F. GEOLOGY, SOILS AND SEISMICITY

This section describes the project site’s geologic environment based on a site reconnaissance, published and unpublished geologic reports and maps, and site-specific technical reports. In addition, this section assesses potential impacts from fault rupture, ground shaking, liquefaction, slope failure, lateral slope deformation, differential settlement, and unstable or expansive soils. Feasible mitigation measures are provided for significant impacts.

1. Setting

A description of the geologic and seismic conditions, seismic hazards, and regulatory setting is found below.

a. Geologic Conditions. The geology, topography and soils of the project site and vicinity are described below.

   (1) Geology. The project is located at the eastern edge of the Coast Ranges Geomorphic Province, just northwest of the Sacramento-San Joaquin Delta region of the Great Valley Geomorphic Province of California. The Coast Ranges province is a relatively geologically young and seismically-active region at the western margin of the North American plate. The regional structure of the Coast Ranges consists of northwest trending folds and faults created by the tectonic setting of colliding plate boundaries and subsequent transitional shear along the San Andreas Fault Zone (SAFZ). As a result, northwest-southeast trending ranges of low mountains and intervening valleys dominate this region. In general, the Coast Ranges are composed of sedimentary bedrock with layers of recent alluvium fill the intervening valleys.\(^1\) The project site is located at the eastern edge of an east dipping (down-sloping) uplifted range of low mountains that is defined by the Green Valley fault to the east and Napa Valley to the west. At the site, the bedrock west of the Green Valley fault consists of the Panoche formation of the Great Valley Sequence. Great Valley Sequence rocks consist primarily of marine sediments; massive mudstone or claystone, interbedded with sandstone, siltstone and shale. Conglomerates are mapped in places within the Great Valley Sequence and may be present on the project site. The lower portions of the formation contain volcanic flows, tuff beds (volcanic ash) and chert in places.\(^2\) The layering of the bedrock in the eastern flank of the ridge above Villages A and B generally strike\(^3\) north-northwest and dip between five and 25 degrees to the east. On a smaller scale within the project area, bedding orientation varies due to small-scale faults and folds, and landslide-related deformations.\(^4\)

   (2) Topography. The project is located in the foothills of the Vaca Mountains, just west of the Suisun Valley which trends to the southeast towards Suisun Bay. The project site is gently to steeply rolling with an elevation of approximately 100 to 415 feet National Geodetic Vertical Datum

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\(^1\) California Geographic Survey (CGS), 2002. *California Geomorphic Provinces, Note 36*.


\(^3\) Note: Strike is the direction of a horizontal line drawn upon an inclined plane. It lies at a right angle to the direction of dip (or slope) of the plane.

(NGVD). The site topography has been somewhat modified from its original form by preliminary grading performed as part of the work associated with the originally-approved tentative map, but generally is upslope to the west with a series of shallow, incised gullies and slope failures, both historic and recent.

(3) Soils. Surface soils at the project site are mapped by the Natural Resource Conservation Service (NRCS) as approximately 64 percent Dibble-Los Osos Clay Loams of 9 to 50 percent slope, which are prone to high shrink-swell hazards, have low soil strength, and are moderately corrosive to concrete and uncoated steel. Approximately 33 percent of the site is mapped as Rincon Clay Loam on 2 to 9 percent slope, which is characterized as having medium strength, medium compressibility, high shrink-swell potential, and moderate to high corrosivity. The remaining portion of the site is mapped as ‘borrow pit,’ and soil properties are not defined for this area.

A site-specific geotechnical report has been prepared for the project site and notes that the site bedrock is typically mantled with 3 to 5 feet of residual soil on bedrock, which typically produces a fine-grained, expansive, clay-based soil. These surficial soils have accumulated as colluvium in swales and at the bases of slopes. Other surface features within the project site include debris fan deposits formed from earthflows and slopewash, and near American Canyon Creek, alluvial deposits consisting of interbedded layers of silty clay, clayey gravel and clayey sand. In addition, during the grading operations of 1999, engineered fill operations were begun and limited amounts of engineered fill was placed on the site.

b. Seismic Conditions. The entire San Francisco Bay Area is located in a region of active seismicity. The seismicity of the region is primarily related to the San Andreas Fault Zone (SAFZ), a complex of active faults forming the boundary between the North American and the Pacific plates. Historically, numerous moderate to strong earthquakes have been generated in northern California by several major faults and fault zones in the SAFZ system. The level of active seismicity results in classification of the San Francisco Bay Area as seismic risk Zone 4 (the highest risk category) in the California Building Code.

The severity of an earthquake is measured by magnitudes and intensities. Magnitude is a measure of the energy released by an earthquake. Intensity is a subjective measure of the perceptible effects of an earthquake at a given point and varies with distance from the epicenter and local geologic conditions. The Modified Mercalli Intensity Scale (MMI) is the most commonly used scale for measurement of the subjective effects of earthquake intensity and is shown in Table IV.F-1. Intensity can also be quantitatively measured using accelerometers (strong motion seismographs) that record ground acceleration at a specific location. Acceleration is measured as a fraction or percentage of the acceleration of gravity (g).

(1) Regional Seismicity. The SAFZ includes numerous faults found by the California Division of Mines and Geology under the Alquist-Priolo Earthquake Fault Zoning Act (A-PEFZA) to be

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5 USGS, 1951 revised 1980, Cordelia Quadrangle 7.5 Minute Topographic Map.
Table IV.F-1: Modified Mercalli Intensity (MMI) Scale

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Not felt except by a very few under especially favorable circumstances.</td>
</tr>
<tr>
<td>II</td>
<td>Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.</td>
</tr>
<tr>
<td>III</td>
<td>Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.</td>
</tr>
<tr>
<td>IV</td>
<td>During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.</td>
</tr>
<tr>
<td>V</td>
<td>Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.</td>
</tr>
<tr>
<td>VI</td>
<td>Felt by all, many frighten and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.</td>
</tr>
<tr>
<td>VII</td>
<td>Everybody runs outdoors. Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.</td>
</tr>
<tr>
<td>VIII</td>
<td>Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.</td>
</tr>
<tr>
<td>X</td>
<td>Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (stopped) over banks.</td>
</tr>
<tr>
<td>XII</td>
<td>Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted.</td>
</tr>
</tbody>
</table>


