5.6 GEOLOGY AND SOILS

This section of the Draft Environmental Impact Report (DEIR) provides an overview of existing geologic conditions within the Project Area, which is situated in the north-central part of unincorporated Los Angeles County where the high Mojave Desert abuts the San Gabriel Mountains. This section also evaluates the potential for implementation of the Proposed Project to result in significant direct and indirect environmental impacts related to geology, soils, and seismicity.

The following analysis also considers the provisions of the Proposed Area Plan's revised Land Use Element; Conservation and Open Space Element; and Public Safety, Services, and Facilities Element, and how those provisions could relate to construction near earthquake faults, exploitation of mineral resources, and hillside development.

5.6.1 Environmental Setting

5.6.1.1 REGULATORY SETTING

The State of California and the County of Los Angeles have established laws and regulations that pertain to geology, soils, and seismicity. The following laws and regulations are relevant to the CEQA review process for this Proposed Area Plan.

State Regulations

The most relevant State laws that regulate geology and soils in the Project Area are the Alquist-Priolo Earthquake Fault Zoning Act, the Seismic Hazards Mapping Act, and the California Building Code, each of which is described below.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the potential hazards of surface fault rupture on occupied structures.[1]The main purpose of the Act is to regulate the construction of buildings used for human occupancy on top of the traces of active faults. It was passed into law in the wake of the February 1971 M_w6.5 San Fernando (Sylmar) Earthquake that resulted in more than $500 million in property damage and 65 deaths.[2] Although the Act addresses the hazards associated with surface-fault rupture, it does not address other earthquake-related hazards, such as liquefaction or landslides.[3]

The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones or Alquist-Priolo Zones) around the surface traces of active faults, and to publish appropriate maps that depict

[1]Originally titled the Alquist-Priolo Special Studies Zones Act until renamed in 1993, Public Resources Code Division 2, Chapter 7.5, Section 2621.
[2]S. CA Earthquake Data Center, 2014. URL: http://www.data.scec.org/significant/sanfernando1971.html, accessed on July 7, 2014.
[3]California Geological Survey, Alquist-Priolo Earthquake Fault Zones, http://www.consrv.ca.gov/cgs/rghm/ap/Pages/index.aspx, accessed on July 7, 2014.

these zones.[4] The maps are then distributed to all affected cities, counties, and State agencies for use in the planning process. In general, construction within 50 feet of an active fault trace must be preceded by a fault investigation before a building permit can be issued.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was enacted by the California State Legislature in 1990.[5] It addresses earthquake hazards other than surface-fault rupture, including liquefaction and seismically induced landslides.[6] Under the Act, seismic-hazard zones are mapped by the State Geologist in order to assist local governments during the land use planning process. The Act states that "it is necessary to identify and map seismic-hazard zones in order for cities and counties to adequately prepare the safety element of their general plans and to encourage land-use management policies and regulations to reduce and mitigate those hazards to protect public health and safety."[7] Section 2697(a) of the Act states that "cities and counties shall require, prior to the approval of a Plan located in a seismic-hazard zone, a geotechnical report defining and delineating any seismic hazard."[8]

Surface Mining and Reclamation Act

The California Geological Survey (CGS) provides geologic expertise and information about California's diverse non-fuel mineral resources. As required by the Surface Mining and Reclamation Act (SMARA) of 1975, the State Geologist classifies these resources in an effort to locate economically significant mineral deposits and potential areas of deposits based upon scientific data. Information relating to California's non-fuel resources, naturally occurring mineral hazards, and active and historic mining activities are collected to classify land under the Mineral Resources and Mineral Hazards Mapping Program. To date, the CGS has completed 97 mineral land classification studies that cover about 34 percent of the state. Of these, only 32 classification studies (covering approximately 25 percent of the state) include the resource areas that provide construction aggregate to over 90 percent of California's population. Construction aggregate is California's primary mineral resource. Please refer to Section 5.11, *Mineral Resources,* for a complete discussion of SMARA and the mineral resources located within the Project Area.

California Building Code

The California Building Standards Code, also known as Title 24 of the California Code of Regulations, reflects various building criteria that have been derived from different sources.[9] One of these sources is the International Building Code (IBC), a model building code adopted across the United States that has been

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[4]Earthquake Fault Zones are regulatory zones around active faults. The zones vary in width, but average about one-fourth mile wide. http://www.consrv.ca.gov/CGS/rghm/ap/Pages/index.htm,accessed on July 7, 2014.
[5]California Legislative Information, California Law, http://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml, accessed on July 7, 2014.
[6]California Geological Survey, Alquist-Priolo Earthquake Fault Zones, http://www.conservation.ca.gov/CGS/rghm/ap/Pages/index.aspx, accessed on February 24, 2014.
[7] California Public Resources Code, Division 2, Chapter 7.8, Section 2691(c).
[8] California Public Resources Code, Division 2, Chapter 7.8, Section 2697(a).
[9]California Building Standards Commission, http://www.bsc.ca.gov/codes.aspx, accessed on February 24, 2014.

modified to suit conditions in the State, thereby creating what is known as the California Building Code (CBC), or Part 2 of CCR Title 24.

The CBC is updated every three years.[10] Through the CBC, the State provides a minimum standard for building design and construction. The CBC contains specific requirements for seismic safety, excavation, foundations, retaining walls, and site demolition. It also regulates grading activities, including drainage and erosion control. The County has adopted the provisions in the CBC as part of the Los Angeles County Building Code.

Local Regulations

Los Angeles County Code

The Los Angeles County (County) Building Code also contains rules and regulations that govern activities that could result in soil erosion or slope instability. These rules and regulations within the County Grading Code Ordinance and Regulations, where provisions for excavation, grading, and earthwork construction have been established, permitting procedures are set forth, and plan approval and grading inspection protocols and procedures have been identified.[11] The appendix also contains provisions for construction-related erosion control, including the preparation of cut-and-fill slopes and the implementation of erosion control measures such as check dams, cribbing, riprap, or other devices or methods.

The ordinances also include seismic safety requirements for certain building types, such as older concrete tilt-up buildings and unreinforced masonry buildings. The stated goal of these ordinances is to promote public safety and welfare by reducing the risk of death or injury that could result from earthquake damage to certain types of older buildings during moderate or strong earthquakes. Based on the findings of required structural analyses, deficient buildings may need to be strengthened or demolished.

5.6.1.2 EXISTING CONDITIONS AND REGIONAL SETTING

This section presents a discussion of the existing geological conditions and soil resources within the Project Area as well as their regional setting.

