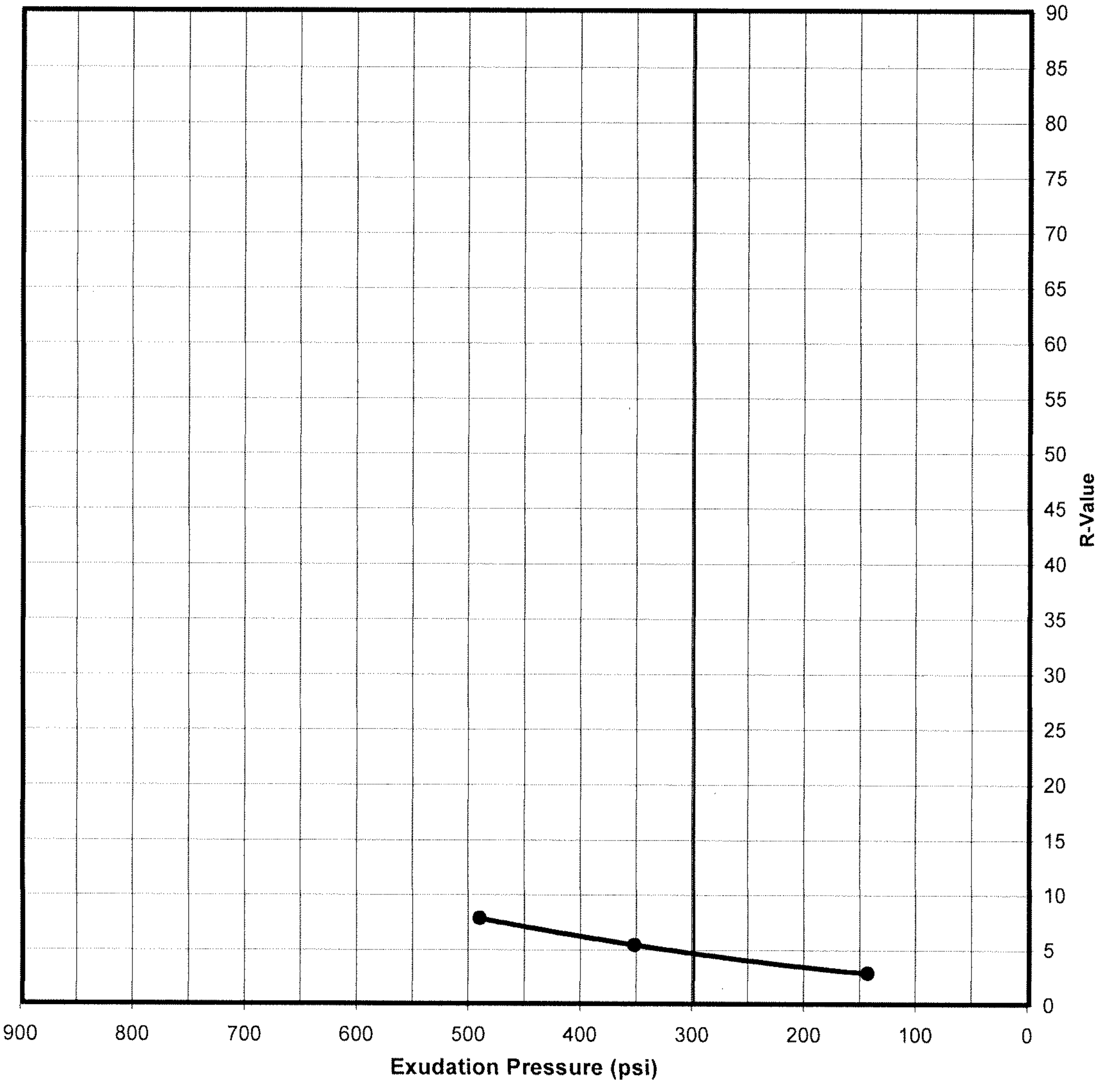
6

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**

R VALUE TEST REPORT
CAL-301

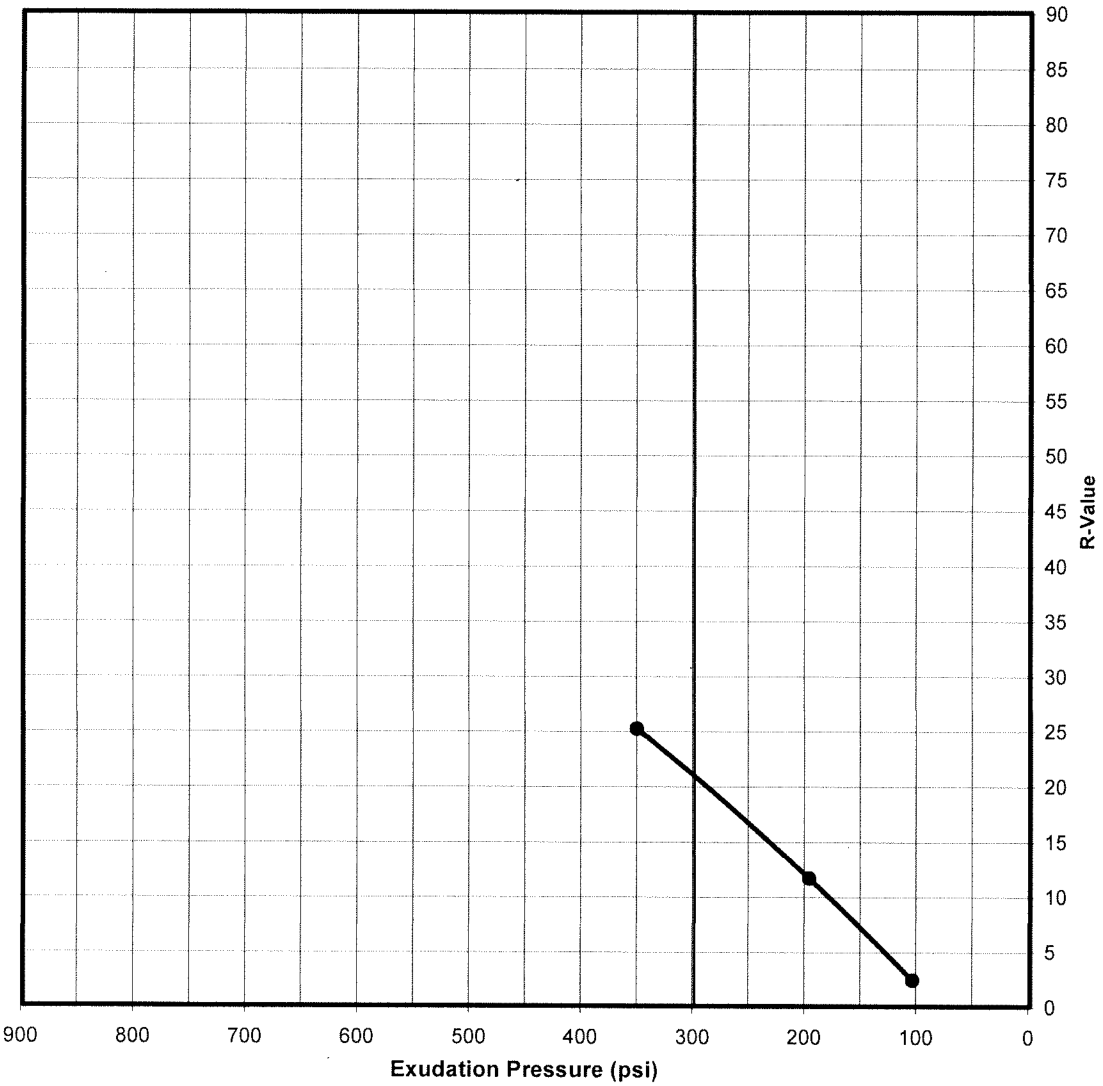


Date: 5/10/06
Project Name: Sand Creek
Project Number: 4371.4.050.01
Sample: Rv #1@surface
Description: Dark grayish brown CLAY

