4.5 Geology, Soils and Seismicity

This section describes geologic and seismic conditions in the Project Site and surroundings to provide relevant background information with respect to soils and potential geologic and seismic hazards. Based on the evaluation of geologic and seismic conditions in the project vicinity, potential impacts are discussed and evaluated and appropriate mitigation are identified, as necessary.

4.5.1 Environmental Setting

Regional Geology

The Project Site and surroundings lie within the geologically complex region of California referred to as the Coast Ranges geomorphic province.[1] The Coast Ranges province lies between the Pacific Ocean and the Great Valley (Sacramento and San Joaquin valleys) provinces and stretches from the Oregon border to the Santa Ynez Mountains near Santa Barbara. Much of the Coast Range province is composed of marine sedimentary deposits and volcanic rocks that form northwest trending mountain ridges and valleys, running subparallel to the San Andreas Fault Zone. The relatively thick marine sediments dip east beneath the alluvium of the Great Valley. The Coast Ranges can be further divided into the northern and southern ranges, which are separated by the San Francisco Bay. The San Francisco Bay lies within a broad depression created from an east-west expansion between the San Andreas and the Hayward fault systems. West of the San Andreas Fault lies the Salinian Block, a granitic core that extends from the southern end of the province to north of the Farallon Islands.

The Northern Coast Ranges are comprised largely of the Franciscan Complex or Assemblage, which consists primarily of graywacke, shale, greenstone (altered volcanic rocks), basalt, chert (ancient silica-rich ocean deposits), and sandstone that originated as ancient sea floor sediments. Franciscan rocks are overlain by volcanic cones and flows of the Quien Sabe, Sonoma and Clear Lake volcanic fields (CGS, 2002a).

Local Geology

The Project Site and surroundings are underlain by weakly consolidated, medium- and coarse-grained alluvial deposits with estimated ages ranging between 10 and 70 thousand years old (Helley and LaJoie, 1979). These deposits originate in the uplands to the west and south as weathered bedrock that is dislodged and transported by water towards the valley. At the valley margins, the younger, less consolidated sediments occur as alluvial fans while older, more consolidated deposits cover the valley floor. The alluvium consists of interbedded clay, silt, sand, and gravel deposits of variable and irregular thickness. Surficial materials are highly variable, typically easy to excavate, and, when wet, tend to be unstable on steep slopes and in excavations.

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[1] A geomorphic province is an area that possesses similar bedrock, structure, history, and age. California has 11 geomorphic provinces.

West and south of the Project Site and surroundings the bedrock uplands consist of moderately deformed sedimentary rocks of Tertiary age (65 to 1.6 million years ago) consisting of the San Pablo Group and the nonmarine sedimentary rocks of the Contra Costa Group. The San Pablo Group consists primarily of marine deposits including sandstone, mudstone, siltstone, and shale with minor tuff. The Contra Costa Group consists primarily of non-marine sandstone, conglomerate, shale and minor claystone, limestone and tuff.

Soils

Native surface soil in the Project Site and surroundings are characterized by Tierra Loam as part of the Tierra Series, as defined by the United States Department of Agriculture ("USDA") Natural Resource Conservation Service (NRCS). These soils occur on moderate slopes and formed from weathered sedimentary terrace deposits. They drain slowly due to clay content. In general, the soils have high shrink-swell potential (USDA NRCS, 1982). The Tierra Loam is associated with the Los Osos clay loam and Misllsholm loam. Runoff is medium to rapid and there is a moderate to high erosion hazard when exposed. The Tierra Loam is also characterized by very slow permeability, high shrink swell potential and high corrosivity.

Subsurface soil investigations conducted in the vicinity of the Project Site and surroundings have revealed that artificial fill materials immediately underlie the ground surface to depths that average approximately four feet. However, fill depths increase in the area of the box culverts. Bedrock in the form of a highly weathered sandstone was encountered at depths ranging from approximately 19 to 65 feet below ground surface ("bgs"). The sandstone is overlain by alluvial deposits that include clays and sands with varying silty contents (Smith-Emery, 2011).

Topography

The Project Site and surroundings are situated on the southern end of the Walnut Creek Valley, sandwiched between the Briones Hills and Shell Ridge near the base of Mount Diablo. The natural slope of the valley is gradual to the north, however the Project Site and vicinity are relatively level. The Project Site and surrounding elevations are approximately in the range of 140 to 150 feet above mean sea level ("msl") (Smith Emery, 2011).

Seismicity

The Project Site and surroundings lie within a region of California that contains many active and potentially active faults and is considered an area of high seismic activity (**Figure 4.5-1**).[2] The USGS along with the California Geological Survey and the Southern California Earthquake Center formed the 2007 Working Group on California Earthquake Probabilities which has evaluated the