Topographic Setting

The Project Area is geographically diverse, and topographic information over this comparatively large area can be gleaned from the U.S. Geological Survey's (USGS) Palmdale, Victorville, Los Angeles, and San Bernardino, California 1:100,000 scale topographic maps. The Project Area is typified by a variety of distinctive landforms and topography, ranging from flat-lying areas of little topographic relief such as the playa lakes and broad alluvial plains of the high Mojave Desert, to tectonically incised valleys such as the Leona Valley and the neighboring Portal and Ritter Ridges, to rugged mountain terrain along the north flank of the San Gabriel Mountains. Elevations are similarly varied, ranging from elevations of 2,100 to 2,800 feet

[10]Los Angeles County Code, Title 26, Chapters 2 through 35, and Appendices C, I, and J, http://library.municode.com/index.aspx?clientId=16274, accessed on February 24, 2014.
[11]Los Angeles County Code, Title 26, Appendix J–Grading, https://library.municode.com/index.aspx?clientId=16274, accessed on February 24, 2014.

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GEOLOGY AND SOILS

above mean sea level (amsl) near the main population centers of Palmdale and Lancaster, California, to peaks in the nearby San Gabriel Mountains that locally exceed 9,000 feet.

Geologic Setting

The surficial and bedrock geology underlying the Project Area has been mapped by a variety of agencies and organizations, including the USGS and the California Division of Mines and Geology, now the California Geological Survey (CGS).

Most of the Project Area lies within the Mojave Desert geomorphic province, a broad interior region of isolated mountain ranges separated by broad desert plains.[12] Most of the drainage in this area is internal, ultimately discharging to evaporate flats and playa lake basins. There are two important fault systems that control topography, one of which, the San Andreas Fault system, imparts a prominent NW-SE structural grain. The other, the Garlock Fault system, locally contributes to an east-west structural grain. The Mojave Desert geomorphic province is tectonically bounded to the north and to the southwest, forming a wedge between the Garlock Fault (i.e., the southern boundary of the Sierra Nevada Mountains) and the San Andreas Fault, where that fault reflects the northeast margin of the Transverse Ranges.

The southwesternmost part of the Project Area lies within the aforementioned Transverse Ranges geomorphic province, a band of east-west trending mountains and valleys that span roughly 250 miles from Point Arguello on the west to the San Bernardino Mountains on the east.[13]Although geologically recent tectonic activity (i.e., middle Miocene and younger) accounts for much of the present-day distribution of bedrock, the local presence of different crystalline metamorphic and igneous basement are suggestive of older tectonism.

The bedrock units of the Project Area can be discussed as two groups: 1) basement rocks—early Cretaceous and older, crystalline metamorphic and igneous rocks; and 2) the overlying sequence of late Cretaceous and Tertiary strata. The basement rocks of the San Gabriel Mountains are comprised of Precambrian, Paleozoic, and pre-middle-Cretaceous Mesozoic metamorphic and igneous rocks. These are the oldest rocks in the Project Area, and they appear to represent old continental crust at the west edge of the North American continent.

In the vicinity of the Leona Valley, in the southwest part of the Project Area, the oldest bedrock units consist of granodiorite, diorite, gneiss, and the Pelona Schist.[14] The Pelona Schist, which crops out on both sides of the San Andreas fault, including Portal and Ritter Ridges immediately to the northeast, has been assigned a general Mesozoic age, based on arguments that metamorphism of the Pelona Schist probably occurred during the Late Cretaceous and that the deposition of the sedimentary protolith may have occurred at some earlier time during the Mesozoic. Younger bedrock units in the Project Area include arkosic sandstone and shale of the Pliocene-age Anaverde Formation.

[12]CA Geological Survey, 2002. California Geomorphic Provinces, Note 36, revised December 2002.
[13]USGS, 2005.Preliminary Geologic Map of the Los Angeles 30´ × 60´ Quadrangle, Southern California, Open-File Report Open-File Report 2005-1019, Compiled by Robert F. Yerkes and Russell H. Campbell.
[14]USGS, 1987. Postcrystalline Deformation of the Pelona Schist Bordering Leona Valley, Southern California, authored by James G. evans, Professional Paper 1039.

The unconsolidated deposits that underlie the Antelope Valley include younger and older alluvium, older fan deposits, windblown dune sand, and playa lake deposits.[15] Older alluvium of possible Pliocene and Pleistocene age and composed of compact gravel, sand, silt, and clay comprises the main groundwater aquifer in the area and underlies most of the valley floor at depth. These deposits are often weathered, as indicated by clay alteration of detrital feldspar. Near the foothills to the southwest, these deposits consist predominantly of gravel, but farther from the hills, beneath the valley area, they tend to be finer grained. The younger, generally less-weathered alluvium of Holocene age largely consists of poorly sorted gravel and sand. The inferred thickness of the younger alluvium is less than 100 feet.[16]

Older alluvial fan deposits of possible Pliocene and Pleistocene age are manifest in the Project Area as erosional remnants and consist of slightly consolidated fanglomerate, or unsorted boulder gravel, cobble-pebble gravel, and sand. These coarse sediments appear to have been derived from a predominantly granitic source. Younger fan deposits of Holocene age are still being deposited in the Project Area and they consist of unconsolidated angular boulders, cobbles, and gravel, with lesser amounts of sand, silt, and clay. These deposits have been deposited by intermittent streams sourced in nearby hills and mountains.

Playa or lacustrine deposits of Pliocene through Holocene age are composed of siltstone, clay, and marl. During periods of relatively heavy precipitation, thick beds of clay (i.e., reportedly up to 400 feet thick) were deposited in perennial lakes. These clays are locally interbedded with lenses of coarser material up to 20 feet thick.

Soils

The soils in the Project Area have been periodically studied and mapped by various agencies and researchers, including the U.S. Department of Agriculture Natural Resource Conservation Service (formerly the Soil Conservation Service). These soil surveys have long recognized the diverse soil types and conditions in this part of Los Angeles County. An early 20th century investigation identified as many as 17 different soil types in the region.[17] Most of the soils were comprised of sands, loams, sandy loams, and adobe, whereas granitic gravel was locally noted in soils found close to major drainages or along mountain fronts.

Previous county-wide environmental studies have discussed soil types based on three geographic settings: Coastal Lowlands, Central Mountains, and Northern Desert areas.[18] The Project Area contains portions of the Central Mountains and Northern Desert Areas. In general, most of the mapped soils are amenable to urban development. Certain parts of the Antelope Valley Region are reportedly underlain by soils that may be susceptible to hydro-collapse or hydro-consolidation, which should be taken into account during site-specific geotechnical investigation and foundation design.

[15]USGS, 1987. Geohydrology of the Antelope Valley Area, California, authored by Lowell F. W. Duell, Jr., Water-Resources Investigations Report 84-4081.
[16]USGS, 1987. Geohydrology of the Antelope Valley Area, California, authored by Lowell F. W. Duell, Jr., Water-Resources Investigations Report 84-4081.
[17]USDA Bureau of Soils (now Natural Resource Conservation Service), 1903. Soil Survey of the Los Angeles Area, California, Mesmer, Louis B.
[18] Environmental Systems Research Institute, 1976. Land Capability/Suitability Study Natural Resources Inventory: Capability for Development Considering Interpretations of Soil Conditions" (Variable 22).

