MIDDLE GREEN VALLEY
SOLANO COUNTY, CALIFORNIA

PRELIMINARY GEOTECHNICAL EXPLORATION

SUBMITTED TO
Mr. Joseph Cusenza
PO Box 2672
Carmel, CA 93921

PREPARED BY
ENGEO Incorporated

March 20, 2019

PROJECT NO.
15480.000.000

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Mr. Joseph Cusenza
PO Box 2672
Carmel, CA 93921

Subject: Middle Green Valley
Solano County, California

PRELIMINARY GEOTECHNICAL EXPLORATION

Dear Mr. Cusenza:

This report summarizes geotechnical and geological existing conditions and constraints and provides preliminary geotechnical recommendations for conceptual planning of the Middle Green Valley project located in Solano County, California. The preliminary conclusions and recommendations of this report are based on geotechnical and geologic studies completed to date.

Based on the results of this study, we identified the following geotechnical and geologic considerations to incorporate in the project planning:

- Disturbed near-surface soil and existing undocumented fill.
- Expansive soil.
- Compressible soil.
- Hennessey Creek embankment stability.
- Agricultural reservoir stability.
- Surface ruptures from the Middle Green Valley Fault.
- Seismically induced settlement of potentially liquefiable soil.

It is our opinion that the proposed Middle Green Valley project is feasible from a geotechnical standpoint provided the recommendations by ENGEO Incorporated, as summarized in this document, are incorporated into project planning.

We trust that this document provides geotechnical guidance appropriate for the current planning process. Please contact us if you have any questions regarding this document.

Sincerely,

ENGEO Incorporated

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this preliminary geotechnical exploration, as described in our proposal dated September 26, 2018, is to provide an assessment of the potential geotechnical and geologic concerns associated with the use of the site for a residential neighborhood and associated improvements. The scope of our services included a site visit, a review of published geologic maps, review of readily available geotechnical reports for the site, advancing ten cone penetration tests (CPTs) to a depth of up to approximately 50 feet below existing grade, and preparation of this report discussing potential hazards.

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

1.2 PROJECT LOCATION

The approximately 125-acre site is located along Green Valley Road near the western boundary of Solano County. The Upper Green Valley, Eastridge, and Hidden Meadows residential developments border the project site to the north, east, and south, respectively. The gently sloped development area is bordered to the west by the northwest-southeast-oriented Hennessey Creek and low-lying hills. The Green Valley Creek is oriented in the northwest-southeast direction and resides northeast of the site. The site is currently used for agriculture and livestock purposes and is occupied by several existing single-family homes.

1.3 PROJECT DESCRIPTION

Based on the Middle Green Valley Specific Plan, dated August 8, 2017, we understand the developable area of the site comprises three separate areas, named from north to south, Three Creeks, Elkhorn, and Nightingale. The smaller Three Creeks area is planned near the westernmost portion of Mason Road. Elkhorn and Nightingale are situated directly northeast of Hennessey Creek and comprise the majority of the developable area (Figure 1). The improvements will consist of approximately 400 units of primarily residential neighborhoods with a small core area comprising higher-density, mixed-use residential and commercial uses. The total acreage for the residential and mixed-use developments is approximately 125 acres. Most of the remaining area of the site will be dedicated to agricultural preserves, watersheds, and rural meadows. In addition to the above-mentioned improvements, we anticipate the development will include minor ancillary structures, street and sidewalk paving, underground utilities, retaining structures, and landscaping. Conceptual grading plans were not available for our review, but we anticipate minor fills and site grading to accommodate the development.

2.0 SITE GEOLOGY AND SEISMICITY

2.1 REGIONAL GEOLOGY

The Middle Green Valley site is located within the northern Coast Range Province of California, an area dominated by northwest-trending fault-bounded uplifted ranges and intervening valleys. Green Valley is a narrow alluvial valley surrounded by steep bedrock highlands along the west, north and east. The valley is drained by Green Valley Creek and a small tributary stream that flow to the south into Suisun Bay. According to mapping by Graymer (1999) (Figure 3), the ridgeline west of Green Valley is underlain by Eocene-age marine rocks of the Markley Formation. As shown on Figure 2, the ridge slopes immediately west of the proposed development are occupied by a very large, deep-seated bedrock landslide complex. The active Green Valley Fault passes through the central portion of the project, as shown on Figures 2 and 5. East of the fault, the bedrock consists of Pliocene-age volcanic and sedimentary rocks of the Sonoma Volcanics. As shown in Figure 3, the floor of Green Valley and most of the proposed development area is underlain by Holocene-aged alluvial fan and fluvial deposits (Qhaf). A regional liquefaction susceptibility map by Witter, et al., (2006) identifies the alluvial deposits as having a moderate liquefaction susceptibility. The United State Geological Survey (Bennett, 2011) performed a site-specific liquefaction study at Mason Road in conjunction with a paleoseismic investigation of the Green Valley fault by (Lienkaemper, et al., 2013). Bennet concluded that the fine-grained alluvium has a low liquefaction potential as discussed below.

2.2 REGIONAL SEISMICITY

The San Francisco Bay Area contains numerous active faults. Figure 4 shows the approximate location of active and potentially active faults and significant historic earthquakes mapped within the San Francisco Bay Region. An active fault is defined by the State as one that has had surface displacement within Holocene time, about the last 11,000 years (Bryant and Hart, 1997). Based on the 2008 USGS National Seismic Hazard Maps, the nearest active fault is the Green Valley fault, which runs through the middle of the site. This fault is considered capable of a moment magnitude earthquake of 6.8. Other active faults located near the site include the Hayward fault, located approximately 18.1 miles west of the site, considered capable of a moment magnitude earthquake of 7.3; and the West Napa fault, located approximately 6.3 miles west of the site.

2.3 GREEN VALLEY FAULT

The Concord-Green Valley fault zone extends for roughly 40 miles from Walnut Creek on the south to Wooden Valley on the north, as depicted on Figure 4. Slip from the Concord Fault appears to transfer to the Green Valley Fault via an eastward step under Suisun Bay. Both the Concord and Green Valley faults experience aseismic creep. Seismic creep rates along the Concord-Green Valley faults are believed to be about 4 mm/yr (McFarland et al., 2007; Galehouse and Lienkaemper, 2003). The long-term slip rate along the Green Valley fault has been estimated by the WGCEP (2007) at 5 ±3 mm/yr.

As shown in Figures 2 and 5, certain segments of the subject site are within the Alquist-Priolo Earthquake Fault Zone established around active traces of the Green Valley Fault. This indicates potential surface rupture hazard to structures within this zone. Lienkaemper, et al., (2013) performed a paleoseismic investigation of the main trace of the Green Valley fault south of Mason Road, between the Nightingale and Elkhorn Neighborhoods. The focus of the investigation was to evaluate slip rate and recurrence intervals on the main fault trace. The study found the fault trace at approximately the mapped location. However, it was not the intent of Leinkaemper, et al., to locate all recently active fault traces associated with the main trace. Fault trenching in the indicated areas, in accordance with Public Resources Code Section 2621.5(a), would be required to build within the Fault Zone.

2.4 SITE CONDITIONS

The proposed Middle Green Valley neighborhoods are located west of Green Valley Creek and immediately east of an unnamed tributary channel. The western side of the Green Valley is formed by east-sloping alluvial fans, while the central portion of the valley adjacent to Green Valley Creek slopes to the south. Site conditions are depicted on Figure 2. As shown on Figure 2, there is an existing agricultural reservoir in the hillside area northwest of the Elkhorn Neighborhood. The reservoir is impounded by a 35-foot-high embankment and covers an area of approximately 3 acres.

One asphalt-paved road runs east-to-west across the central segment of the project site, while gravel roads run north-to-south and east-to-west across the southern segment. Large storage sheds and small single-family residences exist on the central portion of the site.

2.5 FIELD EXPLORATION

We performed a field exploration on October 31 and November 1, 2018. Our field exploration included advancing ten Cone Penetration Tests (CPTs) at various accessible locations at the site, as shown in Figure 2. The location of our explorations are approximately located and were estimated using consumer-grade global positioning system (GPS) and their proximity to existing site features; therefore, the locations shown should be considered accurate only to the degree implied by the method used. Our exploration focused on the Nightingale and Elkhorn neighborhoods. Future explorations should include the Three Creeks neighborhood as well.

We retained a CPT truck rig to push the cone penetrometer to a maximum depth of approximately 50 feet. The CPT has a 25-ton compression-type cone with a 15-square-centimeter (cm^2) base area, an apex angle of 60 degrees, and a friction sleeve with a surface area of 225 cm^2. The cone, connected with a series of rods, is pushed into the ground at a constant rate. Cone readings are taken at approximately 5-cm intervals with a penetration rate of 2 cm per second in accordance with ASTM D5778. Measurements include the tip resistance to penetration of the cone (qt), the resistance of the surface sleeve (fs), and pore pressure (u) (Robertson and Campanella, 1988). CPT logs are presented in Appendix A.

2.6 LIMITED LABORATORY TESTING

Bulk samples were taken of near-surface material at all CPT locations. These samples were submitted to our laboratory for testing. We performed plasticity index tests on near-surface samples at four different CPT locations. Laboratory test results are included in Appendix B.

2.7 SUBSURFACE CONDITIONS

The upper 2 to 3 feet of the proposed development areas are underlain by soil generally consisting of sandy lean clay to clayey sand with plasticity indices ranging from 12 to 22. This is an indication that the near-surface soils have a low to moderate expansion potential. However, below the sandy/silty surficial layer, CPT probes by ENGEO and the USGS encountered clays and silty clays. Testing by the USGS indicate these soils are of moderate to high plasticity. It is therefore likely that high plasticity soils will be encountered during project grading and construction of improvements.

The CPT logs include the specific subsurface conditions at the location of the probes. We include our CPT logs in Appendix A.

2.8 GROUNDWATER CONDITIONS

Groundwater information was not collected during our field exploration and we have not identified any publicly available well information. Further testing is required to determine groundwater conditions for this site.

For preliminary liquefaction analysis, we assumed a groundwater table of 5 feet below ground surface based on pore pressure measured during our CPT exploration.

3.0 DISCUSSION AND PRELIMINARY CONCLUSIONS

Based upon this preliminary study, it is our opinion that the project site is feasible for the proposed residential developments from a geotechnical standpoint provided that the preliminary recommendations contained in this report and future design-level geotechnical studies are incorporated into the development plans. A more comprehensive site-specific geotechnical exploration should be performed as part of the design process. The exploration would include borings and laboratory soil testing to provide data for preparation of specific recommendations regarding grading, foundation design, and considerations for the creek embankment setback for the proposed development. The exploration will also allow for more detailed evaluations of the geotechnical issues discussed below and afford the opportunity to provide recommendations regarding techniques and procedures to be implemented during construction to mitigate potential geotechnical/geological hazards.

Based upon our field exploration and review of readily available published maps for the site, the main geotechnical concerns for the proposed site development include:

- Disturbed near-surface soil and existing undocumented fill.
- Expansive soil.
- Compressible soil.
- Hennessey Creek embankment stability.
- Agricultural reservoir stability.
- Surface ruptures from the Middle Green Valley Fault.
- Seismically induced settlement of potentially liquefiable soil.

3.1 DISTURBED NEAR-SURFACE SOIL AND EXISTING UNDOCUMENTED FILL

As previously mentioned, much of the development area has been used as agricultural land resulting in disturbed near-surface soil. Disturbed near-surface soil and undocumented fill associated with the existing structures and associated underground utilities may undergo excessive settlement, especially when subjected to new loads from grading and the planned building. The extent and quality of existing fills should be evaluated with additional exploration so potential mitigation measures can be recommended at the time of our design-level study.

We present fill removal recommendations in Section 4.1.

3.2 EXPANSIVE SOIL

Based on our laboratory testing, we observed potentially expansive clay in near-surface samples taken at 1-CPT1, 1-CPT5, 1-CPT6, and 1-CPT10. Our laboratory testing indicates that these soils exhibit low to moderate shrink/swell potential with variations in moisture content. Furthermore, testing during the previously mentioned USGS study indicate moderate- to high-expansive soils in relatively shallow soil that would likely be encountered during grading and improvement construction.

Successful performance of structures on expansive soils requires special attention during construction. It is imperative that exposed soils be kept moist prior to placement of concrete for foundation construction. It can be difficult to remoisturize clayey soils without excavation, moisture conditioning, and recompaction.

We have also provided specific grading recommendations for compaction of clay soil at the site. The purpose of these recommendations is to reduce the swell potential of the clay by compacting the soil at a high moisture content and controlling the amount of compaction. Expansive soil compaction recommendations are presented in Section 4.1 of this report.

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

Post-tensioned mat foundations are the preferred foundation system for the residential structures. Design criteria for this foundation type are presented in Section 4.2.

3.3 COMPRESSIBLE SOIL

During our exploration, we encountered soft to medium stiff clay-like soils throughout the site. These soils are potentially susceptible to immediate and long-term settlement associated with the additional load of the proposed structure or/and additional fill. Further exploration and laboratory tests are required to characterize the potential compressibility of the subsurface soils. Once the structural loads are provided, total static settlement can be further evaluated and provided in the design-level geotechnical report.

3.4 HENNESSEY CREEK EMBANKMENT STABILITY

The southwestern portion of the site is bounded by the Hennessey Creek. At the time of exploration, the creek bed was dry. We observed substantial scour and near-vertical banks along much of the creek indicating previous rapid, high water flow. For preliminary planning purposes, we suggest no building or retaining wall foundations be placed within 20 feet of the top of the creek embankment. This should be evaluated further in a design-level report based on bank stability analysis and relevant agency requirements.

3.5 AGRICULTURAL RESERVOIR STABILITY

There is an existing agricultural reservoir in the hillside area northwest of the Elkhorn Neighborhood. The reservoir is impounded by a 35-foot-high embankment and covers an area of approximately 3 acres. We have not reviewed any construction records for the embankment. Given the location of the reservoir above the Elkhorn neighborhood, further study into the static and seismic stability of the earthen berm should be performed to determine if retrofit or inundation measures need to be implemented.

3.6 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, soil liquefaction, and lateral spreading. These hazards are discussed in the following sections.

Based on topographic and lithological data, the risk of regional subsidence or uplift, tsunamis, landslides and seiches is considered low at the site.

3.6.1 Ground Rupture

The Green Valley fault trace is currently mapped to run through the center of the site, with a significant portion of the proposed development residing within the associated Alquist-Priolo Earthquake Fault Zone. This indicates that there is a high risk of surface rupture hazard. Fault trenching in the indicated areas, in accordance with Public Resources Code Section 2621.5(a), would be required to build within the Fault Zone.

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

3.6.3 Liquefaction/Clay Soil Softening

Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. Soils most susceptible to liquefaction are clean, loose, saturated, uniformly graded, fine-grained sands. Empirical evidence indicates that loose to medium-dense gravels, silty sands, low-plasticity silts, and some low-plasticity clays are also potentially liquefiable.

We performed a liquefaction potential analysis of the CPT soundings using the computer software CLiq Version 2.2 developed by GeoLogismiki. The procedure used in the software is based on the methodology by Robertson (2009) with consideration of cyclic softening of clay-like soils. The Cyclic Stress Ratio (CSR) was estimated for a Peak Ground Acceleration (PGA) of 0.78g as outlined in the ASCE 7-10 and moment magnitude of 7.3 based on the nearby Hayward fault. We evaluated the liquefaction potential for the soils using the estimated groundwater level during CPT testing of 5 feet below ground surface.

Our preliminary liquefaction analysis results indicated several layers interpreted as fine-grained material encountered in the CPTs are potentially liquefiable. However, as previously mentioned, the USGS performed a site-specific liquefaction assessment on the subject property (Bennett, 2011). The assessment included advancing CPTs, continuously sampled hollow-stem auger borings, and laboratory testing and concluded that in general, the fine-grained material underlying the site had a low susceptibility to liquefaction.

Additional sampling should be done during the design-level field exploration to further characterize the liquefaction susceptibility based on criteria by Bray and Sancio (2006) and verify the USGS findings.

3.6.4 Lateral Spreading

Lateral spreading involves lateral ground movements caused by seismic shaking. These lateral ground movements are often associated with a weakening or failure of an embankment or soil mass overlying a layer of liquefied sands or weak soils. The creek embankment on the southwestern portion of the site is an exposed free face slope that could be susceptible to lateral spreading.

Further analysis will be conducted in the design-level geotechnical report based on additional exploration and site topography to determine the possible extent and magnitude of lateral spreading. Mitigation will be included in the design-level geotechnical report.

3.7 FLOOD ZONE

The site is located south of the Green Valley Creek. According to the Flood Insurance Rate Maps (FIRMs) by Federal Emergency Management Agency (FEMA, 2009), a special flood hazard area (Zone AE) is mapped along or near to the Green Valley Creek. The eastern edge of the subject site is directly adjacent a Zone AE flood zone. The project civil engineer should determine whether the proposed project boundary resides within the aforementioned flood zone.

3.8 PRELIMINARY BUILDING CODE SEISMIC DESIGN

We provide the 2016 California Building Code (CBC) seismic parameters in Table 3.8-1 below.

**TABLE 3.8-1: 2016 CBC Seismic Design Parameters
Latitude: 38.23597, Longitude: -122.16081**

PARAMETER	VALUE
Site Class	D
Mapped MCE_R Spectral Response Acceleration at Short Periods, S_S (g)	2.04
Mapped MCE_R Spectral Response Acceleration at 1-second Period, S_1 (g)	0.72
Site Coefficient, F_A	1.00
Site Coefficient, F_V	1.50
MCE_R Spectral Response Acceleration at Short Periods, S_{MS} (g)	2.04
MCE_R Spectral Response Acceleration at 1-second Period, S_{M1} (g)	1.08
Design Spectral Response Acceleration at Short Periods, S_{DS} (g)	1.36
Design Spectral Response Acceleration at 1-second Period, S_{D1} (g)	0.72
Mapped MCE Geometric Mean (MCE_G) Peak Ground Acceleration, PGA (g)	0.78
Site Coefficient, F_{PGA}	1.00
MCE_G Peak Ground Acceleration adjusted for Site Class effects, PGA_M (g)	0.78

4.0 PRELIMINARY RECOMMENDATIONS

4.1 GRADING

The following preliminary recommendations are for initial land planning and preliminary estimating purposes. Final recommendations regarding site grading and foundation construction will be provided after more detailed land plans have been prepared.

