Project No.
15480.001.000

May 8, 2020

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

Subject: Middle Green Valley
Solano County, California

GEOLOGICAL PEER REVIEW

Dear Ms. Lindemann:

This letter summarizes our peer review of the Fault Rupture Hazard Evaluation by Quantum Geotechnical Inc. (QG) for the proposed Elkhorn and Nightingale Neighborhoods within the Middle Green Valley Specific Plan in Fairfield, California. Our scope included review of the following documents:

1. Quantum Geotechnical, Inc., Proposed Rural Community Development, Nightingale and Elkhorn Neighborhoods, West and South of Mason Road, Green Valley, California, February 17, 2020.

2. California Division of Mines and Geology, 1993, Revised Official Map of Alquist-Priolo Earthquake Fault Hazard Zones, Cordelia Quadrangle: California Division of Mines and Geology, scale 1:24,000.

3. Lienkaemper, J. J., Baldwin, J. N., Turner, R., Sickler, R. R., and Brown, J., 2013, A Record of Large Earthquakes during the Past Two Millennia on the Southern Green Valley Fault, California. Bulletin of the Seismological Society of America, Vol. 103, No. 4, pp. 2386-2403, August 2013, doi: 10.1785/0120120198.

We also made site visits during the trench explorations between September 24, 2019 and October 10, 2019 to consult with QG and view trench exposures. Based on our observations, we generally concurred with QG interpretations of trench exposures.

BACKGROUND

Portions of the proposed Elkhorn and Nightingale Neighborhoods are located within the Alquist-Priolo Earthquake Fault Zone established around active traces of the Green Valley Fault Zone (GVFZ) (Bryant, 1982; CDMG, 1993). The GVFZ consists of a relatively continuous main strand running through the project from southeast to northwest, and two shorter subparallel strands in the middle portion of the site. The portions of the neighborhoods located in the Alquist-Priolo (AP) Earthquake Fault Zone are generally in lower-lying areas east and west of the main fault strand.

A group of geoscientists working with the United States Geological Survey, previously performed a paleoseismic investigation of the main trace of the Green Valley fault south of Mason Road, between the Nightingale and Elkhorn Neighborhoods. The study included a series of trenches and seismic refraction lines during a multi-year period from 2006 to 2009 (Kimball and others, 2008; and Lienkaemper and others, 2012). The focus of their investigation was to evaluate slip rate and recurrence intervals on the main fault trace. The study found the fault trace generally a few hundred feet east of the mapped location. However, it was not the intent of Leinkaemper, et al. (2013), to locate all recently active fault traces associated with the main trace. Therefore, in accordance with Public Resources Code Section 2621.5(a), a focused fault rupture hazard evaluation is required to construct habitable structures within the Fault Zone.

QG INVESTIGATION AND FINDINGS

The QG fault investigation included review of available geologic and fault maps, documents, and reports, field reconnaissance by the Project Geologist, excavation and geologic logging of six exploratory fault trenches, consultation with ENGEO geologists in the field, and analysis of the data to formulate conclusions and recommendations. Their findings and graphic logs of the trench excavations are presented in Reference 1.

QG excavated and logged four trenches on the Nightingale parcel, identified on their Plate 1 as TN-1, TN-1b, TN-2, and TN-3, and two trenches on the Elkhorn parcel, identified as TE-1 and TE-2. All of the trench locations were surveyed for accuracy.

The trenches generally encountered an upper sequence of stratified sandy to gravelly soil interpreted to be fluvial (alluvial fan and debris flow sediments) overlying fine-grained dark gay fat silty clay. Based on soil development and previous radiocarbon dating, QG interpreted the soil exposed in the trenches to be of Holocene age.

QG logged a single concentrated shear zone up to approximately 15 feet wide in three trenches on the Nightingale parcel labeled TN-1, TN-2, and TN-3. The shear zone alignment was consistent with the strike of the GVF in this area, but located to the east of the mapped fault trace in the central portion of the Nightingale parcel, consistent with the findings of Lienkaemper, (2012). Evidence of surface fault rupture was not found in trenches TE-1 and TE-2 situated across the trend of the western trace identified on the AP map by the CGS on the Elkhorn parcel.

Based on the results of trenching, QG concluded that the Green Valley Fault Zone exists as a single zone of deformation approximately 15 feet wide passing through the west portion of the Nightingale parcel and continuing to the north to pass several hundred feet to the east of the Elkhorn parcel. QG recommends a building exclusion zone measuring approximately 115-foot wide (the zone of mapped deformation plus 50 feet on either side of the deformation zone) around the main fault trace as depicted on their Plate 1.

CONCLUSIONS

We conclude that the QG findings and recommendations are reasonably supported by the conditions revealed in the trench exposures. In our opinion, the level of exploration completed by QG was appropriate to explore fault rupture hazards at the site.

If you have any questions regarding the contents of this letter, please do not hesitate to contact us.

Sincerely,

ENGEO Incorporated

CERTIFIED ENGINEERING GEOLOGIST
PHILIP STUECHELI
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Todd Bradford, PE

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tb/pjs/cjn

Attachment A

FAULT-RUPTURE HAZARD EVALUATION
GREEN VALLEY FAULT ZONE

Of

PROPOSED RURAL COMMUNITY DEVELOPMENT
NIGHTINGALE AND ELKHORN NEIGHBORHOODS

At

Mason Road
Green Valley, California

For
Middle Green Valley Ownership

By
Quantum Geotechnical, Inc.

Project No. F050.G
February 17, 2020

QUANTUM GEOTECHNICAL INC.

Project No. F050.G
February 17, 2020

Ms. Sarah Lindemann
Middle Green Valley Ownership
1744 Mason Road
Fairfield, CA 94534

Subject: Proposed Rural Community Development
Nightingale and Elkhorn Residential Neighborhoods
West and South of Mason Road
Green Valley, California
FAULT-RUPTURE HAZARD EVALUTION
GREEN VALLEY FAULT ZONE

Dear Ms. Lindemann,

In accordance with your authorization, ***Quantum Geotechnical, Inc.,*** has investigated the potential for fault-rupture hazard from the Green Valley Fault Zone to impact the subject site located in Green Valley, California.

The accompanying report presents our review of published and unpublished geologic data and the results of our field investigation. Our findings indicate that development of the sites for the proposed residential neighborhoods is feasible from a geologic and geotechnical standpoint provided the fault setback recommendations of this report are carefully followed and are incorporated into the project plans and specifications.

Should you have any questions relating to the contents of this report or should additional information be required, please contact our office at your convenience.

Sincerely,
Quantum Geotechnical, Inc.

Simon Makdessi, P.E., G.E.
President

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TABLE OF CONTENTS

FAULT-RUPTURE HAZARD EVALUATION
GREEN VALLEY FAULT ZONE

INTRODUCTION

The site is located on privately owned farmland near the west end of Mason Road in the Middle Green Valley area north of Cordelia, California, as shown on Figure 1, "Site Vicinity Map". These lands are proposed to be developed as new rural communities, hosting residences, small retail venues, and access streets. The focus of the work presented herein was to accurately locate the surface trace or traces of the seismically active Green Valley Fault Zone (GVFZ) that have been mapped as passing through the site area as shown on Figure 2, "Site Hazard Map" (California Geological Survey, 1993), and to establish appropriate setbacks from the surface traces for proposed residential structures. Other potential geologic and geotechnical hazards, such as land sliding, liquefaction, lateral spreading, expansive soils, and the extent of old artificial fill areas are beyond the scope of this investigation. These potential hazards and possible future development constraints should be addressed in future design level geological and geotechnical investigations.

We understand that three adjacent new neighborhoods are proposed for this area of Middle Green Valley as shown on Figure 3, "Site Plan". Portions of two of the three proposed new neighborhoods are within a State of California Earthquake Fault Zone for the Green Valley Fault. The affected neighborhoods are known as the Nightingale and Elkhorn Neighborhoods. The proposed Three Creeks Neighborhood is not with the Earthquake Fault Zone and therefore, is not addressed herein.

The GVFZ consists of segments of one to three subparallel mapped fault traces passing through this portion of Middle Green Valley from southeast to northwest. In accordance with the requirements of the Alquist-Priolo Earthquake Fault Zoning Act of 1972, it is necessary to locate the surface trace of active faults and establish setbacks for future construction of habitable structures (Hart and Bryant, 1997). From our discussions with the client's representative, Ms. Charity Wagner, we understand that the goal of this study is to determine building setback zones from active fault traces for proposed habitable structures in furtherance of the goal to redevelop the site as a rural community.

PURPOSE AND SCOPE

The purpose of this geological evaluation for the proposed developments is limited to fault rupture hazards related to the mapped Green Valley Fault surface traces that exist within the bounds of the subject sites, and to establish a building setback zone from the located fault traces that may be used for the proposed development. It is our intent that this report be used exclusively by the client and the client's architect/engineer for the project layout and siting of proposed buildings.

Our evaluation included the following:

a. Field reconnaissance by the Project Geologist;
b. Excavation and geologic logging of six exploratory fault trenches;
c. Collaboration with the project third party geology peer reviewer;
d. Review of available geologic and fault maps, documents, and reports;
e. Review and analysis of historical stereoscopic aerial photographs;
f. Analysis of the data to formulate conclusions and recommendations; and
g. Preparation of this written report with supporting graphics logs of the fault trenches.

PROPOSED DEVELOPMENT

It is our understanding that the Middle Green Valley Ownership is considering developing three disconnected parcels of land totaling approximately 125 acres to construct a rural community. The focus of our fault investigation is the lands west and south of Mason Road, identified on the site development layout as the Nightingale and Elkhorn Neighborhoods. A third neighborhood located farther north from the other two, known as Three Creeks, was determined to be outside of the Earthquake Fault Zone for the Green Valley Fault, and was not included in our study as shown on Figure 3, "Site Plan".

Specific development details are currently not available. A future design level geotechnical study will be necessary to provide foundation and site development recommendations for future construction. These future studies will require additional subsurface exploration, particularly of slope stability on the western end of the Elkhorn site, and laboratory testing of representative soil materials.

SITE SETTING

The project site is located within Green Valley, a broad linear valley flanked by mountain ranges in western Solano County. Access to the site is from Green Valley Road that runs along the east side of the valley. Mason Road connects to Green Valley Road and crosses the valley from east to west. The project site consists of two nearby parcels on relatively level farmland near the west side of Green Valley. There are several isolated farmhouse complexes scattered throughout this portion of Green Valley. Major housing tracts exist to the south in the lower portions of Green Valley.

Surface conditions on the site consist of tilled surface soils from past agricultural use, waist high seasonal grasses, and trees dispersed along Mason Road and along drainages. At the time of our field investigation, the only structures on-site consisted of a series of portable chicken coops, located on the Nightingale parcel. The parcels are surrounded by wire fencing. The site and vicinity are displayed in an aerial image on Figure 3, "Site Plan".

GEOLOGIC SETTING

Regional Geology

The project site is located within the San Francisco Bay portion of the Coast Ranges Geomorphic Province of California, a region characterized by northwest-southeast trending mountain ranges and valleys. Throughout the Cenozoic Era, the western part of California has been affected by tectonic forces associated with lateral or transform plate motion between the North American and Pacific tectonic crustal plates, which has produced a complex system of northwest-trending faults. The San Andreas, Hayward – Rodgers Creek, Calaveras, Concord – Green Valley, Greenville – Marsh Creek Fault systems being the most prominent of these faults (Jennings and Bryant, 2010; and Page, 1998). Earthquakes, uplift of mountain ranges, erosion, and subsequent re-deposition of sedimentary rocks within this province have been driven primarily by the northwest-southeast directed, strike-slip movement of the tectonic plates and associated northeast-southwest oriented compressional stress. The northwest-trending coastal mountain ranges are the result of an orogeny believed to have been occurring since the Pleistocene epoch (approximately 2-3 million years before present).