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In recent years, the County Department of Public Works has assembled a GIS database of the main soil types in the County, including in the Project Area.[19] The information in that database reflects nearly two dozen soil types, including loams; clayey, silty, and sandy loams; clay adobes; and various alluvial and mountain soil types. The prevailing soil types in the Project Area are depicted in Figure 5.6-1. The most prevalent soils are the Antelope Valley Series, predominantly loam, gravelly loam, and sandy loam in area immediately northeast of San Andreas Fault and sandy loam, loam, and silty loam in the area near Acton with lesser Santa Clara River Series.

Regional Faulting and Seismic Setting

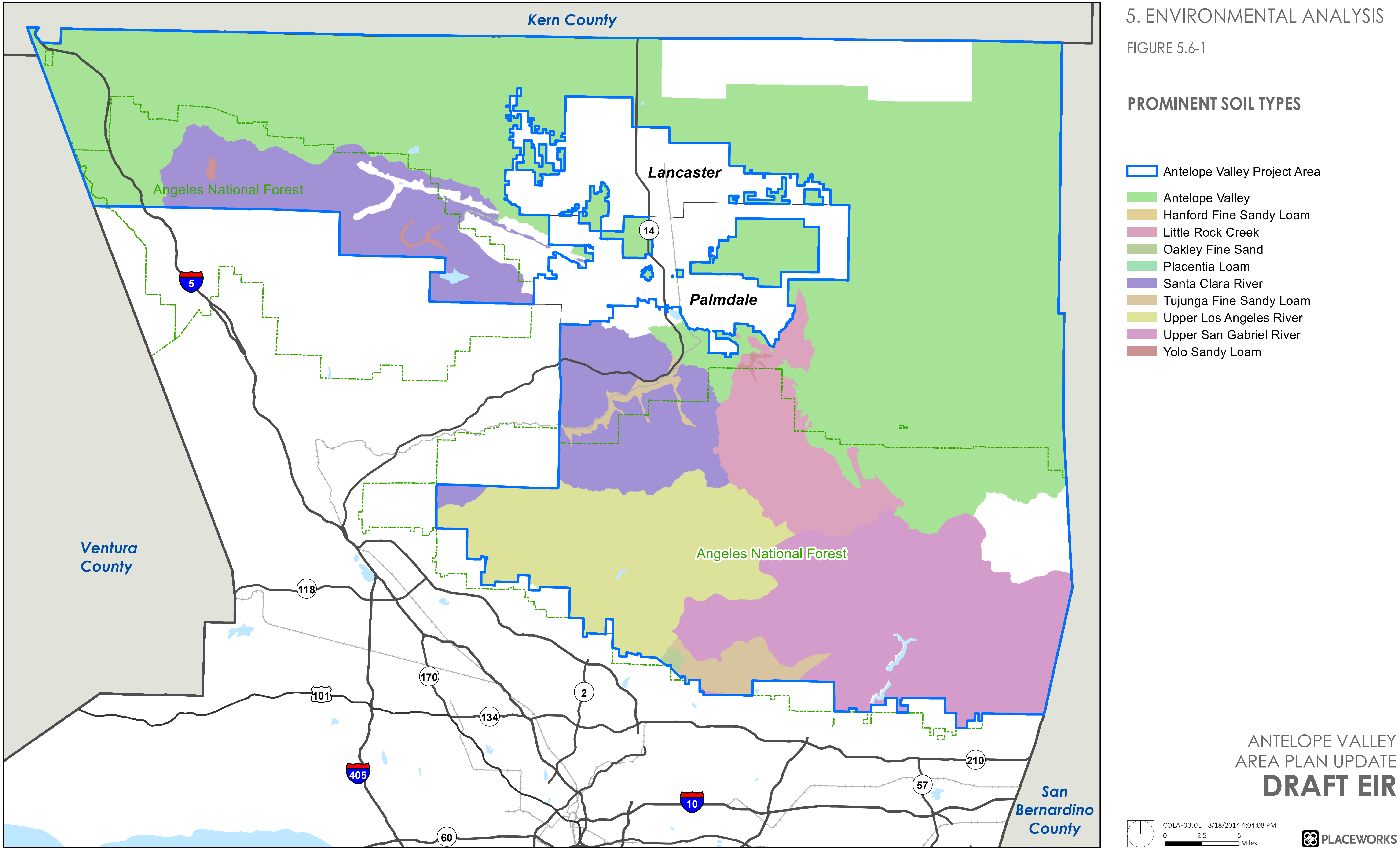
The Project Area is one of the best-known seismically active settings in North America.[20] Assessments of the earthquake hazards in Southern California have concluded that catastrophic earthquakes are inevitable in the region.[21] The probability that a large earthquake will occur sometime during the next 30 years along the San Andreas Fault that traverses the Project Area is currently estimated to be 40 percent or greater.[22] Planned losses of billions of dollars and estimated casualties of tens of thousands could significantly surpass any previous natural disaster in the United States. A catastrophic earthquake would severely strain the emergency-response and recovery capabilities of Federal, State, and local governments.

From a tectonic perspective, the San Andreas Fault system, which traverses the Project Area diagonally from the southeast to the northwest, is a zone of relative motion between the North American and Pacific Plates. The tectonic-driven crustal deformation now taking place along this plate margin is dominated by the intersection of the San Andreas and the Transverse Ranges fault systems. The manifestations of this intersection are varied, ranging from the considerable topographic relief along the north and south flanks of the San Gabriel and San Gorgonio Mountains, to transitory events, such as earthquakes. Although these fault systems are part of an ongoing tectonic process now more than five million years old, they are currently responding to strain related to motion of the Pacific and North American plates through horizontal slip (i.e., strike-slip) along the San Andreas Fault system or by vertical (i.e., thrust) slip on various Transverse Ranges faults. Seismic hazards present within Los Angeles County are shown on Figure 5.6-2, *Seismic Hazards*.

[19] Los Angeles County Department of Public Works, Los Angeles County GIS Data Portal, Soil Types, http://egis3.lacounty.gov/dataportal/2011/01/27/soil-types/, accessed on February 25, 2014.
[20] USGS, 1987. Evaluating Earthquake Hazards in the Los Angeles Region-An Earth-Science Perspective, Professional Paper 1360, J. I. Ziony, Editor.
[21] Federal Emergency Management Agency, 1980. An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake.
[22] Wesson and Wallace, 1985. Predicting the Next Great Earthquake in California: Scientific American, v. 252, no. 2.