4.1.1 Demolition and Stripping

Site development will commence with the demolition of existing structures and improvements, including abandoned utilities and basements, if any exist. All debris should be removed from any location to be graded, from areas to receive fill or structures, or those areas to serve as borrow. The depth of removal of such materials should be determined by the Geotechnical Engineer in the field at the time of grading.

Existing vegetation and pavements (asphalt concrete/concrete and underlying aggregate base) should be removed from areas to receive fill, or structures, or those areas to serve for borrow. Tree roots should be removed down to a depth of at least 3 feet below existing grade. The actual depth of tree root removal should be determined by the Geotechnical Engineer's representative in the field. Subject to approval by the Landscape Architect, strippings and organically contaminated soils can be used in landscape areas. Otherwise, such soils should be removed from the project site. Any topsoil that will be retained for future use in landscape areas should be stockpiled in areas where it will not interfere with grading operations.

All excavations from demolition and stripping below design grades should be cleaned to a firm undisturbed soil surface determined by the Geotechnical Engineer. This surface should then be scarified, moisture conditioned, and backfilled with compacted engineered fill. The requirements for backfill materials and placement operations are the same as for engineered fill.

No loose or uncontrolled backfilling of depressions resulting from demolition and stripping is permitted.

4.1.2 Existing Fill Removal

All existing fill and soft material should be excavated to expose firm native soils. Excavated material may be used as fill material if it meets the requirements of Section 4.1.3.

4.1.3 Selection of Materials

With the exception of construction debris (wood, brick, asphalt, concrete, metal, etc.), trees, organically contaminated materials (soil which contains more than 2 percent organic content by weight), and environmentally impacted soils (if any), we anticipate the site soils are suitable for use as engineered fill provided they are broken down to particles with diameter of 6 inches or less. Other materials and debris, including trees with their root balls, should be removed from the project site.

Imported fill materials should meet the above requirements and have a plasticity index less than 15. ENGEO should sample and test proposed imported fill materials at least 72 hours prior to delivery to the site.

4.1.4 Fill Placement

For land planning and cost estimating purposes, the following compaction control requirements should be anticipated for general fill areas:

- Test Procedures: ASTM D-1557.
- Required Moisture Content: Not less than 4 percentage points above optimum moisture content for soil with PI of 15 or greater.

  Not less than 3 percentage points above optimum moisture content for soil with PI of less than 15.
- Minimum Relative Compaction: 90 percent.

Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same material.

Additional compaction requirements may be required for deeper fills and retaining wall backfill. These additional requirements will be developed during our detailed exploration.

4.2 PRELIMINARY FOUNDATION DESIGN

We developed preliminary foundation recommendations using data obtained from our field exploration, laboratory test results, and engineering analysis. Table 4.2-1 provides our suggested foundation types for the various product types.

For design purposes, we recommend obtaining subsurface geotechnical data below the proposed foundations once the building layouts and types are known to develop design-level foundation recommendations.

TABLE 4.2-1: Suggested Foundation Type by Product

	STRUCTURAL MAT	POST-TENSION MAT	FOOTINGS WITH SLAB-ON-GRADE
Single-Family Homes, Townhomes	-	Yes	-
Commercial	Yes	-	Yes
Mixed-use Podium	Yes	-	Yes

4.2.1 Structural Mat Foundations

For preliminary planning purposes, structural mat foundations may be considered for commercial structures or mixed-use podiums. An allowable bearing capacity of 1,500 per square foot (psf) may be used for dead-plus-live loads. Increase this bearing capacity by one-third for the short-term effects of wind or seismic loading.

4.2.2 Post-Tensioned Mat Foundations

For preliminary purposes, post-tensioned (PT) slab foundations on properly prepared compacted fill may be considered for supporting the proposed single-family and townhome structures. On a preliminary basis, we recommend that PT mats be a minimum of 10 inches thick or greater and have a thickened edge at least 2 inches greater than the mat thickness. The Structural Engineer should determine the actual PT mat thickness using the geotechnical recommendations in the design-level report. We recommend that the thickened edge be at least 12 inches wide.

PT mats are typically underlain by a moisture reduction system as recommended in Section 4.4. In addition, the building pad subgrade is typically moisture conditioned such that the subgrade soil is at a moisture content at least 3 percentage points above optimum immediately prior to foundation construction. The subgrade should not be allowed to dry prior to concrete placement.

4.2.3 Conventional Footings with Slab-On-Grade

Conventional footings with slab-on-grade floors may be suitable provided that the subgrade soils have a low-expansion potential. Expansive soil can be mitigated by removing and replacing it with low-expansive material or via lime treatment. We can provide such recommendations as-needed in a design-level report.

For planning purposes, the footing may use a maximum allowable bearing pressure of 2,000 pounds psf for dead-plus-live loads. Increase this bearing capacity by one-third for the short-term effects of wind or seismic loading. Minimum footing dimensions can be provided once the building size has been determined. Footing dimensions for continuous and isolated footings will be provided in the design-level geotechnical report.

The maximum allowable bearing pressure is a net value; the weight of the footing may be neglected for design purposes. Footings located adjacent to utility trenches should have their bearing surfaces below an imaginary 1:1 (horizontal:vertical) plane projected upward from the bottom edge of the trench to the footing.

4.3 SLAB MOISTURE VAPOR REDUCTION

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

1. Install a vapor retarder membrane directly beneath the mat. Seal the vapor retarder at all seams and pipe penetrations. Vapor retarders should conform to Class A vapor retarder in accordance with ASTM E 1745-11 “Standard Specification for Plastic Water Vapor Retarders used in Contact with Soil or Granular Fill under Concrete Slabs.”

2. Concrete should have a concrete water-cement ratio of no more than 0.5.

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

4. Consider and implement adequate moist cure procedures for mat foundations.

5. Protect foundation subgrade soils from seepage by providing impermeable plugs within utility trenches.

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

4.4 SUBGRADE TREATMENT FOR MAT FOUNDATIONS

The subgrade material under structural mats should be uniform. The upper 12 inches of pad subgrade should be moisture conditioned to a moisture content of at least 4 percentage points above optimum. The subgrade should be thoroughly soaked prior to placing the concrete. The subgrade should not be allowed to dry prior to concrete placement.

4.5 PRELIMINARY PAVEMENT DESIGN

The following preliminary pavement sections have been determined for an assumed Resistance Value (R-value) of 5 and in accordance to the design methods contained in Chapter 630 of Caltrans Highway Design Manual.

TABLE 4.5-1: Preliminary Pavement Section

TRAFFIC INDEX	AC (INCHES)	AB (INCHES)
5.0	3.0	10.0
6.0	3.5	13.0
7.0	4.0	16.0

Notes: AC – Asphalt Concrete
AB – Caltrans Class 2 aggregate base (R-value of 78 or greater)

The above preliminary pavement sections are provided for estimating only. We recommend the actual subgrade material should be tested for R-value, and the Traffic Index and minimum pavement section(s) should be confirmed by the Civil Engineer and the City of San Leandro/Alameda County.

4.6 RETAINING WALLS

4.6.1 Lateral Soil Pressures

Design proposed retaining walls to resist lateral earth pressures from adjoining natural materials and/or backfill and from any surcharge loads. Provided that adequate drainage is included as recommended below, walls restrained from movement at the top, such as basement walls, should be designed to resist an equivalent fluid pressure of 70 pounds per cubic foot (pcf). In addition, design restrained walls to resist an additional uniform pressure equivalent to one-half of any surcharge loads applied at the surface.

Unrestrained retaining walls should be designed with adequate drainage to resist an equivalent fluid pressure of 60 pcf plus one-third of any surcharge loads.

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

Construct a drainage system, as recommended below, to reduce hydrostatic forces behind the retaining wall.

4.6.2 Retaining Wall Drainage

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

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

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

For both types of rock drains:

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

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

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

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

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

4.6.3 Backfill

Backfill behind retaining walls should be placed and compacted in accordance with Section 4.1. Use light compaction equipment within 5 feet of the wall face. If heavy compaction equipment is used, the walls should be temporarily braced to avoid excessive wall movement.

4.6.4 Site Retaining Wall Foundations

For preliminary design purposes, retaining walls may be supported on continuous footings designed in accordance with recommendations presented in Section 4.2.2. Minimum embedment depth should be 24 inches below lowest adjacent soil grade.

4.7 DRAINAGE

The building pad must be positively graded at all times to provide for rapid removal of surface water runoff from the foundation systems and to prevent ponding of water under floors or seepage toward the foundation systems at any time during or after construction. Ponding of stormwater must not be permitted on the building pad during prolonged periods of inclement weather. All surface water should be collected and discharged into the storm drain system. Landscape mounds must not interfere with this requirement.

All roof stormwater should be collected and directed to downspouts. Stormwater from roof downspouts should be directed to a solid pipe that discharges to the street or to an approved outlet or onto an impervious surface, such as pavement that will drain at a 2 percent slope gradient.

5.0 FUTURE STUDIES

As previously discussed, a site-specific design-level geotechnical exploration should be performed as part of the design process. The exploration should include supplemental borings and laboratory soil testing to provide additional data for evaluation of liquefaction-induced settlement and lateral spreading, consolidation of compressible soil, disturbed soil and existing fill, creek bank stability, and corrosion potential. The design-level report will also provide specific recommendations regarding grading, foundation design, retaining wall design, and drainage for the proposed development. Prior to finalizing neighborhood lands plans, it will be necessary to perform a surface fault rupture hazard investigation for both the Nightingale and Elkhorn Neighborhoods

6.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

This report presents preliminary geotechnical recommendations for design of the improvements discussed in Section 1.3 for the subject Middle Green Valley 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 preliminary 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 preliminary conclusions and recommendations contained in this report are solely professional opinions and are valid for a period of no more than 2 years from the date of report issuance.

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

This report is based upon field and other conditions discovered at the time of report preparation. We developed this report with limited subsurface exploration data. We assumed that our subsurface exploration data is representative of the actual subsurface conditions across the site. Considering possible underground variability of soil, rock, stockpiled material, and groundwater, additional costs may be required to complete the project. We recommend that the owner establish a contingency fund to cover such costs. If unexpected conditions are encountered, 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, 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 onsite construction observation, or if other persons or entities are retained to provide such services, ENGEO cannot be held responsible for any or all claims arising from or resulting from the performance of such services by other persons or entities, and from any or all claims arising from or resulting from clarifications, adjustments, modifications, discrepancies or other changes necessary to reflect changed field or other conditions.

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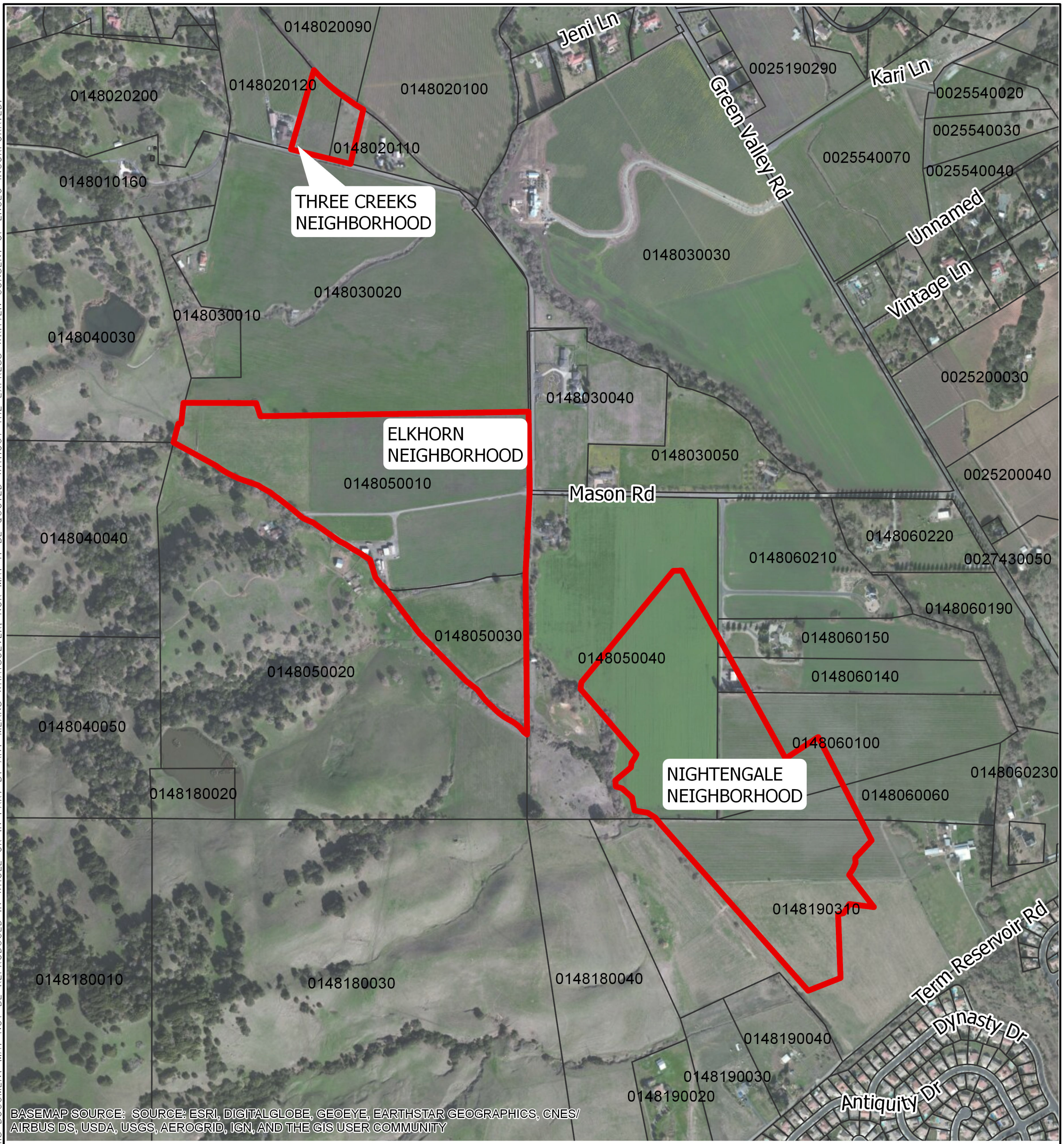
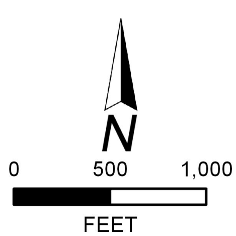
FIGURES





EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

PROJECT SITE

PARCEL BOUNDARY

ENGEO
Expect Excellence

SITE PLAN	PROJECT NO.: 15480.000.000		FIGURE NO.
MIDDLE GREEN VALLEY	SCALE: AS SHOWN		1
FAIRFIELD, CALIFORNIA	DRAWN BY: MAT	CHECKED BY: TTB	

