4.10 GEOLOGY & SOILS

4.10.1 ENVIRONMENTAL SETTING

IN THIS SECTION:

- Regulatory Setting
- Geologic Setting
- Seismic Hazards
- Non-Seismic Geologic Hazards
- Soils & Erosion

This section summarizes technical geologic and soils conditions prepared in a report by Nolan Associates that is included in technical Appendix F-4, which is available for review at the City of Santa Cruz Planning Department[1] and is also included on the Draft EIR CD and on the online version of the Draft EIR on the City's website at www.cityofsantacruz.com - Planning Department link..

REGULATORY SETTING

Federal Regulations

The Uniform Building Code (UBC) is published by the International Conference of Building Officials. It forms the basis of about half of the state building codes in the United States, including California's, and has been adopted by the California Legislature together with Additions, Amendments, and the Repeals to address the specific building conditions and structural requirements in California.

The UBC defines different regions of the United States and ranks them according to their seismic hazard potential. There are four types of these regions, which include Seismic Zones 1 through 4, with Zone 1 having the least seismic potential, and Zone 4 having the highest seismic potential. Further, the UBC provides guidance on foundation design and structural engineering for a variety of soils.

The Federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390), adopted by Congress in October 2000, requires state and local governments to develop hazard mitigation plans as a condition for federal grant assistance. The City of Santa Cruz adopted its "Local Hazard Mitigation Plan" in September 2007. The detailed five-year plan identifies potential natural and man-made hazards, assesses their likely risk, and includes mitigation methods to reduce risks. The potential hazards identified in the plan include earthquakes and liquefaction, wildfires, floods and associated coastal storms, coastal erosion, drought, tsunami, dam failure,

[1] Located at 809 Center Street, Room 107, Santa Cruz, California during business hours: Monday through Thursday, 8 AM to 12 PM and 1to 5 PM.

and landslides. Mitigation measures proposed to address these risks include prioritized actions that include hazard event planning, emergency prepardedness coordination and education, facility upgrades, monitoring actions and other actions in response to specific hazards.

The City of Santa Cruz adopted its "Local Hazard Mitigation Plan" in September 2007. The five-year plan addresses earthquakes and liquefaction, coastal erosion and landslides.

State Regulations

ALQUIST-PRIOLO EARTHQUAKE FAULT ZONING ACT

The Alquist-Priolo Earthquake Fault Zoning Act was passed by the state of California in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The purpose of the act is to prevent the construction of buildings used for human occupancy over the surface trace of active faults. The Act requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones) around the surface traces of active faults and to issue appropriate maps. Local agencies must regulate most development projects within the zones. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults. If an active fault is found, a structure for human occupancy cannot be placed over the trace of the fault and must be set back from the fault (generally 50 feet), although local agencies can be more restrictive than state law requires (California Department of Conservation, 2007a). There are no state-delineated Alquist-Priolo fault zones in the City of Santa Cruz.

SEISMIC HAZARDS MAPPING ACT

The Seismic Hazards Mapping Act (SHMA) addresses non-surface fault rupture earthquake hazards, including strong ground shaking, liquefaction, and seismically induced landslides. The goal is to mitigate seismic hazards to protect public health and safety. Pursuant to the SHMA, the state Department of Conservation is directed to provide local governments with seismic hazard zone maps that identify areas susceptible to amplified shaking, liquefaction, and earthquake-induced landslides or other ground failures. Site-specific geotechnical hazard investigations are required by SHMA when construction projects fall within these areas. Neither the City of Santa Cruz nor any part of Santa Cruz County is located within a currently designated state-Seismic Hazard Mapping Program zone (California Department of Conservation, 2007b).

CALIFORNIA BUILDING CODE

Title 24 of the California Code of Regulations, formerly known as the California Building Code (CBC), sets forth minimum requirements for building design and construction in public buildings and a large percentage of private buildings. In the context of earthquake hazards, the CBC design standards have a primary objective of ensuring public safety and a secondary goal of minimizing property damage and maintaining function during and following a seismic event. The CBC prescribes seismic design criteria for different types of structures, and provides methods to obtain ground motion inputs. The CBC also requires analysis of liquefaction potential, slope-instability, differential settlement, and surface displacement due to faulting or lateral spreading for various categories of construction. Recognizing that the risk of severe seismic ground motion

varies from place to place, the California Building Standards Code seismic code provisions vary depending on location (Seismic Zones 0, 1, 2, 3, and 4—with 0 being the least stringent and 4 being the most stringent). The City of Santa Cruz is located in Seismic Zone 4.

CALTRANS SEISMIC SAFETY RETROFIT PROGRAM

The California Department of Transportation (Caltrans) Seismic Safety Retrofit Program was established by emergency legislation (SB 36X) after the October 17, 1989, Loma Prieta earthquake. The purpose of this program is to evaluate all publicly owned bridges in California and to take actions necessary to prevent their collapse due to earthquakes. The local component of the Seismic Safety Retrofit Program provides funding and other assistance to cities and counties for evaluating bridges and improving their resistance to seismic shaking. The City of Santa Cruz has completed seismic retrofits for all its bridges, except for the Murray Street Bridge, which is planned to commence construction in 2012-2013 .

Local Regulations

The City's Municipal Code Chapter 24.14 (Environmental Resource Management) includes "Conservation Regulations." Section 24.14.030 provides "Slope Regulations" to minimize risks associated with development in areas characterized by combustible vegetation and steep and/or unstable slopes. Generally, areas with 30+ percent slopes cannot be included in the density determination for a project and prohibits development in areas of 30+ percent slopes. The regulations also include setback requirements for buildings near 30-50+ percent slopes. Section 24.14.070 requires a site-specific geotechnical investigation for all development, except projects with less than four units, in areas identified in the General Plan as having a high liquefaction potential. Section 24.16.060 requires an erosion control plan for projects located within high erosion hazard areas as designated in the General Plan or for development on slopes greater than ten percent.

The Grading Ordinance is a subset of Title 18, Buildings and Construction, of the City's Municipal Code and is included in Chapter 18.45 – Excavation and Grading Regulations." It provides technical regulations of grading and excavation, in conjunction with the Environmental Resource Management provisions in Chapter 24.14, in order to safeguard life, health, safety and the public welfare; protect fish and wildlife, riparian corridors and habitats, water supplies, and private and public property, and to protect the environment from the effects of flooding, accelerated erosion and/or deposition of silt. The ordinance accomplishes this by providing guidelines, regulations, and minimum standards for clearing, excavation, cuts, fills, earth moving, grading operations (including cumulative grading), water runoff and sediment control. In addition, the ordinance includes provisions regarding administrative procedures for issuance of permits and approval of plans and inspections during construction and subsequent maintenance. The City revised the Grading Ordinance in April 2004 in order to strengthen the ordinance regarding implementation of BMPs, including those for erosion and sediment control.

GEOLOGIC SETTING

Physiographic Setting

The City of Santa Cruz lies on a narrow coastal plain at the mouth of the San Lorenzo River Valley on the northern shore of the Monterey Bay. The coastal plain is bounded landward by the Santa Cruz Mountains, rising to elevations over 2,600 feet. The San Lorenzo River flows southward from the Santa Cruz Mountains and is the largest drainage in the region, with an area of about 106 square miles. The central district of the City of Santa Cruz is situated on floodplain of the lower San Lorenzo River.

Most of the City lies on a relatively flat topographic bench to the east and west of the San Lorenzo River valley. This bench was formed by marine wave erosion at a time when the land was lower relative to sea level than at present. The bench, referred to as a marine terrace, was preserved by gradual uplift of the region. This terrace is separated from successively higher (older) terraces by steep slopes that mark ancient sea cliffs. The older terraces ascend stair-step like up the mountain front bordering the City to the north.