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 INCORPORATED

R VALUE TEST REPORT
CAL-301



Date: 5/10/06
Project Name: Sand Creek
Project Number: 4371.4.050.01
Sample: Rv #2@surface
Description: Dark grayish brown sandy CLAY

Specimen	A	B	C
Exudation Pressure, p.s.i.	352	197	105
Expansion dial (.0001")	14	0	0
Expansion Pressure, p.s.f.	61	0	0
Resistance Value, "R"	25	12	2
% Moisture at Test	13.4	16.2	20.9
Dry Density at Test, p.c.f.	115.8	109.0	100.2
"R" Value at 300 p.s.i., Exudation Pressure	21		

APPENDIX C

Preliminary Evaluation of Historic Coal Mining on Sand Creek Project

Norfleet Consultants

NORFLEET CONSULTANTS

Engineering
Geology
Geohydrology
Geophysics

6430 Preston Ave.
Suite A
Livermore, CA 94551
(925) 606-8595

May 17, 2006

Mr. Z. Crawford
ENGEO
2880 N. Tracy Blvd, Suite #3
Tracy, CA 95376

Proj. No. 061721

RE: Preliminary Evaluation of
Historic Coal Mining on
Sand Creek Project
Antioch, CA

Dear Mr. Crawford,

At your request, we have completed our preliminary evaluation of the Sand Creek property and surrounding area located northeast of Empire Ranch Road in Antioch, California. The scope of this study was to provide a preliminary evaluation of the extent of underground mine workings beneath the Sand Creek property.

The scope of our evaluation included:

- review of our files concerning historic information about coal mining,

review of a previous ENGEO report, dated Oct 15, 1997, concerning mining in the area, and

- preparation of this summary report of findings.

We did not perform a site visit to the Sand Creek Project or surrounding area as part of this study.

In the late 1990's, we performed an extensive study of the coal mines on the Higgins Ranch property. That property is on the west side of Empire Mine road and is just west of the Sand Creek property. During that study, we researched virtually all of the available documents that described coal mining in this area, including descriptions in the various reports of the State Mineralogist, several master's theses describing the coal mining history of the area as well as the geotechnical properties of the Domengine Sandstone, reviewing most of the newspapers published in this area between 1860 and 1890, and other documents. We visited the Higgins Ranch property several times as well as existing coal workings in the Black Diamond Regional Park (just west of the Higgins property). We reviewed the style and nature of how the underground workings were laid out, had low-level, stereo-pair, aerial photographs flown over the site and surrounding area, reviewed site-specific geophysical studies done on the Higgins property, reviewed several geological field trip guidebooks covering the area, and reviewed the potential for mine-related ground subsidence.

Historic Coal Mining Methods

The location of the Sand Creek property is shown in Figure 1. Also shown are the approximate locations of known historic coal mines in this area. Only two mines were located in the Sand Creek property, the Teutonia and Israel mines. The 1997 ENGEO report contains a good summary of the history of mining in the Sand Creek property area. That history will not be repeated.

The coal veins/seams are located within the Domengine Sandstone. The Domengine Sandstone is about 350 to 450 feet thick in this area. The majority of the Domengine consists of thick sand beds and thinner clay-rich shale beds. Three well known coal veins extend throughout the Domengine. The Black Diamond vein is located 10 to 20 feet above the base of the Domengine, the Clark vein is located near the top of the Domengine, and the Little vein is located between those two veins. The veins vary in height from 18 to 60 inches and all are overlain by thick (50 to 100 feet) sandstone beds. In the Sand Creek area, the coal seams were 24 to 36 inches thick. Other coal veins were occasionally encountered. Those veins were typically thin and discontinuous, and were only occasionally mined. No coal veins are known within the formation directly below the Domengine Sandstone.

The coal was mined using a room and pillar technique (Figure 2). The main slope (also called the hoisting slope) was excavated down dip (26 degrees on the Sand Creek property), parallel to and just below the coal vein. The slope would initially extend 300 to 400 feet down dip. At the bottom of the main slope two gangways would be extended several hundred feet horizontally and perpendicular to the main slope, one to each side. The top of the gangways would be just above the top of the coal vein and the bottom of the gangway would be 4 to 5 feet below the base of the coal vein. About 35 feet from the main slope, a smaller opening (several feet on a side) would be made in within the coal seam exposed on the upslope side of the gangway. This opening would extend up-dip 15 to 20 feet and would end within the coal vein. The opening served two purposes. It provided access and ventilation to the area to be mined (a room) as well as allow mined coal to be slid through the opening and into waiting coal cars in the gangway below the opening. In this area, individual rooms were about 30 feet wide[1], about 300 feet long, and 3 to 4 feet high. The opening to each room was about 30 feet apart.

---

[1] "I noticed several shutes as I was going along, and their use was explained to me. The shutes are put in 30 feet apart. The gangway runs parallel with the length of the vein, is about six feet square. . . the coal is cut out to a width of 5 feet and the thickness of the vein. . . . The miner then extends his opening on a straight line, following the pitch of the vein of coal to the next gangway thus securing an air passage. He then commences taking the coal on each side of him for about fifteen feet, leaving pillows all the way up for supports. In this space the miner crawls, and either sitting or lying down, works out the coal with a pick. . . After inspecting the other gangway, we started for home to get dinner." Ed. Lengen, ~1870; A visit to the Central Coal Mine. This was a newspaper article found in the historic files in the Contra Costa County Library History Room. No date, but likely in the mid-1870's.

"Along the level [*a gangway*] , a piece of coal is left solid on the upper side a distance of about 20 feet. The level is driven far enough below the coal seam to admit of cars going under. A opening is cut up through this solid coal for feet wide, and sheet iron is laid at the bottom. This is called the chute; and all the coal runs into the car through that. . . . After the miner has cut through this solid pillar of coal, he opens to the right and left and goes up the pitch of the vein a width of 24 to 30 feet. This is called his 'room'. . . John Smith is there, who kindly asks me to go down the other slope. . . This is a new lift, the levels having been driven but about 60 feet each way, and one room only is working." – Contra Costa Gazette, June 11, 1870; this was an article about a visit to the Pittsburgh Mine.

It was common for mining to stop approximately 100 feet (slope distance) from the ground surface. The miners recognized that the near surface coals were weathered and were non-economic. The main slope and gangways were critical parts of the mine and 20 to 30 foot wide un-mined zones were left on either side of those features to protect them from damage. When a gangway could no longer be extended (either due to property boundaries or cutoff of a coal vein by faulting), the main slope would be extended deeper (in 350 to 400 foot sections), new gangways were created, and a new set of rooms would be mined.

The coal seam would be mined from the bottom up. Initially, a narrow opening (3 to 4 feet wide and the height of the coal seam) would be excavated the entire length of the room and connected to another part of the mine (another gangway, the ground surface, etc) to provide ventilation. The miner would then start at the bottom of this opening and mine an area 15 feet on either side of this opening until the entire room was mined. The room openings were about 30 feet apart, and several rooms would be mined at the same time. Near the end of mining in an area, openings would be cut between the rooms, leaving support pillars (retreat mining).

Figures 1 through 6 show photographs of late 1880 coal workings in the Clark vein several miles east of the study area. The thickness of the coal seam and the nature of the wooden supports would be similar. This area was retreat mined in the 1930’s (during the depression) and several pillars were removed.