FIGURE 5.6-1

PROMINENT SOIL TYPES



Source: Los Angeles County Department of Public Works, 2014

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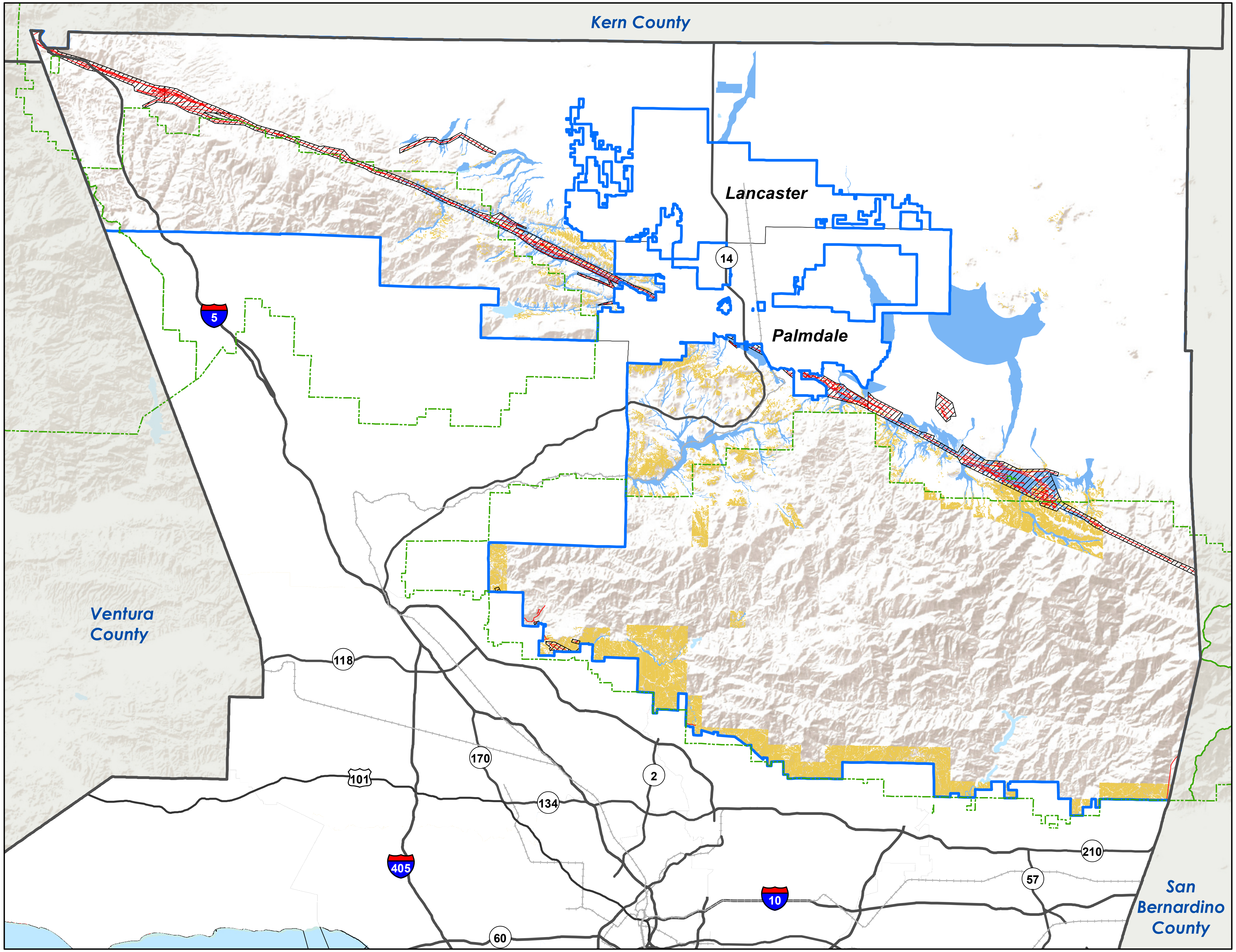
FIGURE 5.6-2

SEISMIC HAZARDS



Active Fault Trace and Alquist -Priolo Earthquake data represented in the this map is derived from to following;

1. California Geological Survey, Seismic Hazard Zone Maps, 1997 -2005.
2. Los Angeles County General Plan, Fault Rupture Hazards and Historic Seismicity Map, 1990. (USGS GIS data was used for refinement of mapped faults.)

Source: DRP,2013, Los Angeles County Department of Public Works, 2014

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Based on subsurface trenching and exploratory borings, surface observations, geomorphologic/topographic patterns, geophysical data, and other evidence, several faults within the Project Area have been classified "active faults" by the California Geological Survey. By definition, such faults must exhibit evidence of seismic failure within the past 11,000 years (i.e., the Holocene Epoch). Under the 1972 Alquist-Priolo Earthquake Fault Zoning Act, California law requires the State Geologist to identify such faults, establish protective regulatory zones known as "Earthquake Fault Zones"(or prior to 1991, "Special Studies Zones") around the traces of these faults, then publish and disseminate maps of these zones. Some of the more significant State-mapped active faults in the Project Area are listed in Table 5.6-1. This table is not intended to be all-inclusive. Instead, it seeks to highlight earthquake faults that have been associated with significant Los Angeles-area seismic events. Potentially active faults, as mapped by the CGS, are those exhibiting surface activity within the past 1.6 million years (i.e., the Quaternary Period). In the Project Area, mapped potentially active faults include an unnamed fault near Fairmont Reservoir north of and adjacent to the San Andreas Fault Zone, and the Clearwater Fault, a roughly 20-mile long, east-west trending reverse fault located south of the Leona Valley and the San Andreas Fault Zone. According to the Southern California Earthquake Data Center (SCEDC), that has exhibited activity in late Quaternary time (i.e., estimated <700,000 years).[23]

Table 5.6-1 Prominent Active Faults in the Project Area

Fault Name	Project Area Location	Comments
San Andreas Fault System	Traverses the Project Area SE to NW	Traversing the north part of the Project Area and as a tectonic plate boundary, it may represent the single most significant earthquake fault zone in California. Quiescent for many decades, it was the site of the 1857 Fort Tejon Earthquake with an estimated magnitude M_W 7.9 and surface rupture that extended more than 350 kilometers.
Garlock Fault, South Branch	Extends nearly 250 km NE from the community of Lebec	This prominent left-lateral strike-slip extends roughly 250 kilometers NE from the community of Lebec. The most recent surface ruptures were believed to have occurred in 1050 A.D. (?) near Tehachapi and 1500 A.D. (?) near Johannesburg (i.e. Searles Valley). Slip rate estimates range from 2 to 11 mm/yr., with a likely average rate of approximately 7 mm/yr. The Garlock fault zone is one of the most prominent geologic features in southern California, as it defines the northern boundary of the Mojave Block, and the southern boundary of the Sierra Nevada. Although no historic earthquakes with surface rupture are associated with the Garlock, at least one section of the fault has shown creep movement (i.e. aseismic) in recent years.
Llano Fault	Approx. 5 miles ENE of the community of Pearblossom	This fault has a reverse sense of motion and is approx. 7 km long. The most recent surface rupture is believed to be of Holocene age. The faulting generally does not extend to the surface, and it is manifest as folded Quaternary sediments that form a 30-foot-high scarp. The fault was documented by trenching studies.