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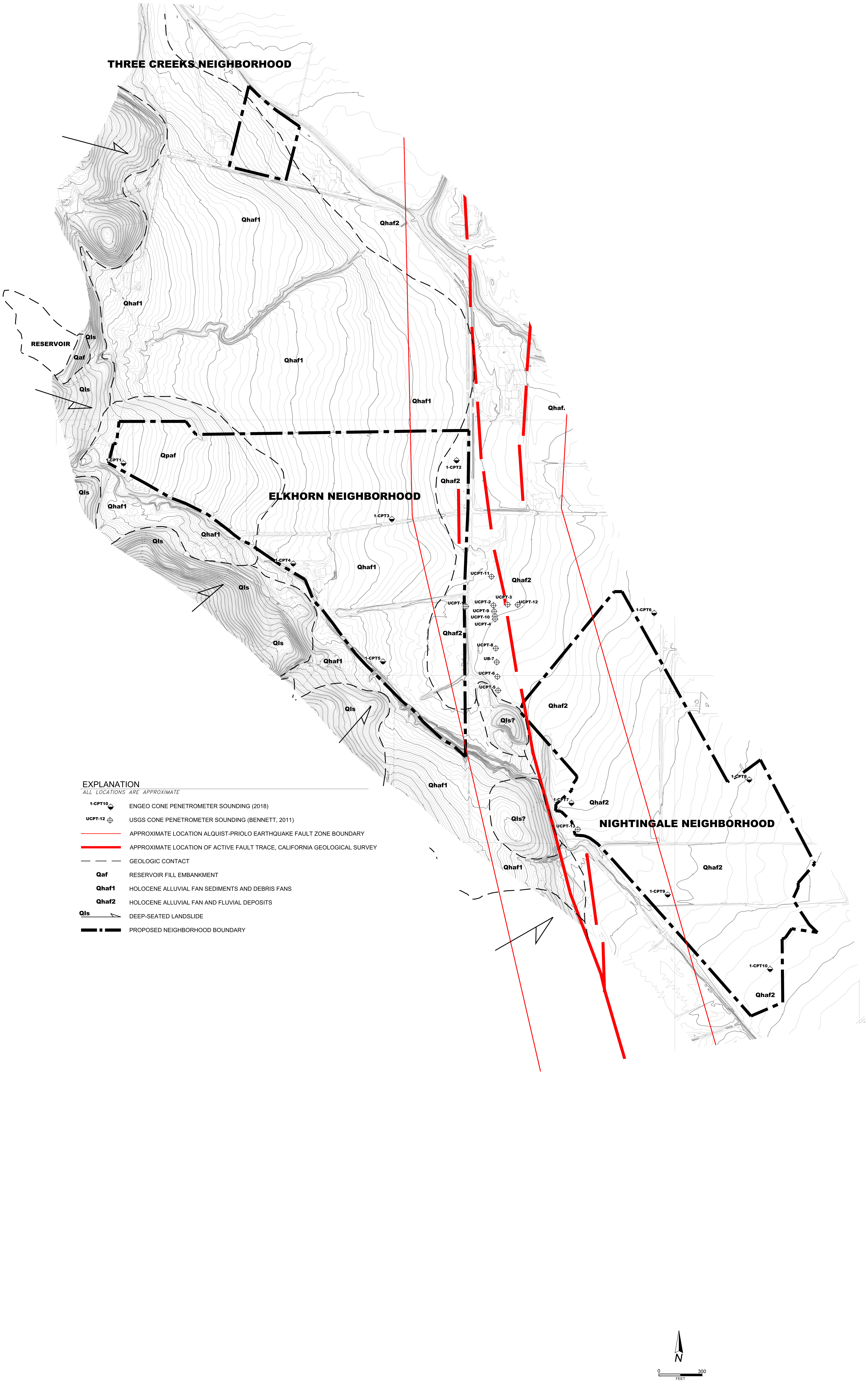
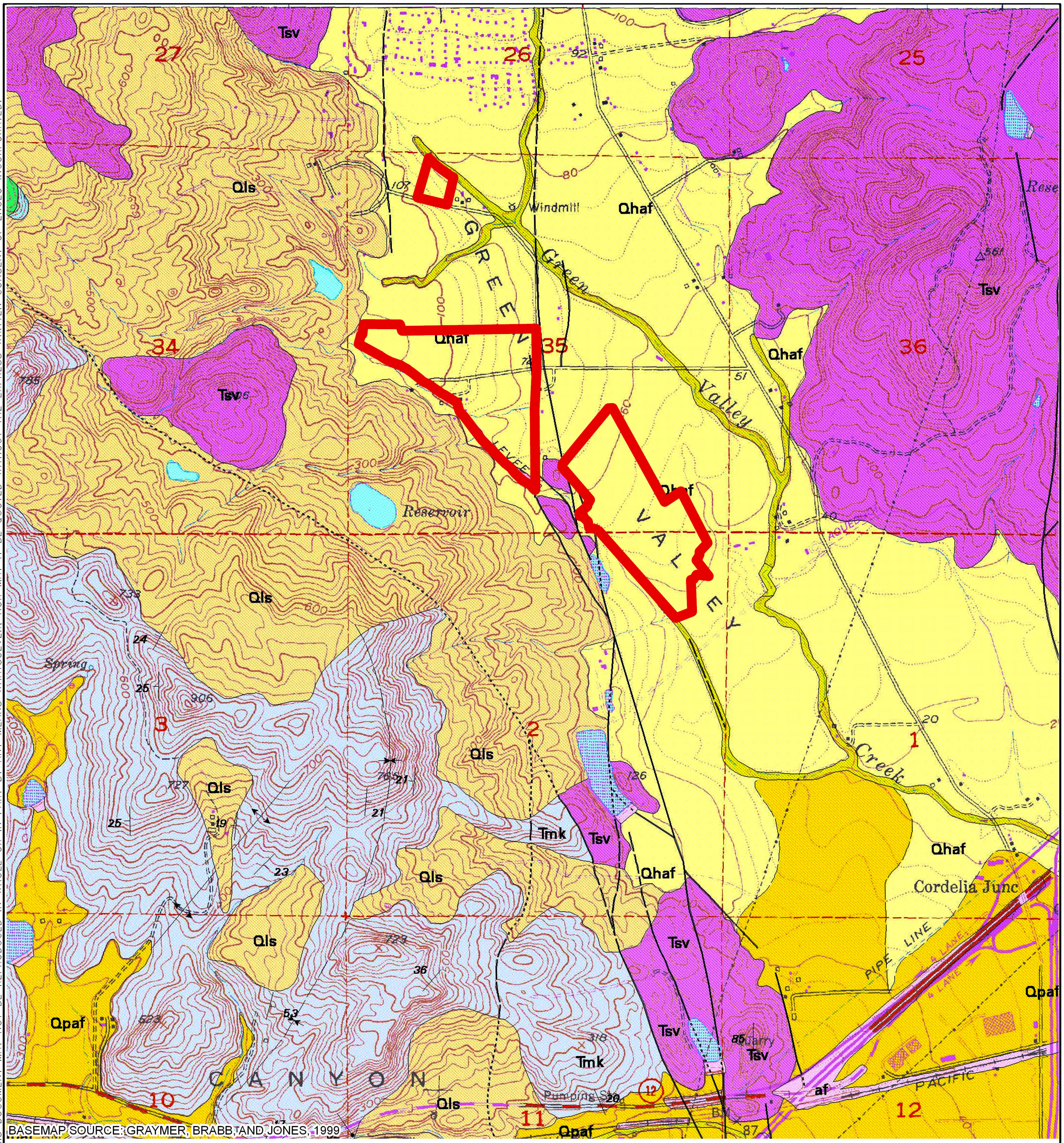


BASE MAP SOURCE: CARLSON BARBEE & GIBSON

ENGEO Expect Excellence	SITE PLAN AND GEOLOGIC MAP MIDDLE GREEN VALLEY FAIRFIELD, CALIFORNIA	PROJECT NO.: 15480.000.000 SCALE: AS SHOWN DRAWN BY: PJS CHECKED BY: TTB	FIGURE NO. 2

ORIGINAL FIGURE PRINTED IN COLOR



N

0 1,000 2,000

FEET

EXPLANATION

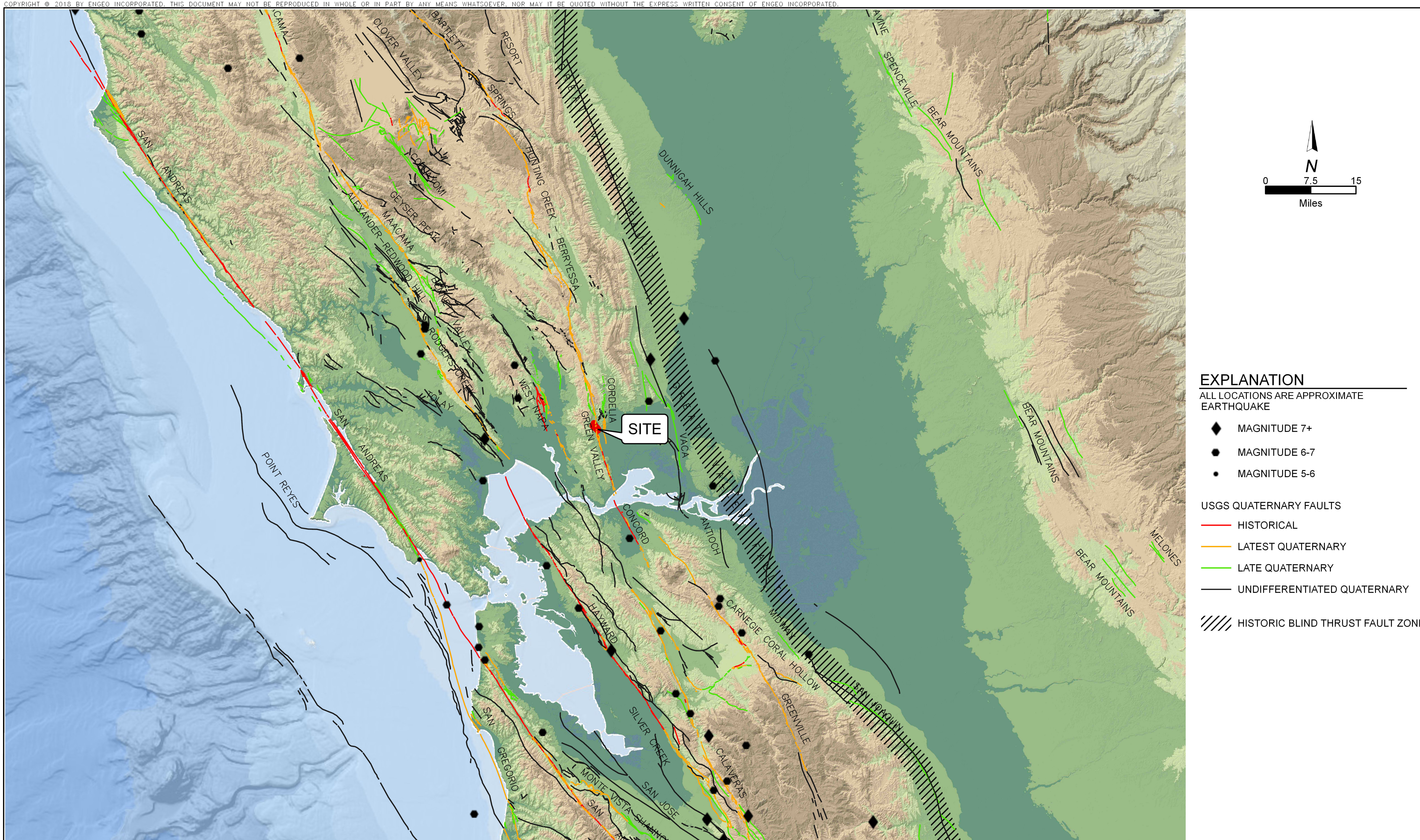
ALL LOCATIONS ARE APPROXIMATE

- PROJECT SITE
- Qhaf — ALLUVIAL FAN AND FLUVIAL DEPOSITS (HOLOCENE)
- Qls — LANDSLIDE DEPOSITS (PLEISTOCENE AND/OR HOLOCENE)
- Tsv — SONOMA VOLCANICS, UNDIVIDED (PLIOCENE AND MIOCENE?)

ENGEO Expect Excellence	REGIONAL GEOLOGIC MAP - GRAYMER MIDDLE GREEN VALLEY FAIRFIELD, CALIFORNIA	PROJECT NO.: 15480.000.000 SCALE: AS SHOWN DRAWN BY: MAT CHECKED BY: TTB	FIGURE NO. 3

PATH: G:\DRAFTING\DRAFTING2_DWG_13000 PLUS\15480\000\GIS\15480GEX3.APRX
USER: MTORRES

ORIGINAL FIGURE PRINTED IN COLOR



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

ENGEO
Expect Excellence

REGIONAL FAULTING AND SEISMICITY
MIDDLE GREEN VALLEY
FAIRFIELD, CALIFORNIA

PROJECT NO.: 15480.000.000		FIGURE NO. 4
SCALE: AS SHOWN		
DRAWN BY: MAT	CHECKED BY: TTB	

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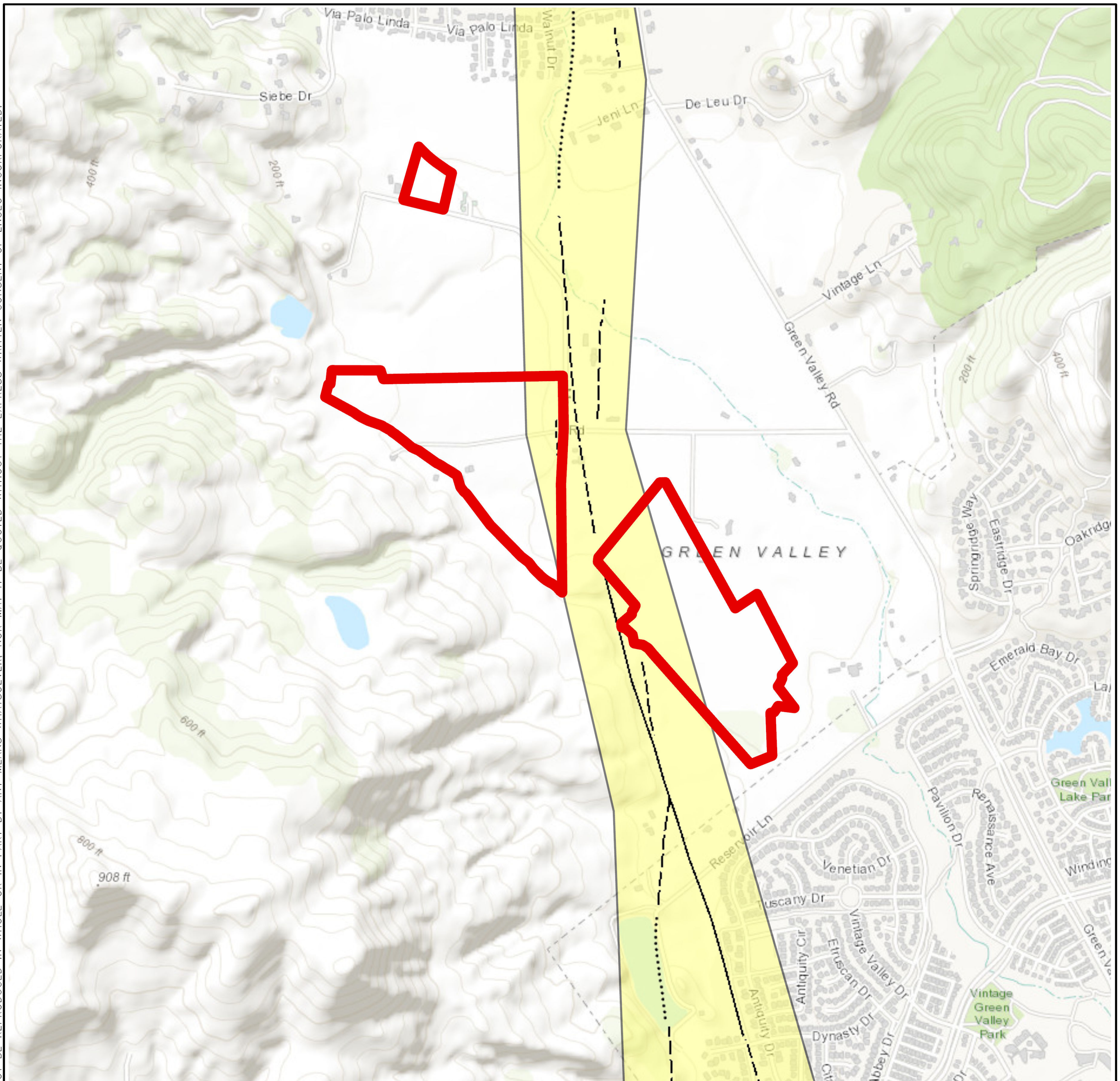

SEISMIC HAZARDS PROGRAM, CALIFORNIA GEOLOGICAL SURVEY, CALIFORNIA DEPARTMENT OF CONSERVATION, SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

N

0 1,000 2,000 FEET

EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

PROJECT SITE

Fault Traces

Approximately Located

Concealed

Accurately Located

Inferred

Earthquake Fault Zone
Zone boundaries are delineated by straight-line segments; the boundaries define the zone encompassing active faults that constitute a potential hazard to structures from surface faultingor fault creep such that avoidance as described in Public Resources Code Section 2621.5(a) would be required.

ENGEO
Expect Excellence

SEISMIC HAZARDS ZONE MAP
MIDDLE GREEN VALLEY
FAIRFIELD, CALIFORNIA

PROJECT NO. : 15480.000.000	FIGURE NO. 5
SCALE: AS SHOWN	
DRAWN BY: MAT	CHECKED BY: TTB

PATH: G:\DRAFTING\DRAFTING2_DWG_13000 PLUS\15480\000\GIS\15480GEX3.APRX
USER: MTORRES

ORIGINAL FIGURE PRINTED IN COLOR

APPENDIX A

Cone Penetration Test Report

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

JOB NUMBER: Engeo Fairfield
HOLE NUMBER: 1-CPT-01aaa
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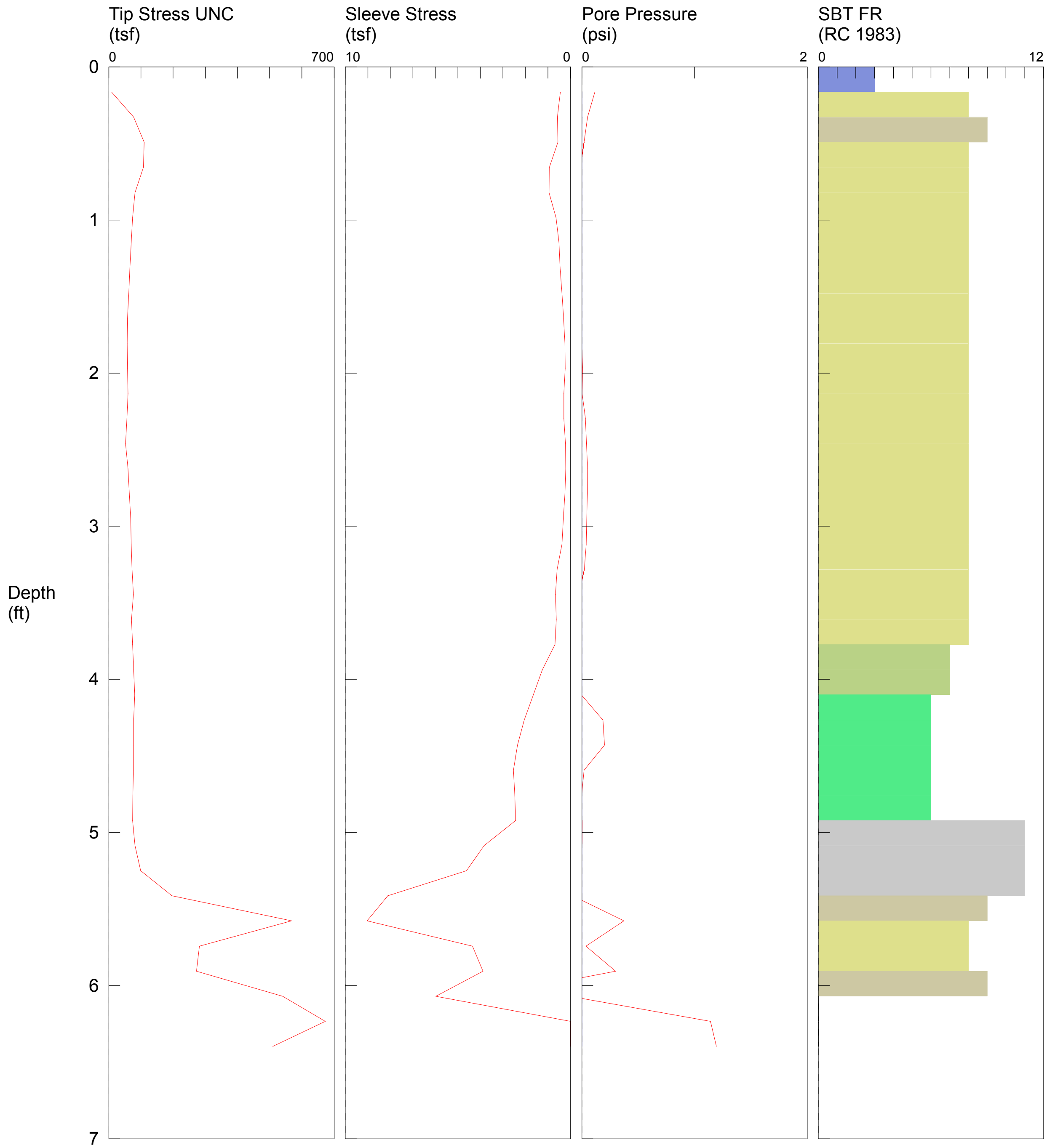
COMMENT: Filter On



