# Appendix D:
# Geotechnical Exploration Report

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# OFFSITE SANITARY SEWER IMPROVEMENTS
# LASSEN PROPERTY - TRACT 8454
LIVERMORE, CALIFORNIA

## GEOTECHNICAL EXPLORATION

SUBMITTED TO
Mr. Jeb Elmore
LD-FUND III LIVERMORE LAND, LLC,
a Delaware limited liability company
1156 North Mountain Avenue
Upland, California 91786

PREPARED BY
ENGEO Incorporated

May 12, 2021
Latest Revision June 2, 2021

PROJECT NO.
13850.001.001



ENGEO
Expect Excellence

Project No.
**13850.001.001**

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Mr. Jeb Elmore
LD-FUND III LIVERMORE LAND, LLC,
a Delaware limited liability company
1156 North Mountain Avenue
Upland, California 91786

Subject: Offsite Sanitary Sewer Improvements
Lassen Property - Tract 8454
Livermore, California

**GEOTECHNICAL EXPLORATION**

Dear Mr. Elmore:

We prepared this geotechnical report for LD-FUND III LIVERMORE LAND, LLC as outlined in our agreement dated March 30, 2021. We characterized the subsurface conditions at the site to provide the enclosed geotechnical recommendations for design.

From a geotechnical engineering viewpoint, in our opinion, the proposed offsite sanitary sewer improvements may be designed as planned, provided the geotechnical recommendations in this report are properly incorporated into the design plans and specifications. Please let us know when working drawings are nearing completion so that we can coordinate review of the plans and specifications and discuss geotechnical observation and testing services during construction.

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

Sincerely,

ENGEO Incorporated

Nicholas Broussard, GE

Mark Gilbert, GE


nb/mmg/dt

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# 1.0 INTRODUCTION

## 1.1 PURPOSE AND SCOPE

ENGEO prepared this geotechnical report for design of the Offsite Sanitary Sewer Improvements associated with the Lassen Property Tract 8454 in Livermore, California. As outlined in our agreement dated March 30, 2021, LD-FUND III Livermore Land, LLC authorized ENGEO to conduct the following scope of services.

- Subsurface field exploration
- Scour evaluation
- Soil laboratory testing
- Data analysis and conclusions
- Report preparation

For our use, we received the RJA January 29, 2021, Offsite Sanitary Sewer Improvement Plans (9 sheets). In addition, we discussed the project with you, Adam Tennant, and Kirk Myers of RJA.

Concurrent with this field exploration, we performed a field exploration for the adjacent Lassen Property Tract 8454 Offsite Trail Improvements project. The recommendations for the adjacent project will be documented in a separate geotechnical report; however, we include the subsurface data and laboratory test results for both field explorations within this report.

This report was prepared under the responsible charge of Mark M. Gilbert, GE, with technical assistance from Nicholas Broussard, GE. Additional contributions were made by Jonathan Buck, GE for the scour evaluation.

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

## 1.2 PROJECT LOCATION

The site is located in Livermore, California, as shown on the Vicinity Map, Figure 1. As shown on the Site Plan, Figure 2, the sanitary sewer alignment starts approximately 400 feet northwest of the northern most point of Las Colinas Road and then extends northeast to Redwood Road. The alignment crosses the Arroyo Seco drainage, just east of the confluence of the Arroyo Seco and Arroyo Las Positas drainages.

## 1.3 PROJECT DESCRIPTION

The plans indicate that the sanitary sewer alignment will be used to replace an existing 33-inch-diameter sanitary sewer line, which is located west of the proposed alignment and east of the Arroyo Las Positas drainage. We understand the improvements will include construction of:

- Approximately 3,800 lineal feet of 24-inch-diameter sanitary sewer (SS) pipeline.

- Seventeen sanitary sewer manholes (SSMH).
- A tie-in to the existing 33-inch-diameter SS at SSMH#1, approximately 540 feet northwest of the Las Colinas Road overcrossing.
- A tie-in to existing 8-inch-diameter SS at existing SSMH 5002, approximately 300 feet west northwest of SSMH#17 and Redwood Road.
- Inverts ranging from Elevation 469.1 feet at the southern tie-in (SSMH#1) to Elevation 476.7 feet at the northern tie-in (existing SSMH 5002); these inverts correspond to roughly 18 to 30 feet below existing grade.
- An undercrossing at Arroyo Seco between Stations 18+24 to 20+75, with a corresponding invert at approximately Elevation 472 feet. We understand open cut trenching and trenchless methods are under evaluation. Based on our conversation with RJA and yourself, we understand the pipe invert will be approximately 8 feet below the drainage bottom. Although the casing diameter has not yet been determined, we anticipate a minimum 36-inch diameter casing would be needed to install a 24-inch diameter pipe using trenchless installation methods. This would result in top of pipe at approximately 5 feet below the drainage bottom. We understand existing tie-in constraints limit deepening the gravity-fed sewer at the crossing.

We understand the sewer pipeline will be installed with open cut trenching except at the Arroyo Seco crossing, where trenchless installation techniques are being considered. Refer to Figure 2 for the location of the proposed improvements.

The plans indicate that the sewer will extend to within approximately 10 to 15 feet of the southern terminus of Redwood Road and the back of residential lots at the northern boundary of the alignment. Near the southern end of the alignment, the plans indicate the sewer will extend through an existing driveway/road owned by Alameda County.

# 2.0 FINDINGS

## 2.1 PREVIOUS GEOTECHNICAL DATA

In 2018, we performed a geotechnical exploration for an adjoining site to the southwest of the alignment, which included several soil borings along a portion of the southwest alignment of the offsite sanitary sewer (ENGEO, 2018). The four borings shown on the Site Plan include 1-B7, 1-B8, 1-B9, and 1-B15. These borings were performed using solid-flight-auger methods and extended to depths of 11½ to 16½ feet within the gravel driveway that extends from Las Colinas Road to the 5426 Las Colinas Road property. The boring logs are attached in Appendix C and described further in Section 2.8. Additional explorations were performed west of the alignment on the adjacent parcel, which are not shown on Figure 2, since they are beyond the limits of the alignment. The surface elevations reported on the 2018 borings were based upon a different topographic datum than what was developed for the Lassen Property offsite sewer improvements project.

## 2.2 HISTORIC AERIAL PHOTO REVIEW

We reviewed historic aerial photos from www.historicaerials.com dated 1949, 1958, 1960, 1966, 1968, 1979, 1982, 1987, 1993, 2002, 2005, 2009, 2010, 2012, 2014, and 2016. In 1949, a driveway projected north from Las Colinas Road that crossed over the Las Positas creek. In addition, the Arroyo Seco appeared to be oriented in a northwest orientation that projected towards the former house located northwest of the Las Positas drainage. In the 1958 photo, the Arroyo Seco appears to have been realigned to the present-day alignment, channelized, deepened, and void of vegetation. The Arroyo Seco drainage alignment location appears relatively unchanged between 1949 and 2016. The approximate location of the 1949 Arroyo Seco alignment is shown on Figure 2; we only show a portion of the former alignment that was in proximity to the proposed improvements.

## 2.3 FIELD EXPLORATION

On April 1 and 2, 2021, we observed drilling of nine borings at the locations shown on Figure 2. An ENGEO representative observed the drilling and logged the subsurface conditions at each location. We retained a truck-mounted CME 75 drill rig and crew to advance the borings using 4-inch-diameter solid-flight auger methods. Borings 3-B1 and 3-B2 were switched to mud rotary drilling methods at depths of 20 and 24½ feet, respectively. Borings 3-B4 through 3-B7 were advanced to depths of 5 to 10½ feet in support of the nearby trail improvements, whereas the other borings performed along the sewer alignment extended to depths of 26½ to 50 feet. We permitted and backfilled the borings in accordance with the requirements of Zone 7 Water Agency.

The location of our explorations are approximate and were estimated by a cell-phone based GPS, while elevations were approximated relative to the topographic map that we received; they should be considered accurate only to the degree implied by the method used.

We obtained bulk soil samples from drill cuttings and retrieved soil samples at various intervals in the borings using standard penetration tests. The standard penetration resistance blow counts were obtained by dropping a 140-pound hammer through a 30-inch free fall. The 2-inch O.D. split-spoon sampler was driven 18 inches and the number of blows was recorded for each 6 inches of penetration. In addition, the 3-inch O.D. split-spoon Modified California Sampler was also driven into the soil with the 140-pound hammer previously described. Unless otherwise indicated, the blows per foot recorded on the boring log represent the accumulated number of blows to drive the last 1 foot of penetration; the blow counts have not been converted using any correction factors. When sampler driving was difficult, penetration was recorded only as inches penetrated for 50 hammer blows.

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

## 2.4 GEOMORPHIC RECONNAISSANCE

On April 27, 2021, we performed a reconnaissance of the Arroyo Seco drainage approximately 200 feet upstream and 200 feet downstream of the proposed sewer crossing. To evaluate the potential for long-term degradation or downcutting of the creek bed at the sewer pipe alignment, we observed the bed and bank conditions of the creek channel upstream and downstream of the proposed sewer pipe crossing.

The proposed alignment is located approximately 200 feet upstream of the Arroyo Seco confluence with Arroyo Las Positas. We observed that approximately 50 feet upstream of the confluence, the Arroyo Seco creek banks have been armored with rock revetment at an abandoned bridge crossing. In the area of the proposed alignment, the creek bed appears to have formed a step-pool and riffle system. Visible flowing water was approximately 1 foot deep and moving at a velocity estimated at less than 1 foot per second. Photos from our reconnaissance are shown on Figure 6. As previously discussed in Section 2.2, the Arroyo Seco drainage appears to have been anthropomorphically modified in the area of the project. The channel bed and banks have a consistent geometry throughout the reach, and the bottom of the channel appears to be over widened. Based on our site observations, neither localized bed erosion nor widespread systematic downcutting of the creek bed appeared to be occurring in this reach of Arroyo Seco. Moreover, existing armorment downstream of the project may stabilize any scour in the reach of the proposed project.

A major geomorphic indicator of the potential for long-term channel degradation in a natural waterway is the measurement of the creeks' bed slope. In a non-eroding channel, the bed slope should be similar to that of other similar creek systems, which are in a state of an erosion/deposition 'equilibrium'. The concept of an 'equilibrium' bed slope is based on principles of fluvial geomorphology and suggests that a creek will adjust its bed slope to a stable gradient over the long term so that the system transports all of its sediment without net deposition or erosion. Our evaluation of the survey data used in the HEC-RAS model of the creek (See Section 2.11) indicates that the bed slope of Arroyo Seco is approximately 0.0035 feet/feet near the proposed sewer crossing. Based on our experience working with other fluvial systems located in the San Francisco East Bay region, this slope is slightly lower than the predicted 'equilibrium' bed slope for a creek system with a 100-year discharge of 3,800 cubic feet per second (cfs).

## 2.5 GEOLOGY

The proposed sewer alignment lies within the Coast Range Geomorphic Province of California, an area dominated by northwest-trending geologic features such as folds and faults. More specifically, the subject site is located in the Livermore Valley within the Diablo Range. The Diablo Range is characterized by anticlines composed of Franciscan cores that are separated by synclinal folds containing younger rocks such as the Livermore Gravels. Overlying these rocks in many locations are alluvial deposits that have filled in the lower elevation areas.

The regional geologic map by Dibblee (2006) is included in Figure 3. Mapping by Dibblee (2006) and Helley and Graymer (1997) indicate the proposed sewer alignment is underlain by Quaternary Alluvium. Helley and Graymer describe these sediments in more detail as Pleistocene Alluvial Fans and Fluvial Deposits containing mixtures of clay, sand, and gravel deposited by ancestral streams and washes. In addition, younger Holocene alluvial deposits are mapped by Knudsen et al. (2000) near the Arroyo Seco drainage. The surrounding hills are mapped as the older Pliocene to Pleistocene Livermore Gravel Formation, a relatively young bedrock that is likely at depth beneath the alluvium. The Livermore Gravel Formation includes poorly to moderately consolidated, indistinctly bedded, cobble conglomerate, gray conglomeratic sandstone, and gray coarse-grained sandstone that includes some siltstone and claystone. The clasts within the unit contain mostly graywacke, chert, and metamorphic rocks likely derived from the Franciscan complex rocks.

## 2.6 FAULTING AND SEISMICITY

The Bay Area Region contains numerous active earthquake faults. The site is not located within a currently designated Alquist-Priolo Earthquake Fault Zone and no known surface expression of active faults is believed to exist within the site. An active fault is defined by the State Mining and Geology Board as one that has had surface displacement within Holocene time (about the last 11,000 years) (Bryant and Hart, 2007).

To determine nearby active faults that are capable of generating strong seismic ground shaking at the site, we utilized the USGS Unified Hazard Tool* and deaggregated the hazard at the peak ground acceleration (PGA).These seismic sources are summarized in Table 2.6-1.

**TABLE 2.6-1: USGS 2014 Seismic Sources Capable of Producing Strong Ground Shaking (Latitude: 37.705487 Longitude: -121.754089)**

| SOURCE | $R_{RUP}$ | | MOMENT MAGNITUDE $M_W$ |
|---|---|---|---|
| | (KM) | (MILES) | |
| Mount Diablo Thrust South [0] | 4.62 | 2.87 | 6.79 |
| Greenville (No) [3] | 8.27 | 5.14 | 6.97 |
| Las Positas [0] | 5.38 | 3.34 | 6.36 |
| Calaveras (No) [4] | 16.24 | 10.1 | 7.22 |
| Hayward (So) [4] | 24.43 | 15.2 | 7.29 |

*USGS Unified Hazard Tool - Edition: Dynamic Conterminous U.S. 2014 (update) (v4.2.0)

Numerous small earthquakes occur every year in the San Francisco Bay Region, and larger earthquakes have been recorded and can be expected to occur in the future. Figure 4 shows the approximate locations of significant historic earthquakes recorded within the San Francisco Bay Region; known faults are also shown in Figure 5.

The third version of Uniform California Earthquake Forecast (UCERF3) developed by the Working Group on California Earthquake Probabilities (Field et al., 2013) provides updated estimates of the 30-year probability of various magnitude earthquakes in the San Francisco Bay Region. The results of the study are summarized in Table 2.6-2.

**TABLE 2.6-2: 30-Year Probability of Earthquake in the San Francisco Bay Area Region**

| EARTHQUAKE MAGNITUDE | 30-YEAR PROBABILITY OF ONE OR MORE EVENTS |
|---|---|
| 5 or Greater | 100% |
| 6 or Greater | 98% |
| 7 or Greater | 51% |
| 8 or Greater | 4% |

The Seismic Hazard Zone Map, illustrated in Figure 5, indicates the southern portion of the alignment extends through a zone mapped as a liquefaction-hazard zone. Witter (2006) maps the liquefaction hazard within the Arroyo Seco as very-high susceptibility of liquefaction, high near Las Colinas Road, and moderate within the majority of the alignment.

## 2.7 SURFACE CONDITIONS

According to the Improvement Plans (RJA, 2021a), site grades are relatively flat to gently sloping towards the southwest. Site grades range from approximately Elevation 487 feet at the southwest terminus of the alignment to Elevation 500 feet at the northeast terminus near Redwood Road. The site is relative flat south of Station 29+00, at which point the elevations gently slope uphill to a high point near Elevation 503 feet towards the north. At the Arroyo Seco crossing, the plans indicate the bottom of creek is at roughly Elevation 480 feet. The top of north and south bank are near Elevation 493 and 498 feet, respectively.

We observed the following site features during our field exploration:

- The southernmost approximately 500 feet of sewer alignment is located within an existing gravel driveway/road, which is indicated to be maintained by Alameda County on the plans. We observed recent utility markings for several utilities located within the driveway/road.

- The remainder of the alignment, outside of the gravel road and Arroyo Seco, was generally within undeveloped land that was vegetated with low grasses and grazed by cattle.

- We observed remnants of an older gravel driveway that extended due north from Las Colinas Road. We also observed remnants of a former bridge that crossed the Arroyo Seco associated with this driveway, approximately 100 feet west of the proposed bridge. We observed the Arroyo Seco creek banks have been armored with rock revetment at the abandoned bridge crossing.

- The Arroyo Seco had up to approximately 1 foot of flowing water within the base of the channel. Relative to the northern bank, the Arroyo Seco appeared to be roughly 10 to 12 feet deep. Some large trees were located within the Arroyo Seco channel in the vicinity of the proposed crossing. The side slopes of the channel were approximately 1:1 to 1.5:1 (horizontal:vertical). Some shallow sloughing near the top of the southern side bank was visible between the proposed bridge and the revetment from the abandoned bridge. The topographic contours along Arroyo Seco drainage indicate the presence of some steeper creek bank slopes approximately 150 feet upstream of the proposed bridge near a bend in the channel, where the water appears to have encroached upon and eroded the creek bank.

- The southern side of the Arroyo Seco channel appeared to be roughly 5 to 8 feet taller than the northern side of the channel. Based on our review of aerial photos, we anticipate this elevated area is a fill berm likely associated with spoils derived from the channelization of Arroyo Seco sometime between 1949 and 1958. At the time we prepared this report, were were unaware of any relative compaction documentation for this fill placement and consider this fill non-engineered.