Local Geology

The project site and the middle to lower portions of Green Valley are within the Cordelia 7.5-Minute Quadrangle. The marshlands of the Suisun Bay are shown to the south of Green Valley. The northwest-trending Howell Mountain Range runs from the Sulphur Spring area, near Vallejo, north through the center of the quadrangle. The Green Valley is a broad, relatively flat sedimentary basin surrounded by peaks of the Howell Range to the west, north, and east. The south-flowing Green Valley Creek drains the valley and outlets into Suisun Bay. Published geologic maps indicate that the surrounding mountains are composed of both volcanic and sedimentary rocks. The slopes at least along the west side of Green Valley adjacent to the project site are mapped as being involved in extensive mass movement deposits and landslides as shown on Figure 4, "Regional Geologic Map" (Dibblee, 2006; Frizzell and others, 1974; Graymer and others, 2002; and Weaver, 1949).

The mountain ranges surrounding Green Valley are generally composed of Pliocene age volcanic deposits and older Eocene age sedimentary rocks belonging to the Markley Formation. The younger rocks represent a variety of volcanic environments and consist of ash-flow tuff, andesite flow breccia, and basalt locally termed the Sonoma Volcanics. The Markley Formation consists of predominately massive, well-bedded marine sandstone and a thinly laminated shale known as the Jameson Canyon member (Bezore and others, 1998; Dibblee, 2006; Ellen and Wentworth, 1995; Graymer and others, 2002; Sims and others, 1973; and Weaver, 1949).

The flatlands of the Green Valley, inclusive of the project site, consist of surficial Late Quaternary alluvial fan and fluvial sediments mobilized from the surrounding mountain ranges and reworked and deposited in the Holocene time by Green Valley Creek and associated tributaries. These deposits generally consist of unconsolidated clay, silt, and sand with varying amount of gravel. In the south portion of Green Valley, the alluvial deposits may interfinger with estuarine Young Bay Mud deposits (Graymer and others, 2002; and Helley and Lajoie, 1979). These surficial deposits were encountered during our field investigation within the project site.

REGIONAL FAULTING AND SEISMICITY

Regional Faults

The San Francisco Bay Region is dominated by the northwest-southeast trending San Andreas Fault and related major faults, such as the Calaveras, Concord – Green Valley, Greenville – Marsh Creek, Hayward – Rodgers Creek, and Seal Cove – San Gregorio Faults as shown on Figure 5, "Regional Seismicity Map". In the global context of plate tectonics, the San Andreas and related faults work as a major shear zone up to 50 miles wide characterized by a combination of strike-slip and reverse displacements. These fault systems have had surface displacement within Holocene time (about the last 11,000 years) and are thus considered to be seismically active by the State of California (Hart and Bryant, 1997). In addition to the seismically active GVFZ impacting the project site, listed below are other seismically active faults and distances from the project site (California Geological Survey, 1993; FRISKSP, 2004; and Jennings and Bryant, 2010).

Table 1
List of Holocene Active San Francisco Bay Area Faults Near the Site

Earthquake Generating Fault	Fault Length (km/mi)	Distance to Nearest Fault Segment* (km/mi)	Upper Bound Earthquake Mw_{max}	Slip Rate (mm/yr)
Concord – Green Valley	56 / 35	0.0 / 0.0	6.9	6.0
Cordelia	20 / 12	2.1 / 1.3	--	--
West Napa	30 / 19	9.9 / 6.2	6.5	1.0
Rodgers Creek	62 / 39	22.3 / 13.8	7.0	9.0
Hunting Creek – Berryessa	60 / 37	24.2 / 15.0	6.9	6.0
Northern Hayward	35 / 22	29.4 / 18.3	6.9	9.0
Greenville – Marsh Creek	42 / 26	34.3 / 21.3	6.9	2.0
Northern Calaveras	45 / 28	43.1 / 26.8	6.8	6.0
Southern Hayward	53 / 33	55.6 / 34.5	6.9	9.0
San Andreas	190 / 118	57.3 / 35.6	7.9	24.0
Seal Cove – San Gregorio	73 / 46	58.4 / 36.3	7.3	5.0

* Table 1: Fault distances measured from bend in Mason Road between sites at Latitude 38.2360°N and Longitude 122.1629°W.

Green Valley Fault Zone

The GVFZ is generally a narrow zone of vertical and near vertical right-lateral strike-slip faulting that runs along the west side of Suisun Bay and continues northwest along the west side of Green Valley. The GVF is thought to connect with the Concord Fault to the south forming a right-stepping shear system creating a pull-apart basin occupied by Suisun Bay. To the north, the GVF may link to the northwest-striking Hunting Creek Fault near Lake Berryessa, and other northwest-striking faults near Clear Lake and beyond including the Bartlett Springs Fault and the Lake Mountain Fault (Bryant, 1982 and 1991).

Several miles of right-lateral offset has been accommodated along the fault since Pliocene time, and an early estimate of the fault creep rate is on the order of 3 mm per year, based on offset of man-made features across the fault. The criteria for a fault zone to be mapped and included within the AP-zone act regulatory framework are that the fault is sufficiently active within the Holocene, and is well-defined. The GVF was determined Holocene-active (Jennings & Bryant, 2010) and established as a State of California mandated special studies zone based upon displacement of Holocene alluvium, faulted alluvium observed during trench work, and displacement of historic manmade features.

The fault rupture regulatory zone is established for areas located within 500 feet of a recognized (mapped) surface trace of a potentially active fault. As such the site is in the near-field of the Holocene active Concord - Green Valley Fault, which produces 6 mm of slip per year on average and is capable of a maximum magnitude 6.9 earthquake (Seismic Source Type B) (ICBO, 1998). Near source factors will apply in the structural design of the structures and associated improvements. A future design level geotechnical investigation will be required to provide seismic considerations for the design of the proposed communities.

Seismicity

Map Sheet 49 from the California Geological Survey (Toppozada and others, 2000) displays the epicenter locations of earthquakes with magnitudes greater than M 5.0 from 1800-1999. No epicenters are located on the GVFZ within the site vicinity. However, other portions of Solano County to the east contain several epicenters within the M 5.5-6.9 range, including the Vacaville Earthquake of M 6.6 that occurred in 1892. The map also includes the site area within a region exhibiting 4 occurrences of earthquake damage from 1800-1999 correlating to Modified Mercalli Intensity of greater than or equal to MMI = 7. The approximate site location superimposed onto Sheet 49 is presented in Figure 6, "Seismic Epicenters". A list of large earthquakes within 100 miles of the site on Table 2 below (EQSEARCH, 2004; and Stover and Coffman, 1993)

Table 2
Large Earthquakes (M>6.0) in Close Proximity to the Site

Epicenter Location	Date	Moment Magnitude	Distance (mi/km)	Compass Direction to Epicenter*
Mare Island	March 31, 1898	6.2	13.1 / 21.1	Southwest
Vacaville	April 19, 1892	6.6	14.4 / 23.1	Northeast
Winters	April 21, 1892	6.2	23.1 / 37.2	Northeast
San Francisco	June 21, 1808	6.3	35.2 / 56.7	West
Hayward	October 21, 1868	6.8	37.2 / 59.8	South
San Francisco	April 18, 1906	8.25	41.3 / 66.5	West
SF Peninsula	June 1, 1838	7.0	45.8 / 73.7	West
San Jose	Nov 26, 1858	6.1	52.8 / 85.0	South
S. Santa Cruz Mt.	October 21, 1865	6.3	66.2 / 106.5	Southwest
Morgan Hill	April 24, 1984	6.2	68.1 / 109.7	South
Loma Prieta	October 18, 1989	7.0	84.3 / 135.6	Southwest
Gilroy	June 20, 1897	6.2	92.7 / 149.2	South

* Table 2: Epicenter direction measured from bend in Mason Road between sites at Latitude 38.2360°N and Longitude 122.1629°W.

In 2014, the Working Group on California Earthquake Probabilities made an update to their 30-year rupture forecast (Aagaard and others, 2016). In this updated model, the Concord-Green Valley Fault has a 16% probability of generating an M ≥ 6.7 earthquake by the year 2043.

EVIDENCE OF FAULTING NEAR THE SITE

Prior Nearby Fault Evaluation Investigations

As part of our background research, we reviewed previous fault investigation studies by private consultants for 14 nearby residential and commercial projects along the GVFZ as shown on Figure 7, “Prior Nearby Fault Investigations”. Most of these previous studies were performed for properties to the south of the project site closer to the Cordelia Junction due to the concentration of development farther south. These prior fault evaluations were completed between 1972 and 2009 utilizing trench excavations, exploratory borings, and seismic refraction surveys.

The closest prior fault evaluation study to the project site was by the team of KC Engineering Company and Joyce Associates in 2008. This study was north and east of Mason Road along the north side of Green Valley Creek, as shown on Figure 2, “Site Hazard Map”. The slight bend in the creek at this location has been where the GVF has been mapped (California Geological Survey, 1993). Here, three trenches were excavated and geologically logged for the purpose of clearing two proposed residential building sites. The trenches generally exposed horizontally layered sediments of constant thicknesses. Trench 2A encountered a downwarping in the sedimentary layers and an associated 4-inch vertical offset in a coarse-grained layer at approximately middle depth in the trench. The consultants concluded that the deformation of the deposits was most likely related to active faulting from the GVFZ. A horizontal setback of 50 feet was established for new residential construction. The location of the fault was approximately 1,800 feet north of Mason Road. The southeastward projection of the fault would cross the east-west segment of Mason Road and align with the fault trace discovered in our trenches performed for this investigation as shown on Plate 1, "Site Geologic Map".

In addition to the various previous nearby fault investigations by private consultants, the U.S. Geological Survey and associated researchers explored the north portion of the Nightingale property with a series of trenches and seismic refraction lines during a multi-year period from 2006 to 2009 (Kimball and others, 2008; and Lienkaemper and others, 2012). The study was between our exploratory trench TN-2 and Mason Road. Backfill from trench 07S of the USGS study was presumptively encountered in trenches TN-1 and TN-1B of this study, and an approximate alignment of their trench is shown on Figure 3, "Site Plan". The exploratory trenches encountered a sequence of horizontally layered alluvial sediments with clay-rich layer near the base of the excavations. A single fault zone up to 15 feet wide was identified in the trenches based on a series of near vertical shears and vertical offsets in alluvial layers. Deeper imaging using seismic refraction confirmed the location of the fault zone showing a "down on the east" geometry. The location and width of the fault zone coincides with our recent trench exploration and projects the fault toward the northwest where it is consistent with the previous trenching by KC Engineering / Joyce Associates (2008) as described above as shown on Plate 1, "Site Geologic Map". The locations of the seismic refraction lines are plotted on Plate 1.

<u>Review of Aerial Photographs</u>

We have reviewed selected single photos and stereo-pairs of vertical aerial photographs for the years 1963, 1966, 1968, 1975, 1981, 1988, 1989, 1992, 1997, and 2000. The horizontal scales of the aerial photographs reviewed ranged from 1:8,400 to 1:54,000. A complete list of the aerial photographs reviewed for this evaluation is included in the back of this report.

Both the Nightingale and Elkhorn parcels contained extensive orchards as seen on the aerial photographs from the 1960s, 1970s, and 1980s. By the late 1980s, the orchards disappeared from the Nightingale property and the lands were tilled. The orchards remained on the Elkhorn parcel through at least the early 2000s, based on our review of the aerial photographs.