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2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

JOB NUMBER: Engeo Fairfield
HOLE NUMBER: 1-CPT-02
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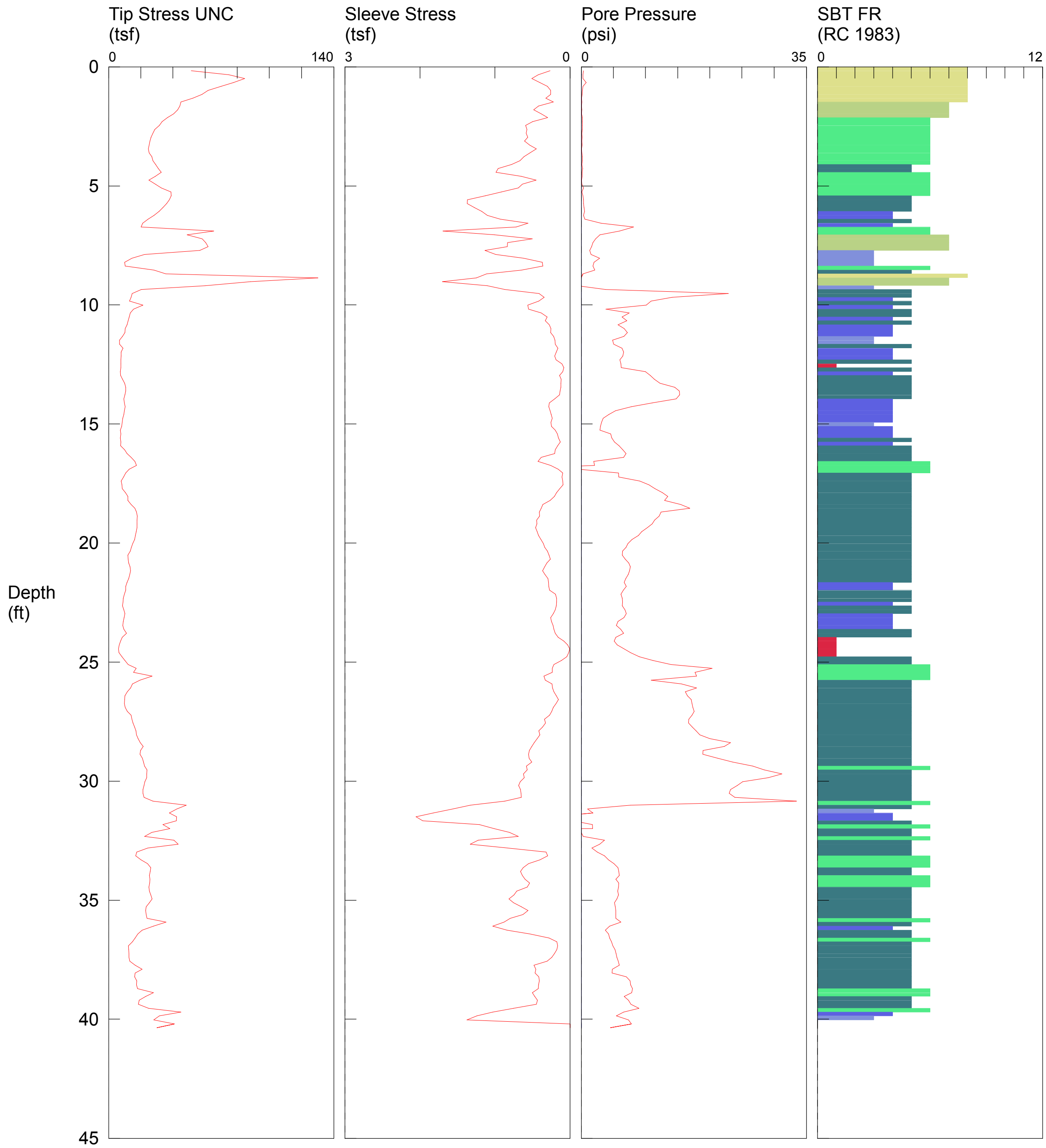

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2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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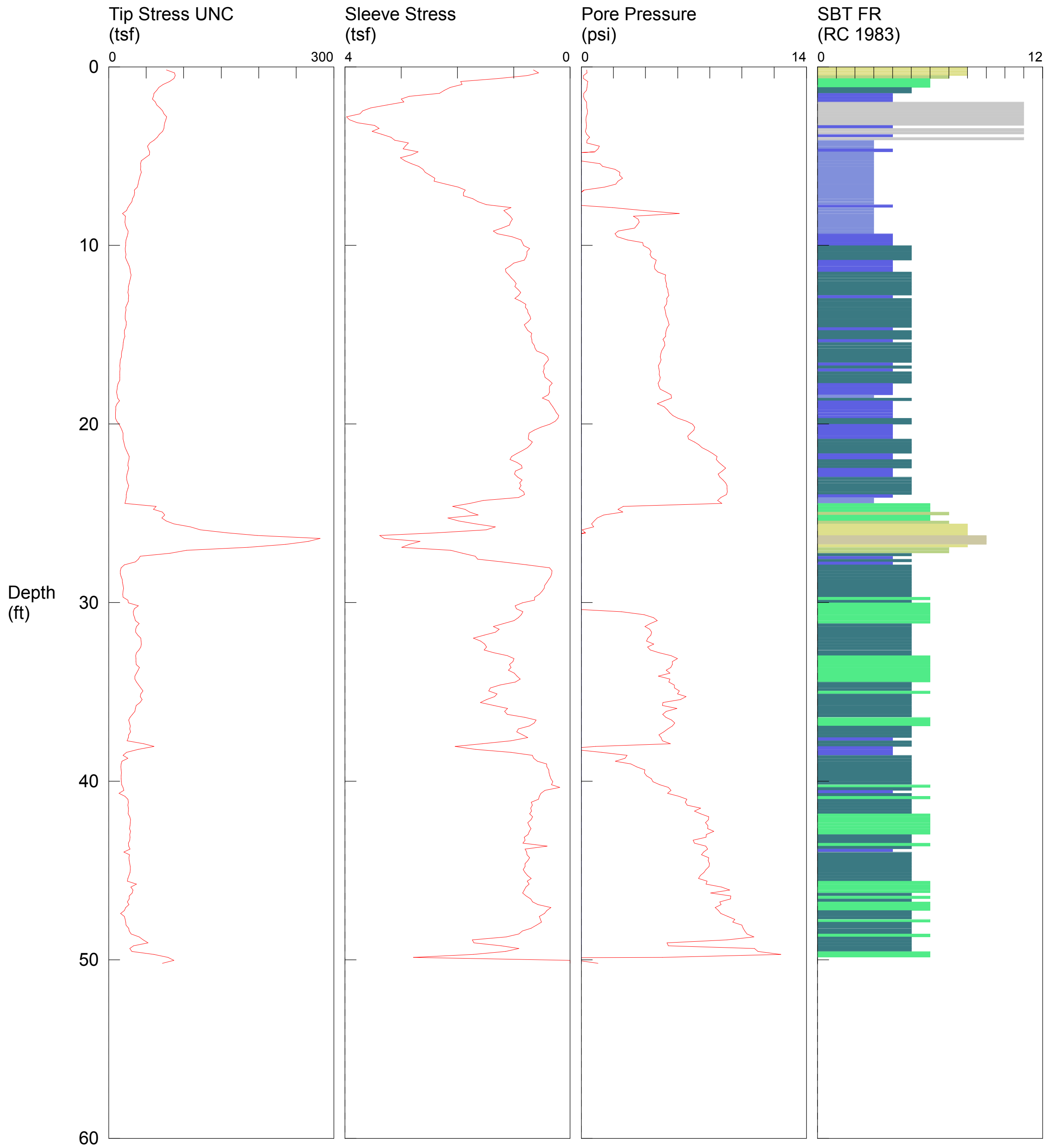

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12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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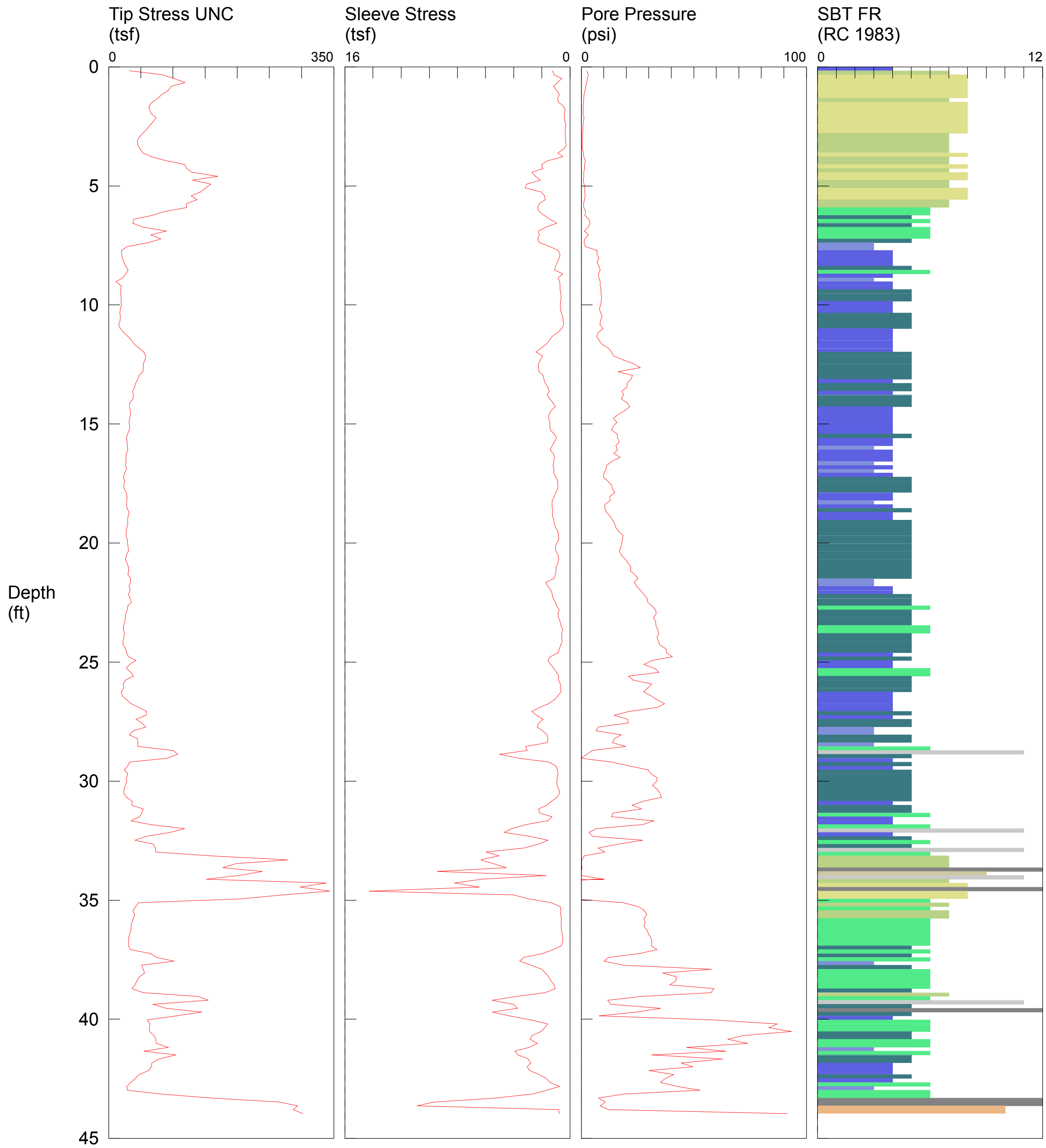

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11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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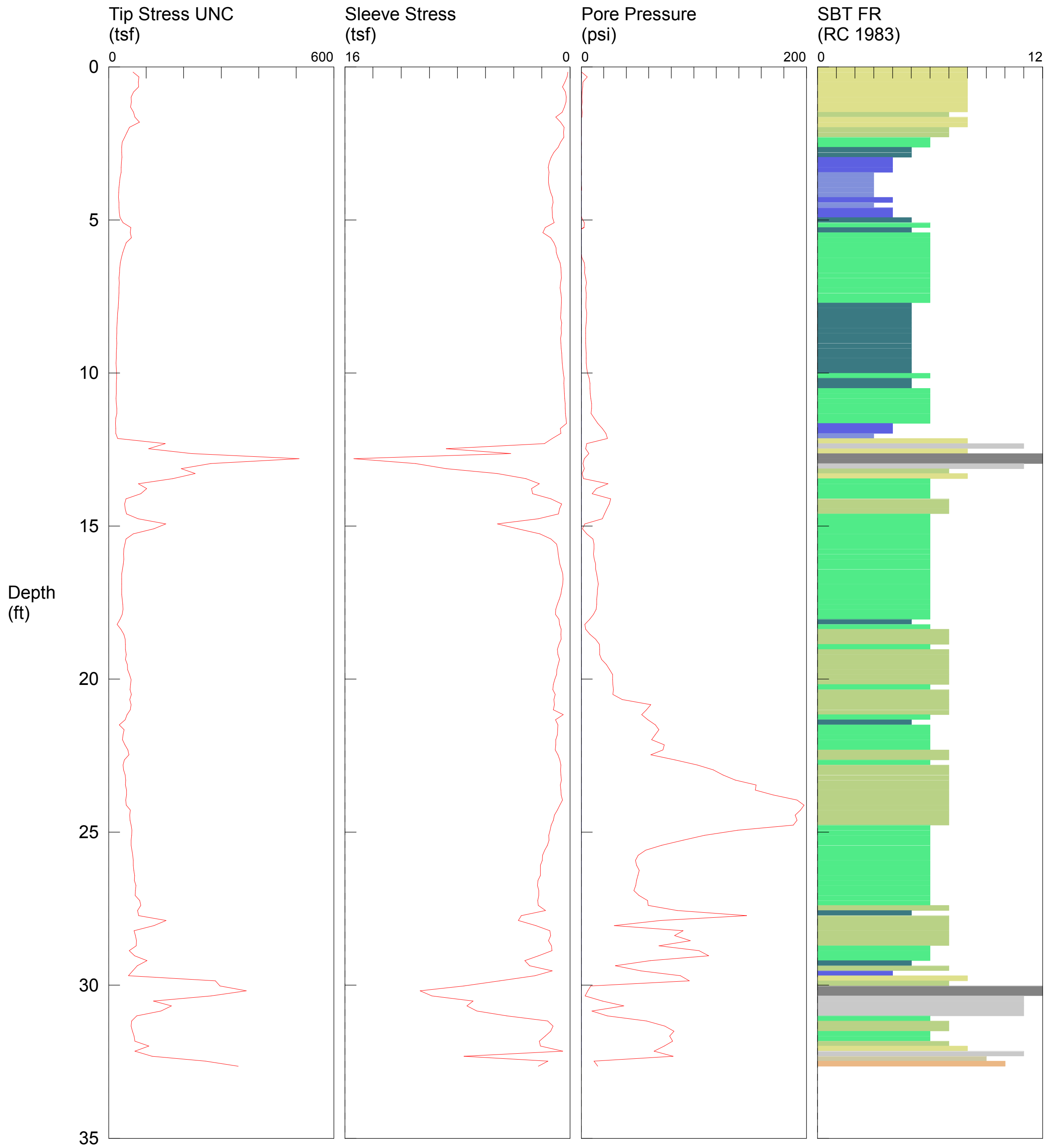