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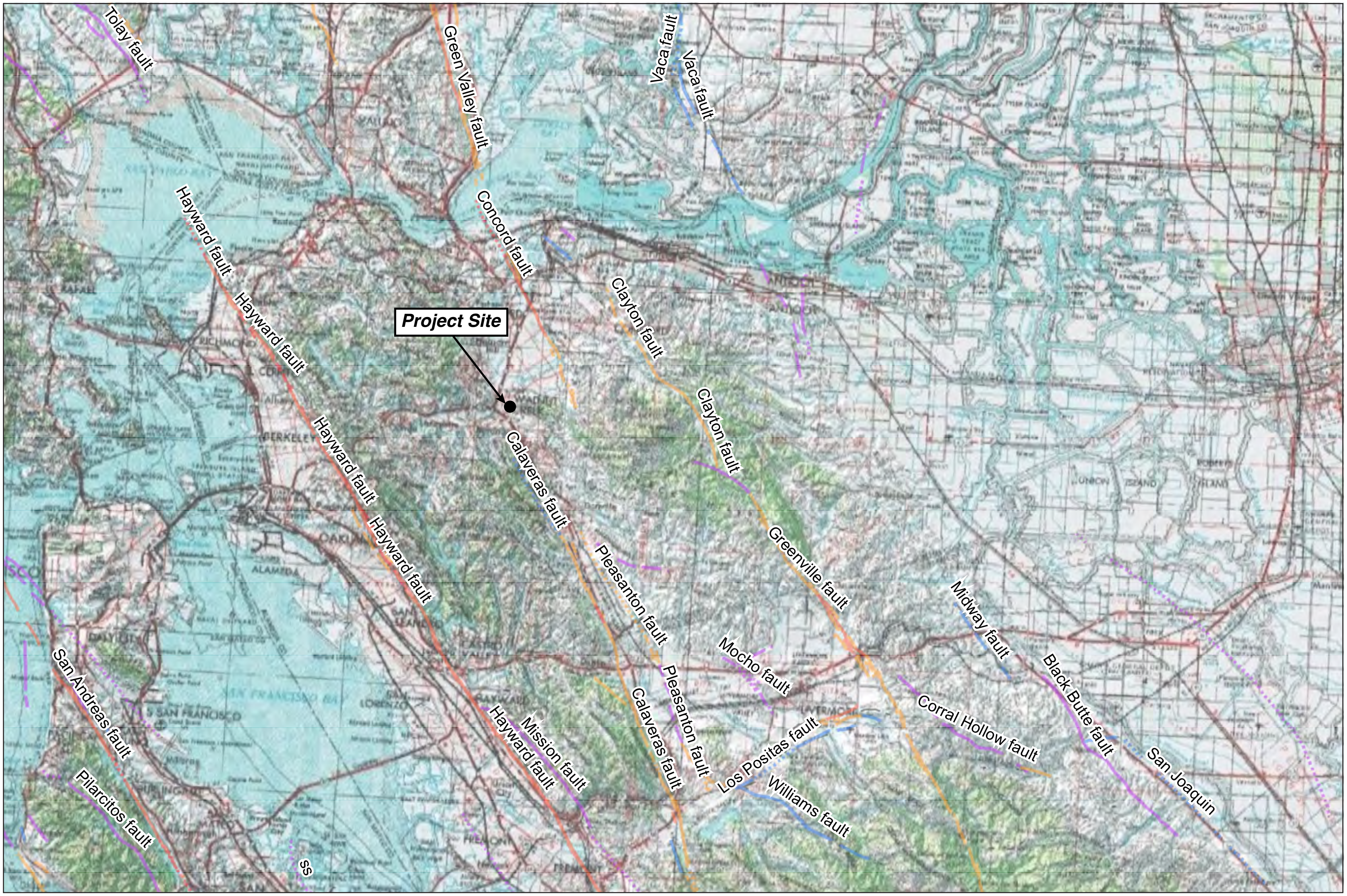
[2] An "active" fault is defined by the State of California as a fault that has had surface displacement within Holocene time (approximately the last 11,000 years). A "potentially active" fault is defined as a fault that has shown evidence of surface displacement during the Quaternary (last 1.6 million years), unless direct geologic evidence demonstrates inactivity for all of the Holocene or longer. This definition does not, of course, mean that faults lacking evidence of surface displacement are necessarily inactive. "Sufficiently active" is also used to describe a fault if there is some evidence that Holocene displacement occurred on one or more of its segments or branches (Hart, 1997).



SOURCE: ESA

Broadway Plaza Long Range Master Plan EIR . 211723

Figure 4.5-1
Regional Fault Figure

TABLE 4.5-1
ACTIVE FAULTS IN THE PROJECT AREA

Fault	Location Relative to Project Area	History of Recent Movement	Fault Classification[a]	Historical Seismicity[b]	Maximum Moment Magnitude Earthquake ("Mw")[c]
Calaveras	4 miles South	Historic (1861 rupture) Holocene	Active	M5.6-M6.4, 1861 M4 to M4.5 swarms 1970, 1990	6.6-6.8
Hayward (southern)	10 miles West-Southwest	Historic (1868 rupture) Holocene	Active	M6.8, 1868 Many <M4.5	6.7-7.5
Greenville-Marsh Creek	8 miles East-Northeast	Historic (1980 rupture) Holocene	Active	M5.6, 1980	6.6-7.3
Concord-Green Valley	4 miles Northeast	Holocene	Active	Active Creep[d]	6.9
San Andreas	28 miles West-Southwest	Historic (1906; 1989 ruptures) Holocene	Active	M7.1, 1989 M8.25, 1906 M7.0, 1838 Many <M6	7.8-8.0
Mt. Diablo Thrust	0.5 miles east	Likely Holocene	Likely Active	n/a	6.0

[a] An "Active Fault" is defined by the State Mining and Geology Board as one that has displayed surface displacement within Holocene time (about the last 10,000 years).
[b] Richter magnitude ("M") and year for recent and/or large events.
[c] The Maximum Moment Magnitude Earthquake ("Mw") is the strongest earthquake that is likely to be generated along a fault zone based on empirical relationships among Mw, surface rupture length, down-dip rupture width, rupture area, and fault type from Wells and Coppersmith (1994).
[d] Slow fault movement that occurs over time without producing an earthquake.

SOURCES: Hart, 1997; Jennings, 1994; Peterson, 1996.

probability of one or more earthquakes of magnitude 6.7 or higher occurring in the state of California over the next 30 years. The result of the evaluation indicated a 63 percent likelihood that such an earthquake event will occur in the Bay Area (USGS, 2008).

