9 Geology & Soils

9.1 Introduction

This chapter describes the existing setting of the proposed project site as it relates to geology and soils; identifies associated regulatory conditions and requirements; presents the criteria used to evaluate potential impacts on geology and soils; and identifies mitigation measures to reduce or avoid each significant impact. The significance of each impact after the incorporation of identified mitigation measures is included at the end of this chapter.

Information used to prepare this chapter came from the following sources:

- ENGEO Incorporated. 1990. Geotechnical Exploration for EIR Report: Brentwood Golf Course Development. (see Appendix E)
- ENGEO Incorporated. 1999. Geotechnical Exploration: Deer Creek Country Club – Unit 2 (see Appendix E)
- ENGEO Incorporated. 2017. Technical Memorandum, Geotechnical Considerations and Foundation Recommendations Update
- City of Brentwood General Plan Update (General Plan), 2014
- City of Brentwood General Plan EIR, Draft Program Environmental Impact Report for the 2014 Brentwood General Plan Update, 2014
- Geologic literature from the U.S. Geological Survey and California Geological Survey

9.2 Scoping Issues Addressed

Written comments and suggestions were provided by members of the public, organizations, and government agencies during the Notice of Preparation (NOP) scoping period conducted from August 4, 2017 through September 5, 2017. The following comments reflect the key issues identified during the NOP comment period regarding geology and soils and are addressed in this section:

- Concern regarding appropriateness of constructing large buildings over or adjacent to abandoned mines

9.3 Environmental Setting

This section presents information on geology and soils conditions in the proposed project site. The Regional Setting provides information on the baseline conditions in the project region. The Project Setting describes baseline conditions for geology and soils within the proposed project site.

9.3.1 Regional Setting

The geology of the region is to a large extent controlled by major active faults in the Coast Range to the west and the alluvial deposits and sediments from the Sacramento-San Joaquin River Delta to the north and east. Plate boundary fault movements are largely concentrated along the San Andreas Fault zone, with eastward distribution of stress along the Hayward, Calaveras, and other relatively short, active faults. Later eastward expansion of strike-slip movement has resulted in movement along the shorter fault segments such as the Concord and Greenville faults.

9.3.2 Project Setting

The 355-acre project area includes relatively flat portions as well as gently sloping hills. Site elevations range from approximately 200 feet above mean sea level (msl) in the south (Deer Ridge) to approximately 250 feet above msl to the north (Shadow Lakes). The approximately 32-acre project site is located in the southwest portion of Brentwood and includes small portions of both the Deer Ridge Golf Club and the Shadow Lakes Golf Club. The Shadow Lakes portion of the site is located directly north of Balfour Road, while the Deer Ridge portion of the site is located directly south of Balfour Road.

Geology

The Brentwood Planning Area is underlain by Upper Cretaceous marine sedimentary rocks, Eocene marine sedimentary rocks, and Quaternary Marine/Alluvium, which contains mostly nonmarine unconsolidated and semiconsolidated alluvium, lake, playa, and terrace deposits. Upper Cretaceous marine sedimentary rocks consisting of sandstone, shale, and conglomerate are located in the southwestern portion of the Planning Area in the hilly terrain. There is a band of Eocene Marine sedimentary rocks consisting of shale, sandstone, conglomerate, and minor limestone located in a band that separates the Quaternary Marine/Alluvium and the Upper Cretaceous.

Faults and Seismicity

Fault rupture is the surface displacement that occurs when movement on a fault deep within the earth breaks through to the surface. Fault rupture and displacement almost always follows preexisting faults, which are zones of weakness; however, not all earthquakes result in surface rupture, i.e., earthquakes that occur on blind thrusts do not result in surface fault rupture. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. In addition to damage caused by ground shaking from an earthquake, fault rupture is damaging to buildings and other structures due to the differential displacement and deformation of the ground surface that occurs from the fault offset. This leads to damage or collapse of structures across this zone. Fault rupture displacements in large earthquakes can range from several feet to greater than 15 feet.

Fault definitions include:

- Faults that have generated earthquakes accompanied by surface rupture during historic time (approximately the last 200 years) and faults that exhibit aseismic fault creep are defined as Historically Active.
- Faults that show geologic evidence of movement within Holocene time (approximately the last 11,000 years) are defined as Active.
- Faults that show geologic evidence of movement during the Quaternary time (approximately the last 1.6 million years) are defined as Potentially Active.
- Faults that show direct geologic evidence of inactivity during all of Quaternary time or longer are classified as Inactive.

Although it is difficult to quantify the probability that an earthquake will occur on a specific fault, this classification is based on the assumption that if a fault has moved during the Holocene epoch, it is likely to produce earthquakes in the future. Blind thrust faults are fault areas that do not intersect the ground surface, and thus are not classified as active or potentially active in the same manner as faults that are present at the earth's surface. Blind thrust faults are "buried" under the uppermost layers of rock in the crust. The Mount Diablo Thrust Fault is located approximately 12 miles west of the city.

There are no known active or potentially active faults located within the Brentwood Planning Area, including Alquist-Priolo Earthquake Fault Zones. However, there are numerous active faults located in the regional vicinity of Brentwood as shown in Figure 9-1 (Regional Fault Zones). Active and potentially active faults in proximity to the project site are presented in Table 9-1 (Regional Faults and Seismicity). There are four other major faults delineated as Alquist-Priolo Fault Zones between 30 and 50 miles from Brentwood (Hayward fault, West Napa fault, Rodgers Creek fault, and the San Andreas fault).