“active” (i.e., to have evidence of surface rupture in the last 11,000 years). The A-PEFZA active faults in the region include the Concord-Green Valley (CGV), Cordelia, West Napa, Rodgers Creek, Hayward, Calaveras, Greenville, and San Andreas faults. The CGV crosses the eastern portion of the project site and the Cordelia Fault is about 1 mile east of the site; both trend approximately north to south. It is possible that the Cordelia is a branch of, or a ‘step over’ of the larger CGV fault. The Vaca Fault has been mapped about 7 miles east of the project site. That fault is not recognized as having evidence of surface rupture within the last 11,000 years. However, there is evidence of

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displacement of late Pleistocene deposits (less than 700,000 years old). Therefore, that fault is considered to be “potentially active”.

The U.S. Geological Survey’s Working Group on California Earthquake Probabilities estimated that there is a 62 percent probability that a 6.7 or greater magnitude earthquake will occur in the San Francisco Bay Area between 2002 and 2031. The probability of a 6.7 magnitude or greater earthquake occurring along individual faults was estimated to be 21 percent along the San Andreas Fault, 27 percent along the Hayward-Rodgers Creek Fault, 11 percent along the Calaveras Fault, 4 percent along the Concord-Green Valley Fault, and 3 percent on the Greenville Fault.

The A-PEFZA maps faults that manifest surface rupture; however, there are other seismic sources in the region. The Coast Range-Sierran Block Boundary (CRSBB) forms the western geomorphic boundary of the Central Valley with the Coast Ranges to the west. A seismically active fold and thrust belt underlies this actively deforming boundary. The CRSBB is currently recognized as a potential seismic source capable of generating moderate earthquakes that could affect the project areas. Eleven moderate earthquakes (magnitude 5.8 to 6.8) have been documented along the CRSBB zone during the last 150 years. Specifically, the Great Valley thrust fault system is located about 15 miles to the east of the project. Representative earthquakes of the Great Valley thrust fault include the Winters (1892, M6.25), Vacaville (1892, M6.5), Antioch (1889 M6.25) and the more recent 1983 Coalinga (M6.7) event.

(2) Site-Specific Seismicity. The A-PEFZA fault zone for the active CGV fault has been mapped indicating a potential for fault rupture hazard at this location as shown in Figure IV.F-2. The CGV is considered capable of generating a moment magnitude (Mw) 6.7 or greater earthquake and the estimated probability of such an event is 4 percent. An earthquake of this magnitude on

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14 Moment magnitude (MW) is now commonly used to characterize seismic events as opposed to Richter Magnitude. Moment magnitude is determined from the physical size (area) of the rupture of the fault plane, the amount of horizontal and/or vertical displacement along the fault plane, and the resistance to rupture of the rock type along the fault.
16 Magnitudes prior to 1898 given as ‘adjusted intensity magnitude’, a subjective rating based on historical description.
18 California Division of Mines and Geology (CDMG), 1993. Special Studies Zone Map of the Cordelia Quadrangle.
FIGURE IV.F-1

Regional Faults

LEGEND

ACTIVE FAULT -
FAULT HAS EVIDENCE OF SURFACE
DISPLACEMENT WITHIN THE PAST
11,000 YEARS (DASHED WHERE INFERRED)

POTENTIALLY ACTIVE FAULT -
FAULT HAS EVIDENCE OF SURFACE DISPLACEMENT
IN THE PAST 1.6 MILLION YEARS, BUT NOT WITHIN
THE PAST 11,000 YEARS

SEISMIC SOURCE WITHOUT SURFACE RUPTURE

is characterized by a zone of discontinuous faulting approximately one-half of a mile wide where it intersects the site. The CGV fault offset, as measured at Red Top Road, has averaged 4.9 millimeter (mm) per year over the last 18 years, and the anticipated ongoing slip rate is 5.0 mm +/- 3.0 mm per year. The CGV fault is made up of three segments totaling approximately 30 miles in length.20

The 1991 Preliminary Geotechnical Exploration by Engeo, Inc.21 as well as subsequent site-specific studies and plans, rely on evidence from several sources to locate the traces of the Green Valley Fault found at the site. Those sources include a separate fault location study undertaken in 1991 by Engeo, Inc. for the vicinity north of the site, and local studies by Brant (1981), Kleinfelder and Associates (1985), and Geomechanics (1978), as well as onsite evidence of faulting discovered during fieldwork. The tentative map22 for the project site indicates the fault traces along the eastern portion of the project site and shows that these relatively low lying areas would be used for the location of detention ponds and wetland mitigation areas, with housing off-set at least 50 feet from the mapped active fault traces. State regulations require that structures for human habitation not be built within 50 feet of an active fault trace (one that has shown surface displacement during the last 11,000 years).23 Human occupancy is defined as:

A “structure for human occupancy” is any structure used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year.24

c. **Seismic and Geologic Hazards.** Seismic and geologic hazards specific to the project site are discussed below.

1. **Surface Rupture.** Surface rupture occurs when the ground surface is broken due to fault movement during an earthquake. Surface rupture generally occurs along an active or potentially active major fault trace. The A-PEFZA required the delineation of active faults in the State and delineation of Special Study Zones surrounding active fault traces where detailed geological investigations would be required if development is proposed.25 An Alquist-Priolo Earthquake Fault Zone has been mapped across the eastern portion of the project site, as shown in Figure IV.F-2,26 therefore, fault rupture hazards are present at the project site.

2. **Ground Shaking.** Ground shaking is a general term referring to the motion of the earth’s surface resulting from an earthquake, and is normally the major cause of damage in seismic events. The extent of ground shaking is controlled by the magnitude and intensity of an earthquake, distance from the epicenter, and local geologic conditions.