Source: Southern California Earthquake Data Center, 2014; US Geological Survey Earthquake Hazards Program, 2014. CGS, 2010, Fault Activity Map of California.

[23]California Institute of Technology, Southern California Earthquake Data Center, http://www.data.scec.org/significant/clearwater.html, accessed on July 22, 2014.

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Seismic Hazards

Active Faults

Seismic slip along a fault (as opposed to seismic creep) may result in one or more geologic effects that can damage or destroy structures and injure their inhabitants. In general, ground shaking and surface fault rupture are the effects of greatest concern when an earthquake occurs along a fault in the Los Angeles region. A related effect, the possible generation of tsunamis by submarine earthquakes, may be of concern to coastal areas. For certain structures such as pipelines, canals, and coastal facilities, the regional scale uplift and subsidence that can result from some large earthquakes could pose a minor hazard.

Seismic records and data, particularly those dating from the mid-20th century, underscore the probability and severity of large earthquakes in the Project Area. Table 5.6-2 summarizes the most significant seismic events within southern California from 1930 to the present time. The listed earthquakes are those whose epicenters/hypocenters lay relatively close to the Project Area. Some larger, recent events located outside of Los Angeles County, such as the June 1992 magnitude (M_w) 7.2 Landers Earthquake, and the October 16, 1999 (M_w) 7.1 Hector Mine Earthquake, have not been included. In total, the listed earthquakes resulted in more than $21 billion in damage and the loss of nearly 250 lives.

Table 5.6-2 Summary of Significant Earthquakes in Southern California (post-1930)

Seismic Event	Date	Fault	Magnitude (M_w)	Damage/Casualties
Northridge EQ	January 1994	Northridge Thrust Fault	6.5	$20B/57
Sierra Madre EQ	June 1991	Clamshell-Sawpit Canyon Fault	5.8	$40M/2
Pasadena EQ	December 1988	Raymond Fault	5.0	Minor/none
Whittier Narrows EQ	October 1987	Unnamed blind thrust fault	5.9	$358M/8
Sylmar/San Fernando EQ	February 1971	San Fernando Fault Zone	6.5	$500M/65
Long Beach EQ	March 1933	Newport-Inglewood Fault	6.4	$50M/120

Source: Southern California Earthquake Data Center.

Surface Fault Rupture

Surface fault rupture can occur during significant seismic events. The process generally involves the sudden failure and displacement of the earth's surface along a fault trace or fault zone. The magnitude and geometry of such ground displacement is highly variable. In general, strike-slip faults such as the San Andreas Fault are more likely to produce lateral offsets in the ground surface, with one side of the fault plane or zone "sliding" past the opposing side. Similarly, faults that generally fail under compressional stress, such as thrust or reverse faults, are more prone to vertical offsets in the ground surface. In either case, buildings or other man-made structures that lie atop the fault can experience serious damage or catastrophic failure during a strong earthquake.

Strong Seismic Ground Shaking

An earthquake of moderate to high magnitude generated within the Project Area could cause significant ground shaking. The severity of shaking experienced at a particular location depends on a variety of site-specific factors that include but are not limited to: the magnitude of the seismic event, the duration of the seismic event, the distance from a particular site to the locus of earthquake rupture (a.k.a. hypocenter), local site-specific geologic conditions (i.e., nature, thickness, and extent of underlying soil and/or bedrock), and broader, often regional geologic factors such as basin geometry, presence of other fault or fracture zones, etc. As a generality, the severity of seismic ground shaking tends to diminish with increasing distance from the event hypocenter. Seismic ground shaking, if sufficiently intense and sustained, can result in significant damage or even catastrophic failure of buildings or other man-made structures.

Seismically Induced Slope Failure

An earthquake of moderate to high magnitude generated within the Project Area could result in slope failure such as landslides. Although landslides can manifest as a variety of earth movements, a recent study of earthquake-related slope failures found that the following were the most prevalent (in order of decreasing frequency): 1) rock falls, disrupted soil slides, and rock slides; 2) soil lateral spreads, soil slumps, soil block slides, and soil avalanches; and 3) soil falls, rapid soil flows, and rock slumps. The potential for such slope failure is often highly site specific and can be exacerbated where saturated soil/bedrock is present, steep and/or eroded slopes are noted, and evidence of historical slides or slide-prone soil or bedrock types is present.

Liquefaction

Liquefaction is a process whereby strong seismic shaking causes unconsolidated, water-saturated sediment to temporarily lose strength and behave as a fluid. This process can lead to near-surface or surface ground failure that can result in extensive damage to or catastrophic failure of buildings, roads, utility lines, and other man-made structures. Liquefaction can manifest as lateral ground spreading or flow, localized sand boils (i.e., eruptions of fluidized sediment), or rapid subsidence and an accompanying loss of bearing strength.

In order to preliminarily evaluate a region's susceptibility to liquefaction, several factors ought to be considered, including:

- The anticipated intensity and duration of ground shaking.
- The origin, texture, and composition of shallow sediments. In general, cohesionless materials such as sands, or areas of uncompacted or poorly compacted fills are susceptible to liquefaction. Liquefiable sediments are found in a variety of depositional environments, including bays, estuaries, river floodplains and basins, lakes, and aeolian deposits such as dunes and loess.
- The presence of shallow groundwater. Saturated sediments are necessary for seismically induced liquefaction to occur. In general, the highest liquefaction susceptibility is found in sediment soils of late Holocene to late Pleistocene age (i.e., 1,000 to 15,000 years before present [B.P.]) in areas where the groundwater is shallower than about 50 feet below ground surface (bgs).

The above-referenced conditions are known to be present in many parts of Southern California. A more detailed overview of the State-mapped seismic hazard zones in the Project Area is presented in the following Table 5.6-3. Comprehensive, Plan-specific or site-specific evaluations necessarily require more detailed

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information, beginning with 7.5-minute quadrangle maps that have been published by the CGS and ranging to detailed, site-specific geotechnical investigations.

Table 5.6-3 Overview of Mapped Seismic Hazards in the Project Area

Seismic-Induced Landslide Zones	Seismic-Induced Liquefaction Zones
Landslide hazard zones have been locally identified in the steep slopes of the San Gabriel Mountains in the south part of the Project Area, as well as the linear ridges (i.e., Portal and Ritter Ridges) that flank the San Andreas Fault Zone to the north (refer to Figure 5.6-2).	Numerous liquefaction hazard zones have been identified in the Project Area. Most are associated with alluvium filled valleys or canyons (i.e., Leona and Anaverde Valleys) and the associated washes and arroyos that generally drain north or northeast into the Mojave Desert (refer to Figure 5.6-2).

Source: CA Geological Survey, Seismic Hazard Zonation Program, 2014.

