4.2 GEOLOGY AND GEOLOGIC HAZARDS

This section focuses on geologic processes, including topography, geology and geohazards, soils, and erosion potential related to the proposed project area which includes the Comstock Homes Development, Coronado Butterfly Preserve, the Phelps Ditch Trail, and proposed Ellwood Mesa Open Space Plan areas; assesses impacts of these proposed uses; and recommends mitigation measures to reduce potential project impacts related to geologic processes. Much of the information contained in this section is based on previous reports. This information has been updated with more recent publications and sources, as listed in the References section, as well as aerial photo interpretation, GIS work, and confirmatory field work performed during August and September of 2003.

4.2.1 Existing Conditions

4.2.1.1 Topographic Setting – Regional Overview

The Ellwood-Devereux Open Space Plan area is located on the southern flank of the Santa Ynez Mountains, in the western portion of the Transverse Ranges Geomorphic and Structural Province. This Province is characterized by east-west trending faults, folds, mountain ranges, and valleys. The Santa Barbara area portion of the Transverse Ranges Province is bounded on the north by the Santa Ynez Mountains, and on the south by the northern Channel Islands. The Santa Barbara Channel separates the offshore islands from the mainland. Between the Santa Ynez Mountains and the Santa Barbara Channel is a transitional zone consisting of a coastal plain and shoreline. The coastal plain is composed of uplifted and dissected marine terraces, hills, and valleys (Dibblee, 1966), some of which form estuaries and lagoons.

The Open Space Plan area, a shallow, east-west trending valley between the Santa Ynez mountains and a low coastal plateau, or mesa, borders the southern side of the Goleta Valley. Much of the Open Space Plan area is on a gently sloping marine terrace that has been uplifted by the More Mesa fault system. The marine terrace that forms the mesa is about 40-85 feet above sea level. It was formed at sea level as a wave-cut abrasion platform that eroded and beveled off a bedrock surface. Subsequent tectonic uplift of the terrace surface resulted in a mesa. Sea level changes during the Quaternary (past 1.8 million years) period due to glacial and interglacial events superimposed upon a rising coastline has resulted in the formation of a series of uplifted marine terraces in Santa Barbara County, and elsewhere in California.

Marine fossils preserved in pebble to cobble conglomerates or in rocky intertidal fossiliferous units can be observed along the sea cliffs immediately above the beveled bedrock surface that formerly formed the shoreline abrasion platform terrace surface. These fossils have been dated by radiocarbon and uranium-series dating, suggesting that the terrace formed about 45,000 years ago.

Devereux Creek cuts through this marine terrace, forming a large, broad estuary (Devereux Slough) that separates the terrace surface upon which Isla Vista is located from the rest of the Open Space Plan area to the west.

Stream erosion has dissected the marine terrace to produce the present isolated mesas and intervening drainages that form most of the upland portions of the Open Space Plan area. Geomorphic and subsurface information suggests that Devereux Slough connected with Goleta Slough in the recent past. Thus, Isla Vista was once an island, separated from the "mainland" by a large estuarine/lagoonal complex.

The topography of the uplifted terrace surface is gently sloping but undulatory, and has been incised by and is controlled by Devereux Creek and, to a lesser extent, smaller drainages. The creek trends east-west and forms a central valley between gently sloping hills. The location of the creek itself is likely fault controlled, as its course closely follows and parallels the trace of the North Branch of the More Ranch fault. The More Ranch fault has uplifted and tilted the 45,000-year-old marine terrace to the south of the fault, creating a barrier. What was once a gently seaward-sloping marine terrace now tilts north, towards the mountains in many places. The uplift and warping of the terrace has also created vernal pools in several locations on the Ellwood and Isla Vista mesas to the south of the fault. Several steep ravines cut through the hills leading to Devereux Creek, and three ravines lead down to the shoreline. Thus, the uplifted mesa (marine terrace) areas have been dissected by stream as well as shoreline erosion.

Many modifications to the natural topography have also been made as the result of human actions. Clearing of land for grazing and agriculture in the 1800s through the early 20th century resulted in erosion and gullying of several areas. Paving of roads and parking lots contributed to runoff and erosion. Consequently, man-induced erosion of gullies occurred as the result of modifications of drainage and increased runoff. Removal of topsoil and infilling of wetlands at Devereux Slough for a golf course and for land development in many areas occurred. Grading for roadways, beach access, and oil development activities all resulted in a highly altered environment.

Elevations in the study area range from sea level at the southern property boundary to 90 feet at the northern boundary. Slope gradients range from 1 to 15 percent along the hills, to 30 percent along Devereux Creek, and to well over 200 percent along the seacliffs and in steep ravines. The uplifted marine terrace slopes toward Devereux Creek in the north, towards the Pacific Ocean in the south, and towards Devereux Slough in the University Coal Oil Point Reserve (COPR) area.

4.2.1.1.1 Comstock Homes Development. The topography of the Comstock Homes Development area consists of a gently south-sloping elevated marine terrace. The topography of the uplifted terrace surface is gently sloping but undulatory, and has been incised by and is controlled by Devereux Creek and to a lesser extent smaller drainages. To the south of Devereux Creek, the terrace has been tilted and folded by uplift on the North Branch of the More Ranch fault. Elevations range from 50 feet to 90 feet above sea level in the proposed Comstock Homes Development (Figure 4.2-1). Devereux Creek has incised a broad canyon, including several

Figure 4.2-1

Local Topography

(slipsheet)

tributary ravines. Grades of 5 to 10 percent characterize most of the northern portion of the parcel, and steepen to more than 30 percent toward Devereux Creek.

4.2.1.1.2 <u>Coronado Butterfly Preserve</u>. The topography of the Coronado Butterfly Preserve area is dominated by an unnamed tributary of Devereux Creek. Elevations range from 17 feet to 75 feet above sea level. Grades range from 5 to 30 percent, with some locally steeper slopes along cut banks of the creek.

4.2.1.1.3 <u>Phelps Ditch Trail</u>. The Phelps Ditch Trail is low lying and relatively flat. Elevations are about 10 feet above sea level. A small stream, Phelps Ditch (also known as El Encanto Creek), runs along the eastern side of the trail.

4.2.1.1.4 <u>Ellwood Mesa Open Space Plan Area</u>. The topography of the Ellwood Mesa Open Space Plan area consists of an elevated marine terrace that has been tilted and folded by uplift on the North Branch of the More Ranch fault. Elevations range from sea level at the shore to 85 feet above sea level atop the mesa (Figure 4.2-1). Much of the area is flat to gently sloping. However, the topography falls off steeply to the north and south due to erosion by Devereux Creek and ocean waves, respectively. The creek has incised a broad canyon, including several tributary ravines. Grades of 5 to 10 percent characterize most of the northern portion of the area, and steepen to more than 30 percent towards Devereux Creek.

The sea cliff along the Ellwood Mesa Open Space Plan area is steep to very steep, ranging in grade from 50 to 300 percent. The cliffs are about 70 to 80 feet high. Several small landslides have occurred along the sea cliffs. Remnants of an old road down to the beach are still present at the southwest end of the Ellwood Mesa Open Space Plan area. This road is believed to be an old oil field access road from a gas plant formerly located near the top of the bluffs leading to a small road at the base of the bluffs. The base-of-bluff road was used to access piers and wells located along the shoreline.

Two small landslides were identified along the bluffs where the Middle Branch of the More Ranch fault meets the cliffs (see Figure 4.2-2). A trail down a large gully leading downward across the landslides offers good beach access. This "Middle Branch Trail" is in need of improvements for public safety and erosion control for resource protection. Some limited grading reportedly was performed at this location in the mid-1960's to create a pond to extinguish an underground oil fire that may have been fueled by an underground oil/tar seep or an abandoned oil well, likely a natural oil seep that had caught on fire as the result of a lightning strike (Baca, 2004).

4.2.1.2 <u>Geology and Geohazards – Regional Overview</u>

4.2.1.2.1 <u>Tectonic Setting</u>. California straddles the transform margin of Western North America. Santa Barbara County is situated to the southwest of the San Andreas Fault, which is generally considered the primary structural boundary between the Pacific and North American tectonic plates. As the Pacific Plate moves towards the northwest at a rate of about 45 mm/year as the result of seafloor spreading, it collides with and slides past the North American Plate. Transpressional forces are created in the 'Big Bend' of the plate boundary zone where the San Andreas Fault deviates to the west from its predominant northwest trend, creating the Transverse Ranges. The Santa Ynez Mountains and northern Channel Islands form the westernmost compartment of the Transverse Ranges, and are actively rising as a result of the oblique plate collision process.