Our review of the aerial photographs revealed that the slope areas along the west side of Green Valley adjacent to the project site exhibited geomorphic characteristics consistent with active landslide terrain, such as hummocky topography, ground scarps, localized depressions, and surface bulges. The transition between the landslide terrain of the hills and the valley floor within the Elkhorn parcel is a gentle east-dipping plain that likely represents alluvial fan deposits shed downslope from erosion of the landslide debris. The south-flowing Green Valley Creek can be seen on all of the aerial photographs as a tree-lined channel located well to the east of the project site.

Typically, a review of stereo-pairs of aerial photographs may reveal linear ground scarps or tonal changes in the landscape from differences in vegetation and varying groundwater depths produced from active faulting. Although surface traces of the GVFZ were identified in exploratory trenches, the aerial photographs reviewed did not show any signs of active faulting passing through the project site. The absence of fault-related features may be due to extensive tilling of the soils for agricultural use that have masked such surface features.

To the north of the project site, a slight bend in the alignment of Green Valley Creek can be seen on the aerial photographs approximately 0.3 miles north of Mason Road. This bend in the creek has been attributed to the GVF (California Geological Survey, 1993). Approximately 0.75 miles to the south of Mason Road, a linear east-facing slope at the base of the hillslope along the west side of Green Valley appears to be related to active faulting and may represent a fault scarp. This location coincides with the mapped GVF (California Geological Survey, 1993). The fault scarp is approximately 0.35 miles south of Trench TN-2. We identified only these two locations as evidence for possible active faulting near the project site from our review of the aerial photographs.

Geologic Reconnaissance

Concurrent with our subsurface field investigation, we performed a geologic reconnaissance of the site area to observe features depicted on published maps and to identify whether or not the location of the GVFZ onsite would impact the proposed development plans. The results of the reconnaissance are shown on the Site Geologic Map, Plate 1. No rock outcrops were observed on the Nightingale or Elkhorn parcels. A low-lying ridge separates the two parcels. Outcrops of bedded sandstone were observed exposed on west face of the ridge, as was an outcrop of poorly sorted sands containing abundant, angular clasts of volcanic rock. These were interpreted to be exposures of Markey Formation sandstone, and landslide debris associated with mass movement in the Sonoma Volcanics underlying the local slopes (Bezore and others, 1998).

It was reported that a series of en echelon cracks in the pavement along the east-west segment of Mason Road indicated right-lateral displacement suggesting the location of the surface trace of the GVF (Lienkaemper and others, 2012). The pavement distress was in alignment with the northwest projection of the single fault trace encountered on the Nightingale parcel in trenches by Lienkaemper and others (2012) and in seismic refraction lines by Kimball and others (2008), and the southeast projection of the single fault trace encountered in trenches by KC Engineering / Joyce Associates (2008). We were unable to observe any right-lateral offset in the Mason Road pavement during our reconnaissance and we suspect that the roadway had been resurfaced sometime in the last 10 years.

CURRENT SUBSURFACE FAULT INVESTIGATION AT THE SITE

General

In August 2019, we began a subsurface investigation to locate the surface expression of the Green Valley Fault within the project site. The investigation consisted of excavating elongated trenches several hundreds of feet long approximately perpendicular to the mapped fault trace. The sides of the trenches were stepped for safety and to maintain the integrity of the trench side walls. The trenches were excavated using a track-mounted excavator with a 36-inch wide bucket. The maximum depth of the excavations was approximately 9.5 feet. The trench walls were cleaned by hand, string lines were used to provide a level datum for logging, and the geologic units were logged at a scale of 1 inch = 2 feet (1:24). Where fault features were identified in the trench, both walls of the trench were logged in this zone. Horizontal stations at 5-foot intervals were outlined on the trench wall and the trench log for reference.

We geologically logged four trenches on the Nightingale parcel, identified as TN-1, TN-1b, TN-2, and TN-3, and two trenches on the Elkhorn parcel, identified as TE-1 and TE-2, at the locations shown on the Site Geologic Map of Plate 2. In total, we logged just over 1,000 linear feet of trench wall for the Nightingale parcel and nearly 750 linear feet of trench wall for the Elkhorn Parcel. The trenches extended for a distance of approximately 0.5 mile along the length of the Green Valley Fault Zone. All of the trench locations were surveyed for accuracy.

A third-party reviewer was hired independently for this project in order to review and comment on our investigative methods, details within the trench exposures, and established building setbacks. Geologists with the reviewing agency, Engeo, Inc., visited the trenches on several occasions. Prior to backfill of the trenches, geologists from Engeo were in general agreement with the location of the surface trace of the GVF as identified within the trench exposures.

Geologic Interpretation of Trench Exposures

Our geologic logging of the trench exposures generally revealed a stacked sequence of Holocene age coarse-grained fluvial deposits directly underlying the upper relatively thin plow zone from agricultural activities within the site area. The younger deposits were deeply incised into older deposits representing at least four distinct fluvial sequences of different ages. The deposits were characteristically fluvial in nature exhibiting cross beds, channel scour, sandy laminations, and gravel lenses. The characteristics of these high energy deposits were best exhibited in Trench TE-2 on the Elkhorn parcel. Finer-grained channel margins were traceable for hundreds of feet in the trench exposures away from the main channel providing a stratigraphic context for the horizontally-layered deposits across the site. Soil development characteristics were superimposed of these surficial deposits such that distinct soil horizons, some containing clay films, blocky soil structure, and calcium carbonate filaments and nodules, representing a progressive weathering profile were logged.

The base of the oldest fluvial deposits was incised into fine-grained deposits of black fat clays that floored most of the trenches. The black clays were in stark contrast to the high energy and generally coarse-grained fluvial deposits logged above and the two units represent distinctly different geologic environments. We interpreted these fat clays as estuarine deposits similar in character, although stiffer in situ, to the Young Bay Mud that is present and mapped along the margins of Suisun Bay and throughout the fringes of San Francisco Bay. Soil testing by the U.S. Geological Survey on samples of the same black fat clays encountered during a previous investigation within the Nightingale site are reportedly highly expansive (*i.e.,* Plasticity Indices = 36–52 and Liquid Limits = 58–79; Bennett and others, 2011). Groundwater in the trenches was just below the black clay.

The deposits identified in Trench TE-1 at the north end of the Elkhorn parcel were the exception to the high energy fluvial deposits incised into the stiff estuarine fat clays encountered in the other trenches. This trench consisted of generally two alluvial deposits of different ages, based on the soil stratigraphy development on both units. The deposits consisted of medium to coarse sands, and poorly sorted angular gravels within a fine-grained soil matrix consistent with debris flow deposition. Sub-horizontal stone lines marked some of the depositional boundaries including one that consisted of well-rounded, volcaniclastic cobbles. We interpret these deposits to represent alluvial fans being shed down the slope from west to east toward Green Valley Creek. This is supported by our review of aerial photographs.

A single concentrated shear zone up to approximately 15 feet wide was identified in three trenches on the nightingale parcel labeled TN-1, TN-2, and TN-3. The shear zone was staked at the ground surface and accurately located by surveyors. The shear zone formed a northwest-southeast alignment consistent with the strike of the GVF in this area, but located to the east of the mapped fault trace in the central portion of the Nightingale parcel. The previous trench exploration by the U.S. Geological Survey (Lienkaemper, 2012) and associated seismic refraction work (Kimball and others, 2008) completed in the same area of the Nightingale parcel as our Trench TN-3 report this as the Green Valley Fault. Farther to the north and north of Mason Road, the site-specific fault study by KC Engineering Company and Joyce Associates in 2008 is in alignment with this trace of the GVF.

In the trenches, the fault zone was initially identified by the warping and truncation of otherwise sub-horizontal beds of consistent thicknesses, usually near the bottom portions of trenches. These truncated beds were logged for 100 feet or more along the trench. As traced upward in the trench exposure from the warping and truncation of the lower deposits, multiple discontinuous sub-vertical shears appeared, although these features were not obvious. Some of these near-vertical shears were observed to offset the base of the horizontal layers. Measurements along the fault zone in the bottom of the trenches indicated strikes of N11W, N15W, and N30W with dips of approximately 35-80 degrees to the west.

Detailed logs of the trench profiles and descriptions of the various deposits and soil stratigraphy are included in Appendix B. We have attempted to assign relative ages to the deposits from previously published information by the U.S. Geological Survey, and from the initial work in the area by Engeo, Inc. Where encountered in our trenches, charcoal samples were collected and submitted for Carbon 14 dating of specific deposits. A compendium of reports detailing the charcoal data is located in Appendix C. Our presentation of the site geology, based on our field investigation and a literature review, is presented on Plate 1, Site Geologic Map.

Groundwater

Groundwater was encountered in the bottom of the trench excavations on the Nightingale parcel from 9 to 10 feet below the existing ground surface. Fault trench excavations on the Elkhorn parcel were not deepened to reach groundwater. Groundwater is known to be relatively shallow along Green Valley.

Groundwater levels can be highly variable based upon the season, rainfall, local topography and geology, and nearby construction activities. According to the California Water Data Library, a well south of the site area, identified as state well 04N03W01D001M, has produced groundwater from just below ground surface to as deep as 24.6 feet, in measurements dating from years 1918 to 2018.

FINDINGS

As explored in recent trench excavations, we identified a zone of deformation approximately 15 feet wide consisting of multiple shears, truncated sediments, and warping of marker beds passing through the west portion of the Nightingale Parcel. This was determined to be the prominent trace of the Green Valley Fault Zone. The fault exposed in trenches was measured as northwest-striking and steeply west-dipping. We reason that the sense of movement of the fault is predominately right-lateral strike-slip with a component of down to the east dip-slip displacement as determined from seismic refraction surveys.

The fault continues to the north of our Nightingale trenches where the U.S. Geological Survey and associated collaborators identified the fault in previous trench excavations and seismic refraction surveys. The fault crosses the east-west segment of Mason Road where asphalt cracking was determined to be fault-related during the same U.S. Geological Survey study. Here, the fault is several hundred feet to the east of the Elkhorn Parcel. The northwest projection of the fault was encountered in trenches by KC Engineering Company and Joyce Associates approximately 1,800 feet north of Mason Road.

The fault identified in Trenches TN-3 and TN-1 in the north portion of the Nightingale Parcel is located to the east of the previously mapped main trace shown on the Earthquake Fault Zone by as much as approximately 80 feet and 100 feet, respectively. The same fault encountered in Trench T-2 in the south portion of the Nightingale Parcel is approximately 240 feet to the east of the previously mapped main trace. However, the fault exposure in Trench T-2 is closest to the alignment of the previously mapped east splay.

Our findings suggest that the Green Valley Fault Zone within the site vicinity exists as a single relatively narrow zone of deformation that is most closely aligned with the east fault trace shown on the Earthquake Fault Zone (see Figure 2). The timing of the last major earthquake to occur along this segment of the Green Valley Fault Zone could not be determined from this study. Near-vertical offsets attributed to active faulting were observed in the uppermost native deposits encountered in the exploratory trenches. These deposits have been previously dated at less than 500 years old.

DISCUSSION AND CONCLUSIONS

Living in or developing property in the geologically complex, seismically active coastal region of central California carries with it a somewhat elevated level of risk from geologic hazards when compared to areas of the state where the geologic hazards are generally lessened by the lack of topographic relief, seismicity and proximity to active faults. Persons living in or developing land in this region must be cognizant of this fact, and should be willing to accept this somewhat elevated level of risk. Furthermore, whereas the level of risk can be reduced to an acceptably low level by implementing mitigative measures (for example, building setbacks from potential hazards, or adherence to building codes), the risk cannot be totally eliminated. Modern building codes are intended to prevent collapse of structures but not to preclude the need for significant repairs or even rebuilding after a major earthquake.