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*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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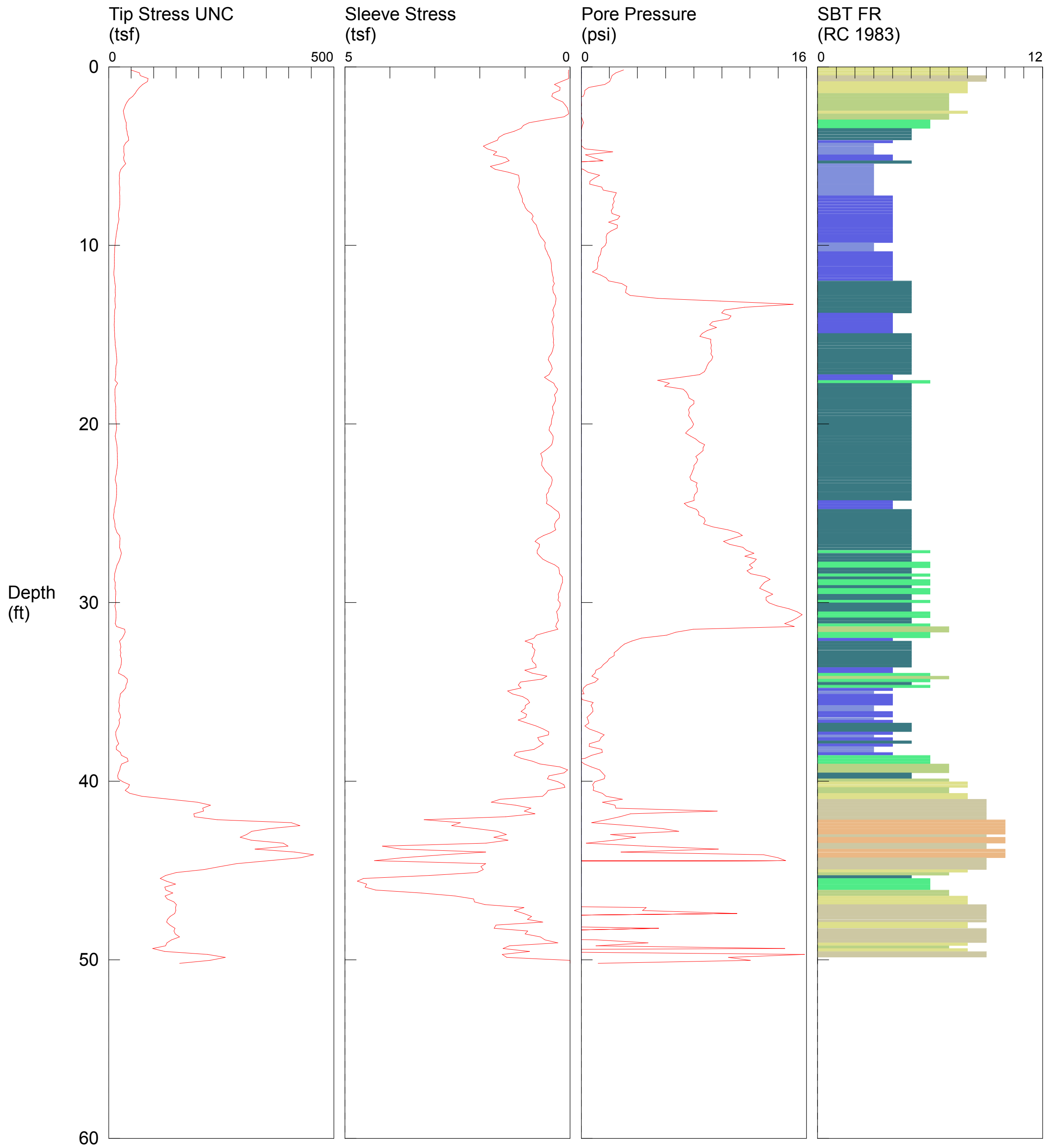

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2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
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*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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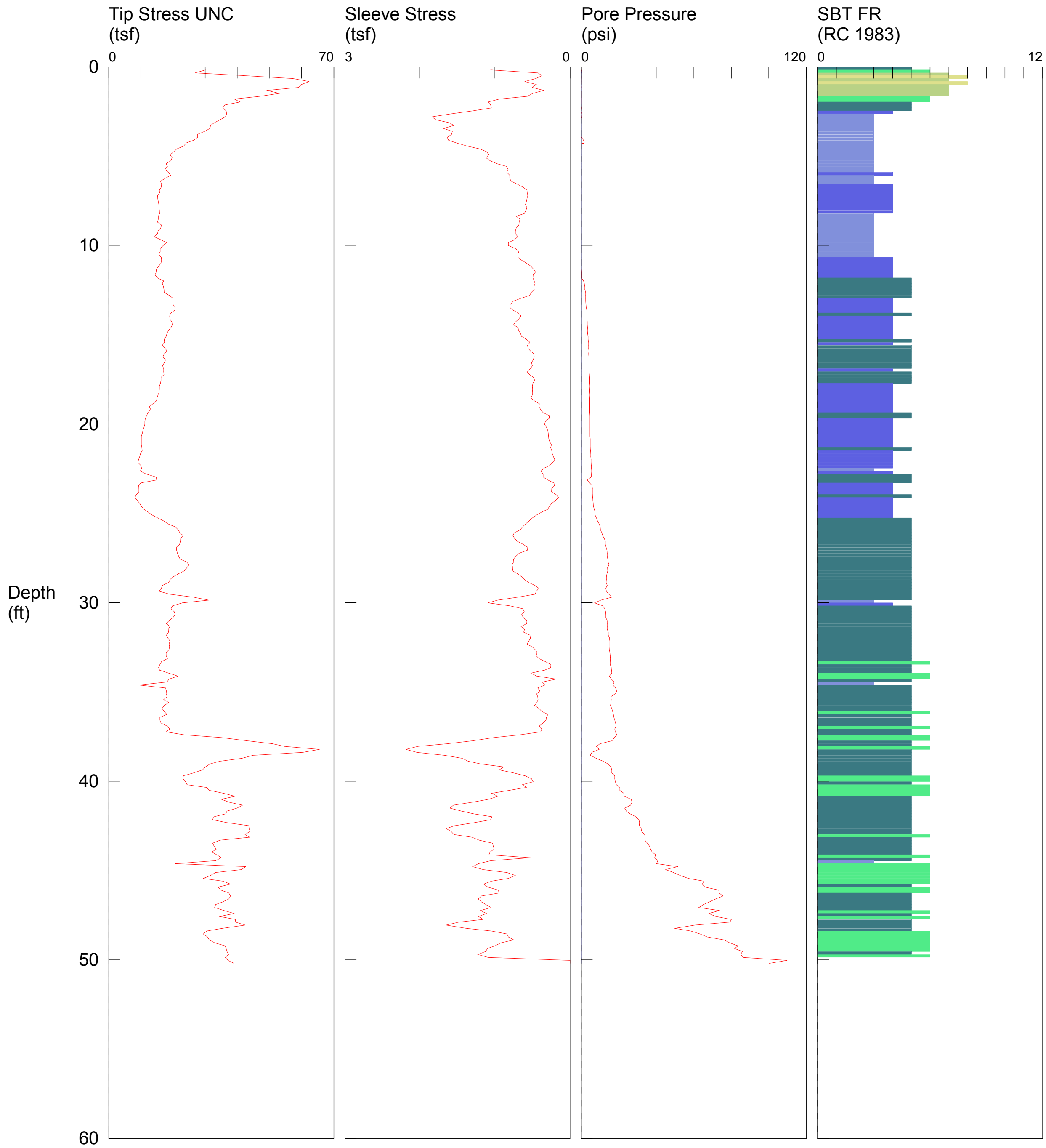

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12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

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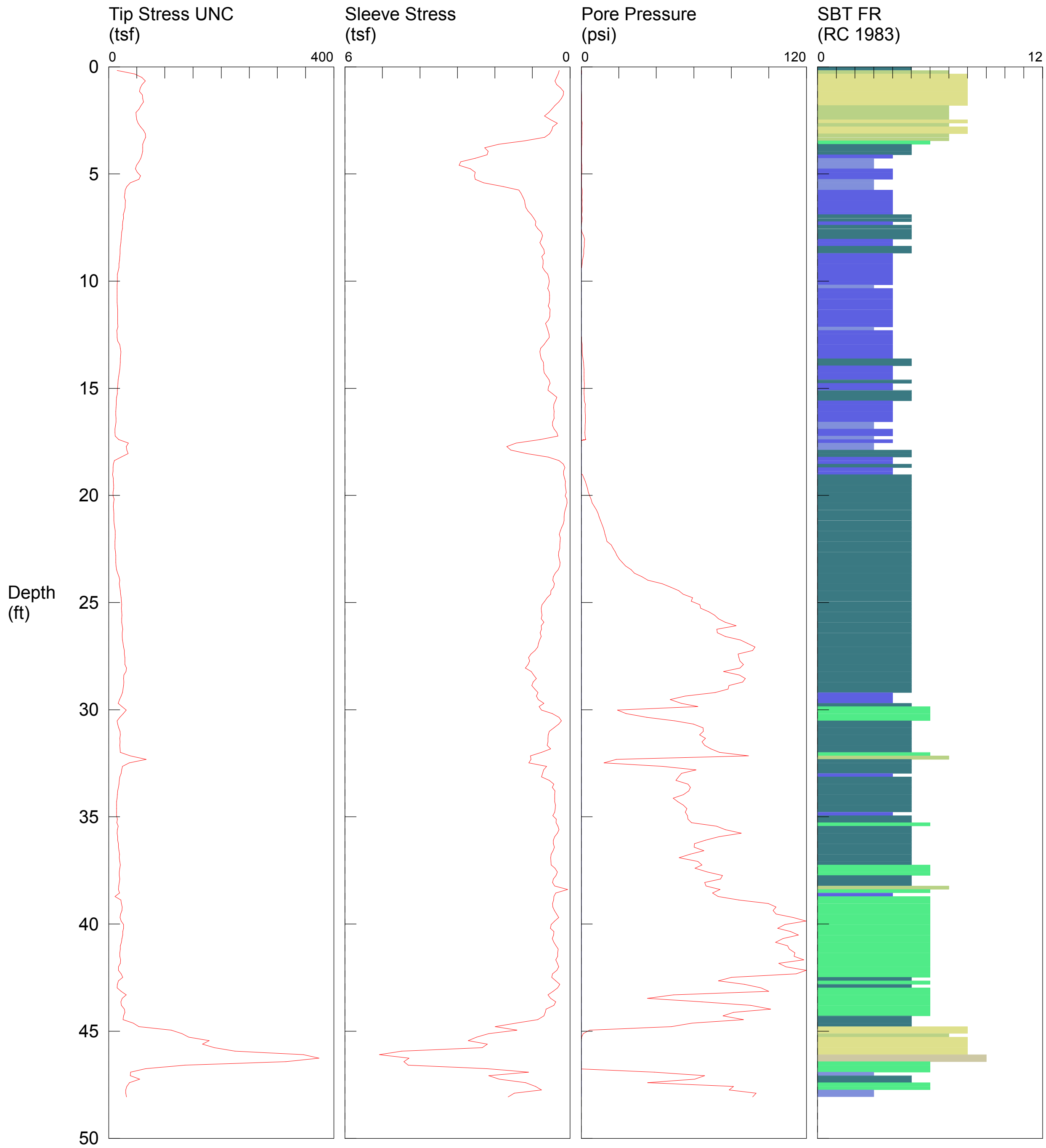

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*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

JOB NUMBER: Engeo Fairfield
HOLE NUMBER: 1-CPT-09
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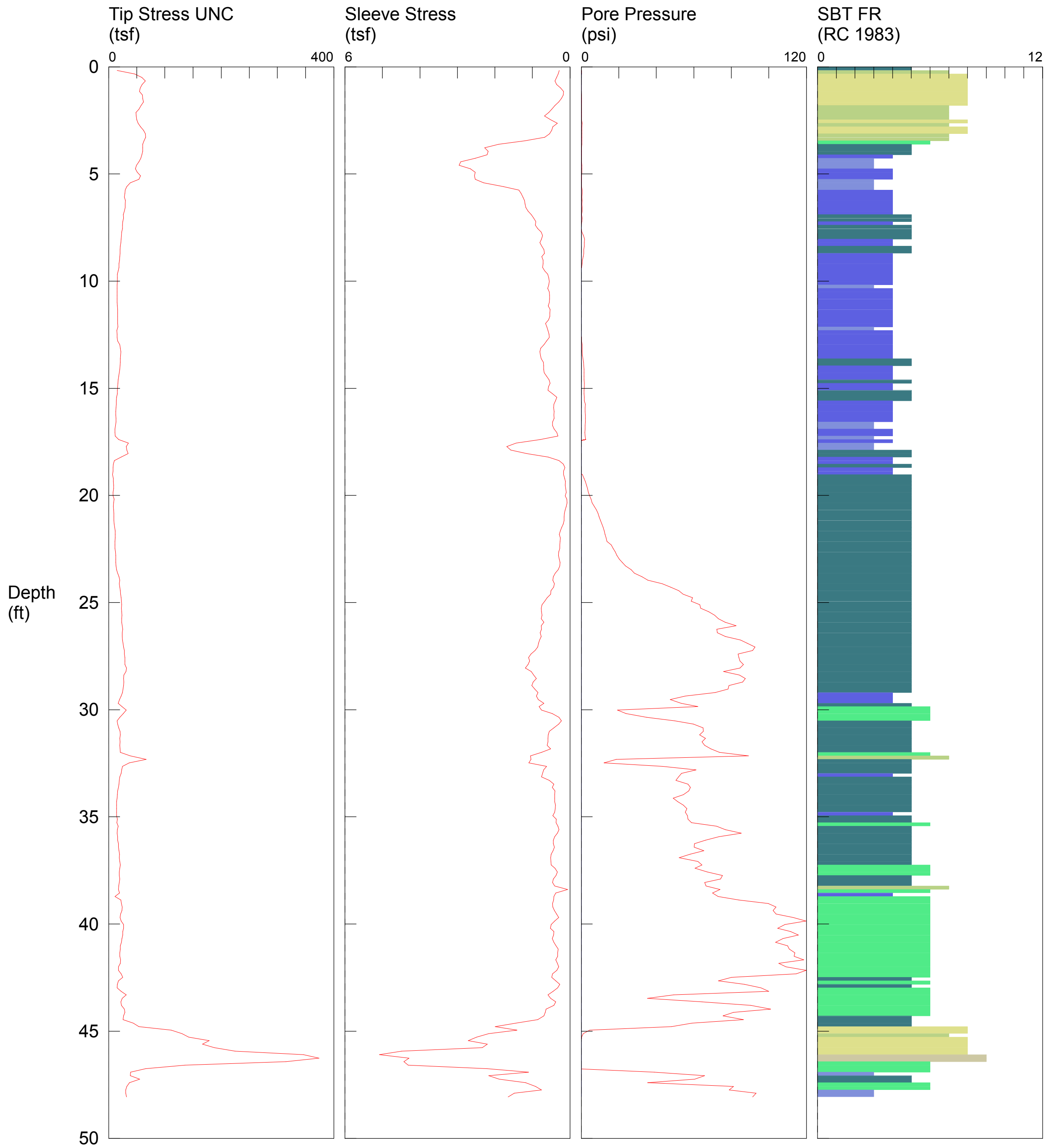

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*SBT/SPT CORRELATION: UBC-1983

Geo-Ex CPT

SOUNDING
CUSTOMER: Geo-Ex CPT
OPERATOR: Mike
CONE ID: DSG1111
LOCATION: Fairfield

JOB NUMBER: Engeo Fairfield
HOLE NUMBER: 1-CPT-10
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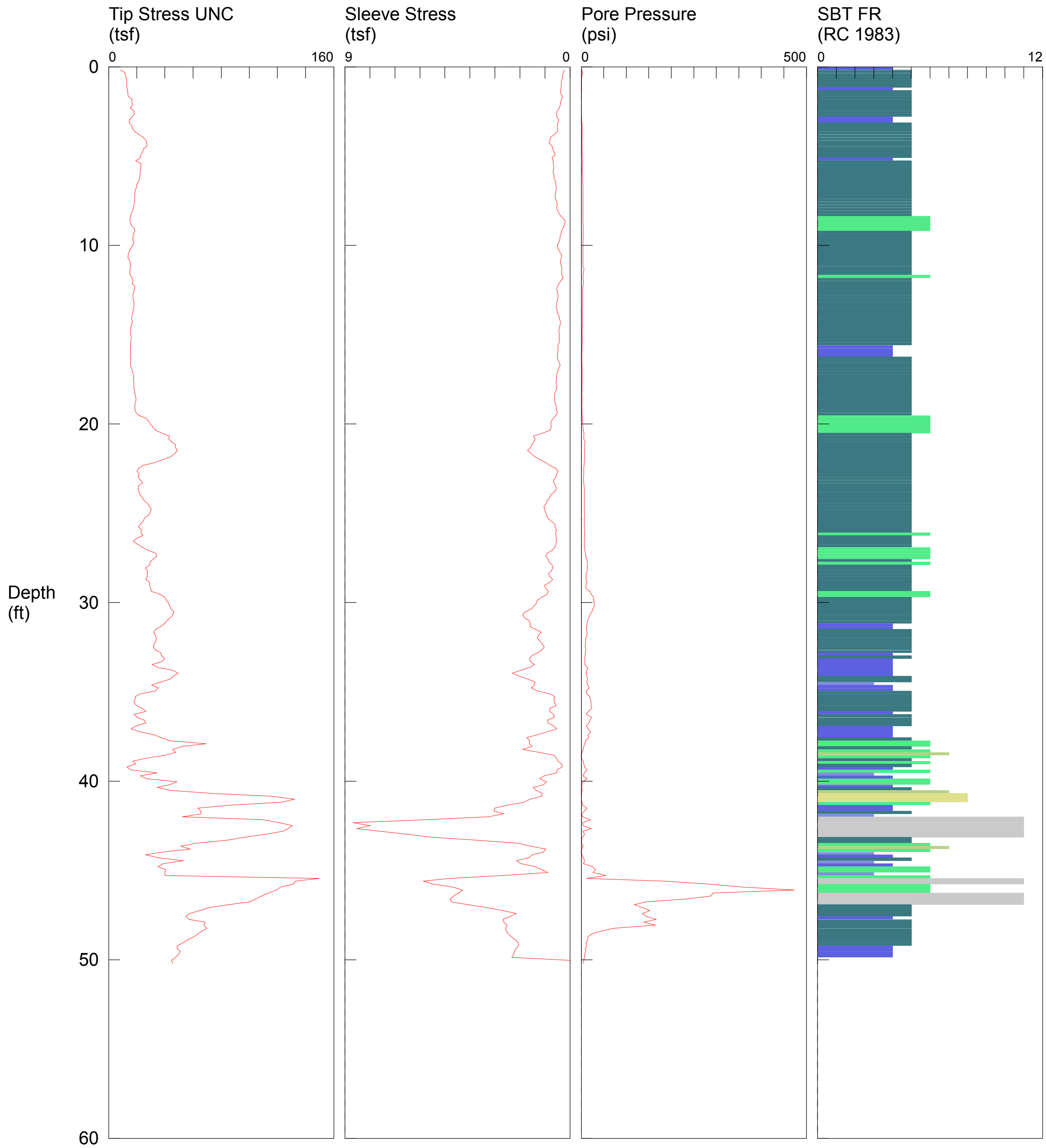

