3.5 - Geology, Soils, and Seismicity

3.5.1 - Introduction

This section describes the existing geologic conditions, including geologic and seismic hazards, for the Warm Springs/South Fremont Community Plan area, summarizes the applicable regulatory framework, identifies potential significant impacts regarding geology, soils, and seismicity for development within the plan area, and provides mitigation measures to reduce these impacts to a less than significant level. Setting information for this section is drawn from regional geologic reports and maps from the United States Geological Survey (USGS), the California Geological Survey (CGS), the Natural Resources Conservation Service (NRCS), and other public sources.

3.5.2 - Environmental Setting

Regional Geologic Setting

The Community Plan area is located near the southeastern margin of San Francisco Bay. San Francisco Bay is a broad, shallow, alluvial depression within the California Coast Ranges that has been subsequently filled with sedimentary or alluvial deposits. San Francisco Bay is located near the margin of the North American and Pacific tectonic plates. Over time, the relative motion of the plates has shaped the region, creating the varied mountainous, valley, and fault-bound blocks seen in the San Francisco Bay area today.

Regional Seismicity

The plan area is located in a seismically active region. The main feature generating the seismic activity in the region is the tectonic plate boundary between the North American and Pacific plates. Locally, this boundary is referred to as the San Andreas Fault Zone and includes numerous active faults found by the CGS under the Alquist-Priolo Earthquake Fault Zoning Act to be “active” (i.e., to have evidence of fault rupture in the past 11,000 years). The closest active fault to the plan area is the Hayward fault, located just east of the plan area. Some of the other major active faults near the plan area within the San Andreas Fault Zone include the Calaveras, San Andreas, and San Gregorio faults. The locations of active faults in the region are shown on Exhibit 3.5-1.

In a fact sheet published in April 2008, the USGS estimated that there was a 63 percent probability that between 2007 and 2036, a 6.7 or greater magnitude earthquake will occur in the San Francisco Bay Region. The probability of a 6.7 magnitude or greater earthquake occurring along individual faults was estimated to be 31 percent along the Hayward-Rogers Creek Fault, 7 percent along the Calaveras Fault, 21 percent along the San Andreas Fault, and 6 percent along the San Gregorio Fault.

Seismic and Geologic Hazards

This section describes the hazards associated with the geologic conditions and the potential for seismic events in the Community Plan area.