Changes to the natural conditions at or adjacent to the site can directly affect the risk levels from geologic hazards to the proposed development. For example, grading activities (cutting or filling), altering natural drainage characteristics, removing vegetative ground cover or excessive landscape irrigation activity can increase the risk from geologic hazards at a site. Conclusions are drawn considering the current site conditions and general recommendations offered.

Potential for Fault-Rupture Hazard and Established Building Setbacks

Our field investigation resulted in bracketing the surface trace of the Green Valley Fault as it passes through the Nightingale parcel and several hundred feet to the east of the Elkhorn parcel within an approximately 15-foot wide zone of deformation, based on our geologic logging of the fault trench. A building exclusion zone measuring approximately 115-foot wide (the zone of mapped deformation plus 50 feet on either side of the deformation zone) has been established along the fault trace. We do not recommend that any structures for habitation be sited within the building exclusion zone as shown on the Site Geologic Map, Plate 1. Since no other fault traces were encountered in our trenches outside of this setback zone, we judge the potential for fault surface rupture within those portions of the site to be low and it would not preclude development of the remainder of the property as long as the setback recommendations we have provided are followed.

Artificial Fill Settlement Mitigation

During the course of our field investigation, we encountered a previously unknown pocket of artificial fill. The fill pocket was first encountered in trench TN-1 at approximately 30 feet wide and extending below the bottom of the trench that was approximately 9.5 feet deep. The fill predominately consisted of historic debris generally consisting of metal scrap from machinery and burned refuse.

The fill extended laterally into two test pits excavated to the south of TN-1. Another trench excavated to the north of TN-1, labeled TN-1b, did not reveal the presence of any fill. The approximate extent of the fill pocket is identified on Plate 1, Site Geologic Map. We recommend that the old fill be removed at the time of grading, and replaced with clean, documented engineered fill.

At the conclusion of our field investigation, the exploratory trenches were loosely backfilled with the trench spoils. Over time, surfaces of the former trenches will begin to settle, forming local depressions over the length of each trench. We recommend that the trench areas, located by survey and identified on plate 1, Site Geologic Map, be re-excavated and brought to design grade with properly compacted engineered fill.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The conclusions of this report are based upon the assumption that the geologic conditions do not deviate from those disclosed in the test excavations and from a reconnaissance of the site. Should any variations or undesirable conditions be encountered during the development of the site, ***Quantum Geotechnical Inc.,*** will provide supplemental recommendations as dictated by the field conditions.

2. This report is issued with the understanding that it is the responsibility of the owner, or his representative, to ensure that the information and recommendations contained herein are brought to the attention of the Architect and Engineer for the project and incorporated into the plans and the necessary steps are taken to see that the Contractor and Subcontractors carry out such recommendations in the field.

3. At the present date, the findings of this report are valid for the property investigated. With the passage of time, significant changes in the conditions of a property can occur due to natural processes or works of man on this or adjacent properties. In addition, legislation or the broadening of knowledge may result in changes in applicable standards. Changes outside of our control may render this report invalid, wholly or partially. Therefore, this report should not be considered valid after a period of two (2) years without our review, nor should it be used, or is it applicable, for any properties other than those investigated.

4. Not withstanding all the foregoing, applicable codes must be adhered to at all times.

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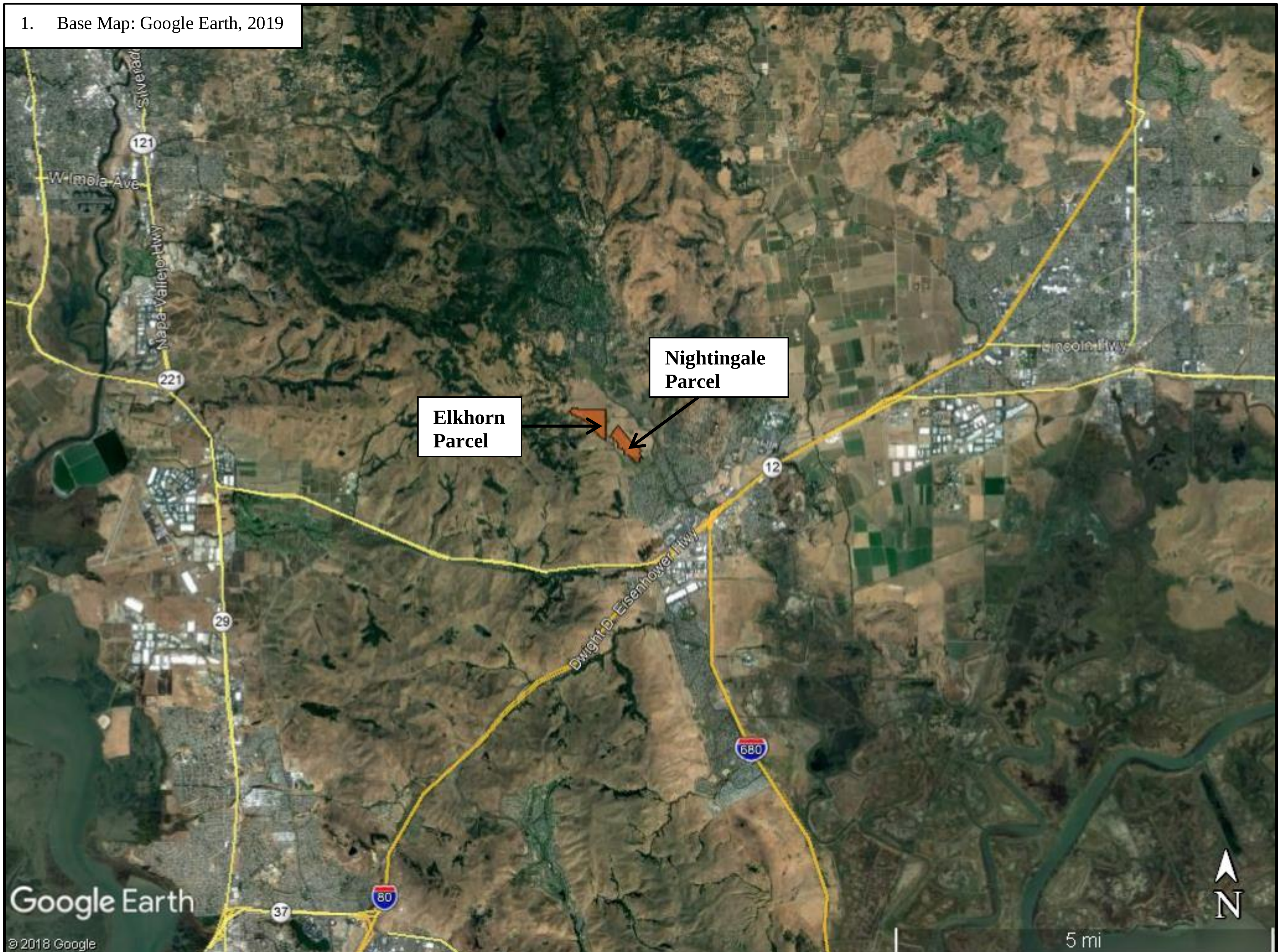
Review of Aerial Photographs

Date	Flight Line	Frames	Scale	Type
07-25-63	AV-550	10-06 & 07	1:36,000	B & W Stereo
04-21-66	AV-710	11-10 & 11	1:36,000	B & W Stereo
04-22-68	AV-8401	15-14	1:30,000	B & W Single
09-04-75	AV-1215	09-10 & 11	1:54,000	B & W Single
11-02-81	AV-2050	09-12 & 13	1:54,000	B & W Stereo
06-02-88	AV-3306	43-20	1:9,600	B & W Single
07-18-89	AV-3601	3-9 & 10	1:36,000	B & W Stereo
04-03-92	AV-4225	8-31 & 32	1:8.400	B & W Stereo
07-28-97	AV-5461	12-4	1:12,000	B & W Stereo
06-29-00	AV-6650	10-15 & 16	1:12,000	B & W Stereo

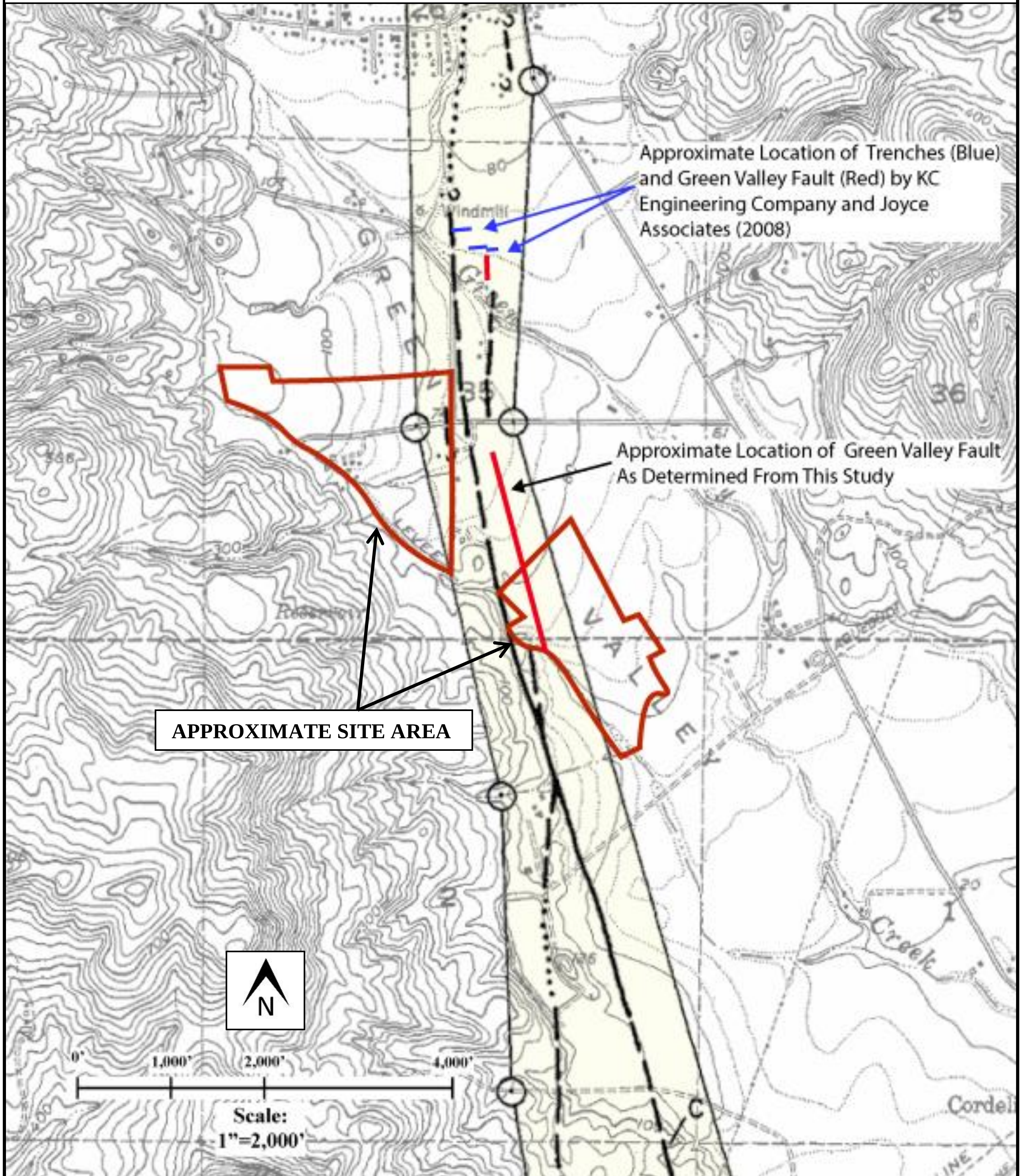
All photographs are available for review at Pacific Aerial Surveys in Novato, California