The lowermost of these terraces forms a broad, gently seaward sloping surface that terminates in a sea cliff at the modern shoreline. This modern seacliff, or coastal bluff, is a result of wave erosion that is cutting a new marine terrace offshore. The upper west side of the City and the Delaveaga Golf Course are situated on an older, higher marine terrace. The marine terrace surfaces are cut by a series of south flowing seasonal streams that occupy smaller stream valleys.

Regional Setting

REGIONAL GEOLOGIC SETTING

The City of Santa Cruz is situated on the southwestern slope of the central Santa Cruz Mountains, part of the Coast Ranges physiographic province of California. The northwest-southeast structural grain of the Coast Ranges is controlled by a complex of active faults within the San Andreas fault system. Southwest of the San Andreas fault, the Coast Ranges, including the Santa Cruz Mountains, are underlain by a large, northwest-trending, fault-bounded, elongated prism of granitic and metamorphic basement rocks. The granitic and metamorphic basement is Cretaceous in age, or older, and is overlain by a sequence of dominantly marine sedimentary rocks of Paleocene to Pliocene age and non-marine sediments of Pleistocene and Holocene age. The older sedimentary rocks are moderately to strongly deformed, with steep-limbed folds and several generations of faults associated with uplift of the Santa Cruz Mountains.

The Santa Cruz Mountains are cut by several active faults, of which the San Andreas is the most important (see Figure 4.10-1[2], Regional Seismicity Map). Along the coast, the ongoing tectonic activity is most evident in the gradual uplift of the coastline, as indicated by the series of uplifted marine terraces that sculpt the coastline.

[2] All EIR figures are included in Chapter 7.0 at the end of the EIR (before appendices) for ease of reference as some figures are referenced in several sections.

REGIONAL SEISMIC SETTING

California's broad system of strike-slip faulting has a long and complex history. Locally, the San Andreas, Zayante-Vergeles and San Gregorio faults and the Monterey Bay-Tularcitos fault zone present a significant seismic hazard to the City (see Figure 4.10-1). These faults are associated with Holocene activity (movement in the last 11,000 years) and are therefore considered to be active. The most severe historical earthquakes to affect the project site are the 1906 San Francisco earthquake and the 1989 Loma Prieta earthquake, with Richter magnitudes of about 8.3 and 7.1, respectively.

City of Santa Cruz Geologic Setting

GEOLOGIC UNITS & STRUCTURE

A geologic map of the City of Santa Cruz is depicted on Figure 4.10-2. The geology of the City and surrounding area displays over 100 million years of geologic history. Rock units in the City are separable into three major groups: granitic intrusive rocks of Late Cretaceous age, pre-Cretaceous metasedimentary rocks, and sedimentary rocks of Tertiary and Quaternary age. The granitic intrusive rocks form the core of Ben Lomond Mountain and underlie the City at depth. These rocks formed from molten rock (magma) that melted its way upward from deep in the earth's crust and then cooled underground, forming granitic rock. The metamorphic and granitic rocks are observed outcropping along the northwestern margins of the City.

The younger sedimentary rocks (Tertiary and Quaternary age) are draped over the older granitic and metamorphic bedrock. The Tertiary rock units include the Santa Margarita Sandstone, the Santa Cruz Mudstone, and sandstones of the Purisima Formation (see Figure 4.10-2). Surficial Quaternary deposits locally overly the Tertiary units. These units include marine terrace deposits, stream or river alluvium, and landslide deposits. The marine terrace deposits directly underlie much of the City, and generally range from a few feet thick to at most a few tens of feet thick. They consist of marine sands, including ancient beach sands, deposited while the marine terrace was being carved by the ocean, and colluvium deposited over the marine sands after the terrace was exposed by falling sea levels. Soil (residuum) derived from weathering of all the older geologic units is present in thicknesses up to a few feet throughout the area.

The older igneous and metamorphic rocks are highly deformed, with many cross-cutting faults and folds. The tectonic forces responsible for the deformation seen in these rocks, however, have long since dissipated and the faults are no longer considered active. The sedimentary rocks overlying the granitic and metamorphic basement, principally the Santa Margarita Sandstone, the Santa Cruz Mudstone, and the Purisima Formation, are younger Tertiary age rocks and, locally, have experienced only gentle uplift and very mild folding. In most exposures, the layering in these rocks is near horizontal.

The only fault mapped within the boundaries of the City is the Ben Lomond fault. This fault trends southward from its intersection with the Zayante fault down the San Lorenzo Valley towards Santa Cruz. The fault has only been confidently mapped as far south as Felton, several miles north of Santa Cruz, but Stanley and McCaffrey (1983) extended the fault

southward through the City into Monterey Bay, based largely on geophysical (indirect) evidence. Vertical movement on the fault, west side up, is thought to be responsible for uplift and tilting of the granitic rock mass that forms Ben Lomond Mountain. Most of the movement occurred on this fault prior to about six million years ago, and it is not presently considered to be active.

SURFACE PROCESSESS

Surficial geologic processes in the area include weathering, erosion, and mass wasting (landsliding). Weathering of surficial materials and erosion by wind and water are the principal processes active in developing natural landscapes. When erosion leads to the development of steep slopes, landsliding may occur. In turn, landsliding breaks up the rock formations on the slope, leading to additional weathering and erosion. Landslides from the County of Santa Cruz landslide map occurring within the City are depicted on Figure 4.10-3.

KARST TERRAIN

The northwest portion of the City is partially underlain by marble bedrock. Marble is distinct from other bedrock types in the area because it is soluble in water. Consequently, percolating ground water will gradually dissolve channels in the rock, resulting in underground conduits and caverns. Where these conduits or caverns intersect the ground surface, sinkholes result. Another aspect of areas underlain by marble is that the surface drainage system may be poorly developed or absent due to the capture of surface runoff by sinkholes. Where sinkholes intercept streams, they are known as swallow holes. A landscape that is dominated by features associated with soluble bedrock is known as karst terrain.

Karst terrain in the Santa Cruz area is of limited extent. Very large areas of the southeastern United States are underlain by karst terrain, and the sudden, spectacular collapse of large sinkholes is a potential hazard there. Most of the karst terrain in Santa Cruz lies on the University of California campus and in a few neighborhoods immediately south of the campus. Sinkholes associated with the karst terrain in the Santa Cruz area are not of great size, and they tend to develop gradually over time, rather than by sudden collapse. However, local sinkholes are often filled with fine grained sediment that has washed into the sinkhole from adjacent terrain. The sinkhole fill can prevent the sinkholes from being recognized. Soil settlement associated with filled sinkholes can damage buildings and other development.

Water flowing through the karst conduits in the marble emerges at the surface in form of springs where the downhill margins of marble outcrop are bounded by relatively impermeable rocks. The springs at Kalkar Quarry and the spring feeding Westlake are examples of such springs. Besides gradual settlement of sinkhole fill, there can also be problems associated with groundwater surfacing under buildings or roads in these areas, especially during the winter rains.

SEISMIC HAZARDS

The City of Santa Cruz is located in a seismically active region of California. Historical earthquakes along the San Andreas fault and its branches have caused substantial seismic

shaking in Santa Cruz County in historical time. The two largest historical earthquakes to affect the area were the moment magnitude (Mw) 7.9 San Francisco earthquake of April 18, 1906 and the Mw 6.9 Loma Prieta earthquake of October 17, 1989 (corresponding to Richter magnitudes of 8.3 and 7.1) . The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Santa Cruz Mountains. The Loma Prieta earthquake may have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, although its regional effects were not as extensive. There were also major earthquakes in northern California along or near the San Andreas fault in 1838, 1865, and possibly 1890. Further description of regional faults and seismic hazards is provided below.