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

**PHOTO 2.7-1: Downstream View of Arroyo Seco Adjacent to Boring 3-B2**

**PHOTO 2.7-2: View Looking Southwest from Boring 3-B2**

**PHOTO 2.7-3: Shallow Sloughing of Southern Bank West of Proposed Bridge and East of Revetment Associated with Abandoned Bridge**

**PHOTO 2.7-4: Fill Berm Adjacent to Boring 3-B1**

## 2.8 SUBSURFACE CONDITIONS

Our borings along the northern two-thirds of the alignment, north of and including Boring 3-B1, generally encountered very stiff to hard lean clay with some interlayered medium dense to very dense sand. At depths that correspond to the bottom of Arroyo Seco down to the planned pipe zone (roughly Elevation 472 to 480 feet), Boring 3-B1 encountered hard sandy lean clay with gravel. Over the same depth range in Boring 3-B2, we encountered loose to medium dense sand, dense clayey sand, and hard sandy lean clay. Based on the relatively high blow counts, hard consistency, and presence of carbonates and iron oxidation, we anticipate the soil in the borings north of and including 3-B1 is Pleistocene-aged (older than 11,000 years).

On the southern approximately one-third of the alignment, including Boring 3-B8 and each of the four borings performed in 2018, the soil we encountered generally consisted of medium stiff to very stiff clay of medium to high plasticity, and loose to medium dense silty sand with varying amounts of gravel. In Boring 1-B7, the silty sand became dense at a depth of approximately 15 feet.

Several of the borings encountered the Livermore Gravel Formation, locally classified as bedrock. In our soil borings, we described the Livermore Gravels Formation using soil classification instead of rock classification methods. The depth of the Livermore Gravel Formation appeared to be shallowest at the north end in Boring 3-B9 and deepest in Boring 3-B8 near the southern end of the alignment.

Consult the Site Plan and boring logs for specific subsurface conditions at each location. We include our 2021 boring logs in Appendix A and 2018 logs in Appendix C. The logs contain the soil type, color, consistency, and visual classification in general accordance with the Unified Soil Classification System. The logs graphically depict the subsurface conditions encountered at the time of the exploration.

## 2.9 GROUNDWATER CONDITIONS

We observed groundwater at the time of drilling in Borings 3-B1, 3-B2, 3-B3, 3-B8, 1-B7, and 1-B8. We summarize our observations in Table 2.9-1.

**TABLE 2.9-1: Groundwater Observations**

| EXPLORATION LOCATION | APPROX. DEPTH TO GROUNDWATER (FEET) | APPROX. GROUNDWATER ELEVATION (NGVD29, FEET) |
|---|---|---|
| 3-B1 (April, 2021) | 13 | 478½ |
| 3-B2 (April, 2021) | 16 | 478 |
| 3-B3 (April, 2021) | 14½ | 480½ |
| 3-B8 (April, 2021) | 14 | 476½ |
| 1-B7 (October, 2018) | 10 | 480* |
| 1-B8 (October, 2018) | 14½ | 473½* |

*Ground surface elevations approximated from RJA topographic data (RJA, 2021a).

Some of the borings may not have been left open a sufficient amount of time to allow water levels to stabilize. Fluctuations in the level of groundwater may occur due to variations in rainfall, irrigation practice, and other factors not evident at the time measurements were made.

## 2.10 LABORATORY TESTING

We performed laboratory tests on selected soil samples to evaluate their engineering properties. We performed moisture content, dry density, unconfined compression, undrained-unconsolidated triaxial compression, direct shear, plasticity index, gradation, resistance value, and soil corrosion potential testing. Moisture contents and dry densities are recorded on the boring logs in Appendix A; other laboratory data is included in Appendix B.

## 2.11 SCOUR EVALUATION

We evaluated scour potential of the Arroyo Seco at the proposed sewer pipe alignment. The purpose of the scour evaluation was to estimate the maximum vertical scour potential of the creek bed at the proposed sewer pipe alignment. Our evaluation included review of Arroyo Seco hydraulic analysis results performed by Zone 7 Water Agency, and a site reconnaissance to evaluate creek geomorphology and local site conditions at the location of the proposed alignment.

We also used our professional judgment having evaluated the scour potential of many similar creeks in the East San Francisco Bay Region.

We obtained a hydraulic analysis of the Arroyo Seco from the Zone 7 Water Agency on March 25, 2021. The hydraulic analysis was performed using the Hydraulic Engineering Center River Analysis System (HEC-RAS) Version 5.0.5 computer program published by the United States Army Corps of Engineers (USACE). HEC-RAS performs one-dimensional hydraulic analyses for natural channels and calculates water surface profiles and velocities in steady, gradually varied flow conditions. Surveyed information used in the model was dated April 8, 2016, and was provided by Joseph C. Truxaw and Associates, Inc., for the cross-sectional geometries of the creek reach.

A 100-year rainfall event having a peak hydrologic flow rate of 3,082 cubic feet per second (cfs) was used through the reach based on a Zone 7 hydrologic model of the Arroyo Mocho watershed.

Table 2.11-1 summarizes the range of velocities and water surface elevation (NAVD 88) calculated from the HEC-RAS program for two cross sections upstream and downstream of the proposed sanitary sewer. For comparison to the datum used for the subject Lassen Property offsite sewer improvements project, we provide a column for NGVD29 elevations that we calculated by subtracting 2.6 feet from the NAVD88 elevations.

**TABLE 2.11-1: Zone 7 Range of Calculated Velocities (100-Year)**

| HEC-RAS STATION | 100-YEAR WSE (NAVD 88) (ft) | 100-YEAR WSE (NGVD 29) (ft) | AVERAGE CHANNEL VELOCITY (ft/sec) |
|---|---|---|---|
| Upstream of Proposed SS | 494.86 | 492.26 | 6.5 |
| Downstream of Proposed SS | 494.33 | 491.73 | 7.36 |

It is our opinion that the actual velocities at the creek bottom and banks are substantially lower than what is reported in the HEC-RAS results summarized above, since HEC-RAS calculates average velocities across a channel, and the velocities are not uniformly distributed in the creek section in reality. Studies performed by Chow (1959) indicate that, due to friction along the walls and bottom of an open channel section, the actual velocity at the boundary of a creek channel is approximately one-half the calculated “average” velocity. Thus, we anticipate the 100-year velocities in the creek bed at the sewer alignment are approximately 3.5 feet-per-second based on the HEC-RAS analysis.

As described in Section 2.4, we observed sand and gravel at the base of the channel. According to erosion threshold guidance for flood control channels published by the United States Army Corps of Engineers (USACE, 1994), the allowable mean velocity for an unlined/unvegetated channel is between 4.0 to 6.0 feet-per-second for sand to gravel. Since creek bed velocities do not appear to exceed published erosion threshold standards by the USACE, we estimate that the potential for bed erosion in the Arroyo Seco due to hydraulic forces is negligible.

# 3.0 CONSTRUCTION MONITORING

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

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

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

If we are not retained to perform the services described above, then we are not responsible for any party's interpretation of our report (and subsequent addenda, letters, and verbal discussions). Furthermore, the firm retained to perform construction monitoring as described above becomes the Geotechnical Engineer of Record.

# 4.0 CONCLUSIONS

From a geotechnical engineering viewpoint, in our opinion, the proposed project may be designed as planned, provided the geotechnical recommendations in this report are properly incorporated into the design plans and specifications.

The primary geotechnical issue related to the design and installation of the proposed sewer line is groundwater, especially at the trenchless crossing beneath the Arroyo Seco. We summarize our conclusions below.

## 4.1 GROUNDWATER

Shallow groundwater will likely be encountered during excavation and temporary construction dewatering should be anticipated. Groundwater can impede construction and affect excavation stability. As discussed in Section 2.9, groundwater was encountered in six of our explorations at depths from 10 and 16 feet below grade. The proposed pipe invert depths will be roughly 18 to 30 feet below existing grade. Fluctuations in the level of groundwater may occur due to variations in rainfall, irrigation practice, and other factors. The selection of dewatering methods should be left to the contractor's judgement.

## 4.2 SCOUR

We estimate that the potential scour hazard at the sewer crossing due to long-term degradation of the channel is low, based on our field reconnaissance and geomorphic evaluation of the creek bed slope from the HEC-RAS modelling performed in Section 2.11. We recommend a minimum

vertical separation of 4 feet between top of pipe and bottom of existing creek bed to account for any temporary movement of creek bed materials during large storm events.

## 4.3 TRENCHLESS CROSSING OF ARROYO SECO

Based on the relatively limited soil cover of approximately 5 feet, and presence of sand below the groundwater, we anticipate there is a relatively high risk that trenchless installation at the undercrossing could detrimentally impact the bottom of the channel. Based on our research, a minimum of three pipe-casing diameters or 10 feet of soil cover would be necessary to reduce potential for significant upheave, frac-out, or settlement of the channel bottom for trenchless installation. Guidance by Caltrans and USACE indicates that the recommended minimum depth of cover for a 24-inch diameter horizontal-directional drilling installation is 10 feet, with minimum 15 feet of cover recommended for diameters of 25 to 48 inches (Caltrans, 2018b). Additional soil cover could be required depending upon local jurisdiction requirements and method of installation. Relative to Boring 3-B2 on the north side of the Arroyo Seco crossing, the top of pipe casing may be near the transition between hard sandy lean clay and poorly graded sand. The low density of this sand and presence below the groundwater could result in post-construction settlement at the crossing (VDOT, 2015).

## 4.4 EXISTING FILL

Although our explorations did not encounter fill, we anticipate existing fill is located along portions of the proposed sewer alignment. We anticipate existing fill will be encountered within the elevated berm on the south side of the Arroyo Seco, the former 1949 alignment of Arroyo Seco that was backfilled, the old gravel driveway between Arroyo Seco and the Alameda County gravel road, and trench backfill associated with existing utilities on the Alameda County gravel road. Based on our review of aerial photos, we anticipate the fill berm on the south side of Arroyo Seco is likely associated with spoils derived from the channelization of Arroyo Seco sometime between 1949 and 1958. At the time we prepared this report, were unaware of any relative compaction documentation for this fill placement and consider this fill non-engineered.

Although non-engineered fills can undergo excessive settlement under new fill or building loads, we anticipate the sewer will be installed deeper than the fill and therefore won't be subject to impacts from the fill. However, the contractor should be aware of this existing fill and anticipate variable conditions compared to the native soil conditions on site. In the former Arroyo Seco drainage, this could potentially include the presence of younger and less dense soil. Refer to Section 5.3 for additional recommendations related to reuse of existing soil associated with this fill.

## 4.5 EXCAVATABILITY

We used a CME 75 drill rig to perform our borings in 2021 and a Soil Test Ranger to perform the borings in 2018. We did not encounter refusal within any of our explorations. Therefore, we anticipate conventional grading and backhoe equipment will likely be able to excavate the soil and Livermore Gravels formation. We provide the above excavatability information for general planning purposes only. This information is not intended for bidding purposes.

## 4.6 TRENCH STABILITY

Trench stability will need to be considered for design of temporary shoring. Soil encountered at our explorations along the alignment generally consisted of interbedded layers of clay and sand. Trench stability should consider the presence of nearby improvements, such as but not limited to Redwood Court, existing utilities on the southern end of the alignment near Las Colinas Road, and private residential lots. We present temporary shoring recommendations in Section 5.2.

## 4.7 SEISMIC HAZARDS

Potential seismic hazards resulting from a nearby moderate to major earthquake can generally be classified as primary and secondary. The primary effect is ground rupture, also called surface faulting. The common secondary seismic hazards include ground shaking and ground lurching. The following sections present a discussion of these hazards as they apply to the site.

### 4.7.1 Ground Rupture

The site is not located within a State of California Earthquake Fault Hazard Zone (Altamont, 1982) and no faults are mapped crossing the site; therefore, it is our opinion that ground rupture is not likely to occur at the site.

### 4.7.2 Ground Shaking

An earthquake of moderate to high magnitude generated within the San Francisco Bay Region, similar to those that have occurred in the past, could cause considerable ground shaking at the site; this level of ground shaking should be considered within the design life of the project. Buried structures, such as pipelines, would be expected to generally move in-phase with surrounding soil and any seismic forces imparted on the pipeline would be nominal.

### 4.7.3 Liquefaction

Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. Soil most susceptible to liquefaction is clean, loose, saturated, uniformly graded, Holocene-aged, fine-grained sand. According to the attached Seismic Hazards Zone Map, Figure 5, the alignment north of the Arroyo Seco drainage is in an area mapped outside of a liquefaction hazard zone. In this northern area, we generally encountered dense sand and very stiff to hard clay and shallower Livermore Gravel Formation. As described in Section 2.8, we also encountered very stiff to hard clay and medium dense to very dense sand within Borings 3-B1 and 3-B2 that we judged to be Pleistocene-aged. Based on the subsurface conditions and Pleistocene- to Pliocene-age of the soil and Livermore Gravel formation in this area, it is our opinion that the potential for liquefaction at the proposed undercrossing and north is low during seismic shaking.

South of the Arroyo Seco, the alignment is within an area mapped with a potential for liquefaction on Figure 5. Knudsen et al (2000) and Witter (2006) mapped this southern portion of the alignment as being within a moderate to very high liquefaction susceptible area. We encountered loose to medium dense sand below the groundwater in this area in Borings 3-B8, 1-B7, and 1-B8 that we judge to be Holocene-aged. Based on the relatively discontinuous nature of the sand and thickness of non-liquefiable capping layer at the surface, we anticipate the risk of liquefaction-induced surface rupture or lateral spreading in these areas is relatively low. Following

a design-level earthquake event, up to 1 inch of liquefaction-induced settlement of the pipe could be expected in this southern area. The amount of settlement at the surface would be expected to be higher.

### 4.7.4 Ground Lurching

Ground lurching is a result of the rolling motion imparted to the ground surface during energy released by an earthquake. Such rolling motion can cause ground cracks to form in weaker soil. The potential for the formation of these cracks is considered greater at contacts between deep alluvium and bedrock. Such an occurrence is possible at the site as in other locations, but the offset or strain is expected to be low at the site and should not affect performance of a pipeline at the site.

### 4.7.5 Earthquake-Induced Landsliding

Earthquake-induced landsliding involves lateral ground movements caused by seismic shaking. The Seismic Hazard Zone Map, Figure 5, indicates the site is outside of an Earthquake-Induced landslide zone. We anticipate that the risk of earthquake-induced landsliding to be low along the alignment.

## 4.8 SOIL CORROSION POTENTIAL

As part of this study and the adjacent study for the pedestrian trail, we obtained four representative soil samples and submitted to a qualified analytical lab for determination of pH, resistivity, sulfate, and chloride. The results are included in Appendix B and summarized in the table below.

**TABLE 4.8-1: Corrosivity Test Results**

| SAMPLE LOCATION | DEPTH (FEET) | PH | RESISTIVITY (OHMS-CM) | CHLORIDE (PPM) | SULFATE (PPM) |
|---|---|---|---|---|---|
| 3-B1 | 3½ | 7.69 | 270 | 152.7 | 1,337 |
| 3-B2 | 13½ | 7.66 | 670 | 56.8 | 124.9 |
| 3-B3 | 15½ | 7.59 | 270 | 125.6 | 686.5 |
| 3-B9 | 21 | 8.87 | 250 | 418 | 633.2 |

The 2019 CBC references the 2014 American Concrete Institute Manual, ACI 318-14, Section 19.3.1 for concrete durability requirements. The sulfate results for the deeper samples in 3-B2, 2-B3, and 3-B9 indicate the soil we encountered is classified as Sulfate Exposure Class S0. The corrosion test performed on the near-surface clay in 3-B1 corresponds with a Sulfate Exposure Class of S1. For this sulfate range, we recommend Type II cement and a concrete mix design that incorporates a maximum water-cement ratio of 0.50. The structural engineering design requirements for concrete may result in more stringent concrete specifications.

The resistivity results indicate the soil we tested is extremely corrosive to buried metal piping. Values tested for chloride do not pose a significant impact to metals or concrete.

Caltrans considers a site to be corrosive to structural elements if one or more samples has a chloride concentration greater than 500 ppm, sulfate concentration greater than 1500 ppm, or a

pH of 5.5 or less (Caltrans, 2018a). Therefore, none of the four samples would be classified as corrosive to structural elements according to Caltrans.

If desired to investigate this further, we recommend a corrosion consultant be retained to evaluate if specific corrosion recommendations are advised for the project.

# 5.0 RECOMMENDATIONS

## 5.1 TEMPORARY SLOPES AND SHORING

Temporary shoring may be required at the subject site based on the anticipated pipe invert depths. The contractor is responsible for evaluating soil/rock conditions and constructing temporary excavations in accordance with OSHA requirements. For planning purposes, we provide the following OSHA information regarding temporary slopes. In general, the soil encountered in our explorations would be considered "Type A" to "Type C" soil.