The miners and mine operators were professionals. They were fully aware of ventilation and mine stability. Vertical ventilation shafts were dug from the gangways up to the ground surface (not from the surface down). These shafts could be 3 to 4 feet square and hundreds of feet long. In one of the mines in Black Diamond Regional Park, the miners dug a 400 foot long vertical shaft, jogged it around older, shallower mine workings, and placed the shaft outlet with 5 foot accuracy at the bottom of a valley. Ventilation openings were also dug from the top of the rooms and between rooms. The miners knew that the deeper they went, the greater the hazard of collapse. They would have increased the size of the support pillars with depth.

Teutonia Mine

The approximate location of the Teutonia Mine is shown on Figure 1. Mr. Z. Crawford indicated that the actual location of the Teutonia Mine had been located in the field. The Teutonia mine was discovered in the early 1860’s and abandoned circa 1867. There is no indication that the mine was worked after 1867.

Figure 2 shows the approximate size and location of the underground workings in the Teutonia Mine. This is based on historic descriptions of the Teutonia Mine and other coal mines in this area. Two air shafts are shown on the diagram. These are schematic and may not exist (or exist in a different location). Such air ways were commonly excavated in more extensive coal mine workings, but they may not have been excavated in the Teutonia Mine. The air shaft openings (if they exist) would be in the range of several feet in diameter (or several feet on a side). Historic information indicates that the western gangway quickly encountered a fault and was abandoned. The eastern gangway was about 100 feet long in 1867. A 100 foot long gangway would be sufficient to create three rooms (shown in Figure 2).

Figure 2 shows one room mined-out and two other rooms in the process of being mined. This is conjecture. It is likely that all rooms were mined at the same time, but the extent of those rooms is unknown. There is no indication that mining occurred in the western gangway. There is no indication that the slope was extended deeper than 400 feet (slope distance). A depression northeast of the Teutonia mine opening is shown on Figure 1 of the 1997 ENGEO report. The location of that depression is approximately shown on Figure 1 of this report. That depression is in the approximate location for it to be the surface expression of an air shaft[2].

Israel Mine

The Israel mine was discovered in early to mid-1858 by Mr. Israel while cleaning out a spring on his land. Mr. Israel opened the vein for a short distance, but not having the capital to work it, they sold the mine to Messrs. Watkins and Noyes. Those gentleman attempted to open the mine, but it was abandoned in 1861 (and was apparently never worked again). Goodyear (1887) stated that the Israel mine slope was about 200 feet long, that some rooms were opened, and several cargoes of coal once shipped from there. There was no railroad in the area at that time and the coal would have been moved by wagon.

This information suggests that the workings in the Israel Mine were small (likely extending no more than 50 to 60 feet from either side of the main slope, allowing the partial excavation of a single room adjacent to either side of the main slope).

FINDINGS

Based on available information, it is likely that the underground workings of the Teutonia Mine, when projected to the ground surface, extend about 360 feet north of the main slope opening and about 100 feet east of the main slope. The mined area did not reach the ground surface. The upper part of the mined rooms would have stopped about 100 feet (down dip) from the ground surface (about 40 feet vertically below the ground surface).

It is possible that one or more ventilation shafts were excavated. Such a shaft would be in the range of 2 to 4 feet in diameter/square. The most likely location would be near the eastern end of the eastern gangway (at the location of the surface depression shown on Figure 1?). If an air shaft is located, it will mark the eastern extent of the mine. It is possible that an air way was excavated from the top of one of the rooms to the ground surface. If this occurred, the opening would exist in a zone about 100 feet wide (north-south, the southern boundary of the zone would be the outcrop of the coal seam) that would extended up to 100 feet east of the mine opening.

LIMITATIONS OF THIS REPORT

This report was prepared at the request of, and for the exclusive use of the addressee. Release to any other company, concern, or individual is solely the responsibility of the addressee. This report does not provide or make predictions regarding the future performance of the subject property or surrounding properties (unless specifically stated), nor does it include the examination or disclosure of the presence of any environmental hazards. The opinions and/or recommendations presented in this report could be subject to revision should additional

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[2] If the depression is related to coal mining. It could be an air shaft or an exploratory slope on another coal seam. If it is an air shaft, it should be located approximate 400 feet north of and 100 feet east of the main slope of the Teutonia mine (if it is further east, then the eastern gangway is longer). It should be several feet square, be vertical, and be located completely in Domengine Sandstone. If it is an exploratory shaft on another coal seam, the opening will dip 25 to 27 degrees north and there should be a coal/clay seam within the opening.

information become available. The contents of this report are valid as of the date of preparation, and are valid for one year after the date of the report. This report may not provide all of the subsurface or geologic or geotechnical information that may be required by the Client for the assessment of geologic or geotechnical hazards in the Study area.

We have employed generally accepted civil engineering and engineering geology procedures. Our observations, professional opinions and conclusions were made using that degree of care and skill ordinarily exercised, under similar conditions, by civil engineers and engineering geologists practicing in this area at this time. Norfleet consultants expressly denies any third party liability arising from the unauthorized use of this report.

Yours Truly,

NORFLEET CONSULTANTS

Digital Version- Original signed by S. Figuers

Dr. Sands Figuers, PE, CEG
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REGISTERED PROFESSIONAL ENGINEER
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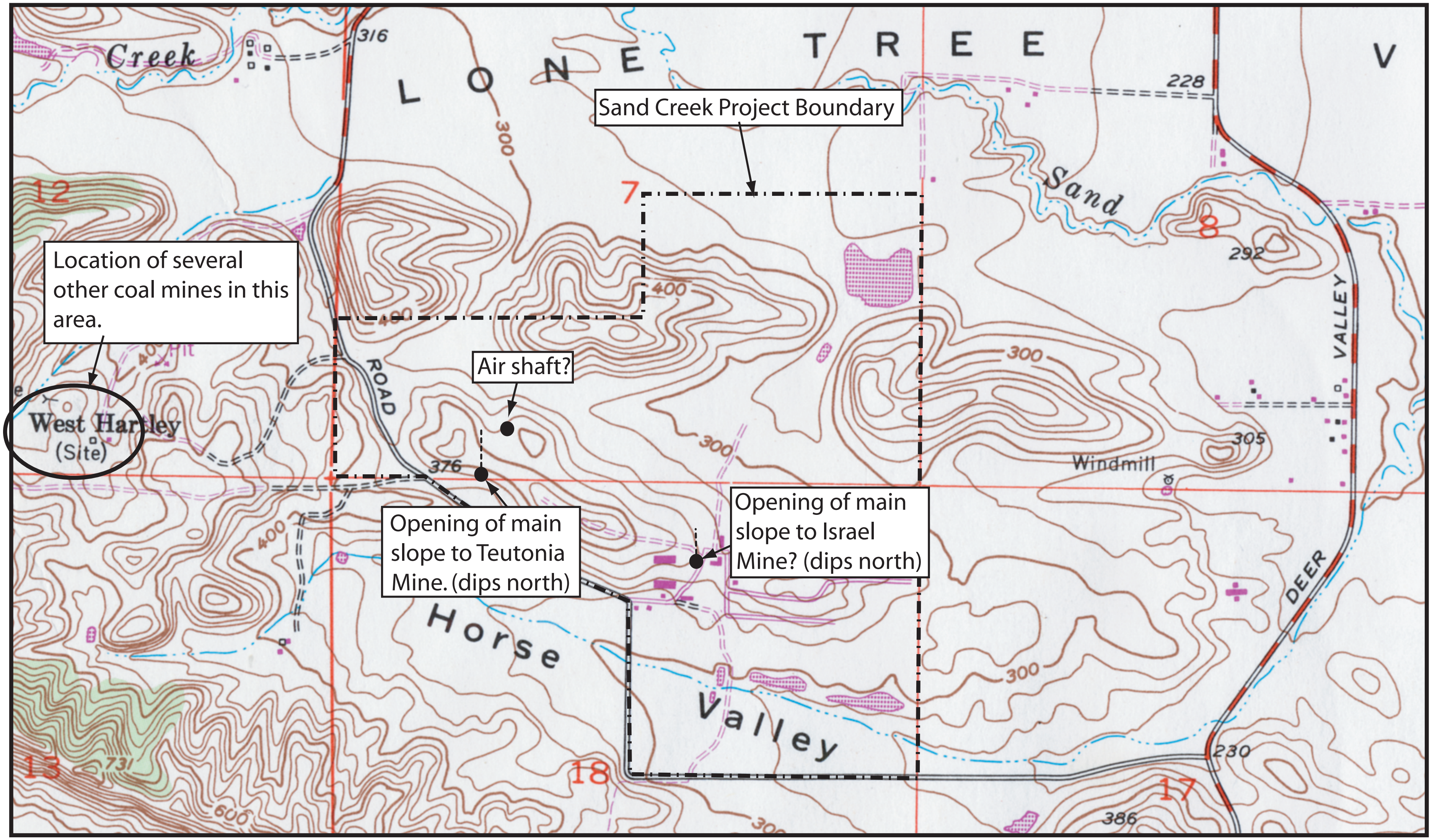
CIVIL
STATE OF CALIFORNIA