Faults

SAN ANDREAS FAULT

The San Andreas fault is active and represents the major seismic hazard in northern California. The main trace of the San Andreas fault trends northwest-southeast and extends over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault passes offshore and merges with the Cascadia fault zone. Surface rupture during historical earthquakes, fault creep, and historical seismicity confirm that the San Andreas fault and its branches, the Hayward, Calaveras, and San Gregorio faults, are all active today.

Geologists have recognized that the San Andreas fault system can be divided into segments with "characteristic" earthquakes of different magnitudes and recurrence intervals. Two overlapping segments of the San Andreas fault system represent the greatest potential hazard to the City of Santa Cruz. The first segment is defined by the rupture that occurred from Mendocino to San Juan Bautista along the San Andreas fault during the great Mw 7.9 San Francisco earthquake of 1906; it has been suggested that this "1906 rupture" segment experiences earthquakes with comparable magnitudes about every 200 years. The second segment is defined approximately by the rupture zone of the Mw 6.9 Loma Prieta earthquake; it has been posited that earthquakes of Mw 7.0 on this segment of the fault have a recurrence interval of 138 years.

ZAYANTE-VERGELES FAULT

The Zayante fault lies southwest of the San Andreas fault and trends about 50 miles northwest from the Watsonville lowlands into the Santa Cruz Mountains (see Figure 4.10-1). The postulated southern extension of the Zayante fault, known as the Vergeles fault, merges with the San Andreas fault south of San Juan Bautista. Stratigraphic and geomorphic evidence indicates that the Zayante-Vergeles fault has undergone late Pleistocene and Holocene movement and is potentially active.

Some historical seismicity may be related to the Zayante-Vergeles fault. A magnitude 4.0 earthquake in 1998 in the Santa Cruz Mountains occurred on the Zayante fault. The Zayante-Vergeles fault should be considered active for design purposes, and is capable of generating an Mw 6.8 earthquake with a recurrence interval of almost 9,000 years.

SAN GREGORIO FAULT

The San Gregorio fault cuts the ocean floor seaward of Monterey Bay and skirts the Santa Cruz County coastline before coming on land at Point Año Nuevo. North of Año Nuevo it passes offshore, intersecting the coast again at Half Moon Bay (see Figure 4.10-1). North of Half Moon Bay, the San Gregorio fault lies offshore until it connects with the San Andreas fault near Bolinas. Southward from Monterey Bay, the San Gregorio fault intersects the coast at Point Sur and eventually connects with the Hosgri fault in south-central California.

The onshore segments of the San Gregorio fault at Point Año Nuevo and at Half Moon Bay show evidence of late Pleistocene and Holocene displacement. In addition to stratigraphic evidence for Holocene activity, the historical seismicity in the region is partially attributed to the San Gregorio fault. Due to inaccuracies of epicenter locations, the magnitude 6+ earthquakes of 1926, tentatively assigned to the Monterey Bay fault zone, may have actually occurred on the San Gregorio fault. The San Gregorio fault in the Santa Cruz County area has a recurrence interval of 400 years with the potential to generate a Mw 7.2 earthquake.

MONTEREY BAY-TULARCITOS FAULT ZONE

The Monterey Bay-Tularcitos fault zone is based on a postulated connection between the Tularcitos fault, located on land near the Monterey Peninsula, and the offshore Monterey Bay fault zone (see Figure 4.10-1). The Monterey Bay fault zone is 6 to 9 miles wide and about 25 miles long.

Both offshore and onshore fault traces in this zone have displaced Quaternary age rock layers and, therefore, are considered potentially active. One offshore trace, which aligns with the trend of the Navy fault, has displaced Holocene beds and is therefore considered active. Seismically, the Monterey Bay-Tularcitos fault zone may be historically active. The largest historical earthquakes tentatively located in the Monterey Bay-Tularcitos fault zone are two events, estimated at 6.2 on the Richter Scale, in October 1926. Because of possible inaccuracies in locating the epicenters of these earthquakes, it is possible that these earthquakes actually occurred on the nearby San Gregorio fault. Another earthquake in April 1890 might be attributed to the Monterey Bay-Tularcitos fault zone. An earthquake of Mw 7.1-7.3 may be expected on the Monterey Bay-Tularcitos fault zone, with an effective recurrence interval of 2,600-2,800 years, based on Holocene offsets noted on an offshore strand of the fault.

Seismic Hazards

Potential seismic hazards include fault rupture, strong seismic shaking, soil liquefaction and related types of seismically induced ground failure, and tsunami. These hazards are discussed individually, below.

GROUND SURFACE RUPTURE DUE TO FAULTING

Earthquakes are caused by slippage along faults, or cracks, in the earth's crust. Where the fault intersects the ground surface, this slippage causes offset of the ground surface that can damage or destroy structures placed over the fault. The only suspected fault trace crossing through the City is the southern extension of the Ben Lomond fault, but it is not considered to be

active and therefore any risk of ground surface rupture across the fault trace must be considered low. Ground surface rupture due to faulting is, therefore, not considered a significant risk in the City of Santa Cruz.

SEISMIC SHAKING HAZARD

For the purpose of evaluating seismic shaking potential in the City, this discussion focuses on the San Andreas, Zayante-Vergeles, San Gregorio, and Monterey Bay-Tularcitos fault systems (see Figure 4.10-1). These faults are considered active seismic sources by the State of California. While other faults in this region may be active, their potential contribution to seismic hazards in the City is overshadowed by these four larger or closer faults. The distances between these faults and the City center are listed in Table 4.10-1, as is the maximum expected earthquake size and the approximate time interval between major earthquakes on each fault. All of these faults are considered capable of magnitude (M) 6.5 or larger earthquakes.

Table 4.10-1
Distances and Directions to Local Faults

Fault	Distance from site (miles)	Maximum Expected Earthquake Magnitude (Moment Magnitude)	Approximate Time Between Major Earthquakes (years)
San Gregorio	9.9	7.2	400
Zayante-Vergeles	7.9	7.9	8821
Monterey Bay-Tularcitos	6.5	6.5	2841
San Andreas	11.2	7.9	210

Source: Nolan Associates

A qualitative measure of earthquake shaking intensity is provided by the Modified Mercalli Intensity Scale (Table 4.10-2). The Mercalli Scale (and other, similar qualitative scales) provides a way to gauge earthquake shaking intensity based on verbal or published descriptions of earthquake damage. It was the principal means of measuring earthquake size before the advent of seismograph arrays in the early 20th Century. Modified Mercalli Intensities of VIII (8) to IX (9) were measured in the City of Santa Cruz for the 1989 Loma Prieta and 1906 San Francisco earthquakes, respectively. Similar shaking intensities are expected in future earthquakes.

The principal factors which affect the severity of seismic shaking in a given area are the magnitude of the earthquake and the distance from the earthquake source to the location of interest. All of the listed faults, because of the size and proximity to the City, are significant potential sources of strong seismic shaking. Another factor which affects the intensity of shaking is the type of geologic materials underlying the site. Certain types of earth materials can amplify or dampen shaking.

There are two methods for estimating the intensity of seismic ground motions that may be expected at a site: "deterministic" and "probabilistic". A deterministic approach estimates the magnitude of the most severe shaking that can reasonably be expected at a particular site, without regard for the likelihood that such shaking will occur. In this type of analysis, the largest earthquake thought credible on each fault is assumed to occur on the portion of the fault nearest the site.