**TABLE 5.1-1: OSHA Technical Manual Table V:2-1. Allowable Slopes (excavations less than 20 feet) ***

| SOIL TYPE | CHARACTERISTICS | HEIGHT:DEPTH RATIO |
|---|---|---|
| Stable Rock | Rock that can be excavated with vertical sides and remain intact while exposed. | Vertical |
| Type A | Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf); commonly includes: clay, silty clay, sandy clay | ¾:1 |
| Type B | Cohesive soils with an unconfined compressive strength greater than 0.5 tsf but less than 1.5 tsf; commonly includes: angular gravel; silt; previously disturbed soils | 1:1 |
| Type C | Cohesive soils with an unconfined compressive strength of 0.5 tsf or less; commonly includes: granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable | 1½:1 |

*For more detail, refer to the most current OSHA Technical Manual.

The specific choice of shoring should be left to the contractor's judgment since economic considerations and/or the individual contractor's construction experience may determine which method is more economical and/or applicable. Excavations greater than 4 feet in depth could be temporarily shored as necessary using trench shields appropriately designed by a qualified registered engineer. Variation in hydrostatic pressures or surcharges may require an increase in design pressures and distribution. The design of the shoring should be sufficiently rigid to prevent detrimental movement of the temporary shoring and possible damage of pavements, sidewalks, adjacent utilities, or other structural improvements.

Excavated soil, construction materials, or other items imposing a surcharge should be stockpiled at least 20 feet away from the edge of excavations to reduce potential adverse effect on slope or trench stability. We recommend that no vertical trench excavations be left open overnight without adequate shoring. Once shoring has been removed, the contractor should backfill the excavation to within 4 feet of the ground surface before the end of the day.

Surcharge loads from structures and vehicles should be included in shoring design if the surcharge loading is situated within 10 feet of the top of the trench or above a 1:1 line of projection extending from the bottom of the trench, whichever is farther. The surcharge should be taken as one-half of any vertical surcharge loads and should be applied as a uniform lateral load. A minimum lateral surcharge load equal to 72 psf, as prescribed in the Caltrans Trenching and Shoring Manual (Caltrans, 2011), should be considered for traffic loading, where applicable.

## 5.2 TEMPORARY DEWATERING

Dewatering groundwater levels should be maintained at least 2 feet below the bottom of trenches or excavations for pipeline and structure installations. The selection of equipment and method should be determined by the contractor. The dewatering system implemented should be selected so as to have minimal impact on the groundwater level surrounding the proposed excavations. In general, trenches and pits should be maintained a minimum of 50 feet from adjacent structures. In addition, the dewatering system should be designed to prevent pumping soil fines with the discharge water. Uncontrolled dewatering may cause settlement of the general area and may affect existing structures in the vicinity of the alignment. Refer to Section 4.1 for more information related to groundwater.

## 5.3 TRENCH BACKFILL

Utility trenches and excavations should be constructed in accordance with City of Livermore standards and recommendations provided in this report, as appropriate. Where conflict occurs, please consult with the Geotechnical Engineer for clarification.

To mitigate water flow into open graded granular bedding and pipe zone backfill, we recommend encapsulating the granular bedding in non-woven filter fabric to prevent fines migration. Additionally, to prevent water from flowing along the granular bedding, we recommend slurry cutoff plugs encapsulating the pipe and extending into the native soil or rock; the cut-off plugs should be placed approximately every 200 feet along the sewer alignment. Alternatively, a flowable fill may be used in place of the granular bedding.

## 5.4 PIPE DESIGN

The sewer pipe should be designed to resist loads imposed from overlying soil cover and from vehicle or construction traffic. Soil loads may be calculated using a total unit weight of 120 pounds pcf and a buoyant unit weight of 60 pcf.

We recommend a minimum vertical separation of 4 feet between the top of casing and bottom of creek based on scour hazard considerations in this reach of Arroyo Seco (Section 4.2).

The pipeline and manholes should be designed for the buoyancy effects of shallow groundwater level. Where buoyancy effects are determined to be high, concrete collars or tie downs should be used to resist uplift.

# 6.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report presents geotechnical recommendations for design of the improvements discussed in Section 1.3 for the Lassen Property Tract 8454 Offsite Sanitary Sewer Improvements project. If changes occur in the nature or design of the project, we should be allowed to review this report and provide additional recommendations, if any. It is the responsibility of the owner to transmit the information and recommendations of this report to the appropriate organizations or people involved in design of the project, including but not limited to developers, owners, buyers, architects, engineers, and designers. The conclusions and recommendations contained in this report are solely professional opinions and are valid for a period of no more than 2 years from the date of report issuance.

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

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

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

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

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

We determined the lines designating the interface between layers on the exploration logs using visual observations. The transition between the materials may be abrupt or gradual. The exploration logs contain information concerning samples recovered, indications of the presence

of various materials such as clay, sand, silt, rock, existing fill, etc., and observations of groundwater encountered. The field logs also contain our interpretation of the subsurface conditions between sample locations. Therefore, the logs contain both factual and interpretative information. Our recommendations are based on the contents of the final logs, which represent our interpretation of the field logs.

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## FIGURES

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BASE MAP SOURCE: GOOGLE EARTH MAPPING SERVICE

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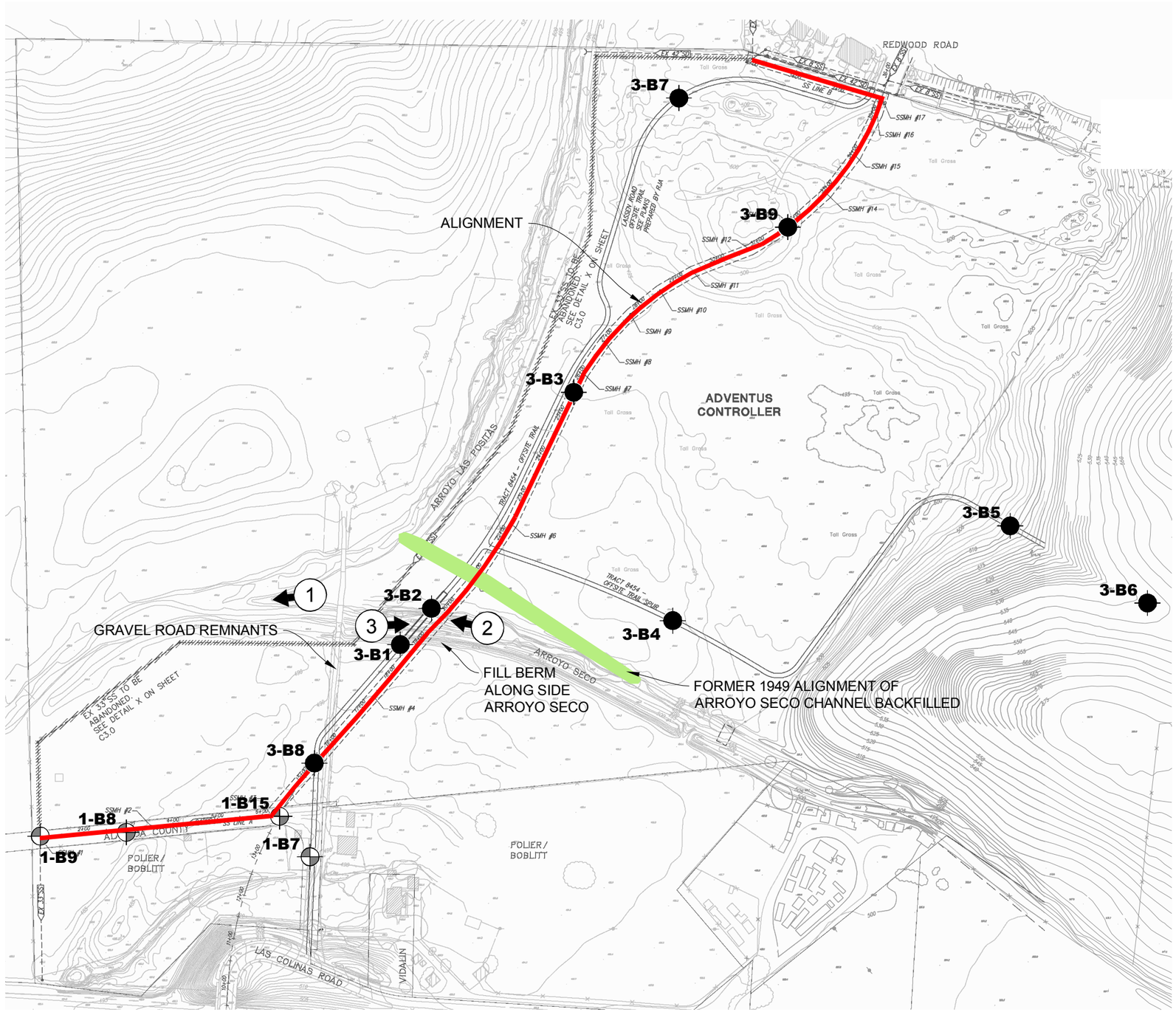
# VICINITY MAP

OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY
LIVERMORE, CALIFORNIA

| | |
|---|---|
| PROJECT NO.: 13850.001.001 | FIGURE NO. 1 |
| SCALE: AS SHOWN | |
| DRAWN BY: LL | CHECKED BY: MMG |

ORIGINAL FIGURE PRINTED IN COLOR




## EXPLANATION

*ALL LOCATIONS ARE APPROXIMATE*

- 3-B9 — BORING (ENGEO, 2021)
- 1-B15 — SOLID FLIGHT AUGER BORING (ENGEO, 2018)
- 3 — PHOTO LOCATION AND DIRECTION (SEE FIGURE 6)

*BASE MAP SOURCE: RJA, 2021*

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**SITE PLAN**

**OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY**

**LIVERMORE, CALIFORNIA**

| | |
|---|---|
| PROJECT NO.: 13850.001.001 | FIGURE NO. 2 |
| SCALE: SITE PLAN | |
| DRAWN BY: LL | CHECKED BY: MMG |

ORIGINAL FIGURE PRINTED IN COLOR

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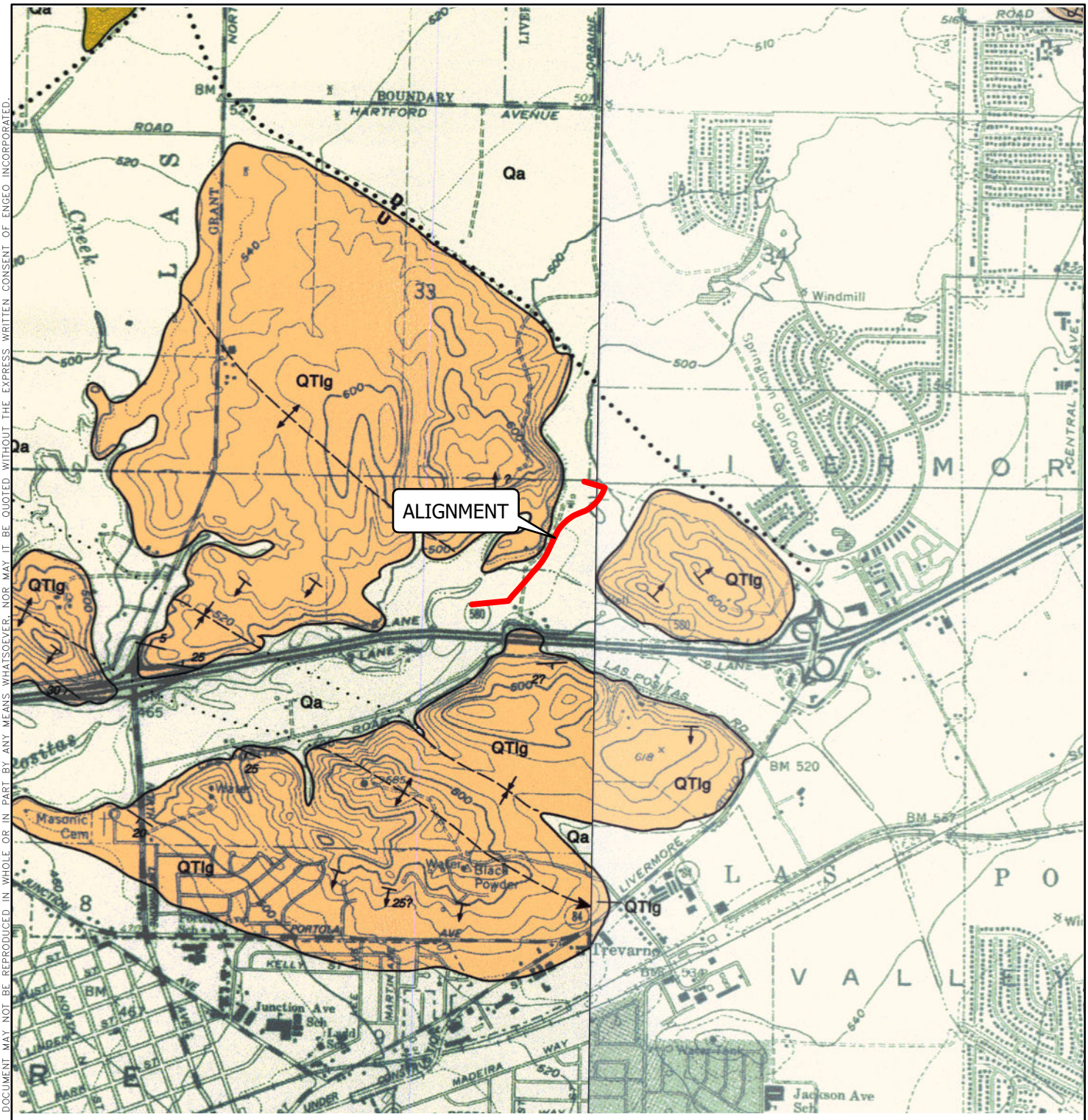


## EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

- Qa — ALLUVIUM GRAVEL
- QTlg — LIVERMORE GRAVEL

BASEMAP SOURCE: DIBBLEE 2006



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# REGIONAL GEOLOGIC MAP

OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY

LIVERMORE, CALIFORNIA

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| PROJECT NO. : | 13850.001.001 |
| SCALE: | AS SHOWN |
| DRAWN BY: QRL | CHECKED BY: MMG |

FIGURE NO. 3

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LAYOUT: GEOLOGIC USER: QLIANG

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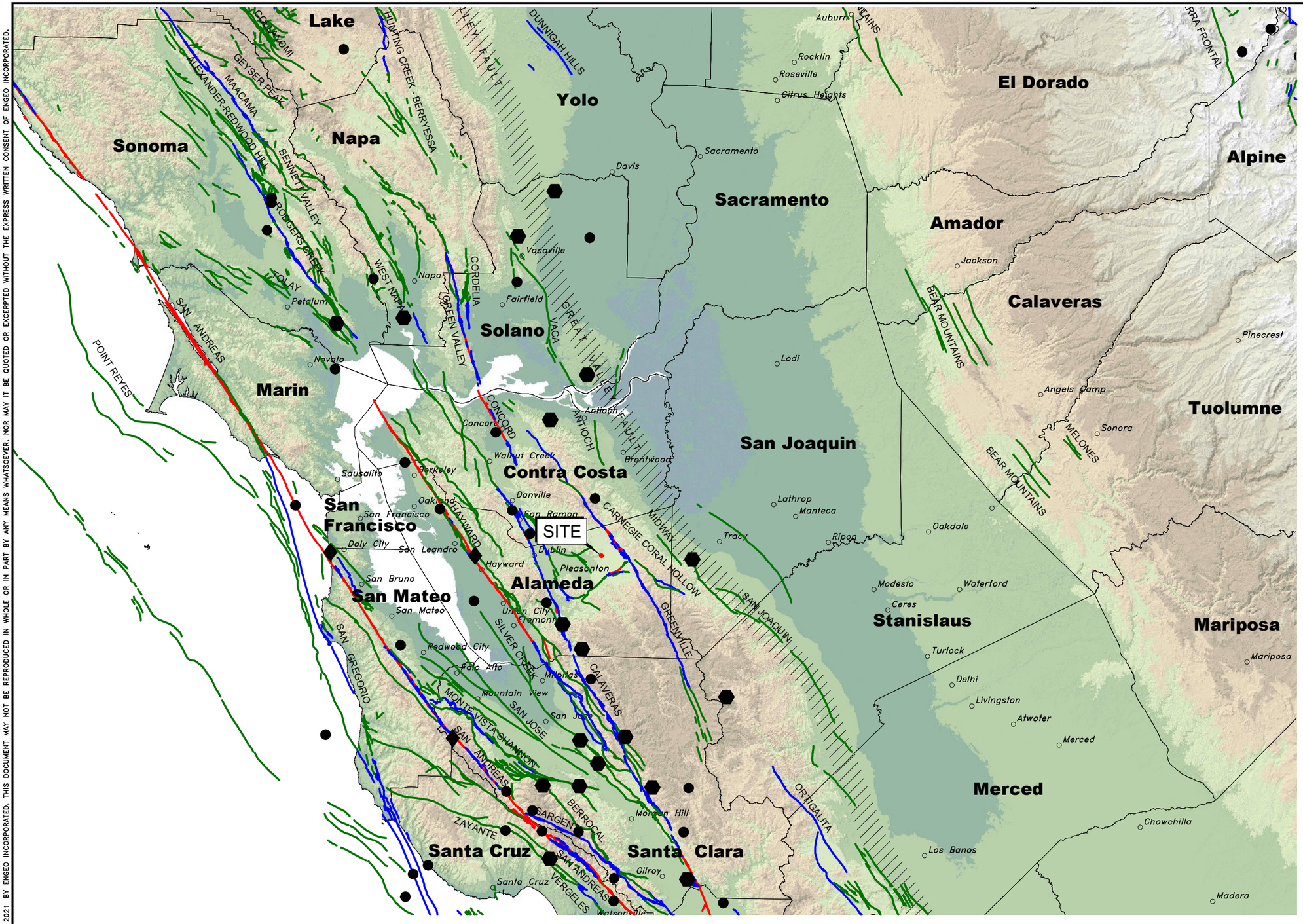