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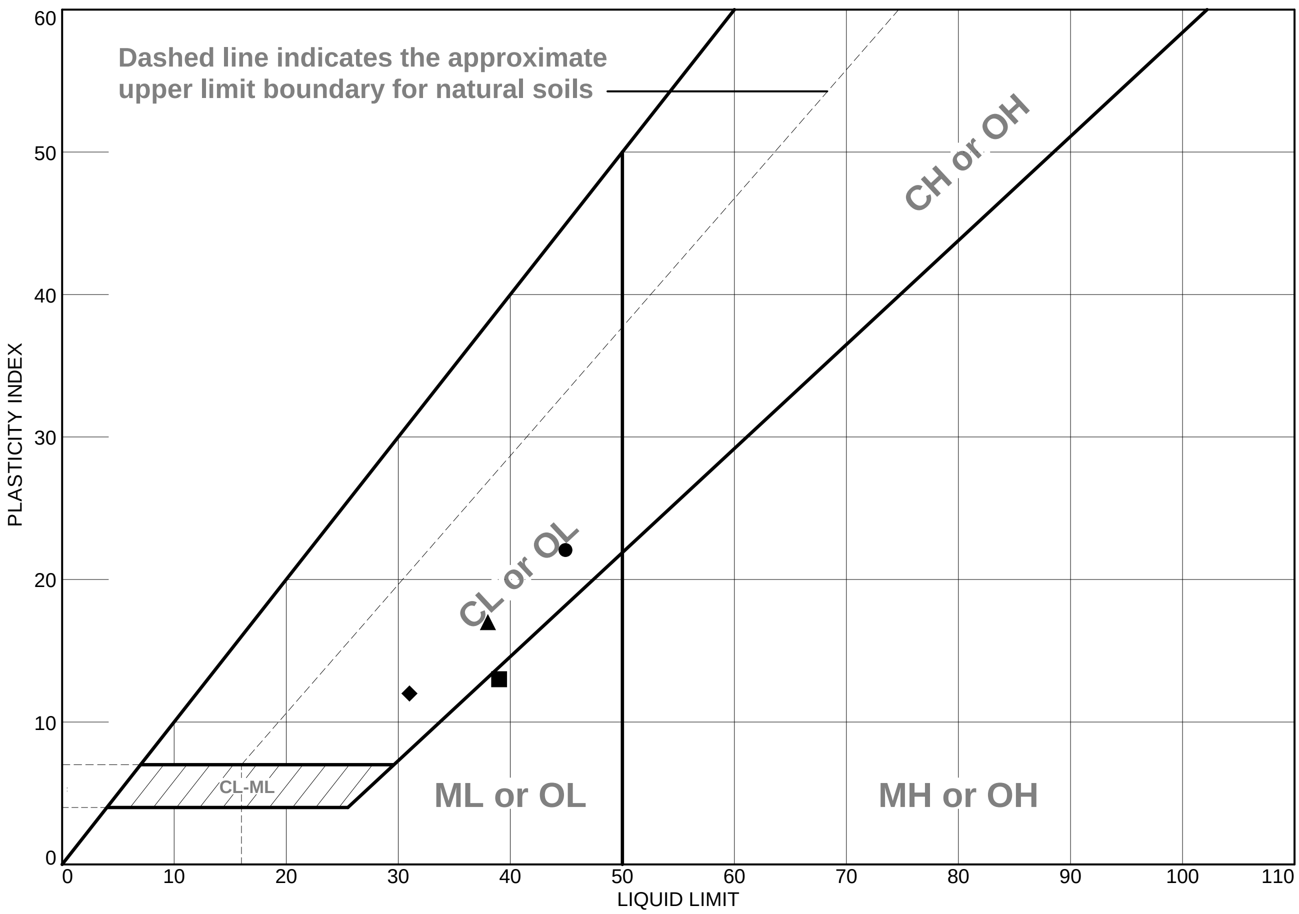
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

APPENDIX B

Laboratory Test Data

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	See exploration logs	45	23	22			
■	See exploration logs	39	26	13			
▲	See exploration logs	38	21	17			
◆	See exploration logs	31	19	12			

Project No. 15480.000.000 **Client:** Joe Cusenza

Project: Middle Green Valley

●**Sample Number:** 1-CPT1
■**Sample Number:** 1-CPT5
▲**Sample Number:** 1-CPT6
◆**Sample Number:** 1-CPT10

Remarks:
●ASTM D4318, Wet method
■ASTM D4318, Wet method
▲ASTM D4318, Wet method
◆ASTM D4318, Wet method

ENGEO INCORPORATED

Tested By: M. Bromfield **Checked By:** M. Quasem

ENGEO
Expect Excellence

MIDDLE GREEN VALLEY
SOLANO COUNTY, CALIFORNIA

SUPPLEMENTAL GEOLOGIC HAZARD STUDY

SUBMITTED TO
Middle Green Valley Landowners
c/o Sarah Lindemann
1744 Mason Road
Fairfield, CA 94534

PREPARED BY
ENGEO Incorporated

August 16, 2019

PROJECT NO.
15480.001.000

ENGEO
Expect Excellence

ENGEO
Expect Excellence

GEOTECHNICAL
ENVIRONMENTAL
WATER RESOURCES
CONSTRUCTION SERVICES

Project No.
15480.001.000

August 16, 2019

Middle Green Valley Landowners
c/o Sarah Lindemann
1744 Mason Road
Fairfield, CA 94534

Subject: Middle Green Valley
Solano County, California

SUPPLEMENTAL GEOLOGIC HAZARD STUDY

Dear Ms. Lindemann:

Thank you for requesting a proposal to perform a supplemental geologic hazard study at Middle Green Valley. This report is focused on the hillside area along the western side of the Middle Green Valley project (Figure 1) and presents the findings of our geologic study, preliminary mapping, and preliminary treatment of geologic hazards for the area cited.

Sincerely,

ENGEO Incorporated

PROFESSIONAL GEOLOGIST
JAMES ALLEN
No. 8335
STATE OF CALIFORNIA

CERTIFIED ENGINEERING GEOLOGIST
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ja/pjs/cjn

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this report is to provide a supplemental geologic hazard study analysis of the hillside portions of the Middle Green Valley (MGV) specific plan area generally located west and north of Hennessey Creek. We previously presented a preliminary geotechnical exploration report for the valley portions of the specific plan area in our report dated March 20, 2019.

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

ENGEO's scope of services included the following:

- Review published LIDAR data of the site.
- Review of published geologic maps.
- Review of selected aerial photographs.
- Site walk to complete additional mapping and confirmation of site conditions.
- Prepare preliminary geologic hazard map

The conclusions and recommendations presented in this report are preliminary in nature. In the event that any changes are made in the character, design or layout of the development, ENGEO should review the conclusions and recommendations contained in this report to determine whether modifications to the report and related recommendations are necessary.

1.2 SITE LOCATION AND PROJECT DESCRIPTION

The hillside portions of the Middle Green Valley specific plan area mapped for this study include approximately 17 properties located west of Green Valley Road as shown on Figures 1 and 4.

The specific plan area is bordered by existing residential development including The Upper Green Valley, Eastridge, and Hidden Meadows projects. The study area is currently used for light agriculture and livestock grazing purposes and is occupied by several unimproved dirt roads, and three small reservoirs with earthen dams.

According to the "Middle Green Valley Specific Plan, Solano County, California", dated August 16, 2017, the area studied for this report contains several proposed building areas (see below).

MAP EXHIBIT 1: Middle Green Valley Specific Plan

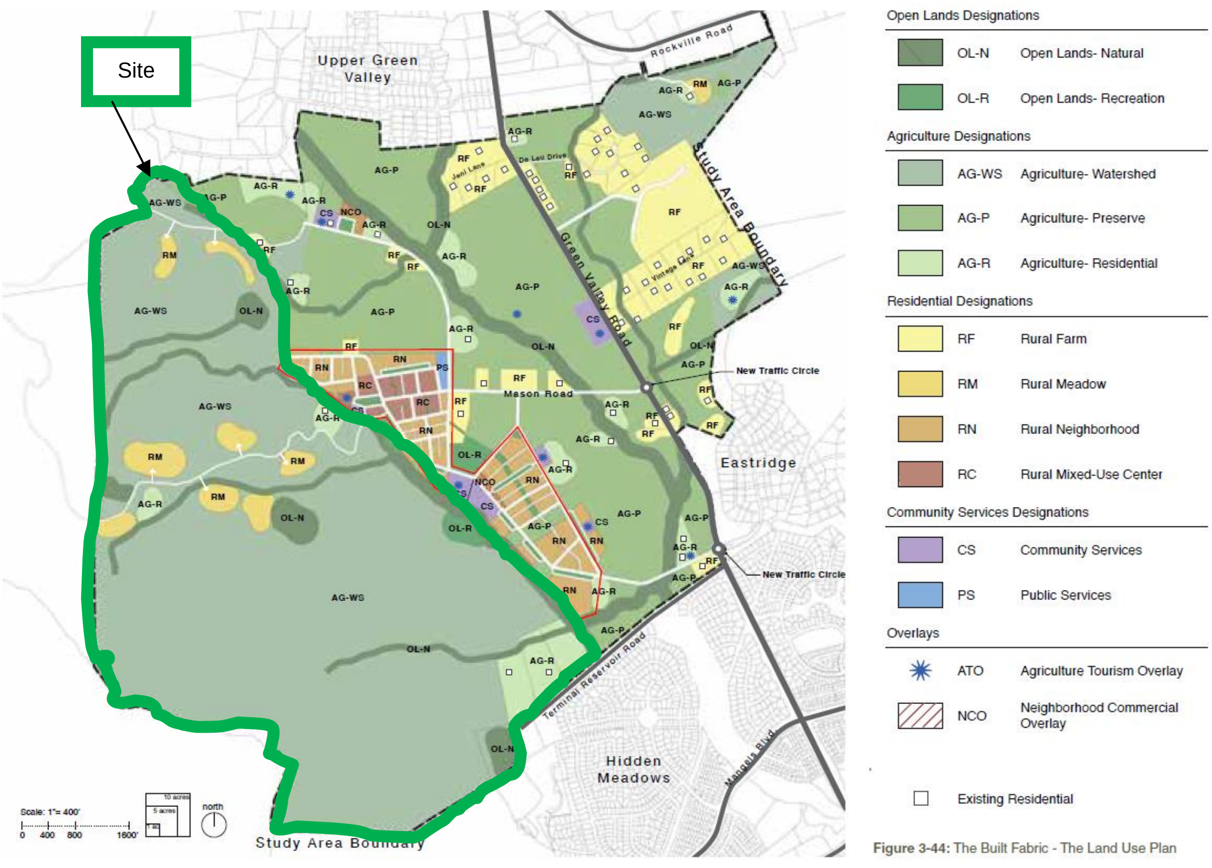

Figure 3-44: The Built Fabric - The Land Use Plan

There are eight proposed residential lot zone designations termed “Rural Meadow”. These eight zones are connected via two proposed roads and six adjoining cul-de-sacs. In addition, the plan depicts three areas/zones with proposed designations of Agriculture-Residential, and four areas/zones as Open Lands-Natural with five associated trails. One area is depicted as Open Lands-Recreation.

1.3 REGIONAL GEOLOGY AND SEISMICITY

1.3.1 Geologic Setting

The Middle Green Valley site is located within the hills of the northern Coast Range Province of California, an area dominated by northwest-trending fault-bounded uplifted ranges and intervening valleys (Page, 1966). Green Valley is a narrow alluvial valley surrounded by steep highlands along the west, north and east. The valley is drained by Green Valley Creek and a small tributary stream that flow to the south into Suisun Bay. According to mapping by Brabb and Graymer, (1999) (Figure 2), the ridgeline west of Green Valley is underlain by Eocene-age marine rocks of the Markley Formation and Sonoma Volcanics. The active Green Valley Fault passes through the eastern side of the valley floor near the hillsides, as shown on Figures 2 - 5. East of the fault, the bedrock consists of late Miocene to Pliocene-age volcanic of the Sonoma Volcanics. As shown in Figures 2-4, the hillside portion of the project is underlain by Sonoma Volcanics and Eocene sedimentary rocks all involved within an extensive deep-seated landslide complex (CGS, 2002; USGS, 1999). A regional liquefaction susceptibility map by Witter, et al., (2006) identifies the alluvial deposits along the lowermost eastern edge of this project as having a moderate liquefaction susceptibility.

1.3.2 Seismicity

The San Francisco Bay Area contains numerous active faults. Figure 6 shows the approximate location of active and potentially active faults and significant historic earthquakes mapped within the San Francisco Bay Region. An active fault is defined by the State as one that has had surface displacement within Holocene time, about the last 11,000 years (Bryant and Hart, 1997). Based on the 2008 USGS National Seismic Hazard Maps, the nearest active fault is the Green Valley fault, which runs through the middle of the site. This fault is considered capable of a moment magnitude earthquake of 6.8. Other active faults located near the site include the Hayward fault, located approximately 18.1 miles west of the site, considered capable of a moment magnitude earthquake of 7.3; and the West Napa fault, located approximately 6.3 miles west of the site.

The major seismic source in close proximity to the hillside portion of the Middle Green Valley specific plan area is the Green Valley Fault. This fault is capable of a magnitude 6 and greater earthquake. Earthquakes of this size, and in close proximity, have been known to trigger dormant/resting massive landslide complexes, such as the one which exists in the project area (Figure 4).

The Concord-Green Valley fault zone extends for roughly 40 miles from Walnut Creek on the south to Wooden Valley on the north, as depicted on Figure 6. Slip from the Concord Fault appears to transfer to the Green Valley Fault via an eastward step under Suisun Bay. Both the Concord and Green Valley faults experience aseismic creep. Seismic creep rates along the Concord-Green Valley faults are believed to be about 4 millimeters per year (McFarland et al., 2007; Galehouse and Lienkaemper, 2003). The long-term slip rate along the Green Valley fault has been estimated by the WGCEP (2007) at 5 ±3 millimeters per year.

1.4 GEOLOGIC MAPPING, SPECIFIC PLAN HILLSIDE AREAS

The geology of the hillside areas extending from the west side of Green Valley to the adjacent ridgeline has been depicted on several published maps (Brabb and Graymer, 1999, Bezore, et. Al., 1998, Dibblee, 2005, and Manson, 1989). All of these maps depict a large deep-seated landslide complex underlying the specific plan area. The maps vary in their depiction of landslide limits and extents, as depicted on Figures 2 through 4, but generally show that most of the 870-acre hillside area of the specific plan is underlain by landslide deposits. Geologic maps prepared by Brabb and Graymer, (1999), Bezore, et. al., (1998), Dibblee, (2005), were focused on depicting bedrock formations and geologic structure, and generally do not provide a detailed assessment of landslide hazards suitable for development planning.

Manson (1989) prepared a map specifically focused on landslide hazards and identification. The mapping by Manson provides a detailed assessment of landslide hazards based on geomorphic features visible on aerial images and identifies boundaries of individual landslide segments, as well as interpretation of the type of landslide. The landslide mapping prepared by Manson is depicted on Figure 4.

We viewed selected aerial images to identify landforms such as hummocky topography, scarps, and toe bulges that are indicative of past landslide activity. Our mapping was focused on the portions of the landslide complex where development is proposed within the Specific Plan area.

We performed a field geologic reconnaissance of the site to verify mapping identified from aerial images. Based on our mapping we identified the following landslide hazard categories:

- Older, deep-seated bedrock landslides covering most of the east facing slopes west of green Valley identified on Figure 5 as Qlso. These landslides display evidence of past, large-scale displacement such as prominent, high headscarps, large scale hummocky topography containing many large displaced bedrock blocks and very large topographic troughs below headscarps that are interpreted to be graben areas formed by detachment of bedrock block from the adjacent ridgelines. Similar deep-seated landslides mantle most of the east facing ridge slope west of the Green Valley Fault from Benicia to the north end of Green Valley (Manson, 1989, Allen et. al, 2009). In the MGV Specific Plan area, the deep-seated landslides appear to be dormant and do not display geomorphic evidence of very recent large-scale movement. They are deeply incised by streams, low-lying areas are filled with colluvium, and the toes of the landslides are covered by younger debris fan deposits. Based on these observations it is likely that the deep-seated landslides are of Pleistocene age. However, the bedrock materials within the Qlso deposits are marginally stable and are mantled with numerous smaller landslides that locally show evidence of more recent activity.

- Earthflows (Qls) typically developed in hollows on the Qlso deposits. These earthflows appear to consist of thick accumulation of soil and rock debris and show geomorphic evidence of more recent activity such as subdued headscarps and toe bulges.

- Recently active earthflows (Qlsa) with well-defined headscarps, hummocky topography and toe bulges. These deposits appear to have experienced activity in the relatively recent past.

- Debris flow fans (Qdf), typically formed at the mouths of incised steams near the toes of deep-seated landslides. Debris flow fans are cone-shaped accumulations of soil and boulders interpreted to have been deposited by debris flows and sediment flows shed from steeper slopes on the adjacent landslide deposits.

1.5 LANDSLIDE HAZARDS

Landslide hazards in the hillside portions of the Specific Plan area can be categorized as follows:

- Dormant deep-seated landslides are unlikely to experience large-scale movements under static (non-seismic) conditions, but may be subject to movement and ground cracking during strong ground shaking caused by earthquakes on the Green valley or other nearby active faults. The magnitude and location of ground deformation and cracking cannot be easily predicted, but experience from past earthquakes such at the 1989 Loma Prieta Earthquake has shown that several feet of movement and potentially damaging ground cracking could be possible.

- Earthflow deposits within the larger deep-seated landslides could be subject to re-activation during seasonal rainfall as well as during seismic ground shaking. Earthflows mapped as Qlsa deposits show evidence of relatively recent activity, and are therefore more likely to re-activate in the near future. Re-activation of earthflow deposits can also be triggered by grading excavations. Earthflows can damage improvements by causing ground deformation and deposition of mud and debris.