The Santa Ynez Mountains and adjacent coastal areas are cut by a series of active, subparallel faults and folds, referred to as the Santa Barbara Fold Belt (SBFB)(Gurrola, 2003). Most of the faults in the SBFB are reverse (thrust) faults, many of which are normal faults that have been inverted. The SBFB has formed on the south flank of the Santa Ynez Mountains Anticlinorium, likely as the result of shortening along a blind basal detachment, the San Cayetano thrust fault (Namson and Davis, 1990). The San Cayetano and associated active shallow crustal faults such as the Red Mountain, North Channel, More Ranch/Mission Ridge/Arroyo Parida, and Santa Ynez faults are the largest seismic sources in the vicinity of the project area.

Uplift of the Santa Ynez Mountains and the coastal terraces on the SBFB and the effects of erosion have largely controlled topographic landform and drainage development. Sedimentary rocks of Cretaceous to Miocene age have been uplifted and eroded, creating the scenic, steeply dipping strike ridges on the south flank of the range. On the Goleta coastal plain, these bedrock units are overlain by relatively flat-lying sediments and soils of Pleistocene through Holocene (Recent) age. These Late-Quaternary sediments and soils have been folded and offset by faults, clearly demonstrating recent fault activity.

The combined effects of repeated, large (120 m=400 feet) sea level changes in the Quaternary (past 1.8 million years) and tectonic uplift of the coastal plain on the More Ranch fault system (Figure 4.2-2) have resulted in uplifted marine terraces, including the mesas upon which the University, Isla Vista, Ellwood, and Devereux areas are located. This marine terrace has been dated at approximately 45,000 years before present (BP).

4.2.1.2.2 Stratigraphy. Regional stratigraphy consists of Tertiary marine and nonmarine sedimentary rocks. The general geology of the coastal mesa consists of a thin veneer of Quaternary marine and nonmarine terrace deposits unconformably overlying Tertiary sedimentary rocks. The Miocene and Pliocene Bedrock formations of the project area are mostly overlain by Holocene and Older Alluvial (Pleistocene) terrace deposits (Dibblee, 1966).

The bedrock lithology of most of the project area is composed of the Monterey shale (Tm). This Miocene-age shale is well exposed along the sea cliffs to the west of Devereux Slough, and exhibits whitish gray, finely laminated bedding planes that are steeply dipping to the south in most places. The Miocene-Pliocene age Sisquoc Formation (Ts) bedrock, which overlies the Monterey Formation, is present to the south and east of Devereux Slough. Both the Sisquoc and Monterey Formations are folded and faulted, so the bedding orientation and dip changes along the coast.

Figure 4.2-2

Local Geology

(11 x 17)

To be revised after receipt of 2004 Fugro Memo and Revised Map

Older Alluvium (Qoa) forms the surficial strata over most of the upland terrace mesas. It consists of marine and non-marine terrace deposits (Dibblee, 1966, 1987a,b). Recent Landslide deposits (Qls) are locally found along the sea cliff. Younger Alluvium (Qa) is common along Devereux Creek and its tributaries, as well as other low-lying areas. Estuarine silts and clays (Qe) are exposed on the tidal flats of Devereux Slough and Goleta Slough. Beach and dune sands (Qs) are found on beaches and near the mouth of Devereux Slough. Finally, artificial fill (Af) is found on golf courses and in many areas that have been developed on former wetlands and other low-lying areas.

4.2.1.2.3 Local Faulting. At least three major fault zones cross the project area (refer to Figures 4.2-2 and 4.2-3). These faults include the South, Central, and North branches of the More Ranch fault. These faults are south-dipping reverse faults which elevate the marine terrace on the mesa from the Goleta Valley to the north. They are visible on the sea cliffs, and in the case of the North Branch More Ranch fault, have clear geomorphic expression. The North Branch More Ranch fault is mapped by Dibblee (1987 a,b), Olsen (1972), Minor et al. (2002), and Gurrola (2003) as trending through the central portion of the Ocean Meadows Golf Course. To the west, the hanging wall anticline of this fault forms the Ellwood Oil Field reservoir, which produced approximately 100,000,000 barrels of oil from 1928 to 1971.

The South Branch More Ranch fault passes through the general vicinity of the above ground oil tanks in the Ellwood Marine Terminal, as mapped by Gurrola (2003). The Middle Branch More Ranch fault parallels the north and south branches, and lies about halfway between them (Hoover and Associates, 1984). The South Branch More Ranch fault reportedly cuts the 45,000-year marine terrace at the University, and is thus considered potentially active. The state of activity of the Middle Branch of the More Ranch fault is unknown, but the basal terrace deposits are offset by the fault on Ellwood Mesa, suggesting that it is also potentially active or active.

Dibblee (1966) indicates displacement of both recent and older alluvial deposits along the North More Ranch fault. Holocene movement of this fault is suggested by north-facing fault scarps that are present on the east and west ends of this 9-mile-long fault. The uplifted coastal mesas (Ellwood, Devereux, Isla Vista, University, and More Mesa) occur to the south of this fault as a result of fault movement. To the east, it connects with the Mission Ridge-Arroyo Parrida fault system.

The Santa Barbara County Safety Element considers the More Ranch fault(s) to be active. However, the More Ranch fault has not yet been zoned as an active fault by the State of California (Jennings, 1994). Based on seacliff exposures, geomorphic expression, and oil well data, the North Branch of the More Ranch fault is likely the most active structure in the More Ranch fault system. It locally warps, folds, and faults the 45,000-year marine terrace platform and overlying alluvial sediments from Ellwood to More Mesa (Gurrola, 2003). Gurrola et al. (2003) consider the More Ranch fault to be potentially active. Fugro West (2003) suggests the North and South Branches converge to the east of the University near the former Mescalitan Island. The North Branch of the More Ranch fault is located more than 200' south of the proposed Comstock Homes Development, and no known faults cross the proposed project site.

A 50-foot offset for human occupancy structures was proposed by Hoover and Associates (1984, 1985) for potentially active faults, including the More Ranch faults described herein. This is the same setback as the State of California's offset distance for active faults. A 50-foot offset requirement is also consistent with the County of Santa Barbara Seismic Safety Element, which suggests that the appropriate setback distance from the trace of a fault would be variable, depending on conditions, but normally would be at least a minimum of 50 feet on each site of the sheared zone.

Some geologists have suggested that other faults, such as the North Ellwood fault, the Coal Oil Point fault, and other unnamed secondary faults, cross the Open Space Plan area (Hoover and Associates, 1985; UCSB, 1990; Fugro West, 1996, 2003). Based on a review of these previous studies, and recent confirmatory field investigations conducted for this EIR, this EIR analysis concludes that the North Ellwood fault is part of the North More Ranch fault zone, rather than a separate structure. This interpretation is consistent with Diblee (1987a), the USGS (Minor et al., 2002; and Gurrola, 2003). The Coal Oil Point and other unnamed secondary faults have not been confirmed and have not been recognized by Jennings (1994), Dibblee (1987 a,b), Gurrola (2003), or Santa Barbara County (Moore and Taber et al., 1979). This EIR analysis concludes that these faults are active, seismogenic structures.

4.2.1.2.4 <u>Seismicity</u>. Santa Barbara is located in a seismically-active area (McLauren and Savage, 2001). The western Transverse Ranges have experienced numerous seismic events over the last two centuries, including a few historic large-scale (magnitude >6.0) events such as the 1812 earthquake. The 1812 event had a probable magnitude of Mw>7.1 (Toppozada et al., 1981), and may have occurred offshore or on the San Cayetano fault to the east (Dolan and Rockwell, 2001) or the Santa Ynez River fault to the northwest (Sylvester, 2003; Sylvester and Darrow, 1979). Other destructive earthquakes struck the Santa Barbara and Goleta area in 1857 (San Andreas fault, Mw=8.4), 1925 (Santa Barbara vicinity, Mw=6.3, possibly More Ranch or Mesa fault), 1927 (Mw=7.3, Hosgri fault, offshore Pt. Arguello), and 1978 (Mw=5.9, offshore North Channel fault).