*BASE MAP SOURCE:*
*COLOR HILLSHADE IMAGE BASED ON THE NATIONAL ELEVATION DATASET (NED) AT 30 METER RESOLUTION*
*U.S.G.S. QUATERNARY FAULT DATABASE, NOVEMBER, 2010*
*U.S.G.S. HISTORIC EARTHQUAKE DATABASE (1800–2000)*

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**REGIONAL FAULTING AND SEISMICITY**
**OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY**
**LIVERMORE, CALIFORNIA**

PROJECT NO.: 13850.001.001
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FIGURE NO. 4

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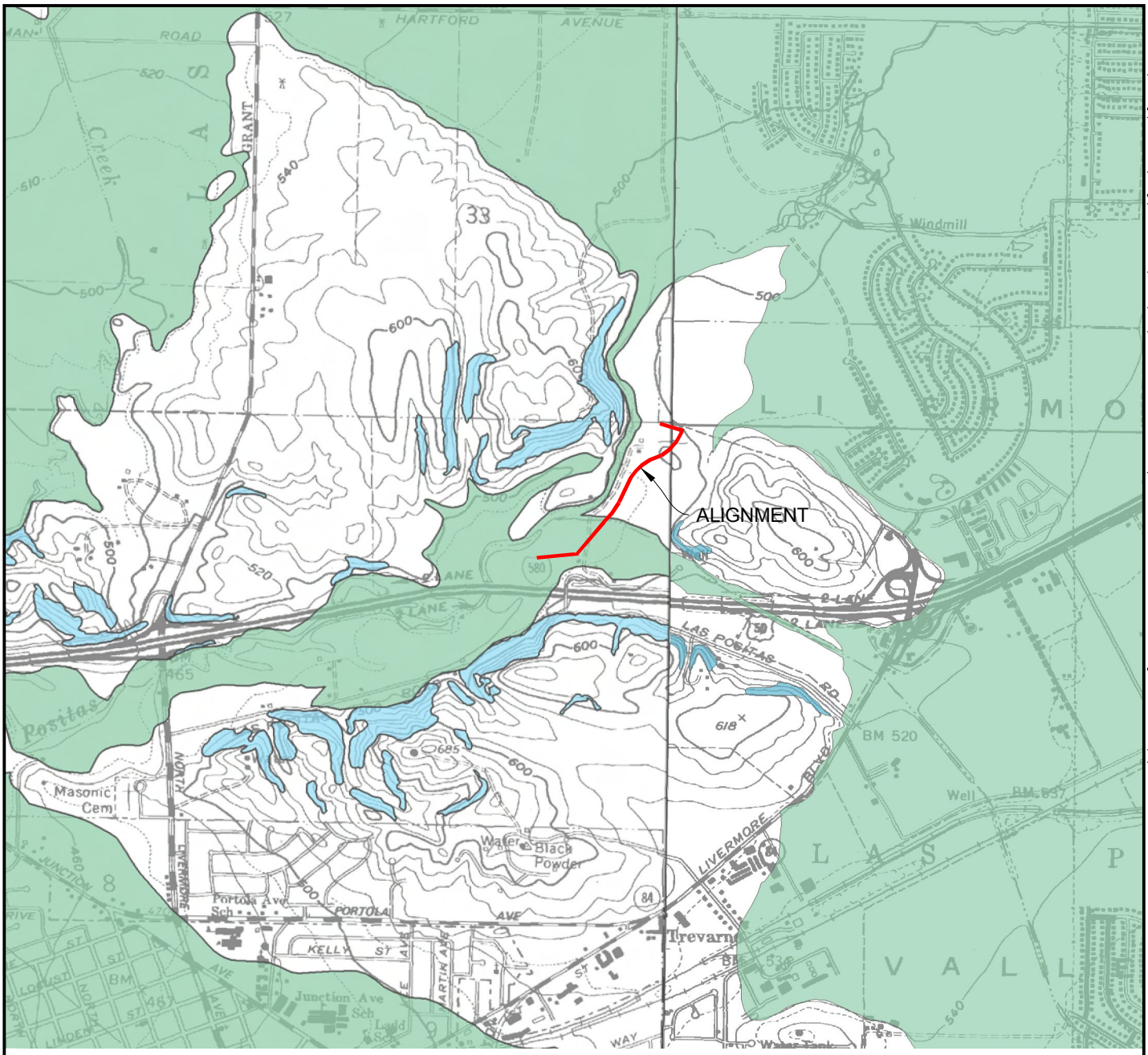


## EXPLANATION

### LIQUEFACTION

AREAS WHERE HISTORIC OCCURRENCE OF LIQUEFACTION, OR LOCAL GEOLOGICAL, GEOTECHNICAL AND GROUNDWATER CONDITIONS INDICATE A POTENTIAL FOR PERMANENT GROUND DISPLACEMENTS SUCH THAT MITIGATION AS DEFINED IN PUBLIC RESOURCES CODE SECTION 2693(c) WOULD BE REQUIRED

### EARTHQUAKE-INDUCED LANDSLIDES

AREAS WHERE PREVIOUS OCCURRENCE OF LANDSLIDE MOVEMENT, OR LOCAL TOPOGRAPHIC, GEOLOGICAL, GEOTECHNICAL AND SUBSURFACE WATER CONDITIONS INDICATE A POTENTIAL FOR PERMANENT GROUND DISPLACEMENTS SUCH THAT MITIGATION AS DEFINED IN PUBLIC RESOURCES CODE SECTION 2693(c) WOULD BE REQUIRED

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*BASE MAP SOURCE: CALIFORNIA DEPARTMENT OF CONSERVATION, CALIFORNIA GEOLOGICAL SURVEY, 2006*

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**SEISMIC HAZARD ZONES MAP**
**OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY**
**LIVERMORE, CALIFORNIA**

| | | |
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| PROJECT NO.: 13850.001.001 | | FIGURE NO. 5 |
| SCALE: AS SHOWN | | |
| DRAWN BY: LL | CHECKED BY: MMG | |

ORIGINAL FIGURE PRINTED IN COLOR



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CONFLUENCE


UPSTREAM OF PROPOSED SANITARY SEWER


DOWNSTREAM OF PROPOSED SANITARY SEWER



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SITE PHOTOGRAPHS

OFFSITE SANITARY SEWER TRACT 8454 - LASSEN ROAD PROPERTY

LIVERMORE, CALIFORNIA

| | | |
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| PROJECT NUMBER: **13850.001.001** | | FIGURE NO. 6 |
| SCALE: **NO SCALE** | | |
| DRAWN BY: **LL** | CHECKED BY: **MMG** | |

ORIGINAL FIGURE PRINTED IN COLOR

# APPENDIX A

## BORING LOG KEY
## EXPLORATION LOGS

# 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 LESS THAN 5% FINES | GW - Well graded gravels or gravel-sand mixtures<br>GP - Poorly graded gravels or gravel-sand mixtures |
| | | GRAVELS WITH OVER 12 % FINES | GM - Silty gravels, gravel-sand and silt mixtures<br>GC - Clayey gravels, gravel-sand and clay mixtures |
| | SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE | CLEAN SANDS WITH LESS THAN 5% FINES | SW - Well graded sands, or gravelly sand mixtures<br>SP - Poorly graded sands or gravelly sand mixtures |
| | | SANDS WITH OVER 12 % FINES | SM - Silty sand, sand-silt mixtures<br>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<br>CL - Inorganic clay with low to medium plasticity<br>OL - Low plasticity organic silts and clays |
| | SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50 % | | MH - Elastic silt with high plasticity<br>CH - Fat clay with high plasticity<br>OH - Highly plastic organic silts and clays |
| | HIGHLY ORGANIC SOILS | | PT - Peat and other highly organic soils |

For fine-grained soils with 15 to 29% retained on the #200 sieve, the words "with sand" or "with gravel" (whichever is predominant) are added to the group name.

For fine-grained soil with >30% retained on the #200 sieve, the words "sandy" or "gravelly" (whichever is predominant) are added to the group name.

## GRAIN SIZES

| U.S. STANDARD SERIES SIEVE SIZE | | | | CLEAR SQUARE SIEVE OPENINGS | | | |
|---|---|---|---|---|---|---|---|
| 200 | 40 | 10 | 4 | 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* |
|---|---|
| VERY SOFT | 0-1/4 |
| SOFT | 1/4-1/2 |
| MEDIUM STIFF | 1/2-1 |
| STIFF | 1-2 |
| VERY STIFF | 2-4 |
| HARD | OVER 4 |

### SAMPLER SYMBOLS

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

### MOISTURE CONDITION

| | |
|---|---|
| DRY | Dusty, dry to touch |
| MOIST | Damp but no visible water |
| WET | Visible freewater |

### LINE TYPES

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

### GROUND-WATER SYMBOLS

- Groundwater level during drilling
- Stabilized groundwater level

(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

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# LOG OF BORING 3-B1

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LATITUDE: 37.705458 LONGITUDE: -121.75219

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 50 ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 491½ ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: SFA, Switch to Mud
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 490 | | SANDY LEAN CLAY (CL), black, medium stiff, moist, some gravel | | | 17 | | | | | | | |
| | | | FAT CLAY WITH SAND (CH), black, hard, moist, carbonate nodules | | | 25 | | | | | | | 4.5+* |
| 5 | 485 | | grades to iron staining and rootlets | | | 21 | 52 | 14 | 38 | 74 | 24.3<br>27.4 | 97.42 | 4.5+* |
| | | | | | | 36 | | | | | | | |
| 10 | 480 | | SANDY LEAN CLAY WITH GRAVEL (CL), olive brown, hard, moist, fine- to coarse-gravel, fine-grained sand | | ▽ | 60 | | | | | | | |
| | | | | | | 50/4 | | | | 62 | 28.3 | | |
| 15 | 475 | | | | | | | | | | | | |
| | | | Becomes wet | | | 50/4 | | | | | | | |
| 20 | 470 | | | | | | | | | | | | |
| | | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, wet, some fine to coarse gravel, iron and manganese oxidation, some carbonates | | | 55 | | | | 59 | 20.3 | | |
| 25 | | | | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

ENGEO
Expect Excellence

# LOG OF BORING 3-B1

LATITUDE: 37.705458 LONGITUDE: -121.75219

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 50 ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 491½ ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: SFA, Switch to Mud
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 465 | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, wet, some fine to coarse gravel, iron and manganese oxidation, some carbonates | | | | | | | | | | |
| | | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, moist, mangnese staining, carbonates | | | 50 | | | | | 18.2 | | 4.5+* |
| 30 | 460 | | | | | 40 | | | | | | | |
| 35 | 455 | | | | | 42 | | | | | 23.1 | | |
| 40 | 450 | | | | | | | | | | | | |
| | | | CLAYEY SAND (SC), dark yellowish brown, very dense, moist, iron and manganese oxidation, some carbonates | | | 50/4 | | | | | | | |
| 45 | 445 | | | | | | | | | | | | |
| | | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, iron and manganese oxidation, some carbonates | | | 80 | | | | | | | 4.5+* |
| 50 | | | End of boring at 50 feet. Groundwater encountered at 13 feet at time of drilling. Switched to mud rotary at depth of 20 feet. | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B2

ENGEO Expect Excellence

LATITUDE: 37.705605 LONGITUDE: -121.748525

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 50 ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 494 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: SFA, Switch to Mud
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LEAN CLAY (CL), black, stiff, slightly moist, some gravel | | | 22 | | | | | 23.2 | 68.2 | |
| | | | becomes hard | | | 35 | | | | | | | 4.5+* |
| | 490 | | SANDY LEAN CLAY (CL), light gray, hard, moist, carbonates | | | | | | | | | | |
| 5 | | | FAT CLAY (CH), black, hard, moist | | | 37 | | | | | 18.7 | 92.2 | 4.5+* |
| | | | SANDY FAT CLAY (CH), light gray and olive gray, hard, moist, with carbonates | | | | | | | | | | |
| | | | FAT CLAY (CH), olive brown, hard, moist, some carbonates, iron staining | | | 38 | | | | | | | 4.5+* |
| | 485 | | | | | | | | | | | | |
| 10 | | | SILTY SAND (SM), yellowish brown to grayish brown, medium dense, moist, non plastic plasticity, fine- to medium-grained sand, iron staining, some carbonates | | | | | | | | | | |
| | | | [PI = NP] | | | 25 | | | | 19 | 13.1 | | |
| | 480 | | grades to loose with pockets of sandy clay | | | 12 | | | | | | | |
| 15 | | | POORLY GRADED SAND WITH SILT (SP-SM), yellowish brown to grayish brown, medium dense, wet, fine- to medium-grained sand, some carbonates | | ▽ | | | | | | | | |
| | 475 | | | | | 23 | | | | 11 | 18.7 | 110.6 | |
| 20 | | | SANDY LEAN CLAY (CL), reddish brown, hard, moist, iron staining, some carbonates | | | | | | | | | | |
| | | | CLAYEY SAND (SC), dark yellowish brown, very dense, wet | | | | | | | | | | |
| | | | | | | 50/6 | | | | | | | |
| | 470 | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B2

ENGEO Expect Excellence

LATITUDE: 37.705605 LONGITUDE: -121.748525

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 50 ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 494 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: SFA, Switch to Mud
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SANDY LEAN CLAY (CL), dark yellowish brown to olive brown, hard, moist, fine- to coarse-grained sand | | | | | | | | | | |
| | 465 | | grades to increased carbonate nodules | | | 19 | | | | | 26.1 | | 4.5+* |
| 30 | | | | | | | | | | | | | |
| | 460 | | | | | 38 | | | | | | | 11 |
| 35 | | | | | | | | | | | | | |
| | 455 | | grades to increased coarse-grained sand | | | 28 | | | | | 20.3 | 112.4 | |
| 40 | | | | | | | | | | | | | |
| | 450 | | | | | 58 | | | | | | | 4.5+* |
| 45 | | | | | | | | | | | | | |
| | 445 | | | | | 66 | | | | | 22 | | |
| 50 | | | End of boring at 50 feet. Groundwater encountered at 16 feet. Switched to mud rotary at depth of 24 1/2 feet. | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B3

LATITUDE: 37.706067 LONGITUDE: -121.749594

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 30½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 495 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SANDY LEAN CLAY (CL), dark brown to black, very stiff, moist, some gravel [Colluvium] | | | 20 | | | | | | | |
| 5 | 490 | | FAT CLAY (CH), grayish brown, very stiff, moist, fine- to medium-grained sand, some carbonates [Livermore Gravels] | | | 24 | | | | | | 98.3 | 3.25* |
| | | | CLAYEY SAND (SC), grayish brown, medium dense, moist, fine- to medium-grained sand, some carbonates | | | | | | | | | | |
| 10 | 485 | | | | | 18 | | | | | | | |
| | | | grades to increased fines | | ▽ | | | | | | | | |
| 15 | 480 | | SANDY LEAN CLAY (CL), bluish gray, hard, moist, some carbonates | | | 29 | | | | 57 | 21.7 | | 4.5+* |
| 20 | 475 | | grades to very dense | | | | | | | | | | |
| 25 | 470 | | increased gravel | | | 50/6 | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B3

LATITUDE: 37.706067 LONGITUDE: -121.749594

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 30½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 495 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SANDY LEAN CLAY (CL), bluish gray, hard, moist, some carbonates | | | | | | | | | | |
| | | | POORLY GRADED SAND (SP), bluish gray to dark gray, dense, very moist, some fines | | | | | | | | | | |
| 30 | 465 | | | | | 36 | | | | 12 | 18.4 | | |
| | | | End of boring at 30 1/2 feet. Groundwater encountered at 14 1/2 feet. | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B4

Expect Excellence

LATITUDE: 37.707881 LONGITUDE: -121.751341

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 5½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 495 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SANDY SILT (ML), olive brown, loose, moist, trace fine gravel | | | | | | | | | | |
| | | | SILTY SAND (SM), light gray, very dense, moist, abondant carbonates | | | 75/8 | | | | | 24.1 | | |
| 5 | 490 | | FAT CLAY (CH), olive brown, hard, moist, carbate nodules | | | 49 | | | | | | | 4.5+* |
| | | | End of boring at 5 1/2 feet. No groundwater encountered. | | | | | | | | | | |

ENGEO
Expect Excellence

# LOG OF BORING 3-B5

LATITUDE: 37.708664 LONGITUDE: -121.752196

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 10½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 510 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SILTY SAND (SM), brown, loose, slightly moist, some gravel [Colluvium] | | | 42 | | | | | 12 | | |
| | | | FAT CLAY (CH), dark brown, hard, moist, carbonates, some fine gravel, rootlets | | | 45 | | | | | | | 4.5+* |
| 5 | 505 | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, moist, carbonate nodules, some fine to medium gravel | | | | | | | | | | |
| | | | grades to increased gravel | | | 65 | | | | | | | |
| | | | CLAYEY SAND (SC), dark yellowish brown, dense, moist, some gravel | | | | | | | | | | |
| 10 | 500 | | | | | 62 | | | | | | | |
| | | | End of boring at 10 1/2 feet. No groundwater encountered. | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B6