Table 9-1: Regional Faults and Seismicity

Fault Segment	Approximate Distance from Project Site (miles)	Direction from Site	Maximum Characteristic Magnitude
Calaveras	17.0	Southwest	6.8
Concord - Green Valley Fault	15.0	West	6.9
Greenville - Marsh Creek Fault	8.0	South/Southwest	6.9

Source: City of Brentwood, 2014; ENGEO, 1999.

Calaveras Fault

The 75-mile-long Calaveras fault is located approximately 17 miles southwest from the proposed project site. This fault extends from an intersection with the Paicines fault south of Hollister, through the Diablo Range east of San Jose, and along the Pleasanton-Dublin-San Ramon urban corridor. The fault consists of three major sections: the southern Calaveras fault (from the Paicines fault to San Felipe Lake), the central Calaveras fault (from San Felipe Lake to Calaveras Reservoir), and the northern Calaveras fault (from Calaveras Reservoir to Danville). The timing of the most recent rupture on the northern Calaveras fault is unknown, but is estimated to have occurred several hundred years ago. Seismologic evidence suggests that the southern and central sections may produce earthquakes as large as Magnitude 6.2. Geologic and seismologic data suggest that the northern section may produce earthquakes as large as Magnitude 7.0.

Concord-Green Valley Fault

The Concord-Green Valley fault is located approximately 15 miles northwest from the proposed project site. This fault is a northwest-striking, right lateral strike-slip fault zone that extends from the Walnut Creek area across Suisun Bay and continues to the north. The Concord fault extends approximately 12 miles, from the northern slopes of Mt. Diablo to Suisun Bay. North of Suisun Bay, the Green Valley fault continues to the north about 28 miles. The Concord fault is an actively creeping structure that has a long-term creep rate of approximately 5 mm/yr. It is estimated that rupture of both faults would produce a maximum earthquake of about Magnitude 6.9 with a recurrence interval of approximately 180 years.

Greenville-Marsh Creek

The Greenville-Marsh Creek fault is located approximately 8 miles south/southwest from the proposed project site. This fault is a northwest-striking strike-slip fault of the San Andreas system in the northern Diablo Range, extending from Bear Valley to the east side of Mt. Diablo. This fault has a lower slip rate than other structures within the San Andreas system with a long-term rate of approximately 1 to 3 mm/yr. This fault produced a moderate magnitude earthquake in 1980. Research is currently being conducted on the fault zone to better constrain its slip rate and its history of past earthquakes. A maximum earthquake of Magnitude 6.9 has been estimated to the Greenville-Marsh Creek fault; the recurrence interval is estimated to be about 550 years.

Surface Fault Rupture

Fault rupture is the surface displacement that occurs when movement on a fault deep within the earth breaks through to the surface. The Alquist-Priolo Earthquake Fault Zoning Act delineates fault rupture zones approximately 1,000 feet wide, or 500 feet on either side of an active fault trace. Fault rupture and displacement almost always follows preexisting faults, which are zones of weakness; however, not all earthquakes result in surface rupture (i.e., earthquakes that occur on blind thrusts do not result in surface fault rupture. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep).

In addition to damage caused by ground shaking from an earthquake, fault rupture is also damaging to buildings and other structures due to the differential displacement and deformation of the ground surface that occurs from the fault offset. This leads to damage or collapse of structures across this zone. Fault rupture displacements in large earthquakes can range from several feet to greater than 15 feet (Scharer, 2010).

Groundshaking

An earthquake is classified by the amount of energy released, which traditionally has been quantified using the Richter scale (M_L). However, seismologists most commonly use the Moment Magnitude (M_W) scale because it provides a more accurate measurement of the size of major and great earthquakes. For earthquakes of less than M 7.0, the Moment and Richter Magnitude scales are nearly identical. For earthquake magnitudes greater than M 7.0, readings on the Moment Magnitude scale are slightly greater than a corresponding Richter Magnitude.

The intensity of the seismic shaking, or strong ground motion, during an earthquake is dependent on the distance between the project site and the epicenter of the earthquake, the magnitude of the earthquake, and the geologic conditions underlying and surrounding the project site. Earthquakes occurring on faults closest to the project site would most likely generate the largest ground motion. According to the 1999 ENGEO Geotechnical Exploration Report, an earthquake of moderate to high magnitude generated within the San Francisco Bay Region could cause considerable ground shaking at the project site.

Liquefaction

Liquefaction tends to occur in loose, saturated fine-grained sands, course silts, or clays with low plasticity. The liquefaction process typically occurs at depths less than 50 feet below the ground surface, although liquefaction can occur at deeper intervals, given the right conditions. The most susceptible zone occurs at depths shallower than 30 feet below the ground surface.

For liquefaction to occur, there must be proper soil type, soil saturation, and cyclic accelerations of sufficient magnitude to progressively increase the water pressures within the soil mass. Non-cohesive soil shear strength is developed by the point-to-point contact of the soil grains. As the water pressures increase in the void spaces surrounding the soil grains, soil particles become supported more by water than point-to-point contact. When water pressures increase sufficiently, soil grains lose the strength to hold to each other and the soils begin to liquefy.

Liquefaction can lead to several types of ground failure, depending on slope conditions and the geological and hydrological settings. The four most common types of ground failure are: 1) lateral spreads, 2) flow failures, 3) ground oscillation, and 4) loss of bearing strength.