Richter magnitude is a measure of the size of an earthquake as recorded by a seismograph, a standard instrument that records groundshaking at the location of the instrument. The reported Richter magnitude for an earthquake represents the highest amplitude measured by the seismograph at a distance of 100 kilometers from the epicenter. Richter magnitudes vary logarithmically with each whole number step representing a tenfold increase in the amplitude of the recorded seismic waves. Earthquake magnitudes are also measured by their Moment Magnitude ("Mw") which is related to the physical characteristics of a fault including the rigidity of the rock, the size of fault rupture, and movement or displacement across a fault (CGS, 2002b).

Ground movement during an earthquake can vary depending on the overall magnitude, distance to the fault, focus of earthquake energy, and type of geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. For this reason, earthquake intensities are also measured in terms of their observed effects at a given locality. The Modified Mercalli ("MM") intensity scale (**Table 4.5-2**) is commonly used to measure earthquake damage due to ground shaking. The MM values for intensity range from I (earthquake not felt) to XII (damage nearly total), and intensities ranging from IV to X could cause moderate to significant structural damage.[3] The intensities of an earthquake will vary over the region of a fault and generally decrease with distance from the epicenter of the earthquake.

TABLE 4.5-2
MODIFIED MERCALLI INTENSITY SCALE

Intensity Value	Intensity Description	Average Peak Acceleration (% ga)
I	Not felt except by a very few persons under especially favorable circumstances.	< 0. 17 g
II	Felt only by a few persons at rest, especially on upper floors on buildings. Delicately suspended objects may swing.	0.17-1.4 g
III	Felt 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 similar to a passing truck. Duration estimated.	0.17-1.4 g
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.	1.4–3.9g
V	Felt by nearly everyone, many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles may be noticed. Pendulum clocks may stop.	3.5 – 9.2 g
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; and fallen plaster or damaged chimneys. Damage slight.	9.2 – 18 g
VII	Everybody runs outdoors. Damage negligible in buildings 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.	18 – 34 g
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.	34 – 65 g
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.	65 – 124 g
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.	> 124 g
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.	> 124 g
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. Objects are thrown upward into the air.	> 124 g

[a] g (gravity) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.

SOURCE: ABAG, 2003; CGS, 2003

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[3] The damage level represents the estimated overall level of damage that will occur for various MM intensity levels. The damage, however, will not be uniform. Not all buildings perform identically in an earthquake. The age, material, type, method of construction, size, and shape of a building all affect its performance.

Regional Faults

The San Andreas, Hayward, and Calaveras Faults pose the greatest threat of significant damage in the Bay Area according to the USGS Working Group (USGS, 2003). These three strike-slip faults have experienced movement within the last 150 years.[4] Other principal faults capable of producing significant ground shaking in the Bay Area are listed on Table 4.5-1 and include the Concord–Green Valley, Marsh Creek–Greenville, San Gregorio, and Rodgers Creek Faults.

An “active” fault is defined by the state as a fault that has had surface displacement within approximately the last 11,000 years. This definition does not mean that faults lacking evidence of surface displacement are necessarily inactive. “Sufficiently active” is also used to describe a fault if there is some evidence that displacement occurred in the last 11,000 years on one or more of its segments or branches. These faults are considered either active or potentially active. Inactive faults are located throughout the Bay Area. Inactive faults with a long period of inactivity do not provide any guarantee that a considerable seismic event could occur. Occasionally, faults classified as inactive can exhibit secondary movement during a major event on another active fault.

San Andreas Fault

The San Andreas Fault zone is a major structural feature that forms at the boundary between the North American and Pacific tectonic plates, extending from the Salton Sea in southern California near the border with Mexico to north of Point Arena, where the fault trace extends into the Pacific Ocean. The main trace of the San Andreas Fault through the Bay Area trends northwest through the Santa Cruz Mountains and the eastern side of the San Francisco Peninsula. As the principal strike-slip boundary between the Pacific plate to the west and the North American plate to the east, the San Andreas is often a highly visible topographic feature, such as between Pacifica and San Mateo, where Crystal Springs Reservoir and San Andreas Lake clearly mark the rupture zone. Near San Francisco, the San Andreas Fault trace is located immediately off-shore near Daly City and continues northwest through the Pacific Ocean approximately six miles due west of the Golden Gate Bridge.

The San Andreas Fault zone was the source of the two major seismic events in recent history that affected the San Francisco Bay Area. The 1906 San Francisco earthquake was estimated at Richter magnitude of M 7.9 and resulted in approximately 290 miles of surface fault rupture, the longest of any known continental strike slip fault. Horizontal displacement along the fault approached 17 feet near the epicenter. The more recent 1989 Loma Prieta earthquake, with a moment magnitude of Mw 6.9, resulted in widespread damage throughout the Bay Area.

Hayward Fault

The Hayward Fault zone is the southern extension of a fracture zone that includes the Rodgers Creek Fault (north of San Pablo Bay), the Healdsburg Fault (County of Sonoma), and the Maacama Fault (County of Mendocino). The Hayward Fault trends to the northwest within the East Bay, extending from San Pablo Bay in Richmond, 60 miles south to San Jose. The Hayward

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[4] A strike-slip fault is a fault on which movement is parallel to the fault’s strike or lateral expression at the surface.

Fault in San Jose converges with the Calaveras Fault, a similar fault that extends north to Suisun Bay. The Hayward Fault is designated by the Alquist-Priolo Earthquake Fault Zoning Act as an active fault.