Expect Excellence

LATITUDE: 37.70685 LONGITUDE: -121.752978

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 9½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 537 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SILTY SAND brown, loose, moist, some gravel [Colluvium] | | | 40 | | | | | 10.1 | | |
| | 535 | | FAT CLAY WITH GRAVEL (CH), dark brown, hard, moist, fine to coarse gravel, carbonate nodules | | | | | | | | | | |
| 5 | | | | | | 30 | | | | | | | 4.5+* |
| | 530 | | | | | | | | | | | | |
| | | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, moist, fine gravels, carbonates | | | 38 | | | | | | | 4.5+* |
| | | | End of boring at 9 1/2 feet. No groundwater encountered. | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

ENGEO
Expect Excellence

# LOG OF BORING 3-B7

LATITUDE: 37.705513 LONGITUDE: -121.754055

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 5 ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 497 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 495 | | SANDY LEAN CLAY (CL), dark brown, hard, moist, carbonates | | | 18 | | | | | 10.6 | | 4.5+* |
| 5 | | | CLAYEY SAND (SC), yellowish brown, medium dense, moist, carbonates | | | 20 | | | | | | | |
| | | | End of boring at 5 feet. No groundwater encountered. | | | | | | | | | | |

# LOG OF BORING 3-B8

ENGEO Expect Excellence

LATITUDE: 37.705288 LONGITUDE: -121.754292

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 31½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 490½ ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 490 | | SANDY FAT CLAY (CH), black, stiff, moist, roots | | | 11 | 84 | 30 | 54 | | 30.8 | | |
| | | | SANDY LEAN CLAY (CL), olive brown, stiff, moist, carbonates | | | 14 | | | | | | | 1.25* |
| 5 | 485 | | | | | 15 | | | | | 39.4 | 81.9 | 2* |
| | | | grades to increased carbonates and iron staining | | | | | | | | | | |
| 10 | 480 | | | | | 16 | | | | | | | 1.5* |
| | | | FAT CLAY (CH), dark gray to dark grayish brown, stiff, moist, some fine to medium gravel | | ▽ | | | | | | | | |
| 15 | 475 | | CLAYEY SAND (SC), dark greenish gray, loose, moist | | | 13 | | | | | | | |
| 20 | 470 | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, moist, some carbonates, iron and manganese staining | | | 14 | | | | | 19.6 | 108.4 | 4.5+* |
| 25 | 465 | | | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

ENGEO
Expect Excellence

# LOG OF BORING 3-B8

LATITUDE: 37.705288 LONGITUDE: -121.754292

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/2/2021
HOLE DEPTH: Approx. 31½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 490½ ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CLAYEY SAND (SC), dark yellowish brown, dense, moist | | | 65 | | | | | 22.5 | | |
| | | | SANDY LEAN CLAY (CL), dark yellowish brown, hard, moist, some carbonates, iron and manganese staining | | | | | | | | | | |
| 30 | 460 | | | | | 50/4 | | | | | | | |
| | | | End of boring at 31 1/2 feet. Groundwater encountered at 14 feet. | | | | | | | | | | |

# LOG OF BORING 3-B9

LATITUDE: 37.704554 LONGITUDE: -121.754943

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 26½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 502 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 500 | | SANDY LEAN CLAY (CL), olive brown, hard, dry, carbonate nodules | | | 43 | | | | | | | |
| 5 | | | grades to dark yellowish brown | | | 29 | | | | 53 | 10.8 | | 4.5+* |
| | 495 | | LEAN CLAY (CL), light gray, hard, moist, carbonates | | | | | | | | | | |
| 10 | | | FAT CLAY (CH), olive gray, hard, moist | | | 55 | | | | | 23.1 | | 4.5+* |
| | 490 | | | | | | | | | | | | |
| 15 | | | | | | 75 | | | | | 19.2 | 111 | |
| | 485 | | | | | | | | | | | | |
| 20 | | | | | | 75 | | | | | | | 4.5+* |
| | 480 | | grades to some carbonates | | | | | | | | | | |
| 25 | | | | | | | | | | | | | |

LOG - GEOTECHNICAL W/ELEV. BORING LOGS.GPJ ENGEO INC.GDT 5/11/21

# LOG OF BORING 3-B9

Expect Excellence

LATITUDE: 37.704554 LONGITUDE: -121.754943

Geotechnical Exploration
Tract 8454 Offsite Improvements
Livermore, CA
13850.001.001/13850.001.002

DATE DRILLED: 4/1/2021
HOLE DEPTH: Approx. 26½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NGVD29): Approx. 502 ft.

LOGGED / REVIEWED BY: M. Bromfield / MMG
DRILLING CONTRACTOR: H1 Drilling Company
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Auto Trip

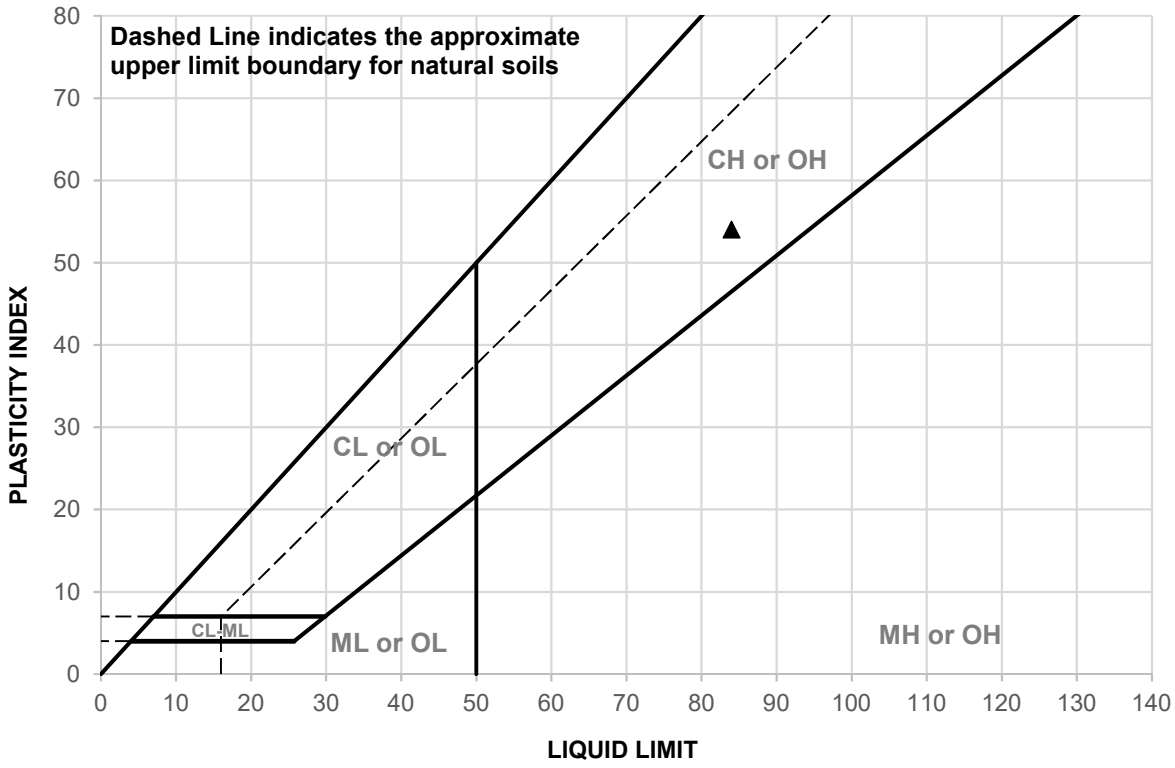
| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Unconfined Strength (tsf) *field approx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| — | | | FAT CLAY (CH), olive gray, hard, moist | | | 50/6 | | | | | | | 4.5+* |
| | | | End of boring at 26 1/2 feet. No groundwater encountered. | | | | | | | | | | |

# APPENDIX B

## LABORATORY TEST DATA

**Liquid and Plastic Limits Test Report**
**Unconfined Compression Test**
**Particle Size Distribution Report**
**R-Value Test Report**
**Unconsolidated Triaxial Report**
**Direct Sheer Report**
**Analytical Results of Soil Corrosion (4 pages)**

# LIQUID AND PLASTIC LIMITS TEST REPORT
ASTM D4318




| | SAMPLE ID | DEPTH | MATERIAL DESCRIPTION | LL | PL | PI |
|---|---|---|---|---|---|---|
| ▲ | 3-B8@2 | 2.0 feet | See exploration logs | 84 | 30 | 54 |

| | SAMPLE ID | TEST METHOD | REMARKS |
|---|---|---|---|
| ▲ | 3-B8@2 | PI: ASTM D4318, Wet Method | |

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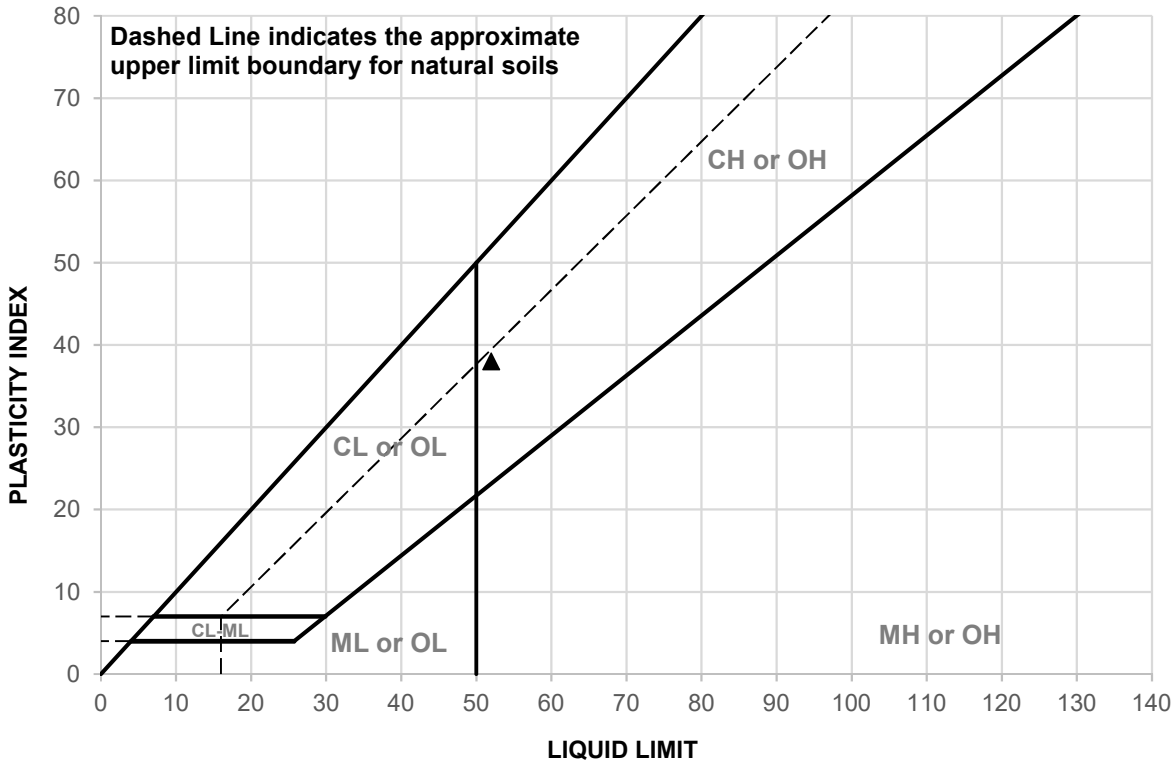
**CLIENT:** Lewis Management Corporation
**PROJECT NAME:** Lassen - Livermore Offsite Sanitary Sewer Improvements
**PROJECT NO:** 13850.001.001 PH001
**PROJECT LOCATION:** Livermore, California
**REPORT DATE:** 4/14/2021
**TESTED BY:** M. Quasem
**REVIEWED BY:** G. Criste

# LIQUID AND PLASTIC LIMITS TEST REPORT
ASTM D4318




| | SAMPLE ID | DEPTH | MATERIAL DESCRIPTION | LL | PL | PI |
|---|---|---|---|---|---|---|
| ▲ | 3-B1@6 | 6 feet | See exploration logs | 52 | 14 | 38 |

| | SAMPLE ID | TEST METHOD | REMARKS |
|---|---|---|---|
| ▲ | 3-B1@6 | PI: ASTM D4318, Wet Method | |

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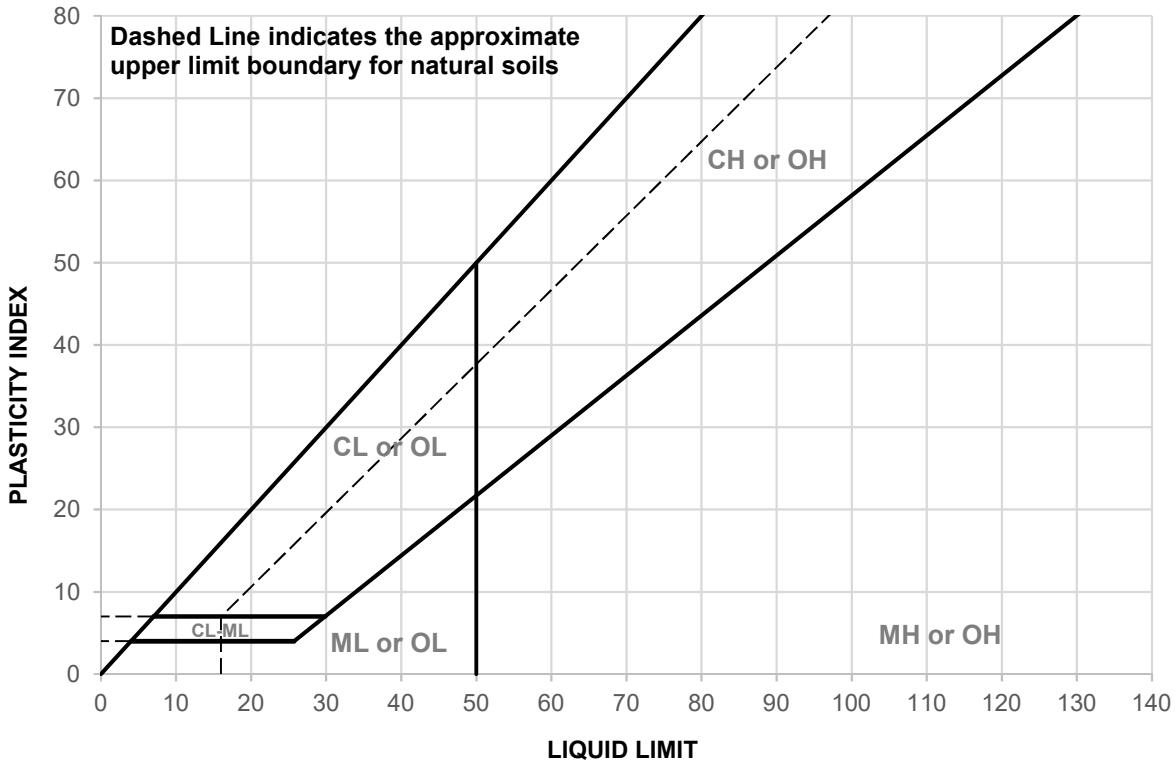
**CLIENT:** Lewis Management Corporation
**PROJECT NAME:** Lassen-Livermore Offsite Trail
**PROJECT NO:** 13850.001.002 PH001
**PROJECT LOCATION:** Livermore, CA
**REPORT DATE:** 4/21/2021
**TESTED BY:** R. Montalvo
**REVIEWED BY:** M. Gilbert