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23 California Department of Conservation (CDC), as revised 1999. *Alquist-Priolo Earthquake Fault Zoning Act, Supplements 1&2, Specific Criteria for Lead Agencies (Sec. 3603)*, Special Publication 42.
24 CDC, 1999. op. cit.
25 CDC, 1999. op. cit.
26 CDC, 1999. op. cit.
Location of Geologic Cross Section, See Figure IV.F-3A

SOURCE: ISAKSON & ASSOC., INC. 2007; ENGO, INC., 2002, SUPPLEMENTAL GEOFICAL EXPLORATION (VOL. 1 OF 2); CALIF. DEPT. OF CONSERVATION, 1993, SPECIAL PUBLICATION 42: FAULT-RUPTURE HAZARD ZONES, CORDELLA QUADRANGLE

FIGURE IV.F-2
Fieldcrest Villages EIR
Geological Conditions Within and in the Vicinity of the Project Site
Estimates of the peak ground acceleration have been made for California based on probabilistic models that account for multiple seismic sources. Under these models, consideration of the probability of expected seismic events is incorporated into the determination of the level of ground shaking at a particular location. The expected peak horizontal acceleration (with a 10 percent chance of being exceeded in the next 50 years) generated by any of the seismic sources potentially affecting the project area, is estimated by the California Geological Survey as 0.57 for the project site.\(^27\) This level of ground shaking is a potentially significant hazard.

(3) **Liquefaction and Lateral Spreading.** Liquefaction is the temporary transformation of loose, saturated granular sediments from a solid state to a liquefied state as a result of seismic ground shaking. In the process, the soil undergoes transient loss of strength, which commonly causes ground displacement or ground failure to occur. Since saturated soils are a necessary condition for liquefaction, soil layers in areas where the groundwater table is near the surface have higher liquefaction potential than those in which the water table is located at greater depths.

The California Geologic Survey’s Seismic Hazards Mapping project does not include the project site; however, seismic hazard potential for the site is available from other sources. The Association of Bay Area Governments (ABAG) regional seismic hazard mapping project identifies the vicinity of the project site as an area of very low to moderate level of susceptibility to liquefaction.\(^28\) Site-specific boring and test pit data indicates that loose saturated sands were not encountered at the project site, and therefore the risk of liquefaction is unlikely.\(^29\)

Lateral spreading is a form of horizontal displacement of soil toward an open channel or other “free” face, such as an excavation boundary. Lateral spreading can result from either the slump of low cohesion unconsolidated material or more commonly by liquefaction of either the soil layer or a subsurface layer underlying soil material on a slope.\(^30\) Earthquake shaking leading to liquefaction of saturated soil can result in lateral spreading where the soil undergoes a temporary loss of strength.

The project site topography is flat to moderately steep. The project site is adjacent to a creek, but otherwise significant bodies of open water or creeks are absent. The lateral spreading hazard will tend to mirror the liquefaction hazard, and by definition needs an open channel or “free” face to expand into; this can include temporary channels resulting from the construction process. The geotechnical investigations for the project site evaluated the liquefaction hazards to be low; therefore the risk of lateral spreading would be low.

(4) **Expansive Soils.** Expansion and contraction of volume can occur when expansive soils undergo alternating cycles of wetting (swelling) and drying (shrinking). During these cycles, the volume of the soil changes markedly. As a consequence of such volume changes, structural damage to building and infrastructure may occur if the potentially expansive soils were not considered in project


design and during construction. Regional studies show that alluvial deposits and soils underlying the project site have moderate to high shrink-swell potential and are generally classified as expansive soils. The site-specific geotechnical exploration for the project site concluded that the expansive nature of the soils and bedrock at the project site were an area of major concern.

(5) Slope Stability. Slope failure can occur as either rapid movement of large masses of soil ("landslide") or slow, continuous movement ("creep"). The primary factors influencing the stability of a slope are: 1) the nature of the underlying soil or bedrock; 2) the geometry of the slope (height and steepness); 3) rainfall; and 4) the presence of previous landslide deposits. Based on a regional scale planning map by the United States Geological Survey (USGS), the upslope areas of the project site are classified as Category 4 (sloped, moderately unstable) and Category 5 (unstable, underlain by, or adjacent landslide deposits), while the flat areas at the foot of the hills were classified as Category 1 (stable) and 2 (sloped, generally stable). Past and existing slope stability conditions at the project site are discussed below.

Original Landslides and Grading Concept. The planning process for the project began in the mid-1980s. ENGEO provided geologic and geotechnical services beginning in 1991 with an exploration to locate traces of the Green Valley fault and to develop a grading plan for a proposed development. Proposed grading in 1991 included maximum cuts of 40 feet and fills to 25 feet, with proposed pad elevations at 170 feet. In 1991 the City of Fairfield responded by recommending lowering the grading elevation to a maximum elevation of 165 feet, constructing benches on cut slopes every 25 feet, and hiring a geotechnical peer reviewer for the ENGEO work (Berlogar Geotechnical Consultants, or BGC). ENGEO performed an additional geotechnical investigation in 1994, which resulted in a tentative grading map dated October 3, 1994 by the civil engineers, Carlson, Barbee, and Gibson. The City of Fairfield approved final construction plans in July 1999, with BGC’s concurrence. According to ENGEO, the configuration of the October 1994 tentative grading map was approximately the same as the grading plan approved in 1999, and showed a “maximum elevation of 150 feet at the western side of Village B, with cut depths of up to 60 feet.”

Project grading began in August 1999. In October 1999, incipient slope failure was noted in the cut slope west of Village B and grading was halted. The cuts at the toe of the slope were within approximately 20 feet of the proposed finished grade. During the following months, the area of the apparent slope movement increased, as manifested by tension cracks in the upper portions of the slope and ground bulging and compression in the toe of the slope area. ENGEO drilled two borings, installed slope inclinometers, and reported movement at a depth of about 35 feet.