APPENDIX A

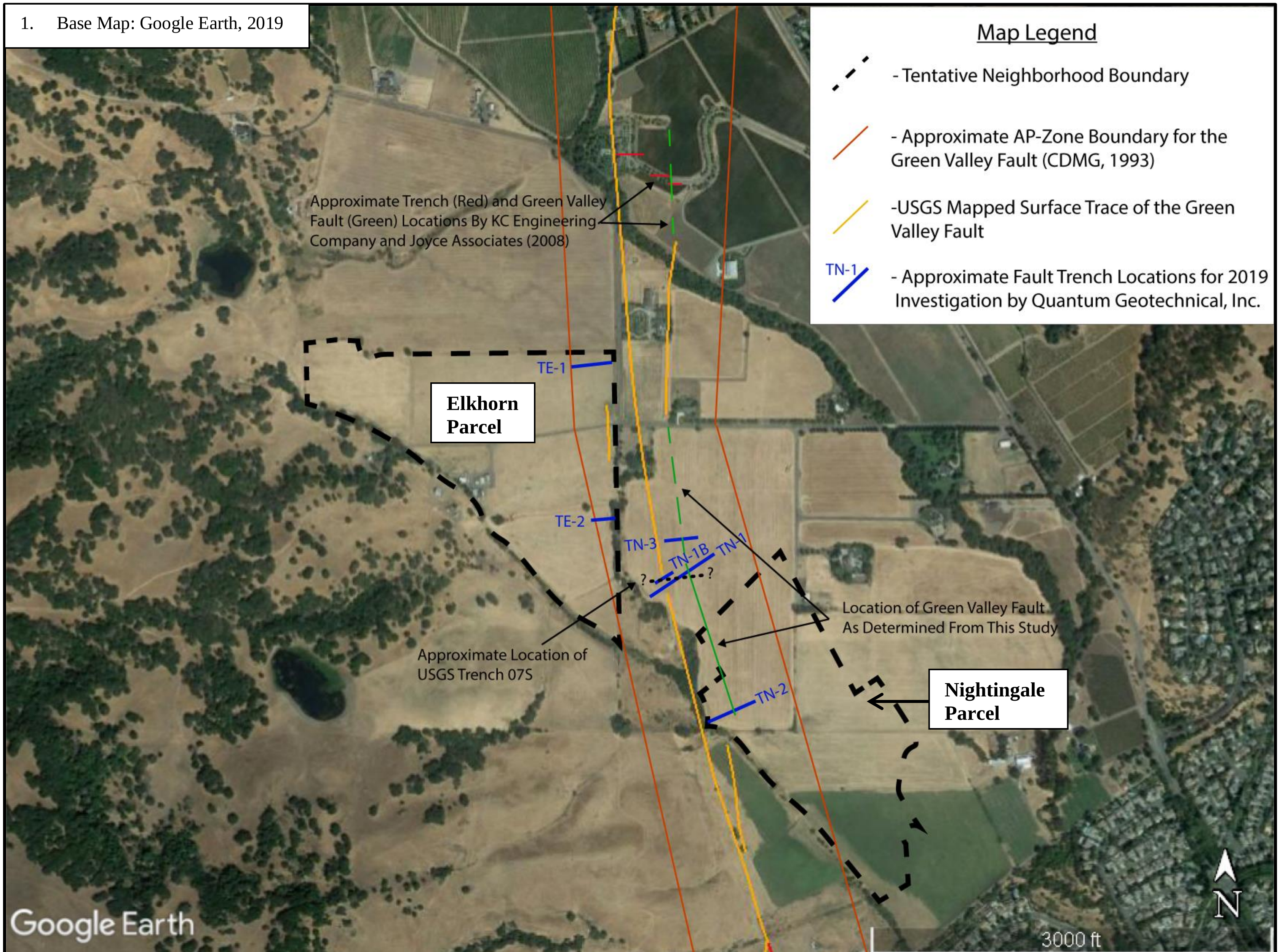


QUANTUM GEOTECHNICAL, INC.	SITE VICINITY MAP			
	Fault-Rupture Hazard Evaluation - Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No. F050.G	Drawn by: D.T.	Figure No. 1

1. Modified from Map Source: California Division of Mines and Geology, *State of California, Special Studies Zones, Cordelia Quadrangle. Official Map*, Effective July 1, 1993, Scale 1:24,000.



QUANTUM GEOTECHNICAL, INC.	SITE HAZARD MAP			
	Fault-Rupture Hazard Evaluation – Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No. F050.G	Drawn by: D.T.	Figure No. 2

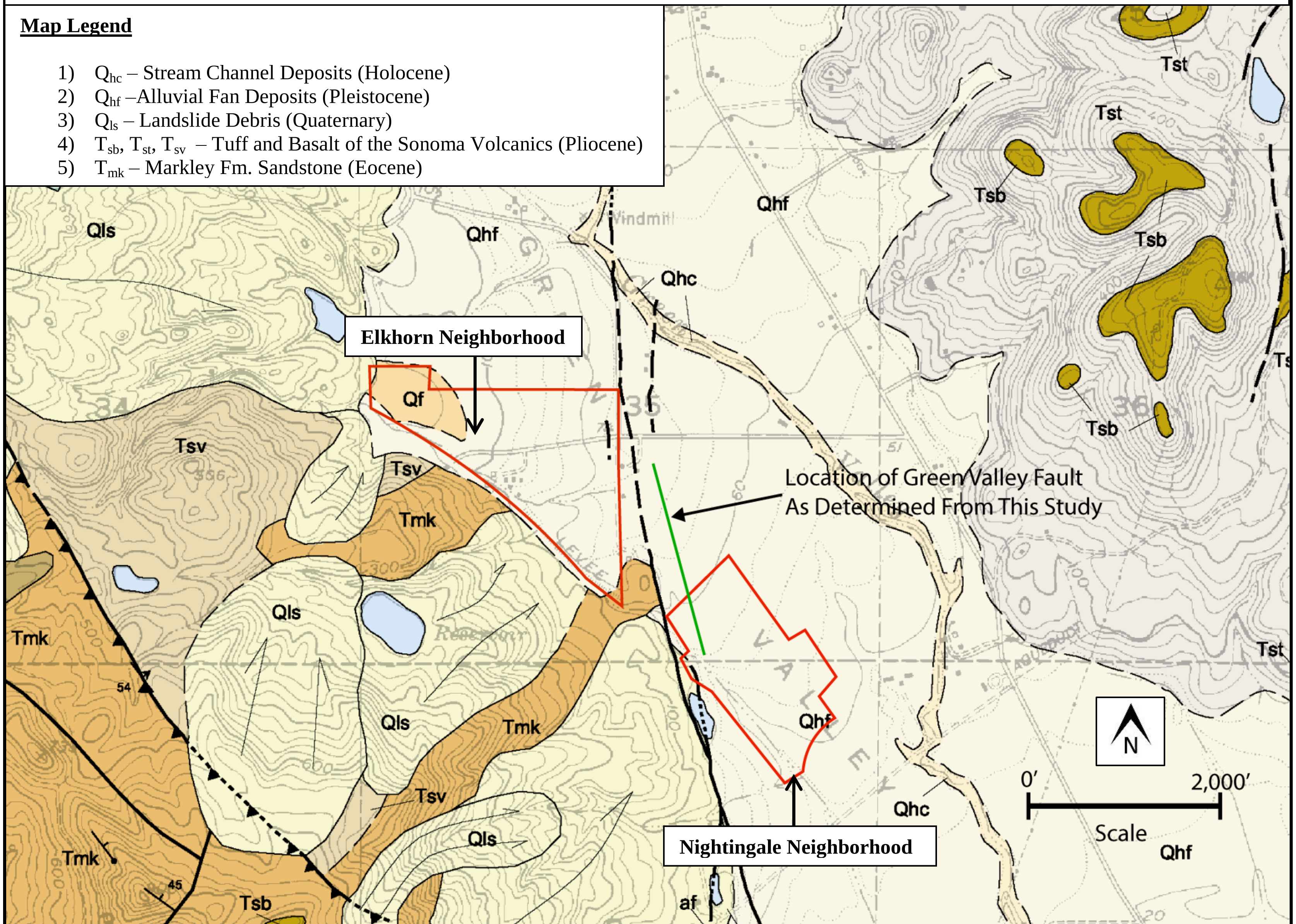


QUANTUM GEOTECHNICAL, INC.	SITE PLAN			
	Fault-Rupture Hazard Evaluation - Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No. F050.G	Drawn by: D.T.	Figure No. 3

1. Modified from Geologic Map Source: Bezore, S.P., Wagner, D.L., Sowers, J.M., 1998, "Geologic Map of the Cordelia 7.5' Quadrangle, Solano and Napa Counties, California", CA Division of Mines and Geology, Cordelia Quadrangle, Scale 1:24,000.

Map Legend

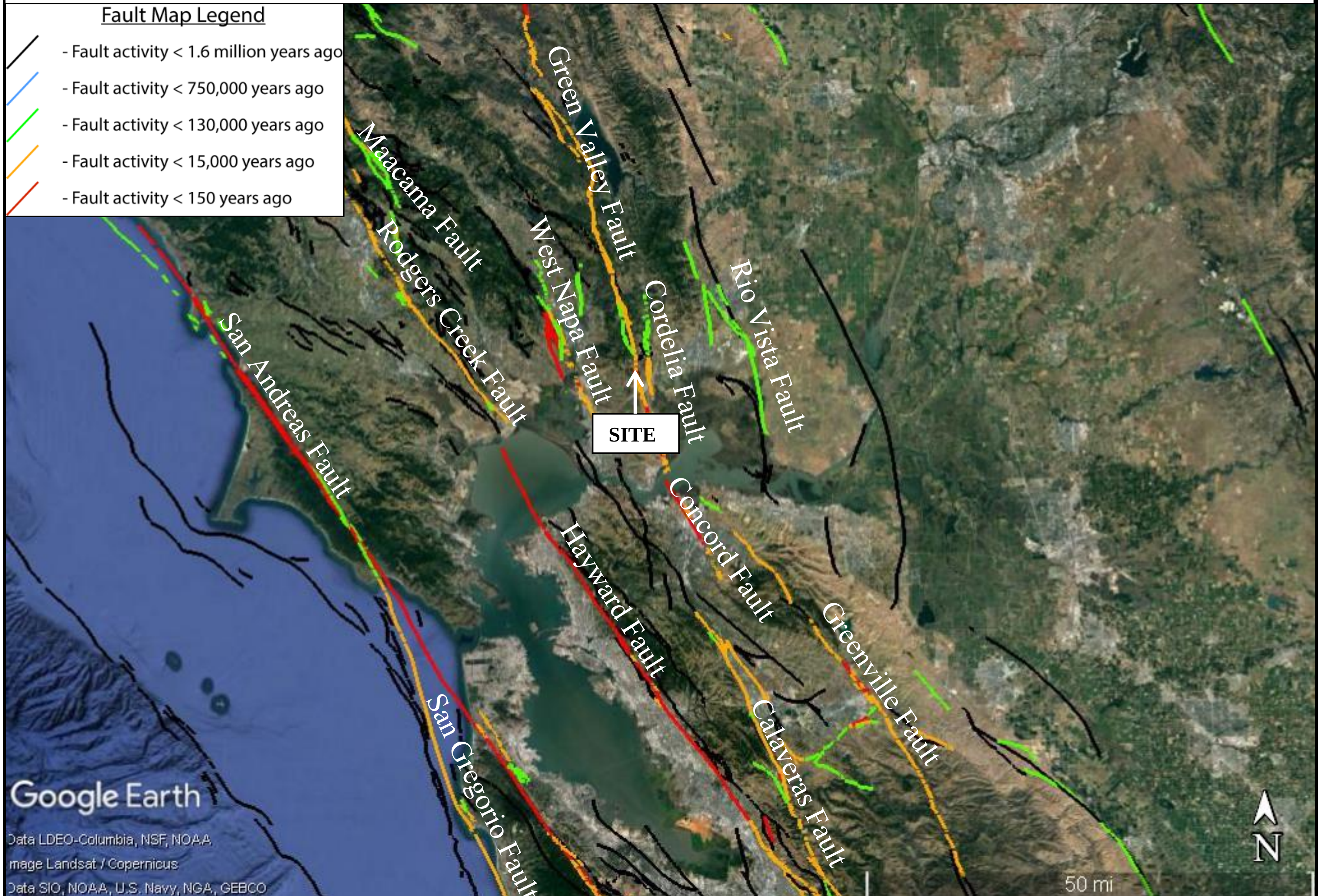
1) Q_{hc} – Stream Channel Deposits (Holocene)
2) Q_{hf} –Alluvial Fan Deposits (Pleistocene)
3) Q_{ls} – Landslide Debris (Quaternary)
4) T_{sb}, T_{st}, T_{sv} – Tuff and Basalt of the Sonoma Volcanics (Pliocene)
5) T_{mk} – Markley Fm. Sandstone (Eocene)