Fault Rupture

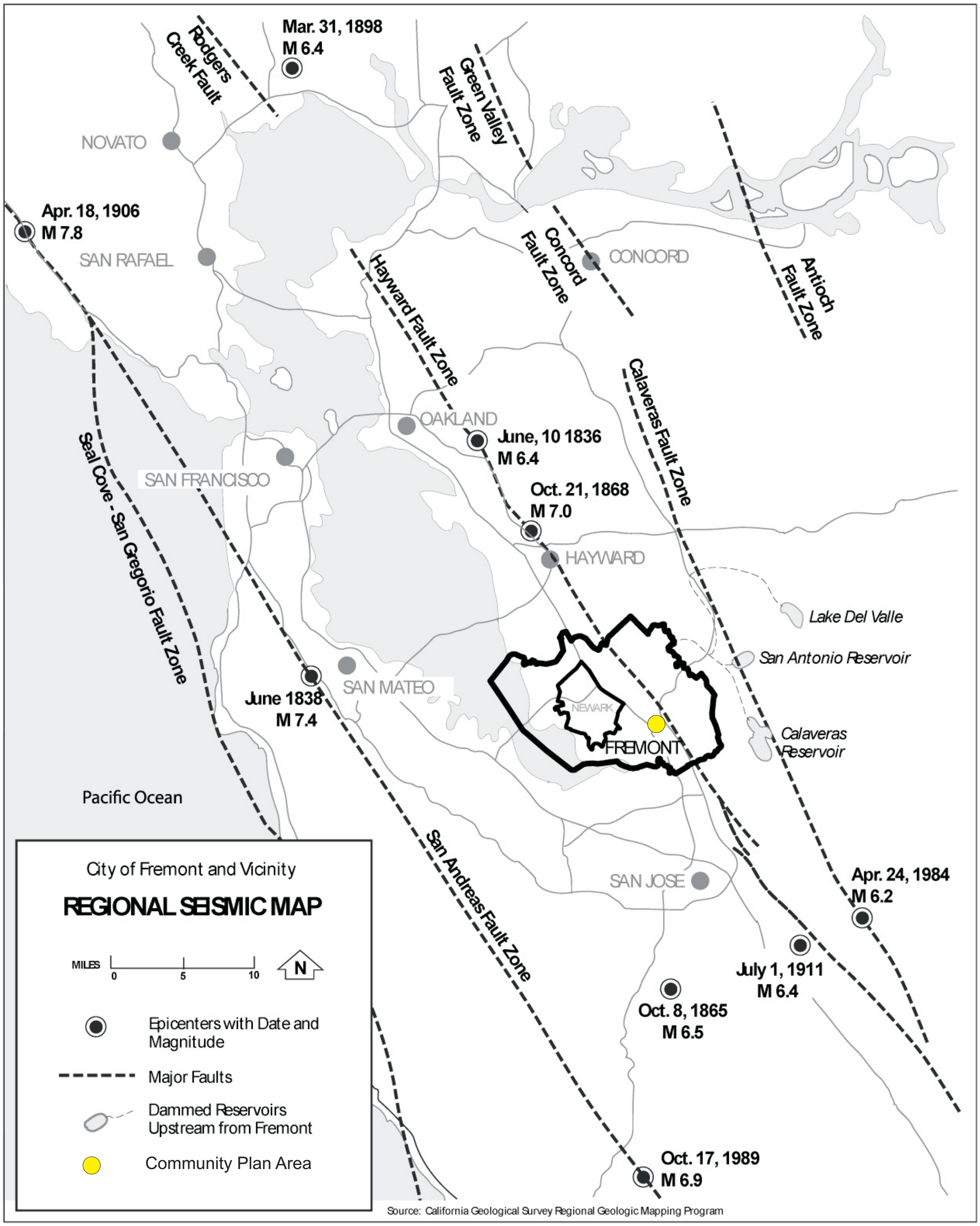
Surface rupture occurs when the ground surface is broken due to fault movement during an earthquake. Active faults in the Community Plan vicinity are shown on Exhibit 3.5-1. The location of surface rupture generally can be assumed to be along an active major fault trace.

The Hayward fault is located near the eastern plan area boundary, and the mapped Alquist-Priolo Fault Zone, where fault rupture would be a potential hazard, is located just east the plan area (Exhibit 3.5-2). The maximum expected earthquake on the southern portion of the Hayward fault is estimated to be magnitude 6.7. Fault rupture would not be expected to be a potential hazard in the plan area, which is outside the mapped Alquist-Priolo Fault Zone.