Location of mine openings and surface depressions taken from ENGEO (1997). The Teutonia Mine opening was confirmed by air photo and field analysis.

The base map is the USGS Antioch South 7.5" topographic map.

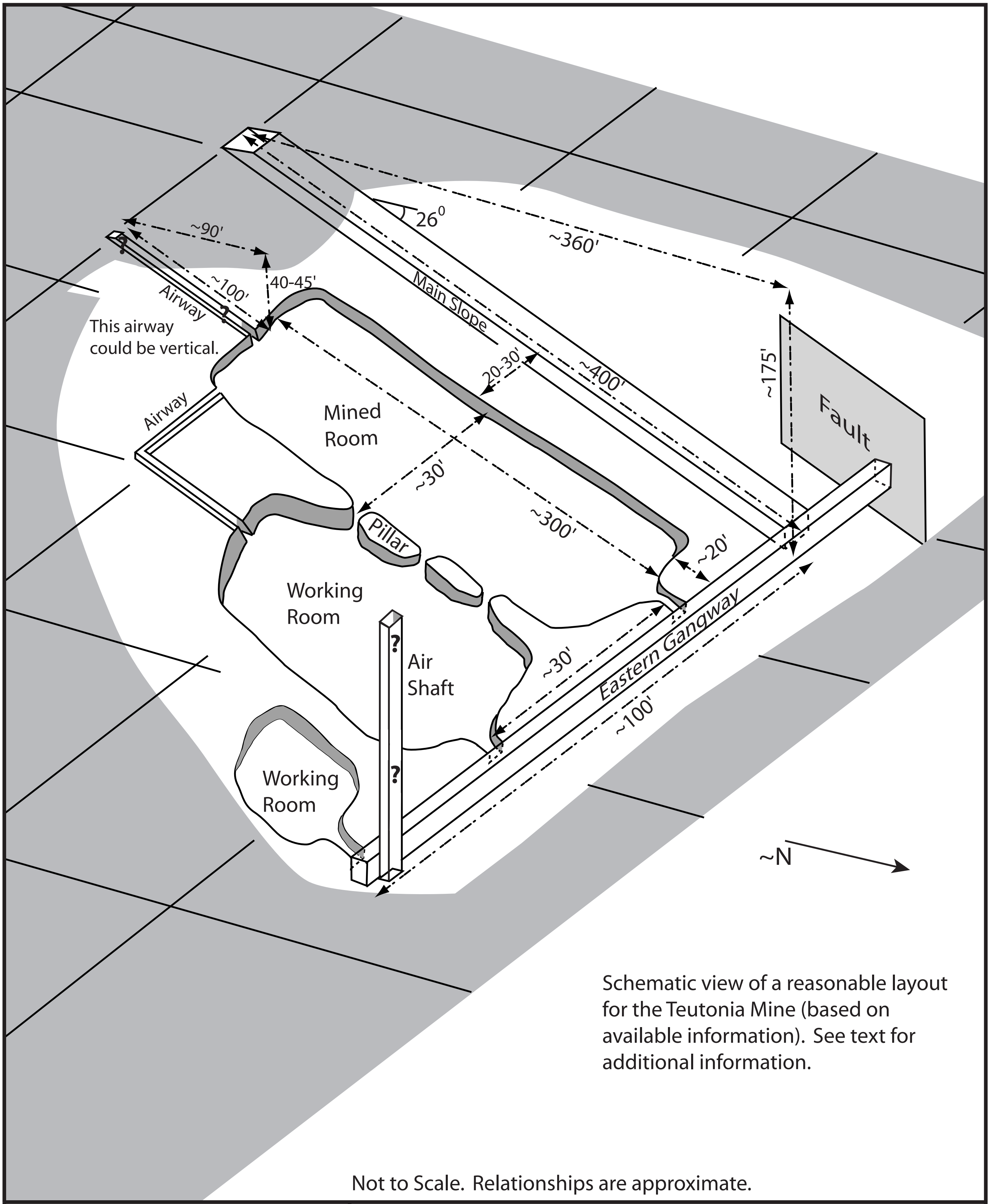
Not to scale.
Relationships are approximate

Norfleet Consultants

Sand Creek Project

Site Location

PROJ NO:	061721	DATE:	5/15/06	FIGURE:	1



Schematic view of a reasonable layout for the Teutonia Mine (based on available information). See text for additional information.

Not to Scale. Relationships are approximate.

Norfleet Consultants	Sand Creek Project
	Teutonia Mine Workings
	PROJ NO: 061721 · DATE: 5/12/06 · FIGURE: 2

Photo 1: Looking down the dip of a mined out room. The wooden posts provide local support for the roof. They do not support the overall mined area. This area was mined more than 100 years ago.

Photo 2: This is a view across a room with the camera kept level. It provides an indication of the dip of the coal seam.

Photo 3: A view looking down the slope of a mined room. The people provide a scale for the height of the room.

Photo 4: This is the edge of a pillar within a room. This pillar was retreat mined. It is now 6 to 8 feet in diameter. It originally would have been 10 to 15 feet in diameter.

Photo 5: This is the upper working edge of a mined room.

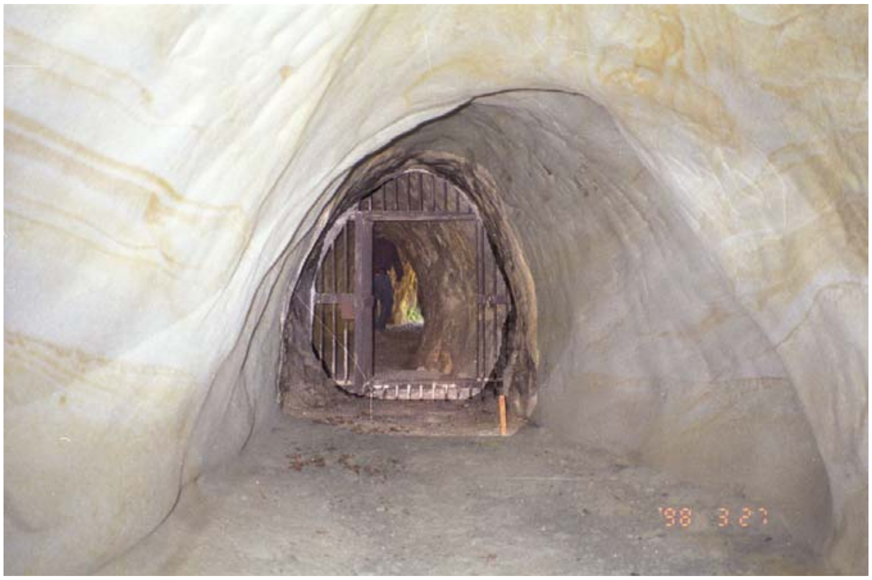


Photo 6: This shows a tunnel extending into the side of a mined room (view is from the room towards the outside). The tunnel is more than 50 feet long and is within the Domengine Sandstone. Daylight can been seen in the distance.