Table 4.10-2
Modified Mercalli Intensity Scale

The modified Mercalli scale measures the intensity of ground shaking as determined from observations of an earthquake's effect on people, structures, and the Earth's surface. This scale assigns to an earthquake event a Roman numeral from I to XII as follows:	
I	Not felt by people, except rarely under especially favorable circumstances.
II	Felt indoors only by persons at rest, especially on upper floors. Some hanging objects may swing.
III	Felt indoors by several. Hanging objects may swing slightly. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	Felt indoors by many, outdoors by few. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle. Wooden walls and frame may creak.
V	Felt indoors and outdoors by nearly everyone; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset; some dishes and glassware broken. Doors swing; shutters, pictures move. Pendulum clocks stop, start, change rate. Swaying of tall trees and poles sometimes noticed.
VI	Felt by all. Damage slight. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks and books fall off shelves; pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked.
VII	Difficult to stand. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in badly designed or poorly built buildings. Noticed by drivers of automobiles. Hanging objects quiver. Furniture broken. Weak chimneys broken. Damage to masonry; fall of plaster, loose bricks, stones, tiles, and unbraced parapets. Small slides and caving in along sand or gravel banks. Large bells ring.
VIII	People frightened. Damage slight in specially designed structures; considerable in ordinary substantial buildings, partial collapse; great in poorly built structures. Steering of automobiles affected. Damage or partial collapse to some masonry and stucco. Failure of some chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed pilings broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	General panic. Damage considerable in specially designed structures; great in substantial buildings, with some collapse. General damage to foundations; frame structures, if not bolted, shifted off foundations and thrown out of plumb. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Landslides on river banks and steep slopes considerable. Water splashed onto banks of canals, rivers, lakes. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground; earth slumps and landslides widespread. Underground pipelines completely out of service. Rails bent greatly.
XII	Damage nearly total. Waves seen on ground surfaces. Large rock masses displaced. Lines of sight and level distorted. Objects thrown upward into the air.

A probabilistic analysis considers the likelihood that a certain earthquake will occur and includes other uncertainties, such as epicentral location, as part of the overall probability. The advantage of a probabilistic analysis over a deterministic analysis is that the probabilistic estimate specifies the intensity of ground motion that is likely to occur during the design life of a project, rather than the greatest intensity that is ever likely to occur. Using probabilistic ground motions, a building may be designed for the shaking intensity that has a reasonable likelihood of occurring during the building lifetime, rather than a maximum value that has very little likelihood of occurring. In most cases, the probabilistically predicted ground motion is lower than the deterministic ground motion. However, in Santa Cruz County, the San Andreas fault produces large earthquakes so often that the deterministic and probabilistic ground motion values tend to be very similar.

Ground motion probabilities are commonly expressed as the probability of exceedance in a given time period. In the past, ground motion with a probability of exceedance of 10% in 50 years has been considered appropriate for design for most residential and commercial development. This probability level means that there is only a 10% chance that the specified ground motion will be exceeded in a 50-year period. For more critical structures, such as hospitals, a much lower probability level (higher ground motion) is specified for design.

The U.S. Geological Survey and the California Division of Mines and Geology have prepared a probabilistic seismic hazard assessment for the state of California. Probabilistic ground motions with 10% in 50 years and 2% in 50 years probability of exceedance are summarized in Table 4.10-3. These numbers can be compared to ground accelerations measured during the Loma Prieta earthquake, Table 4.10-4.

Table 4.10-3
Predicted Seismic Ground Motions in Soft Rock

Probability	Mean Peak Horizontal Ground Acceleration, City Center (g)
10% probability of Exceedance in 50 years	0.41
2% probability of Exceedance in 50 years	0.63

Table 4.10-4
Seismic Ground Motions Measured During the Loma Prieta Earthquake

Measurement Site	Peak Ground Acceleration	Earth Material at Measurement Site
Corralitos	0.64	Landslide deposits
Capitola	0.54	Alluvium
UCSC	0.47	Marble

The expected ground motion values listed in Table 4.10-3 are based on average (soft rock) site conditions; actual ground motions during an earthquake may vary due to differences in the way portions of the earth's crust transmit seismic energy or because of unique site conditions, such as soil type, bedrock type, and topography. Sites underlain by very hard bedrock tend to produce the least damaging effects on buildings, other factors being equal; while relatively soft alluvial deposits can increase the amplitude of ground shaking that affects buildings.

The central district of Santa Cruz is situated on young alluvial deposits of the San Lorenzo River. This type of earth material will amplify the effects of seismic shaking on buildings. Other portions of Santa Cruz are primarily underlain by sandstone and shale that can be categorized as soft rock. The impact of seismic shaking in these areas will be less than on alluvial deposits. Seismic shaking is expected to have the least impact on portions of the City underlain by granitic or metamorphic rocks such as marble (see Figure 4.10-2).

SEISMICALLY INDUCED GROUND FAILURE

This section describes several types of ground failure that may accompany seismic shaking, including liquefaction and its related hazards of lurch cracking and lateral spreading, differential settlement, off-fault ground cracking, and landsliding.

Liquefaction, Lurch Cracking and Lateral Spreading. Liquefaction occurs in loose, cohesionless, granular materials that are saturated with ground water. The effects of seismic shaking can cause this type of sediment to loose strength and flow like a liquid. Liquefaction related ground deformation includes lurch cracking, fissuring, and lateral spreading.

Lurch cracking and fissuring occurs where a liquefied layer at depth is overlain by a surficial layer of relatively brittle, non-liquefied soil. In this situation, the surface layer may crack into individual blocks that can tip or rotate relative to each other. The resulting surface deformation can damage or destroy overlying buildings.

Lateral spreading occurs most often on level terraces or flood plains bounded on one side by a steep stream or river bank. When the sediments adjacent to the river liquefy, they flow into the stream or river channel. Lurch cracking and lateral spreading are potential hazards in areas susceptible to liquefaction.

There are four factors that help geologists and engineers estimate that likelihood that liquefaction will occur in a given area: 1) age of the underlying geologic materials, 2) type of geologic deposit, 3) depth to ground water, and 4) potential intensity and duration of seismic shaking. (See Appendix F-4 for further details.) Once a susceptibility to liquefaction is identified in an area, the risk posed to buildings and other structures by liquefaction depends strongly on the thickness and depth of the liquefiable layer. If the liquefiable layer is only six inches thick and is buried by 40 feet of non-liquefiable sediment, the actual hazard posed to a building at the surface may be relatively small. On the other hand, a 20-foot thick liquefiable layer buried by five feet of dry soil would be very likely to cause damage.

There is evidence for liquefaction in Santa Cruz during both the 1906 San Francisco and 1989 Loma Prieta earthquakes. Potential liquefaction hazard zones within the City are depicted on Figure 4.10-4 based on a ranking of mapped geologic units by liquefaction susceptibility according to age and type of deposit. This ranking draws on historical occurrences of liquefaction and previous liquefaction hazard studies. Susceptibility areas are divided into areas "A" and "B". Both areas are underlain by soils considered to be liquefiable, but the "B" areas are anticipated to have greater depth to groundwater, and therefore, a lesser susceptibility to liquefaction. This map is intended as a planning tool to identify areas where more in-depth analysis of liquefaction potential may be required. Not all of the liquefaction hazard zones showed evidence of liquefaction during the 1906 or 1989 earthquakes. Nevertheless, ground water levels fluctuate over time and different earthquakes can produce different effects.

Seismically Induced Differential Settlement. Seismically induced differential settlement may occur anywhere that soils are in a loose state. In the planning area, soils subject to this hazard will probably be limited to areas of improperly compacted artificial fill or areas of the most recently deposited sediments on the banks of the San Lorenzo River. In general, areas of natural soils that are potentially susceptible to differential settlement will be included in areas that are potentially liquefiable, as these soils are usually the type of soils that would liquefy if they were saturated. Areas of loose soil that could be subject to seismically induced differential settlement are of limited extent in the study area. This hazard can generally be mitigated by appropriate site-specific geotechnical investigations and proper foundation design. Any site screened for liquefaction hazard should also be evaluated for differential settlement potential.