REGIONAL GEOLOGIC MAP

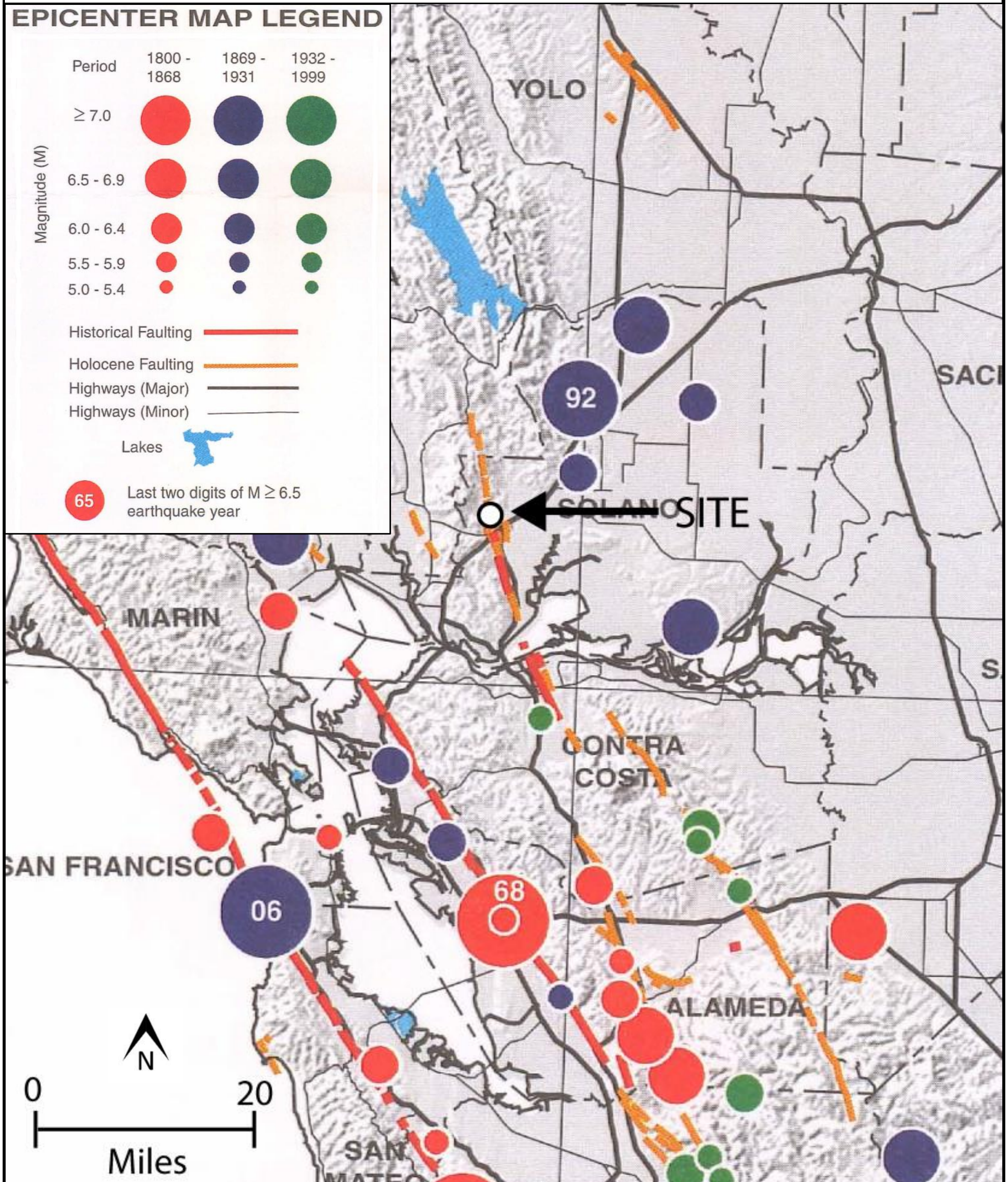
QUANTUM GEOTECHNICAL, INC.	**Fault-Rupture Hazard Evaluation - Green Valley Fault Zone** **Proposed Rural Community Development** **Nightingale and Elkhorn Neighborhoods** **Mason Road, Green Valley, California**	**Project No.** **F050.G**	**Drawn by:** **D.T.**	**Figure No.** **4**

1. Base Map: Google Earth, 2019
2. Fault Map Overlay: U.S. Geological Survey and California Geological Survey. 2006. Quaternary fault and fold database for the United States. Accessed December 12, 2019 from USGS web site: http//earthquakes.usgs.gov/regional/qfaults/.



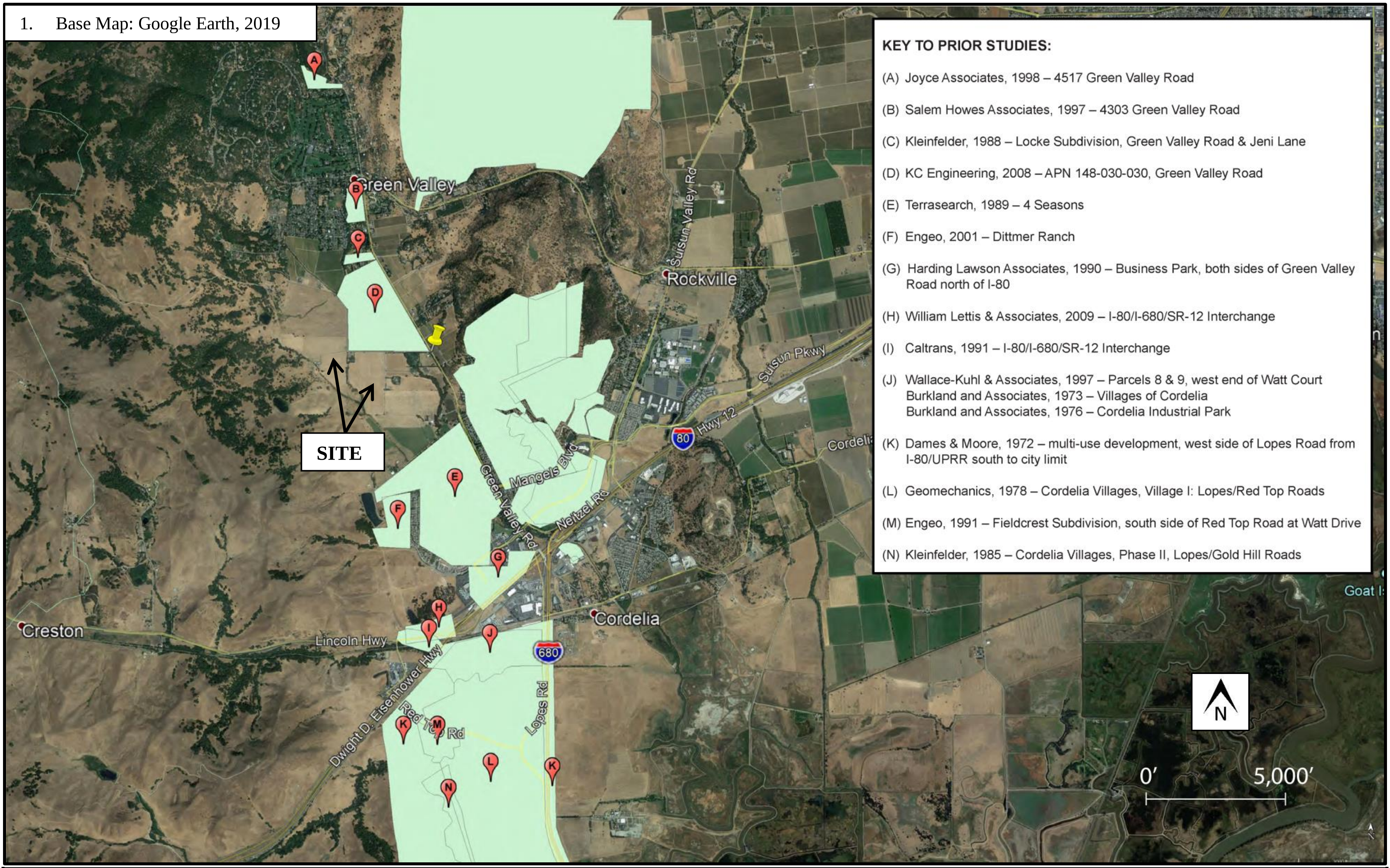
QUANTUM GEOTECHNICAL, INC.	REGIONAL SEISMICITY MAP			
	Fault-Rupture Hazard Evaluation - Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No. F050.G	Drawn by: D.T.	Figure No. 5

Modified from Map Source: Toppozada, T. R., D. Branum, M. Petersen, C. Hall-Strom, C. Cramer and M. Reichle, 2000, "Epicenters of and areas damaged by $M \geq 5$ California earthquakes, 1800-1999", California Division of Mines and Geology, Map Sheet 49.