Regional onshore faults that can be expected to cause seismic shaking in the project area during an earthquake include the San Andreas Fault (52 miles from site), and the Santa Ynez Fault and Santa Ynez River Fault (10 miles from site). Both of these faults are considered active (Dibblee, 1966). The San Cayetano blind thrust fault poses another significant seismic hazard. It is a blind fault, likely buried approximately 10-12 km beneath the site (Namson and Davis, 1988, 1990). The offshore Pitas Point/North Channel and Red Mountain faults (5 and 16 miles from the site, respectively) also are considered active and would cause seismic shaking at the site during an earthquake (Foxall et al., 1995). Finally, the Oak Ridge Fault and the Channel Islands thrust pose significant offshore seismic sources (Shaw and Suppe, 1994; Sorlien et al., 2000).

The maximum probable magnitude of an earthquake along an active, or potentially active, fault may be calculated as a function of the fault's total length or as a function of the fault surface area (Wells and Coppersmith, 1994). The maximum probable earthquake for building design determinations that could theoretically be produced by the More Ranch fault alone is a

Figure 4.2-3

Geohazard Map

(slipsheet)

maximum credible earthquake magnitude of 6.8 (Hoover and Associates, 1985). However, Gurrola et al. (2001) consider the More Ranch fault as part of an extended fault system that includes the Mission Ridge and Arroya Parida faults to the east. This entire fault system has a length of about 44 miles. Given a rupture length of 44 miles, the More Ranch-Mission Ridge-Arroyo Parida fault system is capable of generating a maximum credible earthquake magnitude of about 7.2.

Damage from an earthquake on the More Ranch fault would occur from ground shaking created by seismic waves traveling through rock and soil. The amount of shaking is measured as ground acceleration at the rate of gravity (g). The acceleration onsite is a function of earthquake magnitude, site distance from the earthquake source, and rock and soil types present on the site. Hoover and Associates (1984) suggested that the More Ranch fault could generate a peak bedrock acceleration of 0.80 g. A larger magnitude earthquake on the offshore North Channel fault could generate ground accelerations of about 0.75 g at the site (Hoover and Associates, 1985). Damage to wood-frame structures and underground utilities can be expected to be considerable with these ground accelerations.

Based on a review of these previous studies, and recent confirmatory field investigations conducted for this EIR, this EIR analysis concludes that it is more reasonable to use estimated ground accelerations from Caltrans (Mualchin, 1996). The Caltrans seismic hazard map suggests that the peak ground accelerations on bedrock beneath the project area is approximately 0.6 g, although higher peak accelerations can be generated locally.

4.2.1.2.5 Liquefaction. Liquefaction is a rapid loss of strength in water-saturated sandy soils produced by ground shaking during an earthquake. Seismic waves can increase intergranular pore pressure and cause a rapid loss of bearing strength. Poorly consolidated coarse soils and a water table within 20 feet of the ground surface are prerequisites for this phenomenon to occur. Low coastal areas and alluvial valleys are most susceptible to liquefaction.

The County of Santa Barbara (County) identifies the Ellwood area as having low to moderate liquefaction hazard (Moore and Taber et al., 1979). However, areas of beach sand, the broader area of the Devereux Creek bottom, and areas underlain by estuarine deposits in the present and former Devereux Slough could have a high liquefaction potential if unconsolidated sand layers exist below the water table at shallow depths.

4.2.1.2.6 Flooding. Surface hydrology and flooding are addressed in Section 4.3.

4.2.1.2.7 Slope Stability. Various types and degrees of slope instability are part of the natural weathering and erosional cycles of an area. Factors contributing to slope instability include topography, bedrock and soil types, bedrock orientation, precipitation, vegetation, seismic shaking, and human-induced topographic alteration. Slope stability covers a series of mass-movement phenomena such as large landslides, rockfalls, mudflows, and shallow soil failure. These mass movements may be triggered by seismic activity, rainfall, undercutting of seacliffs by wave erosion, and other factors.

4.2.1.2.8 Expansive Soils. Expansive soils are found on the Santa Barbara Shores portion of the Ellwood-Devereux Mesa. The expansive soils consist of Diablo Clay (soil mapping units DaC and DaD), and have a high shrink swell potential. Diablo Clay soils are mapped in the central and east portion of the West Campus Bluffs (see Figure 4.2-4).

4.2.1.2.9 Differential Settlement and Land Subsidence. Subsidence is displacement of the ground surface vertically over a broad region or at localized areas. Differential settlement often occurs on cut-and-fill slopes, where fill areas often settle through time. Land subsidence is likely in areas occupied by the former Goleta and Devereux Sloughs. Emplacement of fill soils on underlying estuarine deposits could result in compaction and settlement of several inches due to the emplaced loads.

4.2.1.2.10 Other Geologic Hazards. Tsunami, natural gas, and Radon-222 are three geologic hazards that are often overlooked in Santa Barbara County. Sea level rise is another long-term hazard that should be considered when making management decisions. Tsunami hazard is addressed in Section 4.3 (Hydrology and Water Quality).

Radon-222 is a gas commonly found in certain rocks and soils in Santa Barbara County that is harmful to human health. Radon is most common in Rincon Formation siltstone and Rincon-derived soils. Based on regional geologic mapping, no Rincon Fm rocks underlie the project area. Thus, the hazard of Radon gas sourced in rocks and soils in the project area is low. Given that some of the estuarine soils in the former Goleta and Devereux Sloughs were derived from erosion of Rincon Fm rocks, however, it is possible that Radon gas is present in these areas.

Natural gas and oil are expelled from rocks both onshore and offshore in Santa Barbara County. Some of the largest known natural oil and gas seeps in the world occur offshore Coal Oil Point (Quigley et al., 1999). Tar seeps do not present a geohazard, but methane (including H_2S) gas seeps and oil wells that have not been properly abandoned may be toxic and are flammable, presenting a potential hazard to the public.

Sea level is currently on the rise. Contributing factors include the melting of glacial ice, glacial isostatic adjustment, and decrease in water density, all of which are attributed to a global increase in atmospheric temperatures. Sea levels have risen approximately 6 inches in the last 100 years (Peltier and Tushingham, 1989), and continue to rise at a rate of about 1.8 mm/year (Douglas, 1997). A similar long-term trend in sea level has reportedly been observed at Santa Barbara Harbor. This has been posted on the National Oceanographic and Atmospheric Agency (NOAA) website (http://co-ops.nos.noaa.gov/sltrends).

Atmospheric models estimate that greenhouse gas increases will lead to significant global climate warming (Barnett, 1990). This warming will continue to cause a rise in sea level and precipitation patterns that will be felt worldwide. If global warming increases, the rate of sea level rise will accelerate. Assuming acceleration of global warming and associated rise in sea level, estimates of the total increase in sea level over the next century vary from 1.6 feet to 6.6 feet.

Figure 4.2-4

Soils Map

(11 x 17)

This predicted rise in sea level has long-term implications for the project area because it would likely result in increased rates of sea cliff erosion and retreat, loss of beaches, and a higher flood hazard in low-lying portions of the Devereux Slough watershed. Beach access, trail setbacks from cliffs, and facility placement should be planned accordingly.

4.2.1.3 Geology and Geohazards

4.2.1.3.1 Comstock Homes Development. Few geologic hazards exist in the Comstock Homes Development area. Potential geohazards present include strong ground motions from seismicity and flooding in the Devereux Creek area. Potential peak ground acceleration of 0.6 g or greater is possible on the site due to regional ground shaking from an earthquake generated by the More Ranch fault or other active fault systems. Due to the depth of ground water and the lack of sandy soils, the liquefaction potential on area is considered to be low. Some expansive and collapsible soils are present.

4.2.1.3.2 Coronado Butterfly Preserve. Potential geohazards present in the Coronado Butterfly Preserve area include steep slopes, surface fault rupture, seismicity, liquefaction, and flooding. The North Branch of the More Ranch fault system crosses the southern portion of the property. Potential peak ground acceleration of 0.6 g or greater is possible. The flooding hazard is moderate along Devereux Creek and its tributaries. There are also some minor slope stability issues along the banks of the creek due to oversteepening as the result of uplift on the More Ranch fault and erosion.