Off-Fault Ground Cracking. During the 1989 earthquake, numerous ground cracks opened up along the crests and flanks of ridges. The ground cracks ranged from fractions of an inch to many feet wide and up to one-quarter mile long. Where the ground cracks crossed under buildings, the buildings were often severely damaged.

These ground cracks are considered to be co-seismic ground surface rupture; that is, they occur in response to severe ground shaking, but are not caused directly by offset of a fault. Ground cracking can also occur due to liquefaction, but such cracks are generally grouped with lurch cracking and are not included in this category. The co-seismic ground cracks may occur for a variety of reasons, but they are generally associated with steep topography, particularly ridge crests. With the exception of the crest of coastal bluffs, the topography within the City is generally not conducive to formation of co-seismic ground cracks and this hazard is therefore considered to be low throughout the City. Ground cracking is expected to occur in zones up to 50 feet wide landward from the crest of coastal bluffs, or anywhere there is a high, vertical or near-vertical cliff face.

Seismically Induced Landsliding. Seismically induced landsliding results when earthquake shaking adds extra stress to an already marginally stable slope. Landsliding that occurred in the Santa Cruz region as a result of the 1989 Loma Prieta earthquake included: 1) reactivation of existing landslides, including several very large, ancient landslide complexes that had previously been thought to be stable; 2) shallow slumps, calving, and toppling of natural cliffs and stream banks; and 3) slumping of steep cut slopes and embankments associated with grading for roads and development

Movement of the large, ancient landslides that took place during the 1989 earthquake involved incremental movements on the order of a few inches to a few feet. These landslides tended to move while the strong shaking was occurring, and then came to rest as soon as the shaking diminished. Because of the size and limited displacement of these landslides, damage to homes sited on the landslides was often remarkably light, except where the homes spanned the cracks around the landslide margins.

The other types of landsliding that occurred during the Loma Prieta earthquake were generally localized, affecting single homes or blocking roadways with loose soil and rock debris. There were extensive, but very shallow failures of sea cliffs around Monterey Bay and on very steep to vertical banks along creeks and rivers. There were also a number of landslides, mostly from cut slopes, that closed roads in the Santa Cruz Mountains, including State Highway 17. In most cases, the landslides were cleared within a few days, although permanent repair of the roadways took longer.

In terms of hazards posed to public safety, landslide hazards associated with the seismic shaking are similar to those occurring under static (non-seismic) conditions. Additional discussion of landslide hazard is provided below.

Tsunami Hazard. Tsunamis are giant ocean waves generated when uplift or down-dropping movement occurs over a broad area of the ocean floor. Ocean floor displacement may occur due to movement on submarine faults during large earthquakes, submarine landslides, or violent volcanic eruptions.

California is at risk from both local and distant source tsunamis, and tsunamis are a potential hazard to the City of Santa Cruz. There has been minimal damage and loss of life in Santa Cruz during recorded history (City of Santa Cruz, September 2007). However, a tsunami generated by a 9.0 magnitude earthquake in Japan in March 2011 reached Santa Cruz and caused substantial damage to the Santa Cruz Small Craft Harbor. Figure 4.7-2 identifies the potential tsunami inundation area in Santa Cruz, which is also further discussed in the HYDROLOGY, STORM DRAINAGE & WATER QUALITY (Chapter 4.7) section of this EIR.

Tsunamis can be generated locally, by movement on an offshore fault or by landsliding along the banks of the Monterey submarine canyon. The San Gregorio fault and the Monterey Bay fault zone are both considered active and capable of large earthquakes. However, these faults are not likely to produce large vertical offsets of the sea floor and therefore are probably not likely to generate significant tsunamis. Submarine landslides in the Monterey submarine canyon, however, are a more likely local source of tsunamis. Many large landslides have been mapped along the flanks of the canyon. A model of a landslide generated tsunami in the Monterey Bay predicted about 23 feet of runup along the Monterey Bay coastline. A particular hazard with a locally generated tsunami is that there is little warning time before the wave impacts the shoreline; a landslide generated tsunami in the Monterey Bay could strike the coastline in as little as 10 minutes from the time it was generated.

NON-SEISMIC GEOLOGIC HAZARDS

Geologic hazards that are not seismically induced include landslides, slope instability, and coastal cliff retreat.

Landslides and Slope Instability

Landslides are the rapid downward or outward movement of rock, earth or artificial fill on a slope. Factors causing landsliding include rock strength, the orientation of rock structure such as layering or fractures in the slope, erosion, weathering, high rainfall, steepness of slopes, and human activities such as the removal of vegetation and inappropriate grading.

Although landsliding is mostly a natural process that accompanies erosional downcutting and oversteepening of slopes, road building or other types of earth-moving can result in steep cut slopes and loose fill soils, both of which can be prone to landsliding. Roads can also collect naturally dispersed runoff and concentrate it into a rapidly flowing stream that can trigger erosion or landsliding.

A portion of the Santa Cruz County landslide map that covers the City is shown on Figure 4.10-3. This map should not be considered a complete catalogue of all existing landslides, especially where smaller landslides are concerned, but it shows in a general way the distribution of landslides in the City. The City is not as susceptible to landslides as are steeper areas of Santa Cruz County.

Because landslide hazard is associated primarily with steep slopes, landslide hazards in the City are confined to a few particular locations: 1) along the sea cliffs bounding the City to the south, 2) along the steeper banks of the San Lorenzo River valley and along the banks of smaller stream drainages, and 3) along the steep risers separating successively older marine terraces. In general, landsliding can be considered a potentially significant hazard where slopes exceed a gradient of about 50 percent (about 26½°). Slope instability can sometimes occur on less than 50 percent slopes, but the risk is typically much lower. Figure 4.10-5 shows slopes of 30 percent to 50 percent and slopes over 50 percent.

Coastal Bluff Retreat

The City of Santa Cruz is bounded to the south by the Pacific Ocean. Landward erosion by wind and wave action over time has created coastal bluffs along most of the City's coastline. The term bluff retreat is commonly used to describe the horizontal (landward) erosion of the shoreline along the coastline. Coastal erosion includes both cliff or bluff erosion and beach erosion, and is a result of both winter wave attack, as well as slowly rising sea level.

Coastal erosion includes both bluff erosion and beach erosion; wind, waves, and long-shore currents are the driving forces behind coastal erosion. Winter storm waves are larger, steeper and contain more energy, and typically move significant amounts of sand from the beaches to offshore bars, creating steep, narrow beaches. In the summer, lower, less energetic waves allow return of the sand, making for wider beaches. During the winter months when beaches are narrow, or absent altogether, the storm waves attack the cliffs and bluffs more frequently.

Bluff retreat is usually expressed in terms of a uniform rate, such as feet per year or cubic yards of eroded sediment per linear foot of shoreline per year. However, bluff retreat is mostly the result of specific events associated with major coastal storms, earthquakes, or landslides; many years' worth of retreat at a particular point may occur during the course of one particularly intense winter storm or may be due to a single landslide event. Therefore, while average retreat rates calculated over many decades may be accurate, actual retreat events may be much larger than average retreat rates would predict, although infrequent.

Bluff retreat rates are calculated by comparing older survey information along the coast that shows where the bluff was in the past with modern survey data as well as review of aerial photos. Human activities, such as construction of shore protection structures and dredging may also impact retreat rates. Another factor that is having an impact on the rate of bluff retreat is gradual sea level rise due to global warming. The precise impact of observed sea level rise on bluff retreat rates is not known, and uncertainty in the rate of future sea level rise compounds the difficulty in predicting the impacts of sea level rise.
Retreat rates are influenced by the orientation of the cliff relative to the prevailing storm wave direction, coastline geometry, rock type, and beach width and persistence. A number of studies have been done of coastal retreat rates in the Santa Cruz area including area-wide studies and site-specific studies for individual coastal development projects. Average retreat rates along the coastline within the City of Santa Cruz have been measured at 2.75 to 5.9 inches per year for the portion of the shoreline studied, although retreat rates were found that exceeded 23 inches per year for specific locations.