Landslides

Landslides are gravity-driven movements of earth materials that may include rock, soil, unconsolidated sediment, or combinations of such materials. The primary factors influencing the stability of a slope are the nature of the underlying soil or bedrock, the geometry of the slope (height and steepness), and rainfall. The presence of historic landslide deposits is a good indicator of future landslides. Landslides are commonly triggered by unusually high rainfall and the resulting soil saturation, by earthquakes, or a combination of these conditions.

Within Contra Costa County, the hillsides have some susceptibility for landslides, while the valleys have a low susceptibility (City of Brentwood, 2014). According to the two ENGEO reports prepared in 1990 and 1999 respectively, landslides were present at varying degrees on the project site depending on the slope conditions and time of year. There are approximately 10 landslides previously mapped within the Shadow Lakes portion of the project site. Most of these landslides are not currently active. Within the Deer Ridge portion of the project site, there are 12 landslides and colluvial deposits previously mapped along slopes and within hollows in the hillsides.

Lateral Spreading

Lateral spreading generally is a phenomenon where blocks of intact, non-liquefied soil moves down slope on a liquefied substrate of large areal extent. The potential for lateral spreading is present where open banks and unsupported cut slopes provide a free face (unsupported vertical slope face). Ground shaking, especially when inducing liquefaction, may cause lateral spreading toward unsupported slopes. The greatest potential for lateral spreading in the Brentwood Planning Area is in the hilly terrain to the south and west. According to the two ENGEO reports prepared in 1990 and 1999 respectively, lateral spreading on the project site is unlikely, due to the fact that liquefaction is unlikely.

Soil Expansion

Expansive soils can undergo significant volume change with changes in moisture content. In general, expansive soils shrink and harden when dried, and swell and soften when wetted. Such changes can cause distress to building foundations and structures, slabs on grade, pavements, and other surface improvements. Expansive soils are also generally a major contributing factor to soil creep on slopes. The clayey soil and claystone materials in the area of the project site are considered moderately to highly expansive. Conversely, the sandstone and siltstone bedrock at the site is considered low to non-expansive.

Soils

Soils in the project site are comprised predominantly of sediments and recent alluvium. According to the Natural Resource Conservation Service (NRCS, 2017) and the City of Brentwood General Plan EIR, there are 13 different soil series located in the Brentwood Planning Area. These include the Altamont, Brentwood, Briones, Capay, Delhi, Fontana, Kimball, Linne, Pescadero, Piper, Rincon, Sorrento, and Sycamore series. The project site includes approximately 45.7% Alamont, 22.4% Briones, 16.2% Capay, 1.2% Kimball, <1.0% Linne, 5.4% Pescadero, and 8.2% Rincon soil series. The surface soils in the Shadow Lakes portion of the project site consist predominantly of stiff to very stiff silty clays. These clays have enough strength to support moderate to light weight structures. Heavy structures can be supported on deep foundation systems. The soils at the Deer Ridge portion of the project site consist of residual soil that is made up of dark brown silty and sandy clays, clayey and silty sands; colluvial deposits that consist of dark brown and silty clay with lesser amounts of sand and gravel; and alluvial deposits that consist of unconsolidated sand, silt, gravel, and clay with various amounts of weathered bedrock fragments.

Subsidence

Subsidence in Contra Costa County occurs in the Delta plain and is generally caused by the natural process of oxidation of island peat soils, which result in the gradual sinking of the ground (City of Brentwood, 2014). Most reclaimed portions of the Delta in Contra Costa County have subsided at least 10 feet. According to the 1999 ENGEO Geotechnical Exploration, subsidence is low to unlikely at the Deer Ridge portion of the project site. The soils in the Shadow Lakes portion of the project site were found to be predominantly made up of stiff to very stiff silty clays. Since subsidence depends on the natural processes of soils, very stiff silty clays would not likely result in subsidence within the Shadow Lakes portion of the project site.

Past Mining Activities

Historic records and maps discussed in the two ENGEO reports prepared in 1990 and 1999, respectively, indicate evidence of old coal mining operations in the Deer Ridge and Shadow Lakes sites. Previous coal mining operations in the Shadow Lakes portion of the project site included facilities such as mining shafts, mine tunnels, and kilns that appear to have been limited to two locations near the southeast corner of the site. Field observations of the easternmost coal mine site adjacent to the irrigation canal revealed a caved-in mine shaft and an adjacent brick foundation. At the second mine site, located near Deer Creek Dam, no remaining structures were observed. Also, no tunnels, shafts, or adits[1] were observed at the second mine site. One additional excavation was noted within the hill south of the old homesite, but no improvements or tailing piles associated with mine excavations were observed in the Shadow Lakes site.

Previous mining operations in the Deer Ridge portion of the project site included adits, slopes, and vertical shafts that appear to have occurred in the southwest corner of the Deer Ridge portion of the project site. Mining records show gangways, a hoisting shaft, and a brick kiln occurred in the southeastern corner of the site.

Previous Mitigation for Mining Activities

Subsequent to the 1990 ENGEO Geotechnical Exploration Report for Shadow Lakes, soil remediation was conducted during mass grading activities. Where existing on-site structures were located, excavation to a minimum of 20 feet below finished grades occurred to mitigate potentially unstable site soils and covered existing backfilled mining tunnels with geogrid or filling tunnels with open cavities using cement slurry. These areas included the existing surrounding Shadow Lakes residential subdivision.

[1] An adit is an entrance to an underground mine which is horizontal or nearly horizontal, by which the mine can be entered, drained of water, ventilated, and minerals extracted at the lowest convenient level.