4.2.1.3.3 Phelps Ditch Trail. Geohazards present at the Phelps Ditch Trail include seismicity, flooding, ground settlement, and liquefaction. Potential peak ground acceleration of 0.6 g or greater is possible on the site due to regional ground shaking from an earthquake generated by the More Ranch fault or other nearby active fault systems. The flood hazard is moderate to high, given its lowlying topography adjacent to Phelps Ditch.

4.2.1.3.4 Ellwood Mesa Open Space Plan Area. Geohazards present in the Ellwood Mesa Open Space Plan area include steep slopes, mass movement, expansive soils, fault rupture, natural gas expulsion, seismicity, and differential ground settlement.

Slope stability is an important issue on the Ellwood Mesa property for several reasons, including public safety. Rock falls and slides can occur rapidly, resulting in death or injury. Out-of-slope bedding situations do exist along the sea cliffs, so the danger of such failures is real. The sea cliff along the Ellwood Mesa Open Space Plan area is 80 feet high and steep to very steep, ranging in grade from 50 to 300 percent. Several small landslides have occurred along the sea cliffs, and out-of-slope bedding conditions exist locally. Slides, debris flows, and rockfalls pose hazards at the base of the bluffs, particularly under saturated conditions or as the result of earthquake loading. Two small slides have taken out portions of an old road that descends from the top of the bluff to the beach, creating a hazardous condition. Thus, hazardous conditions exist along the top and base of the sea cliffs, as well as the cliff itself.

Steep slopes also pose a fall hazard, both along the sea cliffs and in inland erosion areas where steep ravines exist. Ground surfaces along the steep drainage ravine banks have little vegetation and show a high potential for slope failure during heavy rainfall.

Several northeast trending steep ravines are present on the Ellwood Mesa property leading to the Doty property. There is a broad plateau in the south central portion of the property, bounded to the south-southwest by the sea cliff and by a gentle slope leading away in the other directions. The southern property boundary is composed of sheer sea cliffs broken by two steep ravines leading to the beach.

Expansive (Diablo clay-mapping units DaC and DaD on Figure 4.2-4) soils are mapped in the western portion of the site. Portions of this area have been excavated for soil remediation for a former gas plant. Differential settlement may occur across the footprint of the excavation if the soils were not properly recompacted upon completion of former remediation activities.

All three branches of the More Ranch fault cross the property (see Figure 4.2-3). Two small slumps occur at the seacliff where the Middle Branch of the More Ranch fault meets the cliff. The easternmost of these two slumps appears to be an older feature, whereas the western slump exhibits youthful morphology and may still be active. The Santa Barbara Shores/Ellwood Specific Plan (ESA, 1992) shows the central branch of the More Ranch fault terminating near the bluff on Ellwood Mesa (refer to Figure 4.2-3). However, Crandall and Associates (1966) and Herron (1974) recognize this branch as active and continuing offshore. The Middle Branch of the fault is clearly visible at the sea cliff where a hanging wall anticline cuts footwall bedding of the Monterey Formation.

The North Branch of the fault is located near the southern boundary of the Comstock Homes Development area (Figure 4.2-3). Given that both the North Branch and the Middle Branch are potentially active, ground rupture hazard exists. Strong ground motions could be generated by these or other active regional faults. The seismicity hazard is thus considered to be high.

Potential peak ground acceleration of 0.6 g or greater is possible on the project site due to regional ground shaking from an earthquake generated by the More Ranch fault or offshore fault systems. Improperly abandoned oil wells and natural oil and gas seeps pose a potential hazard on the Ellwood Mesa Open Space Plan area. A possible tar/oil seep is located in the landslide area where the Middle Branch of the More Ranch fault intersects the cliffs reportedly burned for several months in the 1960s prior to being extinguished. It is unknown as to whether the fire was fueled by a natural oil or gas seep, or if it was from an old oil well. Improperly abandoned oil wells and natural oil and gas seeps pose a potential hazard on the Ellwood Mesa property. These hazards, the possible impacts associated with them, and applicable mitigation measures are treated in Section 4.5.

Due to the thin layer of alluvial material, relatively deep ground water, and the lack of sandy soils, the liquefaction potential on the Ellwood Mesa Open Space Plan area is considered to be low.

4.2.1.4 Soils – Regional Overview

The majority of the information presented in this section was obtained from the U.S. Department of Agriculture's (USDA) Soil Survey of Santa Barbara County, California – South Coastal Part (1981). Soils of the Open Space Plan area, including those portions under the City of Goleta's jurisdiction, can be grouped into associations that have formed on foothill and coastal terraces, in canyons and coastal plains, and in wetlands such as estuaries. The Milpitas-Positas-Concepcion association, for example, is composed of nearly level to steep, moderately well drained fine sandy loams on terraces. The Ayar-Diablo-Zaca association is composed of gently sloping to very steep, well-drained clays on uplands. The Camarillo-Aquepts association is composed of nearly level, poorly drained and very poorly drained fine sandy loams on low flood plains and tidal flats. The USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) has mapped the soils located within the region. Approximately 14 mapped soil units have been identified. These soils are shown on Figure 4.2-4 and are listed in Table 4.2-1.

Areas of beach sand (BE) have a severe wind and water erosion hazard.

The Concepcion series consists of moderately well drained soils on low terraces that parallel the coastline. The soils formed in mixed alluvium. Slopes range from 0 to 50 percent and permeability is very slow. Within this series, the Concepcion fine sandy loam (CgA) is a nearly level soil located on low terraces in a narrow band paralleling and adjacent to the ocean (0 to 2 percent slopes). In areas along the coastal cliffs, deep gullies have formed and extend into this soil. Runoff is slow, the shrink-swell potential is low, and the hazard of erosion is slight. The Concepcion fine sandy loam (CgC2) is a gently sloping to moderately sloping eroded soil located on low terraces in narrow bands paralleling the ocean (2 to 9 percent slopes). Most areas have been cultivated and contain numerous gullies and rills. Gullies, as much as 50 feet deep, commonly extend a few feet to several hundred feet into these terraces. Runoff is medium, the shrink-swell potential is low, and the hazard of erosion is moderate. The Concepcion fine sandy loam (CgD2) is a strongly sloping eroded soil along drainageways that have dissected old terraces. Most areas contain deep gullies in the drainageways and gullies and rills on side slopes above the drainageways. Runoff is rapid, the shrink-swell potential is low, and the hazard of erosion is high. The Concepcion fine sandy loam (CgE2) is a moderately steep soil located on terrace breaks along drainageways. Deep-fluted gullies are common in the bottom of the drainageways and on side slopes. Runoff is rapid, the shrink-swell potential is low, and the hazard of erosion is very high.

The Diablo series consists of well-drained soils on low hills within 3 miles of the coast. The soils formed in soft shale and mudstone. Slopes range from 2 to 50 percent and permeability is slow. High shrink-swell potential is a severe limitation for urban development. Within this series, the Diablo clay (DaC) is a gently sloping to moderately sloping soil on low terrace-like hills (2 to 9 percent slopes). Runoff is moderate, and the hazard of erosion is slight. The Diablo clay (DaD) is a rolling soil on low hills and broad ridgetops. Both runoff and the hazard of erosion are moderate.

The Milpitas series consists of moderately well drained soils on terraces. The soils formed in mixed alluvial deposits. Slopes range from 2 to 50 percent and permeability is very slow. Within this series, the Milpitas-Positas fine sandy loam (MeC) consists of gently sloping and moderately sloping soils located on terraces in unpredictable patterns (2 to 9 percent slopes). The complex consists of 40 percent Milpitas fine sandy loam and 40 percent Positas fine sandy loam. Runoff is moderate, the shrink-swell potential is low, and the hazard of erosion is moderate. The Milpitas-Positas fine sandy loam (MeD2) consists of strongly sloping eroded soils located on terraces. The complex consists of 45 percent Milpitas fine sandy loam and 40 percent Positas fine sandy loam. Runoff is rapid, the shrink-swell potential is low, and the hazard of erosion is high.

The Xerorthents cut and fill areas (XA) consist of mechanically manipulated soils where the original profile is no longer discernible. Some areas have been mechanically cut, either to supply fill material or to remove uneven high spots. Other areas have been covered by fill that contains varying amounts of rock, concrete, asphalt, and other debris. This soil is typically well drained. Permeability, runoff, and hazard of erosion are variable and require onsite investigation.