Historically, the Hayward Fault generated one sizable earthquake in the 1800s.[5] In 1868, a Richter magnitude 7 earthquake on the southern segment of the Hayward Fault ruptured the ground for a distance of about 30 miles. Recent analysis of geodetic data indicates surface deformation may have extended as far north as Berkeley. Lateral ground surface displacement during these events was at least three feet.

A characteristic feature of the Hayward Fault is its well-expressed and relatively consistent fault creep. Although large earthquakes on the Hayward Fault have been rare since 1868, slow fault creep has continued to occur and has caused measurable offset. Fault creep on the East Bay segment of the Hayward Fault is estimated at 9 millimeters per year (mm/yr) (Peterson, et al., 1996). However, a large earthquake could occur on the Hayward Fault with an estimated moment magnitude of about Mw 7.1 (Table 4.5-2). The USGS Working Group on California Earthquake Probabilities includes the Hayward–Rodgers Creek Fault systems in the list of those faults that have the highest probability of generating earthquakes of Richter magnitude M 6.7 or greater in the Bay Area (USGS, 2003).

Calaveras Fault

The Calaveras Fault is a major right-lateral strike-slip fault that has been active during the last 11,000 years. The Calaveras Fault is located in the eastern San Francisco Bay region and generally trends along the eastern side of the East Bay hills, west of San Ramon Valley, and extends into the western Diablo Range, and eventually joins the San Andreas Fault zone south of Hollister. The northern extent of the fault zone is somewhat conjectural and could be linked with the Concord Fault.

The fault separates rocks of different ages, with older rocks west of the fault and younger sedimentary rocks to the east. The location of the main, active fault trace is defined by youthful geomorphic features (linear scarps and troughs, right-laterally deflected drainage, sag ponds) and local groundwater barriers. The Calaveras Fault is designated as an Alquist-Priolo Earthquake Hazard Zone (see discussion on this zone designation below). There is a distinct change in slip rate and fault behavior north and south of the vicinity of Calaveras Reservoir. North of Calaveras Reservoir, the fault is characterized by a relatively low slip rate of 5-6 mm/yr and sparse seismicity. South of Calaveras Reservoir, the fault zone is characterized by a higher rate of surface fault creep that has been evidenced in historic times. The Calaveras Fault has been the source of numerous moderate magnitude earthquakes and the probability of a large earthquake (greater than M6.7) is much lower than on the San Andreas or Hayward Faults (USGS, 2003). However, this fault is considered capable of generating earthquakes with upper bound moment magnitudes ranging from Mw 6.6 to Mw 6.8.

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[5] Prior to the early 1990s, it was thought that a Richter magnitude 7 earthquake occurred on the northern section of the Hayward Fault in 1836. However, a study of historical documents by the California Geological Survey concluded that the 1836 earthquake was not on the Hayward Fault (Bryant, 2000).

Concord-Green Valley Fault

The Concord-Green Valley Fault extends from Walnut Creek north to Wooden Valley (east of Napa Valley). Historical records indicate that no large earthquakes have occurred on the Concord or Green Valley Faults (USGS, 2003). However, a moderate earthquake of Richter magnitude M5.4 occurred on the Concord Fault segment in 1955. The Concord and Green Valley Faults exhibit active fault creep and are considered to have a small probability of causing a significant earthquake.

Greenville – Marsh Creek Fault

The Greenville Fault, also known as the Marsh Creek-Greenville Fault, extends along the base of the Altamont Hills, which form the eastern margin of the Livermore Valley. The fault is recognized as a major structural feature and has demonstrated activity in the last 11,000 years. A Richter magnitude M5.6 earthquake on the Greenville Fault in 1980 produced a small amount of surface rupture (approximately three centimeters) on the fault near Vasco Road.

Mt. Diablo Thrust

The Mt. Diablo Thrust fault along with the Monte Vista Shannon thrust fault, located in Santa Clara Valley, are among the few thrust faults in the east Bay Area. Thrust faults are less well understood than strike-slip faults. The most active thrust fault in the Bay Area is the Mt. Diablo thrust fault which has made Mt. Diablo the fastest growing mountain in the Bay Area. According to the USGS working group, the Mt. Diablo Thrust fault has a three percent probability of causing an earthquake larger than M6.7.

Seismic Hazards

Surface Fault Rupture

Seismically induced ground rupture is defined as the physical displacement of surface deposits in response to an earthquake's seismic waves. The magnitude, sense, and nature of fault rupture can vary for different faults or even along different strands of the same fault. Ground rupture is considered more likely along active faults, which are referenced in Table 4.5-1.

The Project Site and surroundings are not within an Alquist-Priolo Fault Rupture Hazard Zone, as designated through the Alquist-Priolo Earthquake Fault Zoning Act, and no mapped active faults are known to pass through the immediate region.

Ground Shaking

Strong ground shaking from a major earthquake could affect the Project Site and surroundings during the next 30 years. Earthquakes on the active faults (listed in Table 4.5-1) are expected to produce a range of ground shaking intensities in the Project Site and surroundings. Ground shaking may affect areas hundreds of miles distant from the earthquake's epicenter. Historic earthquakes have caused strong ground shaking and damage in the San Francisco Bay Area, the most recent being the M 6.9 Loma Prieta earthquake in October 1989. The epicenter was approximately 60 miles southeast of the Project Site, but this earthquake nevertheless caused strong ground shaking for about 20 seconds and resulted in varying degrees of structural damage throughout the Bay Area.