# LIQUID AND PLASTIC LIMITS TEST REPORT
ASTM D4318




| | SAMPLE ID | DEPTH | MATERIAL DESCRIPTION | LL | PL | PI |
|---|---|---|---|---|---|---|
| ▲ | 3-B2@12 | 12.0 feet | See exploration logs | NV | NP | NP |

| | SAMPLE ID | TEST METHOD | REMARKS |
|---|---|---|---|
| ▲ | 3-B2@12 | PI: ASTM D4318, Wet Method | |

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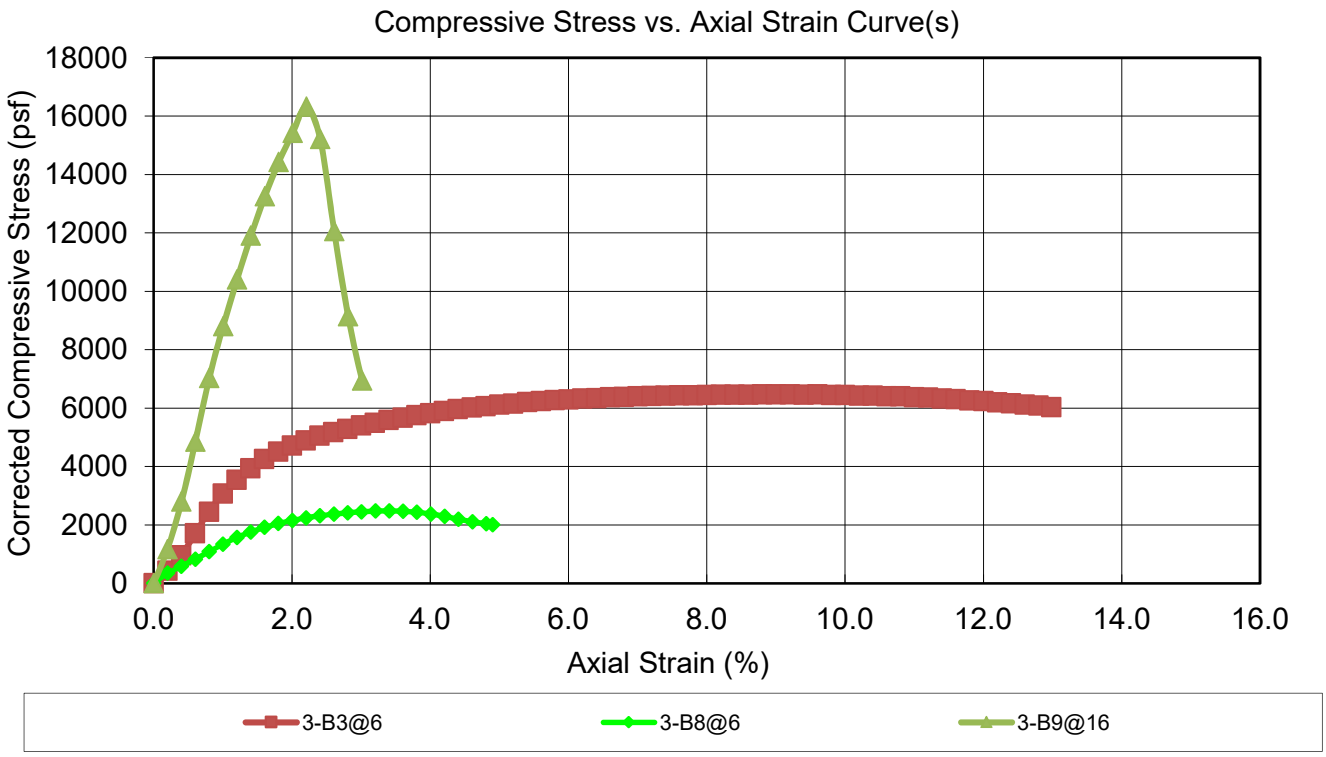
**CLIENT:** Lewis Management Corporation
**PROJECT NAME:** Lassen - Livermore Offsite Trail Improvements
**PROJECT NO:** 13850.001.002 PH001
**PROJECT LOCATION:** Livermore, California
**REPORT DATE:** 4/14/2021
**TESTED BY:** M. Quasem
**REVIEWED BY:** G. Criste

# UNCONFINED COMPRESSION TEST REPORT
# (ASTM D2166)




| BEFORE TEST | SPECIMEN 3-B3@6 | SPECIMEN 3-B8@6 | SPECIMEN 3-B9@16 |
|---|---|---|---|
| Test Moisture Content (%) | 25.52 | 39.44 | 19.22 |
| Dry Density (pcf) | 98.3 | 81.9 | 111.0 |
| Saturation (%) | 95.4 | 100.0 | 98.8 |
| Void Ratio | 0.73 | 1.07 | 0.53 |
| Diameter (in) | 2.400 | 2.390 | 2.410 |
| Height (in) | 5.000 | 4.990 | 4.980 |
| Height-To-Diameter Ratio | 2.08 | 2.09 | 2.07 |
| **TEST DATA** | | | |
| Unconfined Compressive Strength (psf) | 6469 | 2483 | 16323 |
| Undrained Shear Strength (psf) | 3234.55 | 1241.38 | 8161.51 |
| Strain Rate (in/min) | 0.050 | 0.050 | 0.050 |
| Specific Gravity (ASSUMED) | 2.720 | 2.720 | 2.720 |
| Strain at Failure(%) | 9.20 | 3.41 | 2.21 |
| Test Remarks | | | |

| SPECIMEN | DESCRIPTION |
|---|---|
| 3-B3@6 | See exploration logs |
| 3-B8@6 | See exploration logs |
| 3-B9@16 | See exploration logs |

**PROJECT NAME:** Lassen - Livermore Offsite Sanitary Sewer Improvements
**PROJECT NO:** 13850.001.001
**CLIENT:** Lewis Management Corporation
**LOCATION:** Livermore, CA

**Test Date:** 4/12/2021
**Tested By:** M. Quasem
**Reviewed By:** W. Miller

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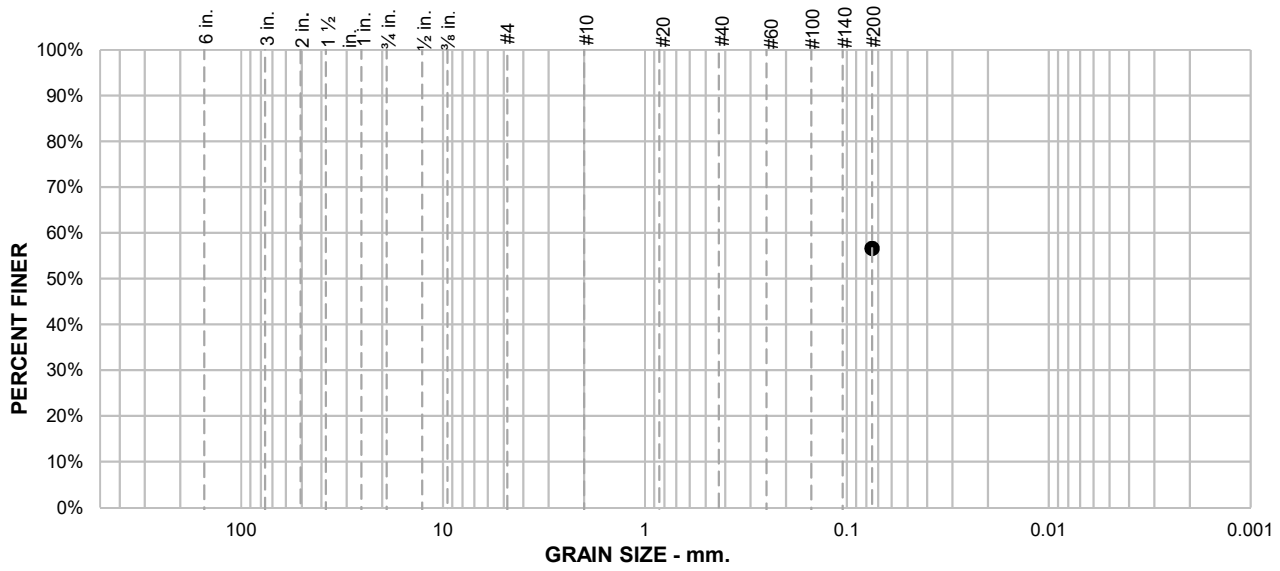
# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B3@16

**DEPTH (ft):** 16

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 56.6 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 56.6 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

Soak time = 240 min
Dry sample weight = 218.5 g

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Sanitary Sewer Improvements

**PROJECT NO:** 13850.001.001 PH001

**PROJECT LOCATION:** Livermore, California

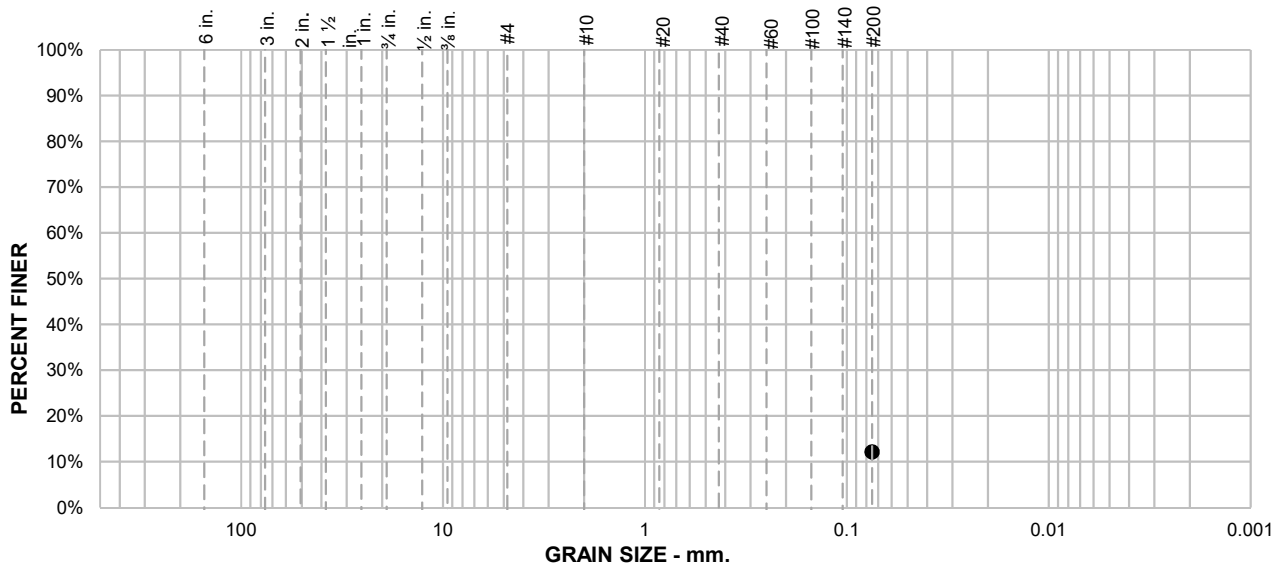
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B3@29

**DEPTH (ft):** 29

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 12.1 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 12.1 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

Soak time = 240 min
Dry sample weight = 247.7 g

* (no specification provided)

ENGEO
Expect Excellence

**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Sanitary Sewer Improvements

**PROJECT NO:** 13850.001.001 PH001

**PROJECT LOCATION:** Livermore, California

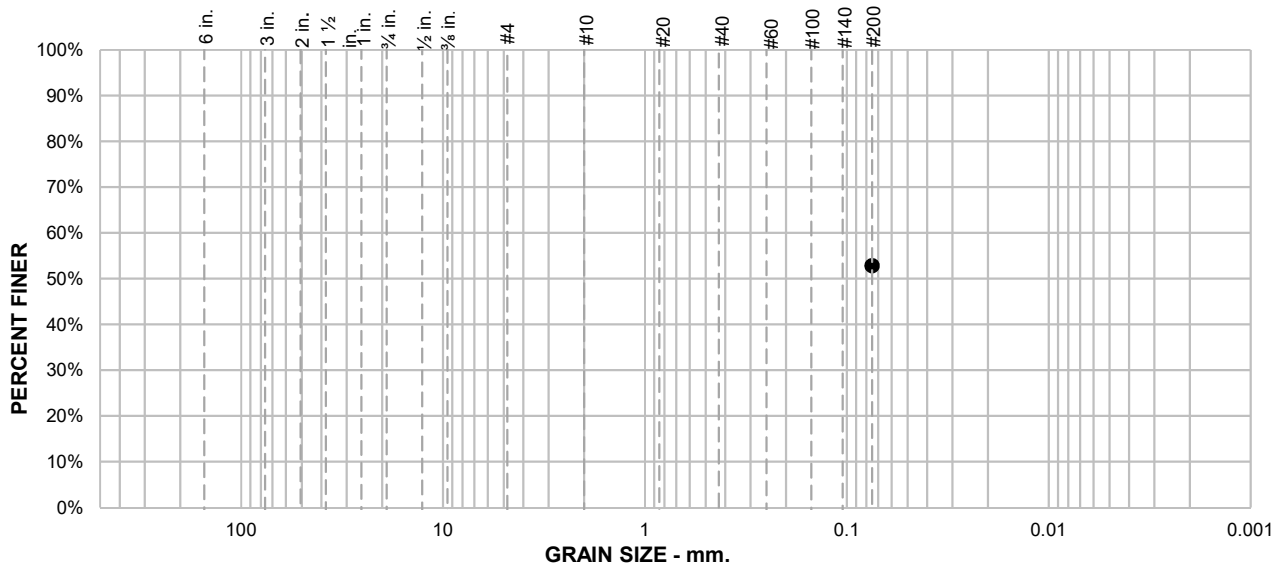
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B9@6

**DEPTH (ft):** 6

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 52.8 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 52.8 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

Soak time = 240 min
Dry sample weight = 752.8 g

* (no specification provided)

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Expect Excellence

**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Sanitary Sewer Improvements

**PROJECT NO:** 13850.001.001 PH001

**PROJECT LOCATION:** Livermore, California

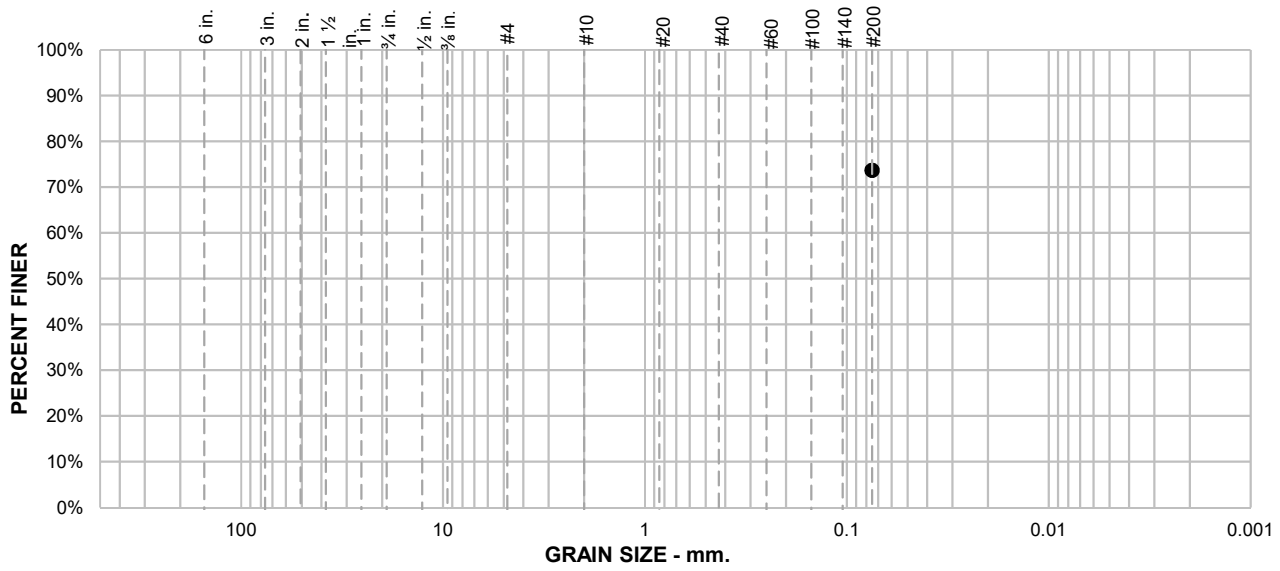
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B1@6

**DEPTH (ft):** 6

**LOCATION:** 3-B1 at 6 feet

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 73.7 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 73.7 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = 14 LL = 52 PI = 38

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS = CH

**REMARKS**

PI: ASTM D4318, Wet Method
USCS: ASTM D2487

Soak time = 180 min
Dry sample weight = 203.1 g

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen-Livermore Offsite Trail

**PROJECT NO:** 13850.001.002 PH001

**PROJECT LOCATION:** Livermore, CA

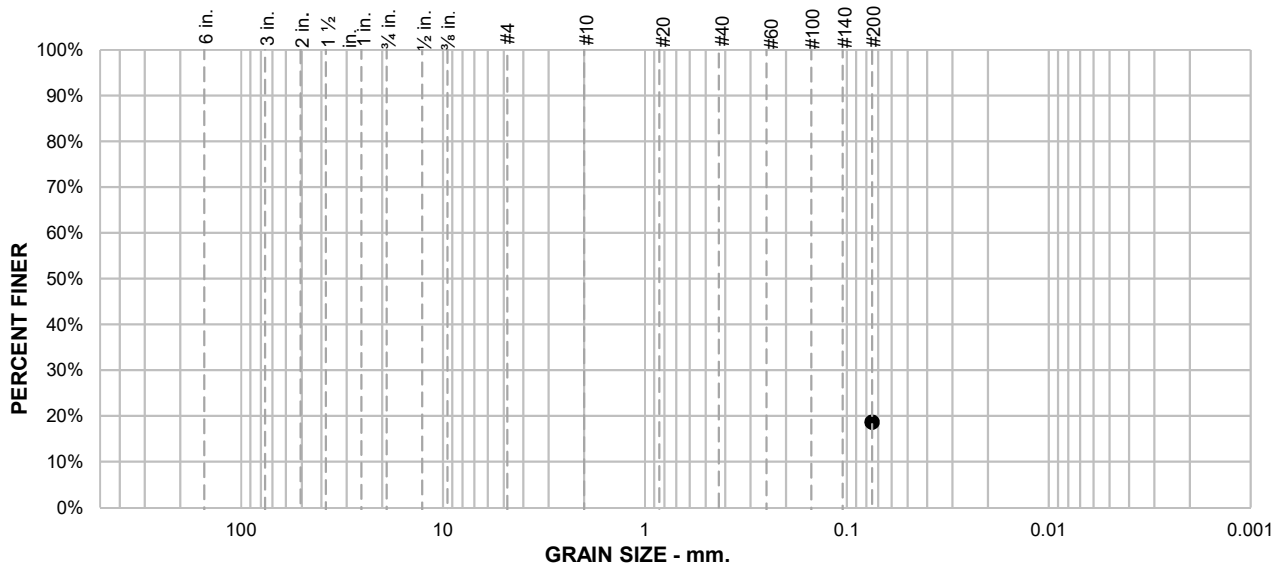
**REPORT DATE:** 4/20/2021

**TESTED BY:** R. Montalvo

**REVIEWED BY:** M. Gilbert

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B2@12

**DEPTH (ft):** 12

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 18.6 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 18.6 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = NP LL = NV PI = NP