APPENDIX D

Guide Contract Specifications

4371.4.050.01
May 24, 2006

GUIDE CONTRACT SPECIFICATIONS

PART I - EARTHWORK

PREFACE

These specifications are intended as a guide for the earthwork performed at the subject development project. If there is a conflict between these specifications (including the recommendations of the geotechnical report) and agency or code requirements, it should be brought to the attention of ENGEO and Owner prior to contract bidding.

PART 1 - GENERAL

1.01 WORK COVERED

A. Grading, excavating, filling and backfilling, including trenching and backfilling for utilities as necessary to complete the Project as indicated on the Drawings.

B. Subsurface drainage as indicated on the Drawings.

1.02 CODES AND STANDARDS

A. Excavating, trenching, filling, backfilling, and grading work shall meet the applicable requirements of the Uniform Building Code and the standards and ordinances of state and local governing authorities.

1.03 SUBSURFACE SOIL CONDITIONS

A. The Owners' Geotechnical Exploration report is available for inspection by bidder or Contractor. The Contractor shall refer to the findings and recommendations of the Geotechnical Exploration report in planning and executing his work.

1.04 DEFINITIONS

A. Fill: All soil, rock, or soil-rock materials placed to raise the grades of the site or to backfill excavations.

B. Backfill: All soil, rock or soil-rock material used to fill excavations and trenches.

C. On-Site Material: Soil and/or rock material which is obtained from the site.

D. Imported Material: Soil and/or rock material which is brought to the site from off-site areas.

E. Select Material: On-site and/or imported material which is approved by ENGEO as a specific-purpose fill.

F. Engineered Fill: Fill upon which ENGEO has made sufficient observations and tests to confirm that the fill has been placed and compacted in accordance with specifications and requirements.

G. Degree of Compaction or Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of the fill and backfill material as compacted in the field to the maximum dry density of the same material as determined by ASTM D-1557 or California 216 compaction test method.

H. Optimum Moisture: Water content, percentage by dry weight, corresponding to the maximum dry density as determined by ASTM D-1557.

I. ENGEO: The project geotechnical engineering consulting firm, its employees or its designated representatives.

J. Drawings: All documents, approved for construction, which describe the Work.

1.05 OBSERVATION AND TESTING

A. All site preparation, cutting and shaping, excavating, filling, and backfilling shall be carried out under the observation of ENGEO, employed and paid for by the Owners. ENGEO will perform appropriate field and laboratory tests to evaluate the suitability of fill material, the proper moisture content for compaction, and the degree of compaction achieved. Any fill that does not meet the specification requirements shall be removed and/or reworked until the requirements are satisfied.

B. Cutting and shaping, excavating, conditioning, filling, and compacting procedures require approval of ENGEO as they are performed. Any work found unsatisfactory or any work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as recommended by ENGEO.

C. Tests for compaction will be made in accordance with test procedures outlined in ASTM D-1557, as applicable. Field testing of soils or compacted fill shall conform with the applicable requirements of ASTM D-2922.

D. All authorized observation and testing will be paid for by the Owners.

1.06 SITE CONDITIONS

A. Excavating, filling, backfilling, and grading work shall not be performed during unfavorable weather conditions. When the work is interrupted by rain, excavating, filling, backfilling, and grading work shall not be resumed until the site and soil conditions are suitable.

B. Contractor shall take the necessary measures to prevent erosion of freshly filled, backfilled, and graded areas until such time as permanent drainage and erosion control measures have been installed.

PART 2 - PRODUCTS

2.01 GENERAL

A. Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required excavating, filling, backfilling, and grading work, and trenching and backfilling for utilities.

2.02 SOIL MATERIALS

A. Fill

1. Material to be used for engineered fill and backfill shall be free from organic matter and other deleterious substances, and of such quality that it will compact thoroughly without excessive voids when watered and rolled. Excavated on-site material will be considered suitable for engineered fill and backfill if it contains no more than 3 percent organic matter, is free of debris and other deleterious substances and conforms to the requirements specified above. Rocks of maximum dimension in excess of two-thirds of the lift thickness shall be removed from any fill material to the satisfaction of ENGEO.

2. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled as required for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed 8 inches and raking free of debris and rubble. Rocks and aggregate exceeding the allowed largest dimension, and deleterious material shall be removed from the site and disposed off site in a legal manner.

3. ENGEO shall be notified at least 48 hours prior to the start of filling and backfilling operations so that it may evaluate samples of the material intended for use as fill and

backfill. All materials to be used for filling and backfilling require the approval of ENGEO.

B. Import Material: Where conditions require the importation of fill material, the material shall be an inert, nonexpansive soil or soil-rock material free of organic matter and meeting the following requirements unless otherwise approved by ENGEO.

Gradation (ASTM D-421):	Sieve Size	Percent Passing
	2-inch	100
	#200	15 - 70

Plasticity (ASTM D-4318):	Liquid Limit	Plasticity Index
	< 30	< 12

Swell Potential (ASTM D-4546B): (at optimum moisture)	Percent Heave	Swell Pressure
	< 2 percent	< 300 psf

Resistance Value (ASTM D-2844): Minimum 25

Organic Content (ASTM D-2974): Less than 2 percent

A sample of the proposed import material should be submitted to ENGEO for evaluation prior to delivery at the site.

2.03 SAND

A. Sand for sand cushion under slabs and for bedding of pipe in utility trenches shall be a clean and graded, washed sand, all passing a No. 4 U. S. Standard Sieve, and generally conforming to ASTM C33 for fine aggregate.

2.04 AGGREGATE DRAINAGE FILL

A. Aggregate drainage fill under concrete slabs and paving shall consist of broken stone, crushed or uncrushed gravel, clean quarry waste, or a combination thereof. The aggregate shall be free from fines, vegetable matter, loam, volcanic tuff, and other deleterious substances. It shall be of such quality that the absorption of water in a saturated surface dry condition does not exceed 3 percent of the oven dry weight of the samples.

B. Aggregate drainage fill shall be of such size that the percentage composition by dry weight as determined by laboratory sieves (U. S. Series) will conform to the following grading:

Sieve Size	Percentage Passing Sieve
1½-inches	100
1-inch	90 - 100
#4	0 - 5

2.05 SUBDRAINS

A. Perforated subdrain pipe of the required diameter shall be installed as shown on the drawings. The pipe(s) shall also conform to these specifications unless otherwise specified by ENGEO in the field.

Subdrain pipe shall be manufactured in accordance with one of the following requirements:

Design depths less than 30 feet

- Perforated ABS Solid Wall SDR 35 (ASTM D-2751)
- Perforated PVC Solid Wall SDR 35 (ASTM D-3034)
- Perforated PVC A-2000 (ASTM F949)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 50 psi minimum stiffness)

Design depths less than 50 feet

- Perforated PVC SDR 23.5 Solid Wall (ASTM D-3034)
- Perforated Sch. 40 PVC Solid Wall (ASTM-1785)
- Perforated ABS SDR 23.5 Solid Wall (ASTM D-2751)
- Perforated ABS DWV/Sch. 40 (ASTM D-2661 and D-1527)
- Perforated Corrugated HDPE double-wall (AASHTO M-252 or M-294, Caltrans Type S, 70 psi minimum stiffness)

Design depths less than 70 feet

- Perforated ABS Solid Wall SDR 15.3 (ASTM D-2751)
- Perforated Sch. 80 PVC (ASTM D-1785)
- Perforated Corrugated Aluminum (ASTM B-745)

B. Permeable Material (Class 2): Class 2 permeable material for filling trenches under, around, and over subdrains, behind building and retaining walls, and for pervious blankets shall consist of clean, coarse sand and gravel or crushed stone, conforming to the following grading requirements:

Sieve Size	Percentage Passing Sieve
1-inch	100
¾-inch	90 - 100
^{3}/8-inch	40 - 100
#4	25 - 40
#8	18 - 33
#30	5 - 15
#50	0 - 7
#200	0 - 3

C. Filter Fabric: All filter fabric shall meet the following Minimum Average Roll Values unless otherwise specified by ENGEO.