Seismic Shaking

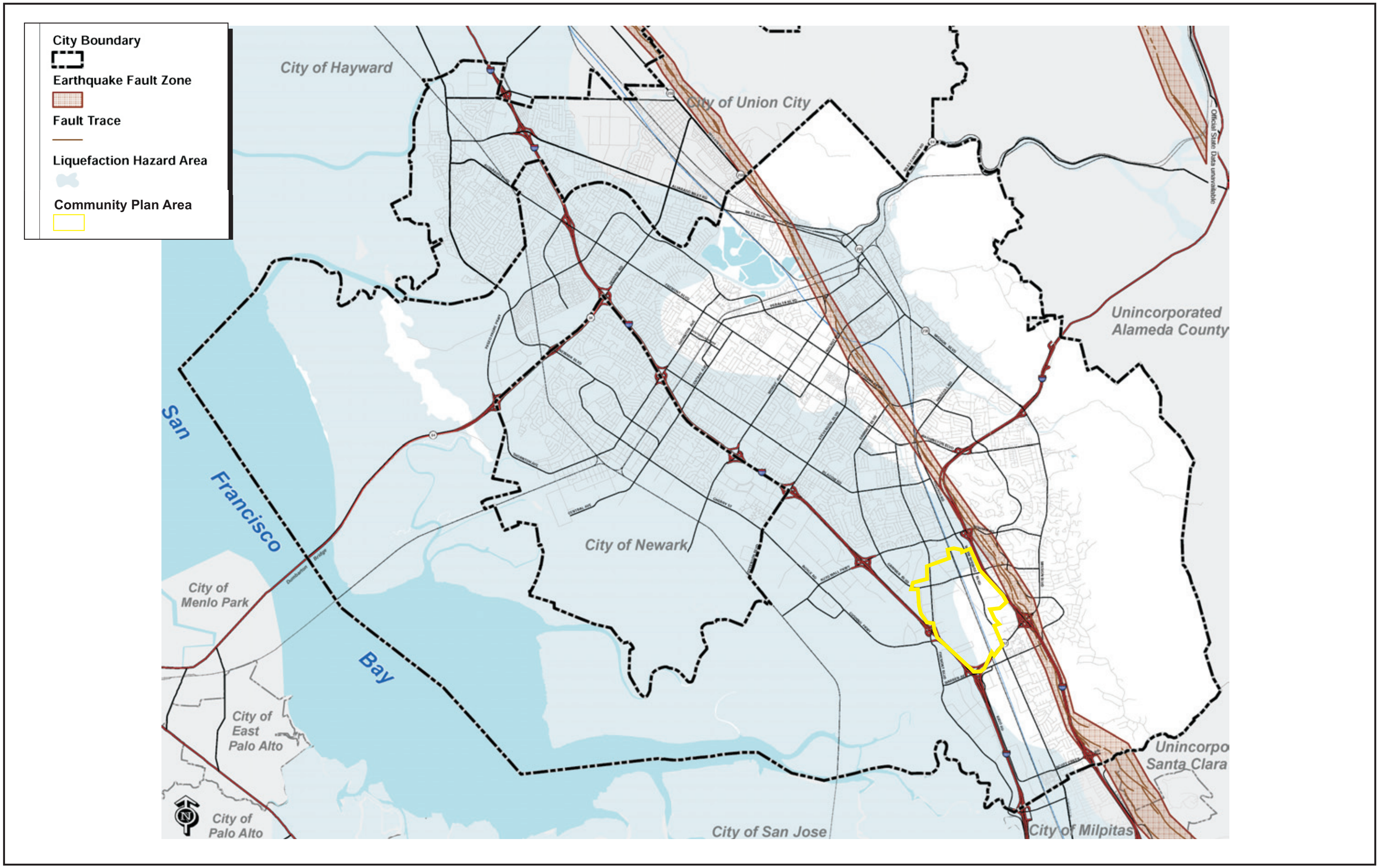
Seismic shaking (or ground shaking) is a general term referring to all aspects of motion of the earth's surface resulting from an earthquake, and is normally the major cause of damage in seismic events. The extent of ground shaking is controlled by the magnitude and intensity of the earthquake, distance from the epicenter, and local geologic conditions. Magnitude is a measure of the energy released by an earthquake; it is assessed by seismographs that measure the amplitude of seismic waves. Intensity is a subjective measure of the perceptible effects of seismic energy at a given point and varies with distance from the epicenter and local geologic conditions. The Modified Mercalli Intensity Scale (MMI) is the most commonly used scale for measurement of the subjective effects of earthquake intensity and is further described in Table 3.5-1. Intensity can also be quantitatively measured using accelerometers (strong motion seismographs) that record ground acceleration at a specific location, a measure of force applied to a structure under seismic shaking. Although the Hayward fault is the closest fault, any of the regional faults (Exhibit 3.5-1) are capable of producing significant ground shaking in the Community Plan area.