SOILS & EROSION

Soil Conditions and Constraints

Soils develop as a result of physical and chemical weathering of geologic materials at the earth's surface combined with biologic mixing due to plants and animals. Based on the Soil Conservation Service Soil Survey for Santa Cruz County (Soil Conservation Service, 1980), there are 57 soil types within the City. Table 4.10-5 lists the soil types found in the City, which are illustrated on Figure 4.10-6.

The many soil types within the City are broadly separable into three principal units: 1) soils developed on marine terraces and alluvial flats along streams, 2) soils on hills and mountains developed under forest canopy, and 3) soils on hills and mountains developed under brush vegetation. The soils developed on marine terraces and stream-side alluvial flats that underlie much of the City include the Watsonville, Watsonville-Tierra, Elkhorn, Pinto, Baywood, Cropley, Danville, and Soquel soil series. (Soil types found within the City are shown on Figure 4.10-6.) These soils cover the largest area out of the three principal units, amounting to 69% of the City. The Watsonville Series underlies broad areas of the City; it is generally poorly drained and causes ponding and shallow groundwater problems. The soils formed under forest canopy include the Ben Lomond, Lompico, and Nisene-Aptos series, which account for15.4% of the soil types within the City. Soils developed on brush covered slopes, primarily along the foot of Ben Lomond Mountain between the coastal plains and the forested uplands, include the Aptos, Los Osos, and Bonny Doon series. They occur mostly in small areas on the western portion of Santa Cruz, covering about 8.9%

of the City. Because of their occurrence on steeper slopes, the soils developed on hills and mountains will be more susceptible to erosion hazard.

Some soils may place constraints on development unless specific measures are implemented to mitigate poor soil conditions Typical constraints that may affect development include expansive soils, low density soils prone to settlement, low permeability soils that can cause ponding and poor drainage, and soils with high erosion potential.

Expansive soils shrink and swell depending on moisture level as the clay minerals in these soils expand and contract. Soils with moderate or high shrink-swell potential are a common cause of foundation deterioration, pavement damage, cracking of concrete slabs, and shifting of underground utilities as they expand and contract with seasonal variations in soil moisture. These soils are undesirable for use as engineered fill or subgrade directly underneath foundations or pavement, and must be replaced with non-expansive engineered fill or require treatment to mitigate their expansion. Although shrink-swell tendency presents a potentially serious hazard to development, it can be mitigated by a variety of standard engineering measures.

The impact of potentially weak or soft soils on development is generally manifested in two ways: as problems associated with low shear strength, affecting primary bearing capacity and slope stability; and as problems associated with loss of strength due to cyclic loading during seismic activity, affecting the potential for liquefaction, lateral spreading and seismically induced differential settlements. Soils with low strengths may fail on steep cut or fill slopes or natural slopes inclined at gradients of 30 percent or greater, and they may settle under the weight of new buildings. As with expansive soils, the hazards associated with weak soils can be mitigated with a series of standard engineering measures. Risks associated with low strength soils or expansive soils can be mitigated with appropriately scoped geotechnical investigations.

Erosion

Soil erosion potential is the susceptibility of the soil to erosion by water or wind. The risk of erosion depends upon the type of soil, slope of the land, slope length, rainfall amount and intensity, and vegetation cover. Removal of vegetation and the disturbance of the ground by mechanical grading or cattle grazing can accelerate the erosion process. Impervious surfaces from urban development can also concentrate runoff, causing gullying and other problems. The result may include not only the loss of valuable soils but also sedimentation of stream beds, habitat degradation, landslides and increased downstream flooding potential (City of Santa Cruz, 1994).

In general, erosion potential increases with the steepness of slope, but it is also affected by soil texture. Finer grained soils with strong cohesion tend to resist erosion better than loose, sandy soils. The Soil Conservation Service soil mapping program (1980) provides a ranking of erosion potential by soil type. These erosion hazard rankings were developed principally to address soil loss due to agriculture, and do not necessarily provide a useful measure of erosion potential with regard to urban planning and development.

The principal risk associated with erosion in an urban or semi-urban setting is due to *accelerated erosion*, is caused directly or indirectly by human activities or land management. Accelerated erosion is caused principally by grading for roads and other development and by land

clearing. Both these processes remove vegetative cover that protects soils from erosion and they change natural drainage patterns in a way that can concentrate runoff, increasing its erosive potential. Consequently, erosion hazards can be best mitigated by proper planning and implementation of erosion control measures on a site-specific basis during construction, and by implementation of permanent, fail-safe drainage systems post-construction.

Erosion potential is rated high to very-high on the Aptos, Ben Lomond, Bonny Doon, Elkhorn, Lompico-Felton, Nisene-Aptos, Pfeiffer, Sur-Catelli, Tierra-Watsonville, Watsonville, and Zayante soil types as shown on Table 4.10-5. Because of the difficulties in preventing erosion, development of these areas must be limited in accordance with soil conservation practices, including minimal grading and retention of existing native vegetation (City of Santa Cruz, 1994).

4.10.2 RELEVANT PROJECT ELEMENTS

PROPOSED GOALS, POLICIES & ACTIONS

The HAZARDS, SAFETY, AND NOISE chapter of the draft *General Plan 2030* includes two goals presented below that are related to geologic hazards, soils constraints, and/or emergency preparedness with several policies and accompanying actions.

GOAL HZ1 Emergency and disaster readiness.

GOAL HZ6 Protection from natural hazards.

Three policies support Goal HZ6 and address erosion hazards, unstable slopes, and seismic hazards.

FUTURE DEVELOPMENT POTENTIAL

The *General Plan 2030* Land Use Map and land use designations are largely unchanged from the 1990-2005 General Plan / Local Coastal Program, except for three new mixed use land designations have been developed and applied to the following major transportation corridors: Mission Street, Ocean Street, Soquel, Avenue, and Water Street. Land Use actions LU1.1.4 and LU1.1.5 address development and land use for specific sites: the Swenson property and the Golf Club Drive property, respectively. LU2.2.3 also includes addition of a 5.5-acre parcel adjacent to the Dimeo Lane landfill and Resource Recovery Center. Specific uses haven't been identified, although the site will not be used as part of expansion of the landfill disposal area. In addition, the proposed *General Plan 2030* supports development of a desalination plant (Policy CC3.1.3), but a specific site is not identified.