Grab Strength (ASTM D-4632)	180 lbs
Mass Per Unit Area (ASTM D-4751)	6 oz/yd^2
Apparent Opening Size (ASTM D-4751)	70-100 U.S. Std. Sieve
Flow Rate (ASTM D-4491) 80 gal/min/ft^2	
Puncture Strength (ASTM D-4833)	80 lbs

D. Vapor Barrier: Vapor barriers shall consist of PVC, LDPE or HDPE impermeable sheeting at least 10 mils thick.

2.06 PERMEABLE MATERIAL (Class 1; Type A)

A. Class 1 permeable material to be used in conjunction with filter fabric for backfilling of subdrain excavations shall conform to the following grading requirements:

Sieve Size	Percentage Passing Sieve
¾-inch	100
½-inch	95 - 100
^{3}/8-inch	70 - 100
#4	0 - 55
#8	0 - 10
#200	0 - 3

PART 3 - EXECUTION

3.01 STAKING AND GRADES

A. Contractor shall lay out all his work, establish all necessary markers, bench marks, grading stakes, and other stakes as required to achieve design grades.

3.02 EXISTING UTILITIES

A. Contractor shall verify the location and depth (elevation) of all existing utilities and services before performing any excavation work.

3.03 EXCAVATION

A. Contractor shall perform excavating as indicated and required for concrete footings, drilled piers, foundations, floor slabs, concrete walks, and site leveling and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required. The bottoms of excavations shall be firm undisturbed earth, clean and free from loose material, debris, and foreign matter.

B. Excavations shall be kept free from water at all times. Adequate dewatering equipment shall be maintained at the site to handle emergency situations until concrete or backfill is placed.

C. Unauthorized excavations for footings shall be filled with concrete to required elevations, unless other methods of filling are authorized by ENGEO.

D. Excavated earth material which is suitable for engineered fill or backfill, as determined by ENGEO, shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations as specified under Section 2.02, "Soil Materials."

E. Abandoned sewers, piping, and other utilities encountered during excavating shall be removed and the resulting excavations shall be backfilled with engineered fill as required by ENGEO.

F. Any active utility lines encountered shall be reported immediately to the Owner's Representative and authorities involved. The Owner and proper authorities shall be permitted free access to take the measures deemed necessary to repair, relocate, or remove the obstruction as determined by the responsible authority or Owner's Representative.

3.04 SUBGRADE PREPARATION

A. All brush and other rubbish, as well as trees and root systems not marked for saving, shall be removed from the site and legally disposed of.

B. Any existing structures, foundations, underground storage tanks, or debris must be removed from the site prior to any building, grading, or fill operations. Septic tanks, including all drain fields and other lines, if encountered, must be totally removed. The resulting depressions shall be properly prepared and filled to the satisfaction of ENGEO.

C. Vegetation and organic topsoil shall be removed from the surface upon which the fill is to be placed and either removed and legally disposed of or stockpiled for later use in approved landscape areas. The surface shall then be scarified to a depth of at least eight inches until the surface is free from ruts, hummocks, or other uneven features which would tend to prevent uniform compaction by the equipment to be used.

D. After the foundation for the fill has been cleared and scarified, it shall be made uniform and free from large clods. The proper moisture content must be obtained by adding water or aerating. The foundation for the fill shall be compacted at the proper moisture content to a relative compaction as specified herein.

3.05 ENGINEERED FILL

A. Select Material: Fill material shall be "Select" or "Imported Material" as previously specified.

B. Placing and Compacting: Engineered fill shall be constructed by approved and accepted methods. Fill material shall be spread in uniform lifts not exceeding 8 inches in uncompacted thickness. Each layer shall be spread evenly, and thoroughly blade-mixed to obtain uniformity of material. Fill material which does not contain sufficient moisture as specified by ENGEO shall be sprinkled with water; if it contains excess moisture it shall be aerated or blended with drier material to achieve the proper water content. Select material and water shall then be thoroughly mixed before being compacted.

C. Unless otherwise specified in the Geotechnical Exploration report, each layer of spread select material shall be compacted to at least 90 percent relative compaction at a moisture content of at least three percent above the optimum moisture content. Minimum compaction in all keyways shall be a minimum of 95 percent with a minimum moisture content of at least 1 percent above optimum.

D. Unless otherwise specified in the Geotechnical Exploration report or otherwise required by the local authorities the upper 6 inches of engineered fill in areas to receive pavement shall be compacted to at least 95 percent relative compaction.

E. Testing and Observation of Fill: The work shall consist of field observation and testing to determine that each layer has been compacted to the required density and that the required moisture is being obtained. Any layer or portion of a layer that does not attain the compaction required shall be reworked until the required density is obtained.

F. Compaction: Compaction shall be by sheepsfoot rollers, multiple-wheel steel or pneumatic-tired rollers or other types of acceptable compaction equipment. Rollers shall be of such design that they will be able to compact the fill to the specified compaction. Rolling shall be accomplished while the fill material is within the specified moisture content range. Rolling of each layer must be continuous so that the required compaction may be obtained uniformly throughout each layer.

G. Fill slopes shall be constructed by overfilling the design slopes and later cutting back the slopes to the design grades. No loose soil will be permitted on the faces of the finished slopes.

H. Strippings and topsoil shall be stockpiled as approved by Owner, then placed in accordance with ENGEO's recommendations to a minimum thickness of 6 inches and a maximum thickness of 12 inches over exposed open space cut slopes which are 3:1 or flatter, and track walked to the satisfaction of ENGEO.

I. Final Prepared Subgrade: Finish blading and smoothing shall be performed as necessary to produce the required density, with a uniform surface, smooth and true to grade.

3.06 BACKFILLING

A. Backfill shall not be placed against footings, building walls, or other structures until approved by ENGEO.

B. Backfill material shall be Select Material as specified for engineered fill.

C. Backfill shall be placed in 6-inch layers, leveled, rammed, and tamped in place. Each layer shall be compacted with suitable compaction equipment to 90 percent relative compaction at a moisture content of at least 3 percent above optimum.

3.07 TRENCHING AND BACKFILLING FOR UTILITIES

A. Trenching:

1. Trenching shall include the removal of material and obstructions, the installation and removal of sheeting and bracing and the control of water as necessary to provide the required utilities and services.

2. Trenches shall be excavated to the lines, grades, and dimensions indicated on the Drawings. Maximum allowable trench width shall be the outside diameter of the pipe plus 24 inches, inclusive of any trench bracing.

3. When the trench bottom is a soft or unstable material as determined by ENGEO, it shall be made firm and solid by removing said unstable material to a sufficient depth and replacing it with on-site material compacted to 90 percent minimum relative compaction.

4. Where water is encountered in the trench, the contractor must provide materials necessary to drain the water and stabilize the bed.

B. Backfilling:

1. Trenches must be backfilled within 2 days of excavation to minimize desiccation.

2. Bedding material shall be sand and shall not extend more than 6 inches above any utility lines.

3. Backfill material shall be select material.

4. Trenches shall be backfilled as indicated or required and compacted with suitable equipment to 90 percent minimum relative compaction at the required moisture content.