Agriculturally, the Diablo clay has an SCS capability Class II designation as prime agricultural land. The State Department of Conservation Important Farmlands mapping program, however, designates the Ellwood Mesa/Santa Barbara Shores sub-areas as land that does not meet the criteria for prime farmland (ESA, 1992).

4.2.1.4.1 Comstock Homes Development. The soils in the Comstock Homes Development area consist of: 1) Milpitas-Positas Sandy Loams on 2 to 9 percent slopes (MeC), and 2) eroded Milpitas-Positas Sandy Loams on 9 to 15 percent slopes (MeD2). The MeD2 soils are found on steeper slopes of gullies and near Devereux Creek. These soils have a moderate to high erosion hazard and a low shrink-swell potential (refer to Table 4.2-1).

4.2.1.4.2 Coronado Butterfly Preserve. The soils in the Coronado Butterfly Preserve area consist of: 1) Milpitas-Positas Sandy Loams on 2 to 9 percent slopes (MeC), and 2) eroded Milpitas-Positas Sandy Loams on 9 to 15 percent slopes (MeD2). The MeD2 soils are found on slopes in the vicinity of the unnamed tributary of Devereux Creek which traverses the Coronado Butterfly Preserve, as well as on slopes near Devereux Creek itself. These soils have a moderate to high erosion hazard and low shrink-swell potential (refer to Table 4.2-1).

4.2.1.4.3 Phelps Ditch Trail. The soils on the Phelps Ditch Trail consist of Xerothents (XA), representing artificial fill that was imported to the site. These soils have variable characteristics.

4.2.1.4.4 Ellwood Mesa Open Space Plan Area. Soil units located within the Ellwood Mesa Open Space Plan area include: CgA, CgC2, CgE2, MeC, MeD2, DaC, DaD, and BE. The Concepcion – Series (Cg-) soils are the predominant soil type on Ellwood Mesa. Concepcion soils on steep slopes (CgD2 and CgE2) are highly erodible, and form deep gullies on north-facing slopes and along the sea bluffs of the mesa. Erosional gullies are evident in various

Table 4.2-1. Project Area Soil Characteristics[1]

Soil Designation /a/	Name/Texture	Slope (percent)	SCS Capability Class	Erosion Hazard	Runoff	Shrink Swell Potential	Flood Hazard	Water Table Depth (feet)
AC	Aquents, fill areas	-	-	Slight	Slow	-	-	2-6
BE	Beach sand	0-2	VIII	Severe	Very slow	Low	Common	Variable
Ca	Camarillo fine sandy loam	0-2	III	Slight	Very slow	Low	Common	1-6
Cb	Camarillo fine sandy loam	0-2	III	Slight	Very slow	Low	Common	1-6
CgA	Concepcion fine sandy loam	0-2	III	Slight	Slow	Low	None	>6
CgC2	Concepcion fine sandy loam	2-9	IV	Mod. (gullying)	Rapid	Low	None	>6
CgD2	Concepcion fine sandy loam	9-15	VI	High	Rapid	Low	None	>6
CgE2	Concepcion fine sandy loam	15-30	VI	Very high (gullying)	Rapid	Low	None	>6
DaC	Diablo clay	2-9	II	Slight	Med.	High	None	>6
DaD	Diablo clay	9-15	III	Mod.	Med.	High	None	>6
DU	Dune land	-	VIII	Severe	Very slow	Low	None	Variable
MeC	Milpitas-Positas fine sandy loam	2-9	III	Mod.	Med.	Low	None	>6
MeD2	Milpitas-Positas fine sandy loam	9-15	IV	High	Rapid	Low	None	>6
W	Water	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
XA	Xerorthents	-[2]	-[2]	Variable	Variable	-[2]	-[2]	-[2]

[1]Source: USDA Soil Survey, 1981.

[2]Dash (-) indicates no interpretation provided by USDA.

portions of the sub-area, particularly in the northeast corner where the largest of the gullies is up to 15 feet deep and 50 feet wide. Past land use practices on the property, and horse, foot, and mountain bike traffic continue to remove vegetation and incise trails adjacent to gully areas and the top of the sea cliff. This may cause increased erosion and siltation during the next period of intense and/or above normal precipitation (ESA, 1992). Diablo clay (DaC, DaD) has a high shrink-swell potential which poses a severe limitation for urban development. Refer to Figure 4.2-4 and Table 4.2-1 for the location and characteristics, respectively, of the soils present in the Ellwood Mesa Open Space Plan area.

4.2.1.5 Inland and Coastal Erosion – Regional Overview

The topography of the overall Open Space Plan area is discussed in Section 4.2.1.1. Local topography is shown on Figure 4.2-1 and areas of steep slopes are shown on Figure 4.2-3. In general, the steeper the slopes the higher the erosion potential. Slope of less than 5 percent are generally considered to have a low erosion potential. Slopes of 5 to 10 percent are considered to have moderate erosion potential. Slopes of 10 to 15 percent are considered to have high erosion potential, and slopes of greater than 15 percent are considered to have very high erosion potential. However, there are many exceptions to this general erosion potential classification, as erosion potential is affected by many factors including vegetation, exposure to erosive forces of streams and waves, topsoil development, bedrock type and inclination, runoff, wastewater, and land use.

Sea cliff erosion and retreat is an ongoing, natural process that cannot be halted. The rate of sea cliff erosion is nonuniform because the composition and orientation of cliff materials is variable, and because wave energy and surface runoff varies along the coast. Aerial photo analysis and survey monuments suggest a range of sea cliff retreat along this segment of coast of about 0.45 to 0.62 feet per year between 1938 and 1983 (Hoover & Associates, 1998). Seacliff retreat rates of 1 to 1.5 feet per year have been documented along the bluffs in Isla Vista, to the east of Ellwood Mesa.

Sea cliff retreat is an episodic, rather than gradual or steady process, and as such failures occur in catastrophic events often years apart. Such slope failures often occur during El Nino winters, when precipitation, surface runoff, and wave energy are greatest. Slumps or slides occur in bedrock, often removing several feet of cliff face bedrock material in seconds. The hazards associated with cliff retreat may be minimized or mitigated by establishing trail setback zones from bluffs, controlling surface water runoff, and providing clearly marked and well-maintained public beach access trails. Slope stabilization measures can also be implemented locally at beach access sites with approval from the California Coastal Commission. Such stabilization measures, however, may not be appropriate for this area, given the desire to preserve natural features and resources.

Inland erosion is taking place in many portions of the Open Space Plan area for a variety of reasons, many of which are directly related to human activities. Some areas, such as the Phelps Ditch Trail, have been cut and filled. Other areas are eroding due to lack of vegetation, having been cleared of native vegetation for farming and grazing. Drainage patterns have also been altered. Off-road vehicles have created gullies, which are conduits for runoff and result in erosion. Finally, some inland erosion is likely the result of natural geologic and hydrologic processes in areas of tectonic uplift and oversteepening, such as along the North Branch of the More Ranch fault system.

4.2.1.5.1 Erosion by Sub-area.

***Comstock Homes Development Site*.** The soil erosion hazard for the proposed Comstock Homes Development site ranges from moderate (soil mapping unit MeC) to high (MeD2).

***Coronado Butterfly Preserve*.** The soil erosion hazard within the Coronado Butterfly Preserve ranges from moderate (soil mapping unit MeC) to high (MeD2).

***Phelps Ditch Trail*.** The soil erosion hazard on the trail is low, due to its low gradient and well-maintained condition for flood control purposes.

***Ellwood Mesa Open Space Plan Area*.** The soil erosion hazard in the proposed Ellwood Mesa Open Space Plan area varies from slight to severe. Soil mapping units with high (MeD2), very high (CgE2), and severe (BE) erosion hazards are listed in Table 4.2-1 and shown on Figure 4.2-4.

4.2.2 Regulatory Framework

4.2.2.1 Federal Authorities and Administering Agencies

The California Building Code (CBC) defines different regions of the United States and ranks them according to their seismic hazard potential. There are four types of these regions, including Seismic Zones 1 through 4, with Zone 1 having the least seismic potential and Zone 4 having the highest seismic potential. Santa Barbara County is within a Seismic Zone 4; accordingly, any future development should be required to comply with all design standards applicable to Seismic Zone 4.