As confirmed in the 2017 ENGEO Technical Memorandum, areas at the Deer Ridge Golf Club where previous known mining activities occurred were mitigated during the original grading of the existing development. Mitigation consisted of excavating to a minimum of 20 feet below finished grades and either covering existing backfilled mining tunnels with geogrid or filling tunnels with open cavities using cement slurry for area where structures would be located. These areas included the surrounding existing residential subdivision. The area for the clubhouse at Deer Ridge was explored prior to building and determined to not contain mine working within 20 vertical feet of the foundation subgrade.

9.4 Applicable Regulations, Plans, and Standards

9.4.1 State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act, Public Resources Code (PRC), section 2621-2630 (formerly the Special Studies Zoning Act), regulates development and construction of buildings intended for human occupancy to avoid the hazard of surface fault rupture. This Act categorizes faults as active, potentially active, and inactive. Historic and Holocene age faults are considered active, Late Quaternary and Quaternary age faults are considered potentially active, and pre-Quaternary age faults are considered inactive. These classifications are qualified by the conditions that a fault must be shown to be “sufficiently active” and “well defined” by detailed site-specific geologic explorations to determine whether building setbacks should be established.

The Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act, PRC, Sections 2690–2699, of 1990 directs the California Department of Conservation, Division of Mines and Geology [now called California Geological Survey (CGS)] to delineate Seismic Hazard Zones. The purpose of the act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards.

Cities, counties, and State agencies are directed to use seismic hazard zone maps developed by CGS in their land-use planning and permitting processes. The act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within seismic hazard zones.

California Building Standards Code

The California Building Code (CBC) is another name for the body of regulations known as the California Code of Regulations (CCR), Title 24, Part 2, which is a portion of the California Building Standards Code and establishes minimum requirements for a building’s structural strength and stability to safeguard the public health, safety, and general welfare. Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under State law, all building standards must be centralized in Title 24 or they are not enforceable.

California Health and Safety Code

Section 19100 et seq. of the California Health and Safety Code establishes the State's regulations for earthquake protection. This section of the code requires structural designs to be capable of resisting likely stresses produced by phenomena such as strong winds and earthquakes.

9.4.2 Local

City of Brentwood General Plan

Project relevant General Plan policies for geology and soils are addressed in this section. Where inconsistencies exist, if any, they are addressed in the respective impact analysis below. Relevant General Plan policies that directly address reducing and avoiding geology and soils impacts include the following:

Safety Goal 1: Protect the Brentwood community from geologic and seismic hazards.

- Policy SA 1-1: Regulate development in areas of seismic and geologic hazards to reduce risks to life and property associated with earthquakes, liquefaction, erosion, landslides, and expansive soils.
- Policy SA 1-2: Where feasible, require new development to avoid unreasonable exposure to geologic hazards, including earthquake damage, subsidence, liquefaction, and expansive soils.
- Policy SA 1-3: Ensure that all new development and construction is reviewed by the City to ensure conformance with applicable building standards related to geologic and seismic safety.
- Policy SA 1-6: Development in areas subject to liquefaction shall be reviewed by qualified soils engineers and geologists prior to development in order to ensure the safety and stability of all construction.
- Policy SA 1-7: Prevent land subsidence and maintain adequate groundwater supplies.
- Policy SA 1-8: Where alterations such as grading and tree or vegetation removal are made to hillside sites, rendering slopes unstable, planting of vegetation or other engineering means shall be encouraged to protect structures at lower elevations.
- Policy SA 1-10: An erosion and sediment control plan prepared by a civil engineer, or other professional who is qualified to prepare such a plan, shall be submitted as part of any grading permit application for new development. The erosion and sediment control plan shall delineate measures to appropriately and effectively minimize soil erosion and sedimentation, and shall comply with the design standards and construction site control measures contained in Chapter 15.52 (Grading, Erosion and Sediment Control) of the Brentwood Municipal Code.
- Policy SA 1-11: All structures and building foundations located within areas containing expansive soils shall be designed and engineered to comply with the most current version of the California Code of Regulations (CCR), Title 24.

Brentwood Municipal Code

Chapter 17.680 of the Brentwood Municipal Code establishes uniform limitations, safeguards, and controls for the present operation of and future drilling for and production of oil, gas, and other hydrocarbon substances within the city, so that such activities may be conducted in harmony with other uses of land within the city, thus protecting the people of the city in the enjoyment and use of their property and providing for their comfort, health, safety, and general welfare.

9.5 Environmental Impacts and Mitigation Measures

9.5.1 Significance Criteria

The State CEQA Guidelines provide guidance in evaluating impacts of projects on geology and soil resources and determining which impacts will be significant. The Act defines "significant effect on the environment" as "a substantial adverse change in the physical conditions which exist in the area affected by the proposed project." Under State CEQA Guidelines Section 15065, a project's effects on geologic and soil resources are deemed significant if the project would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
  - Strong seismic ground shaking.
  - Seismic-related ground failure, including liquefaction.
  - Landslides.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

9.5.2 Impacts of the Proposed Project

Impact GEO-1: Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: rupture of a known earthquake fault; strong seismic ground shaking; seismic-related ground failure including liquefaction; and landslides.

Rupture of Known Earthquake Fault

There are no known active or potentially active faults located within the project site, including Alquist-Priolo Earthquake Fault Zones. Since there are no known active faults crossing the project site and the property is not within an Earthquake Fault Specialty Study Zone, the likelihood of primary ground rupture in the project area is considered low. In addition, the applicant would be required to conform to the California Building Standards Code and the California Health and Safety Code for all structures proposed as part of the project, including the golf cart bridge. The building and safety standards established by these codes have been developed to address structural integrity during a seismic event. As a result, the proposed project would not expose people or structures to potential risk of loss or injury where there is high potential for earthquake-related ground rupture in the vicinity of major fault crossings. Any potential impacts would therefore be less than significant.