Groundshaking maps prepared by the Association of Bay Area Governments (ABAG) project that during the maximum credible earthquake on the Hayward fault, violent to very violent shaking may occur in the plan area.



FirstCarbon® SOLUTIONS

Exhibit 3.5-1
Regional Seismic Map



Source: FirstCarbon Solutions, 2013.

FirstCarbon SOLUTIONS

Exhibit 3.5-2
Earthquake Fault Zones and Liquefaction Hazard Area

Table 3.5-1: Modified Mercalli Scale

Richter Magnitude Correlation (M^a)	Category	Definition
≤ 3	I	Not felt except by a very few under especially favorable circumstances.
	II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
	III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
4	IV	During the day felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
	V	Felt by nearly everyone, many awaken. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
5	VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
6	VII	Everybody runs outdoors. Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
	VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
7	IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
8 ≤	X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
	XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
	XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted.
Source: California Geological Survey, 2002.		

Ground Failure

Liquefaction is the rapid transformation of saturated, loose, fine-grained sediment to a fluid-like state because of earthquake ground shaking. In the process, the soil undergoes transient loss of strength, which commonly causes ground displacement or ground failure to occur.

Since saturated soils are a necessary condition for liquefaction, soil layers in areas where the groundwater table is near the surface have higher liquefaction potential than those in which the water table is located at greater depths. Liquefaction potential increases in the vicinity of the San Francisco Bay and locally near creeks, where loose granular sediments have accumulated as a result of stream processes. Liquefaction has resulted in substantial loss of life, injury, and damage to property. In addition, liquefaction increases the hazard of fires because of explosions induced when underground gas lines break, and because the breakage of water mains substantially reduces fire suppression capability. In general, where there is any potential for liquefaction, site-specific studies are needed to determine the extent of the hazard if development were to occur. Lateral spreading is a form of horizontal displacement of soil toward an open channel or other “free” face, such as an excavation boundary. Ground shaking, especially when inducing liquefaction, may cause lateral spreading toward unsupported slopes. Areas most prone to lateral spreading are those that consist of fill material that has been improperly engineered, that have steep, unstable banks, and that have high groundwater tables. Damage caused by liquefaction and lateral spreading is generally most severe when liquefaction occurs within 15 to 20 feet of the ground surface. Much of the western and northern portions of plan area have been mapped as liquefaction hazard areas, as shown on Exhibit 3.5-2.

Landslides and Slope Failure

The strong ground motions that occur during earthquakes are capable of inducing landslides, generally where unstable slope conditions already exist. In addition, heavy precipitation events can induce mudflows or debris flows in areas where soils on a hillslope or in a stream channel becomes saturated and unstable.

Slope failure can occur as either rapid movement of large masses of soil (“landslide”) or slow, continuous movement (“creep”). The primary factors influencing the stability of a slope are: 1) the nature of the underlying soil or bedrock; 2) the geometry of the slope (height and steepness); 3) rainfall; and 4) the presence of previous landslide deposits. Landslides are commonly triggered by unusually high rainfall and the resulting soil saturation, by earthquakes, or a combination of these conditions. Since the plan area is relatively level and not located in a mapped landside hazard zone, landslides and slope failure would not be a potential hazard.

Soils

Expansive Soils

Mapping performed by the NRCS indicates that the two dominant soils within the Community Plan area are Clear Lake clay and clayey Xerothents. In general, Clear Lake clay is located in the northern half of the Community Plan area, while Xerothents is present in the southern half of the Community Plan area. A summary of soil types mapped in the plan area is presented in Table 3.5-2.

Expansion and contraction of volume can occur when expansive soils undergo alternating cycles of wetting (swelling) and drying (shrinking). During these cycles, the volume of the soil changes markedly. Because of such volume changes, structural damage to building and infrastructure may occur if the potentially expansive soils were not considered in building design and during construction. The predominantly clayey soils in the plan area have a high shrink-swell potential and are classified as expansive soils. Construction on these soils may require appropriate engineering to avoid structural damage.