31 NRCS, 2007, op. cit.
35 Ibid.
36 Ibid.
37 Ibid.
Original Slope Stabilization Concept. In March 2000 ENGEO installed three additional inclinometers in Village B and reported movement at maximum depths of 110 to 130 feet. Based on these data and additional geologic mapping, ENGEO formulated a slope stabilization concept consisting of unloading the upper portion of the landslide with cuts, and adding resisting mass to the toe area by raising grades with fill.38

GeoSyntech Consultants (GSC) was retained by the applicant to assist in development of a comprehensive and mutually agreed upon scope of work to characterize and prepare recommendations for slope stability and revisions to site grading, and prepared a Proposed Field Exploration Plan in August 2001.39 The GSC scope of work was completed by ENGEO with modifications, and reported in December 2002.40 The investigation included 26 borings, 17 trenches, installation of 12 sets of two to three nested piezometers, 19 time-domain reflectory cables (TDR), 41 and 7 inclinometers.

ENGEO concluded in their report that development of the hillside was feasible with corrective grading by cutting the upper portions of the western hillside and placing fill to buttress the lower portions, and prepared a revised grading plan, which was included in the 2002 report. ENGEO proposed to remove as much as 60 to 100 vertical feet of material from the ridge above Villages A and B, and place excavated material as fill in the pad and street areas of Villages A and B. The grade at the toe of the slopes in Villages A and B would be raised as much as 30 feet (to an elevation of 190 feet in Village A and 185 feet in Village B). ENGEO’s proposed stabilization concept also included construction of slope buttress and catchment benches at the toe of slope along the western margins of Villages A and B. The buttress/bench would “function to add resisting mass to increase local stability and to retain any sloughing that may occur on slopes above the bench.” 42

Proposed slope repairs included limiting the elevation of groundwater in slopes west of development, and maintaining groundwater elevations 20 feet below the surface of proposed cut grade west of the buttress and at least 20 feet below the base of the fill in the buttress/bench. Deep subdrains were proposed, anticipated to be backfilled with downslope-oriented slots with a subdrain blanket and collector lines.

Third Party Review and Additional Investigation. BGC, the City’s peer reviewer, responded to ENGEO’s December 2002 report with multiple comments and requests for additional information.43 ENGEO responded in February 2003 by supplying additional calculations and supporting evidence for the adequacy of their original calculations and assumptions.44 ENGEO

40 ENGEO, 2002. op cit.
41 TDR is a method of locating the depth to a shear plane or zone in a landslide. TDR uses an electronic voltage pulse that is reflected like radar from a damaged location in a coaxial cable.
42 ENGEO, op cit.
requested review of their work by Professor James Michael Duncan, who had concerns relating to finding the most critical non-circular slip surface (i.e., the surface with the lowest factor of safety). ENGEO performed a Supplemental Slope Stability Analysis in July 2003 in response to Dr. Duncan’s concerns, and concluded that the new slope stability analyses confirmed the efficacy and acceptability of the designs presented in their December 2002 report.45

Pacific Geotechnical Engineering (PGE) was retained by the City of Fairfield in approximately March 2003 as the City’s peer reviewer to replace BGC. PGE provided comments on ENGEO’s December 2002 report and February 2003 supplement. Between August 2003 and September 2005, ENGEO produced about 30 additional documents with additional data and supporting information, and PGE generated about 15 response documents. PGE agreed with the conceptual site slope stability mitigation concept, as presented in the December 2002 ENGEO report, and described above. However, they had multiple concerns including the following: using a conservative factor of safety (they suggest using at least 1.5); using conservative assumptions for calculations; continuing monitoring to obtain current and historical slope movement and groundwater data; relying more heavily on laboratory and field data rather than “back calculations;” seismic stability evaluation of the historic landslides and the berm east of the site between mapped traces of the Green Valley Fault; and adequacy of the lateral extent of proposed grading above the proposed development.46

ENGEO performed supplemental geotechnical explorations reported in September 10, 200447 and January 12, 2005 reports.48 The investigations included test borings, trenches, and test pits, as well as ongoing monitoring of slope stability instruments and groundwater levels, and resulted in a revised grading plan for Village A. After additional comments by PGE, the grading plan was revised again in August 2005 and December 2005.

The August 2005 revisions included the following changes:

- Extension of corrective grading concepts from Village B and the northern portions of Village A to the southern spur ridge, including flattening and unloading of the upper slopes and construction of an engineered fill buttress at the toe of the slope. The volume of the proposed additional excavation is estimated at approximately 250,000 cubic yards;
- Increasing the width of the engineered fill toe buttresses across the entire frontage of Village A;
- Increasing the size of the catchment basin adjacent to the southern spur ridge; and
- Elimination of natural slopes between ridge cuts and toe buttresses.

The December 2005 revisions included the following changes:

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• Complete removal of a Holocene landslide in the area of exploratory trenches T-3, T-4, and T-24. Trenches T-3 and T-4 were located at the top of the slope above Village B, and Trench T-24 was located southwest and directly above Village A.\(^{(49)}\) Subexcavation is to extend into rock at all locations on the western slopes within Villages A and B, with peripheral keyways founded in alluvium or other suitable materials where landslide stability issues are not a design issue.

ENGEIO also reported that the final grading scheme will include the following standard-of-care practices:\(^{(50)}\)

• Keyways will be excavated through colluvium and earthflow deposits and into reasonable competent material or to minimum depths required by slope stability analyses under fills as the slope buttresses are constructed;
• Constructing subsurface drains at intervals sufficient to provide adequate drainage;
• Select appropriate material for use as keyway and 2:1 slope construction;
• An engineering geologist will be present during grading operations to adjust actual subexcavation and keyway depths, as necessary;
• Laboratory testing will be performed to confirm adequacy of fill materials during buttress construction; and
• Remedial grading will be performed to minimize differential fill thickness below building areas.