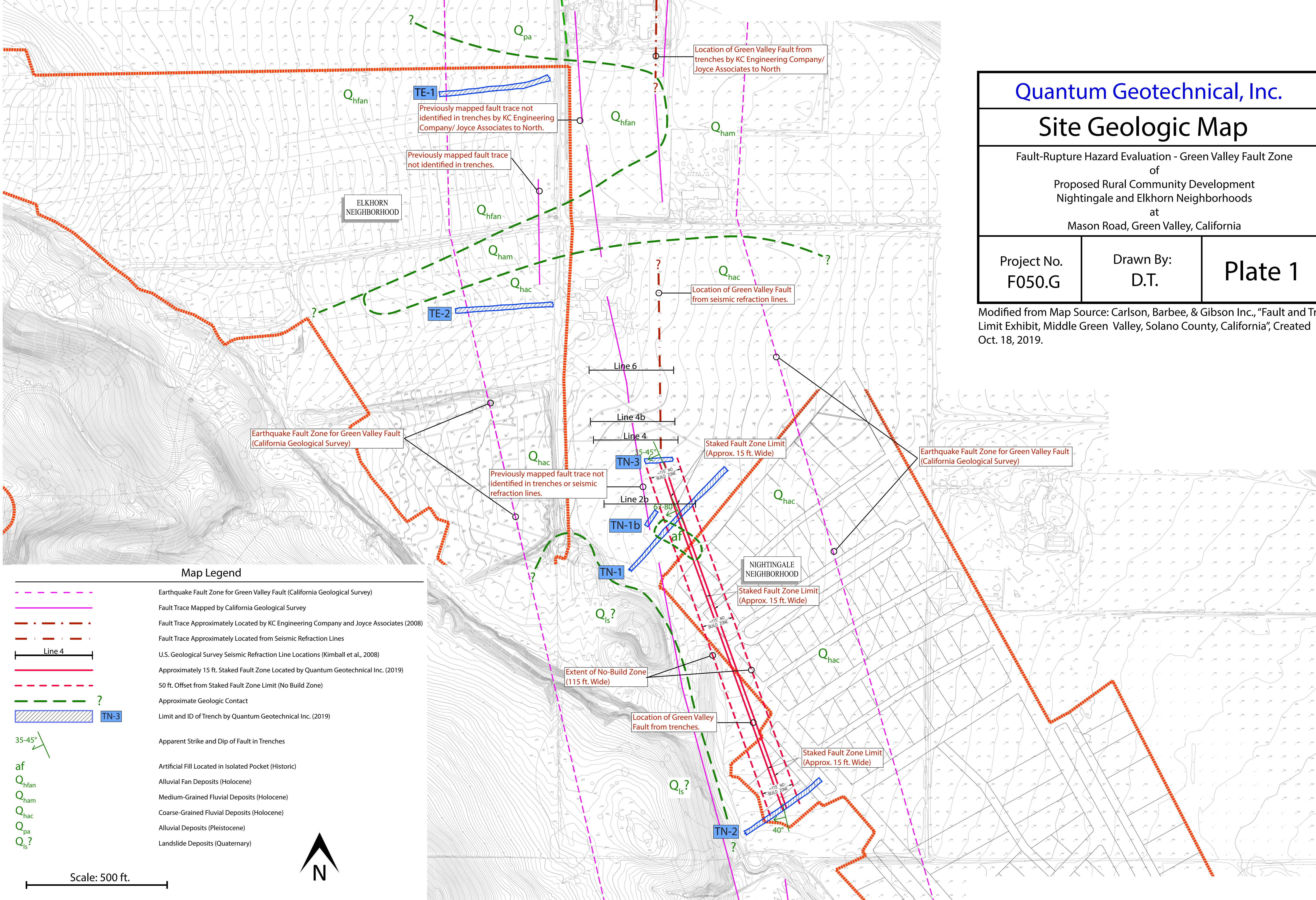
SEISMIC EPICENTER MAP

QUANTUM GEOTECHNICAL, INC.	Fault-Rupture Hazard Evaluation – Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No. F050.G	Drawn by: D.T.	Figure No. 6



PRIOR FAULT STUDIES MAP

QUANTUM GEOTECHNICAL, INC.	Fault-Rupture Hazard Evaluation - Green Valley Fault Zone Proposed Rural Community Development Nightingale and Elkhorn Neighborhoods Mason Road, Green Valley, California	Project No.	Drawn by:	Figure No.
		F050.G	D.T.	7



Quantum Geotechnical, Inc.

Site Geologic Map

Fault-Rupture Hazard Evaluation - Green Valley Fault Zone
of
Proposed Rural Community Development
Nightingale and Elkhorn Neighborhoods
at
Mason Road, Green Valley, California

Project No. F050.G	Drawn By: D.T.	Plate 1

Modified from Map Source: Carlson, Barbee, & Gibson Inc., "Fault and Trench Limit Exhibit, Middle Green Valley, Solano County, California", Created Oct. 18, 2019.

Map Legend

(pink dashed line)	Earthquake Fault Zone for Green Valley Fault (California Geological Survey)
(pink solid line)	Fault Trace Mapped by California Geological Survey
(red dash-dot line)	Fault Trace Approximately Located by KC Engineering Company and Joyce Associates (2008)
(red dashed line)	Fault Trace Approximately Located from Seismic Refraction Lines
Line 4	U.S. Geological Survey Seismic Refraction Line Locations (Kimball et al., 2008)
(red solid line)	Approximately 15 ft. Staked Fault Zone Located by Quantum Geotechnical Inc. (2019)
(red dashed line)	50 ft. Offset from Staked Fault Zone Limit (No Build Zone)
?	Approximate Geologic Contact
TN-3	Limit and ID of Trench by Quantum Geotechnical Inc. (2019)
35-45°	Apparent Strike and Dip of Fault in Trenches
af	Artificial Fill Located in Isolated Pocket (Historic)
Q_{hfan}	Alluvial Fan Deposits (Holocene)
Q_{ham}	Medium-Grained Fluvial Deposits (Holocene)
Q_{hac}	Coarse-Grained Fluvial Deposits (Holocene)
Q_{pa}	Alluvial Deposits (Pleistocene)
Q_{ls}?	Landslide Deposits (Quaternary)

Appendix B

<u>Logs of Nightingale Trenches TN-1 to TN-3 (Sheets 1-5)</u>

<u>Logs of Elkhorn Trenches TE-1 and TE-2 (Sheets 6-8)</u>

Appendix C

<u>Compendium of Reports from Beta Analytic Inc.</u>

Beta Analytic TESTING LABORATORY

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

April 13, 2020

Mr. Dane Tikunoff
Quantum Geotechnical, Inc.
1110 Burnett Avenue Ste. B
Concord, CA 94520
United States

RE: Radiocarbon Dating Results

Dear Mr. Tikunoff,

Enclosed are the radiocarbon dating results for two samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Dane Tikunoff
Quantum Geotechnical, Inc.

Report Date: April 13, 2020
Material Received: December 03, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 545617	**TN-1-07.5-8.0**	**1940 +/- 30 BP**	IRMS δ13C: -24.5 o/oo

(94.2%)	**0 cal BC - 130 cal AD**	**(1950 - 1820 cal BP)**
(1.2%)	**20 - 12 cal BC**	**(1969 - 1961 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 78.54 +/- 0.29 pMC
Fraction Modern Carbon: 0.7854 +/- 0.0029
D14C: -214.56 +/- 2.93 o/oo
Δ14C: -221.08 +/- 2.93 o/oo (1950:2019)
Measured Radiocarbon Age: (without d13C correction): 1930 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Dane Tikunoff	Report Date: April 13, 2020
Quantum Geotechnical, Inc.	Material Received: December 03, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 545618	**TN-1-26.0-2.0**	**1720 +/- 30 BP**	IRMS δ13C: -27.9 o/oo

(95.4%) **248 - 391 cal AD** **(1702 - 1559 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 80.73 +/- 0.30 pMC
Fraction Modern Carbon: 0.8073 +/- 0.0030
D14C: -192.75 +/- 3.01 o/oo
Δ14C: -199.46 +/- 3.01 o/oo (1950:2019)
Measured Radiocarbon Age: (without d13C correction): 1770 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.5 o/oo)

Laboratory number **Beta-545617**

Conventional radiocarbon age **1940 ± 30 BP**

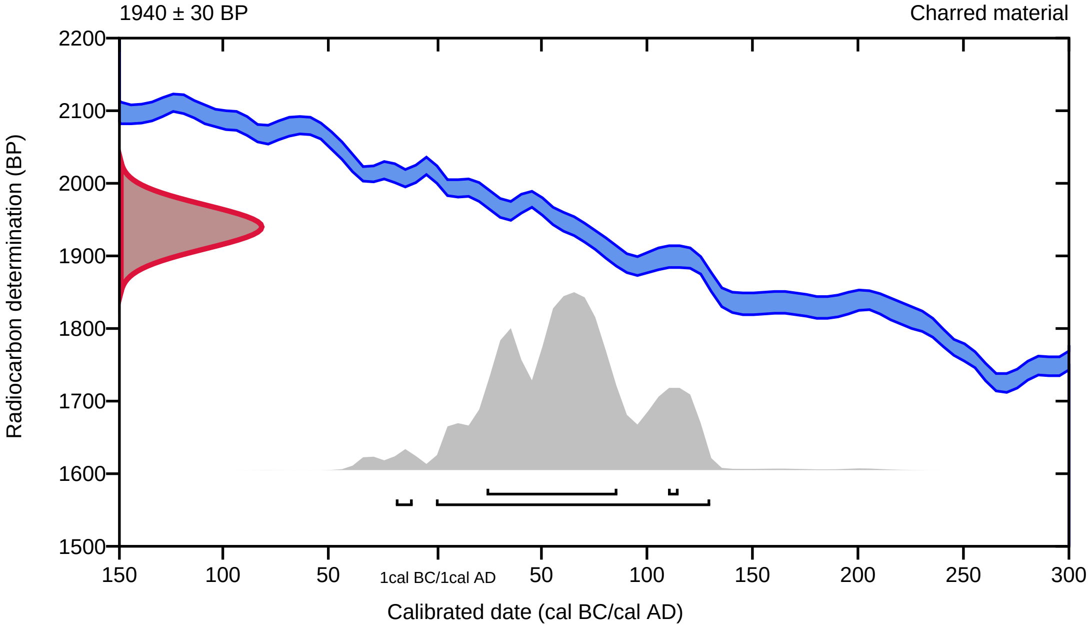
95.4% probability

(94.2%)	0 cal BC - 130 cal AD	(1950 - 1820 cal BP)
(1.2%)	20 - 12 cal BC	(1969 - 1961 cal BP)

68.2% probability

(65%)	24 - 86 cal AD	(1926 - 1864 cal BP)
(3.2%)	110 - 115 cal AD	(1840 - 1835 cal BP)

TN-1-07.5-8.0



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -27.9 o/oo)

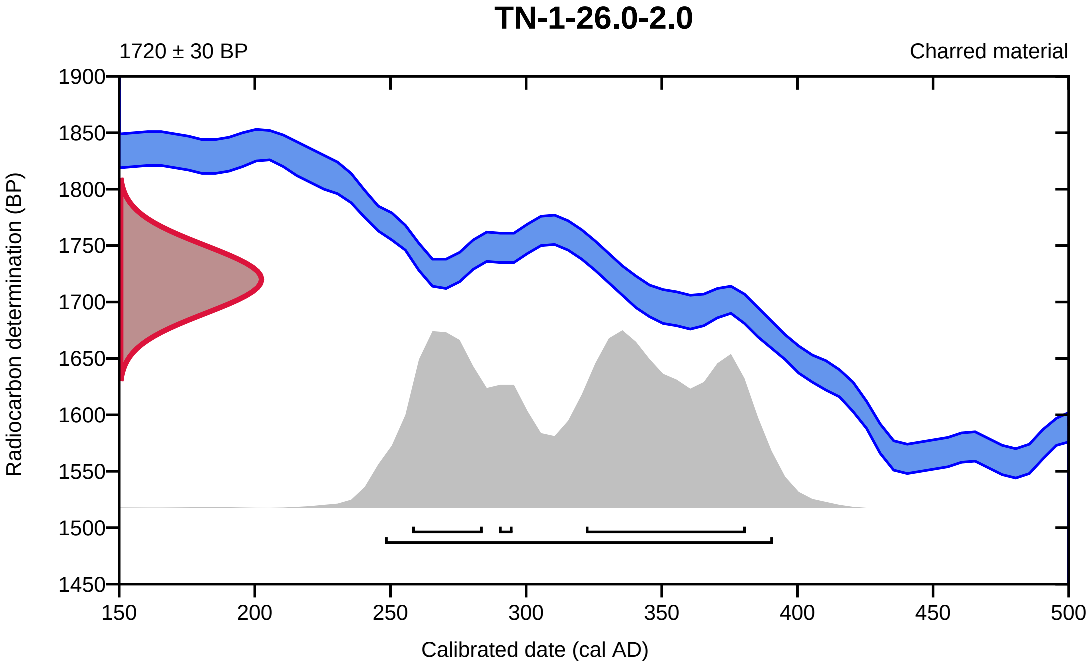
Laboratory number	**Beta-545618**
Conventional radiocarbon age	**1720 ± 30 BP**