Buildings Prone to Seismic Damage

Earthquake risks are not limited to ground shaking, fault rupture, or liquefaction, but also embrace the damage to inhabited buildings or sensitive, man-made infrastructure. Advances in the field of seismic engineering and strengthened building codes have significantly reduced the potential for catastrophic collapse in newly constructed buildings. Nevertheless, many older buildings were designed and constructed before modern seismic design standards were incorporated into the building code. Certain building types are of particular concern:

- **Unreinforced Masonry Buildings:** In the late 1800s and early 1900s, unreinforced masonry was the most common type of construction for commercial buildings, many single-family residential structures, and multi-story apartments and hotels. These were recognized as a collapse hazard following the 1906 San Francisco Earthquake, the 1925 Santa Barbara Earthquake, and again, in the aftermath of the 1933 Long Beach Earthquake. These buildings are generally recognized as the most susceptible to seismic damage.

- **Precast Concrete Tilt-up Buildings:** This commercial/industrial building type gained popularity in the late 1950s and 1960s. Extensive damage to concrete tilt-up buildings during the 1971 San Fernando Earthquake revealed the need for seismic reinforcement, such as better anchoring of walls to the roof, floor, and foundation elements, as well as stronger roof diaphragms.

- **Non-ductile Concrete Buildings:** In recent years, increased public attention and concern has been directed at so-called non-ductile concrete buildings, especially multi-story office buildings constructed prior to the mid-1970s.[24] Research and post-earthquake investigations have shown that non-ductile concrete buildings are particularly prone to damage and occasional failure during large earthquake events. Published research suggests that there may be as many as 40,000 buildings of this design state-wide, including thousands of high-rise office buildings in the Los Angeles Metropolitan Area.

[24]Pacific Earthquake Engineering Research Center and Earthquake Engineering Research Institute, 2010.Inventory of Non-ductile Concrete Buildings in High Seismic Risk Areas of California; Emmett Seymour, Marjorie Greene, Thalia Anagnos, and Craig Comartin, authors.

5.6.2 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a Plan would normally have a significant effect on the environment if the Plan would:

G-1 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. (Refer to Division of Mines and Geology Special Publication 42.)

ii) Strong seismic ground shaking.

iii) Seismic-related ground failure, including liquefaction.

iv) Landslides.

G-2 Result in substantial soil erosion or the loss of topsoil.

G-3 Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Plan and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

G-4 Be located on expansive soil, as defined in Table 18-1B of the Uniform Building Code (1994), creating substantial risks to life or property.

G-5 Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

5.6.3 Relevant Area Plan Goals and Policies

Following is a list of the goals and policies of the Proposed Project that are intended to reduce potentially significant adverse effects concerning geology, soils, or seismicity.

Land Use Element

Goal LU 2: A land use pattern that protects environmental resources.

- **Policy LU 2.4:** Limit the amount of potential development in Mineral Resource Areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.

Goal LU 3: A land use pattern that minimizes threats from hazards.

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- **Policy LU 3.1:** Prohibit new development on fault traces and limit the amount of potential development in seismic zones, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy LU 3.4:** Limit the amount of potential development on steep slopes identified as Hillside Management Areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy LU 3.5:** Limit the amount of potential development in landslide and liquefaction areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.

Conservation and Open Space Element

Scenic Resources

Goal COS 5: The Antelope Valley's scenic resources, including scenic drives, water features, significant ridgelines, buttes, and Hillside Management Areas, are enjoyed by future generations.

- **Policy COS 5.5:** Require adequate erosion control measures for all development in Hillside Management Areas, both during and after construction.

Mineral Resources

Goal COS 8: Mineral resources are responsibly extracted.

- **Policy COS 8.1:** Allow new mineral resource extraction activities only in designated Mineral Resource Areas.
- **Policy COS 8.2:** Where new mineral resource extraction activities are allowed, ensure that applications undergo full environmental review and public noticing. Require site remediation after completion of mineral resource extraction activities.
- **Policy COS 8.3:** Provide strict enforcement of illegal or unpermitted mineral extraction activities.

Public Safety, Services & Facilities Element

Geological Hazards

Goal PS 2: Protection of the public through geological hazard planning and mitigation.

- **Policy PS 2.1:** Limit the amount of potential development in seismic zones and along the San Andreas Fault and other fault traces through appropriate land use designations with very low densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.

- **Policy PS 2.2:** Limit the amount of development on steep slopes (Hillside Management Areas) and within landslide and liquefaction areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.

- **Policy PS 2.3:** Prohibit the construction of new structures on or across a fault trace.

- **Policy PS 2.4:** Ensure that new development does not cause or contribute to slope instability.

5.6.4 Environmental Impacts

The following impact analysis addresses thresholds according to Appendix G of the CEQA Guidelines of significance. The applicable thresholds are identified in brackets after the impact statement.

Increased Development Potential, Population, and Employment due to Plan Buildout

Implementation of the Proposed Project could result in significant development in and around the more than one dozen rural town center areas that comprise the Project Area. Proposed Project buildout would result approximately 81,441 additional housing units compared to existing conditions. These new units would generate about 311,290 additional residents. Buildout of the Proposed Project would also result in a 39 percent increase in non-residential (commercial and industrial) space with an additional 37.1 million square feet. New land uses would result in an increase of 102,513 more jobs than under existing conditions.

Impact 5.6-1: Project Area residents, occupants, or structures could potentially be exposed to seismic-related hazards. [Threshold G-1i, -1ii, -1iii, and -1iv]

Impact Analysis:

Rupture of a Known Earthquake Fault

As depicted on Figure 5.6-2, several parts of the Project Area lie within State-mapped Alquist-Priolo Earthquake Fault Zones, the most notable of which is the San Andreas Fault Zone. Plan implementation would result in the construction of new residential, commercial, and light industrial structures. The siting of such buildings would have to comply with the requirements of the Alquist-Priolo Earthquake Fault Zoning Act and the County Building Code, the purpose of which is to prevent the construction of residential buildings on top of the traces of active faults. Adherence to this law, and the associated setbacks from active fault traces, would help reduce the hazards associated with earthquake fault rupture to a less than significant level. Reducing the maximum residential densities in these areas, as proposed by the Proposed Project, would also help further reduce the hazards associated with earthquake fault rupture.

Strong Seismic Ground Shaking

Buildout of the Proposed Project would inevitably increase the number of residential buildings, commercial/light-industrial buildings, and residents, workers, and visitors to the area. The Antelope Valley is a very seismically active region. Strong ground shaking is very likely to occur in the Project Area during the

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useful lifetime of newly built or redeveloped buildings envisioned in the Proposed Area Plan. The Project Area contains several active and potentially active earthquake faults, the most significant of which are listed in Table 5.6-1 and shown on Figure 5.6-2. Of the faults listed, the southern section of the San Andreas Fault is believed to be capable of generating the largest earthquake, potentially in excess of M_w 7.1. Although the maximum anticipated peak horizontal ground acceleration associated with these faults is approximately 0.50 g, the intensity of seismic shaking can be very location dependent. For example, vertical ground acceleration associated with the 1994 Northridge Earthquake locally exceeded 1.0 g (i.e., more than the force of gravity) at certain monitoring stations.