Strong Seismic Ground Shaking

Moderate to severe earthquakes can cause strong ground shaking, especially for most locations within the San Francisco Bay Area. According to the 1999 ENGEO Geotechnical Exploration Report conducted for the existing Deer Ridge and Shadow Lakes sites, an earthquake of moderate to high magnitude in the San Francisco Bay Area would cause considerable shaking at the project site. To mitigate ground shaking effects, all structures, including the golf cart bridge would be designed using sound engineering practices and the requirements contained in the current adopted version of the CBC. Any buildings constructed within the project site would be required to comply with CBC requirements, which require development projects to perform geotechnical investigations in accordance with State law, engineer improvements to address potential seismic and ground failure issues, and to use earthquake-resistant construction techniques to address potential earthquake loads when constructing buildings and improvements. As a result, impacts associated with strong seismic ground shaking would be less than significant.

Seismic-Related Ground Failure, Including Liquefaction, Lateral Spreading, and Earth Cracking

As discussed previously, while there are no known active or potentially active faults or Alquist-Prolo Earthquake Fault Zones located within the project site, there are numerous faults located in the region. Rupture of any of these faults, or of an unknown fault in the region, could cause seismic ground shaking, which could result in the risk, loss, or death of people or structures. As a result, future development within the project site may expose people or structures to potential adverse effects associated with a seismic event, including strong ground shaking and seismic-related ground failure.

As stated previously, the risk of liquefaction is considered low at both the Deer Ridge and Shadow Lakes sites, based on the material types and densities of granular materials encountered in the test borings. In addition, any buildings constructed within the project site would also be required to comply with CBC requirements, which require development projects to perform geotechnical investigations in accordance with State law, engineer improvements to address potential seismic and ground failure issues, and to use earthquake-resistant construction techniques to address potential earthquake loads when constructing buildings and improvements, including the proposed golf cart bridge (City of Brentwood, 2014).

Mitigation Measure (MM) GEO-1 (Geotechnical Report) would require the applicant to consult with a registered geotechnical engineer to prepare a design-level geotechnical investigation for the project site. The design-level geotechnical report would be required to address site preparation, grading, building foundations, and CBC seismic design parameters. Therefore, with implementation of MM GEO-1, impacts associated with seismic-related ground failure would be less than significant. To reduce the potential impacts associated with seismic-related ground failure, including liquefaction, lateral spreading, and earth cracking, all recommended remedial grading measures in the ENGEO reports dated April 6, 1990 and June 10, 1999 shall be implemented or updated, as identified in MM GEO-1.

Landslides

Within Contra Costa County, the hillsides have some susceptibility for landslides, while the valleys have a low susceptibility. As discussed in Section 9.3, there are 10 landslides mapped within the proposed project site. However, most of these landslides are not currently active. According to the two ENGEO reports, existing landslides would require corrective grading including keyways, subsurface drains, and possibly buttress fill to be stabilized as development is planned in the vicinity.

As a result, impacts associated with landslides would be potentially significant. To reduce the potential impacts associated with landslides, all recommended remedial grading measures in the ENGEO reports dated April 6, 1990 and June 10, 1999 shall be implemented. Refer to MM GEO-1.

Mitigation Measures

MM GEO-1: **The applicant shall prepare a design-level geotechnical investigation and a final geotechnical report with site-specific recommendations, which must be reviewed and approved by the City of Brentwood prior to issuance of any grading permit. All recommended remedial grading measures identified in the ENGEO reports dated April 6, 1990 and June 10, 1999 shall be updated to reflect current building code requirements, and be implemented unless alternative techniques developed by a certified geotechnical engineer or engineering geologist are identified as part of the final geotechnical report.**

Prior to any excavation activities and/or the placement of fill on the Deer Ridge and Shadow Lakes sites, the project applicant shall retain a registered geotechnical engineer to prepare a design-level geotechnical investigation. The design-level geotechnical report shall address, but not be limited to, site preparation and grading, evaluation of subgrade soils, building foundations, CBC seismic design parameters, and the need for conducting any additional subsurface explorations to determine foundation types.

The design-level geotechnical report shall be prepared and submitted in conjunction with building permit applications and reviewed and approved by the City of Brentwood. Recommendations from the design-level geotechnical report shall be incorporated into the final project design and construction documents for each phase of the proposed project.

Implementation of this mitigation measure would reduce impacts associated with the exposure of people and/or structures to potential substantial adverse effects from geological hazards to less-than-significant levels.

Impact GEO-2: Would the project result in substantial soil erosion or the loss of topsoil.

According to the Brentwood General Plan Update EIR, erosion potential of the soils within the Brentwood Planning Area is considered low in most locations due to the generally flat topography and the cohesive nature of the soils. The proposed Deer Ridge and Shadow Lakes portions of the project site are generally flat and would have a very slight potential for soil erosion. However, buildout of the proposed project would involve construction-related activities and during the early stages of construction, topsoil would be exposed due to grading and leveling of the project site. As a result, once grading and leveling is complete but prior to overlaying the ground surface with structures, the potential exists for wind and water erosion to occur, which could affect project site soils, causing a potentially significant impact.