3.08 SUBDRAINS

A. Trenches for subdrain pipe shall be excavated to a minimum width equal to the outside diameter of the pipe plus at least 12 inches and to a depth of approximately 2 inches below the grade established for the invert of the pipe, or as indicated on the Drawings.

B. The space below the pipe invert shall be filled with a layer of Class 2 permeable material, upon which the pipe shall be laid with perforations down. Sections shall be joined as recommended by the pipe manufacturer.

C. Rocks, bricks, broken concrete, or other hard material shall not be used to give intermediate support to pipes. Large stones or other hard objects shall not be left in contact with the pipes.

D. Excavations for subdrains shall be filled as required to fill voids and prevent settlement without damaging the subdrain pipe. Alternatively, excavations for subdrains may be filled with Class 1 permeable material (as defined in Section 2.06) wrapped in Filter Fabric (as defined in Section 2.05).

3.09 AGGREGATE DRAINAGE FILL

A. ENGEO shall approve finished subgrades before aggregate drainage fill is installed.

B. Pipes, drains, conduits, and any other mechanical or electrical installations shall be in place before any aggregate drainage fill is placed. Backfill at walls to elevation of drainage fill shall be in place and compacted.

C. Aggregate drainage fill under slabs and concrete paving shall be the minimum uniform thickness after compaction of dimensions indicated on Drawings. Where not indicated, minimum thickness after compaction shall be 4 inches.

D. Aggregate drainage fill shall be rolled to form a well-compacted bed.

E. The finished aggregate drainage fill must be observed and approved by ENGEO before proceeding with any subsequent construction over the compacted base or fill.

3.10 SAND CUSHION

A. A sand cushion shall be placed over the vapor barrier membrane under concrete slabs on grade. Sand cushion shall be placed in uniform thickness as indicated on the Drawings. Where not indicated, the thickness shall be 2 inches.

3.11 FINISH GRADING

A. All areas must be finish graded to elevations and grades indicated on the Drawings. In areas to receive topsoil and landscape planting, finish grading shall be performed to a uniform 6 inches below the grades and elevations indicated on the Drawings, and brought to final grade with topsoil.

3.12 DISPOSAL OF WASTE MATERIALS

A. Excess earth materials and debris shall be removed from the site and disposed of in a legal manner. Location of dump site and length of haul are the Contractor's responsibility.

PART II - GEOGRID SOIL REINFORCEMENT

1. DESCRIPTION:

   Work shall consist of furnishing geogrid soil reinforcement for use in construction of reinforced soil slopes and retention systems.

2. GEOGRID MATERIAL:

   2.1 The specific geogrid material shall be preapproved by ENGEO.

   2.2 The geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil or rock. The geogrid structure shall be dimensionally stable and able to retain its geometry under construction stresses and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

   2.3 The geogrids shall have an Allowable Strength (T_a) and Pullout Resistance, for the soil type(s) indicated, as listed in Table I.

   2.4 Certifications: The Contractor shall submit a manufacturer's certification that the geogrids supplied meet the respective index criteria set when geogrid was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply test data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

   3.1 Delivery, Storage, and Handling: Contractor shall check the geogrid upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geogrid will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geogrid damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

   3.2 On-Site Representative: Geogrid material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geogrid reinforcement may be joined with mechanical connections or overlaps as recommended and approved by the Manufacturer. Joints shall not be placed within 6 feet of the slope face, within 4 feet below top of slope, nor horizontally or vertically adjacent to another joint.

3.4 Geogrid Placement: The geogrid reinforcement shall be installed in accordance with the manufacturer's recommendations. The geogrid reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geogrid reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. However, if the Contractor is unable to complete a required length with a single continuous length of geogrid, a joint may be made with the Manufacturer's approval. Only one joint per length of geogrid shall be allowed. This joint shall be made for the full width of the strip by using a similar material with similar strength. Joints in geogrid reinforcement shall be pulled and held taut during fill placement.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geogrid reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geogrid reinforcement required for immediately pending work to prevent undue damage. After a layer of geogrid reinforcement has been placed, the next succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geogrid reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geogrid reinforcement and soil.

Geogrid reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geogrid reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geogrid reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geogrid reinforcement before at least six inches of soil have been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geogrid reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geogrid reinforcement shall be placed directly on the compacted horizontal fill surface. Geogrid reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by ENGEO. Correct orientation of the geogrid reinforcement shall be verified by ENGEO.

Table I
Allowable Geogrid Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geogrid Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, T_a (lb/ft)*		
	GEOGRID Type I	GEOGRID Type II	GEOGRID Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

* All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.

** Unified Soil Classifications.

PART III - GEOTEXTILE SOIL REINFORCEMENT

1. DESCRIPTION:

   Work shall consist of furnishing geotextile soil reinforcement for use in construction of reinforced soil slopes.

2. GEOTEXTILE MATERIAL:

   2.1 The specific geotextile material and supplier shall be preapproved by ENGEO.

   2.2 The geotextile shall have a high tensile modulus and shall have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.

   2.3 The geotextiles shall have an Allowable Strength (T_a) and Pullout Resistance, for the soil type(s) indicated as listed in Table II.

   2.4 Certification: The Contractor shall submit a manufacturer's certification that the geotextiles supplied meet the respective index criteria set when geotextile was approved by ENGEO, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Contractor will supply the data from an ENGEO-approved laboratory to support the certified values submitted.

3. CONSTRUCTION:

   3.1 Delivery, Storage and Handling: Contractor shall check the geotextile upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geotextile shall be protected from temperatures greater than 140 °F, mud, dirt, dust, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the geotextile will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be repaired by placing a patch over the damaged area. Any geotextile damaged during storage or installation shall be replaced by the Contractor at no additional cost to the owner.

3.2 On-Site Representative: Geotextile material suppliers shall provide a qualified and experienced representative on site at the initiation of the project, for a minimum of three days, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criterion will apply to construction of the initial slope only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Geotextile Placement: The geotextile reinforcement shall be installed in accordance with the manufacturer's recommendations. The geotextile reinforcement shall be placed within the layers of the compacted soil as shown on the plans or as directed.

The geotextile reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. Joints shall not be used with geotextiles.

Adjacent strips, in the case of 100 percent coverage in plan view, need not be overlapped. The minimum horizontal coverage is 50 percent, with horizontal spacings between reinforcement no greater than 40 inches. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the construction drawings.

Adjacent rolls of geotextile reinforcement shall be overlapped or mechanically connected where exposed in a wrap around face system, as applicable.

The Contractor may place only that amount of geotextile reinforcement required for immediately pending work to prevent undue damage. After a layer of geotextile reinforcement has been placed, the succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geotextile reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geotextile reinforcement and soil.

Geosynthetic reinforcement shall be placed to lay flat and be pulled tight prior to backfilling. After a layer of geotextile reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geotextile reinforcement in position until the subsequent soil layer can be placed.

Under no circumstances shall a track-type vehicle be allowed on the geotextile reinforcement before at least six inches of soil has been placed. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geotextile reinforcement. If approved by the Manufacturer, rubber-tired equipment may pass over the geotextile reinforcement as slow speeds, less than 10 mph. Sudden braking and sharp turning shall be avoided.

During construction, the surface of the fill should be kept approximately horizontal. Geotextile reinforcement shall be placed directly on the compacted horizontal fill surface. Geotextile reinforcements are to be placed within three inches of the design elevations and extend the length as shown on the elevation view unless otherwise directed by ENGEO. Correct orientation of the geotextile reinforcement shall be verified by ENGEO.