Table 3.5-2: Soils in the Plan Area

Soil Association/Name	Slope (degrees)	Approximate Acreage within the Community Plan Area (Percentage)	Linear Extensibility (shrink-swell)
Botella loam	0 to 2	5.8	Moderate
Clear Lake clay	0 to 9	48.8	High
Danville silty clay loam	0 to 9	14.6	High
Marvin silt loam, saline-alkali	N/A	5.2	High
Pescadero clay, drained	N/A	0.5	High
Xerothents, clayey	0 to 9	25.2	High
Source: United States Department of Agriculture, Natural Resources Conservation Service, 2013.			

Subsidence

Subsidence is the lowering of the land-surface elevation. The mechanism for subsidence is generally related to groundwater pumping and subsequent consolidation of loose aquifer sediments. The primary hazards associated with subsidence are increased flooding hazards and damage to underground utilities. Other effects of subsidence include changes in the gradients of stormwater and sanitary sewer drainage systems in which the flow is gravity-driven. Although Fremont's groundwater levels have been lowered due to pumping, no related subsidence has been noted. A groundwater recharge program has been implemented by the Alameda County Water District, and groundwater levels are now stable. Therefore, impacts from subsidence would be unlikely in the plan area.

Settlement and Differential Settlement

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

3.5.3 - Regulatory Framework

Federal

National Earthquake Hazards Reduction Program

The National Earthquake Hazards Reduction Program was established by the U.S. Congress when it passed the Earthquake Hazards Reduction Act of 1977, Public Law 95–124. In establishing National Earthquake Hazards Reduction Program, Congress recognized that earthquake-related losses could be reduced through improved design and construction methods and practices, land use controls and redevelopment, prediction techniques and early-warning systems, coordinated emergency preparedness plans, and public education and involvement programs. The four basic goals remain unchanged:

- Develop effective practices and policies for earthquake loss reduction and accelerate their implementation.
- Improve techniques for reducing earthquake vulnerabilities of facilities and systems.
- Improve earthquake hazards identification and risk assessment methods, and their use.
- Improve the understanding of earthquakes and their effects.

Several key federal agencies contribute to earthquake mitigation efforts. There are four primary National Earthquake Hazards Reduction Program agencies:

- National Institute of Standards and Technology of the Department of Commerce
- National Science Foundation
- USGS of the Department of the Interior
- Federal Emergency Management Agency (FEMA) of the Department of Homeland Security

Implementation of National Earthquake Hazards Reduction Program priorities is accomplished primarily through original research, publications, and recommendations to assist and guide state, regional, and local agencies in the development of plans and policies to promote safety and emergency planning.

State

California Building Code

The 2012 International Building Code is published by the International Conference of Building Officials, and is the widely adopted model building code in the United States. The 2013 California Building Code is another name for the body of regulations known as the California Code of Regulations, Title 24, Part 2, which is a portion of the California Building Standards Code. The California Building Code incorporates by reference the International Building Code requirements with necessary California amendments. Title 24 is assigned to the California Building Standards Commission, which, by law, is responsible for coordinating all building standards. Under state law, all building standards must be centralized in Title 24 or they are not enforceable.

Compliance with the 2013 California Building Code requires that (with very limited exceptions) structures for human occupancy be designed and constructed to resist the effects of earthquake motions. The Seismic Design Category for a structure is determined in accordance with either; California Building Code Section 1613 - Earthquake Loads: or, American Society of Civil Engineers Standard No. 7-05, Minimum Design Loads for Buildings and Other Structures. In brief, based on the engineering properties and soil-type of soils at a proposed site, the site is assigned a Site Class ranging from A to F. The Site Class is then combined with Spectral Response (ground acceleration induced by earthquake) information for the location to arrive at a Seismic Design Category ranging from A to D, of which D represents the most severe conditions. The classification of a specific site and related calculations must be determined by a qualified person and are site-specific.