**Final Grading Plan.** After an extensive review process, in July 2006 PGE, the peer reviewer for the City, stated that the geotechnical submittals and December 2005 Grading Plan “appear to address the large-scale landslide hazards,” and that, “taken together, the submittals adequately address the geologic feasibility of the grading concept as illustrated in the Grading Exhibit contained in Engeo’s report.”\(^{(51)}\) PGE also stated that “the limit, nature, and extent of grading required for the revised grading/development concept differ profoundly from the grading/development concept that went to grading in 1999.”\(^{(52)}\) PGE suggests that ENGEIO revise and update their design-level recommendations to focus on the current grading concept, and have the civil engineer add additional detail to the Grading Plan.\(^{(53)}\)

The Tentative Map Preliminary Grading Plan was completed in December 2007 (see Figure III-3).\(^{(54)}\) This grading plan is significantly more detailed than the original plan initiated in 1999. The excavation above the development to the west is proposed to extend to the ridgeline, and all the excavated soil will be placed lower on the slope. Cross sections showing the approximate profiles of the existing slopes and proposed cuts and fills across the site are shown in Figure IV.F-3. The upper


\(^{(52)}\) Ibid.

\(^{(53)}\) Ibid.

slopes have been flattened and unloaded, to the extent that no natural slopes will exist between the ridge cuts and the toe buttresses. An engineered fill buttress has been proposed at the toe of the slope above the development. Catchment basins have been added to capture any localized failure that may occur as an added factor of safety. Additional groundwater control measures have been proposed for future stability.

ENGEO also recommended that a Geologic Hazard Abatement District (GHAD) should be formed for the project. ENGEO, 2005. op cit. PGE recommended the City require a geotechnical monitoring program as a baseline for possible eventual development. PGE, 2006. op cit.

(6) Settlement and Differential Settlement. Differential settlement or subsidence could occur if buildings or other improvements were built on low-strength foundation materials (including imported fill) or if improvements straddle the boundary between different types of subsurface materials (e.g., a boundary between native material and fill). Although differential settlement generally occurs slowly enough that its effects are not dangerous to inhabitants, it can cause significant building damage over time. Portions of the project that contain loose or uncontrolled (non-engineered) fill may be susceptible to differential settlement.

The project site has been primarily used as grazing land with some agricultural activities occurring on the lower flatter areas. Historically, a borrow pit has existed near the southeast corner of the site where gravel and sand were extracted. In addition, there is an area that was used as pond for cattle. These areas on the lower part of the project site have been largely erased by the grading activities of 1999; however, if the grading the areas was not completed, or if engineered fills are introduced without confirming the stability of the underlying materials, then these materials may be prone to settlement and compression at different rates than undisturbed native soils or engineered fills.

In addition, much of project site to be dedicated to residential construction will consist of pads cut out of the hillsides and/or engineered fill to bring pads up to the desired grades. Where structures straddle these discontinuous materials, differential settlement can lead to damage to buildings, foundations and infrastructure, if improperly constructed.

d. City of Fairfield General Plan Objectives and Policies. General Plan objectives and policies in the Health and Safety Element that specifically address geology, soils or geotechnical hazards and that are applicable to the proposed project are listed below.

- Objective HS 1: Minimize exposure of the community to hazards associated with seismic activity.
  - Policy HS 1.2: All new buildings, structures, and walls shall conform to the latest seismic and geologic safety structural standards of the California Building Code as a minimum standard.
  - Policy HS 1.3: Comply with the requirements of State law and the recommendations of a certified geotechnical consultant when determining setbacks from an active fault trace for new development.
  - Policy HS 1.4: Require detailed geologic studies by a Registered Geologist (RG), Certified Engineering Geologist (CEG), and/or Geotechnical Engineer for projects within areas of potential seismic activity. All studies prepared shall identify the location of all surface fault traces within 100 feet of any proposed structure and determine their

56 PGE, 2006. op cit.
FIGURE IV.F-3

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relative activity. Adequate provisions for mitigation of potential hazards to human life or property shall also be included.

- **Policy HS 1.5**: The City shall restrict the crossing of Alquist-Priolo Act Special Studies zones by new public and private transmission facilities, including power, water, sewer, gas, and oil lines. Owners of all existing transmission facilities which cross active faults shall be required to file an operations plan with the City describing the probable effects of transmission line failure at the fault and various emergency facilities and procedures which exist to assure that failure does not threaten public safety.

- **Policy HS 1.6**: In the event that a transmission facility crosses an Alquist-Priolo Act Special Study Zone, facility design shall include sufficient provisions for valves, switches and other appropriate equipment for minimizing adverse impacts to nearby development from fire, disruption of service, spillage, etc. as a result of fault displacement.

- **Policy HS 1.9**: The City should retain a Registered Geologist, Certified Engineering Geologist and/or Geotechnical Engineer to evaluate geologic reports required where seismic conditions warrant special attention. The cost of such services shall be borne by the applicant.

- **Policy HS 1.10**: Geologists who conduct studies along the upper Cordelia Fault shall contact the California Division of Mines and Geology for early input prior to finalizing the status of this portion of the fault relative to the Alquist-Priolo Special Study Zone.

- **Policy HS 2.1**: No critical structures such as utilities, communications facilities, hospitals, emergency relief facilities, high occupancy structures, and fire and police stations shall be located in areas of high ground failure potential.

- **Policy HS 2.2**: Require soils and geologic studies by qualified professionals for development within Slope Stability Zone 2 identified on Exhibit HS-1.

- **Policy HS 2.5**: Require strict engineering standards for construction on soils subject to significant shrink/swell and areas of high ground failure potential.

- **Policy HS 2.6**: Require strict engineering standards for development projects located in identified landslide prone areas.

- **Policy HS 2.7**: Require a detailed geotechnical report, including borings, for projects involving construction on soils and substrate subject to potential liquefaction, and implement the recommendations of the report by making them condition of project approval.

- **Policy HS 2.8**: Require an erosion control and rehabilitation plan to be prepared for projects requiring substantial groundbreaking activities to control short-term and long-term erosion and sedimentation in nearby streams and rivers.

e. **City of Fairfield Municipal Code.**

   Applicable provisions of the Fairfield Municipal Code are listed below. The citation below has been edited for brevity, please see the full text (included as Appendix B) for an extended discussion of requirements.

   City of Fairfield Municipal Code: Chapter 25: Article VI - Grading and Erosion Control. This section sets forth rules and regulations to control excavation, grading and earthwork construction, including fills and embankments; establishes the administrative procedure for issuance of permits; and provides for approval of plans and inspection of grading construction.