Although strong seismic shaking is a risk throughout Southern California, the Project Area is not at greater risk of seismic activity or impacts than other areas. Additionally, the State regulates development through a variety of tools that reduce hazards from earthquakes and other geologic hazards. The County Building Code contains building design and construction requirements that are intended to safeguard against major structural failures or loss of life caused by earthquakes or other geologic hazards.

The County building regulations are included in the County Building Code. Future development plans pursuant to the Proposed Project would be required to adhere to the provisions of the County Building Code, which are imposed on plan developments by the County during the building plan check and development review process. Each future development would be preceded by a detailed, site-specific geotechnical investigation. The geotechnical investigation would calculate seismic design parameters pursuant to County Building Code requirements, and would include foundation and structural design recommendations, as needed, to reduce hazards to people and structures arising from ground shaking. Compliance with the requirements of the County Building Code for structural safety during a seismic event would reduce the hazards associated with strong seismic ground shaking to a less than significant level.

Liquefaction

Implementation of the Proposed Project would increase numbers of residents, workers, visitors, and structures in the Project Area. Based on assessments of anticipated intensity and duration of seismic shaking; the origin, texture, and composition of shallow sediments; and the local presence of shallow groundwater, several parts of the Project Area have been mapped by the State as areas prone to seismically induced liquefaction as summarized in Table 5.6-3 and shown of Figure 5.6-2. Future development plans considered for approval pursuant to the Proposed Project could subject persons or structures to potentially significant hazards arising from liquefaction.

Although liquefaction zones have been mapped within the Project Area, future development pursuant to the Proposed Project would not result in increased risk of or exposure to liquefaction or other seismic-related ground failures. Geotechnical investigations for future development plans considered for approval by the County pursuant to the Proposed Project would be required to evaluate the potential for liquefaction and other seismic ground failure, such as lateral spreading, under the respective plan sites. Geotechnical investigation reports would provide recommendations for grading and for foundation design to reduce hazards to people and structures arising from liquefaction and other seismic-related ground failure. Future development plans pursuant to the Proposed Project would be required to adhere to existing building and grading codes, and construction-related grading requires the preparation and submittal of site-specific grading plans and geotechnical reports that must be reviewed and approved by the County beforehand. Each future development plan would be required to comply with the recommendations in the geotechnical investigation report and comply with the County Building Code, thereby reducing such hazards to a less than significant level.

Seismically Induced Landslides

Implementation of the Proposed Project at buildout would increase numbers of residents, workers, visitors, and structures in Los Angeles County. The propensity for earthquake-induced landslides is greatest in areas characterized by steep slopes and/or bedrock or soil that are prone to mass movement. Only limited parts of the Project Area have been mapped by the State as zones of seismically-induced landslide hazards under the Seismic Hazard Zonation Program. Nevertheless, the existing County's building plan check and development review process provides meaningful safeguards against exposure to such hazards.

Certain policies in the Land Use Element and Public Safety, Services, and Facilities Element of the Proposed Project are intended to address potential seismic-related hazards associated with ground shaking, liquefaction, and seismically induced landslides:

- **Policy LU 3.1:** Prohibit new development on fault traces and limit the amount of potential development in Seismic Zones, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy LU 3.5:** Limit the amount of potential development in landslide and liquefaction areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy PS 2.1:** Limit the amount of potential development in Seismic Zones and along the San Andreas Fault and other fault traces through appropriate land use designations with very low densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy PS 2.2:** Limit the amount of development on steep slopes (Hillside Management Areas) and within landslide and liquefaction areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy PS 2.3:** Prohibit the construction of new structures on or across a fault trace.

Compliance with existing State and County regulations, as well as the goals and policies set forth in the Proposed Project would ensure that the impacts associated with exposure to strong seismic ground shaking, seismic-related ground failure including liquefaction, and landslides are reduced to a less than significant level.

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Impact 5.6-2:	Plan implementation would result in substantial soil erosion, the loss of topsoil, or development atop unstable geologic units or soils, or expansive soils. [Thresholds G-2, G-3, and G-4]

Impact Analysis:

Erosion

Project buildout would involve construction-related ground disturbance in various parts of the Project Area. During future development, soil would be graded or excavated and temporarily stockpiled. Construction-related grading during future development could result in significant erosion unless appropriate soil-erosion measures are implemented.

Most parts of the Project Area are typified by gentle to moderate topography and are less susceptible to erosion and/or the loss of topsoil. However, grading in areas characterized by steep slopes may substantially increase the likelihood of erosion and/or topsoil loss. The grading process often removes protective vegetation, changes natural drainage patterns, and may produce oversteepened slopes. Policies concerning development in Hillside Management Areas (HMAs) also provide protection against erosion, particularly in areas dominated by steep slopes. In particular, the existing HMA Ordinance encourages development in HMAs on less steep slopes, and requires a Conditional Use Permit (CUP) prior to development in certain HMAs. Through the CUP, projects must protect the safety of current and future residents, and will not create significant threats to life and/or property due to the presence of geologic, seismic, slope instability, fire, flood, mud flow, or erosion hazard.

Adherence to the requirements of the County Building Code, together with the safeguards afforded by the County's building plan check and development review process, would help ensure that appropriate erosion controls are devised and implemented during construction. Furthermore, construction activities on individual development sites larger than one acre would be subject to National Pollution Discharge Elimination System (NPDES) requirements. Under the State-administered NPDES, the preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP) would be required as well as deployment of approved erosion control best management practices (BMPs). Construction Plans on sites one acre or larger are required to prepare and implement a SWPPP. The SWPPP is required to obtain coverage under the Statewide General Construction Activity permit issued by the State Water Resources Control Board. The SWPPP would specify BMPs that would be used during the construction phase of each affected Plan to minimize water pollution, including pollution with sediment. Categories of BMPs used in SWPPPs are described in Table 5.6-4.

Table 5.6-4 Construction Best Management Practices

Category	Purpose	Examples
Erosion Controls	Cover and/or bind soil surface, to prevent soil particles from being detached and transported by water or wind.	Mulch, geotextiles, mats, hydroseeding, earth dikes, swales.
Sediment Controls	Filter out soil particles that have been detached and transported in water.	Barriers such as straw bales, sandbags, fiber rolls, and gravel bag berms; desilting basin; cleaning measures such as street sweeping.
Wind Erosion Controls	The aims and methods of wind erosion control are similar to those of “Erosion Control,” above.	See “Erosion Controls,” above.
Tracking Controls	Minimize the tracking of soil offsite by vehicles.	Stabilized construction roadways and construction entrances/exits; entrance/outlet tire wash.
Nonstorm Water Management Controls	Prohibit discharge of materials other than stormwater, such as discharges from the cleaning, maintenance, and fueling of vehicles and equipment. Conduct various construction operations, including paving, grinding, and concrete curing and finishing, in ways that minimize non-stormwater discharges and contamination of any such discharges.	BMPs specifying methods for: paving and grinding operations; cleaning, fueling, and maintenance of vehicles and equipment; concrete curing; concrete finishing.
Waste Management and Controls (i.e., good housekeeping practices)	Management of materials and wastes to avoid contamination of stormwater.	Spill prevention and control, stockpile management, and management of solid wastes and hazardous wastes.