95.4% probability

(95.4%)	248 - 391 cal AD	(1702 - 1559 cal BP)

68.2% probability

(42.3%)	322 - 381 cal AD	(1628 - 1569 cal BP)
(22.3%)	258 - 284 cal AD	(1692 - 1666 cal BP)
(3.6%)	290 - 295 cal AD	(1660 - 1655 cal BP)



Database used

INTCAL13

References

References to Probability Method

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ISO/IEC 17025:2005-Accredited Testing Laboratory

February 21, 2020

Mr. Dane Tikunoff
Quantum Geotechnical, Inc.
1110 Burnett Avenue
Concord, CA 94520
United States

RE: Radiocarbon Dating Results

Dear Mr. Tikunoff,

Enclosed are the radiocarbon dating results for two samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Digital signature on file

Ronald E. Hatfield President

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Dane Tikunoff	Report Date: February 21, 2020
Quantum Geotechnical, Inc.	Material Received: February 14, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 553202	**TN-3-13.5-3.2**	**860 +/- 30 BP**	IRMS δ13C: -26.6 o/oo

(83.7%)	**1150 - 1256 cal AD**	**(800 - 694 cal BP)**
(9.8%)	**1049 - 1084 cal AD**	**(901 - 866 cal BP)**
(1.9%)	**1124 - 1136 cal AD**	**(826 - 814 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-PRIORITY delivery
Percent Modern Carbon: 89.85 +/- 0.34 pMC
Fraction Modern Carbon: 0.8985 +/- 0.0034
D14C: -101.53 +/- 3.36 o/oo
Δ14C: -109.10 +/- 3.36 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 890 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), “present” = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Dane Tikunoff	Report Date: February 21, 2020
Quantum Geotechnical, Inc.	Material Received: February 14, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 553204	**TE-2-216.0-5.8**	**320 +/- 30 BP**	IRMS δ13C: -24.3 o/oo

(95.4%) **1482 - 1646 cal AD** **(468 - 304 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-PRIORITY delivery
Percent Modern Carbon: 96.09 +/- 0.36 pMC
Fraction Modern Carbon: 0.9609 +/- 0.0036
D14C: -39.05 +/- 3.59 o/oo
Δ14C: -47.16 +/- 3.59 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 310 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -26.6 o/oo)

Laboratory number **Beta-553202**

Conventional radiocarbon age **860 ± 30 BP**

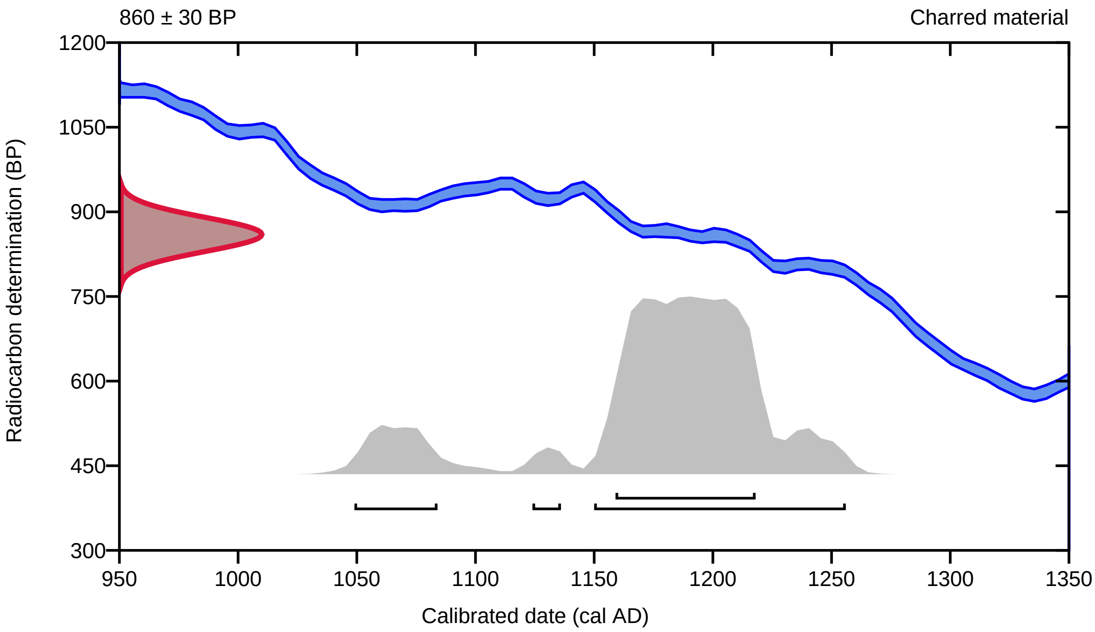
95.4% probability

(83.7%)	1150 - 1256 cal AD	(800 - 694 cal BP)
(9.8%)	1049 - 1084 cal AD	(901 - 866 cal BP)
(1.9%)	1124 - 1136 cal AD	(826 - 814 cal BP)

68.2% probability

(68.2%)	1159 - 1218 cal AD	(791 - 732 cal BP)

TN-3-13.5-3.2



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.3 o/oo)

Laboratory number **Beta-553204**

Conventional radiocarbon age **320 ± 30 BP**

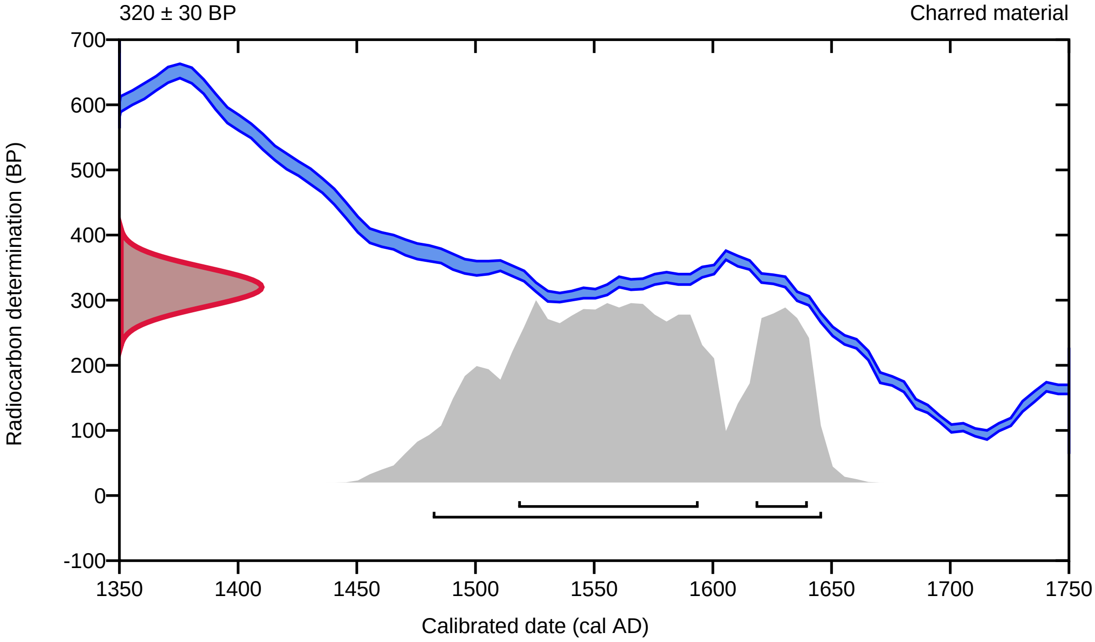
95.4% probability

(95.4%)	1482 - 1646 cal AD	(468 - 304 cal BP)

68.2% probability

(53.5%)	1518 - 1594 cal AD	(432 - 356 cal BP)
(14.7%)	1618 - 1640 cal AD	(332 - 310 cal BP)

TE-2-216.0-5.8



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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ISO/IEC 17025:2005-Accredited Testing Laboratory

March 02, 2020

Mr. Dane Tikunoff
Quantum Geotechnical, Inc.
1110 Burnett Avenue Ste. B
Concord, CA 94520
United States

RE: Radiocarbon Dating Results

Dear Mr. Tikunoff,

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

Thank you for prepaying the analysis. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

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Beta Analytic TESTING LABORATORY

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REPORT OF RADIOCARBON DATING ANALYSES

Dane Tikunoff	Report Date: March 02, 2020
Quantum Geotechnical, Inc.	Material Received: February 26, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 554309	**TN-3-44.0-2.5**	**680 +/- 30 BP**	IRMS δ13C: -24.0 o/oo

(60.2%)	**1270 - 1316 cal AD**	**(680 - 634 cal BP)**
(35.2%)	**1354 - 1390 cal AD**	**(596 - 560 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-PRIORITY delivery
Percent Modern Carbon: 91.88 +/- 0.34 pMC
Fraction Modern Carbon: 0.9188 +/- 0.0034
D14C: -81.17 +/- 3.43 o/oo
Δ14C: -88.91 +/- 3.43 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 660 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.0 o/oo)

Laboratory number **Beta-554309**

Conventional radiocarbon age **680 ± 30 BP**

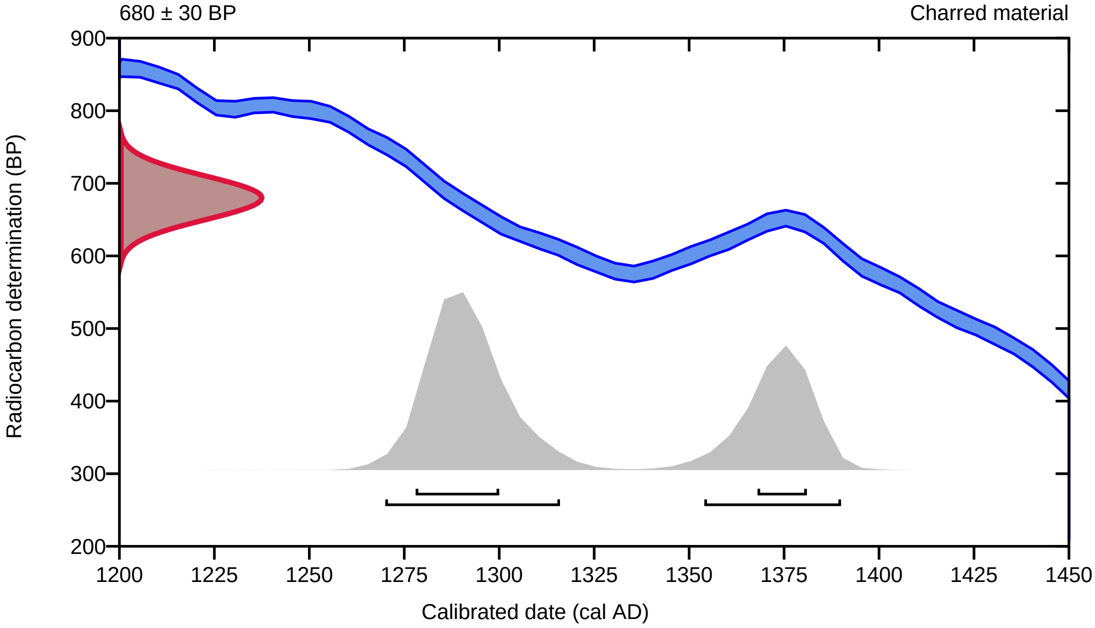
95.4% probability

(60.2%)	1270 - 1316 cal AD	(680 - 634 cal BP)
(35.2%)	1354 - 1390 cal AD	(596 - 560 cal BP)

68.2% probability

(47.2%)	1278 - 1300 cal AD	(672 - 650 cal BP)
(21%)	1368 - 1381 cal AD	(582 - 569 cal BP)

TN-3-44.0-2.5



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

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