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

PI: ASTM D4318, Wet Method

Soak time = 240 min
Dry sample weight = 265.7 g

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Trail Improvements

**PROJECT NO:** 13850.001.002 PH001

**PROJECT LOCATION:** Livermore, California

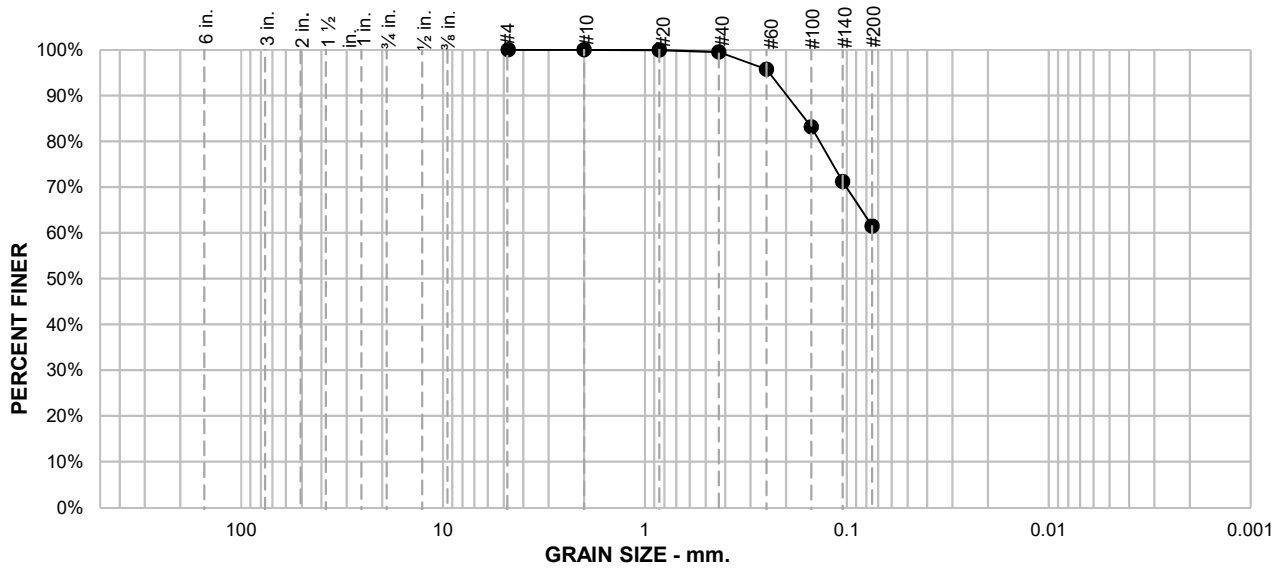
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D6913, Method B




**SAMPLE ID:** 3-B1@14

**DEPTH (ft):** 14

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | 0.4 | 38.1 | 61.5 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #4 | 100.0 | | |
| #10 | 100.0 | | |
| #20 | 100.0 | | |
| #40 | 99.6 | | |
| #60 | 95.8 | | |
| #100 | 83.2 | | |
| #140 | 71.2 | | |
| #200 | 61.5 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = 0.1976 mm $D_{85}$ = 0.1614 mm $D_{60}$ =

$D_{50}$ = $D_{30}$ = $D_{15}$ =

$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Trail Improvements

**PROJECT NO:** 13850.001.002 PH001

**PROJECT LOCATION:** Livermore, California

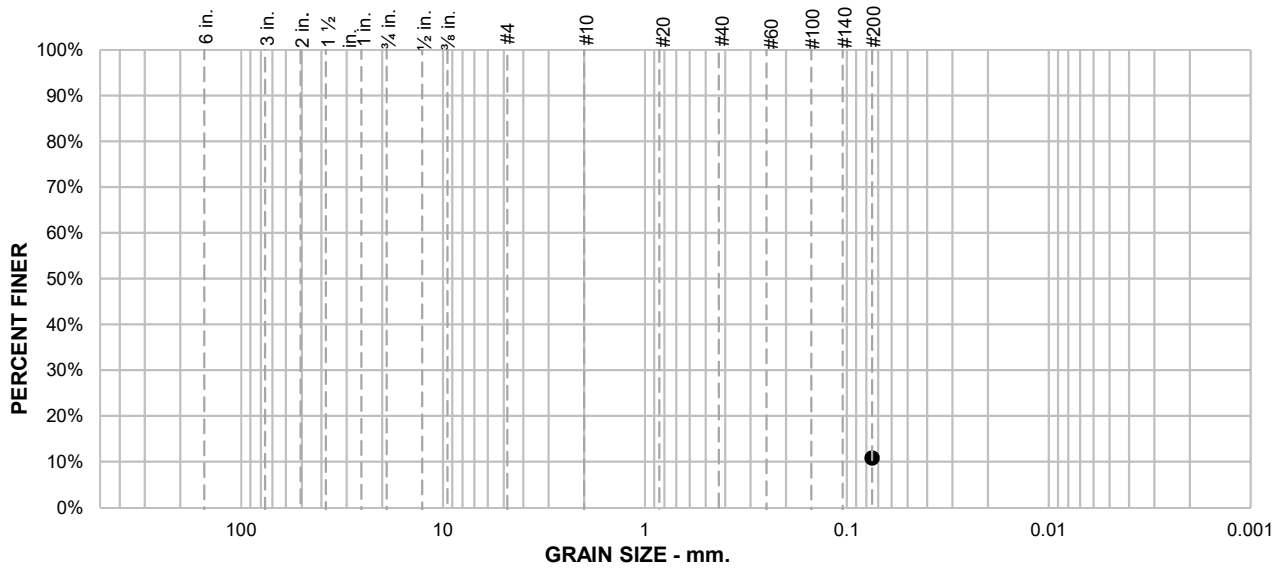
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B2@18.5

**DEPTH (ft):** 18.5

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 10.8 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 10.8 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

Soak time = 240 min
Dry sample weight = 732.2 g

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Trail Improvements

**PROJECT NO:** 13850.001.002 PH001

**PROJECT LOCATION:** Livermore, California

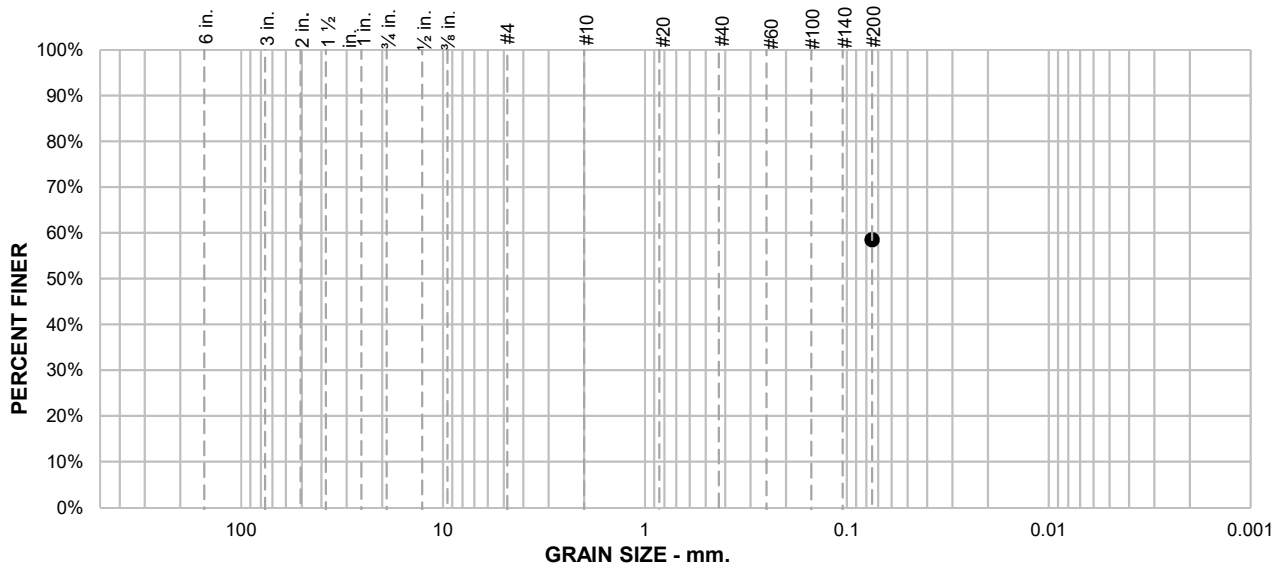
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# PARTICLE SIZE DISTRIBUTION REPORT

ASTM D1140, Method B




**SAMPLE ID:** 3-B1@24

**DEPTH (ft):** 24

| % +75mm | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| | | | | | | 58.5 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #200 | 58.5 | | |

**SOIL DESCRIPTION**

See exploration logs

**ATTERBERG LIMITS**

PL = LL = PI =

**COEFFICIENTS**

$D_{90}$ = $D_{85}$ = $D_{60}$ =
$D_{50}$ = $D_{30}$ = $D_{15}$ =
$D_{10}$ = $C_u$ = $C_c$ =

**CLASSIFICATION**

USCS =

**REMARKS**

Soak time = 240 min
Dry sample weight = 148.1 g

* (no specification provided)

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**CLIENT:** Lewis Management Corporation

**PROJECT NAME:** Lassen - Livermore Offsite Trail Improvements

**PROJECT NO:** 13850.001.002 PH001

**PROJECT LOCATION:** Livermore, California

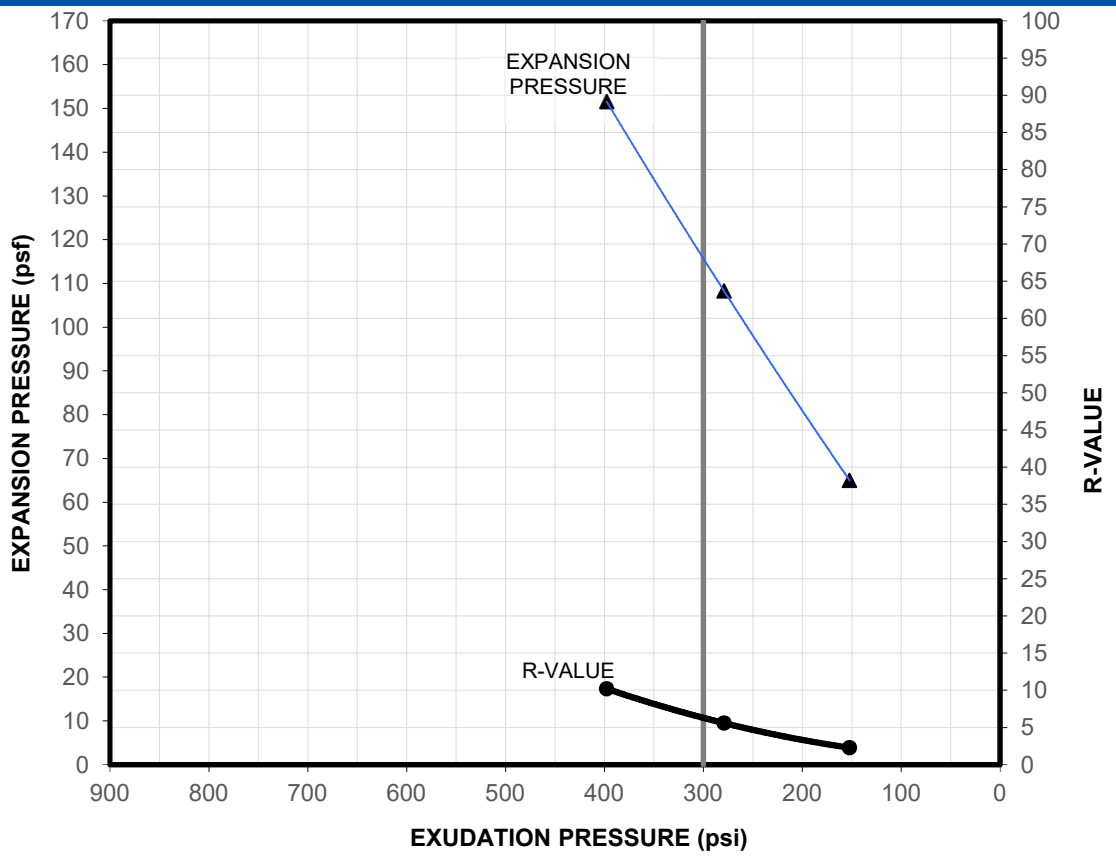
**REPORT DATE:** 4/14/2021

**TESTED BY:** M. Quasem

**REVIEWED BY:** G. Criste

# R-VALUE TEST REPORT

CTM 301




| SAMPLE ID | MATERIAL DESCRIPTION | SAMPLE LOCATION |
|---|---|---|
| RV-01 | Very dark grayish brown CLAY | 3-B1 @ 1 |

| SPECIMENS | 1 | 2 | 3 |
|---|---|---|---|
| EXUDATION PRESSURE (psi) | 398 | 279 | 152 |
| EXPANSION PRESSURE (psf) | 152 | 108 | 65 |
| R-VALUE | 10 | 6 | 2 |
| MOISTURE CONTENT (%) | 38.3 | 40.8 | 43.2 |
| DRY DENSITY (pcf) | 80.3 | 76.8 | 73.2 |
| EXPANSION PRESSURE (psf) AT EXUDATION PRESSURE OF 300 psi | | 115 | |

| **R-VALUE** AT EXUDATION PRESSURE OF 300 psi | TEST RESULT |
|---|---|
| | **6** |

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**CLIENT:** Lewis Management Corporation
**PROJECT NAME:** Lassen - Livermore Offsite Sewer
**PROJECT NO:** 13850.001.001
**PROJECT LOCATION:** Livermore, CA
**REPORT DATE:** 4/15/2021
**TESTED BY:** W. Miller
**REVIEWED BY:** M. Quasem

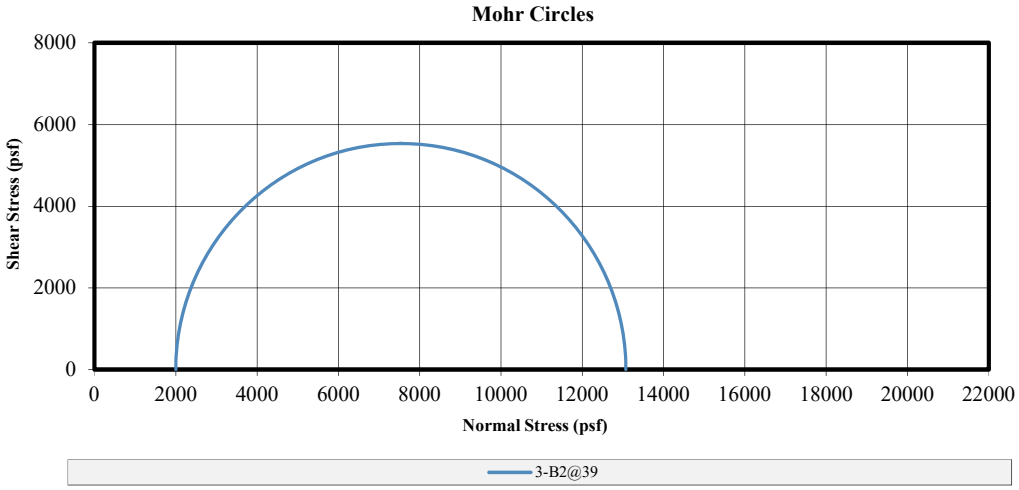
# Isotropic Unconsolidated Undrained Triaxial Test
## ASTM D2850