Table II
Allowable Geotextile Strength
With Various Soil Types
For Geosynthetic Reinforcement In
Mechanically Stabilized Earth Slopes

(Geotextile Pullout Resistance and Allowable Strengths vary with reinforced backfill used due to soil anchorage and site damage factors. Guidelines are provided below.)

SOIL TYPE	MINIMUM ALLOWABLE STRENGTH, T_a (lb/ft)*		
	GEOTEXTILE Type I	GEOTEXTILE Type II	GEOTEXTILE Type III
A. Gravels, sandy gravels, and gravel-sand-silt mixtures (GW, GP, GC, GM & SP)**	2400	4800	7200
B. Well graded sands, gravelly sands, and sand-silt mixtures (SW & SM)**	2000	4000	6000
C. Silts, very fine sands, clayey sands and clayey silts (SC & ML)**	1000	2000	3000
D. Gravelly clays, sandy clays, silty clays, and lean clays (CL)**	1600	3200	4800

* All partial Factors of Safety for reduction of design strength are included in listed values. Additional factors of safety may be required to further reduce these design strengths based on site conditions.

** Unified Soil Classifications.

PART IV - EROSION CONTROL MAT OR BLANKET

1. DESCRIPTION:

   Work shall consist of furnishing and placing a synthetic erosion control mat and/or degradable erosion control blanket for slope face protection and lining of runoff channels.

2. EROSION CONTROL MATERIALS:

   2.1 The specific erosion control material and supplier shall be preapproved by ENGEO.

   2.2 Certification: The Contractor shall submit a manufacturer's certification that the erosion mat/blanket supplied meets the criteria specified when the material was approved by ENGEO. The manufacturer's certification shall include a submittal package of documented test results that confirm the property values. In case of a dispute over validity of values, the Contractor will supply property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for conformance determinations.

3. CONSTRUCTION:

   3.1 Delivery, Storage, and Handling: Contractor shall check the erosion control material upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the erosion mat shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regard to protection from direct sunlight must also be followed. At the time of installation, the erosion mat/blanket shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed by cutting OUT a section of the mat. The remaining ends should be overlapped and secured with ground anchors. Any erosion mat/blanket damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

   3.2 On-Site Representative: Erosion control material suppliers shall provide a qualified and experienced representative on site, for a minimum of one day, to assist the Contractor and ENGEO personnel at the start of construction. If there is more than one slope on a project, this criteria will apply to construction of the initial slope only. The representative shall be available on an as-needed basis, as requested by ENGEO, during construction of the remaining slope(s).

3.3 Placement: The erosion control material shall be placed and anchored on a smooth graded, firm surface approved by the Engineer. Anchoring terminal ends of the erosion control material shall be accomplished through use of key trenches. The material in the trenches shall be anchored to the soil on maximum 1½ foot centers. Topsoil, if required by construction drawings, placed over final grade prior to installation of the erosion control material shall be limited to a depth not exceeding 3 inches.

3.4 Erosion control material shall be anchored, overlapped, and otherwise constructed to ensure performance until vegetation is well established. Anchors shall be as designated on the construction drawings, with a minimum of 12 inches length, and shall be spaced as designated on the construction drawings, with a maximum spacing of 4 feet.

3.5 Soil Filling: If noted on the construction drawings, the erosion control mat shall be filled with a fine grained topsoil, as recommended by the manufacturer. Soil shall be lightly raked or brushed on/into the mat to fill the mat voids or to a maximum depth of 1 inch.

PART V - GEOSYNTHETIC DRAINAGE COMPOSITE

1. DESCRIPTION:

   Work shall consist of furnishing and placing a geosynthetic drainage system as a subsurface drainage medium for reinforced soil slopes.

2. DRAINAGE COMPOSITE MATERIALS:

   2.1 The specific drainage composite material and supplier shall be preapproved by ENGEO.

   2.2 The drain shall be of composite construction consisting of a supporting structure or drainage core material surrounded by a geotextile. The geotextile shall encapsulate the drainage core and prevent random soil intrusion into the drainage structure. The drainage core material shall consist of a three dimensional polymeric material with a structure that permits flow along the core laterally. The core structure shall also be constructed to permit flow regardless of the water inlet surface. The drainage core shall provide support to the geotextile. The fabric shall meet the minimum property requirements for filter fabric listed in Section 2.05C of the Guide Earthwork Specifications.

   2.3 A geotextile flap shall be provided along all drainage core edges. This flap shall be of sufficient width for sealing the geotextile to the adjacent drainage structure edge to prevent soil intrusion into the structure during and after installation. The geotextile shall cover the full length of the core.

   2.4 The geocomposite core shall be furnished with an approved method of constructing and connecting with outlet pipes or weepholes as shown on the plans. Any fittings shall allow entry of water from the core but prevent intrusion of backfill material into the core material.

   2.5 Certification and Acceptance: The Contractor shall submit a manufacturer's certification that the geosynthetic drainage composite meets the design properties and respective index criteria measured in full accordance with all test methods and standards specified. The manufacturer's certification shall include a submittal package of documented test results that confirm the design values. In case of dispute over validity of design values, the Contractor will supply design property test data from an ENGEO-approved laboratory, to support the certified values submitted. Minimum average roll values, per ASTM D 4759, shall be used for determining conformance.

3. CONSTRUCTION:

   3.1 Delivery, Storage, and Handling: Contractor shall check the geosynthetic drainage composite upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geosynthetic drainage composite shall be protected from temperatures greater than 140 °F, mud, dirt, and debris. Manufacturer's recommendations in regards to protection from direct sunlight must also be followed. At the time of installation, the geosynthetic drainage composite shall be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. If approved by ENGEO, torn or punctured sections may be removed or repaired. Any geosynthetic drainage composite damaged during storage or installation shall be replaced by the Contractor at no additional cost to the Owner.

3.2 On-Site Representative: Geosynthetic drainage composite material suppliers shall provide a qualified and experienced representative on site, for a minimum of one half day, to assist the Contractor and ENGEO personnel at the start of construction with directions on the use of drainage composite. If there is more than one application on a project, this criterion will apply to construction of the initial application only. The representative shall also be available on an as-needed basis, as requested by ENGEO, during construction of the remaining applications.

3.3 Placement: The soil surface against which the geosynthetic drainage composite is to be placed shall be free of debris and inordinate irregularities that will prevent intimate contact between the soil surface and the drain.

3.4 Seams: Edge seams shall be formed by utilizing the flap of the geotextile extending from the geocomposite's edge and lapping over the top of the fabric of the adjacent course. The fabric flap shall be securely fastened to the adjacent fabric by means of plastic tape or non-water-soluble construction adhesive, as recommended by the supplier. Where vertical splices are necessary at the end of a geocomposite roll or panel, an 8-inch-wide continuous strip of geotextile may be placed, centering over the seam and continuously fastened on both sides with plastic tape or non-water-soluble construction adhesive. As an alternative, rolls of geocomposite drain material may be joined together by turning back the fabric at the roll edges and interlocking the cuspidations approximately 2 inches. For overlapping in this manner, the fabric shall be lapped and tightly taped beyond the seam with tape or adhesive. Interlocking of the core shall always be made with the upstream edge on top in the direction of water flow. To prevent soil intrusion, all exposed edges of the geocomposite drainage core edge must be covered. Alternatively, a 12-inch-wide strip of fabric may be utilized in the same manner, fastening it to the exposed fabric 8 inches in from the edge and folding the remaining flap over the core edge.

3.5 Soil Fill Placement: Structural backfill shall be placed immediately over the geocomposite drain. Care shall be taken during the backfill operation not to damage the geotextile surface of the drain. Care shall also be taken to avoid excessive settlement of the backfill material. The geocomposite drain, once installed, shall not be exposed for more than seven days prior to backfilling.