Table 4.10-5
Soil Classifications Within City of Santa Cruz

Map Symbol (SCS No.)	Soil Name	Slope (%)
100	Aptos loam, warm	15-30
101	Aptos loam, warm	30-50
103	Aguents, flooded	
104	Baywood loamy sand	0-2
105	Baywood loamy sand	15-30
106	Baywood loamy sand	15-30
109	Beaches	
110	Ben Lomond sand loam	5-15
113	Ben Lomond-Catelli-Sur complex	30-75
114	Ben Lomond-Felton complex	30-50
115	Ben Lomond-Felton complex	50-75
116	Bonnydoon loam	5-30
117	Bonnydoon loam	30-50
118	Bonnydoon-Rock outcrop complex	50-85
119	Clear lake clay, moderately wet	
123	Cropley silty clay	2-9
124	Danville loam	0-2
125	Danville loam	2-9
127	Diablo clay	15-30
128	Dune land	
129	Elder sandy loam	0-2
132	Elkhorn sandy loam	0-2
133	Elkhorn sandy loam	2-9
134	Elkhorn sandy loam	9-15
135	Elkhorn sandy loam	15-30
136	Elkhorn-Pfeiffer complex	30-50
139	Fluvaquentic Haploxerolis-Aquic Xerofluvents complex	0-15
142	Lompico-Felton complex	5-30
143	Lompico-Felton complex	30-50
144	Lompico-Felton complex	50-75
145	Lompico Variant loam	5-30
146	Los Osos loam	5-15
147	Los Osos loam	15-30
157	Nisene-Aptos complex	30-50
158	Nisene-Aptos complex	50-75
159	Pfeiffer gravelly sand loam	15-30
161	Pinto loam	0-2
162	Pinto loam	2-9
164	Pits-Dumps complex	
168	Santa Lucia Shaly clay loam	30-50
170	Soquel loam	0-2
171	Soquel loam	2-9
172	Soquel loam	9-15
173	Sur-Catelli complex	50-75
174	Tierra Watsonville complex	15-30
175	Tierra-Watsonville complex	30-50
176	Watsonville loam	0-2
177	Watsonville loam	2-15
178	Watsonville loam - thick surface	0-2
179	Watsonville loam - thick surface	2-15
180	Watsonville loam - thick surface	15-30
183	Zayante course sand	30-50
184	Zayante-Rock outcrop complex	30-50

Shaded Soils have a high to very high erosion hazard potential

Source: USDA Soil Conservation Service, Soil Survey of Santa Cruz County, 1980

4.10.3 IMPACTS AND MITIGATION MEASURES

CRITERIA FOR DETERMINING SIGNIFICANCE

In accordance with the California Environmental Quality Act (CEQA), State CEQA Guidelines (including Appendix G), City of Santa Cruz plans, policies and/or guidelines, and agency and professional standards, a project impact would be considered significant if the project would:

10a Expose people or structures to potential substantial adverse effects including the risk of loss, injury, or death resulting from the rupture of a known earthquake fault, seismic ground shaking, landslides, or seismic-related ground-failure, including liquefaction, which cannot be mitigated through the use of standard engineering design techniques;

10b 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 an onsite or offsite landslide or slope failure/ instability;

10c Result in substantial soil erosion or the loss of topsoil and subsequent sedimentation into local drainage facilities and water bodies; or

10d Be located on an expansive soil, as defined by the Uniform Building Code (1997) or subject to other soil constraints that might result in deformation of foundations or damage to structures, creating substantial risks to life or property.

IMPACT ANALYSIS

There are no active faults within the City of Santa Cruz, and thus, fault rupture (10a) is not a hazard. The following impact analyses address exposure to seismic hazards (10a); exposure to geologic and slope hazards (10b); erosion (10c); and soils constraints (10d).

Potential Future Development & Buildout

Adoption and implementation of the proposed *General Plan 2030* would not directly result in increased new development. However, the draft General Plan includes policies and a land use map that support additional development as summarized in subsection 4.82 above. Buildout projections indicate that potential new development accommodated by the draft general plan to the year 2030 could total 3,350 residential units, 3,140,000 square feet of non-residential uses, primarily on infill and underutilized lots, as described in the PROJECT DESCRIPTION (Chapter 3.0) and LAND USE (Chapter 4.1) sections of this EIR. Based on the estimated development occurring under the proposed plan,[3] approximately 55 percent of all new housing, 45 percent of new commercial development and 52 percent of new office development would located within new mixed use designations along the City's four major transportation corridors: Mission Street, Ocean Street, Soquel Avenue, and Water Street.

[3] See Table 3-3 in the PROJECT DESCRIPTION (Chapter 3.0) section of this EIR and Figure 2-3 for estimated distribution of new development per specific areas in the City.

Impact 4.10-1: Seismic Hazards
Adoption and implementation of the proposed *General Plan 2030* would accommodate future development that could result in exposure of people and property to seismic hazards, including ground shaking, liquefaction, and ground settlement. With adherence to City regulations, the project would not result in increased risk of exposure to seismic hazards. This is considered a *less-than-significant impact*.

The City is primarily developed, and future development accommodated by the proposed *General Plan 2030* would be considered predominantly infill development within developed areas on vacant infill sites, on underutilized properties, and in the new mixed-use districts along the City's four major street corridors. Based on the estimated development occurring under the proposed plan, approximately one-half of new development would be located along these transportation corridors. There are a few remaining vacant lots and underdeveloped properties located within developed areas (i.e., Swenson site and Golf Club Drive area).

Future development and associated population growth could expose structures and people to seismic hazards, particularly seismic shaking and liquefaction. However, adherence to existing regulations and standards, including the CBC and various policies and actions established in the proposed *General Plan 2030*, would minimize harm to people and structures from adverse geologic events and conditions. Buildings will be required to be designed in accordance with the latest edition of the California Building Code, which sets forth structural design parameters for buildings to withstand seismic shaking without substantial structural damage. Conformance to the CBC as required by state law and the City would ensure the maximum practicable protection available for structures and their associated trenches, excavations and foundations. Project designs are required to include the application of CBC Seismic Zone 4 standards. The continuation of design review and code enforcement to meet current seismic standards is the primary mitigation strategy to avoid or reduce damage from an earthquake, and seismic safety standards are a requirement for all building permits (City of Santa Cruz, September 2007). It is also noted that since the 1989 Loma Prieta Earthquake, all commercial and public buildings have been seismically retrofitted, and as infrastructure is repaired or replaced, updated seismic safety standards are incorporated (Ibid.).

Most of the City's downtown area and areas along watercourses are subject to liquefaction, including the Golf Club Drive area and portion of the Swenson property. Typically, standard geotechnical engineering procedures, soil testing, and proper design can identify and mitigate liquefiable soils. By using the most up-to-date standards, potential damage related to liquefaction, including subsidence and settlement, can be reduced to levels that are generally considered acceptable. Section 24.14.070 of the City's Municipal Code requires preparation of a site-specific geotechnical investigation for all development, except less than four units, in areas identified in the General Plan as having a high liquefaction potential to assess the degree of potential liquefaction and recommend appropriate design/mitigation measures.

The general Plan policies and actions outlined in Table 4.10-6 also serve to reduce exposure to seismic hazards. Policy HZ6.3 seeks to reduce the potential for loss of life, injury and property damage due to earthquakes and liquefaction. The City will adopt new state-approved building

codes (HZ6.3.1), and the plan supports seismic retrofits (HZ6.3.2, HZ6.3.3) and utility design to withstand seismic hazards (HZ6.3.4).

TABLE 4.10-6
Proposed General Plan Policies & Actions that Avoid or Minimize Exposure to Seismic and Geologic Hazards

Type of Measure / Action	Policies / Actions
MINIMIZE RISK OF EXPOSURE TO SEISMIC HAZARDS	• Critical facilities to survive flood & seismic hazards: HZ1.1.8 • Strengthen bridges: HZ1.1.11 • Reduce seismic hazard risks: HZ6.3 • Adopt State building does: HZ6.3.1 • Support seismic retrofits: HZ6.3.2, HZ6.3.3 • Design utilities to withstand seismic shaking: HZ6.3.5
MINIMIZE EXPOSURE TO OTHER GEOLOGIC HAZARDS	• Minimize coastal bluff erosion hazard & building setbacks: HZ6.1.1, HZ 6.1.2 • Require geotech reports within 100 feet of coastal bluffs: HZ6.1.3 • Discourage development on unstable slopes & require geo reports if may be slope instability potential: HZ6.2, HZ6.2.1

Conclusion. Adoption and implementation of the proposed *General Plan 2030* would not directly result in new development, but new development accommodated by the plan would be subjected to seismic hazards, including seismic shaking and liquefaction. With implementation of the proposed *General Plan 2030* goals, policies and actions and adherence to local regulations, buildings would be designed to minimize damages and reduce exposure of people or structures to significant risks associated with seismic hazards. Thus, this is a less-than-significant impact.