In addition to the requirement to prepare a SWPPP, grading during development is subject to erosion control measures in the County's Building Code, specifically the Grading Code Ordinance and Regulations. This code includes restrictions and practices that must be followed by developers in Los Angeles County. The faces of cut-and-fill slopes and development sites shall be prepared and maintained to control against erosion. Required erosion control measures may include temporary and/or permanent erosion control measures such as desilting basins, check dams, riprap, or other devices or methods, as approved by the County. Consequently, impacts would be less than significant.

Unstable Geologic Units or Soils and Expansive Soils

Buildout of the Proposed Project would increase numbers of residents, workers, visitors, and structures in Los Angeles County. The Project Area is geographically expansive, embracing a variety of geologic settings and soil types. In most parts of the Project Area, unstable geologic units or soils, or expansive soils are not of concern. Nevertheless, areas of unstable geologic units or unstable or expansive soils are known to occur locally. Development subsequently considered for approval within the Project Area could expose structures or persons to potentially significant hazards due to unstable geologic units or soils.

Individual development plans would be required to adhere to existing building and grading codes. These codes contain provisions for soil preparation/conditioning to minimize hazards from unstable and expansive soils. Grading and building activities also requires the preparation of site-specific grading plans, soils and geology reports to address liquefaction, subsidence, hydrocollapse, and other potential geologic or soil stability issues. Such plans and reports must be tendered to the County for review and approval before development within the Project Area can commence. Submittal of these technical plans and studies would ensure that hazards arising from unstable and expansive soils would be minimized to the extent practicable.

Policies included in the Land Use Element, Conservation and Open Space Element, and Public Safety, Services, and Facilities Element of the Proposed Project have been developed to address potential hazards associated with soil erosion, topsoil loss, or development atop unstable geologic units or soils, or expansive soils:

- **Policy LU 3.4:** Limit the amount of potential development on steep slopes identified as Hillside Management Areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy COS 5.5:** Require adequate erosion control measures for all development in Hillside Management Areas, both during and after construction.
- **Policy COS 8.3:** Provide strict enforcement of illegal or unpermitted mineral extraction activities.
- **Policy PS 2.2:** Limit the amount of development on steep slopes (Hillside Management Areas) and within landslide and liquefaction areas, through appropriate land use designations with very low residential densities, as indicated in the Land Use Policy Map (Map 2.1) of this Area Plan.
- **Policy PS 2.4:** Ensure that new development does not cause or contribute to slope instability.

Compliance with existing State and County regulations, as well as the goals and policies set forth in the Proposed Project, would ensure that the impacts associated with erosion and topsoil loss, as well as development atop unstable geologic units and soil, or expansive soil are reduced to the maximum extent practicable. Consequently, the overall, associated impacts would be less than significant.

Impact 5.6-3: Soil conditions would adequately support proposed septic tanks. [Threshold G-5]

Impact Analysis:

Some of the development that is anticipated in the Project Area would not require the use of septic tanks or alternative wastewater disposal systems. Wastewater would be discharged into the existing public sanitary sewer systems, where the wastes would be conveyed by pipes to plants for treatment at one of two nearby water reclamation plants operated by the Sanitation District of Los Angeles County. Elsewhere, in more rural parts of the Project Area, septic systems might be necessary, although the prevailing soil conditions are typically amenable to the use of such systems. In addition, all on-site wastewater treatment systems (OWTS) must comply with County Code Titles 11 and 28 and other regulations applicable to OWTS, including requirements for preparation and submittal of feasibility reports in order to obtain the Department of Public Health - Environmental Health approval for construction and installation of OWTS.As such, there would be no impact from implementation of the Proposed Project at sites where soils might otherwise not be capable of supporting the use of septic tanks or alternative wastewater disposal systems.

The impacts associated with the use of OWTS as a consequence of Proposed Project implementation would be less than significant.

5.6.5 Cumulative Impacts

Most of Southern California is situated in an area of a high seismic activity, including the Project Area. All cumulative development, both within the Project Area and within adjacent cities or parts of Los Angeles County, would be subject to the County Building Code, which contains requirements for development in areas subject to Seismic Design Categories E and F. Additionally, cumulative plans would be subject to the Alquist-Priolo Earthquake Fault Zone Act, which restricts development atop the traces of active faults. Due to the site-specific nature of geological conditions (i.e., soil type, bedrock type, topography and slope stability, occurrence of groundwater, etc.), potential impacts associated with geology and soils are typically assessed on a case-by-case basis, rather than on a cumulative basis. Nevertheless, cumulative growth due to plan implementation/buildout would expose a greater number of people to seismic hazards. Future cumulative development under the Proposed Project and the surrounding area would be subject to the same local, State, and Federal regulations pertaining to geology and soils, including County Building Code requirements (or city building code requirements, as appropriate). Therefore, development in the region would not result in a significant cumulative impact. The Proposed Project, in combination with other plans, would not contribute to a potentially significant cumulative impact.

5.6.6 Existing Regulations and Standard Conditions

State

- California Building Code (Title 24, California Code of Regulations, Part 2)
- California Health and Safety Code Sections 17953 et seq.: Geotechnical Investigations
- California Code of Regulations Title 24, Section 3724: Required Investigations in Seismic Hazard Zones
- California Public Resources Code Sections 2621 et seq.:Alquist-Priolo Earthquake Fault Zoning Act
- California Public Resources Code Section 2695: Seismic Hazard Mapping Act
- California Public Resources Code Section 2710 et seq.: Surface Mining And Reclamation Act Of 1975
- Order No. 2009-0009-DWQ, State Water Resources Control Board: General Construction Permit

Los Angeles County Code

- Title 26, Chapters 2 through 35, and Appendices C, I, and J (Adoption of California Building Code)

- Grading Code Ordinance and Regulations (Construction-related erosion control, preparation of cut-and-fill slopes, and the implementation of erosion control measures)

- Title 26, Chapters 95 and 96 (Seismic safety requirements for older concrete tilt-up buildings and unreinforced masonry bearing wall buildings)

5.6.7 Level of Significance Before Mitigation

Assuming compliance with applicable regulatory requirements and conformance with standard conditions of approval, the following impacts would be less than significant: 5.6-1, 5.6-2, 5.6-3, 5.6–4, and 5.6–5.

5.6.8 Mitigation Measures

No mitigation measures are required.

5.6.9 Level of Significance After Mitigation

No significant impacts have been identified and no significant and unavoidable impacts would occur.

5.6.10 References

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