4.2.2.2 California State Authorities and Administering Agencies

4.2.2.2.1 CEQA, Public Resources Code §21000 et seq. The basic goal of the California Environmental Quality Act (CEQA) is to develop and maintain a high-quality environment now and in the future. The State CEQA Guidelines require that the CEQA Lead Agency (i.e., City of Goleta) evaluate whether the proposed project would have a significant effect on the environment, including geologic hazards and soil erosion. Potential impacts that need to be considered include: exposure of people or structures to major geologic hazards, and causation of substantial erosion or siltation. Regulations related to soil erosion and siltation are addressed in Section 4.3.2.

4.2.2.2.2 California Coastal Act §30000 et. seq. As described in Section 1, the Coastal Act is the only set of policies that applies to development projects within the City of Goleta's Coastal Zone, pending certification of the City of Goleta's Local Coastal Plan. The California Coastal Act (CCA) Coastal Resources Planning and Management Policies include provisions requiring minimization of risks to life and property in areas of high geologic hazard (30253(1)), minimization of geologic instability and erosion along bluffs and cliffs (30253(2)). The CCA, however, also includes a mandate to protect natural coastal resources such as sea cliffs and beaches.

4.2.2.2.3 California Building Code. The State of California provides a minimum standard for building design through the 2001 CBC. The 2001 CBC is based entirely on the 1997 Uniform Building Code, but has been modified for California conditions. It is generally adopted on a jurisdiction-by-jurisdiction basis, subject to further modification based on local conditions. Commercial and residential buildings are plan-checked by local building officials of California's 476 cities and 58 counties (not by state agencies).

Chapter 23 of the CBC contains specific requirements for seismic safety. The project area is located in Seismic Zone IV (County of Santa Barbara, 1979). Chapter 29 of the CBC regulates excavation, foundations, and retaining walls. Chapter 33 of the CBC contains specific requirements pertaining to site demolition, excavation, and construction to protect people and property from hazards associated with excavation cave-ins and falling debris or construction materials. Chapter 70 of the CBC regulates grading activities, including drainage and erosion control. Construction activities are subject to occupational safety standards for excavation, shoring, and trenching as specified in Cal-OSHA regulations (Title 8 of the CCR) and in Section A33 of the CBC.

4.2.2.2.4 Alquist-Priolo Earthquake Fault Zoning Act. The Alquist-Priolo (AP) Earthquake Fault Zoning Act of 1972 prohibits the construction of buildings used for human occupancy on active surface faults, which are faults which have moved and ruptured the ground surface in the past 11,000 years (Holocene Time). California Geological Survey (CGS) Special Publication 42 (updated 1999) describes AP Earthquake Fault hazard zones in California. No portions of the project area are included within an Alquist-Priolo Earthquake Fault Zone designated by the State of California.

4.2.2.2.5 Seismic Hazards Mapping Act. CGS also provides guidance with regard to seismic hazards. Under CGS's Seismic Hazards Mapping Act, seismic hazard zones are to be identified and mapped to assist local governments in planning and developing purposes. The intent of this publication is to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure, and other hazards caused by earthquakes. CGS's Special Publications 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, provides guidance for evaluation and mitigation of earthquake-related hazards for projects within designated zones of required investigations.

4.2.2.3 Local Authorities and Administering Agencies

4.2.2.3.1 City of Goleta Coastal Zoning Ordinance. As described in Section 1.0, the County of Santa Barbara's Coastal Zoning Ordinance and other implementing ordinances (including subdivision, and grading ordinances) were adopted by the City of Goleta but have not been certified by the California Coastal Commission. The Coastal Zoning Ordinance provides guidance for those areas of the City of Goleta within the Coastal Zone. Coastal Zoning Ordinance procedures require additional safety measures for utility lines in fault line areas (35-148.c), require a 75-year bluff setback (35-67.1), require vegetation in bluff-top development (35-75.3), require new development and activities on coastal bluffs to protect the bluff from drainage erosion (35-75.4), and prohibit most development on the bluff face (35-75.5). In addition, the City of Goleta Grading Ordinance pertains to new grading, excavations, fills, cuts, borrow pits, stockpiling, and compaction of fill and requires a grading permit for proposed grading activities.

4.2.3 Project Impacts and Mitigation

4.2.3.1 Thresholds of Significance

Impacts would be considered significant if the proposed development activity, including the implementation of proposed mitigation measures, could result in significantly increased erosion, landslides, soil creep, mudslides, or unstable slopes. In addition, impacts would be considered significant if people or structures would be exposed to major geologic hazards, such as seismic hazards, upon implementation of the project.

The Santa Barbara County Environmental Thresholds and Guidelines Manual (Thresholds Manual) (County, 2002a) has been adopted by the City of Goleta for conducting CEQA analysis. Chapter 10 of the Thresholds Manual (updated October 2002) provides preliminary criteria for determining whether a particular activity could have a potentially significant impact on the environment. Given that geologic conditions are highly variable within the County, the guidelines are not fixed thresholds upon which a determination of significant impact would be made. The level of geologic impact assigned to a project is determined based on site-specific geologic information. These guidelines are useful in that they assist in making a determination where further study of site-specific conditions is required in order to assess impacts.

Geologic impacts could have the potential to be significant if the proposed project involves any of the following:

1. The project site or any part of the project is located on land having substantial geologic constraints. Areas constrained by geology include parcels located near active or potentially active faults and property underlain by rock types associated with compressible/collapsible soils or susceptible to landslides or severe erosion.
2. The project results in potentially hazardous geologic conditions such as the construction of cut slopes exceeding a grade of 1.5 horizontal to 1 vertical.

3. The project proposes construction of a cut slope over 15 feet in height as measured from the lowest finished grade.
4. The project is located on slopes exceeding 20 percent grade.

Mitigation measures may reduce impacts to a less than significant level. These measures would include minor project redesign and engineering steps recommended by licensed geologists and engineers subsequent to detailed investigation of the site.

4.2.3.2 Project Impacts

4.2.3.2.1 Comstock Homes Development.

***Impact GEO-1: Change in Topography*.** Project grading during construction would result in substantial changes in topography. The proposed project would require removal of the upper 3 to 4 feet of soils in proposed building areas. Grading would include excavation of approximately 62,000 cubic yards of cut and 62,300 cubic yards of fill to be balanced onsite. Although this volume of material is substantial, few significant geologic hazards would be created as a result. This is because the grading could be spread across a large gently-sloping area, would be constructed pursuant to established State of California CBC and City of Goleta Grading Ordinance standards, and should not involve the creation of unstable slopes. The most significant change in topography would occur on the southern portion of the property, where up to about 6 feet of fill will be placed to infill a shallow gully for a proposed road (Road F). Up to several feet of cut and fill will be required on most of the building pads, which are proposed to approximately coincide with the average existing grade of each lot. Minor grading will also be required for each of the proposed detention basins. Therefore, impacts would be *significant but feasibly mitigated (Class II).*

***Impact GEO-2: Erosion*.** Project grading during construction would potentially cause substantially increased erosion and sedimentation. Project construction would result in temporary exposure of ground surfaces until proposed vegetation could stabilize these areas. Near-surface soils are characterized as having medium to rapid runoff rates and moderate to high erosion hazards. Impervious surfaces installed in the early stages of construction could concentrate water flow, also potentially leading to increased erosion and siltation in Devereux Creek and its tributaries. Impacts associated with short-term exposure of graded soils and potential for sedimentation into Devereux Creek is considered *significant but feasibly mitigated (Class II).*

***Impact GEO-3: Slope Stability*.** The creation of cut and fill slopes during grading are not anticipated to be prone to failure. A preliminary grading plan has been completed delineating existing and proposed final grade elevations and proposed drainage features. Proposed cut-and-fill slope gradients are not delineated on the plan. Given the gently sloping nature of the site in most areas, any final slopes included in the project would not be anticipated to create an unstable slope. In any case, engineered slopes included in the project would be required to meet established standards in the CBC and City of Goleta Grading Ordinance. With adherence to established standards, impacts would be *less than significant (Class III)*.

***Impact GEO-4: Seismic Hazards*.** An earthquake on a nearby fault could result in significant ground shaking and possibly ground rupture at the project site. An earthquake on the More Ranch or other nearby fault could create strong ground motions at the site. Ground motions caused by seismic waves are measured as ground acceleration (g). According to Caltrans (Mualchin, 1996), the estimated peak ground acceleration at the site is approximately 0.6 g. Proposed structures and underground utilities could suffer considerable damage from strong ground motions, and must be designed accordingly.