Alquist-Priolo Earthquake Fault Zoning Act

Surface rupture is the most easily avoided seismic hazard. The Alquist-Priolo Earthquake Fault Zoning Act was passed in December 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Hayward fault Alquist-Priolo Earthquake Fault Zone is located just on the east side of the I-680 freeway from the plan area.

Seismic Hazards Mapping Act

In 1990, following the 1989 Loma Prieta earthquake, the California Legislature enacted the Seismic Hazards Mapping Act to protect the public from the effects of strong ground shaking, liquefaction, landslides and other seismic hazards. The Seismic Hazards Mapping Act established a statewide mapping program to identify areas subject to violent shaking and ground failure; the program is intended to assist cities and counties in protecting public health and safety. The Seismic Hazards Mapping Act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. As a result, the California Geological Survey is mapping Seismic Hazards Mapping Act Zones and has completed seismic hazard mapping for the portions of California most susceptible to liquefaction, ground shaking, and landslides: primarily the San Francisco Bay area and Los Angeles basin. The northern and western portions of the plan area have been designated a potential liquefaction hazard zone under Seismic Hazards Mapping Act mapping (Exhibit 3.5-2).

Local

City of Fremont

General Plan

The City of Fremont General Plan, Safety Element sets forth the following goals and policies, related to geology, soils, and seismicity that are relevant to the proposed project:

- Goal 10-1 and Policies 10-1.1, 10-1.2, and 10-1.3 call for minimizing risks to life and property resulting from land instability and other geologic hazards.
- Goal 10-2 and Policies 10-2.1, 10-2.2, and 10-2.3 promote minimizing risks to life and property resulting from seismic hazards.

Municipal Code
The City of Fremont Municipal Code, Chapter 15.10, adopts the 2013 California Building Code, with amendments, as the Fremont Building Code. The Building and Safety Division is responsible for the administration and enforcement of the Fremont Building Code.

3.5.4 - Thresholds of Significance

According to Appendix G, Environmental Checklist, of the CEQA Guidelines, geology, soils, and seismicity impacts resulting from the implementation of the proposed project would be considered significant if the project would:

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

   i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.

   ii. Strong seismic ground shaking.

   iii. Seismic-related ground failure, including liquefaction.

   iv. Landslides.

b) Result in substantial soil erosion or the loss of topsoil.

c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.

e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater. (Refer to Section 7, Effects Found Not To Be Significant.)

3.5.5 - Project Impacts and Mitigation Measures

Seismic Hazards

Impact GEO-1:	**Buildout of the Community Plan may expose persons or structures to seismic hazards.**

Impact Analysis
Major regional faults located in the Community Plan vicinity are capable of producing violent ground shaking in the Community Plan area, and a major seismic event is likely during the operational lifetime of development and redevelopment projects undertaken under the Community Plan. Strong to violent seismic shaking could cause serious structural damage to buildings not engineered and

constructed to comply with the current California Building Code, and could cause extensive non-structural damage to buildings in the plan area.

Existing federal and state programs, including National Earthquake Hazards Reduction Program, the Alquist-Priolo Earthquake Fault Zoning Act, the Seismic Hazards Mapping Act and the California Building Code, are designed to provide current information detailing seismic hazards, impose regulatory requirements regarding geotechnical and soils investigations, provide limitations on the locations of structures for human habitation, impose requirements for hazard notices to potential users, and establish structural standards for requirements for buildings and grading projects. City General Plan policies require geotechnical investigations for areas with high seismic hazards, specifically including the liquefaction hazard areas shown on Exhibit 3.5-2. However, existing policies would not require a geotechnical study for other portions of the plan area.

Existing programs and policies would serve to reduce risk associated with seismic hazards. However, to address all significant impacts related to seismic hazards within the plan area, site-specific geotechnical reports should be prepared for all development under the Plan. Implementation of Mitigation Measure GEO-1 would reduce this impact to a level of less than significant.

Level of Significance Before Mitigation

Potentially significant impact.