   - **Sec. 25.240 Permits Required.**
     - **Item 9.** For excavation and removal of any earth material to an off site location which involves the hauling of earth material in excess of 50,000 cubic yards, the grading permit process shall include review by the Fairfield planning commission for compliance with the general plan, specific plan, or area wide plan, before issuance by the city engineer. (Ord. No. 86-14, § 1.)

Sec. 25.241 Hazards.

- Whenever the city engineer determines that any existing excavation or embankment or fill on private property has become a hazard to life and limb, or endangers property, or adversely affects the safety, use or stability of a public way or drainage channel, the owner of the property upon which the excavation or fill is located, or other person or agent in control of said property, upon receipt of notice in writing from the city engineer shall within the period specified therein repair or eliminate such excavation or embankment so as to eliminate the hazard and be in conformance with the requirements of this section.

Sec. 25.243 Grading permit requirements.

(a) Permits Required. Except as exempted in sec. 4 [sec. 25.240]59 of this article, no person shall do any grading without first obtaining a grading permit from the city engineer. A separate permit shall be required for each site and may cover both excavations and fills.

(b) Application. To obtain a permit, the applicant shall first file an application therefore in writing on a form furnished for that purpose.

(c) Plans and Specifications. When required by the city engineer, each application for a grading permit shall be accompanied by two sets of plans and specifications, and supporting data consisting of a soil engineering report and engineering geology report. The plans and specifications shall be prepared and signed by a civil engineer when required by the city engineer.

(d) Soil Engineering Report. The soil engineering report required by subsection (c) shall include the following:

1. Description of the site topography, drainage, and vegetation patterns.
2. Classification of the site soils and rocks, including subsurface cross-sections when appropriate.
3. Sufficient borings, test pits, exploratory trenches, soil sampling and field and laboratory testing to determine geotechnical properties affecting structures and grading . . .
4. Findings, recommendations, mitigation measures and design criteria for:
   a. suitability of earth materials
   b. slope stability
   c. bearing values and foundation design
   d. short/long term settlement potential including hydrocompression potential
   e. lateral loading factors and retaining wall design criteria
   f. landslide repair details
   g. surface and subsurface drainage details (subdrain design details)
   h. clearing and grubbing and grading specifications
   i. erosion control measures

2. Impacts and Mitigation Measures

This section outlines potential impacts related to geology, soils, and seismicity and recommends mitigation measures. The criteria of significance are listed below, and then less-than-significant impacts are described, followed by identification of significant impacts.

a. Criteria of Significance. The proposed project would result in a significant geologic, soils or seismic impact if it would have any of the following effects:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  a) 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;

59 Specific minor grading events.
b) Strong seismic ground shaking;
c) Seismic-related ground failure (including liquefaction); and/or
d) Landslides.

- Result in substantial soil erosion or the loss of topsoil;
- 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;
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state; or
- Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan.

b. Less-than-Significant Geology Impacts. The less-than-significant geology impacts are described below.

Liquefaction can occur when saturated soil layers of un-cohesive sands, gravels and fines are exposed to significant seismic shaking. Since saturated soils are a necessary condition for liquefaction, soil layers in areas where the groundwater table is near the surface have higher liquefaction potential than those in which the water table is located at greater depths. The depth to groundwater at higher elevations at the project site was approximately 60 to 90 feet, and at the toe of the slopes, depths less than 30 feet.60 The lack of saturated sandy soils at the proposed project combined with the relatively deep groundwater levels makes liquefaction unlikely and a less than significant hazard. There is no geothermal, gas or oil resource associated with the project site; therefore, there are no significant impacts to known energy sources or production.61 The project site is adjacent to but not within the Sacramento-Fairfield production-consumption boundary as mapped by the California Department Division of Mines and Geology. Lack of inclusion neither precludes nor infers the absence of aggregate resources at the project site. However, the lack of inclusion of the project site in the mapped area means that the implementation of this project would not result in the loss of a known mineral resource that would be of value to the region or residents of the state, nor would it result in the loss of availability of a locally important mineral resource site.62 Potential impacts associated with erosion and losses of topsoil are discussed in the Section IV.G-1, Hydrology and Water Quality, of this EIR.

a. Significant Geology Impacts. Development of the proposed project could result in five significant impacts related to geology, seismic hazards and soil stability, as discussed below.

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Impact GEO-1: Fault rupture at the project site could result in injuries, fatalities, and property damage. (S)

An active trace of the Concord Green-Valley (CGV) Fault has been confirmed and mapped at the project site, and the Alquist-Priolo Earthquake Fault Hazard Zone defined for the CGV Fault includes most of the low-lying area at the eastern edge of the project site. State regulations require that structures for human habitation not be built within 50 feet of an active fault trace (one that has shown surface displacement during the last 11,000 years).63

Implementation of the following three-part mitigation measure would reduce this impact to a less-than-significant level.

Mitigation Measure GEO-1a: The development plan for the proposed project shall not include structures for human habitation across potentially active fault traces, and structures for human occupancy shall be set back 50 feet from identified active fault traces.

Mitigation Measure GEO-1b: The design of project improvements, including sidewalks, parking lots, and subsurface utilities, shall consider the potentially active and active fault traces and incorporate measures to ensure that potential damage due to fault rupture is minimized; utility (electricity, natural gas, telecommunications, water, sewer) crossings at both potentially active and active fault traces shall be engineered with flexible connections or an equally effective alternate engineered solution so as to minimize damage from seismic activity and in accordance with the City of Fairfield General Plan requirements.

Mitigation Measure GEO-1c: Based on the City of Fairfield required geotechnical investigations (including any necessary fault location study), the City Engineer shall determine if compliance with City and State requirements for the evaluation of fault rupture hazard is satisfied prior to issuance of a grading permit. (LTS)

Impact GEO-2: Seismically-induced ground shaking at the proposed project could result in damage to life and/or property after implementing the project. (S)

Ground shaking from earthquakes along the known active faults in the vicinity and general region could cause damage to people and property unless properly mitigated. Ground shaking potential is estimated on a worst-case basis by taking the maximum expected earthquake and designing for the peak accelerations that it could generate. The project will be required to meet California Building Code (CBC) and City design requirements and guidelines for buildings constructed in areas of high seismic risk.