Projects involving disturbance of one acre or more are required to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) that specifies how water quality would be protected during construction activities. The SWPPP would include best management practices (BMPs) to protect the quality of stormwater runoff. Construction BMPs would include, but are not limited to, stabilization of construction entrances, straw wattles on embankments, and sediment filters on existing inlets. These measures would minimize erosion, protect exposed slope areas, control surface water flows over exposed soils, and implement a sediment monitoring plan.

Therefore, the project applicant would be required to prepare preliminary erosion control plans that include stabilization of construction entrances, straw wattles on embankments, and sediment filters on existing inlets. These measures would be further refined with the subsequent preparation of a SWPPP to ensure compliance with the erosion control ordinances required by the City of Brentwood. As a result, impacts associated with soil erosion and loss of topsoil would be less than significant. Refer to Chapter 12 (Hydrology and Water Quality), Section 12.5.2.

Impact GEO-3: Would the project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

As described in the 1999 Geotechnical Exploration Report, 18 test borings were drilled by ENGEO on the Deer Ridge Golf Club site in preparation for construction of the existing development. The borings were drilled to depths ranging between 10.5 and 36.5 feet below existing ground surface. Afterwards, all borings were backfilled with cement grout on the day of drilling in accordance with Contra Costa County Environmental Health requirements. Borings were logged in the field by a registered geologist of ENGEO.

The 1990 Geotechnical Exploration Report discusses the 17 test borings drilled by ENGEO on the existing Shadow Lakes Golf Club site. The test borings were drilled using truck-mounted continuous flight auger equipment, and were drilled under the direction of a ENGEO staff engineer who logged the soil and rock materials encountered and obtained relatively undisturbed samples for visual classification and laboratory testing.

Based on the results of these test borings, the potential risk of landslide, lateral spreading, subsidence, liquefaction, and collapse as a result of the proposed project are summarized below.

Landslides

According to the two ENGEO reports prepared in 1990 and 1999 respectively, the risk of landslides is present at varying degrees on the project site depending on the slope conditions and time of year. There were approximately 10 landslides previously mapped within the Shadow Lakes portion of the project site and 12 landslides previously mapped within the Deer Ridge portion of the project site. However, most of these landslides are not currently active. As discussed in Impact GEO-1, existing landslides would require corrective grading including keyways, subsurface drains, and possibly buttress fill to be stabilized as development is planned in the vicinity. To reduce the potential impacts associated with landslides, Mitigation Measure GEO-1 requires a geotechnical investigation report that includes updates to all recommended remedial grading measures in the ENGEO reports dated April 6, 1990 and June 10, 1999. With implementation of this measure, impacts would be less than significant.

Subsidence

According to the 1999 Geotechnical Exploration Report prepared by ENGEO, the risk from subsidence is considered low to unlikely within the Deer Ridge portion of the project site. As discussed in Section 9.3, the surface soils consist predominantly of stiff to very stiff silty clays, which have enough strength to support moderate to light weight structure. Because subsidence depends on the natural processes of soils, very stiff silty clays would not likely result in subsidence in either the Shadow Lakes or Deer Ridge portions of the project sites and impacts would be less than significant.

Liquefaction and Lateral Spreading

According to the ENGEO reports prepared in 1990 and 1999 respectively, the risk of liquefaction is considered low within both the Deer Ridge and Shadow Lakes portions of the project site, based on the material types and densities of granular materials encountered in the test borings. The different types of ground failure associated with liquefaction often leaves geomorphic evidence after the event in the form of scarps, and open or unfilled groups cracks, and sand volcanoes. According to the previously prepared geotechnical reports, the proposed project site does not appear to have experienced liquefaction historically, as no liquefactions or lateral spreading was reported.

In addition, Mitigation Measure GEO-1 requires a geotechnical investigation report that includes updates to all recommended remedial grading measures in the ENGEO reports dated April 6, 1990 and June 10, 1999.With implementation of this measure, impacts would be less than significant.

Collapse

Subsequent to the preparation of the 1990 ENGEO Geotechnical Exploration Report for Shadow Lakes, mass grading occurred there and remediation with previous mining activity was performed. Where existing on-site structures are located on the Shadow Lakes portion of the project site, excavation to a minimum of 20 feet below finished grades occurred to mitigate potentially unstable site soils and covered existing backfilled mining tunnels with geogrid or filling tunnels with open cavities using cement slurry. These areas included the existing surrounding Shadow Lakes residential subdivision. Remediation was focused on areas where building structures would be placed. As a result, no further mitigation is necessary within the Shadow Lakes portion of the project site.

The area for the existing clubhouse within the Deer Ridge portion of the project site was explored prior to construction of the clubhouse. This exploration determined there were no working mines within 20 vertical feet of the basement subgrade. The recommendations identified in the 1999 ENGEO Geotechnical Exploration Reports would still be applicable and would be required for all areas not remediated during the previous grading activities. MM GEO-2 below requires a qualified Engineering Geologist and a Geotechnical Engineer to seal and repair old coal mining voids in areas subject to potential collapse within the Deer Ridge portion of the project site not previously repaired prior to any construction. Impacts could be potentially significant.

Mitigation Measure

MM GEO-2: Prior to issuance of a grading permit for any development associated with the Deer Ridge portion of the project site, the project applicant shall retain an

Engineering Geologist and Geotechnical Engineer to review proposed building footprints to validate or modify the recommendations as stated for the 1999 ENGEO Geotechnical Exploration Report and new development underlain by old coal mining voids be sealed and repaired should mines be located.