Mitigation Measures

MM GEO-1 Prior to issuance of the first building permit for each development pursuant to the Community Plan, the project applicant shall submit a design-level geotechnical report to the City of Fremont for review and approval. The design-level investigation shall be prepared in accordance with California Building Code Standards and Fremont Municipal Code standards and address the potential for seismic hazards to occur onsite and identify abatement measures to reduce the potential for such an event to acceptable levels. The recommendations of the approved design-level geotechnical report shall be incorporated into the project plans.

Level of Significance After Mitigation

Less than significant impact.

Erosion Hazards

Impact GEO-2: **Buildout of the Community Plan may result in substantial soil erosion or the loss of topsoil.**

Impact Analysis

Development or redevelopment under the Community Plan would include construction activities that would expose soils and could potentially result in substantial erosion. Soil erosion could result in effects to stormwater quality and affect the quality of receiving waters. Following development, soils would be covered with buildings, paved areas, and landscaping, so no exposure of soils or erosion would be anticipated.

As discussed in Section 3.7, Hydrology and Water Quality, the State Water Resources Control Board adopted a National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities, Order No. 2009-0009-DWQ, NPDES No. CAS000002, as amended in 2011 (Construction General Permit). To obtain coverage under the Construction General Permit, a project applicant must submit various documents, including a Notice of Intent and a Storm Water Pollution Prevention Plan (SWPPP). Activities subject to the Construction General Permit include clearing, grading, and disturbances to the ground, such as grubbing or excavation.

The purpose of the SWPPP is to identify the sources of sediment and other pollutants that could affect the quality of stormwater discharges and to describe and ensure the implementation of Best Management Practices to reduce or eliminate sediment and other pollutants in stormwater as well as non-stormwater discharges resulting from construction activity. Implementation of Mitigation Measure HYD-1a would reduce this impact to a level of less than significant.

Level of Significance Before Mitigation
Potentially significant impact.

Mitigation Measures
Implement Mitigation Measure HYD-1a in Section 3.7, Hydrology and Water Quality.

Level of Significance After Mitigation
Less than significant impact.

Unstable Geologic Units or Soils

Impact GEO-3:	**Buildout of the Community Plan may expose persons or structures to hazards associated with unstable geologic units or soils.**

Impact Analysis
The Community Plan area currently includes urban development as well as large undeveloped properties. Portions of the Community Plan area have been developed over a relatively long history, some of the development predating current geotechnical engineering requirements. In addition, the large, previously undeveloped parcels in the Community Plan area are underlain by non-engineered soils and these parcels may potentially contain unstable geologic units or soils. New development under the Community Plan may be subject to differential settlements and other adverse effects related to unstable soils. However, slope instability is not an expected hazard, since the Community Plan area is relatively flat. Implementation of Mitigation Measure GEO-1 would reduce this impact to a level of less than significant.

Level of Significance Before Mitigation
Potentially significant impact

Mitigation Measures
Implement Mitigation Measure GEO-1.

Level of Significance After Mitigation
Less than significant impact.

Expansive Soils

Impact GEO-4:	**Buildout of the Community Plan may expose persons or structures to hazards associated with expansive soils.**

Impact Analysis
Soils in the Community Plan area are predominantly clayey and have a high shrink/swell potential, indicating expansive soils. Structural damage of buildings or rupture of utilities may occur if the potentially expansive and corrosive soils were not considered in the design and construction of development in the Community Plan area. Implementation of Mitigation Measure GEO-1 would reduce this potential impact related to expansive soils to a less than significant level by requiring geotechnical investigations to identify geological hazards for new development and by requiring that the recommendations from a licensed professional be implemented to reduce the identified geological hazard. Implementation of Mitigation Measure GEO-1 would reduce this impact to a level of less than significant.

Level of Significance Before Mitigation
Potentially significant impact

Mitigation Measures
Implement Mitigation Measure GEO-1.

Level of Significance After Mitigation
Less than significant impact.