The common way to describe ground motion during an earthquake is with the motion parameters of acceleration and velocity in addition to the duration of the shaking. A common measure of ground motion is the peak ground acceleration (“PGA”). The PGA for a given component of motion is the largest value of horizontal acceleration obtained from a seismograph. PGA is expressed as the percentage of the acceleration due to gravity (“g”), which is approximately 980 centimeters per second squared. In terms of automobile accelerations, one “g” of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds. For comparison purposes, the maximum peak acceleration value recorded during the Loma Prieta earthquake was in the vicinity of the epicenter, near Santa Cruz, at 0.64 g. The highest value measured in the East Bay was 0.29 g, recorded at the Oakland Wharf near the Naval Supply Center where the soils are artificial fill overlying Bay Mud. The lowest values recorded were 0.06 g in the bedrock on Yerba Buena Island. However, an earthquake on the nearby Hayward Fault would likely produce far more severe ground shaking at the site than was observed during the Loma Prieta earthquake. Probabilistic seismic hazard maps indicate that peak ground acceleration in the region could reach or exceed 0.58g (CGS, 2011).6 The potential hazards related to ground shaking are discussed further in the Impacts and Mitigations section of this chapter.

Liquefaction

Liquefaction is a transformation of soil from a solid to a liquefied state during which saturated soil temporarily loses strength resulting from the buildup of excess pore water pressure, especially during earthquake-induced cyclic loading. Soil susceptible to liquefaction includes loose to medium dense sand and gravel, low-plasticity silt, and some low-plasticity clay deposits. Four kinds of ground failure commonly result from liquefaction: lateral spread, flow failure, ground oscillation, and loss of bearing strength. Lateral spreading is the horizontal displacement of surficial blocks of sediments resulting from liquefaction in a subsurface layer that occurs on slopes ranging between 0.3 and 3 percent and commonly displaces the surface by several meters to tens of meters. Flow failures occur on slopes greater than 3 degrees and are primarily liquefied soil or blocks of intact material riding on a liquefied subsurface zone. Ground oscillation occurs on gentle slopes when liquefaction occurs at depth and no lateral displacement takes place. Soil units that are not liquefied may pull apart and oscillate on the liquefied zone. The loss of bearing

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[6] A probabilistic seismic hazard map shows the predicted level of hazard from earthquakes that seismologists and geologist believe could occur. The map’s analysis takes into consideration uncertainties in the size and location of earthquakes and the resulting ground motions that can affect a particular site. The maps are typically expressed in terms of probability of exceeding a certain ground motion. These maps depict a 10 percent probability of being exceeded in 50 years. There is a 90 percent chance that these ground motions will NOT be exceeded. This probability level allows engineers to design buildings for larger ground motions than seismologists think will occur during a 50-year interval, making buildings safer than if they were only designed for the ground motions that are expected to occur in the 50 years. Seismic shaking maps are prepared using consensus information on historical earthquakes and faults. These levels of ground shaking are used primarily for formulating building codes and for designing buildings.

pressure can occur beneath a structure when the underlying soil loses strength and liquefies. When this occurs, the structure can settle, tip, or even become buoyant and “float” upwards. Liquefaction and associated failures could damage foundations, roads, underground cables and pipelines, and disrupt utility service. According to some mapping of quaternary deposits by the USGS, soils with the potential to liquefy exist in the Project Site and surroundings (DCE, 2005). However, the geotechnical report prepared for the Project Site and surroundings concluded that the high clay content of subsurface soils indicated that the liquefaction potential was practically nil (Smith Emery, 2011).

Earthquake-Induced Settlement

Settlement of the ground surface can be accelerated and accentuated by earthquakes. During an earthquake, settlement can occur as a result of the relatively rapid compaction and settling of subsurface materials (particularly loose, uncompacted, and variable sandy sediments above the water table) due to the rearrangement of soil particles during prolonged ground shaking. Settlement can occur both uniformly and differentially (i.e., where adjoining areas settle at different amounts). Areas underlain by artificial fill will be susceptible to this type of settlement. Since the Project Site and surroundings likely has been developed previously under the recommendations of a licensed geotechnical engineer, the majority of the areas that may have once been susceptible to differential settlement have been eliminated prior to development. Regardless, future development would re-evaluate site soils and fills to determine the potential for settlement according to accepted geotechnical practices.

Geologic Hazards

Considering the geologic context of the Project Site and surroundings, other typical geologic hazards could include slope instability, soil erosion, settlement, expansive soil materials, tsunamis, and seiches. These hazards are discussed briefly below and provide the initial context for further evaluation in this environmental impact analysis.

Corrosive Soils

The corrosivity of soils is commonly related to several key parameters including soil resistivity, the presence of chlorides and sulfates, oxygen content, and pH. Typically, the most corrosive soils are those with the lowest pH and highest concentration of chlorides and sulfates. Wet/dry conditions can result in a concentration of chlorides and sulfates as well as movement in the soil that tends to break down protective corrosion films and coatings on the surface of building materials. High-sulfate soils are also corrosive to concrete and may prevent complete curing, reducing its strength considerably. Low pH and/or low-resistivity soils can corrode buried or partially buried metal structures. Depending on the degree of corrosivity of the subsurface soils, building materials such as concrete, reinforcing steel in concrete structures, and bare-metal structures exposed to these soils can deteriorate, eventually leading to structural failures. According to the geotechnical investigation, the pH levels in the subsurface soils at the site are an indication of potentially corrosivity (Smith-Emery, 2011).

Expansive Soils

Expansive soils possess a “shrink-swell” behavior. Shrink-swell is the cyclic change in volume (expansion and contraction) that occurs in fine-grained clay sediments from the process of wetting and drying. Structural damage may occur over a long period of time, usually the result of inadequate soil and foundation engineering or the placement of structures directly on expansive soils. The native soils underlying the Project Site and surroundings are described as moderately to highly expansive (USDA, 1982).