The adverse impacts of seismically-generated ground shaking on infrastructure, structures and people can be reduced to acceptable levels by incorporating appropriate seismic design standards and construction and conforming to current best standards for earthquake resistant construction per the CBC and City Code. Appropriate grading recommendations and design plans prepared by a certified professional to comply with applicable standards will reduce potential impacts to areas that are prone to secondary effects of ground shaking, such as differential settlement or liquefaction. However, in

63 CDC, 1999, op. cit.
the event of a major earthquake, some structural damage is likely to occur to some residences, structures and infrastructure.

Very Violent and Violent ground shaking is expected at the project site during a large earthquake on the CGV Fault. Very violent ground shaking corresponds to an MMI-X, during which some masonry and frame structures would be damaged, and unbolted structures shifted off their foundations. This level of seismic shaking could cause injuries and/or fatalities and extensive structural and non-structural damage to buildings. The geotechnical investigation reports for the proposed project provide specific design criteria for construction of residential development in response to expected seismic events.

It is acknowledged that seismic hazards cannot be completely eliminated, even with site-specific geotechnical methods and advanced building practices. However, exposure to seismic hazards is a generally accepted part of living in the seismically active areas of California, and therefore the mitigation measure described below would reduce the potential hazards associated with seismic activity to a less-than-significant level.

**Mitigation Measure GEO-2**: Project design and construction shall be in conformance with current best standards for earthquake resistant construction in accordance with the California Building Code (Seismic Zone 4), applicable local codes and in accordance with the generally accepted standard of geotechnical practice for seismic design in Northern California. In addition, project design shall follow the recommendations of the site-specific geotechnical investigation reports as prepared by licensed professional(s). The City Engineer shall approve all final design and engineering plans prior to issuance of a grading permit. (LTS)

**Impact GEO-3**: Settlement and differential settlement at the proposed project could result in damage to proposed buildings and other improvements. (S)

Approximately 4.4 million cubic yards\(^{64}\) of material would be moved during the grading of the project site in preparation for construction of buildings and utilities and would result in areas of cut and fill, however, it is anticipated that little or no off-haul would be required as the grading plan is very close to balanced. Fills of different thickness and fills adjacent to cut areas where native soils are exposed at the surface could create the potential for differential settlement. If the settlement is not uniform, structural damage could occur. In addition, non-uniformly compacted imported fill has potentially been previously placed at the project site, and areas underlain by this non-compacted fill could experience significant differential settlements under new building loads. Buried utilities may also experience differential settlement along their alignments. Structural damage, warping, and cracking of roads and sidewalks, and rupture of utility lines may occur if the nature and location of the imported fill were not considered during design and construction of improvements.

Investigations at the project site have included a variety of borings, test pits, and exploratory trenches for soil and fault investigation purposes. Uncompacted and loose fill potentially placed in these locations may be subject to varying rates of compaction and settlement compared to the native undisturbed soil. Structures built over discontinuous materials of varying densities and compactness

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may be subject to stress or damage due to differential settlement. Implementation of the following two-part mitigation measure would reduce this impact to a less-than-significant level.

**Mitigation Measure GEO-3a:** Prior to issuance of a grading permit, the site-specific grading plan for the project site, prepared by a licensed professional, shall be prepared and submitted to the City Engineer for review and approval. The plans shall include specific recommendations for mitigating potential settlement associated with native soil/fill boundaries and areas of different fill thickness.

**Mitigation Measure GEO-3b:** All investigative trenches and test pits not fully excavated or filled with engineered fill shall be specifically remedied with compacted engineered fill in accordance with the licensed professional’s recommendations during the grading process.

(LTS)

**Impact GEO-4:** Project structures could be adversely affected by expansive soils. (S)

Soils underlying the project site have moderate to high shrink/swell potential. As a consequence, structural damage to buildings and infrastructure may occur if the potentially-expansive soils were not considered during project design and during construction. Implementation of the following mitigation measure would reduce this impact to a less-than-significant level.

**Mitigation Measure GEO-4:** The City-required design-level geotechnical investigations shall identify locations underlain by expansive soils at the proposed project. Areas identified as being underlain by expansive soils shall be considered when preparing the final designs for building foundations and improvements (including sidewalks, roads, and utilities). The geotechnical reports for the site shall include measures to ensure that potential damage related to expansive soils are minimized. Corrective measures may include removal and replacement of problematic soils with engineered and compacted fill, proper drainage design, or design and construction of improvements to withstand the forces exerted by expected shrink/swell cycles. The design criteria shall be in accordance with the recommendations of a licensed professional and submitted to the City Engineer for review and approval prior to issuance of a grading permit. (LTS)

**Impact GEO-5:** Landslide hazards at the project site could result in injuries, fatalities, and property damage. (S)

Landslides have occurred both historically and recently on the east-facing hillsides of the project site adjacent to, and in places, underlying the proposed residential development areas. Most of the historically and recently observed landslides have been slow-moving slides and have occurred as slumps or rotational failures, resulting in alterations of the topography of the upper slopes, and the bulging or expanded areas at the toe of several of the slope failures. Dip-slope conditions exist at the project site wherein the bedrock layers that makes up the hillsides are tilted down towards east, out of the hill, and as a result, the overlying layers are prone to slippage, resulting in the landslides.