Mitigation Measures

No mitigation measures are required as a significant impact has not been identified. However, revision of the following *General Plan 2030* action is recommended to reference a potential liquefaction areas map, to be consistent with Zoning Regulations that require geotechnical investigations in areas of liquefaction identified in the proposed General Plan.

Recommended Revisions to the *Draft General Plan 2030*

Revise or add policies/actions as indicated below. Deleted text is shown in ~~strikeout~~ typeface, and new text is shown in underlined typeface.

HZ5.3.6.1 Require site specific geologic investigations by qualified professionals for proposed development in potential liquefaction areas shown on the Liquefaction Hazard Map[4] to assess potential liquefaction hazards, and

[4] The map is included in this EIR as Figure 4.10-4 as referenced on page 13 of this chapter.

require developments to incorporate the design and other mitigation measures recommended by the investigations.

Impact 4.10-2: Other Geologic Hazards
Adoption and implementation of the proposed *General Plan 2030* would accommodate future development that could result in exposure to people and property to potential hazards associated with landslides, slope stability, and/or coastal bluff retreat. With adherence to City regulations and proposed *General Plan 2030* goals, policies and actions, the future development would not be located on unstable area related to landslides, slope instability or coastal bluff retreat. This is considered a *less-than-significant impact*.

As indicated above, the City is primarily developed, and future development accommodated by the proposed *General Plan 2030* would be considered infill development. Areas of known steep slopes and/or landslides are primarily located within managed open space areas, as well as portions of the west side of Santa Cruz in the Western Drive area and in the northeastern portion of the City in the Prospect Heights and Carbonera areas (see Figures 4.10-3 and 4.10-5). In general, landsliding can be considered a potentially significant hazard where slopes exceed a gradient of about 50 percent (about 26½°). Slope instability can sometimes occur on less than 50 percent slopes, but the risk is typically much lower. Construction on steep slopes can result in creation of unstable slopes if not properly designed. The areas subject to these constraints are limited within the City.

Section 24.14.030 of the City's Municipal Code regulates development on steep slopes and generally prohibits development on slopes greater than 50 percent with setbacks from 30+ percent slopes. The general Plan polices and actions outlined in Table 4.10-6 also serve to reduce exposure to landslide/slope stability exposure. Policy HZ6.2 discourages development on unstable slopes with preparation of engineering geology reports where excavation and grading have the potential to create unstable slopes or be exposed to slope stability (HZ6.2.1).

There are no major vacant or underutilized lands along the coast that would be subject to coastal bluff erosion, except for existing uses. However, the proposed plan seeks to minimize hazards posed by coastal bluff retreat, including requiring setbacks for buildings adjacent to coastal cliffs (HZ6.1.1, HZ6.1.2). The draft General Plan does include an action to allow construction that alters natural shoreline processes, but only when required to serve coastal-dependent uses or to protect existing structures or public beaches from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply (HZ6.1.3). Since the City is in the process of updating its Local Coastal Plan as a separate document from the General Plan, the issue of coastal erosion and protective devices will be reviewed in that document.

Conclusion. Adoption and implementation of the proposed *General Plan 2030* would not directly result in new development, but some new development accommodated by the plan could be subjected to hazards associated with landslides,

slope stability, and coastal bluff retreat. With implementation of the proposed *General Plan 2030* goals, policies and actions and adherence to local regulations, buildings would be designed with appropriate setbacks, where needed, to minimize damages and reduce exposure to significant risks associated with unstable slopes and/or coastal bluff retreat. Thus, this is a less-than-significant impact.

Mitigation Measures

No mitigation measures are required as a significant impact has not been identified. However, deletion of the following *General Plan 2030* action is recommended as is pertains to issues in the coastal zone that will be subject to review as part of the Local Coastal Plan update.

Recommended Revisions to the *Draft General Plan 2030*

Revise or add policies/actions as indicated below. Deleted text is shown in ~~strikeout~~ typeface, and new text is shown in underlined typeface.

~~HZ6.1.3 Allow construction that alters natural shoreline processes only when required to serve coastal-dependent uses or to protect existing structures or public beaches from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.~~

Impact 4.10-3: Soil Constraints
Adoption and Implementation of the proposed *General Plan 2030* would accommodate future development that could result in exposure to soil constraints, such as expansive soils, that could lead to structural damages. With adherence to City regulations, the project would not result in increased risk of exposure to soils constraints. This is considered a *less-than-significant impact*.

Future development accommodated by the proposed *General Plan 2030* would be located on some soil types that may pose constraints to structural development. Expansive soils is one situation, in which soils with high clay content are prone to expansion and contraction, known as "shrink-swell," which can result in damage to building foundations, pavement, and underground utilities. These soils are undesirable for use as engineered fill or subgrade directly underneath foundations or pavement, and must be replaced with non-expansive engineered fill or require treatment to mitigate their expansion potential. Structural designs and construction implementation in accordance with standard geotechnical/soils investigations can mitigate impacts posed by expansive or other unstable soils, i.e. unconsolidated fill. The California Building Code (Chapter 18) requires preparation of a geotechnical report for most new structures, except geotechnical reports are not required for one-story, wood-frame and light-steel-frame buildings of Type II or Type V construction and 4,000 square feet or less in floor area, not located within Earthquake Fault Zones or Seismic Hazard Zones as shown in the most recently published maps from the California Geological Survey (CGS).

Conclusion. Adoption and implementation of the proposed *General Plan 2030* would not directly result in new development, but some new development accommodated by the plan could be subjected to soil constraints from expansive or other unstable soils. With adherence to local and state building codes, buildings would be designed in accordance with recommendations of required geotechnical reports to prevent foundation and other structural damages. Thus, this is a less-than-significant impact.

Mitigation Measures

No mitigation measures are required as a significant impact has not been identified.

Impact 4.10-4: Erosion
Adoption and Implementation of the proposed *General Plan 2030* would accommodate future development that could result in erosion and inadvertent sedimentation into storm drains or watercourses, if not properly controlled. With adherence to City regulations, the project would not result in substantial soil erosion. This is considered a *less-than-significant impact*.

Future development accommodated by the proposed *General Plan 2030* would be located on some soil types that have a moderate to high potential for erosion when soils are disturbed. These soils are identified in Table 4.10-5 and shown on Figure 4.10-6.

Section 24.16.060, part of the City's Municipal Code's Conservation Regulations, requires an erosion control plan for projects located within high erosion hazard areas as designated in the General Plan or for development on slopes greater than ten percent. It also addresses site development features to minimize erosion. The ordinance requires an erosion control plan for residential development of four or more units, grading in excess of one thousand cubic yards, and nonresidential development with a floor area greater than 10,000 square feet or constructed on slopes in excess of 10 percent. Chapter 18.45, Excavation and Grading Regulations," provides technical regulations for grading and excavation, in conjunction with Chapter 24.14. It establishes guidelines, regulations, and minimum standards for clearing, excavation, cuts, fills, earth moving, grading operations (including cumulative grading), water runoff and sediment control. In addition, the ordinance includes provisions regarding administrative procedures for issuance of permits and approval of plans and inspections during construction and subsequent maintenance. The City revised the Grading Ordinance in April 2004 in order to strengthen the ordinance regarding implementation of BMPs, including those for erosion and sediment control. Implementation of erosion control measures and BMPs during construction of future development would minimize the potential for erosion.

Conclusion. Adoption and implementation of the proposed *General Plan 2030* would not directly result in new development, but new development could result in erosion without proper erosion control measures during construction. With adherence to

local regulations, erosion control plans will be required, and potential erosion during construction would be minimized. Thus, this is a less-than-significant impact.

Mitigation Measures

No mitigation measures are required as a significant impact has not been identified.

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