Prior to any excavation activities and/or the placement of fill on the Deer Ridge site, a certified geotechnical engineer shall be retained by the project applicant to evaluate subgrade soils, including any additional subsurface explorations, to determine final foundation types. Additionally, as recommended in the 2017 ENGO Technical Memorandum, building footprint areas for the proposed structures should be explored prior to construction to confirm that no mines are located under the proposed structures. Final techniques shall be (a) developed by the certified geotechnical engineer and (b) reviewed by the City prior to issuance of a grading permit.

Prior to issuance of any grading permits in the areas subject to potential collapse within the Deer Ridge portion of the project site, the project applicant shall retain and Engineering Geologist and the Geotechnical Engineer to seal and repair old coal mining voids not previously repaired during site construction of the two golf courses, subject to review by the City of Brentwood. The preferable form of repair in areas of shallow voids would be to subexcavate and recompact or remove by cut. Special foundation treatment may be necessary in areas adjacent to the hoisting slopes should structure be located in the project area. Treatment may include subexcavation, placement of a steel or concrete system to seal off the hoisting slope at a certain depth, followed by placement and compaction of fill to necessary grades.

With implementation of MM GEO-2, and completion of remedial activities, impacts associated with potential collapse would be less than significant.

Impact GEO-4: Would the project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.

According to the 1999 ENGEO Geotechnical Exploration reports, the expansive nature of the native soil and claystone bedrock is of significant geotechnical concern in the region. The clayey soil and claystone materials in the vicinity of the project site are considered moderately to highly expansive. Conversely, the sandstone and siltstone bedrock at the project site is considered low to non-expansive. However, future development on the project site would be subject to existing CBC regulations and provisions, as adopted in Chapter 15.04.010 of the City of Brentwood Municipal Code and enforced by the City during plan review prior to building permit issuance.

In addition, the Safety Element of the General Plan establishes policies and actions that are designed to protect people and structures from geologic hazards, including expansive soils. Implementation of MM GEO-1 (Geotechnical Report) and consistency with the General Plan policies and actions would require that a site-specific design-level geotechnical investigation be prepared by a licensed professional, and submitted to the City for review and confirmation prior to construction. This design-level geotechnical investigation would identify the potential for damage related to expansive soils and non-uniformly compacted fill and engineered fill. If a risk is identified, design criteria and specification options may include removal of the problematic soils, and replacement, as needed, with properly conditioned and compacted fill material that is designed to withstand the forces exerted during the expected shrink-swell cycles and settlements.

Design criteria and specifications set forth in the design-level geotechnical investigation would ensure impacts from problematic soils are minimized. As a result, with implementation of MM GEO-1 (Geotechnical Report) and compliance with City ordinances and policies, impacts associated with expansive soils would be reduced to less-than-significant levels.

Impact GEO-5: Would the project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

The proposed project would involve disposal of wastewater through the City's existing sanitary sewer system, and there would be no septic systems constructed as part of the project. Therefore, no impacts would occur.

9.5.3 Cumulative Impact Analysis

Because geologic impacts are site-specific and highly dependent upon the structural characteristics of individual projects, cumulative geologic hazards and soils impacts are generally confined to the project site and immediate vicinity.

Impact GEO-6: Would the project contribute to cumulatively considerable effects on geology and soils.

Most geologic-related impacts from development are site-specific and, if properly designed, would not result in worsening of the environment or public health and safety. Cumulative development would be subject to site-specific geologic and/or soils constraints; pursuant to the City of Brentwood requirements, a registered geotechnical engineer would investigate site-specific conditions and minimize exposure to hazards or constraints with implementation of their recommendations.

Cumulative development would also involve the exposure of an increased number of people and/or structures to the risk of earthquakes and their associated geologic hazards. However, new construction would be required to comply with the most current CBC, which establishes building standards to minimize risk based on the geologic and seismic conditions of the region in which a project is located.