Soil Erosion

Erosion is the wearing away of soil and rock by processes such as mechanical or chemical weathering, mass wasting, the action of waves, wind or underground water. Excessive soil erosion can eventually lead to damage of building foundations and roadways. In the Project Site and surroundings, areas that are susceptible to erosion are those that would be exposed during the construction phase. Typically, the soil erosion potential is reduced once the soil is graded and covered with concrete, structures, asphalt, or slope protection. Soil erosion is not considered a potential significant issue at the site considering the likelihood that site soils disturbed during construction would be managed according to local regulations which minimize erosion potential.

Settlement

Settlement can occur from immediate settlement, consolidation, shrinkage of expansive soil, and liquefaction (discussed above). Immediate settlement occurs when a load from a structure or placement of new fill material is applied, causing distortion in the underlying materials. This settlement occurs quickly and is typically complete after placement of the final load. Consolidation settlement occurs in saturated clay from the volume change caused by squeezing out water from the pore spaces. Consolidation occurs over a period of time and is followed by secondary compression, which is a continued change in void ratio under the continued application of the final load.

Soils tend to settle at different rates and by varying amounts depending on the load weight or changes in properties over an area, which is referred to as differential settlement. Soils in the Project Site and surroundings consist of clays, silts, and sands and/or engineered soils that have a low susceptibility to differential settlement.

Landslides and Slope Failure

Slope failures, commonly referred to as landslides, include many phenomena that involve the downslope displacement and movement of material, either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. A slope failure is a mass of rock, soil, and debris displaced downslope by sliding, flowing, or falling. Exposed rock slopes undergo rockfalls, rockslides, or rock avalanches, while soil slopes experience shallow soil slides, rapid debris flows, and deep-seated rotational slides. Landslides may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and transverse ridges. The Project Site and surroundings are located in a predominantly level part of the City that has a low potential for landslides or slope failure.

4.5.2 Regulatory Setting

Federal

There are no federal regulations related to geology and soil resources.

State

California Building Code

The California Building Code (CBC) has been codified in the California Code of Regulations (CCR) as Title 24, Part 2. Title 24 is administered by 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. The purpose of the CBC is to establish minimum standards to safeguard the public health, safety, and general welfare through structural strength, means of egress facilities, and general stability by regulating and controlling the design, construction, quality of materials, use and occupancy, location, and maintenance of all building and structures within its jurisdiction. The CBC is based on the International Building Code (IBC), previously known as the Uniform Building Code. The 2010 CBC is based on the 2009 IBC published by the International Code Conference. In addition, the CBC contains necessary California amendments, which are based on reference standards obtained from various technical committees and organizations such as the American Society of Civil Engineers (ASCE), the American Institute of Steel Construction (AISC), and the American Concrete Institute (ACI). ASCE Minimum Design Standard 7-05 provides requirements for general structural design and includes means for determining earthquake loads as well as other loads (flood, snow, wind, etc.) for inclusion into building codes. The provisions of the CBC apply to the construction, alteration, movement, replacement, and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures throughout California.

The earthquake design requirements take into account the occupancy category of the structure, site class, soil classifications, and various seismic coefficients, which are used to determine a Seismic Design Category (SDC) for a project. The SDC is a classification system that combines the occupancy categories with the level of expected ground motions at the site and ranges from SDC A (very small seismic vulnerability) to SDC E (very high seismic vulnerability and near a major fault). Design specifications are then determined according to the SDC.

Local

General Plan 2025 Policies

The General Plan 2025 Safety and Noise Chapter contains the following goal, policies and actions, which call for the maintenance of data on geologic hazards and require geotechnical investigation and mitigations for projects in areas subject to geologic hazards.

Safety and Noise

- **Goal 1:** Protect life and property from geologic hazards.
  - *Policy 1.1*: Reduce the potential effects of seismic and other geologic hazards, including slope instability.

    Action 1.1.1: Identify areas prone to seismic and other geologic hazards, including slope instability.

    Action 1.1.2: Establish minimum road widths and clearances around structures at risk from known geologic hazards.

    Action 1.1.3: Review and update the existing maps of geologic hazards.

    Action 1.1.4: Require appropriate mitigations for new development or redevelopment in areas prone to seismic and other geologic hazards.

  - *Policy 1.2*: Limit development within high-risk geologic areas to a maximum density of one dwelling unit per 20 acres.

    Action 1.2.1: Identify high risk areas after taking into account soil stability, history of soil slippage, proximity to earthquake faults, slope grad, accessibility, and drainage conditions, and continue to assign low intensity uses, not exceeding a density of one dwelling unit per twenty acres, to such areas.

    Action 1.2.2: As updated seismic-hazard zone maps become available, incorporate them in the general plan.

    Action 1.2.3: Identify areas where surface ruptures are most likely to occur and cause damage to human-made structures, such as dams.

    Action 1.2.4: For development proposals submitted in areas near earthquake fault zones listed under the Alquist-Priolo Act, require a geotechnical evaluation to identify hazard mitigation measures needed to reduce the risk to life and property from earthquake-induced hazards.

    Action 1.2.5: For development proposals submitted in areas near high or very high liquefaction-susceptibility areas, require a geotechnical evaluation to identify hazard mitigation measures needed to reduce the risk to life and property from liquefaction-induced hazards.