- Debris flow fans are areas that have formed by periodic deposition of sediment from existing drainages, likely by both highly concentrated stream flows and by debris flows originating on steep slopes within the hillside areas. Debris flows are a type of fluid, fast-moving landslide that typically develops on steep slopes during heavy, saturating rain events. They can travel large distances from source and can be a significant life and safety hazard. Development on debris fan areas could be subject to damage from both fast-moving debris flows and from mud and debris transported down incised drainages during heavy storm events.

2.0 CONCLUSION AND RECOMMENDATIONS

The hillside portions of the MGV Specific Plan are underlain by an extensive deep-seated landslide complex that currently appears to be dormant, but could experience ground deformation and cracking during a seismic event. Other smaller landslides and debris flows could be re-activated by seasonal rainfall or by grading activity. Development of the proposed neighborhoods would need to consider these geologic hazards. It is likely that hazards from earthflows and debris flows could be successfully mitigated by avoidance of hazards combined with geotechnical earthwork repairs and debris flow catchments or deflection systems. However, any development within the hillside area would unavoidably be subject to seismic deformation and distributed ground cracking that cannot be well defined at this time. Seismic ground deformation hazards are especially likely to be damaging to infrastructure such as roads, utilities and water supply systems such as pipelines and water tanks.

Successful development on the dormant landslide terrain will require careful geotechnical characterization efforts to identify and avoid areas of likely past ground cracking in residential areas. Individual structures would need to be located to avoid ground cracking hazards or be designed to accommodate ground deformation without collapse. It is unlikely that utility systems and roads that will need to cross large areas of terrain could be designed to completely avoid ground cracking hazards. It would therefore be necessary to accept damage to utilities and expect to make repairs as needed. Residential owners in developments would also need to acknowledge the risk of seismic ground deformation damage and accept such risks.

3.0 LIMITATIONS AND UNIFORMITY OF CONDITIONS

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

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

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SOL-48-156, June 21, 1965, Scale 1:24,000
ABO-52-65, August 20, 1937, Scale 1:24,000
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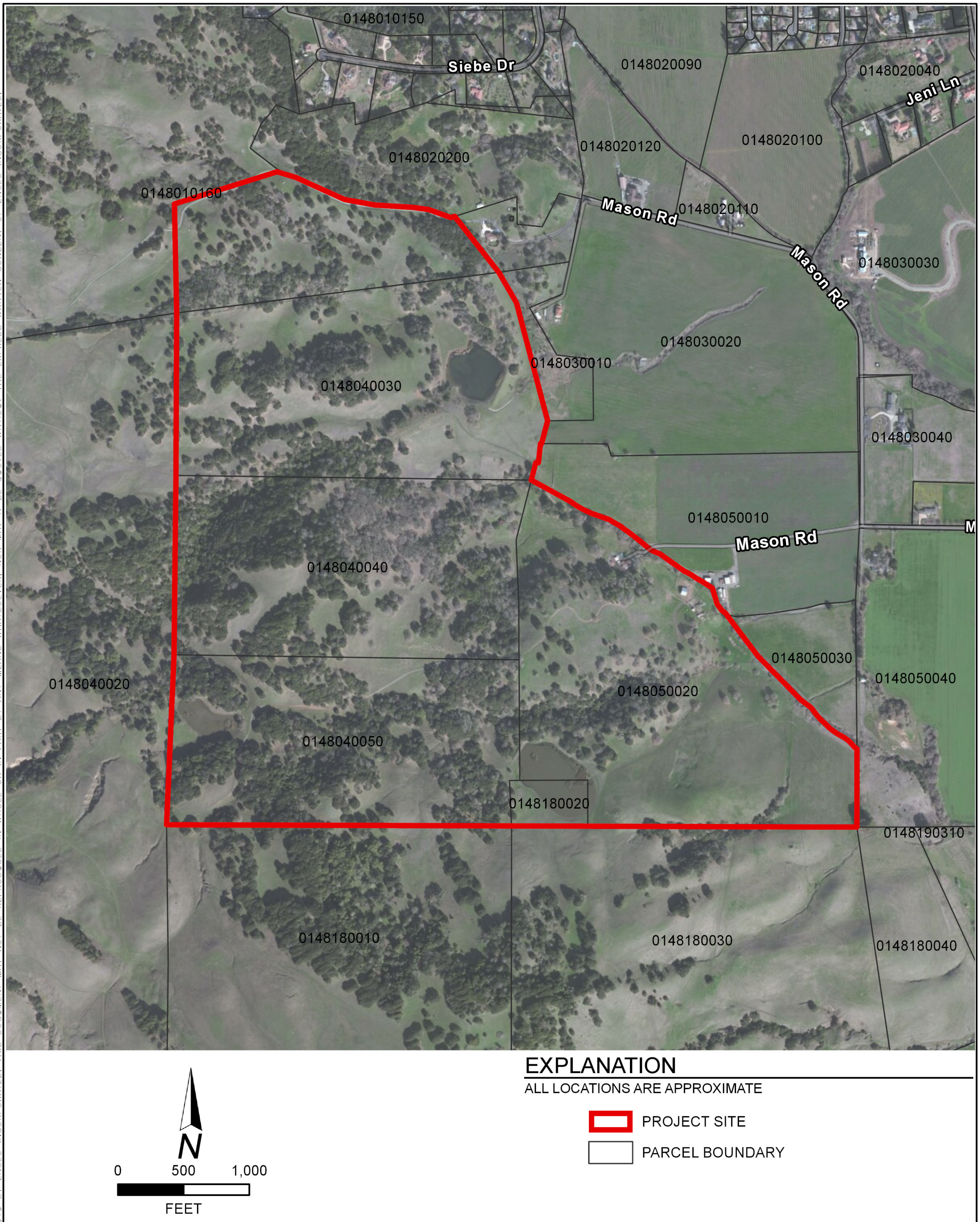
FIGURES



EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

PROJECT SITE

PARCEL BOUNDARY

BASEMAP SOURCE: ESRI MAPPING SERCIVE

ENGEO Expect Excellence

SITE PLAN SUPPLEMENTAL GEOLOGICAL HAZARDS STUDY MIDDLE GREEN VALLEY FAIRFIELD, CALIFORNIA	PROJECT NO. : 15480.001.000		FIGURE NO. 1
	SCALE: AS SHOWN		
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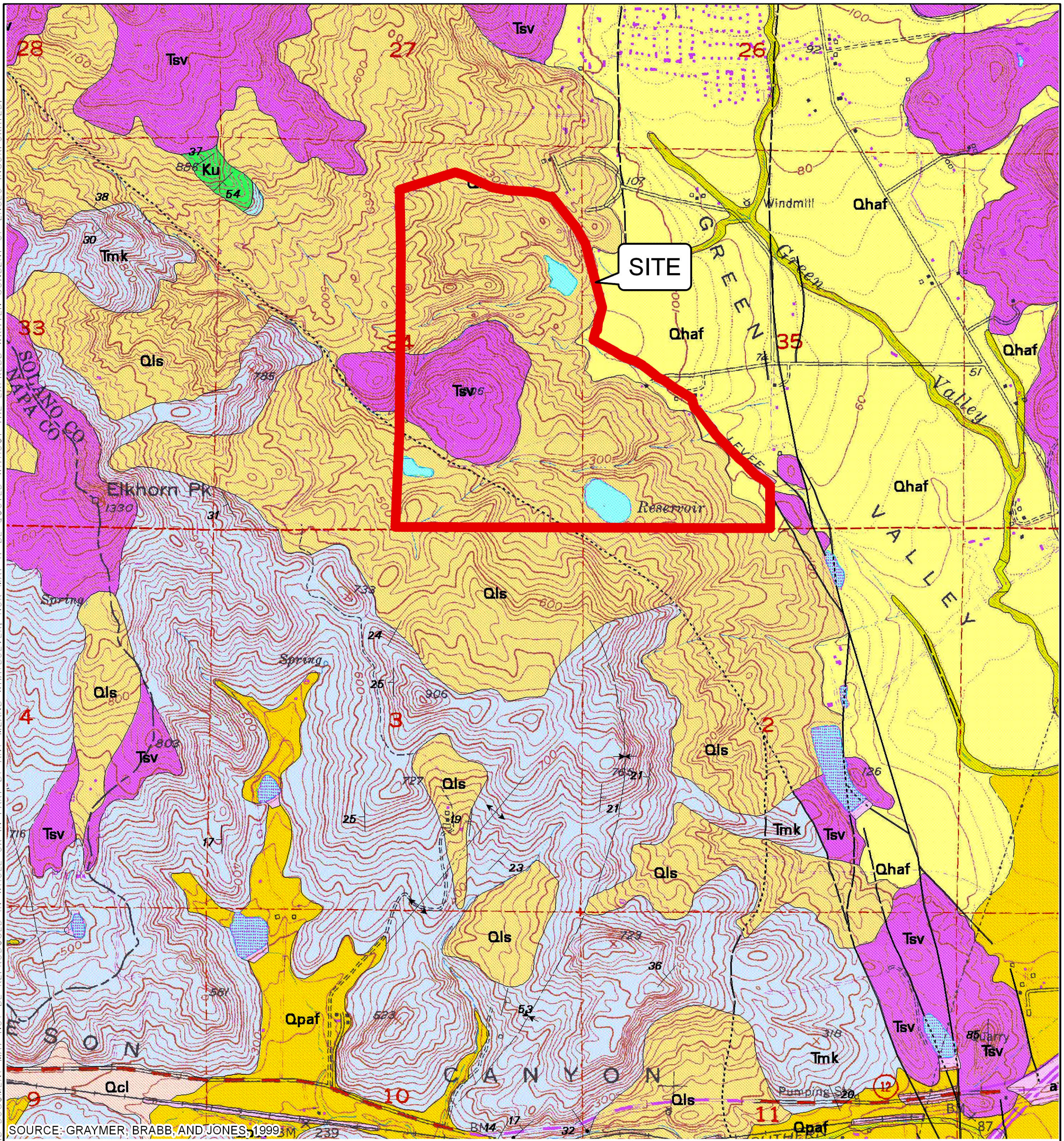

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EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

Qhaf	ALLUVIAL FAN AND FLUVIAL DEPOSITS (HOLOCENE)
Qls	LANDSLIDE DEPOSITS (PLEISTOCENE AND/OR HOLOCENE)
Tmk	MARKLEY FORMATION (EOCENE)
Tsv	SONOMA VOLCANICS, UNDIVIDED (PLIOCENE AND MIOCENE?)

ENGEO Expect Excellence	REGIONAL GEOLOGIC MAP - USGS SUPPLEMENTALGEOLOGICAL HAZARDS STUDY MIDDLE GREEN VALLEY FAIRFIELD, CALIFORNIA	PROJECT NO.: 15480.001.000 SCALE: AS SHOWN DRAWN BY: MAT / CHECKED BY: TTB	FIGURE NO. 2

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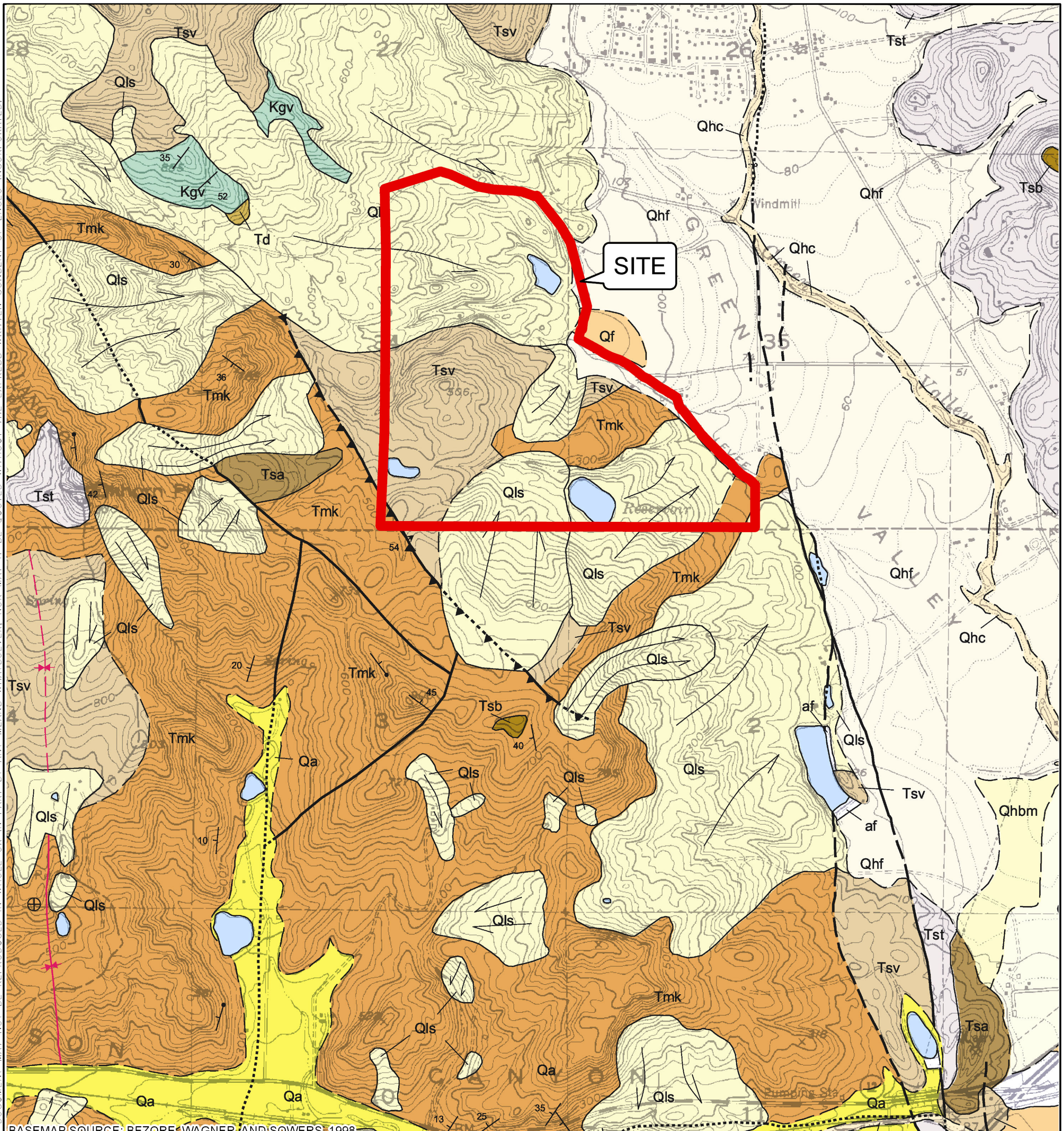

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EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

Qhf	HOLOCENE FAN DEPOSITS
Qf	LATE PLEISTOCENE TO HOLOCENE FAN DEPOSITS
Qls	LANDSLIDE DEPOSITS
Qtl	SONOMA VOLCANICS, UNDIVIDED (PLIOCENE)
Tmk	MARKLEY FORMATION (EOCENE)

ENGEO Expect Excellence

REGIONAL GEOLOGIC MAP - CGS
SUPPLEMENTALGEOLOGICAL HAZARDS STUDY
MIDDLE GREEN VALLEY
FAIRFIELD, CALIFORNIA

PROJECT NO. : 15480.001.000
SCALE: AS SHOWN
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FIGURE NO. 3

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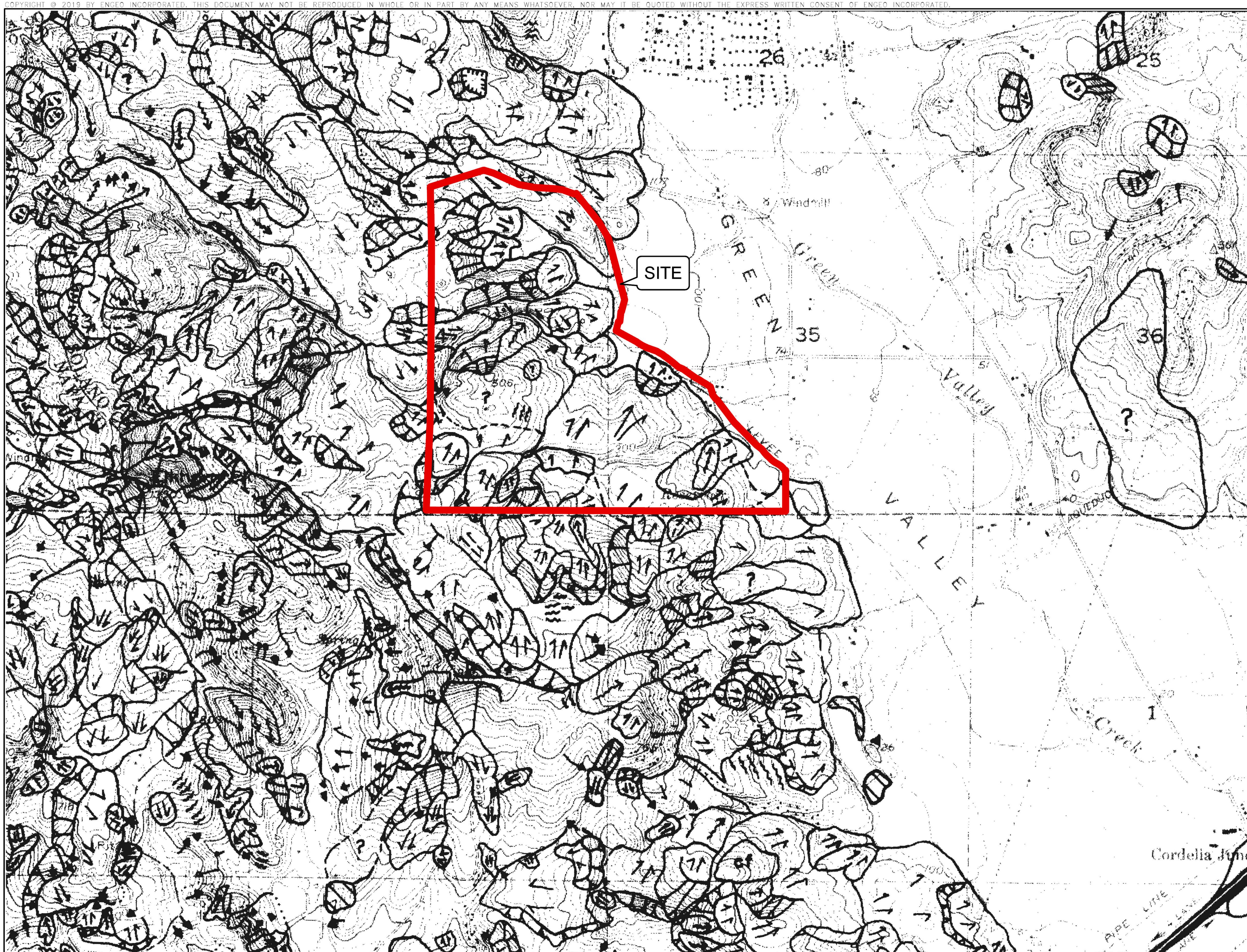

BASEMAP SOURCE: MANSON, 1988

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EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

DEFINITE LANDSLIDE. Exhibits all or nearly all of the diagnostic features, including but not limited to headwall scarps, cracks, rounded toes, well-defined benches, closed depressions, springs, and irregular or hummocky topography, that are common to landslides and indicative of downslope movement. Continuous, single-barbed arrows indicate general direction of movement. Scarp (headwall of slump or block glide) is indicated by hachures where mapped.