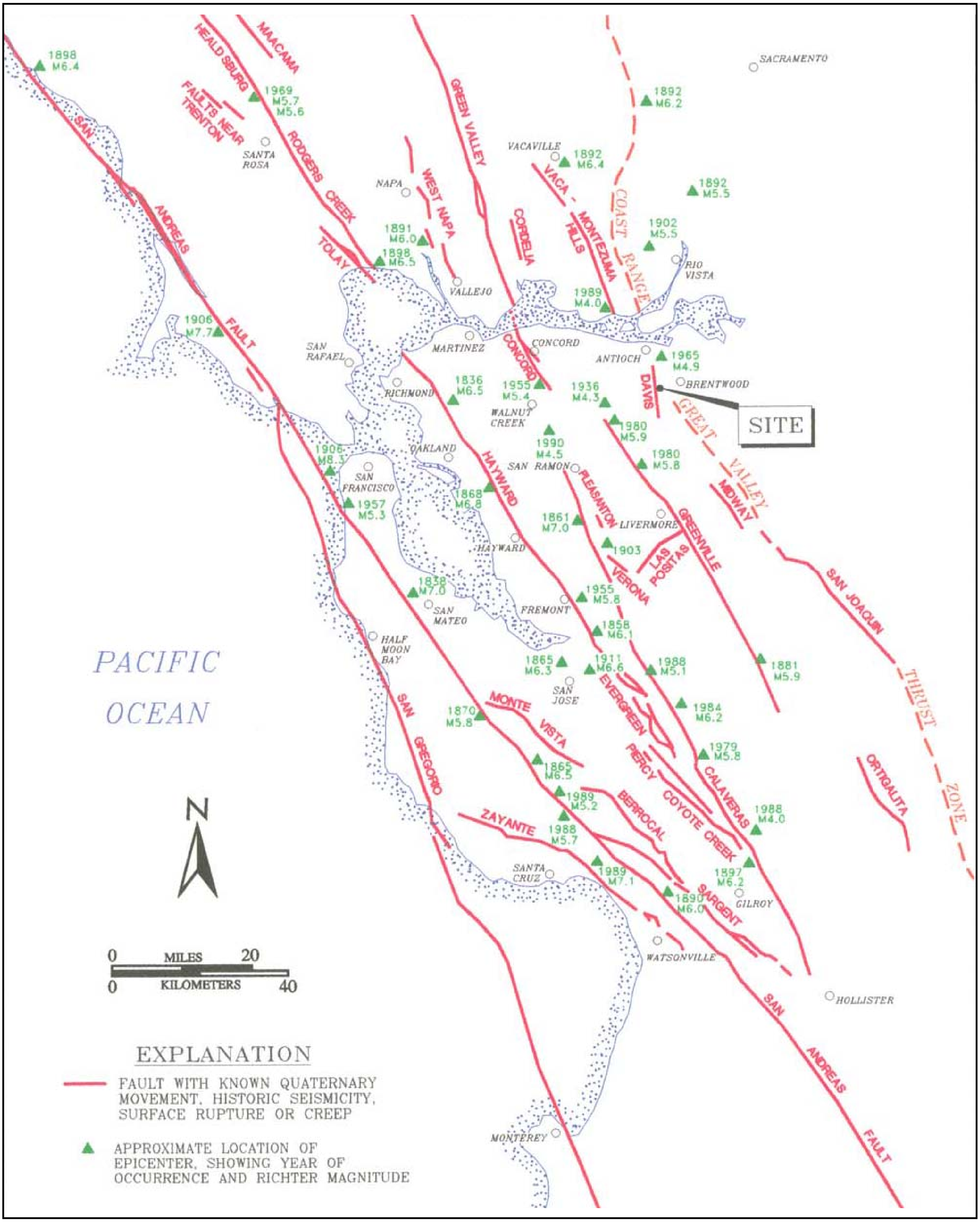
With administration of these requirements, the implementation of Mitigation Measure MM GEO-1, and adherence to CBC requirements, cumulative geologic and soils impacts would be less than significant.

9.5.4 Level of Significance after Mitigation

Table 9-2 (Summary of Impacts and Mitigation Measures – Geology and Soils) summarizes the environmental impacts, significance determinations, and mitigation measures for the project with regards to geology and soils.

Table 9-2: Summary of Impacts and Mitigation Measures – Geology & Soils

Impact	Impact Significance	Mitigation
Impact GEO-1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: rupture of a known earthquake fault; strong seismic ground shaking; seismic-related ground failure including liquefaction; landslides; soils erosion or loss of top soil.	Less than Significant with Mitigation	MM GEO-1: Implement Geotechnical Report and Recommendations
Impact GEO-2: Result in substantial soil erosion or the loss of topsoil.	Less than Significant	None required.
Impact GEO-3: Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.	Less than Significant with Mitigation	MM GEO-1: Implement Geotechnical Report and Recommendations MM GEO-2: Seal and Repair Old Mining Voids
Impact GEO-4: Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.	Less than Significant with Mitigation	MM GEO-1: Implement Geotechnical Report and Recommendations
Impact GEO-5: Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.	No Impact	None required.
Impact GEO-6: Contribute to cumulatively considerable effects on geology and soils.	Less than Significant with Mitigation	MM GEO-1: Implement Geotechnical Report and Recommendations



Source: ENGEO, 1999

Figure 9-1: Regional Fault Zones

Deer Ridge & Shadow Lakes Community Improvement Plan

N Not to scale

This page intentionally left blank.

9.6 References

California Geological Survey (CGS). 1999. *Fault Rupture Hazard Zones in California, CGS Special Publication #42*. Available at: ftp://ftp.consrv.ca.gov/pub/dmg/pubs/sp/Sp42.pdf. Accessed August 8, 2017.

_____. 2002a. California Geomorphic Provinces. *Geological Note 36.* Available at: http://www.conservation.ca.gov/cgs/information/publications/cgs_notes/note_36/Documents/note_36.pdf. Accessed August 8, 2017.

_____. 2002b. *The Revised 2002 California Probabilistic Seismic Hazard Maps, Appendices A and B, 2002 California Fault Parameters*. Available at: http://www.conservation.ca.gov/cgs/rghm/psha. Accessed August 7, 2017.

City of Brentwood. 2014. *General Plan*. Prepared by De Novo Planning Group.

City of Brentwood. 2014b. *Public Draft Environmental Impact Report for the 2014 Brentwood General Plan Update*. Prepared by De Novo Planning Group.

ENGEO Incorporated. 1990. *Geotechnical Exploration for EIR Report: Brentwood Golf Course Development.*

_____. 1999. *Geotechnical Exploration: Deer Creek Country Club – Unit 2.*

_____. 2017. Technical Memorandum, Geotechnical Considerations and Foundation Recommendations Update, Deer Ridge Golf Club. November 27, 2017.

NRCS. 2017. *Soil Survey of Contra Costa County, California*. Available at: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. Accessed August 4, 2017.

United States Geological Survey (USGS). 2010a. *Earthquake Hazards Program, National Seismic Hazard Map*. Available at: http://earthquake.usgs.gov/hazards/. Accessed August 8, 2017.

This page intentionally left blank.