4.5.3 Impacts and Mitigation Measures

Significance Criteria

The Project would have a significant impact if it were to cause impacts to the environment as a result of any of the following:

1. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    (a) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);
    (b) Strong seismic ground shaking;
    (c) Seismic-related ground failure, including liquefaction; or
    (d) Landslides
2. Result in substantial soil erosion or the loss of topsoil;
3. Be located on 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;
4. Be located on expansive soil, as defined in Table 18 1 B of the Uniform Building Code (1994), creating substantial risks to life or property; or
5. 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.

Under CEQA, the analysis extends only to whether the Project would cause impacts on the existing environment. Geologic and soils impacts to future residents and workers of the Project are not within the scope of a CEQA analysis. However, the City has directed that this EIR also evaluate such issues within the Project. Accordingly, the above criteria are applied to non-CEQA issues as well. For ease of reference, both CEQA and non-CEQA issues are addressed together, which means that phrases such as “impact” and “mitigation measure” are applied to both CEQA and non-CEQA analysis. However, insofar as the non-CEQA issues are concerned, “impacts” are regulatory issues, and “mitigation measures” is used to refer to recommended conditions of approval.

Approach to Analysis

The site specific geotechnical characteristics determine the potential for geotechnical hazards that could occur at the Project Site under both the Maximum Commercial Scenario and the Maximum Mixed-Use Scenario. Available U.S. and California Geological Survey maps, the City’s General Plan, and other studies and reports were consulted in order to determine the potential for geological hazard that would occur from the proposed developments.

Topics Briefly Addressed

The Project presents no potential for a significant impact for three of the above CEQA criteria based upon the project characteristics, the geographic context, and data research. Therefore, they will not be evaluated further in this EIR. These criteria are:

- ***Fault Rupture (Criterion 1(a)).*** The faults most susceptible to earthquake rupture are active faults, which are faults that have experienced surface displacement within the last 11,000 years. There are no active faults that cross the Project Site, and the nearest active fault (Mt. Diablo thrust fault) is approximately 0.5 miles away. Therefore, the potential for fault rupture to affect the Project Site and surroundings is very low.

- ***Landslides (Criterion 1(d)).*** The Project Site contains slopes that are less than 15 percent in grade and not considered susceptible to landslides or slope failure. The gentle sloping topography of the area puts the potential for landslides or slope failure to affect any of the proposed development or redevelopment in the Project Site and surroundings very low and is therefore not discussed further.

- ***Wastewater Disposal (Criterion 5).*** The Project is located within an urban area where all development would be able to tie into existing wastewater infrastructure. Therefore, none of the development or redevelopment will require the use of septic or other alternative disposal wastewater systems, and therefore no impact is associated with this hazard.

Impacts by Project Scenario

The following analysis is relevant to both the Maximum Commercial Scenario and the Maximum Mixed-Use Scenario. Because potential geotechnical hazards would largely affect either scenario equally, they are not differentiated; both scenarios are discussed under a single Impact Statement for each criterion. While the Maximum Mixed-Use Scenario may ultimately result in an increased number of people residing at the Project Site, the approach taken in design and construction of proposed improvements would be similar.

Impacts

Expose People or Structures to Potential Substantial Adverse Effects

In the event of a major earthquake in the region, ground shaking and associated secondary effects, such as localized liquefaction, could potentially cause damage, destruction or injury to development and persons resulting from development facilitated by the Project (Criteria 1(b) and 1(c)). (Less than Significant)

According to modeling conducted by the USGS in conjunction with the California Geological Survey, the San Francisco Bay Area would likely experience at least one major earthquake with a greater than moment magnitude 6.7 within the next 30 years. The intensity of such an event would depend on the causative fault and the distance to the epicenter, the magnitude, the duration of shaking, and the characteristics of the underlying geologic materials. The potential for damage or loss during an earthquake of this magnitude is considered a potentially significant impact.

In general, ground shaking tends to be more severe in softer sediments such as alluvial deposits, where surface waves can be amplified causing a longer duration of ground shaking compared to bedrock materials. An area where bedrock is exposed or located relatively shallow tends to experience surface waves from an earthquake as more of a sharp jolt. As discussed above in the setting, groundshaking in the Project Site and surroundings has a 1 in 475 chance of exceeding 0.48g each year. Groundshaking of this magnitude could cause significant damage in structures that are not adequately engineered.

Liquefaction typically occurs in areas underlain with loose, saturated, cohesionless soils within the upper 50 feet of subsurface materials. These soils, when subjected to groundshaking, can lose their strength resulting from the buildup of excess pore water pressure causing them to behave closer to a liquidified state. According to the geotechnical investigation report prepared for the Project, liquefaction susceptibility in the Project Site and surroundings is practically nil (Emery Smith, 2011).

For new construction, all of the aforementioned seismic hazards can be mitigated through the application of current industry standard geotechnical practices and seismic structural design according to the requirements found in the most recent version of the California Building Code, which includes or exceeds the requirements of the Uniform Building Code or International Building Code. After decades of study of past earthquakes and the performance of structures and other improvements, building codes have incorporated measures to reduce the potential for catastrophic damage to occur in buildings, roadways, and utility connections. Although damage and injury cannot be completely avoided during a significant seismic event, construction or renovation in accordance with the California Building Code would reduce the potential damage and personal injury to less than significant levels.

Mitigation: None required.