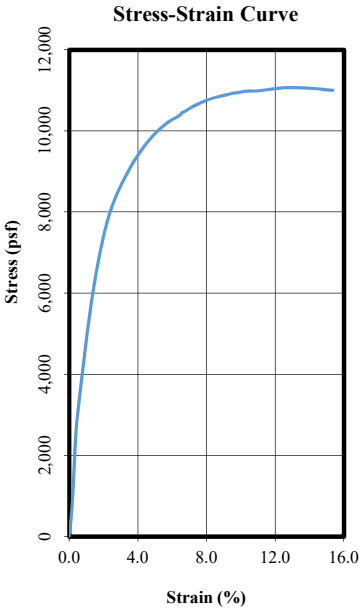
Date: 04/16/21

Checked By: K. Lecce

Date: 4/15/2021

Tested By: G. Criste




| Before Test | Specimen 3-B2@39 | | | |
|---|---|---|---|---|
| Water Content (%) | 20.33 | | | |
| Dry Density (pcf) | 112.40 | | | |
| Saturation (%) | 100.01 | | | |
| Void Ratio | 0.58 | | | |
| Diameter (in) | 2.399 | | | |
| Height (in) | 5.014 | | | |
| Height-to-Diameter Ratio | 2.090 | | | |
| **ASTM D4318 - Wet Method** | | | | |
| Liquid Limit | | | | |
| Plastic Limit | | | | |
| **ASTM D854 - Assumed** | | | | |
| Specific Gravity | 2.841 | | | |
| **After Test** | **3-B2@39** | | | |
| Water Content (%) | 20.33 | | | |
| Saturation (%) | 100.00 | | | |
| Strain Rate (%/min) | 0.05 | | | |
| Peak Deviator Stress (psf) | 11069.5 | | | |
| Axial Strain @ Failure (%) | 12.565 | | | |
| | **Cell Pressure** | | | |
| Cell (psf) | 2001.6 | | | |
| Back (psf) | n/a | | | |
| | **Principle Stresses at Failure** | | | |
| σ1 (psf) | 13071.1 | | | |
| σ3 (psf) | 2001.6 | | | |
| Corrected Peak Deviator Stress | | | | |

| Mohr-Coulomb Parameters with a Non-zero Friction Angle (Ø≠0) | | | Cohesion at Failure with a Zero Friction Angle (Ø=0) | | | |
|---|---|---|---|---|---|---|
| Cohesion, c (psf) | n/a | | 5534.7 | | | |
| Friction Angle Ø | n/a | | n/a | | | |

| Project Information | |
|---|---|
| Project Name: | Lassen - Livermore Offsite Trail Improvements |
| Project Number: | 13850.001.002 PH001 |
| Project Location: | Livermore, California |
| Client: | Lewis Management Corporation |
| Description: | See exploration logs |
| | |
| Test Remarks: | |

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# Isotropic Unconsolidated Undrained Triaxial Test
## ASTM D2850

Date: 04/16/21

Checked By: K. Lecce

Date: 4/15/2021

Tested By: G. Criste

## SPECIMEN PHOTOS

| SAMPLE NUMBER: 3-B2@39 | |
|---|---|
|  | |
| | |
| | |



| Project Information | |
|---|---|
| Project Name: | Lassen - Livermore Offsite Trail Improvements |
| Project Number: | 13850.001.002 PH001 |
| Project Location: | Livermore, California |
| Client: | Lewis Management Corporation |
| Description: | See exploration logs |
| | |
| Test Remarks: | |

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# Consolidated Drained Direct Shear

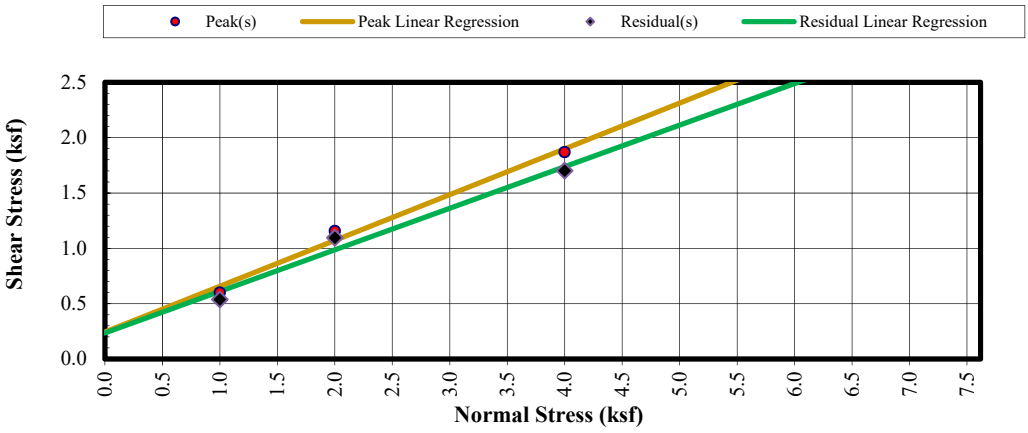
## ASTM D3080

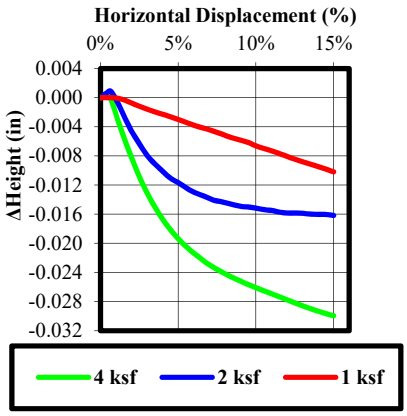
Date 4/21/2021

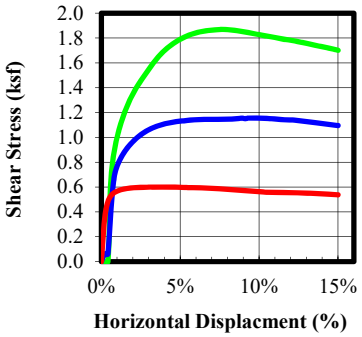
Checked By M. Gilbert

4/14/2021 Date

Tested By R. Montalvo




| Initial Parameters | Specimen 4 ksf | 2 ksf | 1 ksf | |
|---|---|---|---|---|
| Moisture (%) | 19.56 | 19.44 | 19.52 | |
| Dry Density (pcf) | 95.46 | 96.70 | 96.31 | |
| Void Ratio | 0.783 | 0.760 | 0.768 | |
| Saturation (%) | 68.08 | 69.72 | 69.34 | |
| Diameter (in) | 2.412 | 2.412 | 2.412 | |
| Height (in) | 1.000 | 1.000 | 1.000 | |
| Diameter-to-Height Ratio | 2.412 | 2.412 | 2.412 | |
| Specific Gravity (Measured) | 2.727 | 2.727 | 2.727 | |
| **Pre-shear Parameters** | **4 ksf** | **2 ksf** | **1 ksf** | |
| Moisture (%) | 26.85 | 27.01 | 28.39 | |
| Dry Density (pcf) | 98.29 | 98.03 | 95.96 | |
| Void Ratio | 0.732 | 0.737 | 0.774 | |
| Saturation (%) | 100.0 | 100.0 | 100.0 | |
| Diameter (in) | 2.412 | 2.412 | 2.412 | |
| Height (in) | 0.971 | 0.986 | 1.004 | |
| Normal Stress (ksf) | 4.00 | 2.00 | 1.00 | |
| Peak Stress (ksf) | 1.87 | 1.16 | 0.60 | |
| Residual Stress (ksf) | 1.70 | 1.10 | 0.54 | |
| Peak Strain (%) | 7.670 | 9.328 | 3.939 | |
| Max. Residual Strain (%) | 15.0 | 15.0 | 15.0 | |
| Rate (in/min) | 0.00181 | 0.00181 | 0.00181 | |
| Diameter-to-Height Ratio | 2.484 | 2.445 | 2.403 | |

| | |
|---|---|
| **Test Date** | **4/14/2021** |

| | |
|---|---|
| **Project:** | Lassen - Livermore Offsite Trail |
| **Location:** | Livermore, CA |
| **Project Number:** | 13850.001.002 PH001 |
| **Client:** | Lewis Management Corporation |
| **Boring Number** | 3-B1 |
| **Sample Number:** | 3-B1@6 |
| **Depth:** | 6 ft |
| **Sample Type:** | Intact |
| **Description:** | See exploration logs |
| **Test Type:** | Consolidated Drained |
| **Remarks:** | Consolidation data inconclusive, default minimum default shear times used per ASTM D3080. |

| | Phi | C(ksf) |
|---|---|---|
| **Peak Strength:** | **22.5** | **0.24** |
| **Res./Ult. Strength:** | **20.6** | **0.24** |

**ASTM D4318**

| | |
|---|---|
| **Liquid Limit:** | **52** |
| **Plastic Limit:** | **14** |

**ASTM D854**
**Material Passing the #4 Sieve**

ENGEO
Expect Excellence

# *Sunland Analytical*

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557


Date Reported 04/16/2021
Date Submitted 04/12/2021

To: Nick Broussard
Engeo, Inc.
2213 Plaza Dr.
Rocklin, CA 95765

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 13850.001.001 Site ID : 3-B3 @ 15.5.
Thank you for your business.

* For future reference to this analysis please use SUN # 84547-176253.

---

## EVALUATION FOR SOIL CORROSION

| | | |
|---|---|---|
| Soil pH | 7.59 | |
| Minimum Resistivity | 0.27 ohm-cm (x1000) | |
| Chloride | 125.6 ppm | 00.01256 % |
| Sulfate | 686.5 ppm | 00.06865 % |

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m

# *Sunland Analytical*

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557


Date Reported 04/16/2021
Date Submitted 04/12/2021

To: Nick Broussard
Engeo, Inc.
2213 Plaza Dr.
Rocklin, CA 95765

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 13850.001.001 Site ID : 3-B9 @ 21.
Thank you for your business.

* For future reference to this analysis please use SUN # 84547-176254.

---

## EVALUATION FOR SOIL CORROSION

| | | |
|---|---|---|
| Soil pH | 8.87 | |
| Minimum Resistivity | 0.25 ohm-cm (x1000) | |
| Chloride | 417.7 ppm | 00.04177 % |
| Sulfate | 633.2 ppm | 00.06332 % |

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m

# *Sunland Analytical*

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557


Date Reported 04/16/2021
Date Submitted 04/12/2021

To: Nick Broussard
Engeo, Inc.
2213 Plaza Dr.
Rocklin, CA 95765

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 13850.001.001 Site ID : 3-B1 @ 3.5.
Thank you for your business.

* For future reference to this analysis please use SUN # 84547-176255.

---

## EVALUATION FOR SOIL CORROSION

| | | |
|---|---|---|
| Soil pH | 7.69 | |
| Minimum Resistivity | 0.27 ohm-cm (x1000) | |
| Chloride | 152.7 ppm | 00.01527 % |
| Sulfate | 1336.7 ppm | 00.13367 % |

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m

# *Sunland Analytical*

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557


Date Reported 04/16/2021
Date Submitted 04/12/2021

To: Nick Broussard
Engeo, Inc.
2213 Plaza Dr.
Rocklin, CA 95765

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 13850.001.001 Site ID : 3-B2 @ 13.5.
Thank you for your business.

* For future reference to this analysis please use SUN # 84547-176256.

---

## EVALUATION FOR SOIL CORROSION

| | | |
|---|---|---|
| Soil pH | 7.66 | |
| Minimum Resistivity | 0.67 ohm-cm (x1000) | |
| Chloride | 56.8 ppm | 00.00568 % |
| Sulfate | 124.9 ppm | 00.01249 % |

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422m

# APPENDIX C

## 2018 BORING LOGS

# LOG OF BORING 1-B7

ENGEO Expect Excellence

LATITUDE: -121.754982 LONGITUDE: 37.703983

Geotechnical Exploration
3656 Las Colinas Road
Livermore, CA
15426.000.000

DATE DRILLED: 10/4/2018
HOLE DEPTH: Approx. 16½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NAVD88): Approx. 492 ft.

LOGGED / REVIEWED BY: B. Xu /
DRILLING CONTRACTOR: West Coast Exploration
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Shear Strength (psf) *field approximation | Unconfined Strength (tsf) *field approximation | Strength Test Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LEAN CLAY (CL), dark gray to brownish gray, very stiff, moist | | | | | | | | | | | | |
| | 490 | | | | | | | | | | | | | | |
| | | | With coarse gravels | | | 24 | | | | | 22 | | | | |
| 5 | | | | | ▽ | | | | | | | | | | |
| | | | | | | 10 | | | | | | | | 2.75* | PP |
| | | | Increasing fine to coarse grained sand<br>Becomes soft increasing sand content | | | | | | | | | | | | |
| | 485 | | | | | | | | | | | | | | |
| | | | SILTY SAND WITH GRAVEL (SM), gray, loose, wet | | | | | | | | | | | | |
| 10 | | | | | | 7 | | | | 27 | 20 | | | | |
| | 480 | | | | | | | | | | | | | | |
| 15 | | | color changes to light yellowish brown and becomes dense | | | 43 | | | | | | | | | |
| | | | End boring at approximately 16.5 feet below ground surface. Groundwater was encountered at approximately 10 feet below ground surface. | | | | | | | | | | | | |

LOG - GEOTECHNICAL_SU+QU W/ ELEV 10042018 GEX BX.GPJ ENGEO INC.GDT 12/13/18

# LOG OF BORING 1-B8

ENGEO Expect Excellence

LATITUDE: -121.756418 LONGITUDE: 37.704111

Geotechnical Exploration
3656 Las Colinas Road
Livermore, CA
15426.000.000

DATE DRILLED: 10/4/2018
HOLE DEPTH: Approx. 16½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NAVD88): Approx. 492 ft.

LOGGED / REVIEWED BY: B. Xu /
DRILLING CONTRACTOR: West Coast Exploration
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Shear Strength (psf) *field approximation | Unconfined Strength (tsf) *field approximation | Strength Test Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 490 | | LEAN CLAY (CL), gray to brownish gray, very stiff, moist | | | | | | | | | | | | |
| 5 | 485 | | | | | 27 | | | | | 34 | 87 | | 1.75* | PP |
| 10 | 480 | | color changes to brownish gray mottled with greenish yellow | | | 27 | | | | | | | | 2.5* | PP |
| | | | SILTY SAND (SM), gray, medium dense, very moist, some fines. | | ▽ | | | | | | | | | | |
| 15 | | | | | | 24 | | | | | | | | | |
| | | | End boring at approximately 16.5 feet below ground surface. Groundwater was encountered at approximately 14.5 ft below ground surface. | | | | | | | | | | | | |

LOG - GEOTECHNICAL_SU+QU W/ ELEV 10042018 GEX BX.GPJ ENGEO INC.GDT 12/13/18

# LOG OF BORING 1-B9

ENGEO Expect Excellence

LATITUDE: -121.757068 LONGITUDE: 37.704082

Geotechnical Exploration
3656 Las Colinas Road
Livermore, CA
15426.000.000

DATE DRILLED: 10/4/2018
HOLE DEPTH: Approx. 11½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NAVD88): Approx. 491 ft.

LOGGED / REVIEWED BY: B. Xu /
DRILLING CONTRACTOR: West Coast Exploration
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Shear Strength (psf) *field approximation | Unconfined Strength (tsf) *field approximation | Strength Test Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 490 | | FAT CLAY (CH), gray to brownish gray, very stiff, moist, high plasticity | | | | | | | | | | | | |
| 5 | | | | | | 27 | | | | | | | | 2.75* | PP |
| | 485 | | POORLY GRADED SAND (SP), yellowish red mottled with very dark gray, moist, trace fines. | | | | | | | | | | | | |
| | | | SANDY CLAY (CL), pale olive mottled with very dark gray, very stiff, moist, medium plasticity, trace fine sand. | | | | | | | | | | | | |
| | | | | | | 22 | | | | | 24 | 98 | | 2.75* | PP |
| 10 | | | color changes to dark grayish brown, becomes medium stiff to stiff | | | | | | | | | | | | |
| | 480 | | color changes to pale olive mottled with dark gray | | | 30 | | | | | | | | 0.75* | PP |
| | | | | | | | | | | | | | | 1.75* | PP |
| | | | End boring at approximately 11.5 feet below ground surface. Groundwater was not encountered during drilling. | | | | | | | | | | | | |

# LOG OF BORING 1-B15

Expect Excellence

LATITUDE: -121.755233 LONGITUDE: 37.704226

Geotechnical Exploration
3656 Las Colinas Road
Livermore, CA
15426.000.000

DATE DRILLED: 10/4/2018
HOLE DEPTH: Approx. 11½ ft.
HOLE DIAMETER: 4.0 in.
SURF ELEV (NAVD88): Approx. 492 ft.

LOGGED / REVIEWED BY: B. Xu /
DRILLING CONTRACTOR: West Coast Exploration
DRILLING METHOD: Solid Flight Auger
HAMMER TYPE: 140 lb. Rope and Cathead

| Depth in Feet | Elevation in Feet | Sample Type | DESCRIPTION | Log Symbol | Water Level | Blow Count/Foot | Atterberg Limits: Liquid Limit | Atterberg Limits: Plastic Limit | Atterberg Limits: Plasticity Index | Fines Content (% passing #200 sieve) | Moisture Content (% dry weight) | Dry Unit Weight (pcf) | Shear Strength (psf) *field approximation | Unconfined Strength (tsf) *field approximation | Strength Test Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LEAN CLAY (CL), brownish gray with pale olive | | | | | | | | | | | | |
| | 490 | | | | | | | | | | | | | | |
| | | | FAT CLAY (CH), very dark gray, medium stiff, moist, high plasticity | | | 16 | | | | | | | | 1.25* | PP |
| 5 | | | | | | 20 | 63 | 20 | 43 | | 31 | | | | |
| | 485 | | | | | | | | | | | | | | |
| 10 | | | color changes to dark gray to brownish gray | | | 24 | | | | | | | | 1* | PP |
| | | | End boring at approximately 11.5 feet below ground surface. Groundwater was not encountered during drilling. | | | | | | | | | | | | |

ENGEO
Expect Excellence