Several design measures are required by the State of California CBC to minimize the potential earthquake damage resulting from strong ground motions. A 50-foot setback is required from all known active faults, and engineering designs must incorporate reinforcement and materials that can withstand seismic activity effects related to known credible ground acceleration factors. All proposed structures will be located at least 50 feet from the North Branch of the More Ranch fault, and will be required to incorporate designs consistent with the CBC for the anticipated ground accelerations.

Given that these measures are regulated by ordinance, they will be required as part of standard plan check review by the City of Goleta. These regulations should reduce the potential impacts of earthquake ground shaking and ground rupture to *significant but feasibly mitigated (Class II)*.

***Impact GEO-5: Expansive Soils*.** Surficial soils encountered within the depths affected by proposed grading include slightly expansive soils. Test results indicate that the upper 4 feet of onsite soil materials have a low to medium potential for expansion. Soils with expansion potential contain clay minerals that expand when wet and shrink when dry. Repeated shrinking and swelling of the soil can result in damage to foundations, fill slopes, utilities, and other associated facilities. The soil expansion potential is considered *significant but feasibly mitigated (Class II)*.

***Impact GEO-6: Collapsible Soils*.** The surface soils are dry and porous to depths of 36 to 48 inches below existing grade, and are susceptible to collapse, compression, and settlement with increasing moisture content. Potential impacts associated with compressible and collapsible soils such as foundation settling are *significant but feasibly mitigated (Class II)*.

4.2.3.2.2 Coronado Butterfly Preserve. No adverse geologic hazards or soil erosion impacts are anticipated from the proposed rezone of three parcels within the Coronado Butterfly Preserve area from residential to recreation. No adverse geologic or erosion impacts are anticipated from closure and restoration of certain trails within the Preserve. Finally, no adverse geologic or erosion impacts are anticipated from the ongoing maintenance of the open space amenities within the Coronado Butterfly Preserve area (including the City of Goleta's maintenance of the nearby neighborhood trail [Trail 20]), provided that the management practices contained in the Open Space Plan and the Coronado Butterfly Preserve Management Plan (e.g., routine trail maintenance) are adhered to.

4.2.3.2.3 Phelps Ditch Trail. This low-lying area, located on artificial fill overlying estuarine sediments, does have geologic hazard issues such as shallow groundwater, liquefaction potential, and flooding. However, no adverse geologic hazards or soil erosion impacts are anticipated from ongoing maintenance of the existing easement road, or from possible future improvements to the road for recreational access.

4.2.3.2.4 Ellwood Mesa Open Space Plan Area. The proposed rezoning of the Ellwood Mesa Open Space Plan area and implementation of Open Space Plan improvements (as described in Section 3.0 of this EIR) are expected to have impacts relative to geologic hazards and soil erosion as itemized in the following subsections.

***Impact GEO-7: Change in Topography*.** Project grading during trail construction would result in minor changes in topography. The grading required to construct the Anza Trail, Santa Barbara Shores parking area, bluff stairs and infilling of erosional gullies on the southeast portion of Ellwood Mesa is relatively minor. No geologic hazards would be created as a result. This is because the grading would generally be spread across a large gently-sloping area, would be constructed pursuant to established CBC and City of Goleta Grading Ordinance standards, and should not involve the creation of unstable slopes. Beneficial impacts to topography would result from infilling of deep anthropogrenic – induced gullies along the northeast portion of Ellwood Mesa. However, no grading plan has yet been received, and remedial grading could be done incorrectly. Given these uncertainties, impacts could be *significant but feasibly mitigated (Class II)*.

***Impact GEO-8: Erosion*.** Project grading during construction would potentially cause substantially increased erosion and sedimentation. Project construction would result in temporary exposure of ground surfaces until proposed vegetation and/or trail surfacing materials could stabilize these areas. Uncontrolled runoff from blufftop and beach access trails appears to be contributing to erosion of the bluffs. Near-surface soils on Ellwood Mesa are characterized as having medium to rapid runoff rates and moderate to high erosion hazards. Trail surfaces could concentrate water flow, also potentially leading to increased erosion and siltation in Devereux Creek and its tributaries. Impacts associated with short-term exposure of graded soils and potential for sedimentation into Devereux Creek is considered *significant but feasibly mitigated (Class II)*. Refer to Section 4.3.3.2 for additional discussion of erosion and sedimentation impacts to hydrology and water quality.

As discussed further in Section 4.3, the Open Space Plan includes an option to construct bridges, boardwalks, and stairs in the immediate vicinity of Devereux Creek. Short-term impacts associated with these structures could result in erosion, although the long-term beneficial impacts of such structures would significantly reduce erosion. These improvements are considered a beneficial impact. However, given that the short-term impacts could result in erosion, the impacts of the Ellwood Open Space Plan area improvements are considered *significant but feasibly mitigated (Class II).*

Impact GEO-9: Slope Stability. Preliminary grading plans have not been completed for proposed parking, trail construction, or other improvements. These plans will be developed at a later date and will delineate existing and proposed final grade elevations and proposed drainage features. Given the gently sloping nature of the site in most areas, any final slopes included in the project would not be anticipated to create unstable slopes. In any case, engineered slopes included in the project would be required to meet established standards in the CBC and City of Goleta Grading Ordinance. With adherence to established standards and implementation of the Open Space Plan recommended practices for trail construction, impacts will likely be less than significant.) However, given the uncertainties concerning the project and its potential impacts, the impacts of the Ellwood Open Space Plan area improvements are considered *significant but feasibly mitigated (Class II).*

Impact GEO-10: Seismic Hazards. An earthquake on a nearby fault could result in significant ground shaking and possibly ground rupture at the project site. The nearest fault is about 200 feet south of the proposed project site. An earthquake on the More Ranch or other nearby fault could create strong ground motions at the site. Ground motions caused by seismic waves is measured as ground acceleration (g). Peak ground accelerations on bedrock of 0.6 g or greater may occur at the site. Existing as well as any proposed structures and underground oil pipelines and utilities, where present, could suffer considerable damage from this magnitude earthquake. Open Space Plan structures that could be affected include trail surfaces, boardwalks, bridges, stairs, parking, and restrooms. Only habitable structures are subject to Alquist-Priolo fault hazard zone setbacks in California.

However, engineering designs must incorporate reinforcement and materials that can withstand seismic activity effects related to anticipated credible ground acceleration factors.

Given that these measures are regulated by ordinance, they will be required as part of standard plan check review of open space improvements by the City of Goleta. These regulations should reduce the potential impacts of earthquake ground shaking and ground rupture to *significant but feasibly mitigated (Class II).*

Impact GEO-11: Expansive Soils. Surficial soils encountered within the depths affected by proposed grading for the new road, parking lot and restroom at Santa Barbara Shores may include slightly expansive soils. Test results from borings collected from the Comstock Homes Project immediately to the west indicate that the upper 4 feet of onsite soil materials have a low to medium potential for expansion. Soils with expansion potential contain clay minerals that expand when wet and shrink when dry. Repeated shrinking and swelling of the soil can result in damage to foundations, roads, utilities, and other associated facilities. The soil expansion potential is considered *significant but feasibly mitigated (Class II).*

Impact GEO-12: Collapsible Soils. Test results from borings collected from the Comstock Homes Project immediately to the west of the proposed new parking lot and restroom at Santa Barbara Shores indicate that surface soils are dry and porous to depths of 36 to 48 inches below existing grade, and are susceptible to collapse, compression, and settlement with increasing moisture content. Potential impacts associated with compressible and collapsible soils such as restroom foundation or road settling are *significant but feasibly mitigated (Class II).*

4.2.3.3 Cumulative Impacts

Impact GEO-13: Cumulative Impacts. The cumulative impacts related to geologic processes resulting from buildout of proposed projects located within the Devereux Slough Watershed (including soil erosion) could be significant due to the potential for increased erosion and sedimentation in Devereux Slough. The proposed Comstock Home Development project (78 homes on 36 acres) and Ellwood Mesa Open Space Plan improvements have the potential to cause significant short-term impacts. The project's contribution to this cumulative impact caused by erosion and sedimentation would be potentially *significant, but feasibly mitigated (Class II).*

4.2.3.4 Mitigation Measures

The mitigation measures listed below reflect established standards included in the CBC and City of Goleta Grading Ordinance as applicable to the proposed project. Additional ordinance-required measures would be imposed on the project through the grading and building permit process.