Erosion and Loss of Topsoil

Development facilitated by the Project could potentially involve grading and other ground-disturbing construction activities, which could expose soils to erosion and loss of topsoil (Criterion 2). (Less than Significant)

The Project Site is currently largely developed with a majority of the land area covered by impervious surface such as asphalt, buildings, and concrete. The pervious areas are generally landscaped and vegetated. However, development under the Project could require removing the existing cover and thereby exposing underlying soils to the effects of wind and water. The relatively flat topography of the area significantly reduces the potential for erosion and loss of topsoil during construction activities. Nonetheless, areas of the Project Site are subject to concentrated runoff, or areas of unprotected slopes or piles of bare soil, would still pose erosion hazards if left unmitigated. Once covered by asphalt, a new structure, or vegetated at the conclusion of construction, the potential for erosion is significantly reduced.

Protection of soils during construction can generally be mitigated through well established erosion control measures. Every construction project in the State of California that causes a disturbance of one acre or more of soil through grading, clearing, and or excavation is subject to the General Construction Stormwater Permit (General Construction Permit), also referred to as the General Permit, adopted by the State Water Resources Control Board (SWRCB). In order to complete the General Permit application, the applicant must first submit a Notice of Intent (NOI) to obtain coverage under the General Permit. This General Permit requires dischargers to develop and implement a Storm Water Pollution Prevention Plan (SWPPP), which specifies the Best Management Practices (BMPs) that would prevent construction pollutants, including sediment, from reaching storm drains, with the intent of keeping all products of erosion from moving off-site into receiving waters. Furthermore, the SWPPP would also include BMPs to control erosion associated with grading, trenching, and other ground surface-disturbing activities (See also discussion of SWPPP in Section 4.8, *Hydrology and Water Quality*). As a condition of the permits required for the project, which would require compliance with the requirements of the General Permit, impacts from construction would be less than significant.

Mitigation: None required.

Unstable Soils

Development facilitated by the Project could potentially be subjected to geologic hazards, including expansive soils, settlement, corrosivity and differential settlement (Criteria 3 and 4). (Less than Significant)

The geologic materials within the Project Site and surroundings vary and include varying types and thickness of compressible native and/or fill materials that could also be subject to differential settlement or expansive properties. Exposure to one or more of these geologic hazards could cause significant damage to the foundation of structures if not engineered appropriately. However, with appropriate geotechnical engineering or proposed structures, the resulting risk would not impact the existing environment.

Typically, soils that exhibit expansive characteristics are found within the upper five feet of ground surface. Over a long-term exposure to wetting and drying cycles, expansive soils can experience volumetric changes. The effects of expansive soils could damage foundations of above-ground structures, paved roads and streets, and concrete slabs. Expansion and contraction of soils, depending on the season and the amount of surface water infiltration, could exert enough pressure on structures to result in cracking, settlement, and uplift.

Differential settlement could occur where the engineering characteristics of underlying materials vary over an area proposed for new loading. Materials most susceptible to settlement would be undocumented fill materials that did not receive adequate compaction or loose unconsolidated alluvial or floodplain deposits. Differential settlement could damage building foundations and roads, and could affect underground utilities. Settlement would be a concern in redevelopment areas that have not previously supported structures and where new structures would place loads heavier than the soils could tolerate.

Based on pH levels of site soils, the geotechnical investigation determined that potentially corrosive soils could be present at the Project site. However, soluble chloride and sulfate concentrations were indications that corrosive resistant cement would not be necessary. Final testing of any imported fill materials and potential corrosivity would be included as part of the final geotechnical design in accordance with local building code requirements. Therefore, any potentially corrosive soils present at the site would easily addressed through application of widely accepted geotechnical practices.

Building code requirements required by the City in accordance with the California Building Code, would require detailed investigation of subsurface materials and their engineering characteristics. These geotechnical investigations would consider proposed plans and evaluate potential hazards and provide recommendations to mitigate them. Current geotechnical engineering practices have incorporated effective mitigations in accordance with building code requirements to reduce potential damage and personal injury from geologic hazards by ensuring that industry standard controls are implemented in any future development. Therefore, this would be a less than significant impact.

Mitigation: None required.

Cumulative Impact

Geographic Context

Although the entire Bay Area is situated within a seismically active region with a wide range of geologic and soil conditions, these conditions can vary widely within a short distance, making the cumulative context for potential impacts resulting from exposing people and structures to related risks one that is more localized or even site-specific. Potential cumulative geology and seismic impacts do not extend far beyond a project's boundaries, since such geological impacts are typically confined to discrete spatial locations and do not combine to create an extensive cumulative impact. The exception to this generalization would occur where a large geologic feature (e.g., fault zone, massive landslide) might affect an extensive area, or where the development effects from the Project could affect the geology of an off-site location. These circumstances are not likely to occur at the Project Site as there are no large landslide features or fault zones.

Cumulative Geologic and Seismic Hazards

Development facilitated by the Project, combined with other past, present, existing, approved, pending, and reasonably foreseeable future development in the surrounding region, could potentially result in cumulative impacts to geologic and seismic hazards. (Less than Significant)

The Project, combined with other present and foreseeable development in the area, may result in increased population and development in a region susceptible to seismic risks and hazards. While the number of people visiting, living and working in the area might increase incrementally, exposing additional people to seismic and geologic hazards, the risk to people and property would be reduced through the upgrading or demolishing of older buildings that were constructed under less stringent building code requirements. Older buildings would be seismically retrofitted and newer buildings would be constructed to stricter building codes. Implementation of the Project in accordance with the provisions of the California Building Code would reduce the potential hazards associated with seismic ground shaking and ground failure. Other current and future development/redevelopment projects in the region would similarly be required to adhere to standards and practices that include stringent geologic and seismic hazard mitigations. With implementation of these required building standards, the impacts of geologic hazards and seismic ground shaking would be reduced to less than cumulatively considerable for new development and redevelopment consistent with the Project.

Mitigation: None required.

4.5.4 References

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