PROBABLE LANDSLIDE. Exhibits several diagnostic features that are common to landslides and relatively likely to have resulted from downslope movement, but that are not so clearly defined that the existence of the landslide is certain. Interrupted, single-barbed arrows indicate general direction of movement.

QUESTIONABLE LANDSLIDE. Exhibits one or a few, generally very subdued, diagnostic features that commonly are associated with landslides. Typically lacks distinct landslide morphology but may exhibit disrupted terrain or other abnormal features that strongly to vaguely imply the occurrence of downslope movement. Question mark signifies the uncertainty in the existence of the landslide.

SMALL LANDSLIDE. Filled arrowhead indicates a landslide too small to delineate at the scale of the map. Center of arrowhead corresponds to the location of the landslide; arrowhead points in the direction of movement (downhill). Question mark used where existence of the landslide is uncertain.

MULTIPLE SMALL LANDSLIDES. Two or more landslides too small to delineate at the scale of the map.

EARTHFLOW. A relatively shallow deposit of soil or other colluvial material that has oozed downslope, commonly at a rate too slow to observe except over long duration. Head scarp shown by hachures where mapped. Area immediately upslope of failure typically unravels due to successive small slumps that occur in the oversteepened banks left by movement of the main body away from the source area. Wiggly arrow shows general direction of movement.

EARTHFLOW COMPLEX. A group of earthflows that are too numerous to delineate accurately at this map scale.

SMALL EARTHFLOW. Arrow with solid arrowhead shows earthflow too small to delineate at the scale of the map. Center of shaft corresponds to center of failure.

DEBRIS FLOW. (Also called mudflow, soil slip, or debris avalanche.) A short-lived phenomena resulting from the rapid failure of surficial slope materials. Typically leaves a train of debris in a scoured channel following runout of the flow. Curved line delineates channel. Scarp depicted by oval.

DEBRIS FLOW AMPHITHEATER/SLOPE. Area of multiple debris flows and flow scars.

CREEP. (Not a deposit.) Areas where shallow downslope movement of surficial materials, especially soil, is occuring under the influence of gravity. Creep generally is recognizable only on grassy or bare slopes. Slopes undergoing creep typically do not exhibit morphology indicative of specific types of slope failure such as landslides or earthflows. Creep is characterized by indirect evidence such as tilting trees, poles, and posts, and, locally, by terracettes created by animals grazing along slopes.

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LANDSLIDE HAZARDS
SUPPLEMENTALGEOLOGICAL HAZARDS STUDY
MIDDLE GREEN VALLEY
FAIRFIELD, CALIFORNIA

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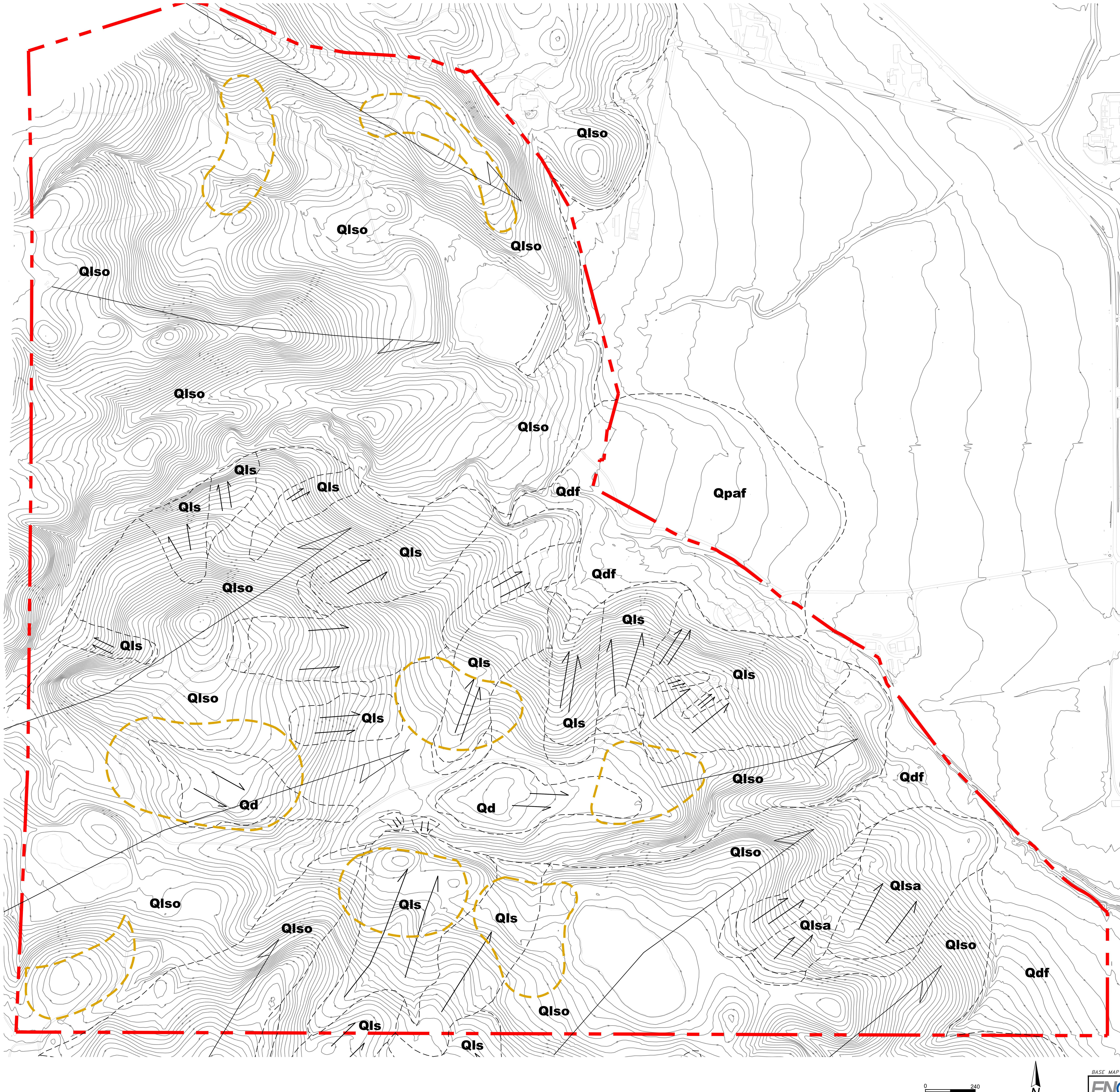

EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

SITE BOUNDARY

RURAL MEADOW RESIDENTIAL DESIGNATIONS (MIDDLE GREEN VALLEY, 2019)

GEOLOGIC CONTACT

Qlsa — ACTIVE EARTHFLOW SHOWING FLOW DIRECTION AND HEADSCARP

Qls — EARTHFLOW SHOWING FLOW DIRECTION AND HEADSCARP

Qlso — DEEP-SEATED BEDROCK LANDSLIDE (DORMANT)

Qpaf — PLEISTOCENE ALLUVIAL FAN DEPOSITS

Qdf — DEBRIS FAN DEPOSIT

Qd — QUATERNARY COBBLE DEBRIS FLOWS

BASE MAP SOURCE: UNKNOWN

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GEOLOGIC SITE PLAN
GREEN VALLEY
FAIRFILED, CALIFORNIA

PROJECT NO.: 15480.001.000	FIGURE NO. 5
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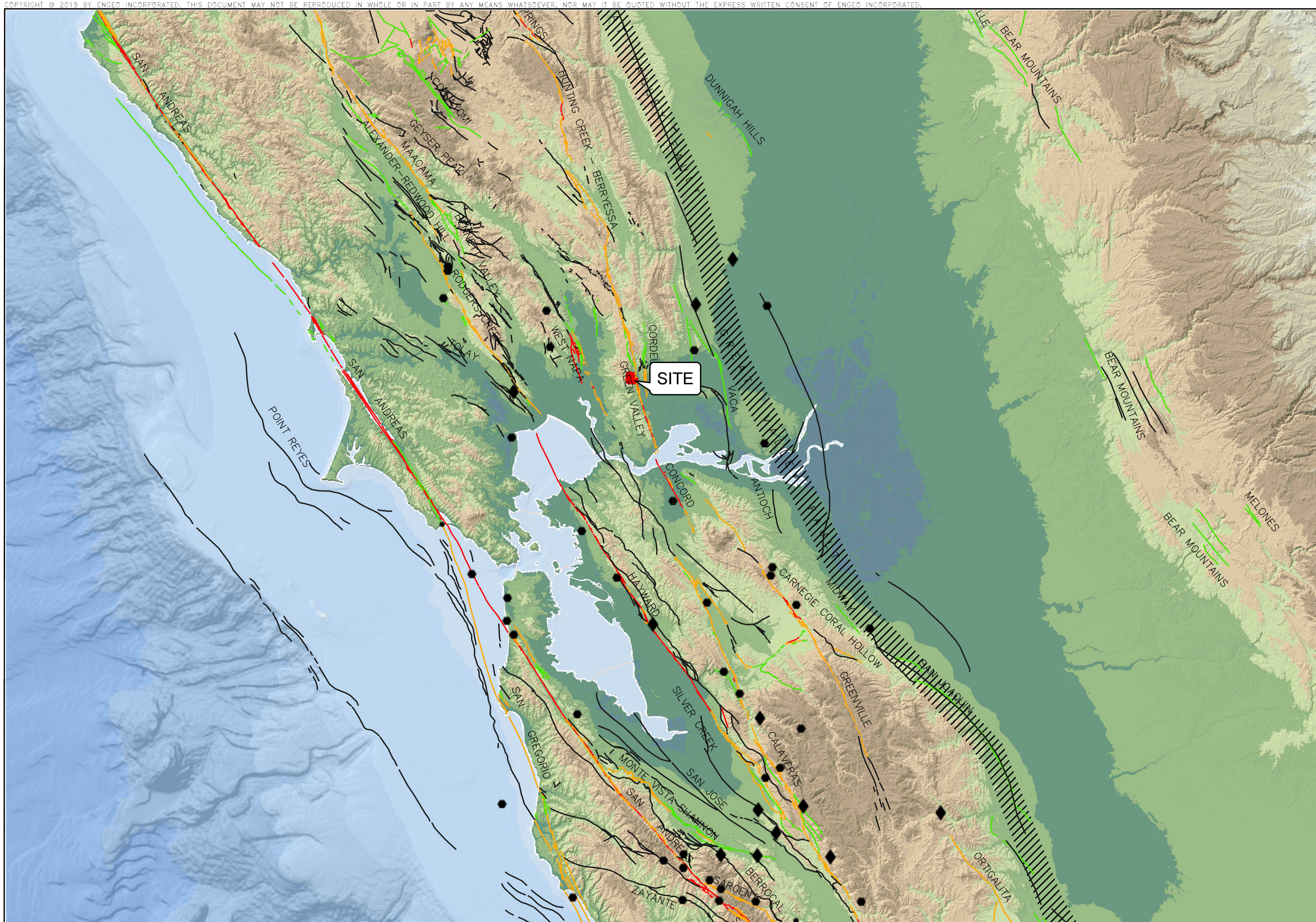

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Miles

EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

EARTHQUAKE

- MAGNITUDE 7+
- MAGNITUDE 6-7
- MAGNITUDE 5-6

USGS QUATERNARY FAULTS

- HISTORICAL
- LATEST QUATERNARY
- LATE QUATERNARY
- UNDIFFERENTIATED QUATERNARY

- HISTORIC BLIND THRUST FAULT ZONE

BASE MAP SOURCE

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

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REGIONAL FAULTING AND SEISMICITY
SUPPLEMENTALGEOLOGICAL HAZARDS STUDY
MIDDLE GREEN VALLEY
FAIRFIELD, CALIFORNIA

PROJECT NO.: 15480.001.000		FIGURE NO. 6
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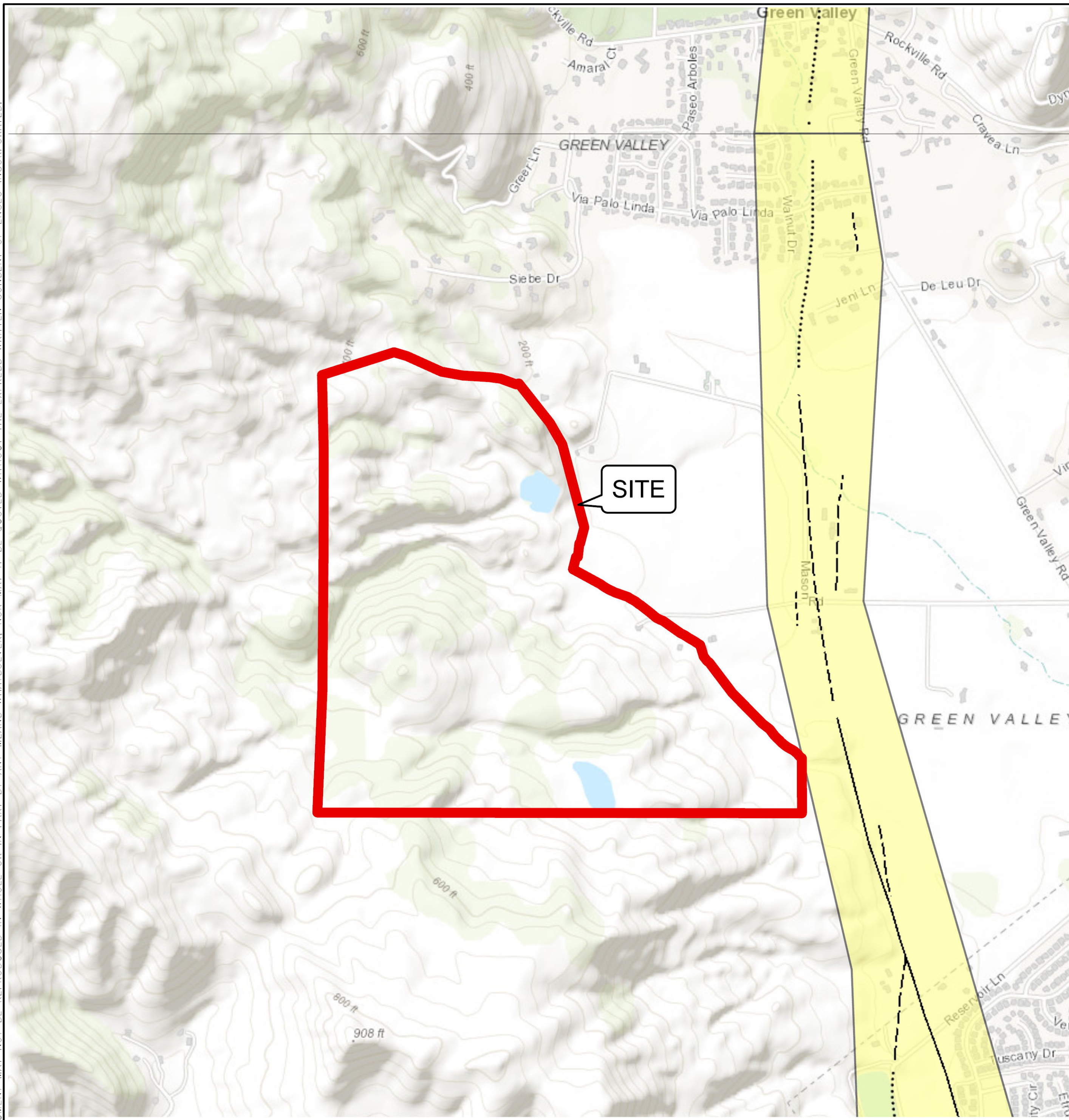

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EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

Fault Traces

- Accurately Located
- Approximately Located
- Inferred
- Concealed

Earthquake Fault Zone
Zone boundaries are delineated by straight-line segments; the boundaries define the zone encompassing active faults that constitute a potential hazard to structures from surface faultingor fault creep such that avoidance as described in Public Resources Code Section 2621.5(a) would be required.

BASEMAP SOURCE: ESRI MAPPING SERVICE
CALIFORNIA DEPARTMENT OF CONSERVATION, CALIFORNIA GEOLOGICAL SURVEY

ENGEO Expect Excellence	SEISMIC HAZARDS ZONE MAP SUPPLEMENTALGEOLOGICAL HAZARDS STUDY MIDDLE GREEN VALLEY FAIRFIELD, CALIFORNIA	PROJECT NO.: 15480.001.000 SCALE: AS SHOWN DRAWN BY: MAT CHECKED BY: TTB	FIGURE NO. 7

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