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65 NRCS, 2007, op. cit.
Additionally, the geological materials blanketing the hillsides are not well consolidated, and consist of slopewash, volcanic ash layers, and poorly-consolidated sedimentary erosional products.66

Extensive geotechnical studies at the project site, including numerous borings and trenches and monitoring, have been conducted starting in approximately 1985. The purposes of extensive investigations and landslide repairs have been to remove or minimize slope instability hazards from the site. The proposed design of the site development would result in construction of homes in the northeastern portion of the site being within areas of recent landsliding shown in Figure IV.F-2. The supplemental geologic exploration report67 concludes that development of the site is feasible from a geotechnical standpoint. Corrective grading will be necessary to reduce the driving forces of the slide mass in Village B and potential slide mass in Village A by cutting away the upper portions of the western hillside and placing it as fill to buttress the lower portions. The proposed corrective grading would remove as much as 60 to 100 feet (measured vertically) of material from the upper portions of the ridge above Villages A and B. The removed material would be used to construct pads of engineered fill for Villages A and B, with the grades at the toe of the slopes in Villages A and B raised by as much as 30 feet, to improve slope stability. Approximately 4.4 million yards of materials are proposed to be moved during grading operations.68

Even with the extensive studies that have been conducted at the site to determine slope instability issues and develop appropriate grading plans for site development, it is still possible that over time, instability may occur. Developments in areas subject to slope instability often use a GHAD as a tool to minimize future risks of instability. A GHAD is a tool to effectively abate geologic hazards that cross property boundaries. It allows property owners to cooperate in solving a common problem. It provides for a cost-effective solution, allowing that a single geotechnical engineering firm and one plan solve the problems of several landowners. The formation of a GHAD is appropriate for the repairs of an existing landslides or prevention of an impending one.69

The formation of a GHAD is enabled by the Beverly Act of 1979 (SB 1195) which allows for financial mechanisms for funding the reduction of hill-slope hazards. Funding for a GHAD may be via owner assessment or by developer funded endowment.70 The enabling statute, (Division 17 of the California Public Resources Code, Sections 26500 - 26654) provides for the formation of local assessment districts for the purpose of prevention, mitigation, abatement, or control of geologic hazards. The Act broadly defines "geologic hazard" as "an actual or threatened landslide, land subsidence, soil erosion, earthquake, or any other natural or unnatural movement of land or earth".71 A GHAD may be proposed by one of two means: (1) a petition signed by owners of at least 10 percent of the real property in the district, or (2) by resolution of a local legislative body. According to guidance provided by the State of California, a GHAD shall include the following features:

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67 Ibid.
70 Regional Water Quality Control Board, 2004, Staff Report, Montara Project, Orinda, CWA Section 401 Certification. May 25.
Plan of Control: A proposal for a GHAD must be accompanied by a "plan of control", prepared by a certified engineering geologist, "which describes in detail a geologic hazard, its location and the area affected thereby, and a plan for the prevention, mitigation, abatement, or control thereof" (Section 26509). The land within a district need not be contiguous; the only requirement is that lands within a GHAD be specially benefited by the proposed construction and that formation of a district is required to ensure the health, safety, and welfare of the residents.

Local District Organization: The Act requires public hearings prior to district formation. If owners of more than 50 percent of the assessed valuation of the proposed district object to the formation, the legislative body must abandon the proceedings. If there are few objections, the legislative body may form the district, initially appointing five property owners to the board of directors. Thereafter, the district becomes an independent entity with an elected board of directors. A GHAD may issue bonds, purchase and dispose of property, acquire property by eminent domain, levy and collect assessments, sue and be sued, and construct and maintain improvements.

Implementation of the following two-part mitigation measure would further limit slope failure and landslide hazards at the proposed project to a less-than-significant level.

Mitigation Measure GEO-5a: Construction-Period Impacts. The final design-level geotechnical investigation report and recommendations regarding slope stability at the proposed project site, as prepared by a licensed professional, shall be submitted to the City of Fairfield Community Development Department and City Engineer for review. The investigation and recommendations shall refer to the guidance provided by California Geological Survey’s (CGS) Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California for establishing standards for analysis and evaluation. In addition, the licensed professional preparing and signing the investigation report(s) will provide criteria and explanation defining the scope of the investigation drawn from their professional judgment and experience. Third party review of the geotechnical investigation report(s), if and as required by the City, will be by a licensed professional familiar with the types of geotechnical issues present at the site, and may rely on guidance for the review as provided by the California Geological Survey in CGS Note 41-Guidelines for Reviewing Geologic Reports.

Upon review, comment and approval of site-specific geotechnical recommendations by the City Engineer, or their designee, the project applicant’s design team shall fully implement and integrate these recommendations into the final site design and grading plans for the proposed project. The applicant’s geotechnical consultant, working in concert with the City of Fairfield’s geotechnical designee conducting the third party review, has developed the following recommendations that shall be addressed in the final design-level geotechnical investigation report:

- Grading plans should be designed based on calculations using conservative shear strengths estimates for site strata;
- Installation and maintenance of hillside monuments housing inclinometers;
- Allowance for adequate buffer and bench areas between potential landslide sites and proposed development;
- Young slide debris will be over-excavated and sub-surface drains installed. Replacement materials to attain design grade will be engineered fill;
- Installation of multiple keyways and subsurface drains in slope areas;
- Installation of swale axis drains;
- Sub-excavation depths for corrective features will generally be to rock and peripheral keyways excavated to cohesive alluvium or better;
- Parameters for analysis and engineering are generated using site-specific materials samples. During grading operations, additional site-specific samples and laboratory testing will be conducted to confirm suitability of re-use of on-site materials for fill in buttressing construction; and
- In general, sub-surface drain construction will be engineered and designed so as to not underlie building areas, minimizing the likelihood of failure or differential settlement.

Implementation of these recommendations should result in less-than-significant risk from present slope stability and landslide hazards for the proposed project.

**Mitigation Measure GEO-5b: Operation-Period Impacts.** The project applicant or homeowners association shall form a Geologic Hazard Abatement District (GHAD) for the affected area. The responsibilities of the GHAD shall, at a minimum, include:

- Funding mechanism and/or “seed” money to ensure GHAD program success;
- Detailed planning for overall program design, monitoring scope, and implementation;
- Response plans for various failure scenarios, including small or large landslides, deep-seated hill-slope deformation, or rotational failure;
- Emergency response plan and implementation resources;
- On-going slope monitoring in perpetuity;
- Slope repair services;
- Bench debris and catchment area cleanup;
- Sub-drain maintenance; and
- Maintenance of upslope open spaces.

Implementation of GHAD would result in less-than-significant risk from future landslide hazards for the proposed project. (LTS)