Mitigation Measure GEO-1. The grading activities for the Comstock Homes Development and improvements requiring grading in the Ellwood Mesa Open Space Plan area shall be performed under the observation and testing of a qualified geotechnical consultant. The results of all such observations and testing shall be documented in a written report prepared by a registered Civil or Geotechnical Engineer. All grading and earthwork recommendations shall be incorporated into the final project design, including the Final Grading Plan. These recommendations would include, but not be limited to, the following:

a. Within the footprint of proposed buildings and foundations, and extending to a minimum distance of 5 feet beyond the foundation footprint, soils should be overexcavated to a depth of 3 feet below existing grade, or 1 foot below bottom of foundation, whichever is deeper.

b. Foundations shall be constructed to compensate for consolidation settlement of 1 inch.

Where feasible, building areas shall be backfilled with nonplastic, low expansion soils to mitigate the potential effects of expansive soils. Highly expansive soil will not be placed within the upper 3 feet below buildings. Measures recommended by Pacific Materials Laboratory (2002) such as providing positive drainage away from slabs, presoaking and compacting soils prior to pouring slabs, and other foundation design recommendations shall be implemented.

Plan Requirements and Timing. The qualifications of the designated registered Civil or Geotechnical Engineer shall be provided to the City of Goleta prior to approval of Land Use

Permits. The documented results of all observations and testing shall be provided for review by the City of Goleta prior to occupancy clearance.

***Monitoring*.** All earthwork and foundation construction shall be monitored by a qualified engineer/ technician under the supervision of the Geotechnical Engineer of Record, including:

- Site preparation including site stripping, removal of subsurface structures, overexcavation, bottom observation, and recompaction
- Temporary excavation
- All foundation excavations
- Placement of all compacted fills and backfills
- Construction of slab and pavement subgrades

A representative of the Geotechnical Engineer of Record shall be present to observe the soil conditions encountered during construction, to evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and to recommend appropriate changes in design or construction if conditions differ from those described herein.

Mitigation Measure GEO-2. Grading and drainage plans for the Comstock Homes Development and for improvements requiring grading in the Ellwood Mesa Open Space Plan area shall be designed to minimize erosion and shall include, but not be limited to, the following:

a. Temporary berms and sedimentation traps shall be installed in association with project grading to minimize erosion of soils into Devereux Creek. The sedimentation basins shall be cleaned after large rain events, and as further directed by the City of Goleta, and the silt shall be removed and disposed of in an appropriate location.

b. Revegetation or restoration shall be completed, including measures to minimize erosion and to reestablish soil structure and fertility. Revegetation shall include native, fast-growing vined plants that shall quickly cover drainage features. Local native species shall be emphasized. A landscape revegetation plan shall be included as part of the Development Plan submittal.

c. Graded areas shall be revegetated immediately after completion of installation of utilities with deep-rooted, native, drought-tolerant species, as specified in a landscape revegetation plan to minimize slope failure and erosion potential. Geotextile binding fabrics shall be used as necessary to hold soils until vegetation is established.

d. Drains shall be designed to cause exiting flow of water to enter sub-parallel downstream (60 degrees or less) to existing Devereux Creek stream flow to avoid eddy currents that would cause opposite bank erosion.

e. An energy dissipater or similar device such as trash racks or baffles shall be installed at the base end of drainage outlets to minimize erosion during storm events.

f. Storm drains shall be designed to minimize environmental damage and shall be shown on drainage plans.

g. With the exception of limited ground disturbance in association with construction of the proposed bridges and walkways, grading shall be prohibited within 50 feet of the Devereux Creek top-of-bank. Hand equipment shall be utilized during any ground disturbances adjacent to creeks, wetlands and on the bluffs.

h. The applicant shall limit excavation and grading to the dry season (April 15th to November 1st) unless a Building and Safety-approved erosion control plan is in place and all measures therein are in effect.

i. Best Management Practices (BMPs) will be employed to control erosion, including temporary siltation protection devices such as silt fencing, straw bales, and sand bags. These shall be placed at the base of all cut and fill slopes and soil stockpile areas where potential erosion may occur. The final grading plan will include erosion control measures including types and locations of BMPs. The plan will be approved by the City of Goleta prior to the commencement of grading operations.

j. If boardwalks, stairs, or other public access improvements are constructed in or across Devereux Creek, these structures shall be designed so as to avoid impacts related to erosion and sedimentation to Devereux Creek. Construction shall take place in the dry season. Construction methods shall include appropriate BMPs to prevent erosion and sedimentation. Structures shall be periodically inspected during the wet season to ensure structural integrity and avoidance of flood hazards or scouring. Maintenance and repairs shall be performed as needed. Project plans shall include provisions for construction in wetlands in consultation with appropriate state, federal and local agencies, including the California Department of Fish and Game, Regional Water Quality Control Board, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers. Work plans and project design details shall minimize the footprint of structures in the creek bed, as feasible for public safe access.

***Plan Requirements and Timing*.** Grading and drainage plans for the Comstock Homes Development and for improvements requiring grading in the Ellwood Mesa Open Space Plan area shall be submitted for review and approval by the City of Goleta prior to approval of Land Use Permits.

***Monitoring*.** The City of Goleta shall inspect construction sites and monitor effectiveness of all erosion control BMPs and other requirements on a routine basis.

Mitigation Measure GEO-3. Although this EIR shows that the proposed project site is 200 feet north of the More Ranch Fault, plans submitted for approval of a Coastal Development Permit for the Comstock Homes Development shall identify the mapped traces of the More Ranch fault, shown in this EIR where appropriate, as well as 50-foot building setback on either side of the mapped fault. No habitable structure shall be located within the seismic fault setback zone.

***Plan Requirements and Timing*.** All grading and structural plans for the Comstock Homes Development shall be submitted for review and approval by the City of Goleta prior to approval of Land Use Permits.

***Monitoring*.** The City of Goleta shall inspect for compliance with all seismic fault requirements.

Mitigation Measure GEO-4. The applicant shall submit foundation and building plans to the City of Goleta for review and approval. The plans shall indicate that all structures are designed to earthquake standards for CBC Seismic Zone 4, and that the site is within one km of a Type B fault.

***Plan Requirements and Timing*.** Plans shall be submitted prior to issuance of any building permits. Permits shall be issued based on compliance with all applicable laws, ordinances, and regulations.

***Monitoring*.** The City of Goleta shall review and approve plans and shall inspect site to ensure compliance.

Mitigation Measure GEO-5. Open Space Plan area improvements that require a foundation (restroom structure) shall be made according to plans that specify earthquake standards for CBC seismic zone 4 and that the site is within one km of a Type B fault.

***Plan Requirements and Timing*.** Prior to plan/check, the applicant shall submit building plans indicating standards to the satisfaction of the City of Goleta.

***Monitoring*.** The plans shall be approved by the Joint Stewardship Task Force and the City of Goleta, and inspected to ensure compliance.

Mitigation Measure GEO-6. Natural sea cliff erosion and retreat shall be monitored every 10 years and after every El Nino winter. The City of Goleta shall intervene and manage the relocation of the Coastal Trail if unsafe conditions exist along the bluffs as the result of landslides, erosion, and cliff retreat.

***Plan Requirements and Timing*.** The City of Goleta shall monitor and document Coastal Trail and beach access trail conditions at a minimum of every 10 years or after every El Nino storm season to ensure unsafe conditions do not exist. Flagging, photo documentation, or other methods will be used by the City of Goleta to manage relocation of Coastal Trail, if needed for safety.

***Monitoring*.** The City of Goleta shall monitor the condition of the Coastal Trail and beach access trails at a minimum of every 10 years or after every El Nino storm season to ensure unsafe conditions do not exist, and to monitor sea cliff retreat rates through time.

4.2.3.5 Residual Impacts

Implementation of Mitigation Measures GEO-1 and GEO-2 would reduce or limit Impacts GEO-1 through GEO-6 associated with grading and construction at the proposed Comstock Homes Development site to less than significant levels. Implementation of Mitigation Measures GEO-1 and GEO-2 would also reduce or limit Impacts GEO-7 through GEO-12 associated with open space plan components to less than significant levels. With implementation of Mitigation Measures GEO-1 and GEO-2, the residual impacts of GEO-7 and GEO-12 would remain adverse, but less than significant.